Mantinea and Carlton Plain Project

Level 1 Flora, Vegetation and Fauna Assessment

KIMBERLEY AGRICULTURAL INVESTMENT PTY LTD

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Mantinea and Carlton Plain Project, Level 1 Flora, Vegetation and Fauna Assessment

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DISCLAIMER

TABLE OF CONTENTS

APPENDICES

FIGURES

TABLES

PLATES

DEFINITIONS

Term	Definition
aff.	Affinitive
AWC	Australian Weeds Committee
BAgrib	Bachelor of Agribusiness
BAM	Biosecurity and Agriculture Management
BSc	Bachelor of Science
CALM	Department of Conservation and Land Management (now DPaW)
DAF	Department of Agriculture and Food
DEC	Department of Environment and Conservation (now DPaW)
DoEE	Department of the Environment and Energy
DPaW	Department of Parks and Wildlife
EPA	Environmental Protection Authority
EPBC	Environment Protection and Biodiversity Conservation
ESA	Environmentally Sensitive Area
ESCAVI	Executive Steering Committee for Australian Vegetation Information
GDA	Geocentric Datum of Australia
GIS	Geographic Information System
GPS	Global Positioning System
IBRA	Interim Biogeographic Regionalisation for Australia
KAI	Kimberley Agricultural Investment Pty Ltd
NVIS	National Vegetation Information System
PEC	Priority Ecological Community
Pty Ltd	Proprietary Limited
sp.	Species
TEC	Threatened Ecological Community
UCL	Unallocated Crown Land
VT	Vegetation Type
WA	Western Australia
WA Herb.	Western Australian Herbarium
WC	Wildlife Conservation
Woodman Environmental	Woodman Environmental Pty Ltd

EXECUTIVE SUMMARY

Kimberley Agricultural Investment Pty Ltd (KAI) has a license granted under the WA *Lands Administration Act 1997* to enable commencement of environmental investigations within the Mantinea farm area within Ivanhoe Station situated approximately 20 km north-west of Kununurra, in the Kimberley region of Western Australia. In addition to this, KAI is freehold owner of Carlton Plain, located to the north of the Mantinea farm area, within Carlton Hill Station. It is intended that both Plains will be developed for irrigated agriculture, with water pumped from the adjacent Ord River. This report presents the results of the flora, vegetation and fauna desktop reviews and field survey components of a Level 1 survey to support site planning and future approval processes for the area, including clearing permit applications.

The Study Area includes the Mantinea Plain (south of the Lower Ord River) and the Carlton Plain (north of the Lower Ord River), and is located between the townships of Wyndham and Kununurra. The Study area covers a total of 24 604 ha, of which 9 428 ha is located within the Mantinea Plain, and 15 176 ha within the Carlton Plain. The Study Area is adjacent to and upstream of the Ord River Floodplain Ramsar Site, an area that encompasses the Parry Lagoons Nature Reserve and the Ord River Nature Reserve. The Mantinea Plain study area is to the north of the Ngamoowalem Conservation Park, an area of more than 70,000ha centred on a sandstone range (Livistona Range).

The flora and vegetation assessment of the Study Area was undertaken at a Level 1 standard as defined by the Environmental Protection Authority's (EPA) Guidance Statement No. 51 (EPA 2004a), and Position Statement No. 3 (EPA 2002). This level of survey was determined to be appropriate given the proponents requested timing of the survey in conjunction with Table 2 of Guidance Statement No. 51, where the Bioregion Group is defined as Group 3 and at project commencement the scale and nature of impact was considered Moderate (EPA 2004a). Given the requested survey timing, a Level 2 survey cannot be completed to standards specified in EPA (2004a) or EPA and Department of Parks and Wildlife (DPaW) (2015).

The fauna assessment of the Study Area was undertaken at a Level 1 standard as defined by the Environmental Protection Authority's (EPA) Guidance Statement No. 56 (EPA 2004b), and Position Statement No. 3 (EPA 2002).

A total of 35 Vegetation Types (VTs) were defined for the Study Area based on data from 119 relevés as well as notes taken in the field. These VTs were described based on species composition, density and occurrence in structural layers. They include woodlands, shrublands, sedgelands and grasslands. The most dominant VTs were VT11 (covering approximately 25 % of the Study Area) which is essentially a mixed grassland on plains, and VT22 (covering approximately 15 % of the Study Area) which is described as a *Corymbia bella* and *Eucalyptus microtheca* woodland.

A number of VTs described are representative of the Ivanhoe Land System Priority 3 PEC. These include 33 of the 35 VTs (all VTs except VT 24, 25 and 27) and comprise all areas not associated with stony hills. Based on the condition of the vegetation and the taxa recorded

at the time of the survey it is considered that no other VTs are representative of any additional listed TECs or PECs.

The vegetation condition of the Study Area ranged from Excellent to Completely Degraded. The majority of the vegetation in the Study Area has been significantly altered by grazing and affected by drought conditions experienced over the preceding 2 years of below average annual rainfall, with large areas mapped as Very poor to Completely Degraded. Mantinea Plain was generally in worse condition than Carlton Plain, which may be due to increased levels of grazing (by both native animals (wallabies) and cows) south of the Ord River. In addition, large areas adjacent to the Ord River and associated drainage lines were mapped as Very Poor to Completely Degraded due to increased cattle movement and grazing by wallabies in these areas, as well as historic introduction of weed seeds from areas upstream. The generally poor condition of the vegetation and the heavy grazing (by both wallabies and cows) caused difficulties in determining grass species in particular, and therefore weed composition/levels as well as vegetation structure.

A total of 200 discrete native vascular flora taxa were recorded within the Study Area, representing 42 families and 112 genera. The most well represented families were Poaceae (46 taxa), Myrtaceae (22 taxa), Fabaceae (20 taxa) and Malvaceae (17 taxa). This is considered a relatively low number of taxa given the size of the Study Area and is attributed to the condition of the vegetation as discussed previously and also the timing of the survey. Ephemeral taxa (annuals, geophytes and aquatic taxa) are largely missing from the survey results as well as many understorey taxa that would have been grazed to the point of eradication or to a state where they could not be identified.

A Level 2 survey conducted at the appropriate time of year for the region (March to May) following monsoonal rain is expected to add considerably to the species list reported here. Many ephemeral taxa will become evident following the wet season and the majority of taxa will flower/fruit and generally become easier to identify as a result of conditions suitable for germination and growth.

No Threatened flora species as listed under the EPBC Act or WC Act were recorded within the Study Area. One Priority flora taxon was recorded within the Study Area; *Brachychiton tuberculatus* (P3). This taxon was recorded at 9 point locations during survey of the Study Area with a total of 22 live individuals and 44 dead individuals recorded. All plants were in poor condition including those recorded as alive. Affected plants appeared dead rather than being in a deciduous state possibly as a result of drought, and these were generally younger (smaller) individuals. Based on the results of DPaW database searches, an additional three conservation significant taxa are known to occur within the Study Area. These are *Echinochloa kimberleyensis* (P1), *Goodenia brachypoda* (P1) and *Solanum pugiunculiferum* (P1). There are a further 26 conservation significant taxa which have the potential to occur within the Study Area given their habitat preferences, including *Typhonium* sp. Kununurra (A.N. Start ANS 1467)(T).

A total of 24 introduced flora taxa were recorded during this survey. Of these, *Parkinsonia aculeata* and *Xanthium occidentale* are Declared Pests under the BAM Act (DAF 2016), and *Parkinsonia aculeata* is also a WoNS (AWC 2016). It is recommended that all locations of

these taxa are recorded and eradicated immediately prior to any clearing activity and also routinely following any disturbance as a result of the proposal to develop the Study Area. Soil disturbance is likely to stimulate germination of soil stored seed of these taxa and soil movement associated with clearing and preparation for agricultural production is likely to spread them further in the local area.

In addition, *Aerva javanica*, *Azadirachta indica*, *Calotropis procera*, *Cenchrus ciliaris* and *Passiflora foetida* var. *hispida* are ranked as 'High' for distribution, invasiveness and impacts in the Environmental Weed Strategy (CALM 1999). While all of these weeds are relatively widespread in the Kimberley and across the north of Western Australia, their control is important to the conservation of biodiversity of areas of native vegetation including local Nature Reserves and Conservation Parks.

Seven broad fauna habitats were recorded in the Study Area. These were; sandstone hills, stony plains, savannah woodlands, floodplains, grasslands, seasonal wetlands and creeklines. The floodplains can be divided into a further four sub-habitats, into those that support either Guttapercha (*Excoecaria parvifolia*) woodland on cracking clays, *Melaleuca* woodlands, Open shrublands or *Eucalyptus camaldulensis* woodlands. The grassland habitat can be further divided into two sub-habitats, tall grassland on cracking clays and mixed grassland.

Important habitats for fauna include those with cracking clays (Tall grasslands and Guttapercha woodlands) and seasonal wetlands. The Study Area has the potential to support a wide range of terrestrial vertebrate species. This includes up to 28 frog, 101 reptile, 234 bird and 49 mammal species. A total of four frog (three native, one introduced), 17 reptile, 103 bird and 18 mammal (15 native, three introduced) species were recorded from the study area during the 2016 Level 1 fauna survey. It is important to note that these records were opportunistic in the dry season only and that no trapping was undertaken.

There are 53 fauna of conservation significance that have the potential to occur in the Study Area. Of these, 28 species are wetland dependent, so are only likely to occur in the creeklines and seasonal wetlands in the Study Area, and outside the study areas on the Ord River and Parry Lagoons.

Although a large number of migratory species are likely to occur, the Study Area is unlikely to support significant populations of most species. Many migratory species are widespread and abundant, and are thus unlikely to occur in ecologically significant numbers. For migratory shorebirds, a site is only likely to be significant if it supports 1% or more of the global population, 15 or more species or more than 20,000 birds. Although unlikely to be significant for most species, the seasonal wetlands in the Study Area may potentially support significant numbers of a migratory shorebird species. To assess significance, ideally several surveys targeting peak non-breeding season (wet season) as well as southward and northward migration are recommended.

Of the remaining conservation significant species, the Red Goshawk, Australian Painted Snipe, Curlew Sandpiper, Kimberley Masked Owl, Grey Falcon, Crested Shrike-tit, Northern Quoll and Ghost Bat are species that have threatened populations. Of these only the Grey

Falcon is known to occur on the Study Area. The remaining species have a moderate (Australian Painted Snipe) or low likelihood of occurring.

The fauna values of the Study Area have been impacted by a long grazing history and by changes to the hydrology of the Ord River after dam construction. However, the Study Area still maintains value as fauna habitat, with important ecological values of the Study Area including:

- Habitats with high vertebrate fauna diversity, particularly around seasonal wetlands but also in structurally diverse habitats such as woodlands and creeklines.
- Regional habitat for bird species that occur in Parry Lagoons and the Ord River.
- Proximity to the Ord River.
- Corridor for fauna movement along the Ord River valley.

Given the long history of agricultural use of the Study Area and in particular cattle grazing, the results of the Level 1 survey for flora and fauna presented here are restricted in the number of taxa recorded. This significant level of disturbance has also obscured the definition of vegetation types present. Additional factors affecting this survey include the preceding two years of below average annual rainfall and the timing of the survey which is sub-optimal for this region. A Level 2 survey would more fully sample the taxa present within the Study Area and include targeted searching for Threatened taxa such as *Typhonium* sp. Kununurra (A.N. Start ANS 1467).

1 INTRODUCTION

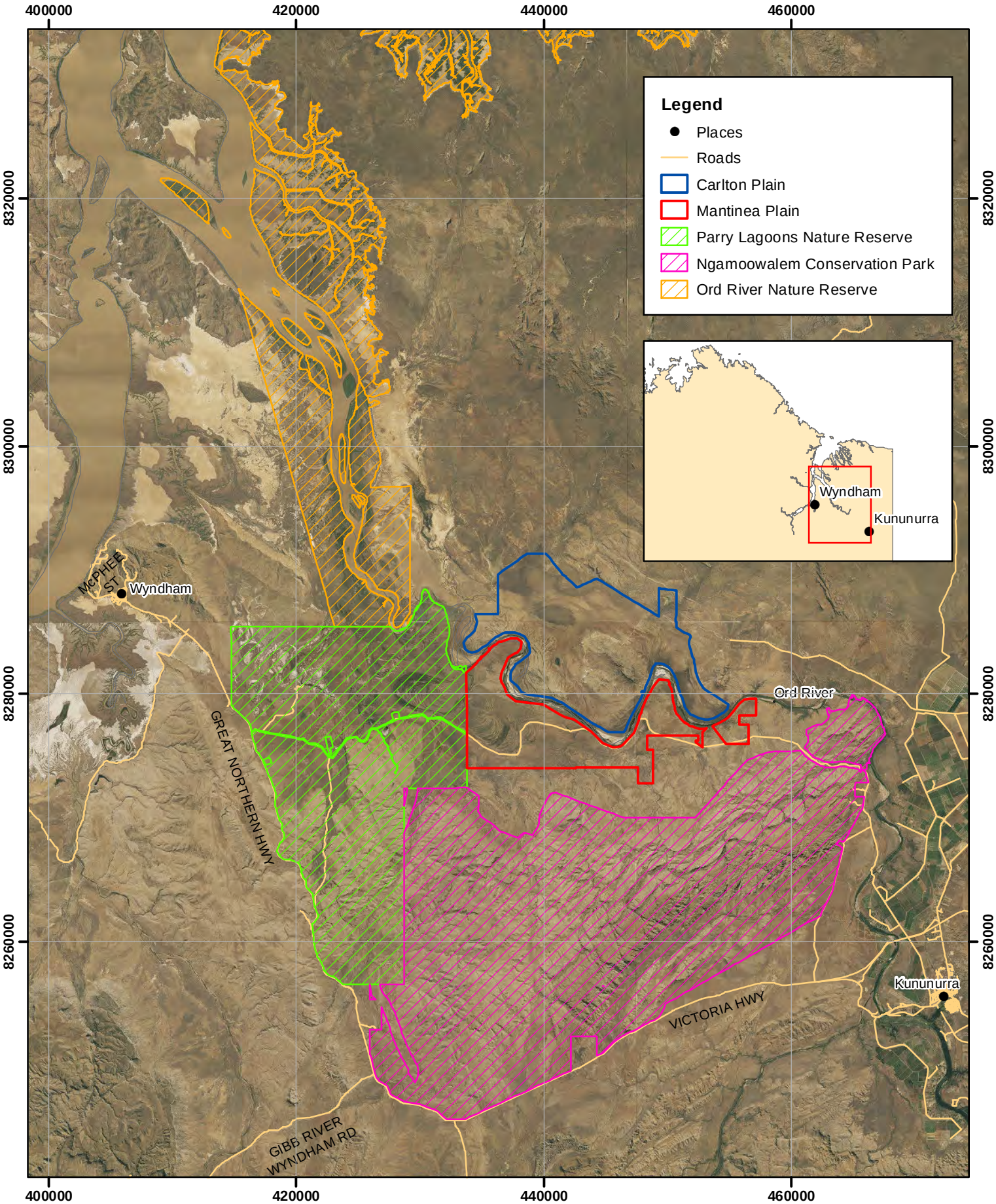
1.1 Project and Assessment Description

Kimberley Agricultural Investment Pty Ltd (KAI) has a license granted under the WA *Lands Administration Act 1997* to enable commencement of environmental investigations within the Mantinea farm area within Ivanhoe Station situated approximately 20 km north-west of Kununurra, in the Kimberley region of Western Australia. In addition to this, KAI is freehold owner of Carlton Plain, located to the north of the Mantinea farm area, within Carlton Hill Station. It is intended that both Plains will be developed for irrigated agriculture, with water pumped from the adjacent Ord River. It is intended that both Plains will be developed for irrigated agriculture, with water pumped from the adjacent Ord River.

Woodman Environmental Consulting Pty Ltd (Woodman Environmental) were commissioned to undertake a Level 1 flora, vegetation and fauna surveys in order to support site planning and future approval processes for the area, including clearing permit applications, as per the Scope of Works (SoW). Western Wildlife was commissioned to undertake the fauna desktop review, field survey and draft reporting with regards to the fauna section of the works. This report presents the results of the flora, vegetation and fauna desktop reviews and field survey components of the Level 1 survey.

1.2 Study Area Definition

The Study Area includes the Mantinea Plain (south of the Lower Ord River) and the Carlton Plain (north of the Lower Ord River), as indicated on Figure 1, and is located between the townships of Wyndham and Kununurra. The Study area covers a total of 24 604 ha, of which 9 428 ha is located within the Mantinea Plain, and 15 176 ha within the Carlton Plain.



Mantinea Plain and Carlton Plain Study Area	Author: Cathy Godden	N
	WEC Ref: KAI16-33-01	
WOODMAN ENVIRONMENTAL	Filename: KAI16-33-01-f01.mxd	**Figure**
	Scale: 1:400,000 (A4)	1
	Projection: GDA 1994 MGA Zone 52	
This map should only be used in conjunction with WEC report KAI16-33-01.	Revision: A - 28 October 2016	

1.3 Level of Assessment

1.3.1 Flora and Vegetation

The flora and vegetation assessment of the Study Area was undertaken at a Level 1 standard as defined by the Environmental Protection Authority's (EPA) Guidance Statement No. 51 (EPA 2004a), and Position Statement No. 3 (EPA 2002). This level of survey was determined to be appropriate given the proponents requested timing of the survey in conjunction with Table 2 of Guidance Statement No. 51, where the Bioregion Group is defined as Group 3 and at project commencement the scale and nature of impact was considered overall Moderate (EPA 2004a). Given the requested survey timing, a Level 2 survey cannot be completed to standards specified in EPA (2004a) or EPA and Department of Parks and Wildlife (DPaW) (2015).

The survey was conducted according to the guidelines presented in the following documents:

- GS 51 (Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia) (EPA 2004a)
- Technical guide on Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment (EPA and DEC 2015)
- EPA PS 2 (Environmental Protection of Native Vegetation in Western Australia) (EPA 2000)
- EPA PS 3 (Terrestrial Biological Surveys as an Element of Biodiversity Protection) (EPA 2002)
- EPB 20 (Protection of Naturally Vegetated Areas through Planning and Development)

1.3.2 Fauna

The fauna assessment of the Study Area was undertaken by Western Wildlife, at a Level 1 standard as defined by the Environmental Protection Authority's (EPA) Guidance Statement No. 56 (EPA 2004b), and Position Statement No. 3 (EPA 2002).

The survey was conducted according to the guidelines presented in the following documents:

- EPA Position Statement No.3 - Terrestrial Biological Surveys as an element of biodiversity protection. (EPA 2002).
- Environmental Protection Authority (EPA) Guidance Statement 56 for Terrestrial Fauna Surveys (EPA 2004b).
- Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA and Department of Environment and Conservation (DEC) 2010).
- Survey Guidelines for Australia's Threatened Birds (Department of the Environment, Water, Heritage and the Arts (DEWHA) 2010).
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) referral guideline for the endangered northern quoll *Dasyurus hallucatus* (Commonwealth of Australia 2011).

1.4 Aims and Objectives

The aim of the assessment was to determine the flora, vegetation and fauna values of the Study Area, and to provide baseline information to support site planning and future approval processes for the area. The overall objectives of the assessment were to:

- Determine the flora composition, vegetation communities, vertebrate fauna and fauna habitats present or potentially present within the Study Area,
- Determine if conservation significant species (flora and fauna), vegetation communities or habitat for significant fauna (listed under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and State *Wildlife Conservation Act 1950* (WC Act)) occur or potentially occur in the Study Area.
- Quantify the area and condition of each vegetation community, to inform future clearing permit applications.
- Quantify areas of weed infestation across both the Mantinea and Carlton Plains areas.
- Report on the ecological values present within the Mantinea and Carlton Plains areas.
- Provide (as a separate document) a risk assessment and draft management recommendations, to minimise risk to identified ecological values, including the adjacent Parry Lagoon and Ord River Floodplain Ramsar Site.

2 BACKGROUND AND LITERATURE REVIEW

2.1 Climate

The Study Area is located within the North Kimberley Region of the Northern Province of Western Australia as defined by Beard (1990), with the climate being dry hot tropical, with a summer wet season, lasting approximately 4 - 6 months (Beard 1990).

Figure 2 displays rainfall recorded at Kununurra Airport, one of the nearest meteorological stations to the Study Area (Bureau of Meteorology 2016). The average annual rainfall for this station is 832.1 mm (data from 1971 - 2016). Average monthly rainfall peaks from December to March (wet season). Rainfall received at Kununurra over the wet season period prior to the 2016 survey being conducted (December 2015 to March 2016) was below the average rainfall for this period, with 560.6 mm received compared to the average of 704.3 mm for the same months. The wet season prior to this (December 2014 to March 2015) was also below average with just 509.2 mm recorded (195.1 mm below average) (Bureau of Meteorology 2016).

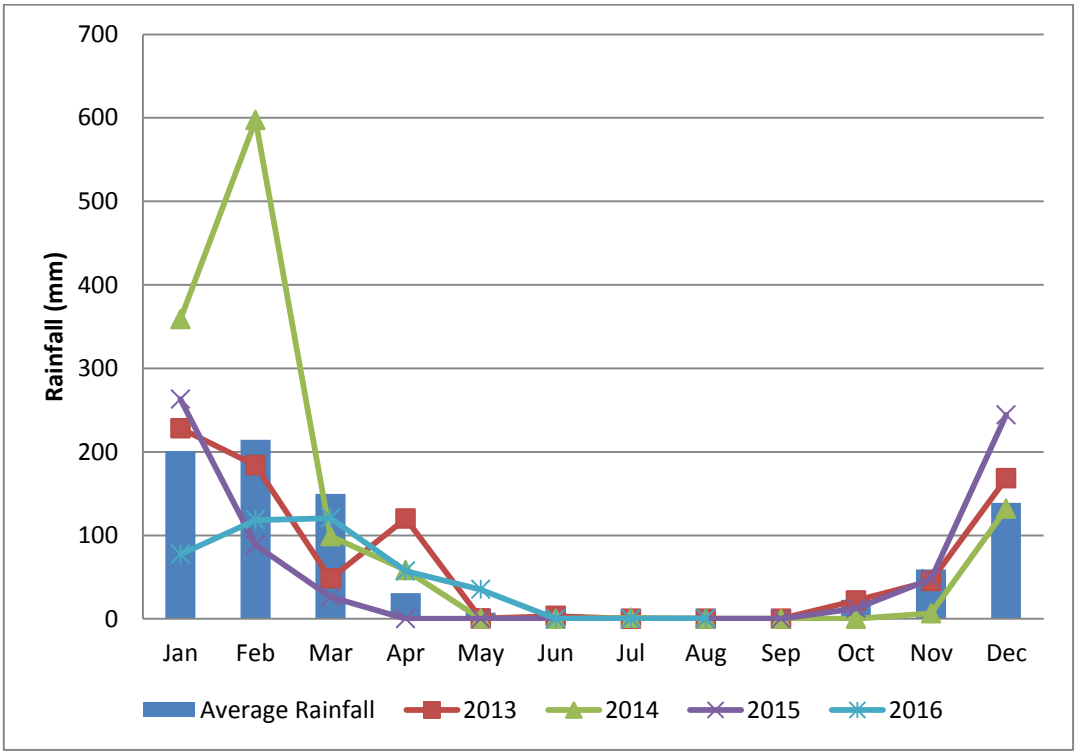


Figure 2: Rainfall (mm) for Kununurra Aero (Bureau of Meteorology 2016)

2.2 Geology, Soils and Landforms

The Study Area is located in the North Kimberley region (Gardner Botanical District), which is formed of Proterozoic siliceous sedimentary and basic volcanic rocks. The region is a dissected plateau with mesa shaped hills and ranges, with chiefly shallow stony and sandy soils on sandstones (Beard 1990).

