Priority Flora of the Mosquito Land System

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Executive Summary

Plantecology Consulting was commissioned by Millennium Minerals Limited (MML) to undertake a survey for Priority Flora that occur within part of their Nullagine Gold Project (NGP) tenements near Nullagine in the Pilbara region of Western Australia and to provide a context for any potential impacts that may result from mining activities.

The Priority Flora within the vicinity of the NGP were surveyed using one of two methods. Firstly, within the approximately 4000 ha comprehensive survey area, the ground was searched in closely spaced traverses. These traverses were directed by the detailed vegetation mapping of the site, which also included a complete census of *Acacia aphanoclada* occurrences. At each occurrence of *Acacia aphanoclada* the location was recorded and a complete count of individual plants taken within a 20m radius. Total counts of individuals of other Priority Flora was also undertaken except for *Acacia fecunda* and *Eucalyptus rowleyi*, which are both frequent and abundant in the Mosquito Land System.

Secondly*, Acacia aphanoclada* was surveyed at 245 sites along roads and tracks at intervals of 1 km in, and 2 km outside of, MML tenements, with the following recorded. At each random point, the data recorded included:

- the distance to the closest plant and the next plant closest to that one; and
- the species as absent where no plants were within 250 m of the site.

For the extent of *Acacia fecunda* and *Eucalyptus rowleyi* within the Mosquito Land System, the presence/absence of each species was recorded within 50 metres of each drainage line that was crossed by each road and track driven. Data was recorded at 325 minor/intermediate channels surveyed, and 14 major channels across the Mosquito Land System.

Two estimates of the total population size of *Acacia aphanoclada* was obtained in this study. The lower estimate (approximately 530 000 plants) still indicates a significant number of plants extant across the Mosquito Land System. This result is likely to under-estimate the total population size as it oversamples parts of the landscape where the species is uncommon (i.e. plains). The higher estimate (approximately 1 360 000 plants) is likely to be a more accurate result as it is extrapolated from complete counts of plants (13,164 plants have been directly counted) over approximately 2% of the Mosquito Land System. Although the species has a restricted distribution, localised disturbances are unlikely to represent a significant threat to local populations or to the species.

Acacia fecunda was recorded from 50% of minor drainage lines crossed during the land-system wide survey and is locally very abundant. It is often the dominant species where it is located. Similarly, *Eucalyptus rowleyi* is widespread and locally abundant.

The main targeted species in this study (*Acacia aphanoclada, Acacia fecunda* and *Eucalyptus rowleyi*) are widespread and abundant within the Mosquito Land System. Localised disturbances are unlikely to represent a significant impact to the viability of the local populations or to the species. *Ptilotus wilsonii,* however, is very restricted within the Mosquito Land System.

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1. INTRODUCTION

Plantecology Consulting was commissioned by Millennium Minerals Limited (MML) to undertake a survey for Priority Flora that occur within part of their Nullagine Gold Project (NGP) tenements near Nullagine in the Pilbara region of Western Australia and to provide a context for any potential impacts that may result from mining activities.

1.1 Objectives and Scope

The scope of this study was to:

- Undertake a review of publically available literature and spatial data relating to Priority Flora in the vicinity of NGP tenements;
- characterise the conservation-significant taxa with the potential to occur onsite (e.g. their lifeforms, habitats and flowering times);
- descriptions and maps of conservation significant plant taxa on site; and
- an assessment of regional significance of the Priority Flora.

1.2 Survey Area

The focus of the survey has been within the approximately 4000 hectare survey area, that extends eastwards from the Nullagine townsite (Figure 1.1). However, to provide context for potential impacts from mining activity on the populations of some taxa, additional studies were required to be undertaken across the extent of the Mosquito Land System.

