APPENDIX J

BIOLOGICAL AND FAUNA SURVEYS OF THE PROPOSED DEVELOPMENT AREA

ORD SUGAR PROJECT

Biological Surveys of the Proposed Development Area - May and June 1999

Prepared for:

WESFARMERS LIMITED,

MARUBENI CORPORATION AND THE WATER

CORPORATION OF WESTERN AUSTRALIA

Level 7, 40 The Esplanade
Perth WA 6000

Prepared by:

Kinhill Pty Ltd
ACN 007 660 317
47 Burswood Road, Victoria Park WA 6100
Telephone 08 9362 5900, Facsimile 08 9362 5627

August 1999

PV8009-FC-008 Rev. 0

Limitations Statement

In preparing this report, Kinhill Pty Ltd has relied upon and presumed accurate certain information (or absence thereof) relative to the site that was obtained from examination of records in the public domain or provided by government officials and authorities. Except as otherwise stated in the report, Kinhill has not attempted to verify the accuracy or completeness of any such information.

The findings, observations and conclusions expressed by Kinhill Pty Ltd in this report are not, and should not be considered, an opinion concerning the feasibility of establishing irrigated agriculture on the site. No warranty or guarantee, whether express or implied, is made with respect to the data reported or to the findings, observations and conclusions expressed in this report. Further, such data, findings, observations and conclusions are based solely upon information in existence at the time of the investigation.
This report has been prepared on behalf of and for the exclusive use of the Wesfarmers Limited, Marubeni Corporation and the Water Corporation of Western Australia, and is subject to and issued in connection with the provisions of the agreement with Kinhill Pty Ltd. Kinhill Pty Ltd accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

CONTENTS

1 Background

Kinhill Pty Ltd were contracted by Wesfarmers Limited, Marubeni Corporation and the Water Corporation of Western Australia to co-ordinate a biological survey of the areas proposed for development as part of the Ord Sugar Project. These areas comprise portions of the black soil (cracking clay) plains of the Weaber Plain, Keep River Plain and Knox Creek Plain in the east-Kimberley region of Western Australia and the adjacent Northern Territory.

The purpose of the biological survey was to supplement data collected previously in the area by Ecologia Environmental Consultants in October 1996 and February 1997 (Ecologia Environmental Consultants 1997). Additional data was sought for:

- vegetation, to allow the preparation of a vegetation map for use in the Environmental Review and Management Programme / Environmental Impact Statement (ERMP/EIS) being prepared for the Ord Sugar Project (Chapter 7 of the ERMP/EIS refers);
- fauna inhabiting the black soil plains, particularly bats and other mammals, reptiles and frogs.

Two botanical field trips were undertaken from 17 – 20 May and 6 – 11 June 1999. The first field trip surveyed the Knox Creek and part of the Weaber Plain and the second completed the survey of the Weaber Plain and the Keep River Plain. The botanists who undertook the survey were Dr Eleanor Bennett and Mr Paul Ellery with assistance from Mrs Rochelle Pyle.

Five fauna specialists were part of the field survey undertaken between 6 – 11 June. This team comprised two bat specialists, Ms Lindy Lumsden and Ms Sue Churchill; two herpetologists Mr Peter Robertson and Mr Greg Harold, and one mammal specialist Dr Ray Hart. Mrs Rochelle Pyle again provided assistance to the team.

2 Scope and Structure of this Report

This report is a compilation of three reports prepared by the specialists who undertook the field surveys in May and June 1999.

Attachment A describes the vegetation communities of the Project Area. This report combines the field data of Ecologia Environmental Consultants (1997) and that from the Kinhill Pty Ltd fieldwork in 1999, from which the vegetation map of the area was prepared.

Attachment B describes the terrestrial fauna survey. The data included is from pitfall traps and opportunistic sightings undertaken by the team.

Attachment C describes the survey for bats undertaken in June 1999. In addition to the project area, recording for the presence of bats was also undertaken in the Point Spring Nature Reserve and adjacent to Cave Spring.

3 References

Ecologia Environmental Consultants (1997) Ord River Irrigation Area - Stage 2 M2 Development Area Terrestrial Biological Assessment. Unpublished report for Department of Resources Development, Perth.

Attachment A

A Vegetation survey to map the vegetation communities of the M2 Development Area of the Ord River Irrigation Scheme

ORD SUGAR PROJECT

A Vegetation survey to map the vegetation communities of the M2 Development Area of the Ord River Irrigation Scheme

Prepared for:

WESFARMERS LIMITED,

MARUBENI CORPORATION AND THE WATER

CORPORATION OF WESTERN AUSTRALIA
Level 7, 40 The Esplanade
Perth WA 6000

Prepared by:

Kinhill Pty Ltd
ACN 007 660 317
47 Burswood Road, Victoria Park WA 6100
Telephone 08 9362 5900, Facsimile 08 9362 5627

October 1999

PV8009-FC-009 Rev. 0

CONTENTS

1 Introduction

Two biological surveys had been undertaken in the M2 Development Area of the Ord River Irrigation Scheme by Ecologia Environmental Consultants (Ecologia) in October 1996 and February 1997. These surveys were commissioned by the Department of Resources Development on behalf of the Governments of Western Australia and the Northern Territory.

The Ecologia surveys were undertaken over the whole of the proposed development area plus some additional areas outside. A total of 17 vegetation associations were recognised from the data obtained. An attempt was made by Kinhill Pty Ltd to produce a vegetation map of the area from the field data obtained by Ecologia, but as found by Ecologia, this was impossible. Many vegetation associations were not soil specific and the 17 vegetation associations encompassed too much variation. In addition, when the sampling sites were overlain on aerial photography, it was apparent that the proposed development area had been inadequately surveyed by comparison to the surrounding country.

The purpose of the additional field work undertaken by Kinhill Pty Ltd was to ground truth a draft vegetation map and to enhance an understanding of the vegetation of the proposed development area, particularly the cracking clay soils. Rock outcrops and riparian areas were not surveyed as these would not be subject to development.

2 Method

Two field trips were undertaken, the first from 17 – 20 May and the second from 6 – 11 June, 1999. Knox Creek Plain and the western section of the Weaber Plain were surveyed in the first field trip and the remainder of the Weaber Plain and the Keep River Plain in the second trip.

The information gathered by Ecologia, including vegetation description, species present and soil type were checked in the field and alterations and enhancements made where appropriate. As these field trips were undertaken at the end of the wet season there were several annual species still flowering which had not been collected during the Ecologia surveys.

Aerial photographs with the soil units superimposed were used in the field. Differences observed in the aerial photographs were surveyed, however access was limited to tracks. Also the *Sorghum* spp. plants were over 3m tall and the grass understorey extremely dense, making cross country access very difficult. The tracks wre abundant and transected the different soil units and vegetation variations seen in the aerial photograph.

All the proposed development area was successfully covered by the Ecologia and Kinhill survey, encompassing the extent and diversity of the vegetation associations.

Additional sites were recorded where the vegetation was found to differ from that recorded by Ecologia. At each new site the following was recorded: soil unit, AMG, each species present, its average height, % cover alive and dead, overall community and a vegetation description. Each site was then entered on the aerial photograph to check the extent of that community.

Collections were made of all readily observed species in the field and representative collections will be sent to the Western Australian Herbarium, Darwin Herbarium and the CALM Herbarium at Kununurra. All specimens were pressed and dried and then checked with named specimens housed at the Western Australian Herbarium. Mr Bruce Maslin from the Western Australian Herbarium is thanked for the identification of the wattle species, especially the dominant species, *Acacia ditricha*.

3 Results

The vegetation of the proposed development area was found to consist of grassland or grassland with emergent trees, occasionally the trees forming a moderately dense canopy. Most grasses and trees were common across all the plains but some species were found to be soil specific (e.g. *Melaleuca minutifolia*) or to occur in damper soil (e.g. *Oryza australiensis*).

The riparian vegetation along the Keep River varied considerably. No specific survey sites were established in these areas but the Keep River was crossed on several tracks and Ecologia sites were visited for confirmation of species and vegetation description. In the northern section the vegetation was open and dominated by *Melaleuca acacioides* and *Bauhinia cunninghamii* with an open to dense understorey of *Heteropogon contortus* and *Panicum decompositum.* Scattered seedlings of the mangrove, *Avicennia marina* were observed but there was no fringing vegetation of this or any other species of mangrove. The vegetation became dense upstream, resembling vine thicket density in several areas, but without the presence of dense vines. In the denser areas the vegetation consisted of trees of *Melaleuca argentea, Barringtonia acutangula, Melaleuca viridiflora* and *Celtis phillipensis* with scattered *Pandanus aquatica* over open grassland dominated by *Panicum laevinode*. The scattered vines included *Marsdenia* sp. *Cardiosperma halicabum* and *Ipomoea muelleri.*

Basically the species present on the Weaber Plain, Keep River Plain and Knox Creek Plain were very similar, varying mainly in the density of each layer and species combination. There were some dominant changes, which are listed below.

- The northern section of the Keep River Plain was dominated by grasslands with no emergent trees whereas the Knox Creek Plain had grasslands with emergent *Eucalyptus microtheca, Bauhinia cunninghamii* and *Excoecaria parvifolia*. The Weaber Plain was very similar to the Knox Creek Plain but included *Terminalia obovata* subsp. *volucris* as a dominant low tree.
- *Iseilema vaginiflora* was one of the dominant grasses on the Knox Creek and Weaber Plains and *Iseilema fragile* was a dominant grass on the Keep River Plain.
- *Acacia diticha* was more abundant in the Keep River Plain than on the other two plains, and *Terminalia obovata* subsp. *volucris* was more abundant on the Weaber Plain than the other two plains.
- The Keep River Plain included several areas of different soil types with distinctive vegetation present. The variation in soils was not as distinct in the Knox Creek and Weaber Plains with only nominal soil variation being present.
- The northern section of the Weaber Plain tended to be retaining its moisture for a longer period than the remainder of the area as evidenced by the presence of *Oryza australiensis* and *Echinochloa kimberleyensis.*

Currently the area is used for pastoral purposes and the vegetation shows the effects of this land use. Cattle congregate at areas retaining water, and permanent water holes with cattle access are highly degraded.

In addition, fire appears to have been through several of the bushland areas at different frequencies. Between the survey in May and June 1999, areas of the Weaber Plain had been burnt and the grasses had been severely damaged and several shrubs killed making identification impossible. The long term effect of frequent fires is not fully understood but could have the capacity to change a woodland or shrubland to an open woodland or shrubland or even grassland. The dominance of individual grass species as a result of the fire cycle is also not fully understood and certain species may benefit from frequent fires while others may not survive.

4 Vegetation Communities

The following descriptions are derived from Ecologia (1997) Appendix C and the field work by Kinhill Pty Ltd.

A total of 72 vegetation communities are described and these are grouped into 17 different categories dependent upon the dominant vegetation storey. One community, G7 is described but is too small to map even at a 1:25000 scale and is therefore combined and mapped with vegetation community GT3. Connors et.al. (1996) used fine scale mapping units for their work int eh Northern Territory, however the communities described below are at an even finer scale mapping unit.

4.1 GRASSLANDS AND SEDGELANDS

G1 Dense Grassland mosaic dominated by *Heteropogon contortus, Iseilema fragile, Themeda triandra, Chrysopogon fallax* or *Sorghum timorense*.

Grasses included *Heteropogon contortus* or *Iseilema fragile* or *Themeda triandra* and *Sorghum timorense* with cover between 50-90%. Additional grasses included *Ophiuros exaltatus, Aristida latifolia, Dichanthium sericeum, Sehima nervosum* and *Panicum decompositum.*

Shrubs with a total cover <1% included *Hibiscus panduriformis, Acacia ditricha* and *Sida spinosa.*

This community occurred in Soil Unit 1 on the Keep River Plain where it formed pure grasslands.

G2 Dense Grassland of *Themeda triandra, Dichanthium sericeum* var. *polystachyum, Sorghum timorense* and *Chrysopogon fallax*.

Grasses included *Themeda triandra* and *Dichanthium sericeum* var. *polystachyum* with cover ca. 35%, *Themeda triandra, Sorghum ? grande* with cover 65%, *Chrysopogon fallax* and *Ophiuros exaltatus* with cover <5% and *Dichanthium sericeum* var. *polystachyum* with cover <10%.

Occasional shrubs included *Terminalia oblongata* subsp. *volucris, Neptunia monosperma* and *Hibiscus panduriformis.*

This community occurred in Soil Unit 3a on the Keep River Plain.

G3 Open Grassland of *Themeda triandra* over *Eriachne* sp.

Grasses included *Eriachne* sp. with cover >50%, *Themeda triandra* with cover 1-2% and *Chrysopogon setifolius* with cover <1%.

Scattered juvenile *Eucalyptus microtheca* up to 1.3m tall were recorded.

This community occurred in Soil Unit 1 on the Keep River Plain.

G4 Open annual grassland of *Sorghum timorense* over dense *Chrysopogon fallax*

Grasses included *Sorghum timorense* with cover 20-50%, *Chrysopogon fallax* with cover 60-90%. Other grass species included *Themeda triandra, Iseilema fragile, Aeschynomene indica, Dichanthium sericeum* var. *polystachyum, Fimbristylis phaeoleuca, Panicum laevinode* and *Eriachne glauca*.

This community occured in Soil Unit 5c towards the east of the Keep River Plain.

G5 Open Grassland of *Imperata cylindrica* over *Xerochloa imberbis* and *Sporobolus virginicus*..

Grasses included *Imperata cylindrica* with cover >85%, *Xerochloa imberbis* with cover >40% and *Sporobolus virginicus* with cover >5%.

Shrubs included **Melochia pyramidata* and *Melaleuca nervosa*.

Occurred in Soil Unit 7a on the Keep River Plain beside Border Creek.

G6 Mixed Sedgeland and Grassland of *Eriachne sulcata, Eleocharis dulcis* and *Eleocharis* sp. B (Kimberley Flora) with emergent *Corymbia confertiflora*.

Grasses included *Eriachne sulcata, Eleocharis* sp. B (Kimberley Flora) with cover >30%, *Eleocharis dulcis* with cover >10%, *Sorghum timorense* with cover <20%, *Oryza australiensis* with cover <5%. *Themeda triandra* occurred in clumps with an overall cover <5%.

Emergent trees included *Corymbia confertiflora*.

This community was recorded at a swamp in Soil Unit 5c/4d on the Weaber Plain.

G7 Open Sedgeland dominated by *Eleocharis dulcis* and *Schoenoplectus praelongatus* with emergent *Excoecaria parvifolia* and *Barringtonia acutangula* on the edge of Milligan's Lagoon.

This community for mapping purposes has been combined with community GT3. However in the lagoons to the south of the windpump where the banks are not steep there is an open sedgeland.

Living in the water were *Pseudoraphis spinescens* and *Eleocharis dulcis* with cover >30%, *Nymphaea violacea* and *Nymphaea gigantea* with cover >10%, *Utricularia muelleri* floating on the surface with cover about 2%. Surrounding the water, but in damp ground, was *Schoenoplectus praelongatus* with cover >8% and *Schoenoplectus dissachanthus* with cover

<1%, *Marsilea angustifolia* with cover <2%. Shrubs included *Excoecaria parvifolia* with cover >5% and *Barringtonia acutangula* with cover 3%.

Occurs in Soil Unit 1, on the Knox Plain at Milligan's Lagoon.

4.2 GRASSLANDS WITH EMERGENT TREES

GT1 Tall Grassland of *Sorghum timorense, Aristida latifolia* and *Heteropogon contortus* with emergent *Eucalyptus microtheca* in Soil Unit 1 on the Keep River Plain.

Trees included *Eucalyptus microtheca* with cover 4% and *Excoecaria parvifolia* cover <1%.

Grasses included *Sorghum timorense* with cover >80%, *Themeda triandra* with cover <5%, *Iseilema fragile* <2% and *Aristida latifolia* with cover 1%.

This Community had a restricted distribution in Soil Unit 1 on the Keep River Plain

GT2 Dense grassland of *Iseilema vaginiflorum, Aristida latifolia, Sorghum timorense, Themeda triandra* with emergent *Eucalyptus microtheca, Excoecaria parvifolia, Atalaya hemiglauca* and *Bauhinia cunninghamii.*

Trees included *Eucalyptus microtheca* with cover <5%, *Excoecaria parvifolia* with cover <15%, *Bauhinia cunninghamii* with cover <10% and *Atalaya hemiglauca* with cover <5%.

Shrubs included *Corchorus fascicularis* with cover 0-25% and *Flemingia pauciflora* with cover <5%.

Grasses included *Iseilema vaginiflorum* with cover 20-45%, *Sorghum timorense* with cover <40%, *Aristida latifolia* with cover <40%, *Brachyachne convergens* of <30%, *Themeda triandra* with cover <15% and *Ophiuros exaltatus* with cover <5%.

This was the dominant community in Soil Unit 1 on the Knox Creek Plain. It consisted of a mosaic of different grass species with the same upper storey species.

GT3 Grassland of *Pancium decompositum, Heteropogon contortus, Themeda triandra* and *Iseilema vaginiflorum* with emergent scattered *Eucalyptus microtheca* and *Corymbia bella.*

Trees included *Eucalyptus microtheca* with cover 1-2%, *Corymbia bella* with cover <10%, *Cathormion umbellatum* subsp. *moniliforme* with cover <15%, **Leucaena leucocephala* with cover <3% and *Bauhinia cunninghamii* with cover <3%.

Shrubs included *Abutilon hannii w*ith cover <1%, *Phyllanthus maderaspatensis* with cover <5%, *Grewia retusifolia* with cover <1%.

Twiners included *Passiflora foetida* var. *hispida* and *Ipomoea muelleri*.

Grasses included *Panicum decompositum* with cover <20%, *Iseilema vaginiflorum* with cover <20%, *Mnesithea rottboellioides* with cover <5% and *Eragrostis tenellula* with cover <2%.

This community occurred on the raised bank on the eastern edge of Milligan's Lagoon in Soil Unit1.

GT4 Grassland dominated by *Themeda triandra* and *Aristida latifolia* with emergent trees of *Eucalyptus microtheca*.

Trees included *Eucalyptus microtheca* with cover <2%.

Shrubs included *Neptunia monosperma* with cover <2% and *Phyllanthus maderaspatensis* with cover <1%

Grasses included *Themeda triandra* with cover 50-70%, *Sorghum timorense* with cover 10-15%, *Aristida latifolia* with cover <10% and *Iseilema vaginiflorum* with cover <5%.

This community occurred in Soil Unit 5a on the southern area of the Keep River Plain.

GT5 Grassland dominated by *Iseilema vaginiflorum* with emergent *Eucalyptus microtheca* and emergent to dense *Excoecaria parvifolia.*

Trees included *Eucalyptus microtheca* with cover <2%, *Excoecaria parvifolia* with cover 2-30% and *Acacia ditricha* with cover <1%.

Grasses included *Iseilema vaginiflorum* with cover 60-70%, *Chionachne hubbardiana* with cover <5%, *Panicum decompositum* with cover <5% and *Sorghum timorense* with cover <5%.

This community occurred in Soil Unit 5b on the Weaber Plain.

GT6 Grassland of *Cymbopogon procerus* and *Themeda triandra* with emergent *Bauhinia cunninghamii* and *Acacia ditricha.*

Trees included *Bauhinia cunninghamii* with cover <1% and *Acacia ditricha* with cover <1%.

grasses included *Themeda triandra* with cover 50-60%, *Cymbopogon procera* with cover 15-30% and *Ophiuros exaltatus* with cover <5%.

This community occurred in Soil Unit 4a on the Keep River Plain.

GT7 Grassland of *Bothriochloa bladhii, Themeda triandra* and *Ophiuros exaltatus* with emergent *Eucalyptus microtheca, Acacia ditricha* and *Bauhinia cunninghamii.*

Trees included *Eucalyptus microtheca* with cover <2%, *Bauhinia cunninghamii* with cover <1%, *Acacia ditricha* with cover <1% and *Excoecaria parvifolia* with cover <1%.

Grasses included *Bothriochloa bladhii* with a cover 45-55%, *Themeda triandra* with cover 10-15%, *Ophiuros exaltatus* with cover 10-15%.

This community occurred in Soil Unit 7a along a small creek and flood plain on the Keep River Plain.

GT8 Grassland of *Themeda triandra, Iseilema vaginiflorum* and *Aristida latifolia* with scattered *Bauhinia cunninghamii, Acacia ditricha* and *Corymbia bella* and shrubs of *Flemingia pauciflora.*

Trees included *Bauhinia cunninghamii* with cover <10%, *Corymbia bella* with cover 3-10% and *Acacia ditricha* with cover <10%.

Shrubs dominated by *Flemingia pauciflora* with cover 25-40%.

Grasses included *Themeda triandra* with cover 2-20%, *Iseilema vaginiflorum* with cover 5-60%, *Aristida latifolia* with cover 1-50% and *Chionachne hubbardiana* with cover <5%.