A review of soil surveys undertaken for Mantinea Plain by Raper *et al* (2014) identified a total of 17 soil and land units within Mantinea Plain by incorporating the best available mapping where datasets overlap. Overall, the review described Mantinea Plain soils as comprising of a mixture of modern alluvial sediments, from fine cracking clays (1500ha, 17%) to sands and loams (6600ha, 73%), and stony soils (800ha, 10%) (Raper *et al* (2014).

Soil surveys undertaken for Carlton Plains by Stoneman (2001) identified two geomorphic units including the clay plains which belong to the Cununurra family of cracking clays, and the levee areas which are generally more variable and of medium texture. A total of 5 soil units within Carlton Plains were mapped including Mantinea clay (6,465 ha), Group A Soils consisting of variable light textured brown soils (3,760 ha), Winbidji Fine Sandy Loam (1,040 ha), Group B Soils which have a gradual increase in texture down the profile (180 ha) and Soil Complex which is mixture of Mantinea clay and Winbidji fine sandy loam (310 ha) (Stoneman 2001).

2.3 Flora and Vegetation

2.3.1 Regional Vegetation

The Study Area is located within the Victoria Bonaparte IBRA (Interim Biogeographic Regionalisation for Australia) Region (Commonwealth of Australia 2012), specifically within the VIB01 (Keep) IBRA Subregion. Six vegetation systems (Government of Western Australia 2015) are located within the Study Area.

The Keep IBRA subregion consists of Phanerozoic strata of the Bonaparte Basin mantled by Quaternary marine sediments supporting Samphire - *Sporobolus* grasslands and mangal, and by red earth plains and black soil plains with an open savannah of high grasses in the north-west, and plateau and abrupt ranges of Proterozoic sandstone, known as the Victoria Plateau, in the south and east, which are partially mantled by skeletal sandy soils with low tree savannahs and hummock grasslands. There are also limited areas of gently undulating terrain on a variety of sedimentary rocks supporting low snappy gum over hummock grasslands and areas of gently sloping floodplains supporting *Melaleuca minutifolia* low woodland over annual sorghums in the south-east. The land is primarily used for native pasture grazing.

As previously mentioned, the Study Area traverses the Gardner Botanical District within the Kimberley region. The Gardner Botanical District is characterised by mainly tropical high-grass savanna with tree layer, forming savanna woodland (Beard 1979). Beard mapped the vegetation of the Kimberley Region at a scale of 1:1 000 000 (Beard 1979). The Study Area traverses 3 broad vegetation units mapped by Beard as listed below:

- Steppe woodland spinifex community of *Melaleuca* spp. Paperbarks with soft spinifex on shale;
- Low tree short bunch grass savanna of *Enneapogon* spp. And other short grasses with scattered eucalypts on dry calcareous plains;
- Sparse tree high grass savanna of grasslands with sparse *Bauhinia* and Coolabah on cracking clay soils.

Shepherd *et al.* (2002) mapped and described vegetation system associations in the Keep IBRA subregion related to physiognomy, utilising mapping undertaken by Beard (1979). Vegetation system associations were described at a scale of 1:250,000. Six vegetation system associations occur in the Study Area, as summarised in Table 1. Table 1 also presents the current extent of each vegetation system association in relation to its pre-European extent, and the percentage of the current extent of each vegetation system association currently protected for conservation (in Department of Parks and Wildlife (DPaW) managed land) (Government of Western Australia 2015). The majority of vegetation system associations present in the Study Area remain very well represented, with more than 98 % of the pre-European extent remaining. Victoria Bonaparte_59 has a higher rate of clearing than surrounding systems however it is still well represented with over 86 % remaining. Half of these vegetation associations are relatively well protected for conservation with over 25 % currently reserved (Victoria Bonaparte_52, 814 and 838). The remaining 3 associations have less than 15 % of their current extent reserved ((Victoria Bonaparte_59, 901 and 914) (Table 1).

Table 1: Extent of Vegetation System Associations within the Study Area (Government of Western Australia 2015)

Vegetation System Association	Description	Current Extent (ha)	Percentage of Pre-European Extent Remaining	Percentage of Current Extent Protected for Conservation
Victoria Bonaparte_52	Grasslands, high grass savanna woodland; bloodwood & stringybark over upland tall grass & curly spinifex	151,894.51	99.96	50.66
Victoria Bonaparte_59	Grasslands, high grass savanna sparse tree; bauhinia & coolabah over mitchell, blue & tall upland grasses	121,189.78	86.92	12.11
Victoria Bonaparte_814	Hummock grasslands, low steppe woodland; silver-leaved box (*Eucalyptus pruinosa*) & melaleuca over Triodia	107,351.20	99.99	25.94
Victoria Bonaparte_838	Grasslands, high grass savanna woodland; ghost gum & bloodwood (*Eucalyptus polycarpa*) over spinifex & tall upland grass	3,280.19	100.00	71.71
Victoria Bonaparte_901	Grasslands, high grass savanna woodland; stringybark & woolybutt over upland tall grass & curly spinifex	9,948.84	98.92	5.10
Victoria Bonaparte_914	Grasslands, high grass savanna woodland; grey box & *Eucalyptus foelscheana* over kangaroo (Themeda australis) & white grass	41,149.92	99.25	10.90

The Land Systems of the Kimberley Region Report describes and maps the landscapes, soils and vegetation of the Kimberley region using information consolidated from a number of surveys carried out by different organisations, across different areas of the Kimberley, since

the 1940s (Schoknecht and Payne 2010). The Study Area is located within the Ord-Victoria survey area described in the Land Systems report which is located in the eastern part of the Kimberley region. Four land systems occur within the Study Area (Table 2). Ivanhoe Land System is a Priority 3 Priority Ecological Community (PEC) (DPaW 2016a). Appendix A presents definitions, categories and criteria for Threatened Ecological Communities (TEC) and PECs (DEC 2013).

Table 2: Land Systems Located within the Study Area (Schoknecht and Payne 2010)

Land System	Mapped Extent (ha)	Description of Land System
Angallari	155,200	Many small areas of timbered gently sloping alluvial plains with benched yellowish loamy or sandy soils scattered through the northern part of the Ord-Victoria survey area.
Cockburn	230,800	Several small patches of undulating to low shaly country with sparse shrub vegetation scattered throughout the Ord-Victoria survey area.
Ivanhoe	123,900	Many small to medium areas of gently sloping alluvial 'black soil' plains with some timbered 'red' soil in the central and northern parts of the Ord-Victoria survey area.
Pinkerton	1,532,500	Rugged stony country on sedimentary rocks in the northern part of the Ord-Victoria survey area.

A search of the Commonwealth Department of the Environment and Energy (DoEE) database with regard to environmental matters of national significance listed under the EPBC Act was performed for the Study Area (DoEE 2016a). The results of this search indicate that no TECs listed under the EPBC Act coincide with the Study Area. The results of this search are presented in Appendix B.

A search of DPaW's TEC and PEC database was undertaken for an area encompassing the Study Area with a buffer of 20 km, to identify the presence of any DPaW-classified TECs and/or DPaW-classified PECs that coincide with the search area (DPaW 2016b). No TECs as listed by DPaW (DPaW 2015a) coincide with the search area. However, 6 DPaW-classified PECs were returned from the search as listed in Table 3.

Table 3: Results of the Search of DPaW's TEC and PEC Databases (DPaW 2016b)

PEC	Status	Description (DPaW 2015a)
Dinnabung Land System	Priority 3	Gently undulating limestone country supporting northern box-bloodwood woodland over Tippera tall grass or upland tall grasses
Ivanhoe Land System	Priority 3	Many small to medium areas of gently sloping alluvial "black soil" plains with some timbered "red" soil in the central and northern parts of the area.
Camaenid land snail and vine thicket assemblage of limestone hills (Jeremiah and Ningbing Ranges)	Priority 3	A suite of species of land snail belonging to the family Camaenidae are only recorded from limestone ranges and outcrops of the East Kimberley. They occur in areas of limited Devonian reef with unusual vine thickets with a boab overstorey. All the Camaenid snails are short-range endemics, with known geographic ranges ranging from 0.01 ha to 5.6 km2. Twenty critically endangered, four endangered and one vulnerable species occur in the Ningbing Ranges and Jeramiah Hills north of Kununurra.

PEC	Status	Description (DPaW 2015a)
Tanmurra Land System	Priority 3	Plateaux, cuestas and hills on limestone or dolomite, supporting bloodwood-southern box sparse low woodland over arid short grass (Victoria Bonaparte IBRA region)
Vegetation Association 838	Priority 3	Grasslands, high grass savanna woodland; ghost gum & bloodwood (*Corymbia polycarpa*) over spinifex & tall upland grass
Willeroo Land System	Priority 3	Gently undulating stony alluvial plains and low rises on basalt, supporting blue grass grasslands and northern box bloodwood woodlands with Tippera tall grasses.

Of these, the Ivanhoe Land System (Priority 3) PEC comprises 88.19 % of the Study Area (21,700 ha) including all areas of plains and undulating plain areas with only sandstone hills excluded (Figure 3). The buffer of Vegetation Association 838 (Priority 3) also overlaps the Study Area in the south west comprising 0.43 % of the Study Area (107 ha) (Figure 3) (note: this area is overlapped by the Ivanhoe Land System). Appendix B presents definitions, categories and criteria for TECs and PECs (Department of Environment and Conservation (DEC) 2013).

In addition, the Ord River Floodplain Environmentally Sensitive Area (ESA) extends into the western section of the Study Area covering an area 822 ha (3.34 % of the Study Area) (Figure 3). The Ord River Floodplain is a listed Ramsar site, covering an area of approximately 141 000 ha (DoEE 2016a). This Ramsar site includes Parry Lagoons Nature Reserve in the south comprising of broad floodplains and permanent waterholes, the Ord River Estuary leading into the Cambridge Gulf in the north, and a series of intertidal creeks and flats towards the coast in the north-east. The site contains extensive and diverse mangrove communities, including 14 of the 18 mangrove species known to occur in Western Australia, making it potentially the most diverse in Western Australia (DoEE 2016a).

There are a number of conservation areas within the vicinity of the Study Area as shown on Figure 1. Parry Lagoons Nature Reserve borders the west side of the Mantinea Plain portion of the Study Area, and is downstream of the Study Area. The next nearest reserves are Ngamoowalem Conservation Park located approximately 2 km to the south of the Study Area, and Ord River Nature Reserve located approximately 6 km to west of the Study Area.

2.3.2 Regional Flora

A search of DPaW's threatened flora databases was undertaken for an area encompassing the Study Area with a buffer of 20 km, including the Western Australian Herbarium (WA Herb.) specimen database, Threatened and Priority Flora database, and Threatened and Priority Flora List (DPaW 2016c). A total of 83 conservation significant flora taxa were returned from the database search (Table 4) including 2 taxa listed as Threatened under the WC Act, and the remainder (81) comprising DPaW-classified Priority flora taxa. Of these, *Brachychiton tuberculatus* (P3), *Echinochloa kimberleyensis* (P1), *Goodenia brachypoda* (P1) and *Solanum pugiunculiferum* (P1) have known locations within the Study Area (Figure 3). Appendix C presents conservation codes for Western Australia flora (DPaW 2015b).

Table 4: Results of the Search of DPaW's Threatened Flora Databases (DPaW 2016c)

Taxon	Status	Source*
Acacia camptocarpa	P1	TP List
Acacia jasperensis	P3	TP List
Acacia leptocarpa	P1	TP List
Acacia richardsii	P3	TP List, WA Herb
Acacia sp. Cockburn Range (R. Pullen 10. 763)	P3	TP List
Adenostemma lavenia var. *lanceolatum*	P3	TP List
Bonamia brevifolia	P1	TP List
Bonamia wilsoniae	P3	TP List
Brachychiton incanus	P3	TP List, WA Herb
Brachychiton tuberculatus	P3	TPFL, TP List, WA Herb
Calycopeplus collinus	P1	TP List
Croton arnhemicus	P1	TP List
Cyperus digitatus	P1	TP List, WA Herb
Desmodium flagellare	P1	TPFL, TP List, WA Herb
Dolichandrone filiformis	P2	TP List
Echinochloa kimberleyensis	P1	TPFL, TP List, WA Herb
Enteropogon minutus	P1	TP List
Eragrostis schultzii	P3	TP List
Eriochloa fatmensis	P3	TP List
Eucalyptus ceracea	T	TP List
Eucalyptus costuligera	P1	TP List
Eucalyptus ordiana	P2	TP List
Euphorbia stevenii	P3	TP List, WA Herb
Ficus lilliputiana	P4	TP List
Fimbristylis laxiglumis	P2	TPFL, TP List, WA Herb
Fimbristylis sp. D Kimberley Flora (A.C. Beauglehole 52448)	P1	TP List
Fuirena incrassata	P3	TPFL
Fuirena nudiflora	P1	TP List
Gmelina schlechteri	P1	TP List
Goodenia brachypoda	P1	TPFL, TP List, WA Herb
Goodenia byrnesii	P3	TP List
Goodenia durackiana	P1	TPFL, TP List, WA Herb
Goodenia heterotricha	P1	TP List
Goodenia malvina	P1	TP List, WA Herb
Goodenia purpurascens	P3	TP List
Goodenia sepalosa var. *glandulosa*	P3	TP List
Goodenia strangfordii	P1	TP List
Helicteres dentata var. *procumbens*	P1	TP List
Heliotropium alcyonium	P1	TP List, WA Herb
Heliotropium cupressinum	P1	WA Herb
Heliotropium discorde	P1	TP List
Heliotropium foveolatum	P1	TP List
Heliotropium tachyglossoides	P1	TP List
Heliotropium uniflorum	P1	TP List
Hibiscus panduriformis	P3	TP List, WA Herb
Hullsia argillicola	P1	TP List
Ipomoea gracilis	P3	TP List, WA Herb
Ipomoea kalumburu	P1	TP List
Ipomoea racemigera	P2	TP List
Isotropis browniae	P3	TP List
Jacquemontia sp. Keep River (J.L. Egan 5051)	P1	TP List, WA Herb

Taxon	Status	Source*
Lepturus xerophilus	P1	TP List
Lophostemon grandiflorus subsp. *grandiflorus*	P3	WA Herb
Melaleuca viminalis	P2	TP List
Nymphaea immutabilis	P2	TP List, WA Herb
Paspalidium distans	P3	WA Herb
Platysace saxatilis	P2	TP List
Polygala crassitesta	P1	TP List
Polymeria sp. Broome (K.F. Kenneally 9759)	P1	TP List
Sauropus hubbardii	P3	TP List, WA Herb
Scleria polycarpa	P1	TP List
Selaginella pygmaea	P2	TP List
Solanum pugiunculiferum	P1	TP List, WA Herb
Sphaeranthus africanus	P1	TP List
Sphenoclea zeylanica	P1	TP List, WA Herb
Stylidium prophyllum	P3	TP List, WA Herb
Tephrosia sp. Kununurra (T. Handasyde TH00 250)	P2	TP List
Tephrosia sp. Saw Ranges (D. Kabay s.n. PERTH 06720544)	P1	TP List, WA Herb
Trachymene oleracea subsp. *sedimenta*	P1	TP List
Triodia cunninghamii	P1	TP List
Triodia fissura	P1	TP List
Triodia prona	P1	TP List
Triodia racemigera	P1	TP List, WA Herb
Triodia triticoides	P1	TP List, WA Herb
Triumfetta rubiginosa	P2	TP List
Typhonium sp. Kununurra (A.N. Start ANS 1467)	T	TPFL, TP List, WA Herb
Utricularia aurea	P2	TPFL, WA Herb
Utricularia muelleri	P3	TP List
Utricularia stellaris	P1	TP List, WA Herb
Utricularia tubulata	P1	TP List
Whiteochloa capillipes	P3	TP List, WA Herb
Zeuxine oblonga	P2	TP List
Zornia areolata	P1	TP List, WA Herb

*Note: Sources of records are:

- TP List – DPaW Threatened and Priority Flora List
- TPFL – DPaW Threatened and Priority Flora Database
- WA Herb. – WA Herb. specimen database

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8320000 8310000 8300000 8290000 8280000 8270000 8260000 8250000 8240000

Significant Flora (DPaW 2016c)

Ari	*Acacia richardsii* (P3)	JspKR	*Jacquemontia* sp. Keep River (J.L. Egan 5051) (P1)
Bin	*Brachychiton incanus* (P3)	Lgrg	*Lophostemon grandiflorus* subsp. *grandiflorus* (P3)
Btu	*Brachychiton tuberculatus* (P3)	Nim	*Nymphaea immutabilis* (P2)
Cdi	*Cyperus digitatus* (P1)	Pdis	*Paspalidium distans* (P3)
Dfl	*Desmodium flagellare* (P1)	Shu	*Sauropus hubbardii* (P3)
Eki	*Echinochloa kimberleyensis* (P1)	Spr	*Stylidium prophyllum* (P3)
Est	*Euphorbia stevenii* (P3)	Spu	*Solanum pugiunculiferum* (P1)
Fin	*Fuirena incrassata* (P3)	Sze	*Sphenoclea zeylanica* (P1)
Fla	*Fimbristylis laxiglumis* (P2)	Tra	*Triodia racemigera* (P1)
Gbr	*Goodenia brachypoda* (P1)	TspK	*Typhonium* sp. Kununurra (A.N. Start ANS 1467) (T)
Gdu	*Goodenia durackiana* (P1)	TspSR	*Tephrosia* sp. Saw Ranges (D. Kabay s.n. PERTH 06720544) (P1)
Gmal	*Goodenia malvina* (P1)	Ttr	*Triodia triticoides* (P1)
Hal	*Heliotropium alcyonium* (P1)	Uau	*Utricularia aurea* (P2)
Hcu	*Heliotropium cupressinum* (P1)	Ust	*Utricularia stellaris* (P1)
Hpan	*Hibiscus panduriformis* (P3)	Wca	*Whiteochloa capillipes* (P3)
Igr	*Ipomoea gracilis* (P3)	Zar	*Zornia areolata* (P1)

Bin Eki Uau Pdis Nim Uau Uau Ust Gbr Gbr Spu Gbr Btu Gbr Eki Gbr Eki Gbr Gbr Btu Eki Fla Fin Btu Btu Hpan Gbr Hcu Gbr TspK Hal Sze Igr Gdu Shu Gmal Tra Fla Est Zar TspK Gbr Cdi Ari Wca Btu Gbr Btu TspK TspK TspK JspKR Spr TspSR Lgrg

Legend

- Mantinea and Carlton Plain
- Ord River Floodplain Environmentally Sensitive Area

Ecological Community Buffers (DPaW 2016b)

- Dinnabung Land System (Priority 3)
- Ivanhoe Land System (Priority 3)
- Camaenid Land Snail and Vine Thicket Assemblage of Limestone Hills (Priority 3)
- Tanmurra Land System (Priority 3)
- Vegetation Association 838 (Priority 3)
- Willeroo Land System (Priority 3)

420000 430000 440000 450000 460000 470000

WOODMAN ENVIRONMENTAL

N

This map should only be used in conjunction with WEC report KAI16-33-01

Mantinea Plain and the Carlton Plain Priority Ecological Communities and Conservation Significant Flora Locations

Revision: A - 08 September 2016 Scale: 1:250,000

Author: Simon Woodman

WEC Ref: KAI16-33-01

Filename: KAI16-33-01-f03.mxd

Projection: GDA 1994 MGA Zone 52

Figure

3

The search of the DoEE database with regard to environmental matters of national significance listed under the EPBC Act (Appendix B) did not return any flora taxa listed as Threatened species. The search identified that 9 significant invasive flora taxa, or habitat for the taxa, are likely to occur or may occur within the Study Area and surrounds including *Andropogon gayanus*, *Cenchrus ciliaris*, *Jatropha gossypiifolia*, *Lantana camara*, *Mimosa pigra*, *Parkinsonia aculeata*, *Salvinia molesta*, *Urochloa mutica* and *Vachellia nilotica*. Of these taxa, 7 are listed as Declared Pests in Western Australia under the *Biosecurity and Agriculture Management Act 2007* (BAM Act) (Department of Agriculture and Food (DAF) 2016), and are Weeds of National Significance (WoNS) (Australian Weeds Committee (AWC) 2016). *Urochloa mutica* and *Cenchrus ciliaris* are not listed as Declared Pests or WoNS but are considered by the States and Territories to pose a particularly significant threat to biodiversity (DoEE 2016b). Five of the taxa returned from the DoEE database including *Jatropha gossypiifolia*, *Lantana camara*, *Mimosa pigra*, *Salvinia molesta* and *Vachellia nilotica,* are not known from within the vicinity of the Study Area, and are unlikely to occur in the area (DPaW 2016d).

A search for records of introduced flora taxa records within the Study Area and surrounds was performed using the online tool NatureMap (DPaW 2016d). A total of 24 introduced taxa were returned, as listed in Table 5. Of these, 3 are listed as Declared Pests (*Parkinsonia aculeata*, *Sida acuta* subsp. *acuta* and *Sida cordifolia*) and 1 is a WoNS (*Parkinsonia aculeata*). Table 5 also presents the ratings for each introduced taxon under the then-Department of Conservation and Land Management's (CALM) (now DPaW) Environmental Weed Strategy for Western Australia (CALM 1999). This strategy assessed and rated environmental weeds in terms of their environmental impact on biodiversity according to invasiveness, distribution and environmental impact, and assigned a score of 'High', 'Moderate', 'Mild' or 'Low'. Three of the introduced taxa returned from the DoEE and DPaW searches were ranked as 'High' for environmental impact (*Cenchrus ciliaris, Passiflora foetida* and *Salvinia molesta*) (Table 5). Appendix D provides descriptions of each rating from CALM (1999).