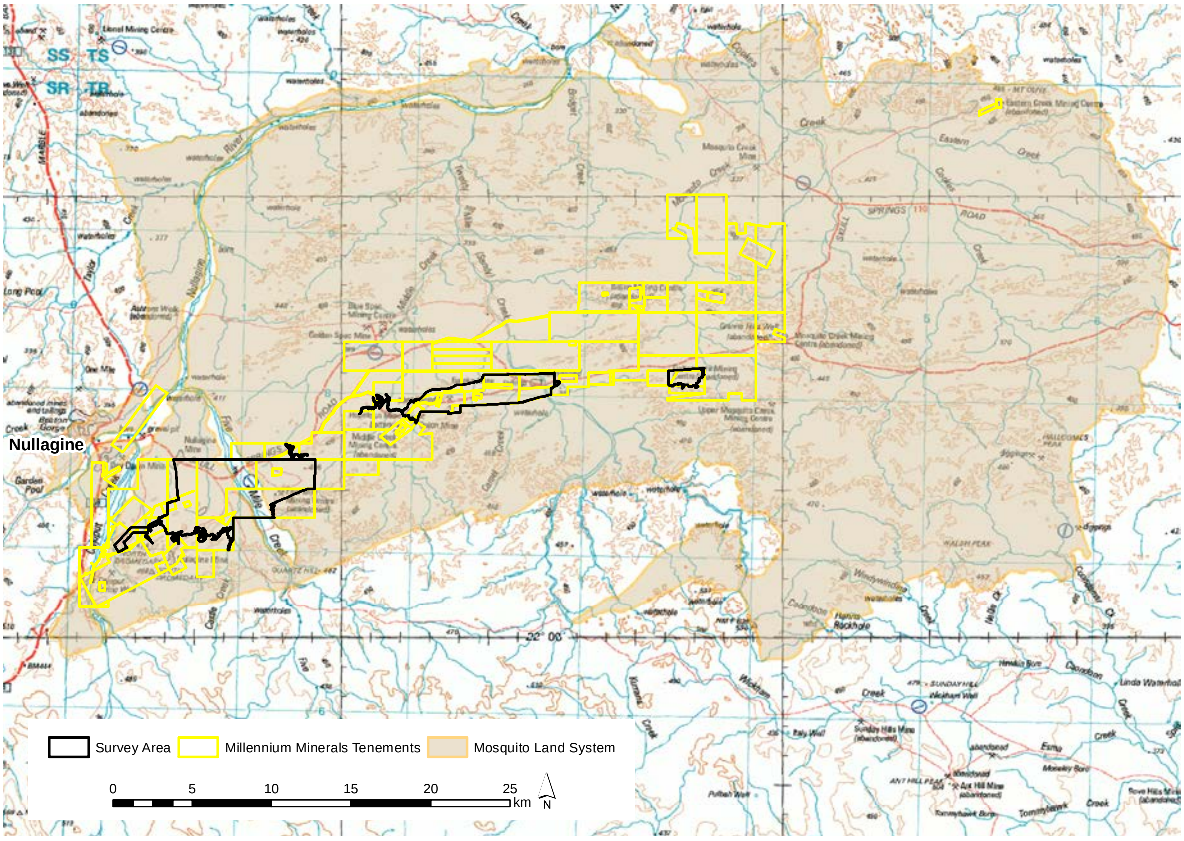

Figure 1.1: Location of Survey Area within the Mosquito Land System.

1.3 Targeted Taxa

Under the Wildlife Conservation Act 1950, the Western Australian Minister for the Environment may declare species of protected flora to be Threatened Flora if they are considered to be in danger of extinction, rare or otherwise in need of special protection. The Department of Parks and Wildlife also maintain lists of Priority Flora. Three categories of Priority Flora cover poorly known species and a fourth category covers species that have been adequately surveyed and are considered to be rare but not currently threatened. The definitions of categories of conservation significant species are as follows:

- **Threatened Flora (Declared Rare Flora - Extant Taxa)**

  Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.

- **Presumed Extinct Flora (Declared Rare Flora – Extinct)**

  Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such.

- **Priority One: Poorly-known taxa**

  Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.