Occurred in Soil Unit 1 on the Weaber Plain.

GT9 Open tussock and annual grassland of *Eulalia aurea, Panicum decompositum* and *Sorghum timorense* with emergent *Corymbia bella* and **Parkinsonia aculeata.*

Trees included scattered *Corymbia bella* and **Parkinsonia aculeata*.

Shrubs included *Barringtonia acutangula* and *Hibiscus panduriformis*.

Grasses included *Eulalia aurea, Panicum decompositum, Sorghum timorense, Aristida latifolia, Ophiuros exaltatus* and *Cyperus conicus*.

This community occurred at a swamp in Soil Unit 5a on the Weaber Plain just off the proposed area for development, on the southern edge of the Weaber Range.

GT10 Open Hummock grassland dominated by *Triodia bynoei* with Open Shrubland of *Calytrix exstipulata* and scattered low trees of *Buchanania obovata, Owenia vernicosa* and *Corymbia confertiflora*.

Trees included *Buchanania obovata, Owenia vernicosa* and *Corymbia confertiflora*.

Shrubs included *Melaleuca alsophila, Calytrix exstipulata, Ficus platypoda, Solanum horridum* and *Phyllanthus reticulatus.*

Grasses included *Heteropogon contortus, Bulbostylis barbata, Triodia bynoei* and *Cyperus cunninghamii*.

This community occurred in Soil Unit 6 on the Weaber Plain on a sandstone ridge which had a narrow sandy margin.

GT11 Open annual grassland and herbfield of *Neptunia monosperma* with emergent trees of *Atalaya salicifolia* and *Excoecaria parvifolia*.

Trees included *Atalaya salicifolia* with cover <2%, *Excoecaria parvifolia* with cover <2% and *Eucalyptus microtheca* with cover <1%.

Shrubs included *Terminalia oblongata* subsp. *volucris, Cathormion umbellatum* subsp. *moniliforme* and *Acacia ditricha*.

Herbs included *Neptunia monosperma* with cover 2-10%.

Grasses included *Sorghum timorense* with cover 10-30%, *Chrysopogon fallax* and *Dichanthium fecundum* with cover 10-30%, *Aristida latifolia, Panicum decompositum* and *Astrebla elymoides*.

This community occurred in Soil Unit 9c on the Weaber Plain.

GT12 Open Grassland of *Sehima nervosum* and *Themeda triandra* with scattered trees of *Bauhinia cunninghamii, Adansonia gregorii, Corymbia foelscheana* and *Eucalyptus microtheca*.

Trees included *Eucalyptus microtheca, Corymbia confertiflora, Corymbia foelscheana, Melaleuca minutifolia, Acacia ditricha* and *Adansonia gregorii* with a total cover <5%.

Grasses included *Themeda triandra* with cover 60-90%, *Sehima nervosum* with cover <5-20%, *Sorghum plumosum* with cover <5% and *Ophiuros exaltatus* with cover <5%.

Occurred in Soil Unit 2b on the Keep River Plain.

GT13 Moderately dense tussock and annual grassland of *Chrysopogon fallax, Themeda triandra* and *Iseilema fragile* with emergent low trees *of Corymbia bella, Excoecaria parvifolia* and *Bauhinia cunninghamii*.

Trees included *Bauhinia cunninghamii* with cover <2%, *Corymbia bella* with cover <1%, *Atalaya salicifolia* with cover <1%, and *Excoecaria parvifolia* with cover <1%.

Shrubs included *Grewia retusifolia* and *Carissa lanceolata*.

Grasses included *Chrysopogon fallax* and *Themeda triandra* with cover 30-70%, *Iseilema fragile* with cover 10-30%, *Panicum decompositum, Aristida latifolia, Dichanthium sericeum* subsp. *polystachyium*

This community occurred in Soil Unit 5c on the Weaber Plain.

GT14 Open grassland and herbland of mixed species with emergent *Eucalyptus microtheca, Corymbia bella* and *Adansonia gregorii*.

Trees included *Eucalyptus microtheca* with cover <2%, *Adansonia gregorii* with cover <1% and *Corymbia bella* with cover <1%.

Herbs included <1% cover *Waltheria indica, Bonamia linearis, Mitrasacme gentianea, Drosera lanata, Stackhousia intermedia, Indigofera colutea, Indigofera linifolia* and *Mitrasacme exserta.*

Grasses included *Themeda triandra* with cover 10-15%, *Eriachne obtusa* with cover <5%, *Sorghum plumosum* and *Enneapogon purpurascens*.

This community occurred in Soil Unit 11 at the base of a rock outcrop on the Knox Creek Plain.

4.3 WOODLANDS

Woodlands of *Eucalyptus microtheca, Atalaya hemiglauca, Bauhinia cunninghamii and Excoecaria parvifolia*

Em1 Dense Woodland of *Eucalyptus microtheca* over a grassland of *Iseilema vaginiflorum* and *Aristida latifolia*.

Trees only *Eucalyptus microtheca* with cover 10-30%.

Shrubs and Herbs included *Hibiscus panduriformis, Flemingia pauciflora, Indigofera colutea,* and *Spermacoce exserta*.

Grasses included *Iseilema* vaginiflorum with cover 10-40%, *Aristida latifolia* with cover 10-40% and *Panicum decompositum* with cover <10%.

Occurred in Soil Unit 1 on the western edge of the Knox Creek Plain near the Pincombe Plain.

Em2 Woodland of *Eucalyptus microtheca* over open *Bauhinia cunninghamii* and *Atalaya hemiglauca* over a grassland of *Chrysopogon fallax, Iseilema vaginiflorum* and *Brachyachne convergens.*

Trees included *Eucalyptus microtheca* with cover <5%, *Bauhinia cunninghamii* with <5% cover and *Atalaya hemiglauca* with <1% cover.

Shrubs and Herbs included *Sesbania cannabina* with cover <5%, *Neptunia monosperma, Corchorus fascicularis, Sida spinosa, Phyllanthus maderaspatensis* and *Stemodia tephropelina.*

Grasses included *Chrysopogon fallax* with 40% cover, *Brachyachne convergens* with 10-15% cover, *Iseilema vaginiflorum* with up to 50% cover.

This community occurred in Soil Unit 1g on the Knox Creek Plain close to the Keep River.

Em3 Woodland of *Eucalyptus microtheca* over a grassland of *Themeda triandra* and *Chrysopogon fallax*.

Trees included *Eucalyptus microtheca* and scattered occurrences of *Bauhinia cunninghamii* and *Atalaya hemiglauca*.

Grasses included *Chrysopogon fallax* with cover 50-80%, *Themeda triandra* with cover 50-80%, *Ophiuros exaltatus* with cover 30% and *Sehima nervosum* with cover <5%.

This community occurred in Soil Unit 4b on the Knox River Plain.

Em4 Woodland of *Eucalyptus microtheca* and *Excoecaria parvifolia* over sedge-grassland of *Aristida latifolia, Panicum decompositum, Chrysopogon fallax, Panicum laevinode, Sorghum timorense* or *Iseilema fragile*.

Trees included *Excoecaria parvifolia* with cover 10-30%,

Herbs included *Corchorus fascicularis* with cover 2-10%, *Sida spinosa* with cover 2-10%

Grasses included *Sorghum stipoideum* and *Sorghum timorense* with cover 30-70%, *Aristida latifolia* with cover 10-30%, *Chrysopogon fallax* with cover 10-30%, *Panicum decompositum* and *Eulalia aurea* with cover 10-70%, *Panicum laevinode* with cover 10-30% and *Iseilema fragile* with cover >40%.

This community occurred in Soil Unit 5a on the Knox and Weaber Plains.

Em5 Woodland of *Eucalyptus microtheca* and *Bauhinia cunninghamii* over a closed tussock grassland of *Themeda triandra* and *Ophiuros exaltatus*.

Trees included *Eucalyptus microtheca* and *Bauhinia cunninghamii* with cover 10-30%.

Shrubs and Herbs included *Hibiscus panduriformis, Rhynchosia minima* and *Neptunia monosperma*.

Grasses included *Themeda triandra* and *Ophiuros exaltatus* with cover 70-100%, *Iseilema vaginiflorum* with cover 2-10%, *Chrysopogon fallax, Aristida latifolia* and *Panicum decompositum*.

This community occurred in Soil Unit 7b on the Weaber Plain.

Em6 Open Woodland of *Eucalyptus microtheca, Bauhinia cunninghamii, Excoecaria parvifolia* and *Atalaya hemiglauca* over an open shrubland of *Terminalia oblongata* subsp. *volucris* open grassland of *Astrebla squarrosa, Aristida latifolia* and *Panicum decompositum*.

Trees included *Atalaya hemiglauca* with cover 10-15%, *Bauhinia cunninghamii* with cover <5-15%, *Acacia ditricha* with cover 1-2% and *Excoecaria parvifolia* with cover <1-15%.

Shrubs and Herbs included *Abelmoschus ficulneus, Corchorus fascicularis* and *Trichodesma zeylanicum* var. *latisepalum*.

Grasses included *Astrebla squarrosa* with cover 10-60%, *Cyperus bifax* with cover 1-2%, *Aristida latifolia* and *Panicum decompositum*.

This community occurred in Soil Unit 1 and 1c on the Weaber Plain.

Em7 Open Woodland of *Eucalyptus microtheca* and *Acacia ditricha* over a tall grassland dominated by *Oryza australiensis, Sorghum timorense* over *Panicum decompositum*.

Trees included *Eucalyptus microtheca* with cover <5% and *Bauhinia cunninghamii* with cover <2% and *Excoecaria parvifolia* with cover <1%.

Shrubs and Herbs included *Hibiscus panduriformis, Neptunia monosperma, Sesbania cannabina* and *Goodenia malvina*.

Grasses included *Sorghum timorense* with cover 15-20%, *Panicum decompositum* with cover 40-50%, *Oryza australiensis* with cover <15%, *Iseilema vaginiflorum* with cover 1-10% and *Fimbristylis laxiglumis* with cover 35%

This community occurred in Soil Unit 1 on the Weaber Plain.

Em8 Low Open Woodland of *Eucalyptus microtheca* and *Excoecaria parvifolia* over a dense grassland dominated *of Ophiuros exaltatus, Sorghum timorense, Oryza australiensis* and *Iseilema fragile*.

Trees included *Eucalyptus microtheca* with cover 2-10% and *Excoecaria parvifolia* with cover 2-10%.

Shrubs and Herbs included *Neptunia monosperma, Ludwigia perennis, Phyllanthus maderaspatensis, Hibiscus panduriformis, Alternanthera nodiflora* and *Corchorus olitorius*.

Grasses included *Ophiuros exaltatus* with cover 30-70%, *Sorghum timorense* with cover 10-30%, *Oryza australiensis, Iseilema fragile* and *Panicum laevinode*.

This community occurred in Soil type 5b on the Weaber Plain.

Em9 Open Woodland of *Eucalyptus microtheca* over open tussock and annual grassland of *Panicum laevinode, Ophiuros exaltatus, Cyperus conicus* and *Neptunia monosperma*

Trees included *Eucalyptus microtheca* with cover 10-30%, *Excoecaria parvifolia* with cover <5%, *Cathormion umbellatum* subsp. *moniliforme* with cover <5%.

Shrubs and Herbs included *Neptunia monosperma* with cover 15-25%, *Cyanotis axillaris* with cover <5% and *Corchorus olitorius*.

Grasses included *Panicum laevinode* with cover 10-30%, *Ophiuros exaltatus* with cover <5%, *Cyperus conicus* with cover <5%, *Aristida latifolia* with cover 5-10%, *Oryza australiensis* with cover ca. 1%.

This community occurred in Soil Unit 5a in the Weaber Plain.

Woodlands of *Eucalyptus microtheca* and *Melaleuca* spp.

EM1 Open Woodland of *Eucalyptus microtheca* over Shrubland of *Melaleuca nervosa* and *Grevillea striata* over a low open grassland of *Themeda triandra, Eriachne obtusa* and *Aristida hygrometrica*.

Trees included *Eucalyptus microtheca* with cover <15%, *Melaleuca nervosa* had cover <5% and *Grevillea striata* had cover <1%.

Shrubs and Herbs included *Hakea arborescens, Grewia retusifolia* and *Evolvulus alsinoides* var. *decumbens*.

Grasses included *Themeda triandra* with cover 50-60%, *Eriachne obtusa* had cover 5-60% and *Aristida hygrometrica* cover <5%.

This community occurred in Soil Unit 1 in Knox Creek Plain.

EM2 Woodland of *Eucalyptus microtheca* over a low woodland of *Excoecaria parvifolia, Melaleuca viridiflora* and *Terminalia oblongata* subsp. *volucris.*

Trees included *Adansonia gregorii, Acacia holosericea, Lophostemon lactifluus, Terminalia platyphylla, Eucalyptus microtheca, Excoecaria parvifolia, Melaleuca viridiflora* and *Terminalia oblongata* subsp. *volucris.*

Grasses included: *Themeda triandra, Eriachne obtusa, Aristida hygrometrica* and *Leptochloa neesii*.

This community occurred in Soil Unit 11 on the Knox Creek Plain along a flow line.

EM3 Woodland of *Eucalyptus microtheca, Melaleuca argentea* and *Lophostemon grandiflorus* subsp. *riparius* over Dense Low Woodland of *Bauhinia cunninghamii*.

Trees included *Bauhinia cunninghamii* with cover 70-100%, *Eucalyptus microtheca* with cover 10-30%, *Melaleuca argentea, Corymbia greeniana, Atalaya salicifolia, Cathormion umbellatum* subsp. *moniliforme, Corymbia bella* and *Lophostemon grandiflorus* subsp. *riparius*.

Shrubs included *Carissa lanceolata* and *Jasminum molle* with cover 2-10%, *Dodonaea platyptera, Celtis philippensis* and *Capparis lasiantha*.

Grasses included *Panicum mindanaense* and *Aristida latifolia*.

This community occurred in Soil Unit 7a in the Weaber Plain and was subject to regular flooding between the river bank and levee crest.

Woodlands of *Eucalyptus microtheca* and Shrubland of *Terminalia oblongata* subsp. *volucis*

ET1 Woodland of *Eucalyptus pruinosa, Eucalyptus microtheca* over Open Shrubland of *Terminalia oblongata* subsp. *volucris, Bauhinia cunninghamii* and *Carissa lanceolata* over a grassland dominated by *Themeda triandra, Sehima nervosum, Chrysopogon pallidus* and *Eriachne glauca* var. *glauca.*

Trees included *Eucalyptus microtheca, Melaleuca viridiflora* with cover <1%, *Terminalia oblongata* subsp. *volucris* with cover 5-10% and the mallee *Eucalyptus pruinosa* with cover <20%.

Shrubs and Herbs included *Waltheria indica* with cover <1%, *Grewia retusifolia* with cover <1%, *Neptunia monosperma, Hibiscus panduriformis* and *Sida spinosa*.

Grasses included *Aristida hygometrica* with cover 40-50%, *Themeda triandra* with cover 5-25%, *Sehima nervosum* with cover <10%, *Chrysopogon pallidus* with cover 5-10%, *Eriachne obtusa* with cover <10% and *Heteropogon contortus* with cover <5%.

This community occurred in Soil Unit 5e on the Knox Creek and the Keep River.

ET2 Woodland of *Eucalyptus microtheca* over *Bauhinia cunninghamii* and *Terminalia oblongata* var. *volucris* over dense grassland of *Themeda triandra* and *Sehima nervosum*.

Trees included *Eucalyptus microtheca* with cover <5%, *Bauhinia cunninghamii* with cover <5%, *Terminalia oblongata* subsp. *volucris* with cover <5%.

Shrubs and Herbs included *Carissa lanceolata, Dolichandrone heterophylla, Hakea arborescens* and *Ludwigia perennis*.

Grasses included *Themeda triandra* with cover 45%, *Sehima nervosum* with cover 20-30%. *Ophiuros exaltatus, Chrysopogon fallax* and *Panicum decompositum*.

This community occurred in Soil Unit 3c on the Knox Creek Plain.

ET3 Woodland of *Eucalyptus microtheca* and *Corymbia greeniana* over *Bauhinia cunninghamii, Terminalia oblongata* subsp. *volucris* and *Hakea arborescens* over scattered tussocks of *Aristida latifolia.*

Trees included *Eucalyptus microtheca, Corymbia greeniana, Bauhinia cunninghamii, Melaleuca argentea, Adansonia gregorii, Terminalia oblongata* subsp. *volucris* and *Hakea arborescens*.

Shrubs and Herbs included *Exocarpos latifolius, Atalaya hemiglauca, Grewia retusifolia, Phyllanthus maderaspatensis, *Alysicarpus vaginalis* and *Hyptis suaveolens*.

Grasses included *Aristida latifolia, Brachyachne convergens, Urochloa reptans* and *Fimbristylis macrantha*.

This community occurred in Soil Unit 5a on the Keep River Plain.

ET4 Low open woodland of *Eucalyptus microtheca, Bauhinia cunninghamii,* over a Shrubland of *Terminalia oblongata* subsp. *volucris* over dense grassland dominated by *Themeda triandra, Aristida latifolia, Sehima nervosum, Chrysopogon fallax* and *Ophiuros exaltatus.*

Trees included *Bauhinia cunninghamii* with cover 2-10%, *Terminalia oblongata* subsp. *volucris* and *Acacia ditricha*.

Shrubs and annuals included *Hibiscus panduriformis, Dolichandrone heterophylla, Rhynchosia minima* and *Phyllanthus maderaspatensis*.

Grasses included *Chrysopogon fallax* and *Ophiuros exaltatus* with cover 30-70%, *Themeda triandra, Panicum decompositum, Sorghum timorense* and *Brachyachne convergens.*

This community was recorded in Soil Unit 4d on the Weaber Plain.

ET5 Open Low Woodland of *Excoecaria parvifolia, Bauhinia cunninghamii* over a Shrubland of *Terminalia oblongata* subsp. *volucris* and *Eucalyptus microtheca* over an Open Tussock Grassland of *Chrysopogon fallax, Panicum decompositum, Astrebla elymoides* and *Iseilema fragile.*

Trees included *Eucalyptus microtheca* and *Excoecaria parvifolia* with cover 10-30%, *Acacia ditricha* and *Bauhinia cunninghamii* with cover 2-10%, *Atalaya salicifolia* and *Terminalia oblongata* subsp. *volucris* with cover 2-10%.

Shrubs and Herbs included *Neptunia monopserma, Rhynchosia minima* and *Phyllanthus maderaspatensis*

Grasses included *Chrysopogon fallax* with cover 30-70%, *Sorghum timorense* with cover 30-70%, *Panicum decompositum* and *Astrebla elymoides* with cover 30-70%, *Iseilema fragile* with cover 30-70% and *Aristida latifolia*.

This community occurred in Soil Units 5b and 5bt on the Weaber Plain.

ET6 Open Low Woodland of *Excoecaria parvifolia, Bauhinia cunninghamii* and *Eucalyptus microtheca* over a Shrubland of *Terminalia oblongata* subsp. *volucris* and a grassland of *Panicum decompositum, Iseilema vaginiflorum* and *Sorghum timorense*

Trees included *Eucalyptus microtheca* with cover <5%, *Terminalia oblongata* subsp. *volucris* with cover 5-10%, *Bauhinia cunninghamii* with cover 0-3%, *Excoecaria parvifolia* with cover 5-10%.

Shrubs and annuals included *Neptunia monosperma* with cover <1%, *Stemodia tephropelina* with cover <1%, *Abelmoschus mosochatus* with cover <1%, *Wedelia* a*sperimma* with cover <1% and *Flemingia pauciflora* with cover <5%.

Grasses included *Panicum decompositum* with cover 30%, *Aristida latifolia* with cover <5%, *Iseilema vaginiflorum* with cover <1%

This community occurred in Soil Unit 1 on the Weaber Plain.

Woodlands of *Eucalyptus miniata*

Min1 Woodland of *Eucalyptus miniata, Eucalyptus tetrodonta* and *Terminalia ? platyphylla* over a shrubland of *Acacia difficilis* over an open grassland of *Aristida* sp.

Trees included *Eucalyptus miniata* with cover 15%, *Eucalyptus tetrodonta* with cover <5%, *Acacia difficilis* and *Terminalia ? platyphylla*.

Shrubs and Herbs included *Grevillea agrifolia, Waltheria indica, Persoonia falcata* and *Spermacoce brachystema.*

Grasses included *Triodia plectrachnoides, Yakirra pauciflora* and *Aristida* sp.

This community occurred in the Cockatoo Soil Unit near the northern end of the Keep River Plain.

Min2 *Eucalyptus miniata* low forest over open *Grevillea agrifolia* over *Triodia acutispicula* or *Triodia burbidgeana* and *Sorghum* sp open grassland.