Table 5: Introduced Flora Taxa Known from within or in the Vicinity of the Study Area

Taxon	Comments	Source	
		DoEE (2016)	DPaW (2016e)
Acanthospermum hispidum (Starburr)	Environmental impact 'Low' (CALM 1999)		X
Andropogon gayanus (Gamba Grass)	Declared Pest (DAF 2016) WoNS (AWC 2016) Environmental impact not assessed (CALM 1999)	X	
Alysicarpus vaginalis	Environmental impact 'Low' (CALM 1999)		X
Cardiospermum halicacabum var. *halicacabum*	Environmental impact not assessed (CALM 1999)		X
Cenchrus ciliaris (Buffel Grass)	Environmental impact 'High' (CALM 1999)	X	X
Crotalaria goreensis (Gambia Pea)	Environmental impact 'Low' (CALM 1999)		X
Cyperus compressus	Environmental impact 'Moderate' (CALM 1999)		X
Cyperus polystachyos (Bunchy Sedge)	Environmental impact not assessed (CALM 1999)		X
Cyperus rotundus (Nut Grass)	Environmental impact 'Moderate' (CALM 1999)		X

Taxon	Comments	Source	
		DoEE (2016)	DPaW (2016e)
Dysphania ambrosioides (Mexican Tea)	Environmental impact 'Low' (CALM 1999)		X
Echinochloa colona (Awnless Barnyard Grass)	Environmental impact 'Mild' (CALM 1999)		X
Eclipta prostrata	Environmental impact not assessed (CALM 1999)		X
Evolvulus nummularius	Environmental impact not assessed (CALM 1999)		X
Hyptis suaveolens (Hyptis)	Environmental impact 'Moderate' (CALM 1999)		X
Ipomoea nil	Environmental impact not assessed (CALM 1999)		X
Jatropha gossypiifolia (Cotton-leaved Physic-Nut)	Declared Pest (DAF 2016) WoNS (AWC 2016) Environmental impact not assessed (CALM 1999)	X	
Lantana camara (Common Lantana)	Declared Pest (DAF 2016) WoNS (AWC 2016) Environmental impact 'Moderate' (CALM 1999)	X	
Leonotis nepetifolia	Environmental impact 'Moderate' (CALM 1999)		X
Malvastrum americanum (Spiked Malvastrum)	Environmental impact 'Moderate' (CALM 1999)		X
Merremia aegyptia	Environmental impact 'Low' (CALM 1999)		X
Mimosa pigra (Giant Mimosa)	Declared Pest (DAF 2016) WoNS (AWC 2016) Environmental impact 'Low' (CALM 1999)	X	
Parkinsonia aculeata (Parkinsonia)	Declared Pest (DAF 2016) WoNS (AWC 2016) Environmental impact 'Moderate' (CALM 1999)	X	X
Paspalum vaginatum (Salt Water Couch)	Environmental impact 'Moderate' (CALM 1999)		X
Passiflora foetida (Stinking Passion Flower)	Environmental impact 'High' (CALM 1999)		X
Salvinia molesta (Salvinia)	Declared Pest (DAF 2016) WoNS (AWC 2016) Environmental impact 'High' (CALM 1999)	X	
Sida acuta subsp. *acuta*	Declared Pest (DAF 2016) Environmental impact 'Mild' (CALM 1999)		X
Sida cordifolia	Declared Pest (DAF 2016) Environmental impact not assessed (CALM 1999)		X
Tribulus terrestris (Caltrop)	Environmental impact not assessed (CALM 1999)		X
Urochloa mosambicensis (Sabi Grass)	Environmental impact 'Mild' (CALM 1999)		X
Urochloa mutica (Para Grass) (previously *Brachiaria mutica*)	Environmental impact 'Moderate' (CALM 1999)	X	
Vachellia nilotica (Prickly Acacia)	Declared Pest (DAF 2016) WoNS (AWC 2016) Environmental impact 'Low' (CALM 1999)	X	

2.3.3 Local Flora and Vegetation Surveys

There is limited publicly available information in regards to previous flora and vegetation surveys undertaken within or in close proximity to the Study Area.

Pilbara Flora (2010) undertook a 'one season' Level 2 equivalent flora and vegetation survey of 7 potential agricultural areas near Kununurra in May and July 2009. Of these areas, the

Mantinea West area and Mantinea East area cover the Mantinea Plain section of the Study Area. The survey included the assessment of 55 quadrats measuring 50 x 50 m, and over 30 GPS survey points within the Mantinea Plain area. A total of 19 Vegetation Types (VTs) were mapped within the Mantinea West and Mantinea East areas with the majority consisting of woodland vegetation types. There were no VTs identified to be representative of any listed TECs or PECs. The condition of the vegetation ranged from 'Excellent' to 'Completely Degraded', with the majority of the vegetation in the north-west of Mantinea, mapped as 'Very Poor', and the majority of the central and eastern areas mapped as 'Excellent', 'Very Good' and 'Good' (Pilbara Flora 2010).

A total of 496 vascular plant taxa, representing 70 plant families and 238 genera were recorded over all 7 areas surveyed by Pilbara Flora (2010). No Threatened Flora (T) taxa were recorded during the survey. There were 2 priority flora species recorded during the survey. *Goodenia brachypoda* (P1) was recorded within the Mantinea Plain Study Area at 3 locations. In addition, *Brachychiton tuberculatus* (P3) was recorded at the West Bank (17 locations; 68 individuals) and Packsaddle (1 locations; 1 individual) areas, with the closest location approximately 10 km to the east of the Mantinea Plain Study Area.

A total of 45 introduced taxa were recorded over the entire survey area. Of these, Declared Pest *Parkinsonia aculeata* was found at a number of locations within the Mantinea Plain Study Area, and Declared Pest *Jatropha gossypiifolia* was found approximately 10 km to the east of the Mantinea Plain Study Area (Pilbara Flora 2010). These results represent an underestimate of the flora taxa present within the areas surveyed due to the timing of the surveys being sub-optimal for the region.

EcoLogical (2013) conducted a conservation significant flora survey of the Ord West Bank area, previously surveyed by Pilbara Flora (Strategen 2010), in late May to early June 2013. Survey was conducted on those vegetation units which were identified by EcoLogical as being suitable habitat for known conservation significant flora. Two *Goodenia* species and *Brachychiton tuberculatus* (P3) were recorded during the survey. One location of *Goodenia campestris* was recorded; this taxon had not previously been recorded within Western Australia, with only four locations known in the Northern Territory (EcoLogical 2013). A total of 31 locations (62 individuals) of an undescribed Goodenia species was also recorded. A total of 280 locations, comprising 372 individuals, of *B. tuberculatus* (P3) were recorded across the Ord West Bank survey area, and was noted to be common across the site (EcoLogical 2013).

2.4 Fauna

Lists of fauna expected to occur in the study area, as presented in Appendix E, were produced using information from a number of sources, including:

Publications that provide information on general patterns of distribution of frogs (Tyler *et al*. 2000), reptiles (Storr *et al*. 1983, 1990, 1999 and 2002), birds (Barrett *et al*. 2003; Johnstone and Storr 1998; Johnstone and Storr 2004) and mammals (Churchill 1998, Menkhorst and Knight 2011; Van Dyck and Strahan 2008).

The databases as listed in Table 6 were searched for fauna records in and around the Study Area. In all cases the extent of the database search was larger than the extent of the Study Area, in order to capture records of species in the wider area that may also occur in the Study Area. This is particularly important for rare species that may be infrequently recorded. Some species may occur on database results that are not likely to be present in the area, usually due to a lack of suitable habitat. These species are not included in lists of expected fauna.

Table 6: Databases used in the Preparation of Lists of Fauna Species that may occur in the Study Area

Database	Type of records held on Database	Area Searched
WA Museum Specimen Database (DPAW 2007-)	Includes records from specimens held in the WA Museum specimen database, including historical data.	30km buffer around 128°28'25"E, 15°32'12"S
Fauna Survey Returns Database (DPAW 2007-)	Records from fauna surveys carried out in Western Australia, including data from trapping and observations.	30km buffer around 128°28'25"E, 15°32'12"S
DPAW's Threatened and Priority Fauna Database	Information and records on Threatened and Priority species in Western Australia.	40km buffer around 52L 443377E, 8282053N.
Birds Australia Atlas Database	Records of bird observations in Australia, 1998-current.	30km buffer around 128°28'25"E, 15°32'12"S
EPBC Act Protected Matters Search Tool	Records on matters protected under the EPBC Act, including threatened species and ecological communities, migratory species and marine species.	30km buffer around 128°28'25"E, 15°32'12"S

The results of previous fauna surveys carried out in the Ord River valley have also been included in Appendix E, as described below:

Strategen (2010) carried out a single season Level 2 Fauna Survey over the Mantinea Plain in 2009, as part of a wider survey that also included the Packsaddle Plain, West Bank and East Bank. This survey was carried out in June 2009 and included (for the Mantinea Plain only):

- Pitfall trapping (6 x 20L buckets and 6 x 150mm diameter PVC pipes per site) for 9 days at 7 sites
- Funnel trapping (12 traps per site) for 9 days at 7 sites
- Cage trapping (4 traps per site) for 9 days at 7 sites
- Elliott trapping (20 traps per site) for 9 days at 7 sites
- Bird surveys (approx. 70hrs by one observer across the Mantinea Plain area)
- Bat call recording (at six sites plus Parry Lagoons)
- Turtle trapping (5 traps at 2 sites for 5 - 6 days)
- Nocturnal searching (mainly road-spotting)
- Hand-searching for reptiles and other fauna

- Targeted searching for threatened species

As the Strategen (2010) survey was carried out in the dry season (June) it is likely that elements of the fauna more active, or only present in the wet (November to April) were under-sampled.

Ecologia (1997) carried out a two season Level 2 Fauna Survey of the Weaber Plain, Keep River Plain and Knox Plain, as part of the environmental investigations for the Ord River Stage 2 - M2 Development Area. The dry season survey was carried out in October 1996 and the post-wet season survey in February 1997. This survey included:

- Pitfall trapping (3 x 20L buckets and 2 x 160mm diameter PVC pipes per site) for 4 - 5 nights at 15 sites in the dry season
- Pitfall trapping (5 x 20L buckets per site) for 1 - 2 nights at 2 sites in the wet season
- Elliott trapping (20 traps per site) for 4 - 5 nights at 18 sites in the dry season
- Elliott trapping (20 traps per site) for 1 - 2 nights at 5 sites in the wet season
- Hand-searching for reptiles and other fauna (the primary method used in the wet season)
- Nocturnal searching (dry season only)
- Turtle trapping
- Mist-netting for micro-bats for 3 nights in the dry season
- Bird surveys (42hrs during the dry season and 22hrs during the wet season)
- Keeping of opportunistic records and records of tracks, scats etc.

These sources of information were used to create lists of species that potentially occur in the Study Area. As far as possible, expected species are those that are likely to utilise the Study Area. The lists exclude species that have been recorded in the general region as vagrants, or for which suitable habitat is absent within the area.

2.5 Summary of Environmental Factors

The desktop review of flora, vegetation and fauna within the Study Area identified the following key issues:

- A total of 6 DPaW-classified PECs within the vicinity of the Study Area, two of which are located within the Study Area – Ivanhoe Land System (Priority 3) and Vegetation Association 838 (Priority 3);
- A total of 83 significant flora taxa are known from within or in the vicinity of the Study Area, including 2 taxa listed as Threatened and 81 DPaW-classified Priority Flora taxa (Table 3);
- A total of 31 introduced flora taxa are known to occur or have the potential to occur within or in the vicinity of the Study Area, including 9 taxa listed as Declared Pests in Western Australia under the BAM Act (Department of Agriculture and Food 2015), and 7 taxa listed as WoNS (Australian Weeds Committee 2015);
- 7 CS reptile species potentially occurring within the vicinity of the Study Area (Appendix E; Table 2);

- 39 CS bird species potentially occurring within the vicinity of the Study Area (Appendix E, Table 3;
- 6 CS mammal species potentially occurring within the vicinity of the Study Area (Appendix E, Table 4).

3 METHODS

3.1 Flora and Vegetation Survey

3.1.1 Personnel and Licensing

Table 7 lists the personnel involved in both fieldwork and plant identifications for the survey of the Study Area. Both field team leaders have had previous field experience in the Kimberley region, with personnel involved in plant identifications also having previous taxonomic experience with the flora of the Kimberley region. All plant material was collected under the scientific licences pursuant to the WC Act Section 23C and Section 23F as listed in Table 5.

Table 7: Personnel and Licensing Information

Personnel	Role	Qualifications	Collecting Permit (WC Act)
Bethea Loudon	Flora and vegetation fieldwork (team leader)	BSc (Biology)	SL011773 (Section 23C) 123-1516 (Section 23F)
Kim Kershaw	Flora and vegetation fieldwork (team leader)	BSc (Biology)	SL011770 (Section 23C) 120-1516 (Section 23F)
Samuel Coultas	Flora and vegetation fieldwork	BSc (Environmental Biology)	2014: SL010963 (Section 23C) 111-1314 (Section 23F) 2016: SL011775 (Section 23C) 124-1516 (Section 23F)
Emalyn Loudon	Flora and vegetation fieldwork	BAgrib (Agriculture) (Hons)	-
Jennifer Wilcox	Supervising Zoologist	BSc (Biology) (Hons) / BSc. (Environmental Science)	01-000012-1 Reg 7
Jeffrey Turpin	Field Zoologist	BSc (Zoology)	01-000012-1 Reg 7
Brenden Metcalf	Field Zoologist	BSc (Environmental Science) (Hons)	01-000012-1 Reg 7
Robert Browne-Cooper	Field Zoologist	BSc (Biology)	01-000012-1 Reg 7
Dr Kyle Armstrong	Specialised Zoological (bat call analysis)	BSc, PhD. (Zoology)	NA
Sharnya Thomson	Plant identifications	BSc (Botany)	NA

3.1.2 Field Survey Methods

The flora and vegetation field survey involved four botanists and was conducted over one visit from the 17th – 25th August 2016. The timing coincided with the 'dry' season in the Kimberley region. The entire Study Area was traversed by vehicle and on foot using all available tracks and roads, with transects walked in areas with no vehicle access. Some

areas could not be accessed by tracks, and could not feasibly be accessed on foot given time constraints.

3.1.3 Plant Collection and Identification

Specimens of any unknown taxa that were collected were pressed for later identification at the WA Herbarium. Identifications were undertaken by experienced botanists Sharnya Thomson and Bethea Loudon. External experts for particular families or genera were consulted for any specimens considered to be difficult to identify or of taxonomic interest.

Taxon nomenclature generally follows *FloraBase* (DPaW 2016e) with all names checked against the current DPaW Max database to ensure their validity. However, in cases where names of plant taxa have been published recently in scientific literature but have not been adopted on *FloraBase* (DPaW 2016e), nomenclature in the published literature is followed. The conservation status of each taxon was checked against *FloraBase*, which provides the most up-to-date information regarding the conservation status of flora taxa in Western Australia.

Specimens of interest, including significant flora taxa, range extensions of taxa and potential new taxa, will be sent to the WA Herbarium for consideration for vouchering as soon as practicable. However, this process is via donation, and the WA Herbarium may not voucher all specimens, in accordance with its own requirements. The specimen vouchering will be supported by completed Threatened and Priority Flora Report Forms submitted to DPaW (Species and Communities Branch) in the case of listed significant flora (e.g. Threatened and Priority flora taxa).

3.1.4 Vegetation Mapping

The vegetation of the Study Area was sampled through site relevés as well as observations recorded while traversing the Study Area. Non-permanent relevés were established in all major vegetation units discernible through aerial photograph interpretation prior to the field survey, with extra relevés included where additional vegetation types were observed during the survey. Quadrats (where all vascular taxa are recorded) were not established during this survey.

The following information was recorded at each relevé location:

- Unique identifying number;
- Relevé location (including GPS co-ordinates);
- Total cover and dominant taxa within each stratum;
- Soil type/colour and presence of outcropping;
- Position of relevé in the landscape (topography/landform type);
- Vegetation condition, including fire history and presence of any disturbance (adapted from Keighery 1994) (presented in Appendix H);
- Height, percentage foliage cover and stratum of dominant taxa present within a 50m radius; and
- Photograph of representative vegetation.

Additional taxa were recorded while traversing the Study Area to assist in the development of a species list for the Study Area. Data collected include locations where changes in vegetation types (i.e. the physical location of boundaries) were observed to assist with mapping.

Species composition, density and occurrence in structural layers were used to identify and describe the structural vegetation types (VT) present. Aerial photography interpretation and field notes taken during the survey were used to develop VT polygon boundaries within the Study Area. These were then digitised using Geographic Information System (GIS) software and displayed on figures. Areas where no vegetation occurred because of human disturbance were mapped as 'Cleared Land'.

VT descriptions were prepared utilising the National Vegetation Information System (NVIS) Australian Vegetation Attribute Manual Version 6.0 (ESCAVI 2003), a system of describing structural vegetation units preferred by the DPaW. Naming conventions within this system were adapted to reflect structural and floristic variation within VTs. This model follows nationally-agreed guidelines to describe and represent vegetation types, so that comparable and consistent data is produced nation-wide. For the purposes of this report, it is considered that a VT is equivalent to a NVIS sub-association as described in ESCAVI (2003).

3.1.5 Vegetation Condition Mapping

Vegetation condition was recorded at relevés, and also opportunistically within the Study Area where significant areas of disturbance to vegetation were noted (e.g. weed infestations, areas of clearing, soil disturbance). Vegetation condition was described using the vegetation condition scale outlined in the Technical Guide for Flora and Vegetation Surveys for Environmental Impact Assessment (EPA and DPaW 2015), which was adapted from Keighery (1994). This scale is presented in Appendix H. Vegetation condition polygons are presented as outlines over aerial photography on a vegetation condition figure.

Areas of specific weed infestation were recorded opportunistically while traversing the Study Area, and were quantified in relation to weed species and levels of infestation present. Quantification of areas of significant weed infestation with regards to cover categories of total weed cover were recorded and digitised on a figure.

3.1.6 Significant Flora and Vegetation

Visual interpretation of aerial photography and review of the desktop study results for the Study Area was undertaken prior to the site visit to gain an understanding of the flora and vegetation that may encountered. The habitat requirements or preferences of conservation significant flora and the composition of significant vegetation communities were investigated using available resources (e.g. DPaW 2015a, 2016a, 2016e) to determine the likelihood of their occurrence in the Study Area, and to be able to identify potential habitat and the occurrence of these taxa and communities during the field survey. Where potential habitat for conservation significant flora was encountered in the field, localised inspections were conducted to identify each taxon, season permitting.

3.2 Fauna Survey

3.2.1 Habitat Mapping

Habitat mapping was undertaken using vegetation data provided by the flora and vegetation survey for the Study Area, examination of aerial photography and observations made by fauna personnel in the field.

3.2.2 Field Studies

The field study component of a Level 1 fauna survey is primarily to place the desk-top study into context while characterising the habitats present and making opportunistic observations of fauna. The field survey for the Mantinea and Carlton Plains Study Area included some additional techniques to sample fauna, as described in the following sections. All fieldwork was undertaken under Regulation 17 Licence to Take Fauna for Scientific Purposes 01-000012-1 (Table 7).

3.2.3 Targeted bird and hand-searching surveys

A total of 44 locations across the Mantinea and Carlton Plains were targeted for opportunistic fauna observations (Figure 4; Appendix F). The sites were chosen in order to sample the variety of habitats present, as well as targeting areas that were likely to support a diversity of fauna during the dry season (e.g. dams, seasonal wetlands containing water or dense vegetation along creeklines). At each location all birds seen or heard were recorded, and hand-searching for reptiles was carried out. Hand-searching involved raking through leaf litter or loose soil, turning over rocks or logs, stripping bark and using a torch to inspect hollows or rock crevices. The presence of any other species, e.g. diurnal mammals, were also recorded if encountered.

At all times, observations of fauna were noted when they contributed to the accumulation of information on the fauna of the site. These included casual observations of reptiles, mammals and birds seen while travelling on tracks within the Study Area.

3.2.4 Spotlighting and Head-torching

Spotlighting was carried out on the evening of 23rd August 2016, from sunset (17:30) to 21:00. The spot-lighting was carried out by two teams, each of two observers. It involved targeted head-torching (e.g. on termite mounds, around water or rocky areas) and road-spotting between sites using a combination of the vehicle headlights and handheld spot-lights.

435000 440000 445000 450000 455000

8300000 8295000 8290000 8285000 8280000 8275000 8270000 8265000

WWCAM3
WWCAM4
WWCAM2
SM2 (8072)
WWCAM5
CM20

CM24 CM25 CM26 CM42 CM27 CM18 CM23 CM28 CM22 CM11 CM19 CM07 CM09 CM08 CM10 WWCAM6 WWCAM9 CM06 WWCAM7 SM2 (10890) CM01 CM04 CM03 CM34 CM16 CM37 CM35 CM21 CM44 CM02 CM38 CM12 CM29 CM36 CM05 WWCAM8 CM43 CM14 CM31 CM41 CM13 CM30 CM39 CM15 CM32 CM33 CM40

435000 440000 445000 450000 455000

Legend

- Camera Trap Sites
- Targeted Fauna Observation Sites
- Bat Detector Sites
- Carlton Plain
- Mantinea Plain

WOODMAN ENVIRONMENTAL

N

This map should only be used in conjunction with WEC report KAI16-33-01.

Mantinea and Carlton Plains: opportunistic fauna survey sites; bat and trap sites

Revision: A - 31 October 2016 Scale: 1:100,000 (A3)

Author: Bethea Loudon

WEC Ref: KAI16-33-01

Filename: KAI16-33-01-f04.mxd

Projection: GDA 1994 MGA Zone 52

Figure

4

3.2.5 Bat Survey

Bats were surveyed on Carlton Plain using two SM2 ultrasonic bat detectors set for four nights in August 2016 (Table 8, Figure 4). Analysis of the recordings was undertaken by Dr Kyle Armstrong of Specialised Zoological. The report on bat call analyses are provided in Appendix G. This method of bat detection does not form part of a standard Level 1 survey, however were utilised at Carlton Plain to complement the Level 2 survey data previously collected at Mantinea (Strategen 2010).

Table 8: Location and Habitat of SM2 and Camera Sites on Carlton Plain

Camera/SM2 code	Date set	Date collected	Location (GDA 94 Zone 52 L)	Habitat
WWCAM2	20/8/16	24/08/16	446009 E 8282537 N	Houseroof Hill: flat sandy pad under overhang.
WWCAM3	20/8/16	24/08/16	445701 E 8282564 N	Houseroof Hill: base of cliff.
WWCAM4	20/8/16	24/08/16	445555 E 8282543 N	Houseroof Hill: boulder scree slope.
WWCAM5	20/8/16	24/08/16	445821 E 8282507 N	Houseroof Hill: boulder scree slope.
WWCAM6	20/8/16	24/08/16	448701 E 8282154 N	Open eucalypt woodland.
WWCAM7	20/8/16	24/08/16	438318 E 8281777 N	Pool in creek.
WWCAM8	20/8/16	24/08/16	445391 E 8277346 N	Open eucalypt woodland.
WWCAM9	20/8/16	24/08/16	445391 E 8282101 N	Woodland on the edge of a dry billabong.
SM2 (8072)	20/8/16	24/08/16	438370 E 8282523 N	Houseroof Hill: among boulders at base of cliff.
SM2 (10890)	20/8/16	24/08/16	445812 E 8282523 N	Pool in creek.