- **Priority Two: Poorly-known taxa**

  Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.

- **Priority Three: Poorly Known taxa**

- Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.

- **Priority Four: Rare, Near Threatened and other taxa in need of monitoring**

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

  Near Threatened. Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

- **Priority Five: Conservation Dependent taxa**

  Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxa becoming threatened within five years.

In addition to this recognition of significance by the Government of Western Australia, some Threatened Flora (Declared Rare Flora) are additionally also listed as Matters of National Environmental Significance (threatened species) and protected under the Commonwealth EPBC Act 1999.

A total of 66 threatened and priority vascular flora taxa are listed for the Pilbara region.

A total of 22 threatened and priority flora taxa were targeted in the survey (Table 1) based on:

- a DPaW database search on 26/04/2016 (reference number 08-0516FL) that listed 21 threatened or priority taxa within 50 km of the survey area; and
- *Euphorbia sarcostemmoides* (P1), that was previously recorded nearby by Mattiske Consulting Pty Ltd (2012), but as discussed in Section 3.8 may have been a misidentification.

Seven of the targeted priority flora were recorded during the flora and vegetation survey undertaken by Plantecology Consulting (2016). These were *Acacia aphanoclada* (P1), *Acacia fecunda* (P3), *Eucalyptus rowleyi* (P3), *Ptilotus wilsonii* (P1), *Ptilotus mollis* (P4), *Atriplex spinulosa* (P1) and *Goodenia nuda* (P4). Additionally, three priority taxa had been recorded during previous surveys by Mattiske Consulting Pty Ltd (2005, 2006a, 2006b, 2012 and 2016). These were *Themeda* sp. Hamersley Station (P3), *Lepidium catapycnon* (P4) and *Euphorbia sarcostemmoides* (P1).

1.3.1 *Acacia aphanoclada (P1)*

Acacia aphanoclada is a slender shrub to 5m in height and is indicative of ridges and hills in the Mosquito Land System, a landform that occupies 40% of the 1,840 km^2 land system (van Vreeswyk, et al., 2004) (Plates 1.1 – 1.3). It occurs on skeletal stony soils, rocky hills, ridges and rises (DPaW, 2016), although it also extends in small quantities onto the flat terrain at the base of the hill, and occasionally in low-lying or flat areas or near drainage lines (Barker, 2007). It occurs with rocky "spinifex" (*Triodia* spp.) hills with scattered eucalypts and acacias on (Maslin 1998), generally in narrowly fissured vertical rock (Plate 1.4) and disturbed areas (Plate 1.5).

Table 1: Conservation-significant taxa identified as recorded or potentially occurring in the survey area and their recorded habitats.

Lifeform		Priority Species	Habitat
Trees, Mallees and Shrub >1m	P1	*Acacia aphanoclada*	Rocky hills, ridges and rises in skeletal stony soils
		Acacia cyperophylla var. *omearana*	Stony & gritty alluvium. Along drainage lines.
		Acacia sp. Nullagine	Rocky clay, low lying area between rocky hills.
		Cochlospermum macnamarae	Granite boulders.
		Euphorbia sarcostemmoides	Sandstone ridges, quartzite hills.
	P3	*Acacia fecunda*	Associated with quartzite gibbers over grey-red skeletal soil
		Eucalyptus rowleyi	Red sandy loams on plains and very minor and broad flood-outs
Shrubs < 1m	P1	*Ptilotus wilsonii*	Stony gravelly soils. Rocky hills.
		Stemodia sp. Battle Hill	Cracking clay. Floodplain.
	P2	*Indigofera ixocarpa*	Skeletal red soils over massive ironstone.
	P3	*Rostellularia adscendens* var. *latifolia*	Ironstone soils. Near creeks, rocky hills.
	P4	*Lepidium catapycnon*	Skeletal soils on hillsides.
		Ptilotus mollis	Stony hills and screes.
Perennial Grass < 1m	P3	*Themeda* sp. Hamersley Station	Claypans
		Triodia basitricha	Crest of sandstone hill.
Annual Grass < 1m	P3	*Eragrostis crateriformis*	Clay-loam or clay. Creek banks, depressions. In Pilbara mainly coastal, also Millstream-Chichester NP (WA Herbarium, 2015)
Annual Herb < 1m	P1	*Atriplex spinulosa*	Footslope of low hill, drainage floor with quartz covered surface, slopes of creek, stony pavement
	P3	*Goodenia* sp. East Pilbara	Red-brown clay soil, calcrete pebbles. Low undulating plain, swampy plains
		Nicotiana umbratica	Shallow soils. Rocky outcrops. Grows in shade of large boulders (WA Herbarium, 2015)
		Swainsona thompsoniana	Gibber plains, crabhole plains and gilgai
	P4	*Goodenia nuda*	Open depression. Brown sandy loam with granite stones.
Annual Sedge < 1m	P1	*Fimbristylis* sp. Shay Gap	Edge of small pool in basalt creekline.