Trees included *Eucalyptus miniata* with cover 1-2%, *Xanthostemon paradoxus* with cover 10-12%, *Adansonia gregorii, Corymbia confertiflora* and *Erythrophleum chlorostachys*

Shrubs and Herbs include *Flueggia virosa* subsp. *melanthesoides, Calytrix exstipulata, Cochlospermum fraseri, Waltheria indica, Grevillea pyramidalis* and *Ptilotus spicatus*.

Grasses included *Triodia burbidgeana, Cyperus microcephalus, Triodia acutispicula* and *Sorghum* sp.

This community occurred on a moderate slope of the Cockatoo Soil Unit on the Knox Creek

Woodland of *Eucalyptus papuana*

Ep1 Woodland of *Eucalyptus papuana* over a Shrubland of *Flueggea virosa* var. *melanthesoides* over Grassland of *Heteropogon contortus.*

Trees included *Eucalyptus papuana* with cover 45-55% and *Corymbia bella, Acacia holosericea.*

Shrubs and Herbs included *Flueggia virosa* var. *melanthesoides* with cover 20-35%, **Calotropis procera, Abutilon indicum* subsp. *australiense, *Corchorus olitorius* and *Indigofera hirsuta.*

Grasses included *Heteropogon contortus* with cover 50-60%.

This community occurred in Soil Unit 7 on a raised bank of the Keep River.

Woodland of *Eucalyptus tetrodonta*

Et1 Woodland of *Eucalyptus tetrodonta, Corymbia greeniana* and *Terminalia canescens* over a shrubland of *Acacia* affin. *lamprocarpa*

Trees included *Eucalyptus tetrodonta* with cover <5% and *Corymbia greeniana*.

Shrubs and Herbs included *Acacia lamprocarpa, Terminalia canescens* with cover 10-30%, *Grevillea refracta, Buchanania obovata*

Grasses included *Sorghum stipoideum, Eriachne ciliata, E. melicacea* and *Heteropogon contortus.*

This community occurred in Cockatoo Soil Unit on the Keep River Plain

Woodlands of *Corymbia bella*

Cb1 Open woodland of *Eucalyptus microtheca, Corymbia bella, Corymbia greeniana, Excoecaria parvifolia* and *Bauhina cunninghamii* over a grassland of *Sehima nervosum* and *Heteropogon contortus*.

Trees included *Eucalyptus microtheca* with cover 20-30%, *Corymbia bella* with cover <2%, *Excoecaria parvifolia* with cover <1% and *Bauhinia cunninghamii* with cover <1%.

Shrubs and Herbs included *Carissa lanceolata, Enneapogon purpurescens, Indigofera linifolia, Polycarpaea corymbosa* and *Abutilon hannii*

Grasses included *Sehima nervosum* with cover 40-50%, *Heteropogon contortus* with cover 5% and *Sorghum stipoideum.*

This community occurred on the edge of the Keep River in the Knox Creek Plain in Soil Units 7a and 7a/b.

Cb2 Woodland of *Eucalyptus microtheca, Corymbia greeniana, Corymbia confertiflora, Corymbia bella* and *Adansonia gregorii* over an open shrubland of *Bauhinia cunninghamii* and a grassland of *Sehima nervosum* and *Themeda triandra.*

Trees included *Eucalyptus microtheca* with cover 10-12%, *Corymbia greeniana* with cover 5-7%, *Corymbia confertiflora* with cover 2-3%, *Corymbia bella* with cover <2% and *Adansonia gregorii* cover <1%.

Shrubs and Herbs included *Grewia retusifolia* with <1% cover, *Indigofera linifolia, Goodenia sepalosa* var. *sepalosa, Heliotropium foveolatum* and *Uraria cylindracea*.

Grasses included *Sehima nervosum* with cover 50%, *Themeda triandra* with cover 10-15%, *Chrysopogon fallax, Cyperus viscidulus* and *Heteropogon contortus*.

This community occurred in Soil 7f on the Knox Creek Plain.

Cb3 Woodland of *Eucalyptus microtheca, Corymbia bella, Bauhinia cunninghamii* and *Excoecaria parvifolia* over a grassland dominated by *Ophiuros exaltatus, Chrysopogon fallax, Dichanthium sericeum* var. *polystachyum*.

Trees included *Eucalyptus microtheca* with cover 1-4%, *Corymbia bella* with cover <1%, *Bauhinia cunninghamii* with cover 2-3% and *Excoecaria parvifolia* with cover 2-3%.

Shrubs and Herbs included *Hibiscus panduriformis, Commelina ensifolia, Trichodesma zeylanicum* var. *latisepalum, Phyllanthus maderaspatensis* and *Alternanthera nodiflora*.

Grasses included *Ophiuros exaltatus* with cover >40%, *Chrysopogon fallax* with cover 20%, *Dichanthium sericeum* subsp. *polystachion* with cover 10-15%

This community occurred in Soil Unit 5e on the Knox Plain.

Cb4 Woodland of *Bauhinia cunninghamii, Eucalyptus bigalerita, Terminalia grandiflora* and *Corymbia bella* over an open tussock and annual grassland of *Heteropogon contortus* and *Chrysopogon fallax*.

Trees included *Bauhinia cunninghamii* with cover 10-30%, *Eucalyptus bigalerata, Terminalia grandiflora, Corymbia bella, Bauhinia cunninghamii, Adansonia gregorii* and *Hakea arborescens.*

Shrubs and Herbs included *Ficus oppositifolia, Phyllanthus reticulatus, Carissa lanceolata, Pterocaulon verbascifolium, Drosera petiolaris, Hybanthus enneaspermus* subsp. *enneaspermus* and *Alternanthera nodiflora*.

Grasses included *Heteropogon contortus, Chrysopogon fallax* with cover 10-30%, *Sorghum stipoideum* with cover 2-10%, *Aristida inaequiglumis, A. holathera, Cyperus conicus* and *Eriachne obtusa*.

This community occurred in Soil Unit 8b on the Weaber Plain.

Cb5 Open Woodland of *Terminalia platyphylla, Corymbia bella* over an open woodland of *Bauhinia cunninghamii* and *Terminalia oblongata* subsp. *volucris* and scattered *Acacia ditricha* over a dense annual and tussock grassland of *Themeda triandra, Heteropogon contortus, Aristida latifolia, Ophiuros exaltatus* and *Sorghum timorense*.

Trees included *Corymbia bella* with cover 2-10%, *Terminalia platyphylla* with cover 2-10%, *Corymbia greeniana, Bauhinia cunninghamii* with cover <2-10% and *Terminalia oblongata* subsp. *volucris* with cover <2%.

Shrubs and Herbs included *Hibiscus panduriformis, Waltheria indica, Carissa lanceolata, Pterocaulon verbascifolium*

Grasses included *Themeda triandra* with cover 10-70%, *Sorghum timorense* with cover 30-70%, *Heteropogon contortus, Aristida latifolia* with cover 2-10% and *Ophiuros exaltatus* with cover 5-10%

This community occurred in Soil Units 4a, 4b and 4c on the Weaber Plain and Lower Keep River Plain.

Cb6 Open Woodland of *Corymbia bella, Corymbia polycarpa,* and *Melaleuca viridiflora* over a dense grassland of *Themeda triandra*.

Trees included *Corymbia bella, Corymbia polycarpa, Melaleuca viridiflora, Buchanania obovata* and *Acacia holosericea*.

Shrubs and Herbs included *Ficus oppositifolia, Acacia lamprocarpa* and *Opercularia* sp..

Grasses included *Themeda triandra* with cover 50-70%.

This community occurred in Soil Unit 7a on the Keep River Plain, on a gentle slope to the river.

Cb7 Open Woodland of *Corymbia bella* and *Acacia ditricha* over a Grassland of *Themeda triandra, Chrysopogon fallax* and *Heteropogon contortus*.

Trees included *Corymbia bella* with cover 2-10%, *Bauhinia cunninghamii* with cover <2%, *Terminalia oblongata* subsp. *volucris* with cover <1% and *Acacia ditricha* with cover <8%.

Shrubs and Herbs included *Hibiscus panduriformis* with cover <1%, *Phyllanthus maderaspatensis* with cover <1%, *Sesbania simpliciuscula* with cover <1 and *Abelmoschus moschatus* with cover <1%.

Grasses included *Chrysopogon fallax* and *Themeda triandra* with cover 30-70%, *Sorghum timorense* with cover 10-30%, *Sehima nervosum* with cover 40-50% and *Panicum decompositum.*

This community occurred in Soil Unit 1 on the Weaber Plain and Keep River Plain.

Cb8 Open Woodland of *Corymbia bella, Planchonia careya, Atalaya salicifolia* and *Acacia ditricha* over tussock grassland of *Themeda triandra, Ophiuros exaltatus* and *Eulalia aurea*.

Trees included *Corymbia bella, Bauhinia cunninghamii, Corymbia ferruginea, Planchonia careya, Atalaya salicifolia* and *Acacia ditricha*.

Shrubs and Herbs included *Phyllanthus maderaspatensis, Goodenia purpurascens* and *Ludwigia perennis.*

Grasses included *Aristida latifolia, Themeda triandra, Sehima nervosum, Chrysopogon fallax, Panicum decompositum* and *Ophiuros exaltatus*.

This community occurred in Soil Unit 8 on the Weaber Plain in a flow line at the northern tip of the Sorby Hills.

Cb9 Very Open Woodland of *Corymbia bella* over tussock and annual grassland of *Themeda triandra, Ophiuros exaltatus* and *Sorghum stipoideum*.

Trees included *Corymbia bella* with cover 2-10%, *Bauhinia cunninghamii*, and *Atalaya salicifolia*.

Shrubs and Herbs included *Carissa lanceolata, Hibiscus panduriformis, Rhynchosia minima, Phyllanthus maderaspatensis, Sesbania simpliciuscula, Trichodesma zeylanicum* subsp. *latisepalum.*

Grasses included *Themeda triandra* and *Ophiuros exaltatus* with cover 30-70%, *Sorghum stipoideum* with cover 30-70%, *Sehima nervosum*, *Aristida latifolia* and *Sorghum timorense.*

This community occurred in Soil Unit 9c on the Weaber Plain.

Woodlands of *Corymbia confertiflora*

Cc1 Open Woodland of *Corymbia confertiflora, Planchonia careya* and *Terminalia latipes* var. *latipes* over moderately dense *Bauhinia cunninghamii* and a very open tussock grassland of *Heteropogon contortus, Themeda triandra* and *Sorghum plumosum*.

Trees included *Corymbia bella* and *Corymbia confertiflora* with cover 2-10%, *Bauhinia cunninghamii* with cover 30-70%, *Planchonia careya, Terminalia latipes* var. *latipes, Adansonia gregorii* and *Gyrocarpus americanus*.

Shrubs and Herbs included *Grewia retusifolia, Walthera indica, Cajanus mamoratus, Cymbidium canaliculatum*, and *Achyranthes aspera*.

Grasses included *Heteropogon contortus* with cover 2-30%, *Sorghum plumosum* with cover 2-10% and *Aristida inaequiglumis*.

This community occurred in Soil Unit 2b on the Weaber Plain.

Cc2 Woodland of *Corymbia bella, Acacia ditricha, Corymbia confertiflora, Planchonia careya* and *Bauhinia cunninghamii* over an open grassland of *Themeda triandra, Heteropogon contortus* and *Sehima nervosum*.

Trees included *Corymbia bella* with cover <5%, *Planchonia careya* with cover 10-15%, *Corymbia confertiflora* with cover <5% *Acacia ditricha* with cover <1% and *Bauhinia cunninghamii* with cover <1%.

Shrubs and Herbs included *Ficus opposita* cover <2%, *Grewia retusifolia* with cover <1%, *Hibiscus panduriformis* and *Rhynchosia minima*.

Grasses included *Themeda triandra* with cover 15-20%, *Heteropogon contortus* with cover <90%, *Sehima nervosum* with cover 1-2%.

This community occurred in Soil Unit 4d on the Keep River Plain.

Cc3 Woodland of *Corymbia confertiflora, Corymbia greeniana* and *Planchonia careya* over scattered mallees of *Corymbia foelscheana* over a grassland of *Heteropogon contortus* and *Sehima nervosum*.

Trees included *Corymbia bella* with cover >10%, *Corymbia confertiflora, Corymbia greeniana, Planchonia careya* and *Corymbia foelscheana* with cover <5%.

Shrubs and Herbs included *Hibiscus panduriformis, Goodenia sepalosa, Uraria cylindracea* and *Hakea arborescens*.

Grasses included *Heteropogon contortus* and *Sehima nervosum* with cover 30-40%, *Themeda triandra* with cover <80% and *Aristida latifolia*.

This community occurred in Soil 2a on the Keep River Plain.

Cc4 Woodland of *Corymbia confertiflora, Eucalyptus microtheca* and *Eucalyptus tectifica* over a Grassland dominated by *Aristida holathera* var. *holathera, Themeda triandra, Sorghum plumosum* var. *plumosum*.

Trees included *Eucalyptus microtheca* with cover 5%, *Eucalyptus tectifica* with cover 5%

Shrubs and Herbs included *Acacia lamprocarpa, A. hemignosta, Terminalia canescens, Heliotropium foveolatum* and *Polygala eriocephala*.

Grasses included *Themeda triandra* with cover 30-40%, *Aristida holathera* var. *holathera* had cover 10%, *Dichanthium sericeum* var. *polystachyum* had cover 1-2%, *Eragrostis cumingii*, *Triodia acutispicula* and *Sorghum stipoideum*.

This community occurred in Soil Unit 8a on the Knox Creek Plain.

Woodlands of *Corymbia tectifica*

Ct1 Woodland of *Eucalyptus tectifica* over open tussock grassland of *Heteropogon contortus, Themeda triandra, Chrysopogon fallax* and *Themeda triandra*.

Trees included *Eucalyptus tectifica* with cover 10-30%, *Corymbia greeniana* with cover 10-30% and *Bauhinia cunninghamii* with cover <2%

Shrubs and Herbs included *Terminalia canescens* with cover <2%, *Indigofera hirsuta* with cover 2-10%, *Grewia retusifolia* and *Waltheria indica*.

Grasses included *Heteropogon contortus* and *Themeda triandra* with cover 10-30%, *Chrysopogon fallax, Eriachne obtusa* and *Aristida inaequiglumis*.

This community occurred in Soil Unit 2a and 2c on the Weaber Plain.

Ct2 Low Woodland of *Eucalyptus tectifica* over dense tussock and annual grassland of *Themeda triandra, Panicum decompositum* and *Sorghum timorense*.

Trees included *Eucalyptus tectifica* with cover 10-30%, *Bauhinia cunninghamii, Corymbia bella* and *Terminalia oblongata* subsp. *volucris.*

Shrubs and Herbs included *Neptunia monosperma, Hibiscus panduriformis, Carissa lanceolata, Capparis lasiantha* and *Phyllanthus reticulatus*.

Grasses included *Themeda triandra* with cover 30-70%, *Sorghum timorense* with cover 30-70%, *Chrysopogon fallax, Sehima nervosum* and *Sorghum plumosum.*

This community occurred in Soil Unit 4a on the Weaber Plain.

Woodlands of *Corymbia* sp., *Brachychiton diversifolius* and *Gyrocarpus americanus*

CBG Woodland of *Corymbia* spp. *Brachychiton diversifolius, Bauhinia cunninghamii* with scattered taller *Gyrocarpus americanus* over an open grassland of *Themeda triandra*.

Trees included *Corymbia confertiflora, Corymbia polycarpa, Atalaya hemiglauca, Brachychiton diversifolia, Bauhinia cunninghamii* and *Gyrocarpus americanus.*

Shrubs and Herbs included *Grewia retusifolia, Hibiscus panduriformis, Neptunia monosperma, Carissa lanceolata, Sesbania cannabina* and *Pterocaulon verbascifolium*

Grasses included *Themeda triandra* with cover 25%, *Sehima nervosum* with cover 1-2%, *Heteropogon contortus* with cover 2-3%, *Chrysopogon fallax* with cover <1%.

This community occurs in Soil Unit 6e on Knox Creek.

Woodland of Bauhinia cunninghamii

Bc1 Low Woodland of *Bauhinia cunninghamii* over tussock and annual grassland of *Iseilema* sp., *Panicum decompositum, Sehima nervosum, Aristida latifolia, Cyperus bifax, Sehima nervosum, Chrysopogon fallax* and *Sorghum timorense*.

Trees included *Eucalyptus microtheca* with cover<2%, *Bauhinia cunninghamii* with cover 10-30%, *Terminalia oblongata* subsp. *volucris* with cover 2-10%

Shrubs and Herbs included *Flemingia pauciflora* with cover 5-15%, *Clerodendrumfloribundum, Hibiscus panduriformis, Acacia ditricha, Neptunia monosperma* and *Phyllanthus maderaspatensis*.

Grasses included *Sorghum timorense* with cover 10-30%, *Sehima nervosum* and *Chrysopogon fallax* with cover 30-70%, *Chionachne hubbardiana, Iseilema vaginiflorum* and *Sorghum stipoideum*.

Community occurred in Soil Unit 1 on the Weaber and Keep River Plains.

Bc2 Low Shrubland of *Bauhinia cunninghamii* and *Atalaya hemiglauca* over grassland of *Chrysopogon fallax* with lianes of *Rhynchosia minima*.

Trees included *Bauhinia cunninghamii* with cover 2-10%, *Terminalia oblongata* subsp. *volucris* and *Atalaya salicifolia*.

Shrubs and Herbs included *Rhynchosia minima* with cover 2-10%, *Neptunia monosperma, Flemingia pauciflora, Abelmoschus moschatus* and *Ptilotus spicatus*.

Grasses included *Chrysopogon fallax* with cover 30-70%, *Panicum decompositum, Aristida latifolia, Sorghum timorense, Iseilema fragile* and *Eragrostis tenellula*.

This community occurred in Soil Unit1 on the Weaber and Knox Creek Plains.

Bc3 Low Woodland of *Bauhinia cunninghamii* occasionally with scattered *Acacia ditricha* over grassland of *Themeda triandra, Sehima nervosum* and *Chrysopogon fallax*.

Trees included *Bauhinia cunninghamii* with cover 5-10%, *Acacia ditricha* with cover 1-5% , *Terminalia oblongata* subsp. *volucris* with cover 1-5% and *Atalaya hemiglauca* with cover 1-5%.

Shrubs and Herbs included *Neptunia monosperma, Hibiscus panduriformis, Rhynchosia minima, Flemingia pauciflora* and *Capparis lasiantha.*

Grasses included *Sehima nervosum* with cover <60%, *Themeda triandra* with cover 10-90%, *Chrysopogon fallax* with cover 60-80%, *Cyperus bifax* with cover <10%, *Sorghum timorense* 10-25%.

This community occurred in Soil Unit 1 in the Keep River Plain.

Woodlands of *Excoecaria parvifolia*

Ex1 Woodland of *Excoecaria parvifolia* with scattered *Corymbia bella* and *Bauhinia cunninghamii* over mixed grass species.

Trees included *Excoecaria parvifolia* with cover 15-20%, *Corymbia bella* with cover <1%, *Bauhinia cunninghamii* with cover <5% and *Terminalia obovata* subsp. *volucris* with cover <5%.

Shrubs and Herbs included *Waltheria indica* with cover <1%, *Flueggea virrosa* with cover <2%,*Wedelia asperrima* with cover <1%.

Grasses included *Panicum trachyrhachis* with cover 40%, *Pancium decompositum* with cover 5%, *Iseilema vaginiflorum* with cover 5%, *Cyperus bifax* with cover <5%, *Aristida latifolia* with cover <5% and *Oryza australiensis* with cover <5%.

This community occurred in Soil Unit 1 on the Weaber Plain.

Ex2 Woodland of *Excoecaria parvifolia* over an open to dense grassland dominated by *Ophiuros exaltatus, Iseilema fragile* or *Heteropogon contortus*.

Trees included *Excoecaria parvifolia* with cover 15-20% and *Eucalyptus microtheca* with cover <1%.

Shrubs and Herbs included *Sesbania cannabina* with cover <1%, *Flemingia pauciflora* with cover <1%, *Hibiscus panduriformis* with cover <1%, *Neptunia monosperma* with cover <1%.

Grasses included *Heteropogon contortus* where dominant with cover >60%, *Iseilema fragile* where dominant with cover <90% or *Ophiuros exaltatus* where dominant with cover >60%.

Typically this community occurred along minor drainage lines within the Grasslands of the Keep River and is an extension of the grassland community G1 in Soil Unit 1.

Ex3 Woodland of *Excoecaria parvifolia* with scattered *Eucalyptus microtheca* over a Low Grassland dominated by *Sehima nervosum* and *Cyperus viscidulus*.

Trees included *Excoecaria parvifolia* with cover 40-45%, *Eucalyptus microtheca* with cover <5%.