3.2.6 Camera traps

Eight Bushnell motion-sensor camera traps were deployed on Carlton Plain for four nights in August 2016 (Table 8, Figure 4). Half the sites were on Houseroof Hill to target fauna that only occur in rocky areas. All cameras were baited with a mixture of sardines, rolled oats and peanut butter. As with Section 3.4.5, camera traps do not form part of a standard Level 1 survey. However, they were utilised at Carlton Plain due to the rocky habitat only present in this section of the Study Area, and the chance of the presence of the Northern Quoll.

3.2.7 Targeted Searches for Conservation Significant Fauna

Conservation significant fauna may not necessarily be readily sampled by standard fauna survey techniques. Although detailed searches for conservation significant species were outside the scope of the level 1 fauna survey, habitats where conservation significant species may occur were targeted.

- Northern Quoll (*Dasyurus hallucatus*)

The four camera traps deployed on Houseroof Hill were primarily to target this species (see section 3.5.6). Camera traps are a method recommended by Commonwealth of Australia (2011) for identifying the presence of the Northern Quoll.

- Gouldian Finch (*Erythrura gouldiae*)

The Gouldian Finch can occur as part of a mixed flock of finches, in which they can be relatively inconspicuous. Birds in immature plumage are particularly drab. All flocks of finches encountered in the study area (e.g. when travelling between sites) were examined through binoculars to search for this species. As Gouldian Finches are known to visit waterholes during the dry season, dams and wetlands containing water were also targeted for this species.

- Northern Leaf-nosed Bat (*Hipposideros stenotis*), Orange Leaf-nosed Bat (*Rhinonicteris aurantia*) and Ghost Bat (*Macroderma gigas*)

Two bat detectors were deployed to target these species on Carlton Plain (see section 3.4.5).

Species not targeted during the survey were migrant species only present in the wet to post-wet seasons. The likely presence of these species was determined on the presence of suitable habitat and records in surrounding areas only.

3.2.8 Assessment of Conservation Significance

Three levels of conservation significance are used within this report to indicate the level of significance of fauna species. These are described in the following sub-sections.

Conservation Significance 1

Conservation Significance 1 (CS1) is the highest level of conservation significance, describing species that are protected under State or Commonwealth legislation. These species are considered to be of state and/or national conservation significance, and some species (e.g. some migratory species) may be considered of international significance.

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) is the Commonwealth Government's primary piece of environmental legislation. Listed under Part 3 of the EPBC Act are 'Matters of National Environmental Significance'. These include threatened species, threatened ecological communities and migratory species.

Fauna species are assessed against categories based on International Union for Conservation of Nature (IUCN) criteria, as listed below.

Category	Description
Extinct	Taxa not definitely located in the wild during the past 50 years
Extinct in the wild	Taxa known to survive only in captivity
Critically Endangered	Taxa facing an extremely high risk of extinction in the wild in the immediate future
Endangered:	Taxa facing a very high risk of extinction in the wild in the near future
Vulnerable:	Taxa facing a very high risk of extinction in the wild in the medium-term future
Conservation Dependent	Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened

Of the above, only fauna classified as 'extinct in the wild' 'critically endangered', 'endangered' or 'vulnerable' are listed as Matters of National Environmental Significance.

The migratory species listed under the EPBC Act are those recognised under international agreements. These agreements are the China-Australia Migratory Bird Agreement (CAMBA), the Japan-Australia Migratory Bird Agreement (JAMBA), the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA), or species listed under the Bonn Convention for which Australia is a range state.

Reports on the conservation status of most vertebrate fauna species have been produced by the Department of Environment and Energy (DoEE) in the form of Action Plans. An Action Plan is a review of the conservation status of a taxonomic group against IUCN categories. Action Plans have been prepared for amphibians (Tyler 1998), reptiles (Cogger *et al*. 1993), birds (Garnett and Crowley 2000) and mammals (Woinarski *et al*. 2014). These publications also use categories similar to those used by the EPBC Act. The information presented in some of the earlier Action Plans may be out of date due to changes since publication.

The *Western Australian Wildlife Conservation Act 1950* (WC Act) is State legislation for fauna protection administered by the Department of Parks and Wildlife (DPAW). The WC Act lists species under a set of Schedules, as listed below.

Schedule	Description
Schedule 1	Fauna that is rare or likely to become extinct (critically endangered fauna)
Schedule 2	Fauna that is rare or likely to become extinct (endangered fauna)
Schedule 3	Fauna that is rare or likely to become extinct (vulnerable fauna)
Schedule 4	Fauna presumed to be extinct
Schedule 5	Migratory birds protected under an international agreement
Schedule 6	Fauna that is of special conservation need (conservation dependent fauna)
Schedule 7	Other specially protected fauna

Conservation Significance 2

Species of Conservation Significance 2 (CS2) are not listed under State or Commonwealth Acts, but are listed as Priority species by DPAW. These species may be considered to be

regionally significant. In Western Australia, DPAW maintains a list of Priority Fauna made up of species that are not considered Threatened under the WC Act, but for which DPAW feels there is cause for concern. There are four levels of Priority as defined by DPAW, as listed below.

Priority Code	Description
Priority 1	Poorly known species (on threatened lands)
Priority 2	Poorly known species in few locations (some on conservation lands)
Priority 3	Poorly known species in several locations (some on conservation lands)
Priority 4	Rare, near threatened and other species in need of monitoring

Conservation Significance 3

Conservation Significance 3 (CS3) species are not listed under State or Commonwealth Acts or in publications on threatened fauna or as Priority species by DPAW, but are considered by the author to potentially be of local significance because they are at the limit of their distribution in the area, they have a very restricted range or they occur in breeding colonies (e.g. some waterbirds). This level of significance has no legislative recognition and is based on interpretation of information on the species patterns of distribution. For example, the Government of Western Australia (2000) used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of Bush Forever. Recognition of such species is consistent with the aim of preserving regional biodiversity.

4 LIMITATIONS OF SURVEY

4.1 Flora and Vegetation Survey Limitations

Table 9 presents the limitations of the flora and vegetation survey of the Study Area in accordance with EPA Guidance Statement No. 51 (EPA 2004a).

Table 9: Limitations of the Flora and Vegetation Assessment of the Study Area

Potential Limitation	Limitation of Survey	Comment
Level of Survey	No	Level 1 survey is considered appropriate given the timing of the survey and as Study Area occurs in the Bioregion Group 3 and scale and nature of impact is considered Moderate.
Competency/experience of the consultant conducting the survey	No	Botanists with extensive experience undertaking flora and vegetation surveys, in particular within the Kimberley region, conducted the survey and undertook plant identifications.
Scope (floral groups that were sampled; some sampling methods not able to be employed because of constraints?)	No	All vascular groups that were present during the survey were sampled. There were no constraints that prevented appropriate sampling techniques from being employed.
Proportion of flora identified	Yes	Lower proportion of perennial vascular taxa recorded (200 native taxa) based on complexity of vegetation and level of survey/survey method (200 taxa from 119 relevés compared to 496 taxa from 55 quadrats recorded by Pilbara Flora (2010) which overlaps the southern portion of the Study Area). Vascular taxa recorded that were not known to the botanists had at least one reference specimen collected, with specimens identified at the WAHerb. A number of taxa were unable to be identified due to the absence of appropriate material.
Sources of information (historic/recent/new data or anecdotal)	No	Sources of information used included government databases (DPaW, DoE) and unpublished data from the vicinity of the Study Area. Good contextual information for the Study Area was available prior to the survey.
Proportion of the task achieved and further work that may be need to be undertaken	Yes	All objectives of the task achieved and the Level 1 survey completed. As survey was conducted out of season for the region, further survey is required to determine the presence of conservation significant taxa and in particular Threatened flora.
Timing/weather/season/ cycle	Yes	The survey was undertaken in the dry season (August), outside the optimal flowering period for flora in the Kimberley Region. In addition the rainfall recorded in the area for the previous 2 wet seasons was below average (section 2.1). Sufficient features (e.g. fruit) were not present to accurately identify a number of taxa present.
Disturbances (e.g. fire, flood, accidental human intervention etc.), which affected results of survey	Yes	The vegetation of the Study Area has been significantly altered by grazing and affected by drought, resulting in difficulties in identifying taxa and weed presence along with difficulties describing vegetation structure and classification into the respective vegetation types.
Intensity of survey (e.g. in retrospect was the intensity of the survey adequate)	Yes	Parts of the Study Area were inaccessible or difficult to reach within the allotted time. The survey intensity was considered adequate for the level of survey and to identify a reasonable number of flora taxa present given the timing of the survey.

Potential Limitation	Limitation of Survey	Comment
Completeness and mapping reliability	Yes	Difficulties in reaching parts of the Study Area within the allotted time meant a level of aerial photography interpretation was required in order to map the entire Study Area. VTs described were influenced by the vegetation condition.
Resources (e.g. degree of expertise available for plant identification)	No	Botanist with previous plant identification skills and knowledge of taxa and vegetation of the Kimberley region, in addition to knowledge of cultivated and introduced taxa, undertook the plant identifications using relevant plant identification resources
Remoteness and/or access problems	Yes	Parts of the Study Area were inaccessible or difficult to reach within the allotted time. However several station tracks and gravel roads were in good condition enabling the Study Area to be broadly accessed.

4.2 Fauna Survey Limitations

Various factors can limit the effectiveness of a fauna survey. Pursuant to EPA Guidance Statement 56 (EPA 2004), these factors have been identified and their potential to impact on the effectiveness of the surveys has been assessed in Table 10. All fauna surveys have limitations, and not all fauna species present on the site are likely to be sampled during a survey. Fauna may not be recorded because they are rare, they are difficult to trap or observe, or because they are only present on the site for part of the year.

Table 10: Limitations of the Fauna Survey of the Study Area

Potential Limitation	Limitation of Survey	Extent of limitation for the fauna survey
Experience of fauna personnel	Not limiting:	The supervising zoologist has 16 years experience in fauna consulting. Team members have 10 – 16 years experience.
Types of traps or other survey methods used	Not limiting:	Methods appropriate to a level 1 survey were used.
Number of trapping sites	Not limiting:	Trapping is not a part of a Level 1 survey.
Ability to survey all habitats present	Not limiting:	All habitats present were surveyed during the fauna survey.
Availability of fauna information for the area in literature and on databases	Not limiting:	Moderate amount of fauna information available on databases. There are fauna data from other fauna surveys in the area, including a single-season survey from the Mantinea Plain in 2009.
Effects of weather during the survey	Not limiting:	Weather is not generally limiting on a level 1 survey. Conditions were warm and dry throughout the survey.
Seasonal effects	Minor limitation:	Season is not generally limiting on a level 1 survey. The survey was undertaken during the dry season when it was difficult to ascertain the relative importance of seasonal wetlands in the study area.
Disturbance to site such as recent fires, cattle grazing	Not limiting:	Most of site is grazed by cattle and many areas are in poor condition, particularly around troughs and dams.
Ease of access to site	Not limiting:	Site access is generally very good with numerous tracks to all habitat types.

5 RESULTS – FLORA AND VEGETATION

5.1 Vegetation

A total of 35 VTs were defined for the Study Area based on data from 119 relevés as well as notes taken in the field. Relevé locations are shown on Figure 5. These VTs were described based on species composition, density and occurrence in structural layers. The VTs described include:

- 16 woodlands on plains, slopes, low hillocks and hills;
- 9 woodlands associated with drainage lines;
- 3 shrublands on hills with isolated clumps of trees;
- 1 open chenopod shrubland on flats;
- 1 sedgeland on closed depressions;
- 3 grasslands on plains;
- 2 forests / woodlands on closed depressions.

The raw data recorded in relevés is provided in Appendix I, with a full list of taxa recorded during the survey presented in Appendix J. Appendix K presents a description of the VTs defined for the Study Area, including areas mapped, relevees surveyed and a representative photograph.

Table 11 presents the areas (ha) of vegetation condition type mapped for each VT within both the Mantinea Plain Carlton Plain areas. In total, the most dominant VTs were:

- VT11 (approximately 25 % of the Study Area); a mixed grassland on plains; and
- VT22 (approximately 15 % of the Study Area); *Corymbia bella* and *Eucalyptus microtheca* woodland.

Table 11: The Area and Condition of each Vegetation Type Mapped within the Study Area

Area	VT	Area of Vegetation Condition Ranking (ha)											Area Total (ha)
		E	VG-E	VG	G-VG	G	P	P-VP	VP	D-VP	D	C	
Carlton	1			220.02		898.05	83.62		282.2				1483.89
Carlton	2					19.9							19.9
Carlton	3					10.05							10.05
Carlton	4			113.23		27.17			0.73		115.27		256.4
Carlton	5			0.61					22.6				23.21
Carlton	6			4.1		0.47			7.18				11.75
Carlton	7								11.87				11.87
Carlton	8			5.77									5.77
Carlton	9			2.58									2.58
Carlton	10					76.44							76.44
Carlton	11				3590.27	322.68	124.45		563.63				4601.03
Carlton	12				396.77								396.77
Carlton	13			59.99									59.99
Carlton	14			239.82		6.73	159.43		66.14		13.55		485.67
Carlton	15					32.92	43.84		41.11		3.93		121.8
Carlton	16										3.76		3.76
Carlton	17						302.57		168.79	119.92			591.28
Carlton	18				23.43			588.13					611.56
Carlton	19								907.58	495.44	322.44		1725.46
Carlton	20										307.67		307.67
Carlton	21								21.35				21.35
Carlton	22						21.86		28.33		795.9		846.09
Carlton	23			212.47		109.83			7.34		9.9		339.54
Carlton	24	57.88				4.84							62.72
Carlton	25	34.9				2.94							37.84

Area	VT	Area of Vegetation Condition Ranking (ha)											Area Total (ha)
		E	VG-E	VG	G-VG	G	P	P-VP	VP	D-VP	D	C	
Carlton	26						125.83		93.49				219.32
Carlton	27						43.47						43.47
Carlton	28		1661.57	1.72					0.98				1664.27
Carlton	29			66.31									66.31
Carlton	30										23.96		23.96
Carlton	31				11.45								11.45
Carlton	34								139.86		825.66		965.52
Carlton	C											67.07	67.07
Mantinea	1						14.38	173.77	150.56	344.28	15.84		698.83
Mantinea	4			234.34			51.56	1229.37			28.18		1543.45
Mantinea	9						326.79		3.72				330.51
Mantinea	11				74.09		960.87		302.26		247.13		1584.35
Mantinea	14						17.69						17.69
Mantinea	17										628.42		628.42
Mantinea	18							87.47			50.64		138.11
Mantinea	19								132.05		21.44		153.49
Mantinea	21						29.8						29.8
Mantinea	22						166.9		23.29	2660.17			2850.36
Mantinea	25						10.35						10.35
Mantinea	26						65.58						65.58
Mantinea	29						2.86						2.86
Mantinea	31					2.49			9.63				12.12
Mantinea	32					63.47	207.23		767.94				1038.64
Mantinea	33						55.96		18.38				74.34
Mantinea	34						9.47						9.47
Mantinea	35			217.8		11.35		11.12					240.27
Study Area	1			220.02		898.05	98	173.77	432.76	344.28	15.84		2182.72

Area	VT	Area of Vegetation Condition Ranking (ha)											Area Total (ha)
		E	VG-E	VG	G-VG	G	P	P-VP	VP	D-VP	D	C	
Study Area	2					19.9							19.9
Study Area	3					10.05							10.05
Study Area	4			347.57		27.17	51.56	1229.37	0.73		143.45		1799.85
Study Area	5			0.61					22.6				23.21
Study Area	6			4.1		0.47			7.18				11.75
Study Area	7								11.87				11.87
Study Area	8			5.77									5.77
Study Area	9			2.58			326.79		3.72				333.09
Study Area	10					76.44							76.44
Study Area	11				3664.36	322.68	1085.32		865.88		247.13		6185.37
Study Area	12				396.77								396.77
Study Area	13			59.99									59.99
Study Area	14			239.82		6.73	177.12		66.14		13.55		503.36
Study Area	15					32.92	43.84		41.11		3.93		121.8
Study Area	16										3.76		3.76
Study Area	17						302.57		168.79	119.92	628.42		1219.7
Study Area	18				23.43			675.61			50.64		749.68
Study Area	19								1039.63	495.44	343.88		1878.95
Study Area	20										307.67		307.67
Study Area	21						29.8		21.35				51.15
Study Area	22						188.76		51.62	2660.17	795.9		3696.45
Study Area	23			212.47		109.83			7.34		9.9		339.54
Study Area	24	57.88				4.84							62.72
Study Area	25	34.9				2.94	10.35						48.19
Study Area	26						191.41		93.49				284.9
Study Area	27						43.47						43.47
Study Area	28		1661.57	1.72					0.98				1664.27

Area	VT	Area of Vegetation Condition Ranking (ha)											Area Total (ha)
		E	VG-E	VG	G-VG	G	P	P-VP	VP	D-VP	D	C	
Study Area	29			66.31			2.86						69.17
Study Area	30										23.96		23.96
Study Area	31				11.45	2.49			9.63				23.57
Study Area	32					63.47	207.23		767.94				1038.64
Study Area	33						55.96		18.38				74.34
Study Area	34						9.47		139.86		825.66		974.99
Study Area	35			217.8		11.35		11.12					240.27
Study Area	C											67.07	67.07

5.1.1 Conservation Significance

A number of VTs described are representative of the Ivanhoe Land System Priority 3 PEC. These include 33 of the 35 VTs (all VTs except VT 24, 25 and 28) and comprise all areas not associated with stony hills. Based on the condition of the vegetation and the taxa recorded at the time of the survey it is considered that no other VTs are representative of any listed TECs or PECs.

Although it is noted that the Ord River Floodplain (listed Ramsar Site; as noted in Section 2.3.1) contains potentially the most diverse mangrove suite in Western Australia, this is not located within the Study Area, with only two mangrove species recorded.

5.1.2 Vegetation System Associations

Table 12 presents the relative area (ha) of each Vegetation System Association (as described in Table 1) within the Study Area, against the area remaining within the IBRA Keep Subregion assuming the entire Study Area (or portion of Carlton Plain or Mantinea Plain) is cleared.

The remaining pre-European mapped extent of each VSA in the Keep IBRA Subregion, assuming total clearing of the Study Area, would be above the 30% threshold for each VSA (as per EPA 2000).

Table 12: Potential Impact to Vegetation System Associations within the Study Area

Area	Vegetation System Association	Current Extent (ha)	Current Pre-European Extent Remaining (%)	Extent within Surveyed Area (ha)	Potential Pre-European Extent Remaining (%)
Study Area	VICTORIA BONAPARTE_52	151,894.51	99.96	402.67	99.70
	VICTORIA BONAPARTE_59	121,189.78	86.92	20491.09	72.63
	VICTORIA BONAPARTE_814	107,351.20	99.99	2198.33	97.96
	VICTORIA BONAPARTE_838	3,280.19	100	2.69	99.92
	VICTORIA BONAPARTE_901	9,948.84	98.92	1.64	99.30
	VICTORIA BONAPARTE_914	41,149.92	99.25	1380.41	96.05
Carlton Plain	VICTORIA BONAPARTE_52	151,894.51	99.96	402.67	99.70
	VICTORIA BONAPARTE_59	121,189.78	86.92	13159	77.92
	VICTORIA BONAPARTE_814	107,351.20	99.99	1541.26	98.57
Mantinea Plain	VICTORIA BONAPARTE_59	121,189.78	86.92	7332.09	82.13
	VICTORIA BONAPARTE_814	107,351.20	99.99	657.07	99.39
	VICTORIA BONAPARTE_838	3,280.19	100	2.69	99.92
	VICTORIA BONAPARTE_901	9,948.84	98.92	1.64	99.30
	VICTORIA BONAPARTE_914	41,149.92	99.25	1380.41	96.05

5.1.3 Vegetation Condition

The vegetation condition of the Study Area ranged from Excellent to Completely Degraded. The majority of the vegetation in the Study Area has been significantly altered by grazing (by both native animals (wallabies) and cows), as well as being affected by drought conditions

experienced over the preceding 2 years of below average annual rainfall, with large areas mapped as Very Poor to Completely Degraded. Mantinea Plain was in generally in worse condition than Carlton Plain possibly due to increased levels of grazing (by both native animals and cows) south of the Ord River. In addition, large areas adjacent to the Ord River and associated drainage lines were mapped as Very Poor to Completely Degraded due to increased cattle movement and grazing by wallabies in these areas, as well as historic introduction of weed seeds from areas upstream. A total of 0.27 % of the Study Area (67.1 ha) was mapped as Cleared. Condition mapping polygons are displayed on Figure 6, with total areas given in Table 11.

5.2 Flora

A total of 200 discrete native vascular flora taxa were recorded within the Study Area, representing 42 families and 112 genera. The most well represented families were Poaceae (46 taxa), Myrtaceae (22 taxa), Fabaceae (20 taxa) and Malvaceae (17 taxa). A full list of taxa is presented in Appendix J.

5.2.1 Conservation Significant Flora

No Threatened species as listed under the EPBC Act or WC Act were recorded within the Study Area. One Priority flora taxon was recorded within the Study Area during the survey; *Brachychiton tuberculatus* (P3). Locations of *Brachychiton tuberculatus* (P3) recorded within the Study Area are presented in Appendix L and shown in Figure 8.

Brachychiton tuberculatus (P3) is a shrub or tree erect growing from 2 to 7 m high (Plate 1), on undulating plains on red or yellow sand (DPaW 2016e). This taxon generally occurs in Eucalypt woodlands dominated by either *Eucalyptus tetrodonta* or *Corymbia grandifolia*, or occasionally in frontage woodland dominated by *Adansonia gregorii*, *Melaleuca nervosa*, *M. argentea* and *Terminalia platyphylla* (Guymer 1988).

There are 35 DPaW records of *Brachychiton tuberculatus* occurring over a range of approximately 135 km (DPaW 2016e), with an additional 9 records located within the Northern Territory (Council of Heads of Australasian Herbaria 2016). Of the DPaW records, 6 records are located within DPaW tenure; 2 within Jemarnde-wooningim Conservation Park and 4 within Ngamoowalem Conservation Park (DPaW 2016d). Two of the DPaW records are specimens lodged at the WAHerb (collected 1997), both of which occur within the Study Area with the location details as being 'Near Carlton Hill Homestead' (DPaW 2016e).

Brachychiton tuberculatus was recorded at further 9 point locations during survey of the Study Area with a total of 22 alive individuals and 44 dead individuals recorded (Appendix L; Figure 8). All plants were in poor condition including those recorded as alive. Affected plants appeared dead rather than being in a deciduous state possibly as a result of drought, and these were generally younger (smaller) individuals. Locations of dead individuals were recorded in order to capture potential habitat and the likely presence of viable soil-stored seed for future occurrences of the taxon at these locations.