1.3.2 *Atriplex spinulosa (P1)*

Atriplex spinulosa has been recorded as growing amongst hummock grasses on gibber plains on Mosquito Creek Series metasediments or along drainage lines (WA Herbarium, 2015), and this is consistent with where specimens have been collected from DAFWA inventory and traverse sites as part of an investigation by Land Assessment (2017) (see Plates 1.6 - 1.9).

1.3.3 *Ptilotus wilsonii (P1)*

Ptilotus wilsonii is a perennial dome-shaped woody shrub to 50 cm high and is superficially similar to *Ptilotus albidus*, but this species does not grow in the Pilbara (WA Herbarium, 2015) (Plate 1.10). It grows on stony gravelly soils and near rocky hills. As well as the Mosquito Land System, it has been recorded farther to the east in the Little Sandy Desert IBRA region (WA Herbarium 2015) (Plates 1.11 – 1.13).

Plate 1.1: *A. aphanoclada* habit

Plate 1.2: *A. aphanoclada* – Quadrat 15

Plate 1.3: *A. aphanoclada* typical slopes

Plate 1.4: *A. aphanoclada* soils

Plate 1.5: *A. aphanoclada* in disturbance


Plate 1.6: *A. spinulosa* habitat – DAFWA Site 51_21


Plate 1.7: *A. spinulosa* habitat – DAFWA Site 51_24


Plate 1.8 *A. spinulosa* habitat – DAFWA Site 258_13


Plate 1.9: *A. spinulosa* habitat – DAFWA Site 279


Plate 1.10: *P. wilsonii* domed habit


Plate 1.11: *P. wilsonii* habitat - Quadrat 22

Plate 1.12 *P. wilsonii* typical habitat

Plate 1.13: *P. wilsonii* hillside habitat

Plate 1.14: *A. fecunda* habit

Plate 1.15: *A. fecunda* habitat - Quadrat 24

Plate1.16: *A. fecunda* orange branchlets

Plate 1.17: *A. fecunda* habitat – Quadrat 29

1.3.4 *Acacia fecunda (P3)*

Acacia fecunda is a local endemic centred around the Mosquito Land System with 19 records across an area approximately 100 km north-south by 50 km east-west (DPaW, 2016). It favours water-gaining sites in areas underlain by the Mosquito Creek sedimentary rocks (Maslin & van Leeuwen, 2008) (Plates 1.14 - 1.17). It is not expected that this species has a particularly extensive geographic range (Maslin & van Leeuwen, 2008).

1.3.5 *Eucalyptus rowleyi (P3)*

Eucalyptus rowleyi is a smooth barked mallee to between 3-5m and occurs on red sandy loams on plains and very minor and broad flood-out plains, often in small pure stands or in open mallee vegetation with other eucalypt species (Nicolle & French, 2012). In the Plantecology Consulting (2016) survey it consistently occurred where clay was at the surface in either washout areas or drainage lines (Plates 1.18 and 1.20).