Shrubs and Herbs included *Corchorus fascicularis* with cover <1%, *Nesaea repens* with cover <1%, *Hygrophila angustifolia* with cover <1%. *Ludwigia perennis* with cover <1% and *Aeschynomene indica* with cover <1%.

Grasses included *Sehima nervosum* with cover 50-60%, *Cyperus viscidulus* with cover <20%, *Iseilema vaginiflorum* with cover <5%, *Aristida latifolia* with cover <5%, *Panicum decompositum* with cover 1-2% and *Oryza australiensis* with cover <1%.

This community occurred in Soil unit 1e on the Knox Plain.

Ex4 Woodland of *Excoecaria parvifolia, Melaleuca nervosa* and *Cathormion umbellatum* subsp. *moniliforme* over scattered *Strychnos lucida* shrubs and mid-dense **Passiflora foetida* var. *hispida* lianes.

Trees included *Melaleuca nervosa, Excoecaria parvifolia, Cathormion umbellatum* subsp. *moniliforme* with patches of 90% cover, *Barringtonia acutangula* with cover >90% close to river edge.

Shrubs and Herbs included *Acacia holosericea, Neptunia monosperma, Abelmoschus moschatus, Hibiscus panduriformis, Ammania baccifera*.

Grasses included *Panicum mindanaense, Leptochloa neesii, Eriachne glauca* and *Iseilema fragile*.

This community occurred in Soil Unit 7 along the Keep River.

<u>Woodlands of *Melaleuca* species</u>

Me1 Woodland of *Eucalyptus* sp., *Corymbia* sp., *Terminalia grandiflora, Melaleuca nervosa* and *Acacia difficilis* over and open grassland of *Eriachne obtusa, Chrysopogon setifolius* and *Aristida holanthera* var. *holathera*.

Trees included *Eucalyptus microtheca, E. tectifica, Corymbia confertiflora, Terminalia grandiflora* with cover 2-23%, and *Melaleuca nervosa.*

Shrubs and Herbs included *Cochlospermum fraseri, Platyzoma microphyllum, Buchanania obovata, Triodia acutispicula* and *Acacia difficilis*.

Grasses included *Eragrostis cumginii, Setaria apiculata, Yakirra pauciflora*.

This community occurred in Soil Type 8e on the Knox Creek Plain.

Me2 Low Woodland of *Melaleuca viridiflora* and *Eucalyptus tectifica* over open shrubland of *Acacia difficilis* over open grasses and sedges.

Trees included *Melaleuca viridiflora* with cover 5-10%, *Eucalyptus miniata* with cover <1%, *E. microtheca* with cover <1%.

Shrubs and Herbs included *Grevillea agrifolia* with cover 2-3%, *Acacia difficilis* with cover 2-3%, *Grewia retusifolia* with cover <5%.

Grasses included *Yakirra pauciflora, Schoenus punctatus, Aristida hygrometrica, Fimbristylis squarrulosa.*

This community occurred in Soil Unit 7a on the Keep River Plain.

Me3 Open shrubland of *Melaleuca acacioides* and *Excoecaria parvifolia* over scattered grassland of *Heteropogon contortus.*

Trees included *Melaleuca acacioides* with cover 5-25%, *Excoecaria parvifolia, Cathormion umbellatum* subsp. *moniliforme.*

Shrubs and Herbs included *Hibiscus panduriformis, Ammania baccifera, Alternanthera nodiflora, Flaveria australasica*.

Grasses included *Ophiuros exaltatus, Sporobolus australasicus, Chloris pumilio, Iseilema fragile.*

This community occurred in Soil Unit 7f on the Keep River Plain.

Me4 Woodland of *Melaleuca minutifolia, Melaleuca viridiflora, Excoecaria parvifolia,* and *Cochlospermum fraseri* over an open to dense grassland of *Themeda triandra* and *Sorghum timorense*.

Trees included *Melaleuca minutifolia* with cover 15-35%, *Melaleuca viridiflora* with cover 1-10%, *Bauhinia cunninghamii* with cover 1-2%, *Eucalyptus microtheca* with cover 1-2%, *Corymbia bella* with cover <5%, *Eucalyptus pruinosa* with cover <5%.

Shrubs and Herbs included *Cochlospermum fraseri* with cover <5%, *Dolichandrone heterophylla, Carissa lanceolata, Bergia pedicellaris, Waltheria indica, Grevillea striata, Polymeria calycina, Spermacoce auriculata, Abutilon hannii, Carissa lanceolata, Mimulus uvedaliae* all with cover <1%.

Grasses included *Themeda triandra* with cover 15-90%, *Sehima nervosum* with cover <15%, *Eragrostis scabra* with cover <1%, *Bulbostylis barbata* with cover <1%, *Sorghum plumosum* with cover <1%, *S. timorense* with cover <1%.

This community occurred in Soil Units 2a, 2a/3a, 3a/4a on the Keep River Plain.

<u>Woodland of *Buchanania obovata*</u>

Bo1 Low Woodland of *Buchanania obovata* and *Bauhina cunninghamii* over Open Grassland of *Sehima nervosum* and *Sorghum stipoideum*.

Trees included *Buchanania obovata, Bauhinia cunninghamii* with cover 10-30%, *Adansonia gregorii, Grevillea pyramidalis, Corymbia confertiflora*.

Shrubs and Herbs included *Hibiscus panduriformis, Exocarpos latifolius, Waltheria indica, Grewia retusifolia, Rhynchosia minima, Phyllanthus maderaspatensis.*

Grasses included *Sehima nervosum* with cover 10-30%, *Sorghum stipoideum* with cover 10-30%, *Eragrostis elongata, Panicum mindanaense*.

This community occurred in small pockets of soil amongst dolomite blocks on a Dolomite Hill in the Weaber Plain

Woodlands of *Terminalia canescens*

Tc1 Low Woodland of *Terminalia canescens* over a very open *Heteropogon contortus* grassland.

Trees included *Terminalia canescens* with cover 10-15%, *Cochlospermum fraseri* with cover 2-3%, *Ventilago viminalis* with cover 1-2%, *Atalaya hemiglauca, Grevillea pyramidalis, Strychnos lucida*.

Shrubs and Herbs included *Owenia vernicosa, Flueggea virosa* subsp. *melanthesoides, Capparis lasiantha*

Grasses included *Sehima nervosum, Sorghum* sp., *Enneapogon purpurescens*.

This community occurred on a Sandstone Hill on the Knox Creek Plain.

Attachment B

A Fauna survey of the M2 Development Area of the Ord River Irrigation Scheme

ORD RIVER IRRIGATION AREA STAGE 2 PROPOSED DEVELOPMENT OF THE M2 AREA

A Fauna survey of the M2 Development Area of the Ord River Irrigation Scheme

Prepared for:

WESFARMERS LIMITED,

MARUBENI CORPORATION AND THE WATER

CORPORATION OF WESTERN AUSTRALIA
Level 7, 40 The Esplanade
Perth WA 6000

Prepared by:

Dr Ray Hart for

Kinhill Pty Ltd
ACN 007 660 317
47 Burswood Road, Victoria Park WA 6100
Telephone 08 9362 5900, Facsimile 08 9362 5627

October 1999

PV8009-FC-010 Rev. 0

CONTENTS

1 Summary

A survey of the vertebrate fauna of the black soil of the M2 Development Area of the Ord River Irrigation Scheme was carried out in June 1999 to supplement a previous survey. Pit and Elliott trapping was used at six sites, two in each of the Weaber, Knox Creek and Keep River plains, and birds were recorded opportunistically.

The survey recorded four species of frogs, 12 species of lizards, six species of snakes, 48 species of birds and three species of small mammals. This is a relatively small fraction of the species which may occur in the area, but a significant part of the common species. The numbers were limited by the early dry season timing, and the short duration of the trapping programme. The black soil plain areas are not rich in species or individuals. Small mammals are particularly limited, with only two species widespread and common. The black soil plain environment is harsh for fauna, with limited structural diversity in the vegetation, a single soil type, prolonged flooding in summer, and dry conditions in winter coupled with hard-setting soils.

The numbers of species and individuals caught by the trapping are too small to make any useful statements about the variations between sites except that frogs were most common in the wettest site. There is very limited variation between the sites in terms of habitat features for fauna, and it is not surprising that there are no obvious differences.

The survey did not locate *Ctenotus rimacola* which has recently been described as a black soil plain endemic, although this species is not thought to be rare.

At least five of the reptile species collected are undescribed species, but this high number of undescribed species is the result of limited collecting in this environment and the region in general rather than any concentration of rare species. There is also doubt about the identification of some of the small mammals and further taxonomic work needs to be carried out.

A list of the vertebrate fauna species which might be present is given. Although a large fauna is probably present there are few rare species.

On the basis of rare species it is unlikely that the proposed development would have a significant impact.

2 Introduction

A previous survey of the vertebrate fauna was undertaken by Ecologia Environmental Consultants in October 1996 and February 1998. These surveys covered a larger area than that proposed for development, with limited trapping on the black soil plains that would be the focus of development. Wesfarmers Limited, Marubeni Corporation and the Water Corporation of Western Australia therefore commissioned an additional survey of the black soil plain areas in June 1999 and this latter survey is the subject of this report.

3 Methods

Six sites were surveyed, with two in each of the Weaber, Knox Creek and Keep River plains. The sites were selected to cover the geographic range of the study area and the range of variation within the black soil plains. The sites are described in Appendix 1, and can be summarised as:

- Site 1: Open woodland including *Eucalyptus microtheca* over dense short grasses.
- Site 2: Woodland of mixed trees over dense short grasses, and slightly damper than site 1.
- Site 4: Woodland of mixed trees over tall grasses in a relatively wet site.
- Site 5: Scattered trees over dense short grasses.
- Site 7: Open woodland over dense short grasses.
- Site 8: Scattered trees including *Eucalyptus microtheca* over tall grasses, and slightly damper than site 7.

Lines of eight pit traps of 20 litre buckets were set in a drift fence of 50m, and 10 Elliott traps were used at each site, except for Site 4 where only 5 Elliott traps were used. The Elliott traps were particularly aimed at rats and mice. The pit traps were not baited, but the Elliott traps were baited with oats, peanut paste and fish.

The traps were run between the 7 – 12 of June 1999 for five nights at Sites 7 and 8, four nights at Sites 1, 2 and 5, and two nights at Site 4. The weather was warm throughout the trapping time.

Other species were recorded opportunistically during the day and night, including road kills and any calls or other signs which could be identified.

4 Results

4.1 SURVEY RESULTS

The survey was carried out at a time when the ground was just drying out after a prolonged wet season. The weather was warm and with no rain, so that the soil was drying out rapidly. A tractor-mounted auger was necessary to excavate holes for the pit traps.

The species and individuals caught in the traps or nearby are listed in Table 1, along with other records from black soil areas but not near a trapping site.

In addition to the results given in Table 1, the dragon lizard *Diporiphora magna* was found near the Keep River, but not strictly on black soil.

Searching at night produced only large numbers of frogs that were difficult to catch because they were in cracks in the soil, but most were the same species listed in Table 1.

Birds were recorded opportunistically, and the species identified are listed in Table 2.

Vertebrate species excepting bats that could be expected to occur on the black soil plains are listed in Appendix 2. Aquatic species, more typical of rivers, pools and wet sites within the black soil were also not sampled. Appendix 2 provides a full taxonomic list of the species.

Table 1 Individuals caught at the trapping sites or nearby

Species	Trapping sites						
	1	2	4	5	7	8	Other
Limnodynastes convexiusculus						7	2
Limnodynastes tasmaniensis *	3	3		1		3	4
Litoria inermis						1	
Litoria nasuta	1					8	10
Heteronotia binoei	2			1	2		
Delma aff. tincta	1						
Gemmatophora gilberti	6				3	3	
Carlia munda	3			2			
Cryptoblepharus aff. carnabyi						6	
Cryptoblepharus aff. plagiocephalus				1			
Ctenotus robustus	1			1			
Menetia aff. greyii	5			1	5	1	
Tiliqua scincoides							1
Varanus panoptes							2
Varanus scalaris *	2					2	
Ramphotyphlops ligatus		1		1	2		

Table 1 Individuals caught at the trapping sites or nearby (continued)

Species	Trapping sites						
	1	2	4	5	7	8	Other
Ramphotyphlops sp. 2 *				1			
Acanthophis praelongus	1						
Demansia sp. ?simplex *		1					
Furina aff. ornata	1						
Pseudechis australis							1
Planigale ingrami	2	1		1		1	
Planigale maculata *		2				1	
Leggadina lakedownensis				1			

** species not recorded in Ecologia Environmental Consultants (1997) surveys.*

Table 2 Species of birds observed within the study area

Species	**Common Name**
ARDEIDAE	
Ephippiorhynchus asiaticus *	Jabiru
Ardea pacifica	White-necked Heron
Egretta garzetta	Little Egret
Nycticorax caledonicus	Nankeen Night Heron
THRESKIORNITHIDAE	
Threskiornis molucca	Australian White Ibis
ACCIPITRIDAE	
Hamirostra melanosternon	Black-breasted Buzzard
Milvus migrans	Black Kite
Haliastur sphenurus	Whistling Kite
Circus assimilis	Spotted Harrier
Aquila audax	Wedge-tailed Eagle
Hieraaetus morphnoides	Little Eagle
FALCONIDAE	
Falco berigora	Brown Falcon
Falco cenchroides	Nankeen Kestrel
GRUIDAE	
Grus rubicunda	Brolga
OTIDIDAE	
Ardeotis australis	Australian Bustard
BURHINIDAE	
Burhinus grallarius	Bush Stone-curlew
COLUMBIDAE	
Ocyphaps lophotes	Crested Pigeon
Geopelia striata	Peaceful Dove
Geopelia humeratus	Bar-shouldered Dove

Table 2 Species of birds observed within the study area (continued)

Species	Common Name
CACATUIDAE	
Calyptorhynchus banksii	Red-tailed Black-Cockatoo
Cacatua roseicapilla	Galah
Cacatua sanguinea	Little Corella
Nymphicus hollandicus	Cockatiel
PSITTACIDAE	
Trichoglossus haematodus	Rainbow Lorikeet
Aprosmictus erythropterus	Red-winged Parrot
Melopsittacus undulatus	Budgerigar
STRIGIDAE	
Ninox novaeseelandiae	Southern Boobook
TYTONIDAE	
Tyto alba	Barn Owl
PODARGIDAE	
Podargus strigoides	Tawny Frogmouth
CAPRIMULGIDAE	
Eurostopodus argus	Spotted Nightjar
HALCYONIDAE	
Dacelo leachii	Blue-winged Kookaburra
Todiramphus pyrrhopygia	Red-backed Kingfisher
MEROPIDAE	
Merops ornatus	Rainbow Bee-eater
PARDALOTIDAE	
Pardalotus striatus	Striated Pardalote
MELIPHAGIDAE	
Lichmera indistincta	Brown Honeyeater
POMATOSTOMIDAE	
Pomatostomus temporalis	Grey-crowned Babbler
DICRURIDAE	
Grallina cyanoleuca	Magpie-lark
Rhipidura leucophrys	Willie Wagtail
CAMPEPHAGIDAE	
Coracina novaehollandiae	Black-faced Cuckoo-shrike
Lalage sueurii	White-winged Triller
ARTAMIDAE	
Artamus cinereus	Black-faced Woodswallow
Cracticus nigrogularis	Pied Butcherbird
Gymnorhina tibicen	Australian Magpie
CORVIDAE	
Corvus orru	Torresian Crow
ALAUDIDAE	
Mirafra javanica	Singing Bushlark
HIRUNDINIDAE	
Hirundo ariel	Fairy Martin
SYLVIIDAE	
Cinclorhamphus mathewsi	Rufous Songlark
Cisticola exilis	Golden-headed Cisticola

** not recorded in Ecologia Environmental Consultants (1997) survey*

4.2 CONSERVATION STATUS OF SPECIES

The following species have a recognised conservation status:

Schedule 1 of the Wildlife Act as "Rare or likely to become extinct".

Gouldian Finch (*Erythrura gouldiae*). Discussed in Ecologia Environmental Consultants 1997 report.

Schedule 4 of the Wildlife Act as "In need of special protection".

The Peregrine Falcon (*Falco peregrinus*), which is a widespread although uncommon species which is threatened by egg-shell thinning due to pesticides, illegal hunting as a pest, and capture for falconry and the cage trade. Pesticides are a problem in only restricted areas and in Western Australia this species is regarded as uncommon but secure.

In addition to these species which have a formal gazetted conservation status, the Department of Conservation and Land Management also maintains a Priority list of species which are restricted, vulnerable or too poorly known to be considered for gazetting. These species have no special protection, but their presence is normally considered.

The Priority list species which might occur are:

Priority 3

- Brush-tailed Phascogale (*Phascogale tapoatafa*) which is widespread across northern Australia but poorly known. It is apparently sparsely distributed and possibly vulnerable. It is also present in the south where it is has declined greatly and is regarded as very vulnerable.

Priority 4

- The Square-tailed Kite (*Lophoictinia isura*) which occurs widely across most of Australia except the driest regions. It prefers woodland areas but can be found in almost any habitat. This species is scarce but widespread and would not be threatened by the loss of small areas of habitat.
- The Grey Falcon (*Falco hypoleucos*) which occurs widely from the northern half of Western Australia across into south-eastern and eastern Australia. It occurs in a variety of mainly open habitats. It is rare everywhere and subject to great fluctuations, but it is widespread and does not appear to have declined. Again it would not be threatened by the loss of small areas of habitat.
- The Bush Stone-Curlew (*Burhinus grallarius*) which is widespread over much of Australia although it has declined greatly in more settled areas and may have been affected by fox predation in southern areas. It prefers woodland with grass but can be found in a variety of habitats. It is present on the areas considered as a resident species, and was recorded in the present survey. It is potentially threatened in southern areas but is probably secure in the north.
- Lakeland Downs Mouse (*Leggadina lakedownensis*) which occurs in disjunct populations in the Pilbara and Kimberleys but its status is uncertain. While apparently rare this species is now known to be widespread in northern Australia and it may turn out to be

poorly collected rather than rare due to the limited collecting which has been carried out regionally.

Priority 3 species are defined as "Taxa with several, poorly known populations, some on conservation lands. Taxa which are known from few specimens or sight records from one or a few localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna".

Priority 4 species are defined as "Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands".

DISCUSSION

The survey produced four species of frogs, 12 species of lizards, six species of snakes, 48 species of birds and three species of small mammals. This is a relatively small fraction of the species which may occur in the area, but a significant part of the common species. The numbers were limited by the early dry season timing, and the short duration of the trapping programme. The black soil plain areas are not rich in species or individuals. Small mammals are particularly limited, with only two species widespread and common. The black soil plain environment is harsh for fauna, with limited structural diversity in the vegetation, a single soil type, prolonged flooding in summer, and dry conditions in winter coupled with hard-setting soils.

The numbers of species and individuals caught by the trapping are too small to make any useful statements about the variations between sites. The only obvious feature is the high number of frogs at Site 8 which was the wettest site pit trapped. There is very limited variation between the sites in terms of habitat features for fauna, and it is not surprising that there are no obvious differences.

Five of the species recorded in the June survey, as indicated in Tables 1 and 2, were not recorded in the Ecologia Environmental Consultants (1997) surveys. The June survey did not record *Ctenotus rimacola* which has recently been described as a black soil plain endemic (Horner and Fisher 1998) and which was listed in the Ecologia Environmental Consultants (1997) as *Ctenotus ? joanae*. Two specimens of the sibling species *Ctenotus robustus* (from which *Ctenotus rimacola* was separated) were caught. These results suggest that *Ctenotus rimacola* is possibly not a common species.

At least five of the species collected (the species of *Delma*, both species of *Cryptoblepharus*, the species of *Menetia*, and the species of *Furina*) are undescribed species. These are known to be different, and this high number of undescribed species is the result of limited collecting in this environment and the region in general rather than a concentration of rare species. There is also doubt about the identification of the Planigales and further work will be carried out by the W.A. Museum.

On the basis of rare species it is unlikely that the proposed development will have a significant impact.

5 REFERENCES

Horner, P. and A. Fisher (1998). *Ctenotus rimacola* sp. nov. (Scincidae), a new species of lizard with two allopatric subspecies, from the Ord-Victoria region of northwestern Australia. Records of the Western Australian Museum 19, 187-200.

Ecologia Environmental Consultants (1997) Ord River Irrigation Area - Stage M2 Development Area Terrestrial Biological Assessment. Unpublished report for Departmnet of Resources Development, Perth.