Plate 1: *Brachychiton tuberculatus* (P3) (Photo: Woodman Environmental)

Echinochloa kimberleyensis (P1) and *Solanum pugiunculiferum* (P1) have historical known locations within the Study Area (Figure 3). Both *E. kimberleyensis* (P1) and *S. pugiunculiferum* (P1) are annual taxa, occurring on either black soil and swamps (the former taxon) or on the margins of seasonal wetlands or lagoons (the latter taxon) (DPaW 2016e). Neither of these taxa would have been observable given the timing and climatic conditions experienced during the survey period. There is currently some dispute with regards to the taxonomic clarity of *Goodenia brachypoda* (P1), with collected specimens confirmed as *Goodenia sepalosa* var. *sepalosa* (sens lat) (Western Australian Herbarium).

A total of 32 conservation significant flora have known locations within 20 km of the Study Area as returned from the DPaW database search (DPaW 2016c) (Figure 3; Table 11). As noted above, four taxa have previously been recorded in the Study Area including *Brachychiton tuberculatus* (P3), *Echinochloa kimberleyensis* (P1), *Goodenia brachypoda* (P1) and *Solanum pugiunculiferum* (P1).

There are a further 26 conservation significant taxa which have the potential to occur within the Study Area given their habitat preferences including *Typhonium* sp. Kununurra (A.N. Start ANS 1467) (T), one taxon (*Heliotropium alcyonium* (P1)) with preferred habitat unknown and 1 taxon (*Sphenoclea zeylanica* (P1)) which is unlikely to occur with the Study Area (Table 13).

Table 13: Conservation Significant Flora Risk Assessment

Taxon	Status	Habitat (DPaW 2016e)	Likelihood of Occurrence within the Study Area
Acacia richardsii	P3	Sandstone. Hills, creek beds, rocky areas.	Potential
Brachychiton incanus	P3	Sandy soils over sandstone or quartzite. Rocky slopes, scarps & ridges.	Potential
Brachychiton tuberculatus	P3	Red or yellow sand. Undulating plains.	Present
Cyperus digitatus	P1	Waters' edge.	Potential
Desmodium flagellare	P1	Cracking clay.	Potential
Echinochloa kimberleyensis	P1	Black soils. Swamps.	Present
Euphorbia stevenii	P3	Clay, sandy soils.	Potential
Fimbristylis laxiglumis	P2	Black clay.	Potential
Fuirena incrassata	P3	Sand, sandy clay. Swamps, creek beds, claypans, semi-saline lakes.	Potential
Goodenia brachypoda	P1	Red sandy loam.	Present (possibly now *G. sepalosa* var. *sepalosa*)
Goodenia durackiana	P1	Black clay. Grassland.	Potential
Goodenia malvina	P1	Cracking black clay. Seasonally wet areas.	Potential
Heliotropium alcyonium	P1	Not available	Unknown
Heliotropium cupressinum	P1	Stony sandy soils, sandstone.	Potential
Hibiscus panduriformis	P3	Basin/swamp associated with the river sandplain. Black-grey clay, sandstone, black cracking clay.	Potential
Ipomoea gracilis	P3	Black cracking clay or black sand. Irrigated areas.	Potential
Jacquemontia sp. Keep River (J.L. Egan 5051)	P1	Ridge, lower sandy slopes, sandstone hills. Brown loam with limestone. Black sand over sandstone.	Potential
Lophostemon grandiflorus subsp. *grandiflorus*	P3	Damp habitats (swamps, seepages).	Potential
Nymphaea immutabilis	P2	Permanent or ephemeral waterholes.	Potential
Paspalidium distans	P3	Loam. River banks.	Potential
Sauropus hubbardii	P3	Mixed grassland, heavy dark-brown soil.	Potential
Solanum pugiunculiferum	P1	Heavy soils. Margins of seasonal wetlands or lagoons.	Present
Sphenoclea zeylanica	P1	Grey clay to black peaty clay. Monsson thickets, mound spring.	Unlikely
Stylidium prophyllum	P3	Sandy, black silty or clayey sandy soils, loam. Seasonally wet floodway depressions & seepage areas.	Potential
Tephrosia sp. Saw Ranges (D. Kabay s.n. PERTH 06720544)	P1	Sandstone ridges/hills.	Potential
Triodia racemigera	P1	Sandstone. Steep rocky slopes, crevices, cliffs & ridges.	Potential
Triodia triticoides	P1	Rocky sandstone & limestone hillslopes.	Potential

Taxon	Status	Habitat (DPaW 2016e)	Likelihood of Occurrence within the Study Area
Typhonium sp. Kununurra (A.N. Start ANS 1467)	T	Dark grey clay, black soil. Sites which are waterlogged in the wet season and inundated after rain.	Potential
Utricularia aurea	P2	River edges.	Potential
Utricularia stellaris	P1	Swamps, lagoons.	Potential
Whiteochloa capillipes	P3	Plains of dark red cracking clay over ironstone or crabhole clay.	Potential
Zornia areolata	P1	Plains, grey silt.	Potential

Unknown = One record known to occur within 20 km of the Study Area (from 1969), predominantly occurs in the Northern Territory, preferred habitat unknown
Unlikely = Known to occur within 20 km of the Study Area, however no potential habitat present within the Study Area
Potential = Known to occur within 20 km of the Study Area, with potential habitat possibly present within the Study Area
Present = Previous records known from within the Study Area, with additional potential habitat present within the Study Area

Potential habitat for *Typhonium* sp. Kununurra (A.N. Start ANS 1467) is present within the Study Area comprising areas of black soils mapped as VT1. The likelihood of this taxon occurring in the Study Area has been ranked as 'Potential' rather than 'Likely' due to the generally poor condition of the habitat areas. Survey to confirm the presence of this taxon in the correct season (flowering time; March) would be required prior to any clearing.

A total of 2,182.7 ha of area of potential habitat for *Typhonium* sp. Kununurra (A.N. Start ANS 1467) has been mapped (VT1; Figure 8). This represents 8.87% of the Study Area, and was predominantly mapped on the Carlton Plain (68.0% of the mapped area). The majority of the Very Good and Good mapped condition of VT1 was also mapped at the Carlton Plain (51.2% of the mapped area).

5.2.2 Introduced Taxa

A total of 24 introduced flora taxa were recorded during this survey of the Study Area. Table 14 presents a list of the introduced flora taxa recorded in the Study Area, together with location information, and ratings for each introduced taxon under the Environmental Weed Strategy for Western Australia (CALM 1999). Of the introduced taxa recorded in the Study Area, *Parkinsonia aculeata* and *Xanthium occidentale* are Declared Pests under the BAM Act (DAF 2016), and *Parkinsonia aculeata* is also a WoNS (AWC 2016). In addition, *Aerva javanica, Azadirachta indica*, *Calotropis procera, Cenchrus ciliaris* and *Passiflora foetida* var. *hispida* are ranked as 'High' for distribution, invasiveness and impacts in the Environmental Weed Strategy (CALM 1999). These significant weeds are discussed further below. Locations of introduced flora taxa (recorded at relevés and opportunistically) are presented in Appendix L, and displayed on Figure 7.

Both the Carlton Plain and Mantinea Plain are located downstream of the Ord River Irrigation Area, and have been exposed to tailwater and stormwater from the irrigation area since the 1960s. The majority of the weed infestation in the Study Area has resulted from the spread of weed seeds from the irrigation area.

Table 14: Summary of Introduced Taxa Recorded from within the Study Area

Taxon	Number of Locations Recorded in the Study Area	Approximate Plant Counts	Comments
**Aerva javanica*	6	2180+	Environmental impact 'High' (CALM 1999)
**Azadirachta indica*	1	50+	Environmental impact 'High' (CALM 1999)
**Bidens ?pilosa*	5	10+	Environmental impact not assessed (CALM 1999)
**Calotropis procera*	60	1,000,000+	Environmental impact 'High' (CALM 1999)
**Cardiospermum halicacabum* var. *halicacabum*	1	Not Recorded	Environmental impact not assessed (CALM 1999)
**Cenchrus ciliaris*	8	100+	Environmental impact 'High' (CALM 1999)
**Citrullus lanatus*	2	2+	Environmental impact 'Low' (CALM 1999)
**Datura inoxia*	1	10+	Environmental impact 'Low' (CALM 1999)
**Echinochloa colona*	2	Not Recorded	Environmental impact 'Mild' (CALM 1999)
**Heliotropium indicum*	1	2+	Environmental impact 'Low' (CALM 1999)
**Hyptis suaveolens*	35	3000+	Environmental impact 'Moderate' (CALM 1999)
**Macroptilium lathyroides* var. *semierectum*	1	Not Recorded	Environmental impact 'Moderate' (CALM 1999)
**Malvastrum americanum*	6	Not Recorded	Environmental impact 'Moderate' (CALM 1999)
**Melochia pyramidata*	2	Not Recorded	Environmental impact 'Mild' (CALM 1999)
**Moringa oleifera*	1	Not Recorded	-
**Parkinsonia aculeata*	50	4300+	Declared Pest (DAF 2016) WoNS (AWC 2016) Environmental impact 'Moderate' (CALM 1999)
**Passiflora foetida* var. *hispida*	6	Not Recorded	Environmental impact 'High' (CALM 1999)
**Physalis angulata*	2	1+	Environmental impact 'Low' (CALM 1999)
**Sida acuta* subsp. *acuta*	6	200+	Environmental impact not assessed (CALM 1999)
**Sida cordifolia*	14	20+	Environmental impact not assessed (CALM 1999)
**Stylosanthes hamata*	5	Not Recorded	Environmental impact 'Mild' (CALM 1999)
**Urochloa mosambicensis*	7	Not Recorded	Environmental impact 'Mild' (CALM 1999)
**Vachellia farnesiana*	52	12,000+	Environmental impact 'Moderate' (CALM 1999)
**Xanthium occidentale*	6	57+	Declared Pest (DAF 2016) Environmental impact 'Moderate' (CALM 1999)

Aerva javanica (Kapok Bush) (Plate 2) is an erect perennial herb growing to 1.6 m in height. It is a widespread weed occurring in numerous vegetation types from the Kimberley to Carnarvon (Hussey *et al.* 2007). It is often found on sandy soils and along drainage lines (DPaW 2016e). This taxon is considered to be a significant weed, rated as 'High' under the Environmental Weed Strategy for Western Australia (CALM 1999). *Aerva javanica* was recorded at 6 locations in the Study Area (Appendix L; Figure 7).

Plate 2: *Aerva javanica* (Kapok) (Photo: Woodman Environmental)

Azadirachta indica (Neem) (Plate 3) is a tree growing to 6 m occurring near creeks and in cultivated land on cultivated black soil, disturbed pindan, sandstone (DPaW 2016e). It is spreading rapidly into native woodlands and grasslands at Kununurra and Broome and is becoming a major woody weed in the tropics (Hussey *et al.* 2007). *Azadirachta indica* is considered to be a significant weed, rated as 'High' under the Environmental Weed Strategy for Western Australia (CALM 1999). This taxon was recorded at 1 location within the Study Area (Appendix L; Figure 7).

Plate 3: *Azadirachta indica* (Neem) (Photo: Queensland Government 2016)

Calotropis procera (Rubber Tree) (Plate 4) is a garden escape which has become a serious weed in the Kimberley region. It is a shrub to small tree, growing to 4 m, occurring on sandy and clayey soils (Hussey *et al.* 2007; DPaW 2016e). *Calotropis procera* was rated as 'High' under the Environmental Weed Strategy for Western Australia, and is therefore considered to be a significant weed (CALM 1999). It was widespread throughout the Study Area, recorded at 60 locations (Appendix L; Figure 7).

Plate 4: *Calotropis procera* (Rubber Tree) (Photo: Woodman Environmental)

Cenchrus ciliaris (Buffel Grass) (Plate 5) is a perennial tussock grass to 1.5 m high (DPaW 2016e). It is distributed widely, occurring from Geraldton to the Pilbara and Kimberley regions, and the adjacent desert areas. It is most often found on roadsides, in creek lines and on river edges. It was originally introduced into pastoral regions as a pasture grass, and alters the fire characteristics by generating a high level of flammable fuel (Hussey *et al.* 2007). This taxon is considered to be a significant weed, rated as 'High' under the Environmental Weed Strategy for Western Australia (CALM 1999). *Cenchrus ciliaris* was recorded at 8 locations in the Study Area (Appendix L; Figure 7).

Plate 5: *Cenchrus ciliaris* (Buffel Grass) (Photo: Woodman Environmental)

Hyptis suaveolens (Plate 6) is an upright, strongly aromatic annual or perennial herb growing to 3 m high (DPaW 2016e). It is found in dense clumps along roadsides, overgrazed pastures and around stockyards across the tropics, including the Kimberley region (Hussey *et al.* 2007). This taxon was ranked as 'Moderate' under the Environmental Weed Strategy for Western Australia (CALM 1999). It is considered a significant weed for this project given the high levels of infestation of this taxon throughout the Study Area (Plate 7). *Hyptis suaveolens* was recorded at 35 locations in the Study Area, though it was generally common throughout (Appendix L; Figure 7).

Plate 6: *Hyptis suaveolens* (Hyptis) (Photo: Australian National Botanic Gardens 2016)

Plate 7: *Hyptis suaveolens* infestation (Photo: Woodman Environmental)

Parkinsonia aculeata (Plate 8) is a spiny shrub or tree growing to 8 m (DPaW 2016e). It has become a serious weed in the Kimberly and Pilbara, often found along rivers and in pastoral areas forming dense impenetrable thickets (Hussey *et al.* 2007). *Parkinsonia aculeata* is considered a significant weed as it is a Declared Pest (DAF 2016) and WoNS (AWC 2016). This taxon was recorded at 50 locations throughout the Study Area (Appendix L; Figure 7).

Plate 8: *Parkinsonia aculeata* (Parkinsonia) (Photo: Woodman Environmental)

Passiflora foetida var. *hispida* (Stinking Passion Flower) (Plate 9) is a woody climber which has become common in disturbed areas of creek and river banks from the Kimberley region to Carnarvon. (Hussey *et al.* 2007; DPaW 2016e). It is considered to be a significant weed, rated as High under the Environmental Weed Strategy for Western Australia (CALM 1999). *Passiflora foetida* var. *hispida* was recorded at 6 locations within the Study Area (Appendix L; Figure 7).

Plate 9: *Passiflora foetida* var. *hispida* (Stinking Passion Flower) (Photo: DPaW 2016e)

Vachellia farnesiana (Mimosa Bush) (Plate 10) is an erect, spreading, thicket-forming, thorny tree or shrub, to 4 m high (DPaW 2016e). It is a widespread weed of roadsides, creeks, rivers and disturbed floodplains throughout pastoral regions from the Kimberly to Carnarvon and Wiluna (Hussey *et al.* 2007). This taxon is considered to be a significant weed for this project given its high levels of occurrence throughout the Study Area. *Vachellia farnesiana* was recorded at 52 locations in the Study Area (Appendix L; Figure 7).

Plate 10: *Vachellia farnesiana* (Mimosa Bush) (Woodman Environmental)

Xanthium occidentale (Noogoora Burr) (Plate 11) is a shrubby perennial herb with inconspicuous spiny burrs which can be a serious contaminant of wool. It is found along the Ord and Fitzroy river systems in the Kimberley (Hussey *et al.* 2007). This taxon is considered to be a significant weed as it is a Declared Pest (DAF 2016). *Xanthium occidentale* was recorded at 6 locations in the Study Area (Appendix L; Figure 7).

Plate 11: *Xanthium occidentale* (Noogoora Burr) (DPaW 2016e)

The history of grazing on both the Carlton and Mantinea Plains has resulted in significant levels of weed infestation with weed covers recorded as very low (<2%) across much of the Carlton Station portion of the Study Area and very high (>80%) for much of the Mantinea Plain (Figure 7). This difference in levels of weed infestation and corresponding vegetation condition between the two areas is likely the result of differences in stocking levels and land management practices over time. Table 15 presents the areas of each weed cover class across both Carlton Plain and Mantinea Plain.

Table 15: Weed Cover Class extents within the Study Area

Weed Cover Class	Area (ha)		
	Carlton Plain	Mantinea Plain	Total
<2	9771.83	2078.16	11849.99
2-20	1763.14	3176.63	4939.77
20-50	1741.8	1078.56	2820.36
50-80	1861.54	549.53	2411.07
>80	11.86	2545.76	2557.62
C	25.65	0	25.65

There was also a strong correlation observed between weed levels and topography/soils with upland areas comprised of rockier dry environments having much lower covers of weeds and subsequently vegetation recorded in better condition. Conversely, most areas low in the topography with wetter clay soils recorded significantly higher weed covers and reduced vegetation condition scores. All areas associated with the Ord River and associated creeks recorded high weed covers as these areas would experience higher levels of grazing and disturbance by cattle, as well as historic introduction of weed seeds from upstream sources.

6 RESULTS - FAUNA

6.1 Fauna Habitats

The broad fauna habitats in the Study Area were identified on the basis of the 35 structural vegetation types identified by Woodman Environmental (2016) and observations made in the field.

The seven broad fauna habitats are:

- Sandstone hills
- Stony plains
- Savannah woodlands
- Floodplains
- Grasslands
- Seasonal wetlands
- Creeklines

Table 16 presents the area (ha) of each fauna habitat mapped within the Carlton Plain, Mantinea Plain and the Study Area as a whole.

Table 16: Fauna Habitat Areas

Fauna Habitat	Area (ha)		
	Carlton Plain	Mantinea Plain	Study Area
Cleared Land	67.07	0	67.07
Creeklines	539.19	92.03	631.22
Floodplains	3652.25	1474.83	5127.08
Grasslands	4997.79	1584.33	6582.12
Sandstone hills	1866.95	10.35	1877.3
Savannah woodlands	3366.15	5894.65	9260.8
Seasonal wetlands	344.22	41.93	386.15
Stony plains	342.13	330.51	672.64

The floodplains can be divided into a further four sub-habitats, into those that support either Guttapercha (*Excoecaria*) woodland on cracking clays, Melaleuca woodlands, Open shrublands or *Eucalyptus camaldulensis* woodlands. The grassland habitat can be further divided into two sub-habitats, tall grassland on cracking clays and mixed grassland. There are some localised highly degraded areas in the Study Area, often areas where livestock congregate around dams, tanks and bores. The most degraded areas are characterised by a lack of understorey vegetation and a disturbed ground surface. As the entire Study Area is grazed by cattle, evidence such as cattle tracks and scats were common throughout the study area, except on the taller sandstone hills. Each habitat is described in the sections below and presented in Figure 9.

435000 440000 445000 450000 455000

8300000 8295000 8290000 8285000 8280000 8275000 8270000 8265000

Legend

- Carlton Plain
- Mantinea Plain

Fauna Habitat

- Cleared Land
- Creeklines
- Floodplains
- Grasslands
- Sandstone hills
- Savannah woodlands
- Seasonal wetlands
- Stony plains

WOODMAN ENVIRONMENTAL

This map should only be used in conjunction with WEC report KAI16-33-01.

N

Mantinea and Carlton Plains: Fauna Habitat Areas

Revision: A - 31 October 2016 Scale: 1:100,000 (A3)

Author: Bethea Loudon

WEC Ref: KAI16-33-01

Filename: KAI16-33-01-f09.mxd

Projection: GDA 1994 MGA Zone 52

Figure

9

6.1.1 Sandstone Hills

Houseroof Hill is a large sandstone hill that dominates the Carlton Plain study area. The edges of large sandstone ranges adjacent to the Study Area encroach a small distance into the northern edge of the Carlton Plain study area and the south-eastern edge of the Mantinea study area. The vegetation on Houseroof Hill is generally in good condition, as it is relatively undisturbed by livestock. The upper slopes have outcropping sandstone and boulder scree with a grassland of Spinifex (*Triodia spp*.) and mixed grasses. The lower slopes of the hills are more densely vegetated, with a low open woodland of Boab (*Adansonia gregorii*), *Bauhinia cunninghamii*, *Erythrophleum chlorostachys* and *Terminalia canescens* over a tall open shrubland of *Calytrix exstipulata*, *Cochlospermum fraseri* and *Melaleuca minutifolia* over mixed grassland. The base of the sandstone hills grades into stony plains (see section 6.1.2).

Plate 12: Sandstone hills

The sandstone hills are likely to support a suite of fauna that favour rocky habitats, some of which are unlikely to occur on the surrounding plains. Areas of outcropping rock provide crevices that shelter reptiles such as the Black-palmed Rock Monitor (*Varanus glebopalma*) and small mammals such as the Common Rock Rat (*Zyzomys argurus)*. Birds of prey are likely to use high points on hills as perches and potentially as nesting sites. Although the hills lack significant caves, rock crevices are likely to shelter roosting bats, including conservation significant bat species. If present, the Northern Quoll (*Dasyurus hallucatus*) would occur in this habitat.

6.1.2 Stony Plains

The stony plains generally occur in association with the base of Houseroof Hill on the Carlton Plain, and the base of the Livisona Ranges (outside the Study Area) on the Mantinea Plain. This habitat comprises brown clay plains and low rises with a stony surface. Around Houseroof Hill the vegetation is generally open grassland, while on the Mantinea Plain the stony plains are vegetated with sparse woodland of *Melaleuca minutifolia* over a mixed grassland of Spinifex (*Triodia bitextura*) and other grasses.

Plate 13: Stony Plains

The stony plains are likely to support relatively few species compared with more structurally diverse habitats. However, reptile species that favour rocky areas may occur in this habitat and in the sandstone hills, but not in the remainder of the Study Area. The stony plains are unlikely to be important for conservation significant species.

6.1.3 Savannah Woodlands

A widespread habitat type in the Study Area, the savannah woodlands consist of open woodlands of mixed species over grasslands, generally on sandy clay soils. Tree species include *Corymbia greeniana*, *Corymbia cadophora* and/or *Bauhinia cunninghamii*, but also include Whitewood (*Atalaya hemiglauca*), *Eucalyptus camaldulensis*, Beefwood (*Grevillea striata*), Acacia and scattered Boab trees (*Adansonia gregorii*). Where this habitat is near tanks, troughs or dams it is heavily disturbed by cattle and in poor condition, the remainder is in variable condition dependent on the level of grazing pressure. As this habitat is quite variable, it is likely to support a large number of vertebrate fauna. Termitaria are present in some areas, and some tree species contain hollows suitable for roosting or nesting fauna.

Plate 14: Savannah woodlands

6.1.4 Floodplains

The floodplains occur in association with the Ord River, and in low-lying parts of the Study Area. The floodplain habitat can be further divided into four sub-habitats; Guttapercha (*Excoecaria parvifolia*) woodlands on cracking clays (Plate 15), Eucalyptus camaldulensis woodlands (Plate 15), Melaleuca woodlands and Open shrublands.