1.3.6 *Goodenia nuda (P4)*

Goodenia nuda is an erect to ascending herb up to 0.5m in height. It has been recorded throughout the Pilbara and extends to the Little Sandy Desert and Gascoyne IBRA regions (DPaW 2016) (Plate 1.21). Many *Goodenia* species prefer water-gaining sites, the margins of watercourses, or depressions (Sage & Pigott, 2003) and *Goodenia nuda* is a water-associated species (Sage & Pigott, 2003), mostly recorded from seasonally inundated clay soils and drainage lines, also recorded from sand in scoured river beds and from hillsides (WA Herbarium, 2015).

1.3.7 *Ptilotus mollis (P4)*

Ptilotus mollis is a compact shrub to 0.5m in height and typically occurs on steep rocky slopes, usually in full sun on massive ironstone formations throughout the Pilbara (WA Herbarium, 2015) (Plate 1.22).

Plate 1.18: *E. rowleyi* in clay riverbank

Plate 1.19: *E. rowleyi* - Quadrat 21

Plate 1.20: *E. rowleyi* along creek in background

Plate 1.21: *G. nuda* habit

Plate 1.22 *P. mollis* habit

2. METHODS

2.1 Surveys

The Priority Flora within the vicinity of the NGP were surveyed using three approaches. Firstly, within the approximately 4000 ha comprehensive survey area, the ground was searched in closely spaced traverses. These traverses were directed by the detailed vegetation mapping of the site, which also included a complete census of *Acacia aphanoclada* occurrences. At each occurrence of *Acacia aphanoclada* the location was recorded and a complete count of individual plants taken within a 20m radius. Total counts of individuals of other Priority Flora was also undertaken except for *Acacia fecunda* and *Eucalyptus rowleyi*, which are both frequent and abundant in the Mosquito Land System.

Secondly, to provide context for the potential impact of mining activity on the populations of *Acacia aphanoclada,* a survey of the density, extent and frequency of the species was conducted across the Mosquito Land System. This involved traversing the land system and surrounds by vehicle along all accessible roads and tracks at 245 randomised points, spaced at intervals of 1 km in, and 2 km outside of, MML tenements. At each random point, the data recorded included:

- the distance to the closest plant and the next plant closest to that one; and
- the species as absent where no plants were within 250 m of the site.

Finally, for the extent of *Acacia fecunda* and *Eucalyptus rowleyi* within the Mosquito Land System, the presence/absence of each species was recorded within 50 metres of each drainage line that was crossed by each road and track driven. Data was recorded at 325 minor/intermediate channels surveyed, and 14 major channels across the Mosquito Land System. The traverse points are shown in Figure 2.1.

It was agreed with DPaW that *Acacia aphanoclada* abundance estimates be based on plotless T-square sampling (based on distances between and within stands from points at predetermined intervals along roads and tracks), with data partitioned by landform to reflect that the species is concentrated on hills. However, in the field landform boundaries could not be consistently delineated at a sufficiently fine scale to reliably compartmentalise distance measurements within landforms, and this could not be resolved satisfactorily by either:

- combining all data to produce an overall density for the land system as sampling undertaken along the track network (that is concentrated on valley flats) did not sample landforms proportional to their extents within the land system. Also, random points along roads are often outside the extent of *Acacia aphanoclada* occurrences (which are concentrated on slopes), which results in distances to the first nearest individual having a positive bias (higher than expected by chance), and a bias to selecting isolated individuals on the outside of patches. Calculations based on such data is highly likely to significantly underestimate densities;
- only using the limited number of sites where paired measurements were both recorded on the same slope category (from either field observations or generated from a 30 metre grid DEM) as the majority of sites included an initial point on a relatively level road/track and the associated plant records on slopes; or
- alternatively calculating density using nearest neighbour analysis (which doesn't require pairing measurements as it only considers distances between individual plants within stands) as this significantly overestimates densities of highly clustered populations.