APPENDIX 1
LOCATIONS AND DESCRIPTIONS OF THE STUDY SITES

Site 1: Knox Plain

0498221; 827 6512

Open Woodland of *Eucalyptus microtheca* and *Excoecaria parvifolia* over *Grassland dominated by Aristida latifolia, Panicum decompositum* and *Iseilema vaginiflorum.*

Eucalyptus microtheca	600-1200cm	5%
Excoecaria parvifolia	300-600 cm	15%
Terminalia oblongata ssp. *volucris*	150-300cm	1%
Iseilema vaginiflorum	120cm	15%
Aristida latifolia	150cm	50%
Panicum decompositum	120cm	5%

Site 2: Knox Plain

0498726; 8291463

Woodland of *Eucalyptus microtheca, Terminalia oblongata* ssp. *volucris* and *Atalaya hemiglauca* and *Acacia ditricha* over Grassland dominated *by Panicum decompositum, Aristida latifolia* and *Iseilema vaginiflorum.*

Terminalia oblongata ssp. *volucris*	400cm	15%
Atalaya hemiglauca	200-800cm	5%
Eucalyptus microtheca	600-1200cm	5%
Acacia ditricha	200-450cm	1.5%
Panicum decompositum	80cm	60%
Aristida latifolia	150cm	5%
Iseilema vaginiflorum	80cm	5%
Herbs	120cm	5%

Site 4: Keep Plain

0510139; 8297462

Woodland of *Bauhinia cunninghamii, Terminalia oblongata* ssp. *volucris, Acacia ditricha, Excoecaria parvifolia* and *Atalaya hemiglauca* over Tall Grassland dominated by *Ophiuros exaltatus, Sorghum timorense* and *Iseilema vaginiflorum*.

Bauhinia cunninghamii	350-900cm	15%
Terminalia oblongata ssp. *volucris*	300-600cm	5%
Atalaya hemiglauca	200-600cm	5%
Acacia bidwillii	200-600cm	15%

Excoecaria parvifolia	200-600cm	5%
Ophiuros exaltatus	250cm	20%
Sorghum timorense	350cm	20%
Iseilema vaginiflorum	150cm	15%
Dichanthium sericeum	150cm	30%
Chionachne hubbardiana	120cm	5%

Site 5: Keep Plain

0512806; 8302302

Grassland dominated by *Themeda triandra* and *Aristida latifolia* with emergent trees of *Acacia ditricha* and *Bauhinia cunninghamii*.

Acacia ditricha	100-400cm	2%
Bauhinia cunninghamii	200-400cm	8%
Themeda triandra	150cm	30%
Aristida latifolia	80cm	40%
Sorghum timorense	150cm	5%
Herbs	120cm	2%

Site 7: Weaber Plain

0495013; 8295571

Open Woodland of *Bauhinia cunninghamii* and *Terminalia oblongata* ssp. v*olucris* over grassland dominated by *Aristida latifolia*.

Bauhinia cunninghamii	300-800cm	15%
Terminalia oblongata ssp. *volucris*	400cm	10%
Acacia ditricha	200-600cm	2%
Aristida latifolia	100cm	85%
Panicum decompositum	60cm	5%
Flemingia pauciflora	20cm	5%
Sehima nervosum	80cm	8%
Herbs		1%

Site 8: Weaber Plain

0489154; 8294255

Tall Grassland dominated by *Oryza australiensis* with *emergent Eucalyptus microtheca* and *Excoecaria parvifolia.*

Eucalyptus microtheca	600-1200cm	5%
Excoecaria parvifolia	300cm	3%
Oryza australiensis	300cm	55%
Ophiuros exaltatus	300cm	15%
Sorghum timorense	400cm	25%
Herbs		2%

APPENDIX 2
LIST OF VERTEBRATE SPECIES EXCEPT BATS WHICH MAY OCCUR OR WHICH WERE RECORDED, EXCEPT FOR PREDOMINANTLY AQUATIC SPECIES

INTRODUCED SPECIES ARE IDENTIFIED BY AN ASTERISK (*)

Species	Common Name
FROGS	
LEPTODACTYLIDAE	
Limnodynastes convexiusculus	Marbled Frog
Limnodynastes tasmaniensis	Spotted Grass Frog
Uperoleia trachyderma	Blacksoil Toadlet
HYLIDAE	
Cyclorana australis	Giant Frog
Cyclorana cryptotis	Hidden-ear Frog
Cyclorana cultripes	Knife-footed Frog
Cyclorana vagitus	Wailing Frog
Litoria inermis	Peter's Frog
Litoria nasuta	Rocket Frog
Litoria pallida	Pale Frog
Litoria rubella	Red Tree Frog
Litoria wotjulumensis	Wotjulum Frog
REPTILES	
GEKKONIDAE	
Diplodactylus stenodactylus	Widespread Gecko
Gehyra australis	Top-end Dtella
Heteronotia binoei	Binoe's Prickly Gecko
Oedura rhombifera	Zig-zag Gecko
Strophurus ciliaris ciliaris	Spiny-tailed Gecko
PYGOPODIDAE	
Delma borea	Northern Delma
Delma aff. tincta	
Lialis burtonis	Burton's Legless Lizard
Pygopus nigriceps schraderi	Schrader's Scaly-foot
AGAMIDAE	
Chelosania brunnea	Chameleon Dragon
Chlamydosaurus kingii	Frilled Lizard
Gemmatophora gilberti gilberti	Gilbert's Arboreal Dragon
Tympanocryptis lineata macra	Blacksoil Earless Dragon
SCINCIDAE	
Carlia munda	Neat Carlia
Cryptoblepharus aff. carnabyi	
Cryptoblepharus aff. plagiocephalus	
Ctenotus militaris	Military Ctenotus
Ctenotus pantherinus acripes	Spiny-footed Leopard Ctenotus
Ctenotus rimacola camptris	Western Black Soil Ctenotus
Ctenotus robustus	Robust Ctenotus
Glaphyromorphus isolepis	Northern Bar-lipped Skink
Menetia aff. greyii	
Proablepharus tenuis	Northern Pygmy Skink
Tiliqua scincoides intermedia	Northern Bluetongue

Species	Common Name
VARANIDAE	
Varanus panoptes panoptes	Northern Yellow-spotted Monitor
Varanus scalaris	Spotted Tree Monitor
Varanus storri ocreatus	Rusty Ground Monitor
Varanus tristis	Black-tailed Monitor
TYPHLOPIDAE	
Ramphotyphlops diversus diversus	Northern Blind Snake
Ramphotyphlops guentheri	Guenther's Blind Snake
Ramphotyphlops ligatus	Robust Blind Snake
Ramphotyphlops unguirostris	Claw-beaked Blind Snake
BOIDAE	
Antaresia childreni	Children's Python
Aspidites melanocephalus	Black-headed Python
Liasis olivaceus olivaceous	Olive Python
COLUBRIDAE	
Boiga fusca ornata	Northern Brown Tree Snake
Dendrelaphis punctulatus	Common Tree Snake
Styporhynchus mairii	Mair's Keelback
ELAPIDAE	
Acanthophis praelongus	Northern Death Adder
Demansia atra	Black Whip Snake
Demansia olivacea	Olive Whip Snake
Furina aff. ornata	
Pseudechis australis	Mulga Snake
Pseudonaja ingrami	Ingram's Brown Snake
Pseudonaja modesta	Ringed Brown Snake
Pseudonaja nuchalis	Gwardar
Rhinoplocephalus pallidiceps	Northern Small-eyed Snake
Simoselaps roperi	Northern Shovel-nosed Snake
Suta ordensis	Ord Curl Snake
Vermicella multifasciata	Many-ringed Bandy Bandy
BIRDS	
CASUARIIDAE	
Dromaius novaehollandiae	Emu
PHASIANIDAE	
Coturnix ypsilophora	Brown Quail
ACCIPITRIDAE	
Elanus axillaris	Black-shouldered Kite
Lophoictinia isura	Square-tailed Kite
Hamirostra melanosternon	Black-breasted Buzzard
Milvus migrans	Black Kite
Haliastur sphenurus	Whistling Kite
Circus assimilis	Spotted Harrier

Species	Common Name
Accipiter fasciatus	Brown Goshawk
Accipiter cirrhocephalus	Collared Sparrowhawk
Haliaeetus leucogaster	White-breasted Sea-eagle
Aquila audax	Wedge-tailed Eagle
Hieraaetus morphnoides	Little Eagle
FALCONIDAE	
Falco berigora	Brown Falcon
Falco longipennis	Australian Hobby
Falco hypoleucos	Grey Falcon
Falco peregrinus	Peregrine Falcon
Falco cenchroides	Nankeen Kestrel
GRUIDAE	
Grus rubicunda	Brolga
OTIDIDAE	
Ardeotis australis	Australian Bustard
TURNICIDAE	
Turnix velox	Little Button-quail
Turnix pyrrhothorax	Red-chested Button-quail
BURHINIDAE	
Burhinus grallarius	Bush Stone-curlew
CHARADRIIDAE	
Elseyornis melanops	Black-fronted Dotterel
Vanellus miles	Masked Lapwing
GLAREOLIDAE	
Glareola maldivarum	Oriental Pratincole
Stiltia isabella	Australian Pratincole
COLUMBIDAE	
Phaps chalcoptera	Common Bronzewing
Ocyphaps lophotes	Crested Pigeon
Geopelia cuneata	Diamond Dove
Geopelia striata	Peaceful Dove
Geopelia humeratus	Bar-shouldered Dove
CACATUIDAE	
Calyptorhynchus banksii banksii	Red-tailed Black-Cockatoo
Cacatua roseicapilla	Galah
Cacatua sanguinea	Little Corella
Nymphicus hollandicus	Cockatiel
PSITTACIDAE	
Trichoglossus haematodus rubritorquis	Rainbow Lorikeet

Species	Common Name
Psitteuteles versicolor	Varied Lorikeet
Aprosmictus erythropterus	Red-winged Parrot
Platycercus venustus	Northern Rosella
Melopsittacus undulatus	Budgerigar
CUCULIDAE	
Cuculus pallidus	Pallid Cuckoo
Chrysococcyx osculans	Black-eared Cuckoo
Chrysococcyx basalis	Horsfield's Bronze-Cuckoo
Scythrops novaehollandiae	Channel-billed Cuckoo
STRIGIDAE	
Ninox novaeseelandiae	Southern Boobook
TYTONIDAE	
Tyto alba	Barn Owl
PODARGIDAE	
Podargus strigoides	Tawny Frogmouth
CAPRIMULGIDAE	
Eurostopodus argus	Spotted Nightjar
AEGOTHELIDAE	
Aegotheles cristatus	Australian Owlet-nightjar
APODIDAE	
Apus pacificus	Fork-tailed Swift
HALCYONIDAE	
Dacelo leachii	Blue-winged Kookaburra
Todiramphus pyrrhopygia	Red-backed Kingfisher
Todiramphus sanctus	Sacred Kingfisher
MEROPIDAE	
Merops ornatus	Rainbow Bee-eater
CORACIIDAE	
Eurystomus orientalis	Dollarbird
MALURIDAE	
Malurus melanocephalus	Red-backed Fairy-wren
PARDALOTIDAE	
Pardalotus rubricatus	Red-browed Pardalote
Pardalotus striatus	Striated Pardalote
ACANTHIZIDAE	
Smicrornis brevirostris	Weebill

Species	Common Name
MELIPHAGIDAE	
Philemon citreogularis	Little Friarbird
Entomyzon cyanotis	Blue-faced Honeyeater
Manorina flavigula	Yellow-throated Miner
Lichenostomus plumulus	Grey-fronted Honeyeater
Lichenostomus flavescens	Yellow-tinted Honeyeater
Melithreptus gularis	Black-chinned Honeyeater
Lichmera indistincta	Brown Honeyeater
Ephthianura crocea	Yellow Chat
PETROICIDAE	
Melanodryas cucullata	Hooded Robin
POMATOSTOMIDAE	
Pomatostomus temporalis	Grey-crowned Babbler
PACHYCEPHALIDAE	
Pachycephala rufiventris	Rufous Whistler
Colluricincla harmonica	Grey Shrike-thrush
DICRURIDAE	
Myiagra inquieta	Restless Flycatcher
Grallina cyanoleuca	Magpie-lark
Rhipidura leucophrys	Willie Wagtail
CAMPEPHAGIDAE	
Coracina novaehollandiae	Black-faced Cuckoo-shrike
Coracina maxima	Ground Cuckoo-shrike
Lalage sueurii	White-winged Triller
ORIOLIDAE	
Oriolus sagittatus	Olive-backed Oriole
ARTAMIDAE	
Artamus leucorhynchus	White-breasted Woodswallow
Artamus personatus	Masked Woodswallow
Artamus superciliosus	White-browed Woodswallow
Artamus cinereus	Black-faced Woodswallow
Cracticus torquatus	Grey Butcherbird
Cracticus nigrogularis	Pied Butcherbird
Gymnorhina tibicen	Australian Magpie
CORVIDAE	
Corvus orru	Torresian Crow
PTILONORHYNCHIDAE	
Chlamydera nuchalis	Great Bowerbird

Species	Common Name
ALAUDIDAE	
Mirafra javanica	Singing Bushlark
MOTACILLIDAE	
Anthus novaeseelandiae	Richard's Pipit
Motacilla flava	Yellow Wagtail
PASSERIDAE	
Taeniopygia bichenovii	Double-barred Finch
Poephila acuticauda	Long-tailed Finch
Poephila personata	Masked Finch
Neochmia ruficauda	Star Finch
Erythrura gouldiae	Gouldian Finch
DICAEIDAE	
Dicaeum hirundinaceum	Mistletoebird
HIRUNDINIDAE	
Hirundo rustica	Barn Swallow
Hirundo nigricans	Tree Martin
Hirundo ariel	Fairy Martin
SYLVIIDAE	
Cinclorhamphus mathewsi	Rufous Songlark
Cisticola exilis	Golden-headed Cisticola
MAMMALS	
DASYURIDAE	
Dasyurus hallucatus	Northern Quoll
Planigale ingrami subtilissima	Long-tailed Planigale
Planigale maculata maculata	Common Planigale
Phascogale tapoatafa pirata	Brush-tailed Phascogale
MACROPODIDAE	
Macropus agilis nigrescens	Agile Wallaby
Macropus antilopinus	Antilopine Wallaroo
Macropus robustus	Euro
Onychogalea unguifera	Northern Nailtail Wallaby
MURIDAE	
Leggadina lakedownensis	Lakeland Downs Mouse
Pseudomys delicatulus	Delicate Mouse
* Mus musculus	House Mouse
Rattus colletti	Dusky Rat
Rattus villosissimus	Long-haired Rat

Species	Common Name
CANIDAE	
* Canis lupus dingo	Dingo
FELIDAE	
* Felis catus	Feral Cat
EQUIDAE	
* Equus asinus	Donkey

Attachment C

A SURVEY OF BATS FOR THE ORD RIVER IRRIGATION AREA STAGE 2

A Survey of Bats for the Ord River Irrigation Area Stage 2 Project

A report to Kinhill Pty Ltd

Ghost Bat *Macroderma gigas*

Lindy Lumsden [1] **and Sue Churchill** [2]

[1] Arthur Rylah Institute for Environmental Research,
Department of Natural Resources and Environment,
123 Brown St, Heidelberg, Vic 3084

[2] 26 Riverview Drive, Paradise, SA 5075

July 1999

Table of Contents

List of Tables

List of Figures

List of Plates

Introduction

This study was conducted to examine the impact of proposed clearing of land for agricultural development in Stage 2 of the Ord River Irrigation Area project. The proposal envisages the clearing of extensive areas of floodplain vegetation. Natural vegetation corridors will be retained along waterways and rocky hillsides for conservation purposes. This study surveyed the bat fauna of both the proposed development areas and the conservation corridors to predict the impact of the proposal on populations of bats.

Methods

Study area

The study was conducted on Legune and Spirit Hills Stations in the Northern Territory and on Ivanhoe and Carlton Hill Stations in Western Australia. These properties are adjacent along the Northern Territory and Western Australian border, north of Kununurra. The survey was conducted from the 6th to the 11th June 1999. The area consists of isolated rocky ranges of sandstone and quartzite of up to 200 m elevation, separated by floodplains of black cracking clays. The vegetation is predominantly open savannah woodland of mixed eucalypt species. Riverine (*Pandanus* and *Melaleuca*) forest and monsoon forest occur along waterways and near springs.

Survey sites were selected to sample the geographic range and the broad habitat types found in the area. Details of these sites are provided in Table 1.

Table 1. Location and habitat of sites used to survey bats.

Site	Location	Latitude	Longitude	Date	Habitat
1	Spirit Hills Camp	15° 26.3S	129 ° 01.2E	6/6/99	Rocky outcrop
2	Legune Rd (pit trap site 4)	15 ° 23.8S	129 ° 05.6E	7/6/99	Floodplain
3	Keep River, 0.4 km N Legune Rd	15 ° 23.9S	129 ° 04.5E	7/6/99	Riverine
4	Kneebone dam	15 ° 24.6S	129 ° 07.4E	7/6/99	Floodplain (dam)
5	1.3 km S of Kneebone Yd (pit trap site 3)	15 ° 25.4S	129 ° 07.5E	7/6/99	Floodplain
6	Nth Keep, 1.6 km N of Legune Rd	15 ° 22.7S	129 ° 07.7E	8/6/99	Floodplain (dam)
7	Nth Keep (pit trap site 5)	15 ° 21.3S	129 ° 07.1E	8/6/99	Floodplain (dam)
8	Keep River, end of tk past pit site 5	15 ° 20.1S	129 ° 05.7E	8/6/99	Riverine
9	Main Nth Keep Tk, 1 km N of tk to site 7	15 ° 21.3S	129 ° 07.8E	8/6/99	Floodplain (dam)
10	Nth Keep, fenceline W of locked gate	15 ° 19.2S	129 ° 07.9E	8/6/99	Floodplain
11	Nth Keep, 1.1 km S of locked gate	15 ° 19.6S	129 ° 07.8E	8/6/99	Floodplain
12	Milligans Tk, 3.6 km S of Legune Rd (pit trap site 2)	15 ° 28.0S	128 ° 58.5E	9/6/99	Floodplain
13	Milligans Lagoon	15 ° 37.0S	129 ° 00.3E	9/6/99	Riverine
14	Point Springs Tk, 5.2 km N of Legune Rd	15 ° 25.3S	128 ° 53.4E	10/6/99	Floodplain
15	Point Springs	15 ° 24.6S	128 ° 53.2E	10/6/99	Wetland/rocky hills
16	Cave Springs Cave	15 ° 31.7S	128 ° 50.0E	11/6/99	Rocky hills

Survey methods

Mist nets

Monofilament mist nets were set over water at dusk and monitored continuously for several hours. Net effort is expressed as net-hours (the number of mist nets times the hours of operation). Bats were caught in the net as they flew over the water to drink or to forage for insects. All bats captured were held in individual cloth bags until processed. Bats were weighed to the nearest 0.5 gram and a range of measurements taken to confirm species identification. Individuals were examined to determine sex, age and reproductive condition. All captured bats were released on the same night at their point of capture, after the nets had been closed.

Harp traps

Harp traps (Austbat, Lower Plenty Vic) were set in a variety of locations both near water and out in the open, often near large trees or along tracks where trees were denser. The traps consist of a large aluminium frame strung with fine fishing line with a catching bag underneath. They were set during the day and left for the entire night, as unlike mist nets they do not require constant attention. Traps were usually checked once or twice during the evening and again in the morning. Bats caught prior to the night checks were processed and released immediately. Those caught during the pre-dawn period were kept in individual cloth bags and released at the capture site the following evening after dark. Trapping effort is defined as the number of traps per night (trapnights).

Searching caves

Rocky outcrops and cliff lines were searched during the day for caves and rock splits which could provide potential roost sites for bats. All accessible caves and splits along a length of cliff line were examined for the presence of bats. Individuals were captured with a hand net, identified and released.

Trapping (using either mistnets, harp traps or hand caught in caves) allowed positive identification of individuals for all species, except for two species of broad-nosed bats *Scotorepens greyi* and *S. sanborni*. These species can not be reliably separated on external features (Churchill 1998), and hence in this report have been combined.

Ultrasonic detectors

Anabat ultrasonic detectors (Titley Electronics, Ballina NSW) were used to monitor levels of bat activity. These units detect the high frequency echolocation calls produced by insectivorous bats and divide the frequency down to an audible level. The calls are then downloaded onto a laptop computer via an Anabat zcaim. The detector units, consisting of a detector, zcaim, laptop computer and external 12 V batteries (Plate 1) were set at sites in the afternoon and collected in the morning. Sites were selected both near water and away from water. An additional unit, which was used primarily to record reference calls, was set for several hours during mistnetting.

Detectors have the advantage over trapping in that they do not require individuals to be handled for identification, and they are not dependent on flight paths to funnel bats into traps or nets. To confidently identify species using this technique it is necessary to obtain reference calls from the local bat population. This requires individuals being trapped and

their calls recorded on release. Detectors are appropriate for only certain types of bats. Several species cannot be recorded as their calls are too soft, of too high a frequency or because they do not use ultrasound (fruit bats). However many high-flying species of sheathtail and freetail bats that are difficult to trap, are readily recorded using this technique.

Plate 1. The ultrasonic bat detector units used to record bat activity.