Plate 15: Guttapercha woodland on cracking clays (left) and *Eucalyptus camaldulensis* woodland (right)

The floodplains are likely to support a diverse range of vertebrate fauna. Where the vegetation is dense, it forms shelter and nesting sites. Cracking clays are likely to support a small but distinct suite of species, including the locally significant Blacksoil Skink (*Ctenotus rimacola*), Ord Snake (*Suta ordensis*) and Curl Snake (*Suta suta*).

6.1.5 Grasslands

The grasslands habitat can be further divided into two sub-habitats; tall grassland and mixed grassland.

The tall grassland consists of *Sorghum stipoideum* and *Ophiuros exaltas* over *Chysopogon fallax*, *Heteropogon contortus* and *Themeda triandra* on cracking clays. The mixed grassland is more widespread, and is dominated by *Chysopogon fallax*, *Iseilema* spp. and *Themeda triandra*, occurring on red, grey and brown clays (Plate 16).

The mixed grassland habitat varies in condition, from very good to very poor, particularly around tanks and troughs where it has been trampled by livestock (Plate 17). The tall grassland habitat is generally in good condition.

Plate 16: Tall grassland (left) and mixed grassland (right) on Carlton Plain

Plate 17: Degraded grasslands on the Carlton Plain (left) and Mantinea Plain (right)

The grasslands are likely to support a small suite of native fauna. A small group of species favour cracking clays, and these potentially occur in association with the tall grassland habitat. Conservation significant species that potentially occur include the Oriental Plover (*Charadrius veredus*), as this species inhabits open plains habitats, including degraded areas around tanks and bores. The conservation significant Grey Falcon (*Falco hypoleucos*) is likely to forage over the grasslands, though they nest elsewhere on tall trees.

6.1.6 Seasonal Wetlands

The seasonal wetlands in the Study Area were variable in size and vegetation. Beyond the wetlands mapped in Figure 9, there is also likely to be small pools that form in the drainage lines and floodplains during wet conditons. Other sources of water in the study areas were from man-made sources (e.g. dams, turkey's nest dams and tanks). Wetlands were generally clay depressions, some of which were holding water during the survey period (Plate 18) while others were dry (Plate 19). The vegetation was generally degraded by livestock, and the introduced Cane Toad (*Rhinella marina*) was common wherever water was present. Vegetation varied from Freshwater Mangrove (*Barringtonia acutangula*) over sedgelands of Chinese Water Chestnut (*Eleocharis dulcis*), to a large dry wetland of introduced *Parkinsonia aculeata* over chenopod shrubland and grasses.

Plate 18: Seasonal wetlands on Carlton Plain that held water in August 2016

Plate 19: Seasonal wetlands on Carlton Plain (left) and Mantinea Plain (right) that were dry in August 2016

Seasonally wet areas are likely to be used by a variety of fauna that move into the area to take advantage of the temporary availability of water. Areas of water are likely to be used by both wetland-dependent fauna (such as crocodiles, waterbirds and frogs) and other fauna coming into drink or bathe. Seasonal wetlands may support conservation significant migratory shorebirds during the wet season, as well as other conservation significant

waterbirds such as the Glossy Ibis (*Plegadis falcinellus*). The Water-Rat (*Hydromys chrysogaster*) and crocodile species may be present when water is present.

6.1.7 Creeklines

The creeklines and associated floodplains support a woodland, generally of Boab (*Adansonia gregorii*), *Bauhinia cunninghamii* and *Terminalia* spp. over isolated clumps of *Flueggea virosa* and mixed grasses (Plates 20 and 21). Near the Carlton Hill homestead, the creekline is dominated by a mixed forest of *Corymbia bella, Melaleuca leucadendra* and *Terminalia hadleyana* over a tall shrubland of *Flueggea virosa* and *Pandanus spiralis* over grasses.

Although usually denser than surrounding habitats, the creeklines attract sheltering livestock and some areas are degraded. The introduced Cane Toad (*Rhinella marina*) was also present.

Plate 20: Creekline channels

Plate 21: Creekline floodplains

Creeklines are likely to provide habitat for a large number of vertebrate fauna species, and provide a 'corridor' through which fauna may move through the landscape. The larger trees and dense vegetation provide nest sites for birds. Boab and other larger trees may have hollows for hollow-nesting birds and roosting bats. The banks of the creekline channels

provide nesting habitat for the Rainbow Bee-eater (*Merops ornatus*), a conservation significant species.

6.2 Vertebrate Fauna Assemblages

The numbers of vertebrate species potentially occurring in the Study Area are summarised below in Table 17. The amphibians, reptiles, birds and mammals that have the potential to occur in the Study Area are listed in Appendix E; with the fauna observed during the Level 1 fauna field survey listed in Appendix M.

Fauna of the Study Area are discussed below, with those of conservation significance summarised also in Appendix O.

Table 17: Summary of Terrestrial Vertebrate Fauna that Potentially occur in the Study Area

Taxon	Total species	Introduced species	Conservation significant species		
			CS1	CS2	CS3
Amphibians	28	1	-	-	-
Reptiles	101	2	2	1	5
Birds	234	1	39	-	-
Mammals	49	6	2	4	-
Totals:	**357**	**6**	**19**	**14**	**2**

6.2.1 Amphibians

There are 28 species of frog that have the potential to occur in the Study Area, of which four species were recorded during the field survey (Appendix M). In general, the Kimberley region has a more diverse frog fauna than the south-west or arid regions of Western Australia, with frogs reliant on wet season rains for breeding (Tyler *et al*. 2000).

Frogs are likely to occur throughout the Study Area, and potentially breed anywhere that holds fresh water after rainfall. This includes temporarily inundated grasslands, seasonal wetlands, creeklines and man-made water sources such as turkeys nests, dams and tanks. During the dry season some frogs aestivate underground in grasslands and cracking clays so are not easily sampled during dry season fauna surveys.

Some of the listed species inhabit caves, rock crevices and rocky creeks or pools, including Copland's Rock Frog (*Litoria coplandi*), Rockhole Frog (*Litoria meiriana*), Carpenter Frog (*Limnodynastes lignarius*), Chattering Rock Frog (*Litoria staccato*) and Magnificent Tree Frog (*Litoria splendida*) (Tyler *et al*. 2000). Although some of these species are common in the region, there is little suitable habitat present in the study areas. These species are likely to

be absent from the Mantinea Plain area, though they potentially occur around Houseroof Hill in the Carlton Plain area.

The Cane Toad (*Rhinella marina*) front moved through the study areas in about 2010 - 2011. Cane Toads were very commonly encountered in the Study Area, particularly around dams, creeks (including dry creeks) and seasonal wetlands. The Cane Toad is listed as a key threatening process under the EPBC Act, and is likely to have had an impact on the overall faunal assemblage in the Study Area.

No frogs of conservation significance are likely to be present in the Study Area.

6.2.2 Reptiles

There are 101 species of reptile that have the potential to occur in the Study Area, of which 17 species were recorded in the study area during the fauna surveys (Appendix M).

Many species are widespread, occurring on a range of substrates (sands, clays and rock) in a range of vegetation types (grasslands, shrublands, woodlands or wetland margins). However, there are suites of reptiles that show more specific habitat requirements, and these are likely to be restricted to parts of the Study Area.

Some of the listed species usually only occur in rocky habitats, including the *Gehyra koira*, *Gehyra nana*, Northern knob-tailed Gecko (*Nephrurus sheai*), Two-spined Rainbow Skink (*Carlia amax*), Ring-tailed Dragon (*Ctenophorus caudicinctus*), Kimberley Rock Monitor (*Varanus glauerti*), Black-palmed Monitor (*Varanus glebopalma*), Long-tailed Rock Monitor (*Varanus kingorum*) and Storr's Monitor (*Varanus storri*). These species potentially occur on sandstone hills (Houseroof Hill) and stony plains in the Study Area.

Species strongly associated with wetland habitats include crocodiles, turtles, the Water Python (*Liasis mackloti*), Keelback (*Tropidonophis mairii*), Merten's Water Monitor (*Varanus mertensi*) and Mitchell's Water Monitor (*Varanus mitchelli*). These species are likely to occur on the Ord River, as well as in seasonal wetlands, creeklines or floodplains in the Study Area. The Water Python was recorded in a wetland in the Carlton Plain area, and the crocodiles were recorded in dams (Appendix M).

Cracking clays in floodplain and grassland habitats are likely to support a specific suite of reptiles, including the Black-soil Skink (*Ctenotus rimacola*), Ord Snake (*Suta ordensis*) and Curl Snake (*Suta suta*).

Woodlands support reptiles that inhabit trees, including the Zigzag Velvet Gecko (*Amalosia rhombifer*), Spotted Tree Monitor (*Varanus scalaris*), Frill-neck Lizard (*Chlamydosaurus kingii*) and Chameleon Dragon (*Chelosania brunnea*). These species are likely to be absent from grasslands and other treeless habitats.

There are seven reptiles of conservation significance that may occur in the Study Area, two of CS1 and five of CS2. Each species is listed and discussed below.

Conservation Significance 1

Freshwater Crocodile *Crocodylus johnstoni*
This species is listed under Schedule 7 (specially protected fauna) of the WC Act.

Saltwater Crocodile *Crocodylus porosus*
This species is listed as Migratory under the EPBC Act and under Schedule 7 (specially protected fauna) of the WC Act.

The Freshwater Crocodile was recorded in a dam on the Carlton Plain area and the Saltwater Crocodile was recorded from a dam in the Mantinea Plain area (Appendix M). Both species are common in the nearby Ord River and capable of moving over dry land, so may be present even in isolated pools and seasonal wetlands in the areas surveyed. Although listed as CS1, these species are both common in the region and the Study Area is unlikely to provide significant habitat.

Conservation Significance 2

Sandamarra Blind Snake *Anilios troglodytes*
This species is listed as Priority 1 by DPAW.

The Sandamarra Blind Snake is known only from the Kimberley region of Western Australia, between Napier Range and Kununurra. As it is known from very few records and its habitat preferences are unknown, it is difficult to state with certainty the likelihood of this species occurring in the Study Area, or which habitats it may occur in.

Conservation Significance 3

Black-soil Skink	*Ctentous rimicola*
Ord Snake	*Suta ordensis*
Curl Snake	*Suta suta*
Wide-banded Northern Bandy-bandy	*Vermicella intermedia*
Narrow-banded Northern Bandy-bandy	*Vermicella multifasciata*

There are five species potentially occurring in the Study Area that could be of local conservation significance due to their restricted range. All are known from the general area on the WA Museum Specimen Database (Appendix E). Of these, the Black-soil Skink, Ord Snake and Curl Snake are known to favour cracking clays and are likely to be restricted to floodplains and grasslands with cracking clays in the Study Area.

The Wide-banded and Narrow-banded Northern Bandy-bandys are known from few records in Western Australia (Storr *et al*, 2002). Because of the paucity of information on these species it is difficult to ascertain their status in the Study Area.

6.2.3 Birds

There are 234 species of bird that have the potential to occur in the Study Area, of which 103 were recorded during the fauna survey (Appendix M).

A significant proportion of the birds listed in Appendix M are waterbirds and wetland-dependent species such as ducks, herons, ibis, cormorants and shorebirds. These species are likely to occur along the adjacent Ord River, as well as in the Study Area in seasonal wetlands, dams and in pools along creeklines. Vegetated wetland areas are potential breeding sites for waterbirds, including those that breeding trees (e.g. herons and ibis) and those that breed on the ground amongst vegetation.

Birds tend to be more common in more wooded areas, such as along creeklines, as well as around water sources such as seasonal wetlands and dams. Where trees such as *Bauhinia cunninghamii* and *Erythrina vespertilio* were in flower, honeyeaters were common. The abundance and distribution of honeyeaters is likely to change between seasons, depending on the plant species flowering.

Species that nest in hollows are likely to favour savannah woodlands and wooded creeklines and floodplains. Areas of dense vegetation are likely to support breeding by smaller passerines.

There are 39 birds of conservation significance that have either been recorded or may potentially occur in the Study Area. The majority of the species listed are migratory shorebirds. Each species is listed in the boxes below, and discussed.

Conservation Significance 1 – Threatened Species or Specially Protected Species

Red Goshawk *Erythrotriorchis radiatus*
This species is listed as Vulnerable under the EPBC Act and under Schedule 3 (Vulnerable) of the WC Act.

Australian Painted Snipe *Rostratula benghalensis australis*
This species is listed as Vulnerable and Migratory under the EPBC Act and under Schedule 3 (Vulnerable) of the WC Act.

Curlew Sandpiper *Calidris ferruginea*
This species is listed as Critically Endangered and Migratory under the EPBC Act and is listed under Schedules 3 (Vulnerable) and 5 of the WC Act.

Masked Owl (Kimberley) *Tyto novaehollandiae kimberli*
This species is listed as Vulnerable under the EPBC Act and as Priority 1 by DPAW.

Grey Falcon *Falco hypoleucos*
This falcon is listed under Schedule 3 (Vulnerable) of the WC Act.

Peregrine Falcon *Falco peregrinus*
This falcon is listed under Schedule 7 (other specially protected fauna) of the WC Act.

Crested Shrike-tit (Northern) *Falcunculus frontatus whitei*
This species is listed as Vulnerable under the EPBC Act and as Priority 4 by DPAW.

Gouldian Finch *Erythrura gouldiae*
This species is listed as Endangered under the EPBC Act and as Priority 4 by DPAW.

The Red Goshawk is an uncommon bird of prey that is thought to have a population size of only 1,400 individuals (Garnett and Crowley 2000). It inhabits tall open forests and woodlands, savannah woodlands with large rivers and nests in a tall tree usually near a river. The Red Goshawk has been recorded nearby at Parry's Lagoon in 2005 (Appendix E), and may occur in the Study Area. The *Eucalyptus camaldulensis* woodland is potential nesting habitat for this species.

The Australian Painted Snipe is an extremely cryptic and scarce species and generally occurs in the north and east of Australia, with a few records from the south-west of Western Australia (Johnstone and Storr 1998). The population is thought to be declining and consists of 1,000 - 1,500 individuals (Garnett *et al*. 2011). This species generally inhabits shallow but well-vegetated ephemeral, seasonal or temporary wetlands, feeding on the water's edge (Garnett and Crowley 2000, Garnett *et al*. 2011). This species is known to occur at the nearby Parry Lagoons, with records from the 1980s and 1990s. Loss and degradation of suitable shallow wetlands has been a cause of the decline of this species. Grazing and trampling of native wetland vegetation by cattle and replacement of native wetland vegetation with weeds are also potentially threatening processes (Garnett *et al*. 2011). This species may possibly occur in the Study Area in the seasonal wetlands, or on the edges of floodplains, though it seems unlikely given that the vegetation is weedy and degraded by cattle.

The Curlew Sandpiper is a migratory shorebird that had declined significantly in recent years (DoEE 2016b). This species is uncommon in the region, though it has been recorded nearby at Parry's Lagoon in 1999 and 2000. This species may be a non-breeding visitor to seasonal wetlands in the Study Area during the wet season, though significant numbers of birds are unlikely to occur.

The Kimberley subspecies of the Masked Owl is poorly known, with a population estimated at 3,000 individuals and declining (Garnett *et al*. 2011). It has been recorded from riparian forest, rainforest, open forest, *Melaleuca* swamps and mangrove edges (DoEE 2016b), usually nesting in a eucalypt hollow within forest patches (Garnett *et al*. 2011). There is a single record of this species from 1931, within 40km of the study areas on DPAW's Threatened and Priority Fauna Database. If present, it is unlikely the Study Area supports more than one pair of birds. The home-range size of other subspecies is estimated at 500 - 1,000ha and the northern subspecies is thought to occur at even lower densities (Garnett *et al*. 2011). This species may inhabit the *Eucalyptus camaldulensis* or *Melaleuca* woodland habitats.

The Grey Falcon forages over lightly timbered plains, including *Acacia* shrublands, with its distribution centred on inland drainages. The Grey Falcon nests in tall trees on watercourses (Garnett *et al*. 2011) and occasionally on man-made structures such as transmission line towers (pers. obs.). The population of this species is estimated at 1,000 individuals and declining (Garnett *et al*. 2011). The Grey Falcon was recorded on the Mantinea Plain area in 2009. This species potentially breeds nearby on the Ord River or in the Study Area on timbered creeklines, transmission line towers or the *Eucalyptus camaldulensis* woodlands on the floodplain. The Grey Falcon potentially forages over the grasslands and open woodland habitats of the Study Area. As this species occurs at very low densities (Garnett *et al*. 2011), it is unlikely that more than a single pair of birds is present.

The Peregrine Falcon is a widespread bird of prey that globally has a very large range and a very large population that appears to be secure (BirdLife International 2016). The Peregrine Falcon nests mainly on ledges on cliffs or rocky outcrops, and it may also use tall trees (Johnstone and Storr 1998). This species also takes advantage of man-made structures such as abandoned open pits or quarries. The Peregrine Falcon has been recorded nearby at Kununurra and Parry Lagoons on DPAW's Threatened and Priority Fauna Database (Appendix E). The Peregrine Falcon may forage in the project area, with potential breeding habitat present on Houseroof Hill (Carlton Plain study area) and in larger trees.

The northern subspecies of the Crested Shrike-tit is endemic to northern Australia and is generally poorly known. This species was originally listed as Endangered in the Action Plan for Australian Birds 2000 as it was thought to have a declining and highly fragmented population of only 2,500 individuals (Garnett and Crowley 2000). However, it is not listed in the Action Plan for Australian Birds 2010 on the basis that this species has subsequently been found at many more sites and is not declining (Garnett *et al*. 2011). This species inhabitats open woodlands, particularly those dominated by flaky-barked bloodwood trees such as *Corymbia opaca*, *Eucalyptus tectifica* or *C. confertifolia*, and less commonly among *E. miniata*, *E. tetradonta* or *Melaleuca spp*. (DoEE 2016b). The Crested Shrike-tit was recorded on Ivanhoe Station in the 1950s (Appendix E) and 8,600ha of potentially suitable habitat has been mapped in the Ngamoowalum Conservation Park, south of the Mantinea Plain study area (Shedley 2012). The Northern Crested Shrike-tit may occur in the Study Area, in areas of *Eucalyptus* and *Melaleuca* woodland, though the lack of records in the East Kimberley suggests that this species is either very uncommon or under-reported.

The Gouldian Finch is distributed across northern Australia, and inhabits open forests and woodlands with a grassy understorey (Johnstone and Storr 2004). These finches are often found near fresh water, particularly in the dry season. Breeding occurs in the early dry season (April to July), generally in hilly or rocky areas with the birds building nests in hollows in smooth-barked *Eucalyptus* and *Corymbia* trees such as *Eucalyptus brevifolia* (Johnstone and Storr 2004, DoEE 2016b). Non-breeding (late dry - wet season) habitat is in woodlands where the birds feed on an understory of perennial grasses such as Spinifex (*Triodia*), *Alloteropsis* and *Chrysopogon* (Shedley 2012). Grazing by cattle and altered fire regimes are thought to be the most likely causes of declines in this species (Garnett *et al*. 2011). This species was listed as Endangered in the Action Plan for Australian Birds 2000 (Garnett and Crowley 2000). However, it is currently listed as Near Threatened in the Action Plan for Australian Birds 2010 on the basis that the declines in the population have ceased, even though the population size is well below historical levels at about 1,000 mature individuals (Garnett *et al*. 2011). Gouldian Finch breeding habitat is absent from the Study Area, but the grassland and savannah woodland habitats may support finches in the non-breeding season.

Conservation Significance 1 – Migratory Species

Species listed as both Migratory under the EPBC Act and under Schedule 5 of the WC Act.

- **Glossy Ibis** *Plegadis falcinellus*
- **Eastern Osprey** *Pandion haliaeetus (cristatus)*
- **Greater Sand Plover** *Charadrius leschenaultii*
- **Oriental Plover** *Charadrius veredus*
- **Pacific Golden Plover** *Pluvialis fulva*
- **Sharp-tailed Sandpiper** *Calidris acuminata*
- **Red-necked Stint** *Calidris ruficollis*
- **Long-toed Stint** *Calidris subminuta*
- **Swinhoe's Snipe** *Gallinago megala*
- **Black-tailed Godwit** *Limosa limosa*
- **Eastern Curlew** *Numenious madagascariensis*
- **Whimbrel** *Numenious phaeopus*

- **Ruff** *Philomanchus pugnax*
- **Wood Sandpiper** *Tringa glareola*
- **Common Sandpiper** *Tringa hypoleucos*
- **Common Greenshank** *Tringa nebularia*
- **Marsh Sandpiper** *Tringa stagnatilis*
- **Oriental Pratincole** *Glareola maldivarum*
- **Oriental Pratincole** *Glareola maldivarum*
- **Caspian Tern** *Sterna caspia*
- **Gull-billed Tern** *Sterna nilotica*
- **Oriental Cuckoo** *Cuculus opatus*
- **Fork-tailed Swift** *Apus pacificus*.
- **Red-rumped Swallow** *Cecropis daurica*
- **Barn Swallow** *Hirundo rustica*
- **Grey Wagtail** *Motacilla cinerea*
- **Yellow Wagtail** *Motacilla flava*

Species listed under Schedule 5 of the WC Act only.

- **Eastern Great Egret** *Ardea modesta*
- **Cattle Egret** *Ardea ibis*
- **Rainbow Bee-eater** *Merops ornatus*

Species is listed as Migratory under the EPBC Act only.

- **Arafura (Rufous) Fantail** *Rhipidura dryas (rufifrons)*

The Glossy Ibis, Eastern Great Egret and Cattle Egret are listed as Migratory, but their populations are large and secure (Birdlife International 2016). The Glossy Ibis is locally common in the Kimberley, both during and after the wet season (Johnstone and Storr 1998). The Eastern Great Egret was recorded during the site visit. This bird is common in shallow freshwaters of the Kimberley (Johnstone and Storr 1998), and is likely to commonly occur as individual birds or small flocks in the region. The Cattle Egret was not recorded during the fauna survey, though it was noted to be present on agricultural areas on Weaber Plains road, between Kununurra and the Carlton Plain study area. The Cattle Egret is generally uncommon, occurring in wetlands and short-grass pastures, often in association with cattle (Johnstone and Storr 1998). All three species are likely to occur in small flocks in the Study Area, generally around wetlands or roosting in trees near the Ord River.

The Eastern Osprey is generally a coastal species, but also ranges inland on estuaries and large rivers (Johnstone and Storr 1998). Although the Eastern Osprey may overfly the Study Area on occasion, there is unlikely to be important habitat present.

Several migratory shorebirds of the familes Charadriidae (plovers), Scolopacidae (sandpipers and allies) and Glareolidae (pratincoles) are known from the region, and have been recorded in the 40km surrounding the Study Area on DPAW's Threatened and Priority Fauna Database. These species breed overseas, and migrate to Australia for the non-breeding season, usually between September and March. A site is internationally significant to migratory shorebirds if it meets Ramsar criteria, i.e. it regularly supports 1% or more of the flyway population of a waterbird species or 20,000 or more waterbirds. A nationally important site is one that regularly supports 0.1% of the flyway population of a migratory shorebird species, 2,000 migratory shorebirds or 15 shorebird species (DoE 2015a). The 1% and 0.1% population threshold criterion for each species is listed in Appendix N.