Also, the T-square method does not allow for zero distances at a sampling point, so that data from points where *Acacia aphanoclada* was absent had to be excluded from the analysis.

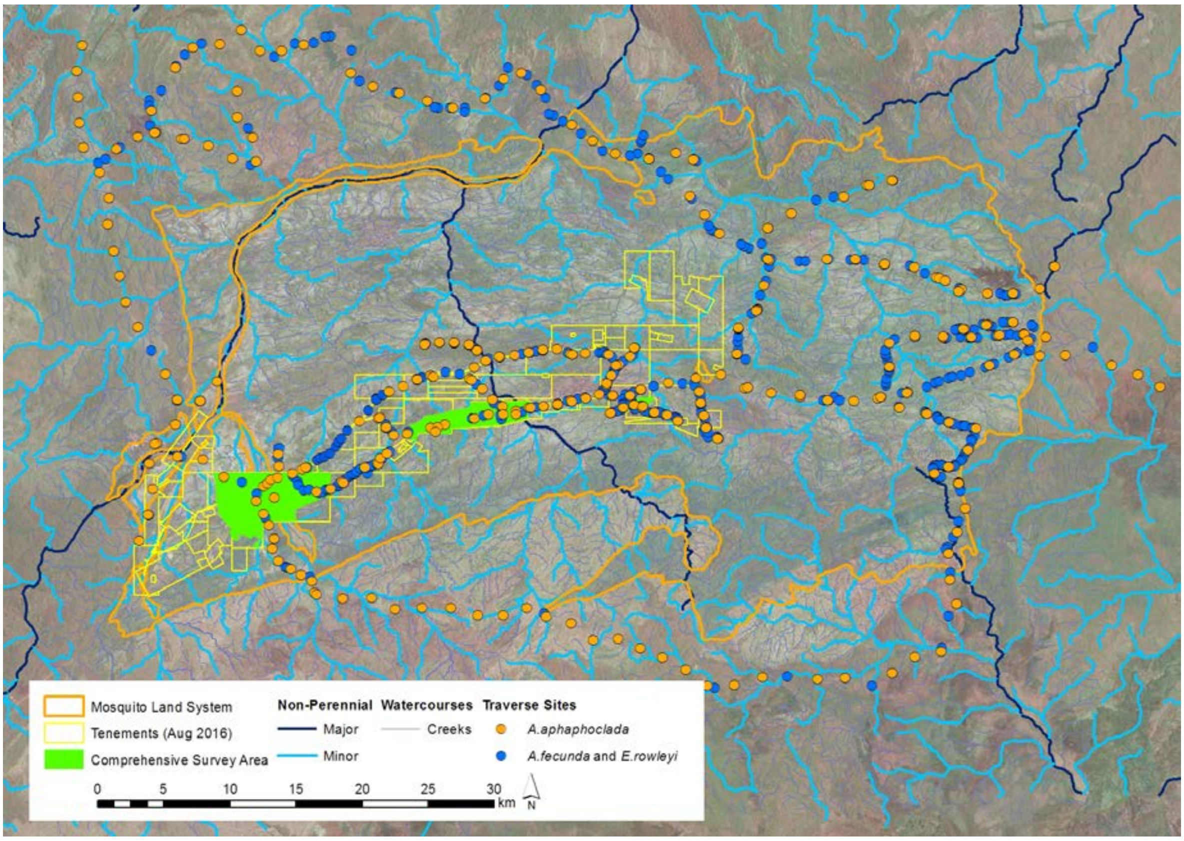

Figure 2.1: Location of sampling points along traverses across the Mosquito Land System

As the density estimates from the T-square sampling would be unreliable, an alternative method for estimating abundance from presence/absence frequencies for landforms was used. Also, a plant density extrapolated from the comprehensively surveyed areas.

2.2 Timing

Priority Flora census data was collected during surveys undertaken between the following dates:

- 12-21 April 2016;
- 11-16 May 2016;
- 02-09 September 2016;
- 03-18 August 2016 (Mosquito Land System traverse);
- 12-20 January 2017; and
- 23-30 March 2017.