Reference calls were recorded from most trapped individuals on their release. To ensure that the released bat could be followed and distinguished from other bats flying in the area, individuals were fitted with a small chemical light (Cyalume). This capsule was lightly glued to the belly fur, and the bat released in the dark. To obtain diagnostic calls bats need to be free flying in the open. A total of 80 useable reference calls were obtained from 11 species. An example of a reference call from each species is provided in Appendix 1. We did not catch several species known from the region, and therefore were unable to obtain local reference calls from these species. Additional reference calls were obtained from elsewhere in Australia, however there is still a certain level of uncertainty about some call identifications, where known species maybe confused with other unrecorded species.

Identification of several species was not possible, even with good reference calls, as their calls overlap in all measurable parameters. *Chalinolobus nigrogriseus* and *Scotorepens greyii* were combined during the analysis as we, and other researchers (Linda Reinhold, pers. comm.) found their calls to be inseparable. From the limited number of *Scotorepens sanborni* calls available from north Queensland the calls of this species overlapped as well and so it was also combined with this group. Other species could be distinguished from some, but not all, calls. These were separated where possible and combined into a species complex where not possible. For example, *Chalinolobus gouldii* could at times be reliably identified, however other calls could not be confidently distinguished from *Scotorepens balstoni*.

A number of species trapped in the area are rarely recorded on detectors because of the limited range of their echolocation calls, for example the long-eared bats (*Nyctophilus*), leaf-nosed bats (*Hipposideros* and *Rhinonycteris*) and Ghost bats (*Macroderma*). We were able to obtain reference calls from these species only when they were very close to the detector microphone. For example, *Hipposideros ater* could only be detected about 20 cm from the microphone. Detecting this species on the remote detector units was therefore very unlikely.

Species of freetail bats (*Chaerophon* and *Mormopterus*) and sheathtail bats (*Taphozous* and *Saccolaimus*) have loud and often distinctive calls. These are usually well represented in the call data. These species however are rarely captured, illustrating the importance of using a combination of techniques in a survey of bats.

Flying foxes (*Pteropus*) and blossom bats (*Macroglossus*) do not use echolocation and are therefore not detected using this method.

The amount of survey effort at each site using each of the techniques is shown in Table 2.

Table 2. The amount of survey effort undertaken during the five nights of sampling.

Site No.	Mist net hours	Trap nights	Detector hours	Cave Search
1		5	9.5	2 hr
2			12	
3		3	12	
4	6	2	1.5	
5		1	0 (failed)	
6		1		
7	9	1	12	
8		1		
9			12	
10		1	12	
11		1		
12		1	12	
13	12	5	14 *	
14		1	12	
15	12	4	12	1 hr
16				1 hr
Total	**39 hr**	**27 trapnights**	**121 hr**	**4 hr**

* two detectors were set at Milligans Lagoon – one for the entire night at the southern end of the lagoon, and one for 2 hrs while mistnetting at the northern end.

Limitations of the survey

Time limitations were a problem during this survey. With only 5 nights available it was difficult to sample the study area adequately. It also restricted the number of reference calls we could collect, which in turn influenced our ability to be able to identify the unknown detector calls. Species for which no reference calls were available (from either this or other areas) could not be identified during this study.

Results

A total of 14 species of bats were recorded during this survey of the Ord River Irrigation Stage 2 area. All these species are insectivorous, except for *Macroderma gigas* which is carnivorous. No fruit and blossom feeding species were recorded during this survey. During 39 hours of mistnetting and 29 harp trapnights, 98 individuals of 12 species were trapped (Table 3). An additional species, *Taphozous georgianus*, was caught during cave searches (Plate 2). A total of 5860 bat detector calls were identified revealing six species and two species complexes. The most commonly trapped species was *Chalinolobus nigrogriseus* with 47% of all captures. Similarly, the species complex of *Chalinolobus nigrogriseus*/*Scotorepens greyii*/*S. sanborni* was the most commonly recorded with over 60% of the calls attributed to this complex. The trapping results would suggest that the majority of these calls were *C. nigrogriseus*. The fast flying species which forage high above the canopy were recorded frequently using the detector, but were rarely trapped (eg. *Saccolaimus flaviventris*, *Taphozous georgianus*, *Chaerophon jobensis*). In contrast, the species with very low intensity echolocation calls were more readily trapped than recorded on the detectors (Table 3).

Table 3. The number of individuals of each species caught and the number of bat calls recorded on the detectors. Individuals hand caught include those from cave and building searches.

Species		Mist net	Bat trap	Hand caught	Bat detector
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*	1			654
Common Sheathtail Bat	*Taphozous georgianus*			10 *	261
Ghost Bat	*Macroderma gigas*	1			0
Dusky Leaf-nosed Bat	*Hipposideros ater*		4	1	0
Orange Leaf-nosed Bat	*Rhinonycteris aurantius*		1		0
Gould's Wattled Bat	*Chalinolobus gouldii*	2			27
Hoary Wattled Bat	*Chalinolobus nigrogriseus*	25	29		-
Large Bent-wing Bat	*Miniopterus schreibersii*	2	3		208
Arnhem Long-eared Bat	*Nyctophilus arnhemensis*		2		0
Pygmy Long-eared Bat	*Nyctophilus walkeri*		6		0
Inland Broad-nosed Bat	*Scotorepens balstoni*	2			0
Little/Northern Broad-nosed Bat	*Scotorepens greyii/sanborni*	1			-
Northern Cave Bat	*Vespedalus caurinus*	2	17	5	568
Northern Freetail Bat	*Chaerophon jobensis*				30
Composite groups	*Chalinolobus nigrogriseus / Scotorepens greyii / S. sanborni*				3566
	Chalinolobus gouldii / Scotorepens balstoni				49
Total		**36**	**62**	**16**	**5860**

* another 20 seen but not caught.

Plate 2. The Common Sheathtail Bat *Taphozous georgianus* was found roosting in caves and rock crevices.

To assess the impact of the proposed development on the foraging habitat of the bats in the region, a comparison was made between sites located in the floodplain habitat and those associated with riverine or rocky habitat which are proposed as conservation reserves. Results from trapping data is presented in Table 4. Six species were caught in the development area while 11 species were caught in the conservation areas. The most commonly trapped species, in both the development and conservation areas, was *Chalinolobus nigrogriseus* (Plate 3). Several of the species caught in the conservation areas but not in the floodplain area were species which roost in caves (eg. *Macroderma gigas, Hipposideros ater, Rhinonycteris aurantius*). One individual of the *Scotorepens greyii/sanborni* complex was caught in the development area, while none were trapped in the conservation area.

Plate 3. The Hoary Bat *Chalinolobus nigrogriseus* was the most common species in the area.

Table 4. Comparison of species of bats captured on proposed development areas versus conservation areas.

a) Proposed development areas – floodplain habitat.

Species	Site								Total
	4	**5**	**6**	**7**	**10**	**11**	**12**	**14**	
Chalinolobus gouldii				2					2
Chalinolobus nigrogriseus	2		9	19					30
Miniopterus schreibersii	2		1			1			4
Scotorepens balstoni				1					1
Scotorepens greyii/sanborni	1								1
Vespedalus caurinus			1						1
Number of species	3	0	3	3	0	1	0	0	6
Number of captures	5	0	11	22	0	1	0	0	39

b) Proposed conservation areas – riverine and rocky habitat.

Species	Site						Total
	1	**3**	**8**	**13**	**15**	**16**	
Saccolaimus flaviventris				1			1
Taphozous georgianus	1				3	6	10
Macroderma gigas				1			1
Hipposideros ater	3				1	1	5
Rhinonycteris aurantius	1						1
Chalinolobus nigrogriseus	3	15		6			24
Miniopterus schreibersii	1						1
Nyctophilus arnhemensis		1			1		2
Nyctophilus walkeri		1			5		6
Scotorepens balstoni					1		1
Vespedalus caurinus	8	8		3	4		23
Number of species	6	4	0	3	6	2	11
Number of captures	17	25	0	11	15	7	75

Six species and one species complex were identified using the detectors. All of these were found in both the proposed development and conservation areas (Table 5). However, overall levels of bat activity were much lower in the development areas, with seven times as many calls recorded in the conservation areas as in the development areas (86 calls/hr compared to 12 calls/hr). The comparative levels of activity in the two areas in shown in Fig. 1. The *Chalinolobus nigrogriseus*/*Scotorepens greyii*/*S. sanborni* complex was the most commonly recorded in both areas, representing 75% of calls in the floodplain and 59% in the conservation areas. *Taphozous georgianus* and *Vespadelus caurinus* were recorded proportionally more often in the conservation areas (5% vs 0.5% and 12% vs 0.3% of total records respectively). The other species were recorded in the same relative proportions in both areas.

Table 5. Comparison of the number of bat detector calls recorded on proposed development areas versus conservation areas.

a) Proposed conservation areas – riverine and rocky habitat.

Species	Site							Total	Calls / hr
	2	4	7	9	10	12	14		
Saccolaimus flaviventris	4	25	2	11	9	3	1	55	0.89
Taphozous georgianus				1	1		2	4	0.07
Chalinolobus gouldii		3				1		4	0.07
Chalinolobus nigrogriseus / Scotorepens greyii/sanborni	10	151	4	218	16	167	4	570	9.27
Miniopterus schreibersii		8		5	18	2		33	0.54
Vespedalus caurinus					1		1	2	0.03
Chaerophon jobensis	1		1					2	0.03
Unidentified	3	2		13	28	31	13	92	1.50
Number of 'species'	3	4	3	4	5	4	4	7	
Number of calls	18	191	7	248	73	204	21	762	12.39

b) Proposed conservation areas – riverine and rocky habitat.

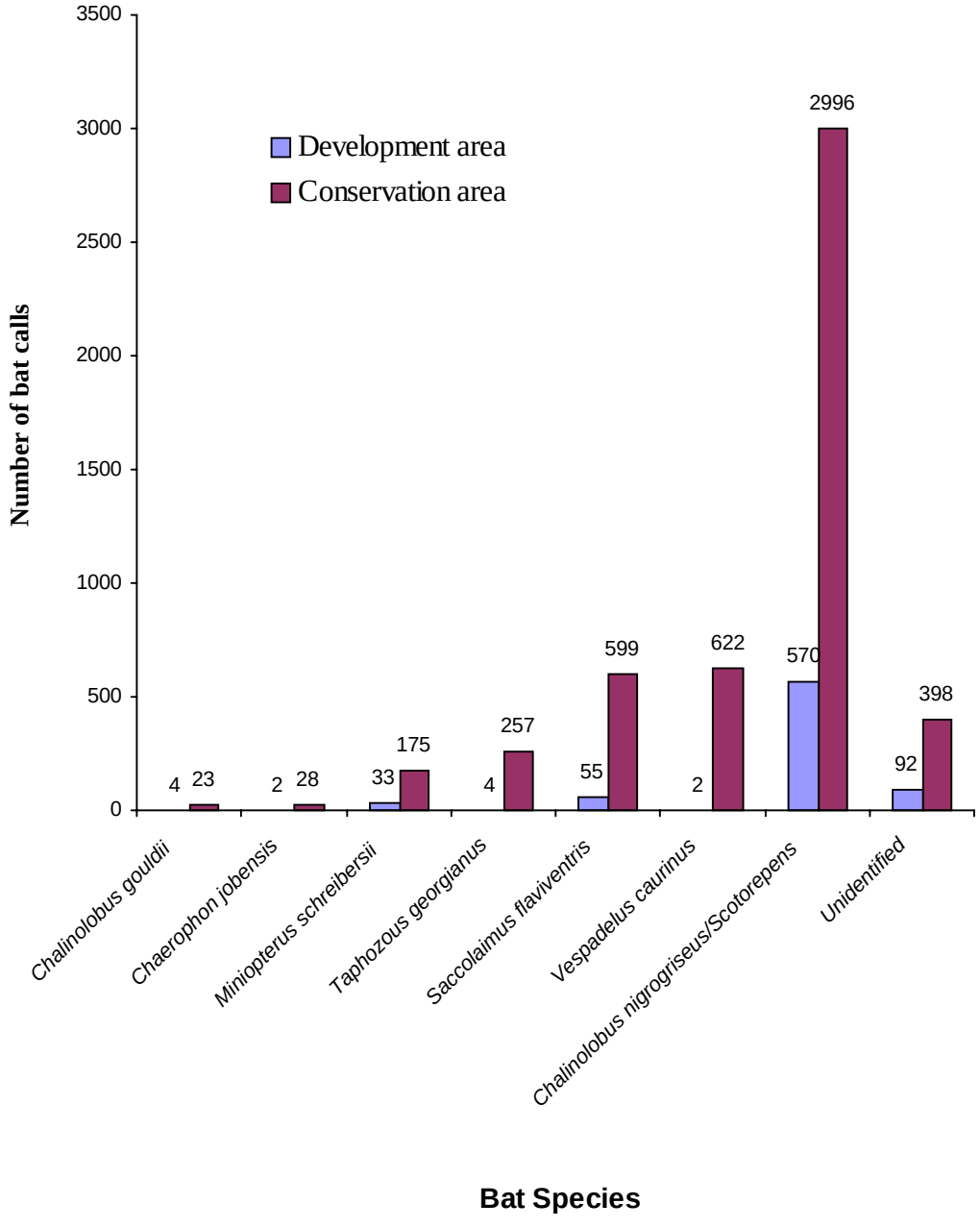
Species	Site				Total	Calls / hr	Total both areas	% total records
	1	3	13	15				
Saccolaimus flaviventris	84	246	223	46	559	9.39	654	11.1%
Taphozous georgianus	231	21	1	4	257	4.32	261	4.5%
Chalinolobus gouldii		1	16	6	23	0.39	27	0.5%
Chalinolobus nigrogriseus / Scotorepens greyii/sanborni	627	1225	302	842	2996	50.35	3566	60.9%
Miniopterus schreibersii	136	8	21	10	175	2.94	208	3.5%
Vespedalus caurinus	66	160	187	209	622	10.45	624	10.6%
Chaerophon jobensis	18	7	2	1	28	0.47	30	0.5%
Unidentified	92	174	58	74	398	6.69	490	8.4%
Number of 'species'	6	7	7	7	7		7	
Number of calls	1254	1842	810	1192	5098	85.68	5860	

Table 6. Summary of the detector and trapping results from proposed development areas versus conservation areas and corridors.

Proposed Development Areas floodplain habitat (Sites 2, 4, 5, 6, 7, 9, 10, 11, 12, 14)	**Proposed Conservation Areas waterways & rocky outcrops (Sites 1, 3, 8, 13, 15, 16)**
• average 12.4 bat calls / hr • 762 calls during 61.5 detector hr • 7 species recorded	• average 85.7 bat calls / hr • 5098 calls during 59.5 detector hr • 7 species recorded
• 6 species captured • 39 captures during 15 net hours and 8 trap nights	• 11 species captured • 72 captures during 24 net hours and 19 trap nights
• total of 9 species recorded	• total of 13 species recorded

An overall comparison of the results from the sites in the conservation and proposed development areas is provided in Table 6. Species diversity and abundance were higher in the conservation areas. All the species recorded in the development area were recorded in the conservation area, with the possible exception of *Scotorepens greyii/sanborni*. This species complex was only caught in the development area. As its calls could not be distinguished from the common *Chalinolobus nigrogriseus* its distribution and habitat use can not be fully ascertained. These species however are generally common and widespread in northern Australia.

Fig. 1. Comparison of the number of bat calls recorded from the proposed development and conservation areas.



Annotated species list

Species recorded during the study

Yellow-bellied Sheathtail Bat *Saccolaimus flaviventris*

Saccolaimus flaviventris is a fast, high-flying species that forages over a wide region searching for insect prey (Plate 4). They usually roost in tree hollows but have been recorded from a variety of strange sites, such as cracks in dry clay. They are rarely captured, as they stay high above the canopy out of range of nets and traps. During the survey they were often seen in the beam of a spotlight more than 10 m above the ground. This species can be identified in flight by its large size, flight pattern and distinctive white belly fur. The one individual we caught was coming down to water to drink at Milligans Lagoon. Although rarely caught, they have loud and distinctive calls and are readily recorded using detectors. They occur in all habitats and were encountered at all detector sites.

Plate 4. Yellow-bellied Sheathtail Bat *Saccolaimus flaviventris* was commonly recorded on the detectors and regularly seen in spotlights.

Common Sheathtail Bat *Taphozous georgianus*

This species is an inhabitant of the rocky hills and outcrops throughout the study area. They usually roost in caves and rock splits in small groups of 2 to 3, and several were found while searching cliff lines at Spirit Hills and Point Springs. A larger colony of 35 individuals was found roosting at Cave Springs. They typically roost in the twilight zone

near the entrance to caves and crevices, however retreat into darker sections when disturbed. They are fast high-flying bats that are capable of foraging for insects over large areas. All roosting sites for this species in this area will be within the proposed conservation areas. The detector results revealed that the majority of the foraging also occurs close to rocks, with 98% of the calls of this species recorded from the proposed conservation areas.

Ghost Bat *Macroderma gigas*

This species is an inhabitant of caves and rock splits. It is still moderately common in the Top End of the Northern Territory although it has suffered a massive decline in its range in inland and southern Australia this century (Churchill and Helman 1990). This unusual species is carnivorous and eats birds, lizards, small mammals, bats and large invertebrates. It was recorded only once during the survey, with a single individual captured in a mist net at Milligans Lagoon. Due to its quiet echolocation call it was not expected to be recorded on the detectors. It is able to utilise a broad range of habitats. Most foraging occurs within 2 km of roost sites.

Orange Leaf-nosed Bat *Rhinonycteris aurantius*

Rhinonycteris aurantius is a rare species that is restricted in its range to the Top End, Kimberley and Pilbara. It only roosts in caves with unusually high temperature and humidity (28^{o}C to 32^{o}C, and 96-100% humidity) (Churchill 1998). These cave conditions are rare and this usually limits the distribution of the species. The presence of this species in the area is of conservation significance. Only one individual was captured, in a harp trap near the Spirit Hills Camp. It is not known where this individual was roosting. No caves located in the area matched the microclimate used by this species, except for Cave Springs. One specimen was collected from this cave in 1966, however, none were using the site during our survey, nor during numerous visits over the last 20 years (Churchill pers. obs.). As the caves often used by this species have small entrances it is possible that there are undiscovered caves in the Cave, Pincombe or Weber Ranges that may be suitable for this species. Individuals can forage up to 30 km from their roost site. Cave Springs is 25 km from where this individual was caught at Spirit Hills.

Dusky Leaf-nosed Bat *Hipposideros ater*

Hipposideros ater is also a restricted cave dwelling species(Plate 5). This slow flying species does not range far from its cave roosts and usually forages in cluttered habitats. Several were captured in bat traps near rocky areas, two were seen in the cave at Cave Springs and a dead one was found in a small cave near Spirit Hills Camp.

Gould's Wattled Bat *Chalinolobus gouldii*

Chalinolobus gouldii is a very common species that is widespread throughout Australia. It is a tree-dwelling species that flies rapidly, usually below the canopy. It was surprisingly uncommon in the study area with only two individuals captured. It was represented in the detector calls in only low numbers and at only a few of the sites, mostly in the conservation areas.

Plate 5. Dusky Leaf-nosed Bat *Hipposideros ater* is a small cave-dwelling species.

Hoary Wattled Bat *Chalinolobus nigrogriseus*

Chalinolobus nigrogriseus is a very common species across northern Australia. Like *C. gouldii* it roosts in tree hollows and eats flying insects. It was the most common species recorded in this study. 60% of all the echolocation calls were identified as the species complex which included this species. It was the most commonly captured bat (54 captures) representing 47% of all bats trapped. This suggests that the majority of the calls recorded as the species complex were likely to be *C. nigrogriseus*. It appears to be the dominant species of both the floodplain and proposed conservation areas, and the call was detected at every site. It was encountered far more commonly in the conservation areas than the proposed development area, with the recording rate over five times greater.

Large Bent-wing Bat *Miniopterus schreibersii*

Miniopterus schreibersii is a common cave-dwelling species of northern and eastern Australia. In northern Australia it roosts in a variety of cave climates and is often found in small colonies. It is not known where this species roosts within the study area. It is a very mobile species and will forage over a large area. It was captured more commonly in the proposed development area (although this is based on only a small number of captures), but their calls were detected more commonly in the conservation areas.

Arnhem Long-eared Bat *Nyctophilus arnhemensis*

Nyctophilus arnhemensis is restricted to the Top End and the Kimberley. It is rarely found far from the coast or from waterways. It has a preference for riverine, monsoon and mangrove vegetation and will roost under the loose bark of Melaleuca trees and in Pandanus. This species was only captured twice, both times near water along the Keep

River and at Point Springs. The echolocation call is faint, and like most species of long-eared bats, is rarely recorded on detectors.