It was not possible to survey for migratory shorebird species during the fauna survey as these species are absent during the dry season.

In the study areas, the habitats that may support migratory shorebirds are seasonal wetlands, intertidal creeks, dams, short grasslands and sparsely vegetated areas such as degraded grasslands. The Greater Sand Plover, Pacific Golden Plover, Eastern Curlew and Whimbrel are known to prefer sandy beaches, intertidal mudflats or mangroves (Geering *et al*. 2007), habitats that are generally absent from the Study Area. These species are likely to occur nearby in the Ord River Floodplain Ramsar site, but are only likely to occur in the Study Area on occasion, potentially on the tidally influenced creeks in the Mantinea Plain area.

The Oriental Plover inhabits dry grasslands and sparsely vegetated plains and the Little Curlew occurs on short dry grasslands (Geering *et al*. 2007). The grasslands of the nearby Parry Lagoons are known to support internationally signifcant numbers of Little Curlew (Hale 2008). These species potentially occur in the Study Area in significant numbers.

The Oriental Pratincole occurs across northern Australia, where it occurs on bare ground near water (Johntone and Storr 1998). This species potentially occurs near seasonal wetlands or floodplains in the Study Area.

The Caspian Tern was recorded in the Mantinea study area in 2009 (Table 17). Globally, this tern has a large range and large population size (Birdlife International 2016). The Caspian Tern generally occurs on coasts, estuaries and tidal creeks, and is an uncommon dry season visitor to the north (Johnstone and Storr 1998). The Caspian Tern is likely to occur nearby on the Ord River Floodplain Ramsar Site and as an occasional non-breeding visitor to the tidal creeks in the Mantinea study area.

The Gull-billed Tern occurs along the coast of Western Australia, but also utilises inland waters including river pools and freshwater wetlands (Johnstone and Storr 1998). This species is known to be moderately common around Kununurra and Wyndham (Johnstone and Storr 1998). Small numbers of Gull-billed Terns may occur as non-breeding visitors to the Study Area, foraging over the wetland areas.

The Oriental Cuckoo is a regular wet season visitor to northern Australia between September and May (DoE 2015). In the Kimberley, it occurs in riparian forests, vine thickets and rainforest patches, as well as in open woodlands (Johnstone and Storr 1998, DoE 2015). Globally, this species has a very large range and a large population (Birdlife International 2016) and a site would need to support over 10,000 individuals or contain 25,000ha of suitable habitat to be nationally or internationally important. The Oriental Cuckoo is likely to be a visitor to the Study Area, where it is most likely to occur along the more densely vegetated creeks and eucalypt woodlands. However, it is unlikely to occur in ecologically significant numbers.

The Fork-tailed Swift is a non-breeding visitor to Australia between September and April (Boehm 1962). While it can be scarce in south-west Australia this species is generally more common in the north (Johnstone and Storr 1998). The bird is often observed foraging for insects in proximity to cyclonic weather (Boehm 1962), and can occur in small groups or flocks of more than 1,500 (DoE 2015). Although a migratory species, the Fork-tailed Swift has a large range and a large population that appears to be stable (Birdlife International 2016). The Study Area may support large numbers of this species at times. However, the Fork-tailed Swift is largely an aerial species in Australia and is unlikely to be impacted by clearing in the Study Area.

The Rainbow Bee-eater is a common species that is likely to be a breeding visitor to the Study Area. It was commonly recorded in both the Carlton and Mantinea Plains areas during the survey. This species may forage anywhere over the study areas, and is likely to breed where there are lighter soils in which to burrow, such as along the banks of creeks.

The Arafura Fantail is treated as a separate species to the Rufous Fantail according to WA Museum taxonomy, but is treated as a subspecies by the DoE (2015). Although listed as a Migratory species under the EPBC Act, the Arafura Fantail is not thought to migrate like other subspecies of Rufous Fantail. Although recorded in the 40km surrounding the Study Area on the Birds Australia Atlas Database (Appendix E), this species is likely to be rare in the Study Area, occurring only in the densest vegetation. To be nationally significant, a site would need to support 2,200 birds or contain 450ha of habitat, and it is unlikely that this is the case.

The Red-rumped Swallow and Barn Swallow are regular, but uncommon, non-breeding visitors to northern Australia in the wet season (DoE 2015). Globally, these species occur across a very large range and have very large populations (Birdlife International 2016). For a site to be internationally important for these species it would need to support over 10,000 individuals, or 1,000 individuals to be nationally important. These species forage over wetlands and open vegetation such as grasslands (DoE 2015). A single Barn Swallow was recorded foraging over a wetland in the Carlton Plain study area (Table 17). Both species may occur in the Study Area in the wet season, but are not likely to be present in ecologically significant numbers.

The Grey Wagtail and Yellow Wagtail are both migratory species with a very large range and a very large global population (Birdlife International 2016). Occurring as non-breeding visitors to northern Australia in the wet season, the Grey Wagtail is rare visitor and the Yellow Wagtail is a regular but uncommon visitor in small numbers (DoE 2015). The Grey Wagtail generally favours rocky areas near water, though it also occurs in other wetlands (DoE 2015). The Yellow Wagtail inhabits well-watered grasslands, wetland fringes and dams. The Yellow Wagtail has been recorded in the area on DPAW's Threatened and Priority Fauna Database (Appendix E). A site would need to support over 1,000 individuals of either species to be nationally important, and 10,000 individuals to be internationally important (DoE 2015). Both species may occur in wetlands and seasonally inundated grasslands in the Study Area, but are likely to occur as single birds or small flocks rather than in ecologically significant numbers.

6.2.4 Mammals

There are 49 species of mammal that have the potential to occur in the Study Area, of which 43 are native and six introduced. Eighteen species (15 native and three introduced) were recorded opportunistically during the fauna survey. The mammal assemblage is likely to have changed in the 100+ years since the area was established as pastoral property. The overall species richness is likely to be slightly lower due to regional extinctions, and the abundance of some species is likely to have changed. Species negatively affected by structural habitat changes (e.g. loss of understorey vegetation) are likely to have decreased in abundance, while those favoured by anthropocentric changes (e.g. provision of artificial water sources) are likely to have increased.

The Agile Wallaby (*Macropus agilis*) was common across both survey areas, and was observed particularly around creeklines and on the Carlton Hill Homestead near water and watered lawns. The Euro (*Macropus robustus*) was recorded in the vicinity of Houseroof Hill. The Common Rock Rat (*Zyzomys argurus*) and Ningbing False Antechinus (*Pseudantechinus ningbing*) and Short-eared Rock-Wallaby (*Petrogale brachyotis*) were recorded on camera traps on Houseroof Hill. These species are likely to be restricted to the sandstone hills and stony plains.

The grasslands and floodplains with cracking clays are likely to support small ground-dwelling mammals that shelter in the soil cracks, such as the Long-tailed Planigale (*Planigale ingrami*). Some species such as the Western Chestnut Mouse (*Pseudomys nanus*) are likely to favour creeklines, though they are also likely to occur in tall grasslands.

Eight species of bat were positively identified in the Carlton study area, on the basis of their calls recorded during the site visit (Appendix G). Up to a further six species may be present, but their calls are unable to be distinguished reliably and their presence can only be confirmed through capture. Depending on the species, bats generally roost in hollows or crevices in trees, or in caves and crevices in rocky habitats. The Study Area lacks caves, but tree hollows are present in the savannah woodlands and rock crevices are present on the sandstone hills.

There are six mammals of conservation significance that may occur in the Study Area. Each species is listed and discussed below.

Conservation Significance 1

Northern Quoll *Dasyurus hallucatus*
This species is listed as Endangered under the EPBC Act and under Schedule 2 (Endangered) of the WC Act.

Ghost Bat *Macroderma gigas*
This bat is listed as Vulnerable under the EPBC Act and under Schedule 3 (Vulnerable) of the WC Act.

The Northern Quoll is a medium-sized carnivore that was listed under the EPBC Act in 2005 partly due to concern about the impact of the Cane Toad on the species. The Northern Quoll has apparently disappeared from its range in the south-east and south-west Kimberley, remaining in rocky areas of the Mitchell Plateau (Braithwaite and Griffiths 1994). The range contraction is possibly due to the effects of changed fire regimes and cattle grazing (Van Dyck and Strahan 2008). Except for Houseroof Hill, the Study Area lacks the rocky habitats that are considered to be the core habitat for the Northern Quoll. The Northern Quoll was not recorded on camera traps set on Houseroof Hill (Figure 4), though it should be noted that four camera traps were insufficient to sample the entire hill.

The Ghost Bat is a large carnivorous bat that occurs across northern Australia. The population is thought to be less than 10,000 individuals, with two thirds of those in the Kimberley region (Woinarski *et al*. 2014, TSSC 2016). Permanent roosts are in deep caves and mines with relatively stable temperatures and high humidity (Woinarski *et al*. 2014). Rock crevices and shallow caves are also used as daytime roosts. Ghost bats use several roost sites, contracting back to relatively few permanent roost sites when breeding. Studies have found that foraging occurs within 1.9km from the roost on average, with a mean foraging area of 61ha (Woinarski *et al*. 2014). Ghost Bats are threatened by loss of roosting habitat (mostly in the Pilbara), disturbance at roost sites, degradation of foraging habitat, mortality on barbed wire fences near roost sites and poisoning by Cane Toads (Woinarski *et al*. 2014, TSSC 2016). Although not recorded during the survey, the Ghost Bat may roost at Houseroof Hill in the Carlton Plain study area, and forage over the remaining habitats in the Study Area. No permanent (maternity) roosts are likely to be present.

Conservation Significance 2

Northern Leaf-nosed Bat *Hipposideros stenotis*
This bat is listed as Priority 2 by DPAW.

Orange Leaf-nosed Bat *Rhinonicteris aurantia*
This bat is listed as Priority 4 by DPAW.

Water-Rat (Rakali) *Hydromys chrysogaster*
This species is listed as Priority 4 by DPAW.

Lakeland Downs Mouse *Leggadina lakedownensis*
This mouse is listed as Priority 4 by DPAW.

The Northern Leaf-nosed Bat occurs across northern Australia. It is thought to have a population of about 10,000, and a decline has been inferred due to the loss of some known mainland colonies and a reduction in reporting rates (Woinarski *et al*. 2014). This species occurs in rocky hills, roosting in caves, mines and boulder piles. At night it forages in a range of habitats adjacent to the rocky roosting areas. This species may be threatened by loss of roost sites, disturbance at roosts and inappropriate fire regimes (Woinarski *et al*. 2014). The calls of this species were recorded on Houseroof Hill on the Carlton area. The Northern Leaf-nosed Bat may roost in deep crevices on Houseroof Hill and in the ranges outside the Study Area. It is likely to forage across the Study Area.

The Orange Leaf-nosed Bat occurs across northern Australia and in the Pilbara. Although the Pilbara form is listed as Vulnerable under the EPBC Act, the taxon as a whole is considered of Least Concern in the Action Plan for Australian Mammals 2012 (Woinarski *et al*. 2014). The Orange Leaf-nosed Bat roosts communally in warm, humid caves or mine adits, foraging in adjacent habitats (Woinarski *et al*. 2014, Duncan *et al*. 1999). This species is known from caves in the surrounding area, and has been recorded on DPAW's Threatened and Priority Fauna Database (Appendix E). The calls of this species were recorded on Houseroof Hill and the woodland site on the Carlton study area (Figure 4; Appendix M). The Orange Leaf-nosed Bat roosts in ranges outside the Study Area and is likely to forage over habitats in the Study Area.

The Water-Rat is patchily distributed throughout its range, but is usually found near permanent water where it forages mainly for aquatic prey such as large insects, crustaceans and fish (Van Dyck and Strahan 2008). There are several recordings of this species for Kununurra on DPAW's Threatened and Priority Fauna Database, including a recent record from 2008. This species may occur adjacent to the Study Area on the Ord River. Its use of the Study Area is likely to be sporadic, as individuals may opportunistically move into inundated seasonal wetlands.

The Lakeland Downs Mouse mostly inhabits grasslands (including seasonally inundated sandy-clays and cracking clays), but also occurs in tropical eucalyptus woodlands and stony

ranges (Van Dyck and Strahan 2008, Woinarski *et al*. 2014). Populations of this species can fluctuate dramatically (Van Dyck and Strahan 2008), so it may be common in one year and virtually absent in another. The population is thought to be declining, with current threats including habitat loss and degradation, predation by feral cats and inappropriate fire regimes. The Lakeland Downs Mouse was recorded in the Mantinea Plains study area in 2009 (Strategen 2010) and is likely to be widespread in the larger Study Area. This species potentially occurs in most habitats, but particularly grasslands.

7 DISCUSSION AND CONCLUSIONS

7.1 Flora and Vegetation

7.1.1 Vegetation Types

The Mantinea and Carlton Plains Study Area has 35 VTs defined by the dominant species recorded within each vegetation stratum. The definition of these units was significantly influenced by the condition of the vegetation and seasonal constraints at the time of survey. It is likely that a Level 2 survey (EPA 2004a) conducted during the appropriate season may rationalise this number of units, amalgamating some and potentially dividing others to reflect the floristic composition of each. Despite this, the units as presented also reflect topographic and soil factors recorded across the Study Area and provide a suitable level of detail to describe the vegetation of the area and inform the design of any future detailed investigations.

7.1.2 Conservation Significance of Vegetation types

Conservation significance of VTs is determined by comparison of units with descriptions of Threatened and Priority listed ecological communities as listed by DPaW or the DOEE. Additional levels of significance are assigned through assessment of the spatial representation of units in the local and regional setting to determine whether particular units may be restricted in distribution. The presence of conservation significant flora or fauna may also confer conservation significance on a particular VT.

Thirty three VTs mapped within the Study Area comprise a DPaW listed PEC (Ivanhoe Landsystem – Priority 3). Comparison of the VT mapping with the earlier Landsystem mapping conducted at a scale of 1:1 000 000 indicates that the earlier work was highly accurate given the scale of data capture, with an observed high correlation of mapped boundaries with soils and geology of the area.

Nineteen VTs were mapped with their individual areas comprising less than one percent of the total Study Area indicating a restricted coverage and distribution locally. Some of these were associated with upland systems at the edge of the Study Area (8, 10, 13, 24, 25, 29, and 35) that may have broader distributions. However others were recorded as isolated landscape units; usually associated with minor wetlands or drainage units, and potentially represent VTs that may be restricted in the local area and potentially regionally (3, 21, 31 and 33). Determination of the conservation significance of these units is difficult in the absence of a regional quadrat dataset for comparison however a Level 2 survey at the appropriate time of year would provide further data required to confirm the VT groupings

presented here and potentially provide additional data to clarify conservation significance of units.

Vegetation Type 1, while not particularly restricted in the Study Area comprises suitable habitat for the Threatened taxon *Typhonium* sp. Kununurra (A.N. Start ANS 1467) and as such should be considered in the absence of a suitable seasonal survey to be conservation significant. A survey of this VT prior to the commencement of any clearing at the appropriate time of year for identification of the taxon is recommended in accordance with the WC Act.

Shepherd *et al.* (2002) mapped and described vegetation system associations in the Keep IBRA subregion related to physiognomy, utilising mapping undertaken by Beard (1979). Six vegetation system associations occur in the Study Area. The majority of vegetation system associations present in the Study Area remain very well represented, with more than 98% of the pre-European extent remaining. All are represented within the conservation estate and total clearing of the Study Area would not result in any of the 6 VSAs falling below the 30% pre-European threshold at which they are considered to be restricted (as per EPA 2000).

7.1.3 Vegetation Condition

The vegetation condition of the Study Area ranged from Excellent to Completely Degraded at the time of survey. The majority of the vegetation in the Study Area has been significantly altered by grazing (by bother native animals (wallabies) and cows), and affected by drought conditions experienced over the preceding 2 years of below average annual rainfall, with large areas mapped as Very poor to Completely Degraded.

The generally poor condition of the vegetation and the heavy grazing (primarily by wallabies and cows) caused difficulties in determining grass species in particular, and therefore weed composition/levels as well as vegetation structure. The vegetation of Mantinea Station was in particular heavily grazed and in generally poor condition. The vegetation of Carlton Station was generally in better condition than Mantinea, however the southwestern parts particularly areas in close proximity to the Ord River were more heavily grazed and had higher weed levels. Grazing pressure was evident from cattle, however significant numbers of agile wallabies were observed on both sides of the Ord River and therefore had contributed to grazing impact.

In comparing the results and photographs taken during the Pilbara Flora survey in 2010 with the vegetation surveyed in 2016 it appears that vegetation condition at many sites has declined significantly. The current survey recorded many less introduced grasses and at much lower cover/density than the earlier survey.

7.1.4 Flora

A total of 200 discrete native vascular flora taxa were recorded within the Study Area during this survey. This is considered a relatively low number of taxa given the size of the Study Area and is attributed to the condition of the vegetation as discussed previously and also the timing of the survey. Ephemeral taxa (annuals, geophytes and aquatic taxa) are largely

missing from the survey results as well as many understorey taxa that would have been grazed to the point of eradication or to a state where they could not be identified.

A Level 2 survey conducted at the appropriate time of year for the region (March to May) following monsoonal rain is expected to add considerably to the species list reported here. Many ephemeral taxa will become evident following the wet season and the majority of taxa will flower/fruit and generally become easier to identify as a result of conditions suitable for germination and growth.

7.1.5 Conservation Significant Flora

No Threatened taxa as listed under the EPBC Act or WC Act were recorded within the Study Area. *Brachychiton tuberculatus* (P3) was recorded at 9 separate locations within the Study Area, with a further historical location known near Carlton Homestead (DPaW 2016e). This taxon has a relatively wide distribution within Western Australia, with locations referenced on *Naturemap* (DPaWd) extending between 60km north and south of Kununurra, westwards to Carlton Hill Station and eastwards to the Western Australia – Northern Territory border (DPaW 2016e). Large numbers of this taxon have previously been recorded on the Western side of the Ord River in proximity to the Parry Creek Road (Woodman Environmental records), and in the Ord West Survey area (EcoLogical 2013), indicating potentially large populations within the local areas. This taxon is also known from conservation estate (Jemarnde-wooningim Conservation Park Ngamoowalem Conservation Park (DPaW 2016d).

The interrogation of the DPaW databases (DPaW 2016c) identified a total of 32 conservation significant flora with known locations within 20 km of the Study Area. The risk assessment presented in Section 5.2.1 indicated that four taxa are known to occur within the Study Area including *Brachychiton tuberculatus* (P3), *Echinochloa kimberleyensis* (P1), *Goodenia brachypoda* (P1) and *Solanum pugiunculiferum* (P1). A further 26 conservation significant taxa have the potential to occur within the Study Area given their habitat preferences including *Typhonium* sp. Kununurra (A.N. Start ANS 1467)(T). A single taxon (*Heliotropium alcyonium* (P1)) has an unknown preferred habitat and therefore may also occur in the Study Area.

Potential habitat for *Typhonium* sp. Kununurra (A.N. Start ANS 1467) is present within the Study Area comprising areas of black soils mapped as VT1. As discussed in Section 5.2.1, the likelihood of this taxon occurring in the Study Area has been ranked as 'Potential' rather than 'Likely' due to the generally poor condition of the habitat areas. This taxon is ephemeral in nature emerging from below ground following periods of significant rainfall and only flowering for a relatively short period before dying back to below ground parts. A targeted survey of potential habitat areas at the appropriate time to confirm the presence of this taxon would be required prior to any clearing.

7.1.6 Introduced Taxa

A total of 24 introduced flora taxa were recorded during this survey of the Study Area. Of the introduced taxa recorded in the Study Area, *Parkinsonia aculeata* and *Xanthium occidentale* are Declared Pests under the BAM Act (DAF 2016), and *Parkinsonia aculeata* is also a WoNS (AWC 2016). It is recommended that all locations of these taxa are recorded

and eradicated immediately prior to any clearing activity and also routinely following any disturbance as a result of the proposal to develop the Study Area. Soil disturbance is likely to stimulate germination of soil stored seed of these taxa and soil movement associated with clearing and preparation for agricultural production is likely to spread them further in the local area.

Aerva javanica, *Azadirachta indica*, *Calotropis procera*, *Cenchrus ciliaris* and *Passiflora foetida* var. *hispida* are all ranked as 'High' for distribution, invasiveness and impacts in the Environmental Weed Strategy (CALM 1999). While all of these weeds are relatively widespread in the Kimberley and across the north of Western Australia, their control is important to the conservation of biodiversity of areas of native vegetation including local Nature Reserves and Conservation Parks.

7.2 Fauna

The Mantinea and Carlton Plains study areas have seven main habitats: sandstone hills, stony plains, savannah woodlands, floodplains, grasslands, seasonal wetlands and creeklines. The floodplains habitat can be divided into four sub-habitats and the grassland habitat can be divided into two sub-habitats, to give a total of eleven habitats in the study areas. These habitats occur elsewhere in the region, but some (e.g. seasonal wetlands) are much less common. Except for the sandstone hills, all the habitats were somewhat disturbed by both native animal (wallaby) and livestock grazing, resulting in loss of understorey vegetation and ground disturbance. The amount of disturbance varied across the Study Area, with some parts remaining in relatively good condition. In general, structurally diverse habitats, such as woodlands and creeklines support a greater number of vertebrate species.

Significant habitats for fauna include:

- Habitats with cracking clays (Tall grasslands and Guttapercha woodlands)

This habitat is likely to support a small, but unique, suite of vertebrate species.

- Seasonal wetlands

This habitat is likely to support a large number of vertebrate species and potentially a large number of conservation significant species, albeit many of them in low numbers.

Overall, the Mantinea and Carlton Plain study areas have the potential to support a wide range of terrestrial vertebrate species. This includes up to 28 frog, 101 reptile, 234 bird and 49 mammal species. A total of four frog (three native, one introduced), 17 reptile, 103 bird and 18 mammal (15 native, three introduced) species were recorded from the Study Area during the 2016 Level 1 fauna survey. It is important to note that these records were opportunistic in the dry season only and that no trapping was undertaken.

Of the 53 species of conservation significant fauna, 28 species are wetland dependent, so are only likely to occur in the creeklines, seasonal wetlands and seasonally inundated

floodplains in the Study Area, and outside the Study Area on the Ord River and Parry Lagoons. There are no frogs of conservation significance likely to occur, but there are eight reptiles, 39 birds and six mammals of conservation significance that may occur.

Although a large number of migratory species are likely to occur, the Study Area is unlikely to support significant populations of most species. Many migratory species are widespread and abundant, including the Glossy Ibis, Eastern Great Egret, Cattle Egret, Barn Swallow, Red-rumped Swallow, Oriental Cuckoo, Fork-tailed Swift and Rainbow Bee-eater. The Study Area is likely to support many of these species, though not in ecologically significant numbers.