2.3 Taxonomic Nomenclature and Identification

Nomenclature used in this report is consistent with that of the Western Australia Herbarium at the time of writing the report. This was verified by reference to up-to-date tables in the Max 3.2 software package.

2.4 Personnel

The roles and experience of the personnel involved the production of this report are summarised in Table .

Table 2: Project Team

Team Member	Professional Experience		Project Tasks
Andrew Waters (Licence SL009144). • Graduate Certificate in GIS • Bachelor of Science • Advanced Certificate of Horticulture	16 years in: • Avon Wheatbelt • Esperance Plains • Geraldton Sandplains • Jarrah Forest	• Mallee • Murchison • Pilbara • Swan Coastal Plain	• Mapping • Flora Survey • Report Writing
Dr Shane Chalwell (Licence SL00959) • PhD • Bachelor of Science (Honours)	15 years in: • Avon Wheatbelt • Central Ranges • Coolgardie • Dampierland • Esperance Plains • Gascoyne • Geraldton Sandplains	• • Great Sandy Desert • Jarrah Forest • Mallee • Murchison • Ord-Victoria Plains • Pilbara • Swan Coastal Plain	• Flora Survey
Frank Obbens • Bachelor of Science	16 years in: • Avon Wheatbelt • Coolgardie • Jarrah Forest • Mallee	• Murchison • Northern Sandplains • Pilbara • Swan Coastal Plain	• Plant Identifications

2.5 Limitations

Consistent with EPA Guidance Statement No. 51 (EPA, 2004), and reduce any possible misinterpretations of this report, an indication is provided below of the degree to which the following have limited data collection or the interpretation thereof:

- contextual information;
- disturbances;
- access, resources and intensity of sampling;
- identification of plant taxa; and
- timing and weather.

2.5.1 *Contextual Information*

Although the flora of the Chichester IBRA subregion is relatively poorly known, with few intensive studies, and quadrat-based floristic data available from only some localities (DPaW, 2002), reports from local vegetation surveys were available for this survey and *Acacia aphanoclada* has previously been researched by Barker (2007). The availability of these sources meant that background information was not as limiting as it often is in the Pilbara.

Priority Flora data was available from:

- a DPaW database search on 26/04/2016 (reference number 08-0516FL) that listed 21 threatened/priority taxa within 50 km of the survey area;
- The Distribution of *Acacia aphanoclada* and the Effect of Soil Mineralogy and Water Availability on Habitat Preference (Barker, 2007) presented results from counts of *Acacia aphanoclada* plants in 146 one hectare quadrats at 1.5 km spacing along tracks and roads across the Mosquito Land System;
- *Flora and Vegetation of proposed Tailings Storage Facility* (Mattiske Consulting Pty Ltd, 2016) that included a count of plants on one slope of a hill;
- the *Flora and Vegetation of the Nullagine Project Areas* (Mattiske Consulting Pty Ltd, 2012), that consolidated the following previous reports that typically recorded locations of plants but did not include a count of plants:
- Flora and Vegetation of the Golden Gate Lease (Mattiske Consulting Pty Ltd, 2006);
- Flora and Vegetation of the Shearers Lease (Mattiske Consulting Pty Ltd, 2006); and
- Flora and Vegetation of the Barton Lease (Mattiske Consulting Pty Ltd, 2005).

2.5.2 *Disturbances*

Approximately 170 ha of the comprehensively surveyed area had been burnt within a month of the January 2017 site visit (Figure 2.2). As only mature (dead) plants could be counted, population counts would be lower than usual.

Historic and current mining activity has also cleared significant areas of vegetation within the comprehensive survey area.