Pygmy Long-eared Bat *Nyctophilus walkeri*

Nyctophilus walkeri is restricted to the Top End and western Kimberley (Plate 6). The capture of 6 individuals during this study represents a slight range extension, the first record from the eastern Kimberley. This is not unexpected as there has been little previous survey of bats in this region and it is likely that their range will be found to be continuous along the coast. They have a preference for foraging in the dense vegetation along riverbanks and mangroves and are rarely captured far from water. During this study individuals were caught along the Keep River and at Point Springs.

Plate 6. The Pygmy Long-eared Bat *Nyctophilus walkeri* is the smallest species of long-eared bat.

Inland Broad-nosed Bat *Scotorepens balstoni*

Scotorepens balstoni is a common species throughout inland Australia. Its distribution rarely extends to the coast and its presence in the study area was a surprise and a range extension of several hundred kilometres. Only two individuals were captured, one at Point Springs, and one in the proposed development area in the northern Keep. Their echolocation calls overlap with *Chalinolobus gouldii* and none of the calls recorded during this study could be confidently attributed to this species. Therefore little data could be obtained on their use of habitats within the area.

Little Broad-nosed Bat and Northern Broad-nosed Bat *Scotorepens greyii/ Scotorepens sanborni*

It is not possible to distinguish these two species from external characteristics, and therefore it was necessary to combine them. Broad-nosed bats are common and usually readily caught throughout northern Australia. It was therefore surprising that only one was caught during this survey. This individual was trapped in the proposed development area at the Kneebone dam. Their echolocation calls are indistinguishable from those of the

common *C. nigrogriseus* and these were combined into a species complex (*C. nigrogriseus / S. greyii / S. sanborni*) during the call analysis. Without further survey effort it is difficult to say how common these species are likely to be in the area.

Northern Cave Bat *Vespadelus caurinus*

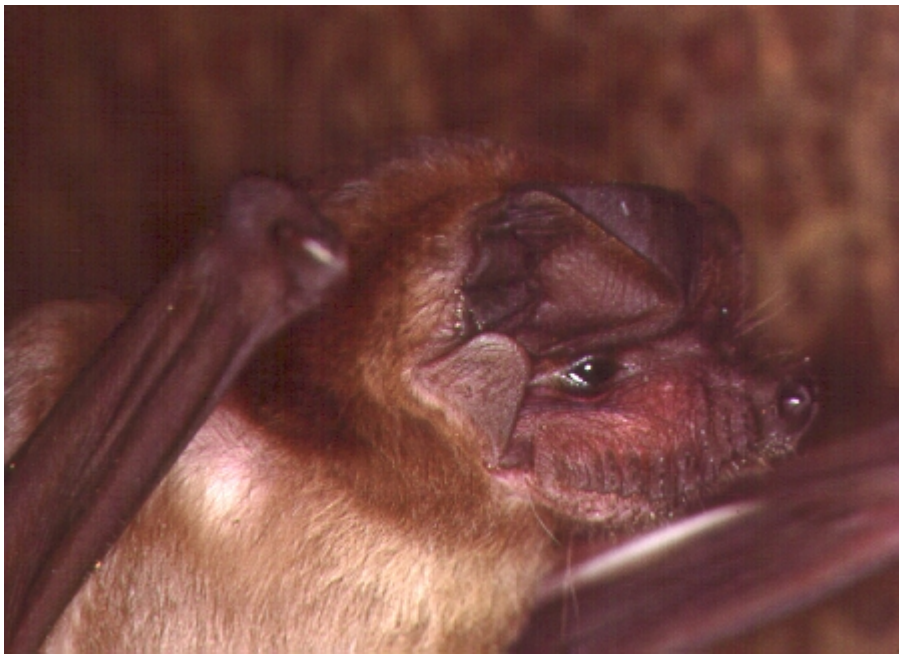
Vespadelus caurinus is restricted to the Top End and the Kimberley where it is found commonly, roosting in small numbers in caves, abandoned mines and buildings (Plate 7). A colony of 6 was found roosting in one of the rooms in the Spirit Hills camp, and judging by the quantity of droppings on the floor in these rooms, this building is a common roost site. Only one individual was captured in the development area, but they were captured at most sites in the conservation areas. They were recorded commonly at all conservation sites using the detectors, but by only a single call at two sites in the proposed development area. The roost sites of this species are likely to be in the conservation areas, and from the detector data it is apparent that this species rarely forages away from these areas, and little use is made of the floodplain.

Plate 7. The Northern Cave Bat *Vespadelus caurinus* was found roosting in buildings at the Spirit Hills station.

Northern Freetail Bat *Chaerophon jobensis*

This species (Plate 8) was not captured during the study but it has a distinctive echolocation call that was recorded at all sites in the conservation area. In contrast, it was only recorded at two sites in the proposed development areas, by a single call at each. It therefore appears to make little use of the floodplain in this area. It is widespread across northern Australia and extends well into the arid regions. It is a fast, high-flying species that usually forages well above the canopy for large insects. It usually roosts in tree hollows, but will occasionally use caves or buildings.

Plate 8. Northern Freetail Bat *Chaerophon jobensis* was not caught during this survey but could be identified by its distinctive echolocation call.



Species not recorded during the study but expected to be present

Northern Long-eared Bat *Nyctophilus bifax*

This species occurs in a discontinuous belt along the east and north coasts of Australia. It favours wetter habitats such as monsoon forests and riverine vegetation but also extends a short distance out onto the floodplain. It is not a commonly captured species but is likely to occur in the study area in the conservation areas, along the rivers and waterways.

Lesser Long-eared Bat *Nyctophilus geoffroyi*

Nyctophilus geoffroyi is one of the most common and widespread bats in Australia. It is found in almost all habitats and roosts almost anywhere (except caves). It was surprising therefore, that none were caught during this study. As with all long-eared bats its echolocation calls are faint and difficult to record. While we did not find this species in the area, it is likely to occur there or nearby.

Beccari's Freetail Bat *Mormopterus beccarii*

Mormopterus beccarii is a common species across tropical Australia and uses a wide range of habitats from rainforests to arid shrublands and spinifex. It usually roosts in tree hollows. It was not captured during this study and was not recorded on the bat detectors. We were unable to obtain definite reference calls on which to base call identification, however, it appears that its calls are similar to those of *Taphozous georgianus*. Therefore it is possible that calls may have gone unrecognised. Elsewhere in its range *M. beccarii* is often recorded at waterholes in floodplain areas, and as virtually all of the calls identified as *T. georgianus* in this study were close to rocky areas used as roosts by *T. georgianus* it is most likely that they did represent that species. To determine if the species does occur in the region further trapping would be required. When individuals were caught reference

calls could be collected which would then enable the use of detectors to fully ascertain its distribution and habitat use.

Black Flying-fox *Pteropus alecto*

This flying-fox was not seen during the survey. These bats are frugivorous and nectarivorous, feeding primarily on the blossoms of eucalypts, Melaleuca and Grevillea. Their local distribution is very dependent on what trees are in fruit or flower at the time. Very few trees were in flower in the study area during our survey, and hence it was not surprising that we did not record them. The aboriginal people that we met at the camp told us that they form large camps near Milligans Lagoon when these trees are in flower. They are common across northern Australia and can occur in camps containing many thousands of individuals. Although the development will result in the loss of flowering trees used for foraging, the retention of the vegetation along the waterways is the most important consideration for their conservation. These areas provide the most suitable camp sites and also support many flowering trees such as the Melaleucas.

Little Red Flying-fox *Pteropus scapulatus*

This species was not recorded during the study but it would undoubtedly occur there at times. Like *P. alecto* they depend on flowering trees for their food. They tend to be more solitary and nomadic than *P. alecto*. The proposed development, while reducing the availability of food resources, would cause relatively little impact on this species.

Other species of bats that may occur in the study area

Northern Blossom Bat *Macroglossus minimus*

Macroglossus minimus has not been recorded from this part of the Kimberley but it is possible that it does occur there. It is restricted to riverine vegetation and monsoon thickets. If it does occur in the study area, it is likely to be found only in the conservation areas, and hence the impact of the proposed development on this nectar-eating species would be minimal.

Northern Pipistrelle *Pipistrellus westralis*

Pipistrellus westralis is a coastal species that has been recorded from mangroves and along waterways into Melaleuca swamps and freshwater mangroves. It is possible that it occurs along the lower reaches of the Keep River, but is unlikely to occur elsewhere in the study area. No individuals were caught during the survey, and it was not possible to obtain reference calls of this species. To ascertain its presence in the area, further trapping would be required and reference calls collected. If it does occur in the area its preferred habitat is unlikely to be affected by development.

Discussion

Effect of clearing on bat populations

Clearing the floodplain vegetation will have an impact on the bat populations in that available foraging habitat will be reduced and some roost trees destroyed. However, the areas of natural vegetation preserved on the hills and along waterways will minimise the impact. During this survey all of the 14 species recorded were found in the proposed conservation areas except for *Scotorepens greyii/sanborni* which was only caught in the development area. As its calls could not be distinguished from the common *Chalinolobus nigrogrieus* it was not possible to ascertain its habitat use by the detector calls. These species are usually widespread and common and so it is likely that they also occur in the conservation areas. Bats are very mobile and consequently forage over a wide area, and in a number of habitats. Their most limited resources are roost sites. The retention of vegetation corridors along waterways will provide sufficient large trees and thick vegetation to support many roost sites for forest dwelling bats. The hills already provide suitable roost sites for the cave dwelling species. The data collected during this survey has shown that there is both a lower diversity and abundance of bats foraging out on the floodplain. In addition the species recorded on the floodplain are all ubiquitous species that occur commonly throughout much of northern Australia. While none of the species recorded during this survey are listed as threatened in the national Action Plan for Australian Bats (Duncan et al. in press), several are considered to be of conservation significance, such as *Macroderma gigas, Rhinonycteris aurantius* and *Hipposideros ater*. These are all cave dwelling and although parts of their foraging habitat will be modified (and probably support less invertebrate prey) their roosts will be left intact. This is also the case with the uncommon *Nyctophilus walkeri* and *N. arnhemensis*. These species are primarily restricted to riverine habitats and are known to roost under the bark of paperbark trees, in palm fronds, and inside Pandanus leaf clumps. All these roosts are found along rivers. The fast flying bats such as *Saccolaimus flaviventris, Taphozous georgianus* and *Chaerophon jobensis*, are likely to continue foraging above the floodplain even after clearing as they are commonly encountered in agricultural lands elsewhere in Australia. However, it is not known to what extent the abundance of their insect prey will be affected.

Suggestions for monitoring and further work

This survey was restricted by the limited time available. A longer survey would allow a more intensive coverage of the area. However, the overall pattern of greater diversity and abundance of bats in the proposed conservation areas compared to the development area is unlikely to change with further work. More trapping, however, may result in additional species being recorded for the area, such as *Nyctophilus geoffroyi, N. bifax, Pipistrellus westralis* and *Mormopterus beccarii*. Collection of reference calls from the latter two species would enable clarification of presence and distribution within the area using the detectors.

It would be useful to compare the diversity and abundance of bats using the existing sugar crops in the region to determine what species are able to forage over these modified areas.

An investigation of the abundance of invertebrate prey in these areas compared to the existing floodplain, riverine and rocky habitats would enable an assessment of the likely changes to the available food resources for the insectivorous species.

To determine more precisely where individuals roost and forage, a radio tracking study would be required. For cave-dwelling species such a study would ascertain how far from the roost sites individuals foraged and how important the floodplain area was as foraging habitat. For tree-dwelling species it could be determined what proportion of roosts were within the floodplain area compared to the conservation areas, and how much of the foraging time was spent in the floodplain. Radio tracking studies such as these can provide invaluable information on roost sites and foraging areas, however they require considerable time and financial investment.

A long-term monitoring program could be established to investigate the impact of clearing the floodplain vegetation. However, if this was to be undertaken, further pre-clearing sampling would be required. Bat trapping and detector results can be highly variable between nights and seasons and there needs to be a sufficiently large number of sites in both the conservation and development areas to enable this variation to be evened out. If for example, another one week sample was undertaken after the clearing had occurred, a comparison with the current study could be inconclusive. However, good baseline data on which to make future comparisons could be established with only several more weeks of sampling.

Acknowledgments

We would like to thank Bob Anderson and Eleanor Bennett of Kinhill for organising this survey, and Warren Ford, Phil and Rochelle Pyle for logistical support. Roger Coles, Greg Ford, Alex Kutt, Damian Milne, Linda Reinhold and Greg Richards kindy provided useful discussions on reference calls.

References

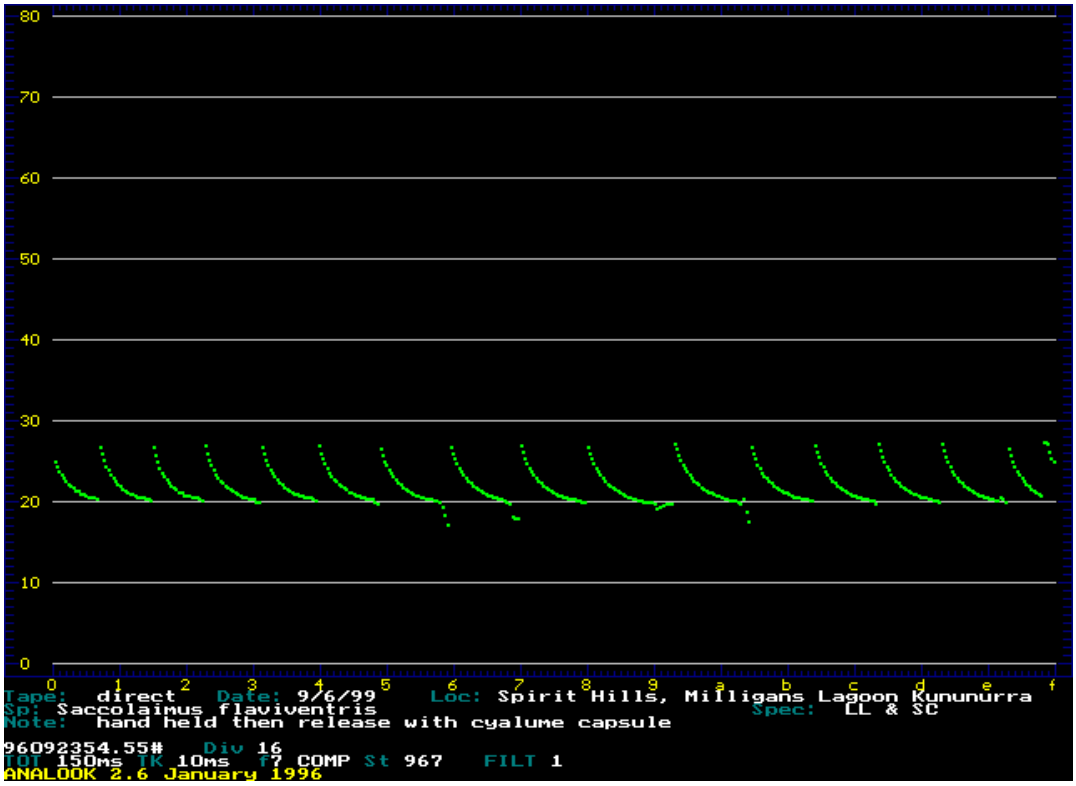
Churchill, S. (1998). *Australian Bats*. Reed New Holland Publishers: Sydney. 230 pp.

Churchill, S. K. and Helman, P.M. (1990). Distribution, population and status of the Ghost Bat, *Macroderma gigas* (Chiroptera: Megadermatidae) in central and South Australia. *Australian Mammalogy* **13**: 149-156.

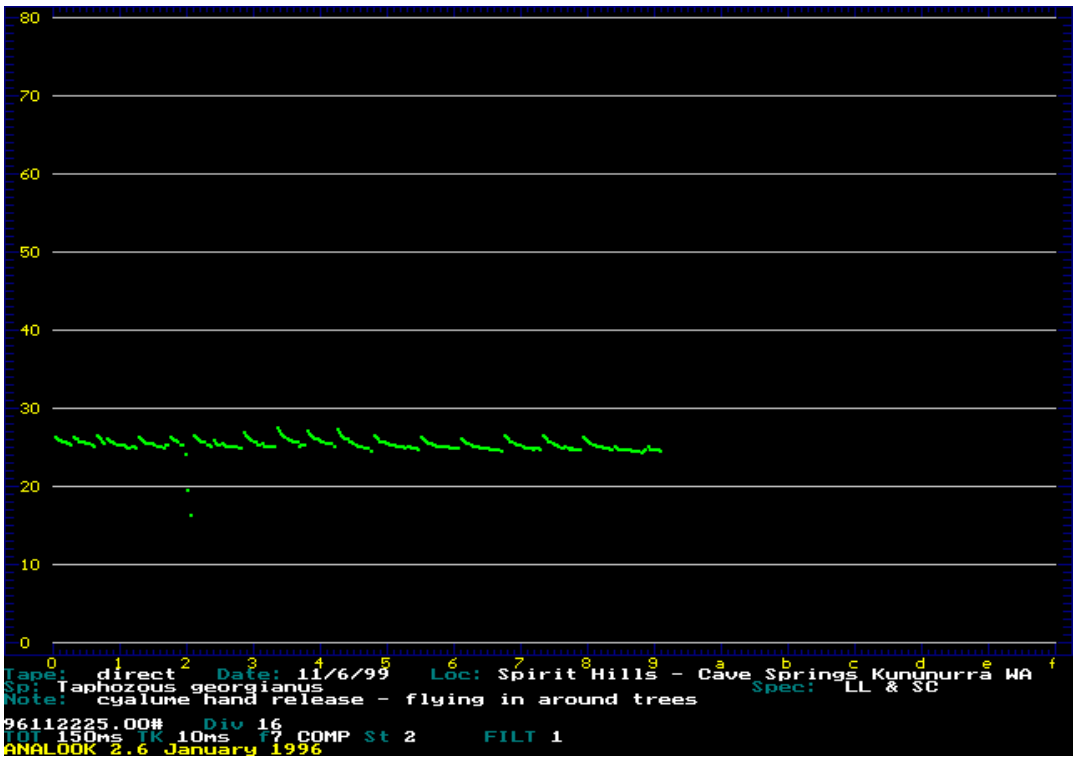
Duncan, A., Baker, G.B. and Montogomery, N. (in press). The 1999 Action Plan for Australian Bats. Environment Australia.

Appendix 1. Reference calls taken from individuals caught during the survey of the Ord Stage 2 survey.

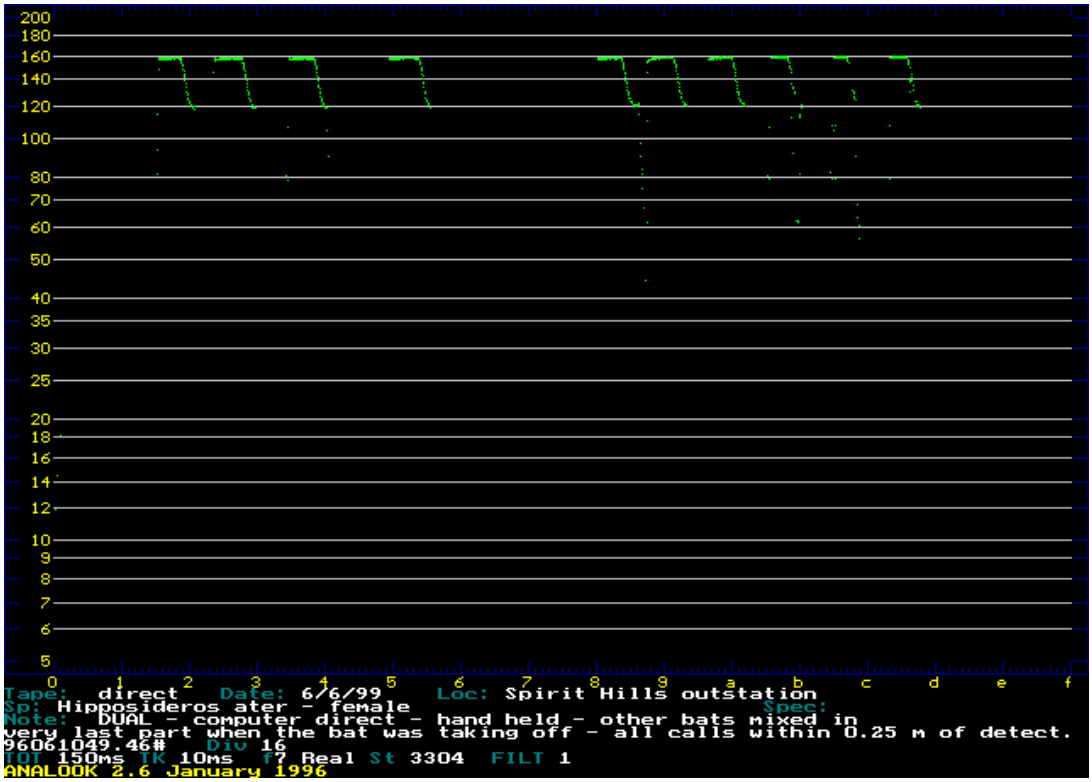
a) Yellow-bellied Sheathtail Bat *Saccolaimus flaviventris*.