For migratory shorebirds, a site is only likely to be significant if it supports 1% or more of the global population (Appendix N), 15 or more species or more than 20,000 birds. Although unlikely to be significant for most species, the seasonal wetlands in the Study Area may potentially support significant numbers of a migratory shorebird species. To assess significance, ideally several surveys targeting peak non-breeding season (wet season) as well as southward and northward migration are recommended (DoE 2015).

Of the remaining conservation significant species, the Red Goshawk, Australian Painted Snipe, Curlew Sandpiper, Kimberley Masked Owl, Grey Falcon, Crested Shrike-tit, Northern Quoll and Ghost Bat are species that have threatened populations. Of these only the Grey Falcon is known to occur on the Study Area. The remaining species have a moderate (Australian Painted Snipe) or low likelihood of occurring.

The ecological values of the Study Area has been impacted by a long grazing history and by changes to the hydrology of the Ord River after dam construction. However, the area still maintains some value as fauna habitat. Important ecological values of the Study Area include:

- Habitats with high vertebrate fauna diversity, particularly around seasonal wetlands but also in structurally diverse habitats such as woodlands and creeklines.
- Regional habitat for bird species that occur in Parry Lagoons and the Ord River.
- Proximity to the Ord River.
- Corridor for fauna movement along the Ord River valley.

The Study Area is also likely to aid in supporting populations of fauna that occur in the broader area. Some species that occur in the adjacent Parry Lagoons and Ord River are likely to utilise the Study Area on a seasonal basis, e.g. waterbirds may disperse from permanent wetlands at Parry Lagoons to use seasonal resources on the Carlton and Mantinea Plains. Populations of fauna are likely to be continuous between the Study Area and the wider region.

7.3 Survey Constraints

7.3.1 Flora and Vegetation

The flora and vegetation survey undertaken satisfied the requirements of a Level 1 survey. However, it was not possible to sample ephemeral taxa and due to the generally poor condition of the vegetation following prolonged drought conditions many taxa, including conservation significant taxa were not visible or unidentifiable reducing the comprehensiveness of the survey and obscuring vegetation types.

A Level 2 post wet season flora and vegetation survey would more fully characterise the flora and vegetation of the Study Area, including identification of conservation significant flora and also allow the vegetation to be described in terms of floristic composition which provides a more repeatable and consistent description method. This would provide quantitative data comparable with more regional surveys and also allow a more comprehensive assessment of impacts should a formal impact assessment under the EP Act be required. Any Level 2 assessment should include the vegetation and habitats of the Ord River to allow assessment of potential impacts to the flora and vegetation of the riverine community as a result of development of the Carlton and Mantinea Plains.

7.3.2 Fauna

The fauna survey undertaken satisfied the requirements for a Level 1 fauna survey. However, it was not possible to assess the significance of the Study Area to migratory bird species that are only present in the wet season. A wet or post-wet season survey would enable a better understanding of the value of the seasonal wetlands to migratory species.

A Level 2 fauna survey, involving trapping and targeted surveys for vertebrate fauna, would give a more complete picture of the faunal assemblages present in each habitat. Ideally a Level 2 survey is undertaken in two seasons, with the most important survey occurring after the season of the highest rainfall. Any Level 2 assessment should include the habitats of the Ord River to allow assessment of potential impacts to the fauna of the riverine community as a result of development of the Carlton and Mantinea Plains.

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Legend

- Relevee

Vegetation Types

1 Low open to low woodland of mixed tree species including *Excoecaria parvifolia, Eucalyptus microtheca*, *Adansonia gregorii* and *Terminalia hadleyana* over low open to low closed sedgeland of *Cyperus* spp. over low isolated grasses to low closed grassland of mixed species including *Ophiuros exaltatus*, *Eulalia aurea* and *Chrysopogon fallax* over mixed low isolated forbs to open forbland flats, plains, floodplains and minor drainage lines on grey or brown cracking clay or loamy clay.

2 Low open woodland of *Adansonia gregorii* and *Bauhinia cunninghamii* over tall isolated clumps of shrubs of *Carissa lanceolata*, *Ehretia saligna* var. *saligna* and *Terminalia canescens* over low to mid grassland of mixed species including *Chrysopogon fallax*, *Cynodon convergens*, *Eriachne* ?*sulcata* and *Themeda triandra* over low isolated clumps of forbs of *Corchorus aestuans* and *Heliotropium euodes* on gentle slopes of low hillocks on grey-brown clay loam, with surface stones.

3 Mid isolated clumps of trees of *Adansonia gregorii* and *Eucalyptus microtheca* over low woodland of *Bauhinia cunninghamii* and *Excoecaria parvifolia* over tall sparse shrubland of *Flueggea virosa* subsp. *melanthesoides* over low open shrubland of **Sida cordifolia*, *Tribulopis pentandra* and *Waltheria indica* on plains with drainage lines and sinkholes on brown sandy clay.

4 Low open woodland to low woodland of *Eucalyptus microtheca* over tall isolated clumps of shrubs of *Melaleuca* ?*nervosa* occasionally with mid isolated clumps of shrubs of *Carissa lanceolata* over low to mid closed grassland to grassland of mixed species including *Chrysopogon fallaxa*, *Heteropogon contortus* and *Dichanthium fecundum* occasionally with low isolated clumps of trees of *Excoecaria parvifolia* on plains and floodplains on brown sandy clay.

5 Low woodland of *Eucalyptus microtheca* and *Excoecaria parvifolia* over mid isolated clumps of shrubs of *Carissa lanceolata* over low open grassland of *Chrysopogon fallax*, *Cynodon convergens* and *Aristida holathera* var. *holathera* on plains on orange clayey sand.

6 Mid open woodland to woodland of *Corymbia bella* and *Corymbia polycarpa* over low open woodland to woodland of *Acacia neurocarpa* and *Melaleuca* ?*nervosa* over low to mid sparse shrubland to shrublandÂ of * *Hyptis suaveolens* over low to mid grassland of mixed species including *Cynodon convergens* and *Setaria apiculata* on plains and drainage lines on brown sandy clay.

7 Low woodland of *Bauhinia cunninghamii* and *Grevillea striata* over tall isolated clumps of shrubs of *Carissa lanceolata* over low open grassland of *Chrysopogon fallax* and *Eriachne* sp. on plains on orange clayey sand.

8 Low isolated clumps of trees of *Corymbia* ?*grandifolia* over tall sparse shrubland of *Calytrix exstipulata* over tall isolated clumps of grasses of *Sorghum* ?*stipoideum* over low isolated clumps of forbs of *Spermacoce* ?*brachystema* on low hillocks on brown loamy sand, with sandstone outcropping and surface stones.

9 Low open woodland of *Melaleuca minutifolia* over mixed grassland dominated by species including *Chrysopogon fallax* and *Eriachne obtusa* often with *Triodia bitextura* on stony plains and low rises on light brown clay.

10 Low open woodland of *Terminalia platyptera* over mid isolated shrubs of *Bauhinia cunninghamii* and *Carissa lanceolata* over mid closed grassland of *Aristida holathera* var. *holathera* and *Sorghum* ?*stipoideum* on low hillocks on brown sandy clay, with surface stones.

11 Mid grassland of mixed species dominated by *Chrysopogon fallax*, *Iseilema* spp. and *Themeda triandra* on plains with red, grey and brown sandy clay and loamy clay.

12 Tall open to tall closed grassland of *Sorghum stipoideum* and *Ophiuros exaltatus* over mid isolated clumps of grasses to tall closed grassland of *Chrysopogon fallax*, *Heteropogon contortus* and *Themeda triandra* on plains on red or brown medium or loamy cracking clay.

13 Tall isolated clumps of shrubs of *Cochlospermum fraseri* and *Grevillea striata* over tall open grassland of *Sorghum stipoideum* over low closed grassland of mixed species including *Sorghum stipoideum* and *Triodia bitextura* on gentle slopes on brown sandy clay, between patches of low open woodland of *Corymbia* ?*grandifolia* and *Erythrophleum chlorostachys*.

14 Mid woodland of *Adansonia gregorii*, *Bauhinia cunninghamii* and *Terminalia* spp. *over tall isolated clumps of shrubs of* Flueggea virosa *subsp.* melanthesoides *over tall closed grassland of mixed species including* Heteropogon contortus*,* Chrysopogon fallax*,* Dichanthium fecundum *and* Panicum decompositum *on flats,* in drainage lines and on adjacent floodplains on brown-grey sandy to loamy clay and clay.

15 Mid isolated clumps of trees of *Corymbia bella* over low open woodland of *Bauhinia cunninghamii*, *Corymbia polycarpa* and *Eucalyptus microtheca* over mid isolated clumps of shrubs of *Carissa lanceolata* over mid grassland of *Themeda triandra* on plains on brown sandy clay.

16 Mid forest of **Moringa oleifera* in closed depressions of brown clay.

17 Low isolated clumps of trees of *Erythrina vespertilio* and *Gyrocarpus americanus* subsp. *pachyphyllus* over tall isolated clumps of shrubs to tall shrubland of **Calotropis procera*, *Ficus aculeata* var. *indecora* and *Flueggea virosa* subsp. *melanthesoides* over mid isolated clumps of shrubs to mid sparse shrubland of *Heliotropium muelleri* over low isolated clumps of forbs of **Hyptis suaveolens* occasionally with open woodland of *Eucalyptus camaldulensis* subsp. *obtusa* on floodplains on brown clay to clayey sand.

18 Mid woodland of *Eucalyptus camaldulensis* subsp. *obtusa* over tall sparse shrubland to shrubland of *Flueggea virosa* subsp. *melanthesoides* on drainage lines/floodplains on brown sandy clay to loamy clay.

19 Low to mid isolated clumps of trees to mid woodland of mixed trees dominated by *Corymbia bella*, often with *Ficus aculeata* var. *indecora* over tall isolated clumps of shrubs to tall open shrubland of **Calotropis procera* and *Flueggea virosa* subsp. *melanthesoides* over low to mid open shrubland of **Hyptis suaveolens*, between bands of bare soil or low isolated clumps to sparse grassland of mixed species on flats and plains on brown clay or loamy clay.

20 Tall open shrubland of **Parkinsonia aculeata* over low sparse to open chenopod shrubland of *Chenopodium auricomum* over sparse grassland of *Panicum decompositum* and ? *Dichanthium fecundum* fringed by tall sparse grassland of *Ophiuros exaltatus* and low open woodland of *Excoecaria parvifolia* on flats on grey clay.

21 Low woodland of *Barringtonia acutangula* subsp. *acutangula* over mid sedge-land of *Eleocharis dulcisover* over low sparse forbland of *Glinus lotoides* and ?*Heliotropium* sp. on closed depressions on grey clay.

22 Mid woodland to open forest of *Corymbia bella* and *Eucalyptus microtheca* over tall sparse to open shrubland of *Ficus aculeata* var. *indecora* and *Flueggea virosa* subsp. *melanthesoides* over low to mid open grassland to grassland of mixed species including and *Cynodon convergens* and **Urochloa mosambicensis* or occasionally with low isolated clumps to mid open forbland of **Hyptis suaveolens* on plains on brown clay and loamy clay.

23 Low open grassland of *Eriachne pulchella* subsp. *dominii* on outwash stony plains on brown clay.

24 Mid isolated clumps of trees of *Eucalyptus miniata* over low isolated clumps of trees of *Corymbia* ?*collina*, *Erythrophleum chlorostachys*, ?*Gardenia* sp. and *Owenia vernicosa* over tall isolated clumps of shrubs of *Calytrix exstipulata* over mid isolated clumps of shrubs of *Tephrosia* sp. over tall open grassland of *Sorghum stipoideum* on steep ridges and gullies with sandstone outcrops on brown clayey sand.

25 Low isolated clumps of trees *of Erythrophleum chlorostachys* and *Eucalyptus obconica* over tall isolated clumps of shrubs of *Calytrix exstipulata* and *Cochlospermum fraseri* over tall isolated clumps of grasses of *Sorghum* ?*stipoideum* over *Triodia bitextura* and *Triodia stenostachya* on midslopes with sandstone outcrops on light brown clay.

26 Low woodland to open forest of *Corymbia bella*, *C. polycarpa* and *C. confertiflora* over tall shrubland of mixed species including *Acacia neurocarpa*, *Melaleuca* ?*nervosa* and **Hyptis suaveolens* over mixed open grassland of Poaceae spp. on flats, plains and drainage lines on light brown sandy clay.

27 Mid open forest of mixed species dominated by *Corymbia bella*, *Melaleuca leucadendra* and *Terminalia hadleyana* over tall shrubland of *Flueggea virosa* subsp. *melanthesoides* and *Pandanus spiralis* var. *thermalis* over mid open forbland of **Hyptis suaveolens* and mid isolated clumps of grasses of *Setaria apiculata* on drainage lines on light brown silty sand.

28 Low woodland to open forest of species including *Adansonia gregorii*, *Bauhinia cunninghamii*, *Erythrophleum chlorostachys* and *Terminalia canescens* over tall open shrubland of *Calytrix exstipulata*, *Cochlospermum fraseri* and *Melaleuca minutifolia* over mixed open grassland to grassland on lower to upperslopes and hill top on light brown clay with metamorphic sandstone.

29 Low open woodland of *Bauhinia cunninghamii*, *Terminalia platyptera* and *Grevillea striata* over mid isolated clumps of shrubs of *Carissa lanceolata* over low grassland of mixed species including *Aristida holathera* var. *holathera*, *Eriachne obtusa* and *Sorghum* ?*stipoideum* with *Heliotropium euodes* on floodplains to outwash areas on light brown clay.

30 Low woodland of *Eucalyptus pruinosa* subsp. ?*pruinosa* and *Bauhinia cunninghamii* over mid isolated shrubs including *Carissa lanceolata* over grassland dominated by ?*Dichanthium fecundum* and *Heteropogon contortus* on drainage lines on brown clay.

31 Mid sparse to closed sedgeland of *Eleocharis dulcis* and occasionally *Cyperus macrostachyos* over low forbland of *Glinus lotoides* with occasional tall sparse shrubland dominated by *Ludwigina perennis* and *Excoecaria parvifolia* on closed depressions on brown clay.

32 Low open woodland of mixed *Adansonia gregorii*, *Corymbia greeniana, Corymbia confertiflora* and *Gyrocarpus americanus* subsp. *pachyphyllus* over tall open shrubland including *Ficus aculeata* var. *indecora* and *Flueggea virosa* subsp. *melanthesoides* over low shrubland of **Hyptis suaveolens* over mid open grassland to grassland dominated by *Heteropogon contortus* on plains on brown sandy to loamy clay.

33 Mid open forest of mixed species dominated by *Lophostemon grandiflorus* subsp. *riparius* over tall sparse shrubland dominated by *Flueggea virosa* subsp. *melanthesoides* over mid shrubland of **Hyptis suaveolens* over tall sparse grassland of *Heteropogon contortus* over low open grassland dominated by *Cynodon convergens* on drainage lines on brown loamy clay.

34 Low woodland of *Melaleuca argentea* and *Acacia neurocarpa* over tall shrubland of **Hyptis suaeveolens* overlow grassland dominated by *Cynodon convergens* on floodplains on brown clay.

35 Low woodland of mixed species including *Adansonia gregorii*, *Bauhinia cunninghamii* and *Corymbia confertiflora* over tall mixed grassland dominated by *Chrysopogon fallax* sometimes with *Triodia bitextura* on plains to low hills on brown clay.

C Cleared Land

WOODMAN ENVIRONMENTAL

N

This map should only be used in conjunction with WEC report KAI16-33-01.

Mantinea and Carlton Plains: Vegetation Type Mapping and Relevee locations Legend

Revision: A - 31 October 2016 Scale: 1:20,000 (A3)

Author: Bethea Loudon

WEC Ref: KAI16-33-01

Filename: KAI16-33-01-f05.mxd

Projection: GDA 1994 MGA Zone 52

Figure

5.0

433000 434000 435000 436000 437000

8294000 8293000 8292000 8291000 8290000 8289000 8288000

2
KAI-181
KAI-184
KAI-187
KAI-188
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4
11

433000 434000 435000 436000 437000

WOODMAN ENVIRONMENTAL

N

This map should only be used in conjunction with WEC report KAI16-33-01.

Mantinea and Carlton Plains: Vegetation Type Mapping and Relevee locations

Revision: A - 31 October 2016 Scale: 1:20,000 (A3)

Author: Bethea Loudon

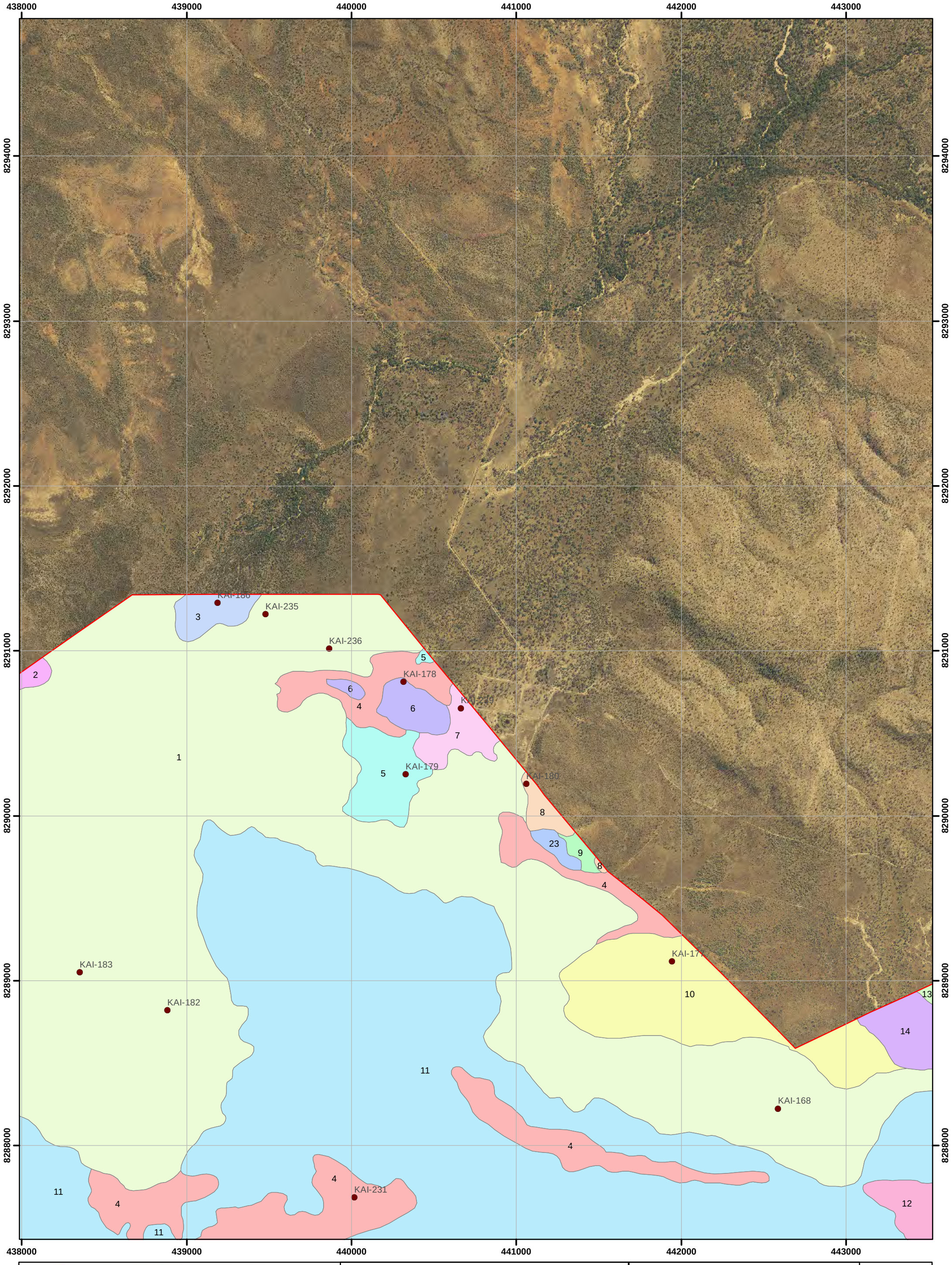
WEC Ref: KAI16-33-01

Filename: KAI16-33-01-f05.mxd

Projection: GDA 1994 MGA Zone 52

Figure

5.1



WOODMAN ENVIRONMENTAL

This map should only be used in conjunction with WEC report KAI16-33-01.

N

Mantinea and Carlton Plains: Vegetation Type Mapping and Relevee locations

Revision: A - 31 October 2016 Scale: 1:20,000 (A3)

Author: Bethea Loudon

WEC Ref: KAI16-33-01

Filename: KAI16-33-01-f05.mxd

Projection: GDA 1994 MGA Zone 52

Figure

5.2

444000 445000 446000 447000 448000 449000

8294000 8293000 8292000 8291000 8290000 8289000 8288000

KAI-166

13 1 11 12 13 14 15 11 14

WOODMAN ENVIRONMENTAL

This map should only be used in conjunction with WEC report KAI16-33-01.

N

Mantinea and Carlton Plains: Vegetation Type Mapping and Relevee locations

Revision: A - 31 October 2016 Scale: 1:20,000 (A3)

Author: Bethea Loudon

WEC Ref: KAI16-33-01

Filename: KAI16-33-01-f05.mxd

Projection: GDA 1994 MGA Zone 52

Figure

5.3

450000 451000 452000 453000 454000

8294000 8293000 8292000 8291000 8290000 8289000 8288000

450000 451000 452000 453000 454000

WOODMAN ENVIRONMENTAL

This map should only be used in conjunction with WEC report KAI16-33-01.

N

Mantinea and Carlton Plains: Vegetation Type Mapping and Relevee locations

Revision: A - 31 October 2016 Scale: 1:20,000 (A3)

Author: Bethea Loudon

WEC Ref: KAI16-33-01

Filename: KAI16-33-01-f05.mxd

Projection: GDA 1994 MGA Zone 52

Figure

5.4

433000 434000 435000 436000 437000

8287000 8286000 8285000 8284000 8283000 8282000 8281000

4
11
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11
19
18
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KAI-191
KAI-193
KAI-205a
KAI-205
KAI-204
KAI-199
KAI-195
KAI-194
KAI-198
KAI-197
KAI-196
KAI-092

WOODMAN ENVIRONMENTAL

This map should only be used in conjunction with WEC report KAI16-33-01.

N

Mantinea and Carlton Plains: Vegetation Type Mapping and Relevee locations

Revision: A - 31 October 2016 Scale: 1:20,000 (A3)

Author: Bethea Loudon

WEC Ref: KAI16-33-01

Filename: KAI16-33-01-f05.mxd

Projection: GDA 1994 MGA Zone 52

Figure

5.5