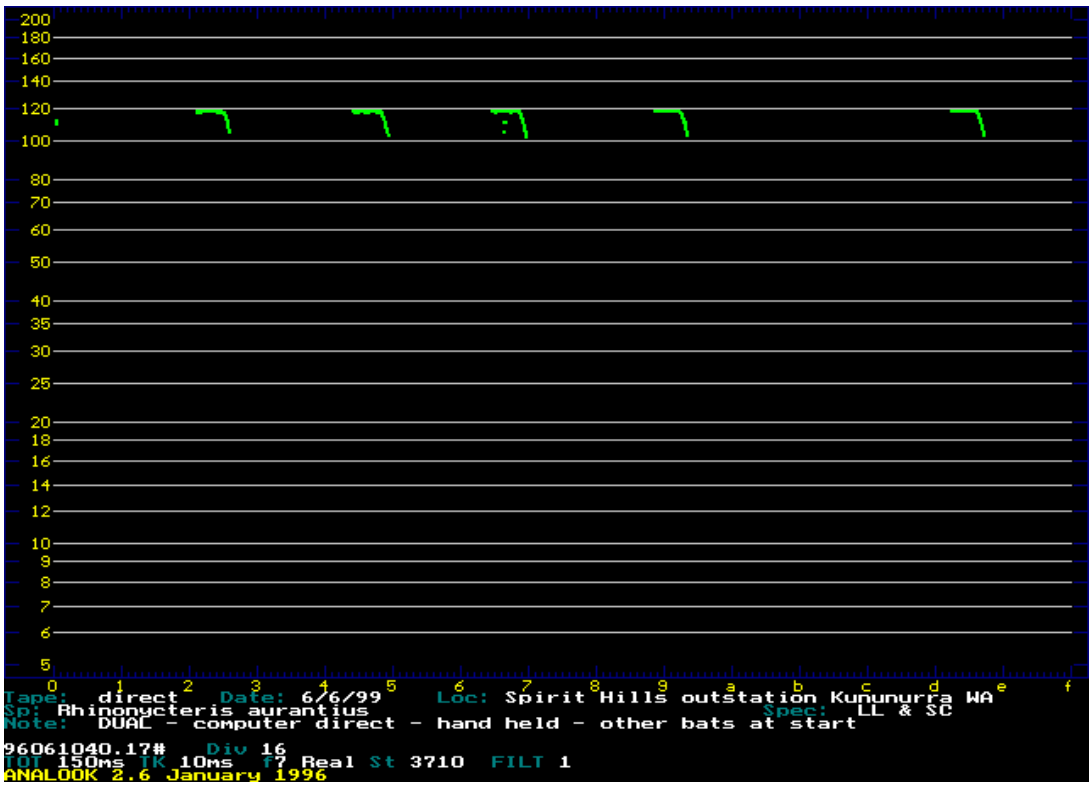
b) Common Sheathtail Bat *Taphozous georgianus.*



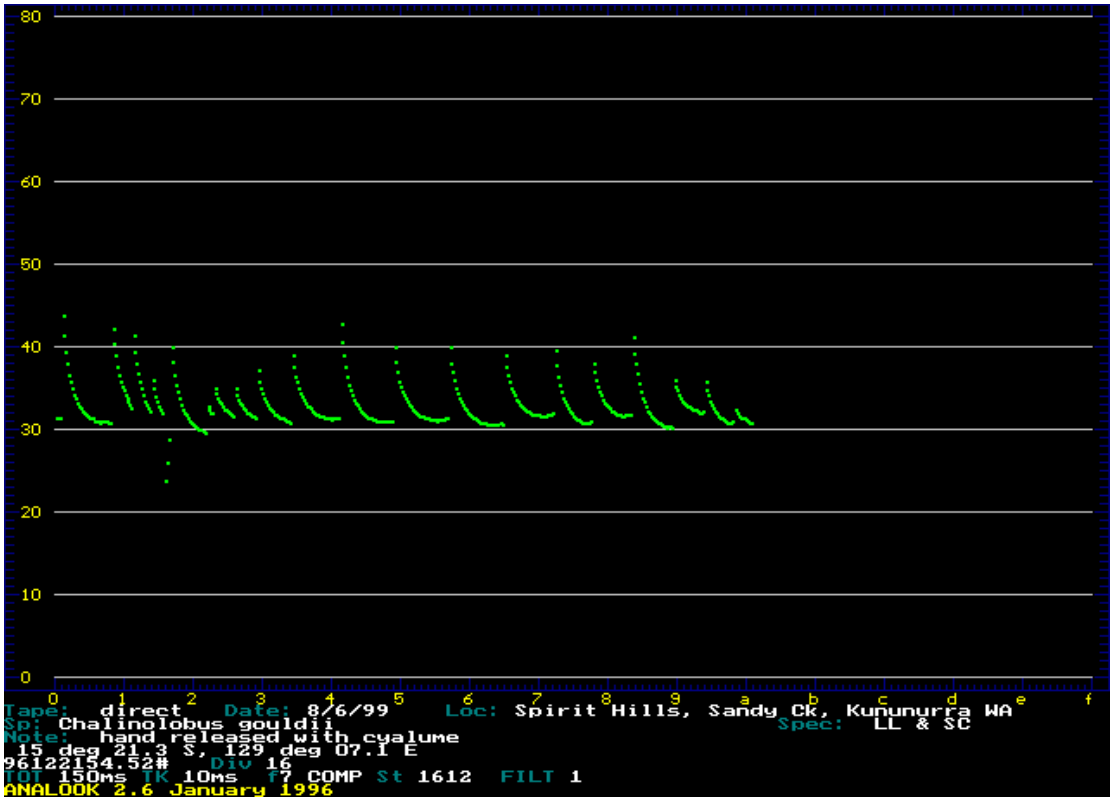
c) Dusky Leaf-nosed Bat *Hipposideros ater*.



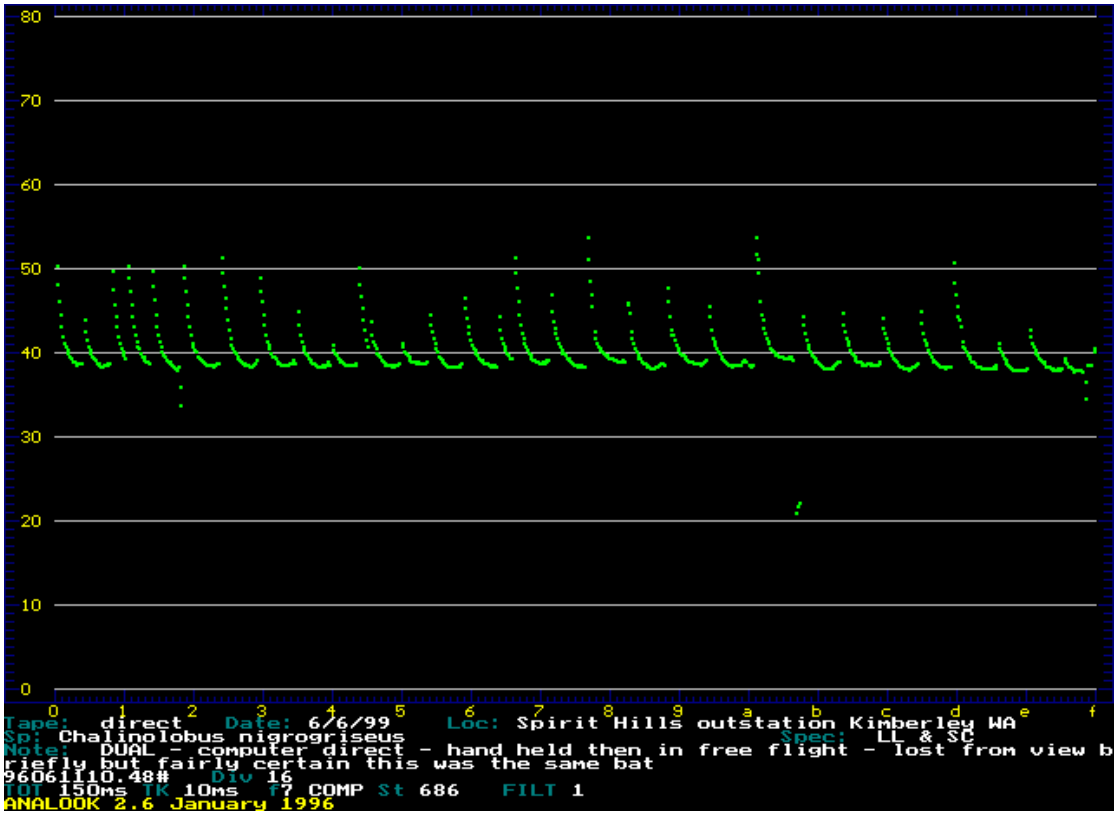
d) Orange Leaf-nosed Bat *Rhinonycteris aurantius.*



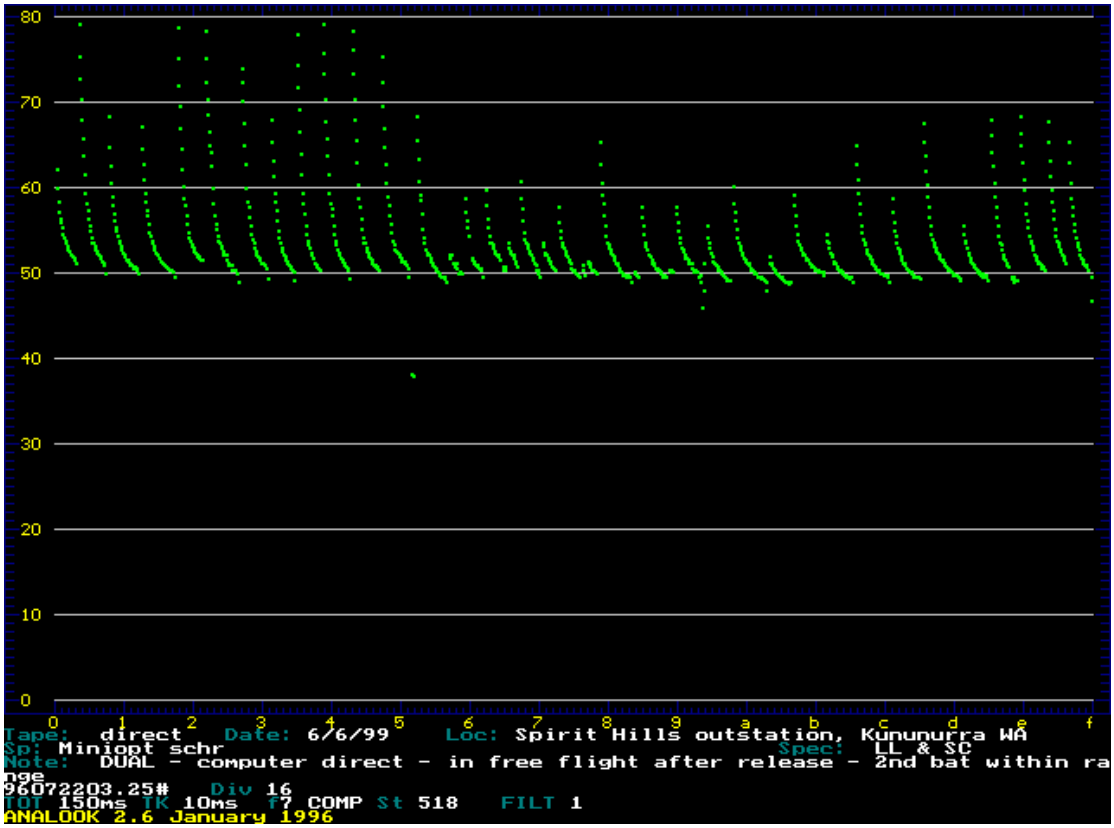
e) Gould's Wattled Bat *Chalinolobus gouldii*.



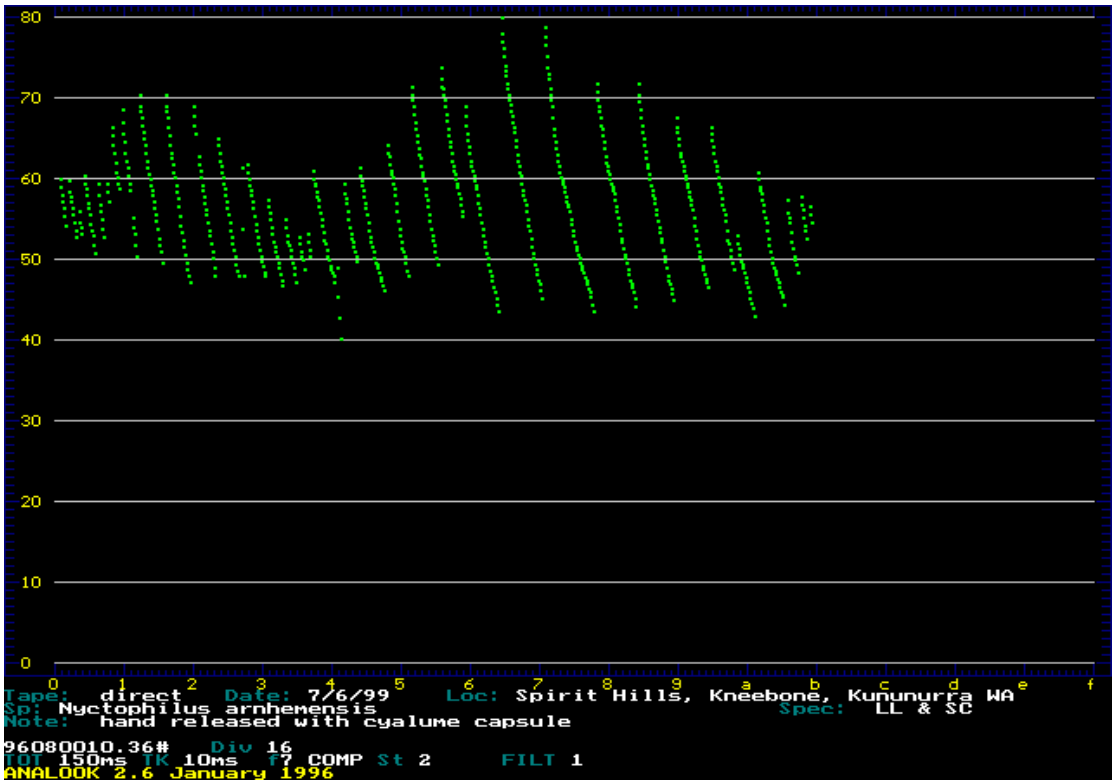
f) Hoary Wattled Bat *Chalinolobus nigrogriseus*.



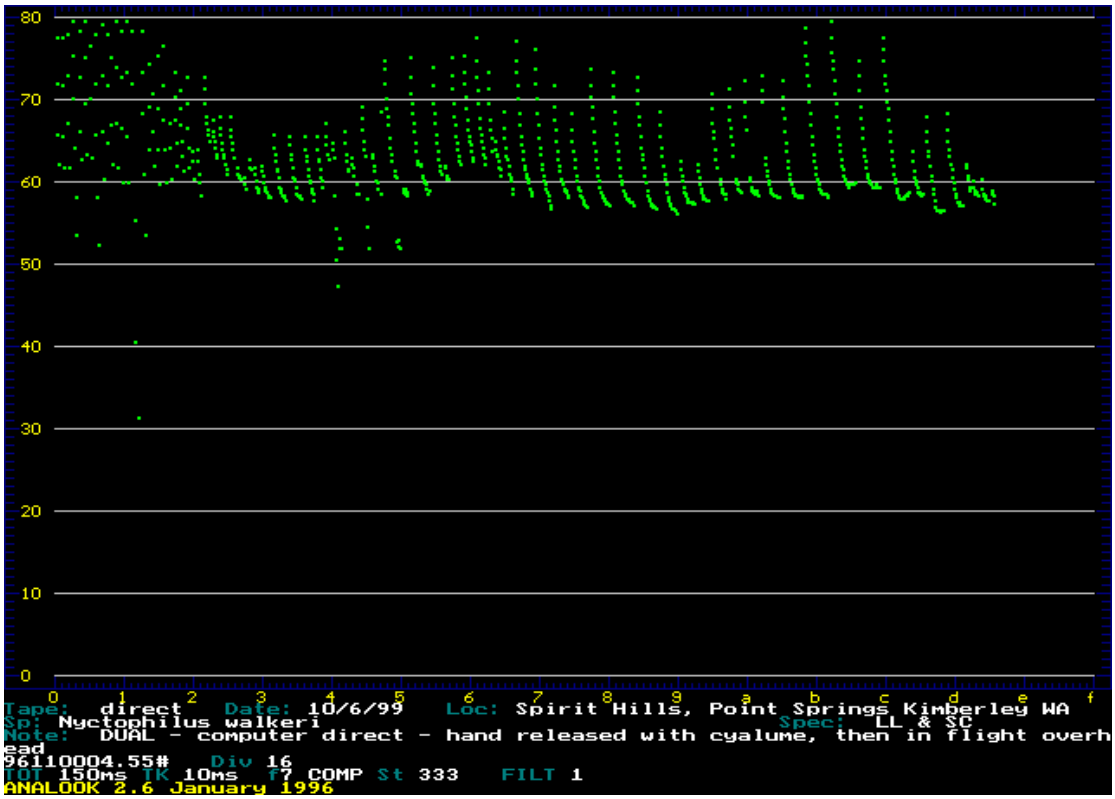
g) Large Bent-wing Bat *Miniopterus schreibersii*.



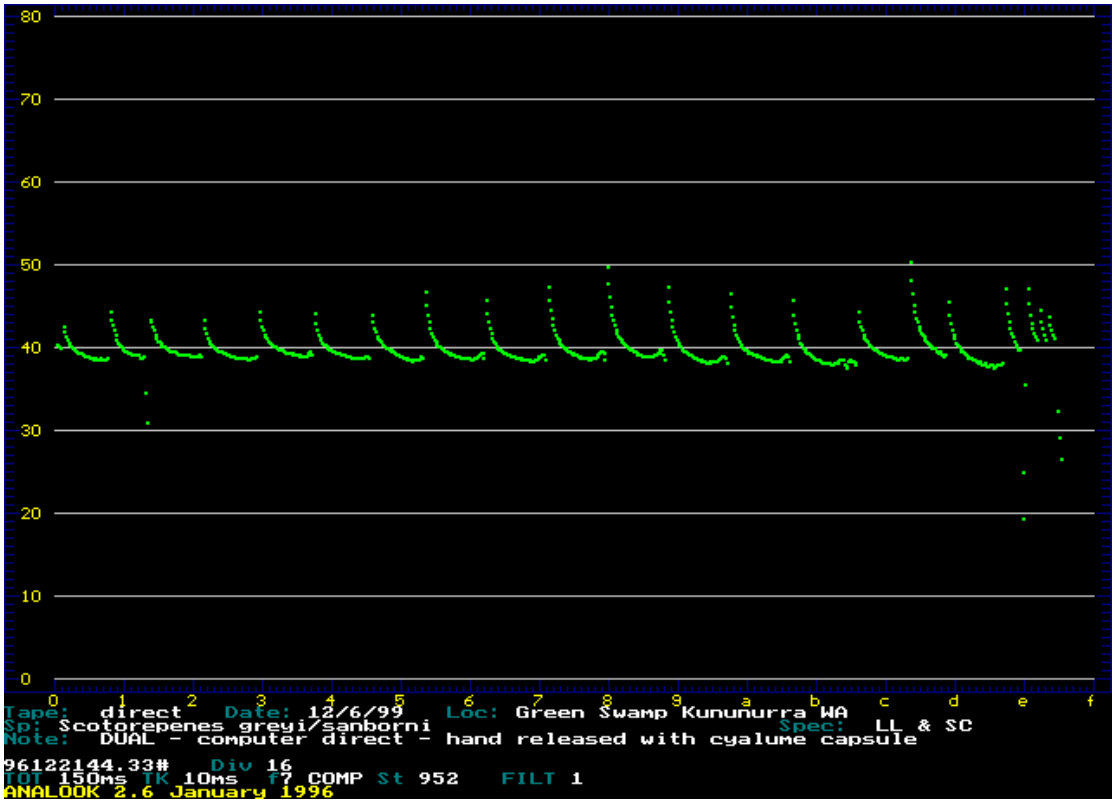
h) Arnhem Long-eared Bat *Nyctophilus arnhemensis*.



i) Pygmy Long-eared Bat *Nyctophilus walkeri.*



j) Little/Northern Broad-nosed Bat *Scotorepens greyii/sanborni*.



k) Northern Cave Bat *Vespadelus caurinus*.