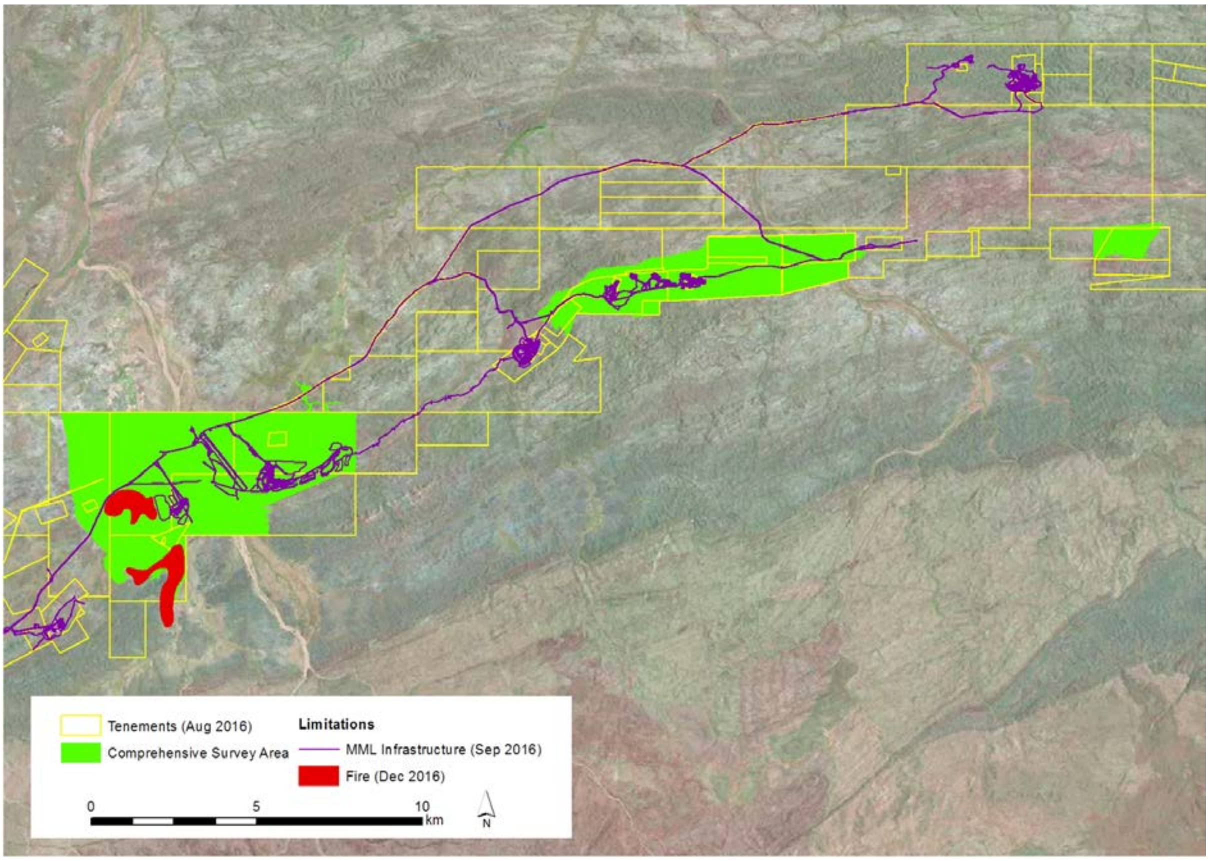

Figure 2.2: Areas of disturbance within the comprehensive survey area.

2.5.3 *Access, Resources and Intensity of Sampling*

The intensity of the survey was sufficient to record all occurrences of the following species in the comprehensive survey area:

- *Acacia aphanoclada* (P1)
- *Ptilotus wilsonii* (P1)
- *Acacia fecunda* (P3)
- *Eucalyptus rowleyi* (P3)
- *Ptilotus mollis* (P4)

Survey timing is more critical than intensity of survey for some species as they respond to seasonal or disturbance factors. Therefore, not all occurrences may have been recorded for the following species:

- *Goodenia nuda* (P4)
- *Lepidium catapycnon* (P4).
- *Atriplex spinulosa* (P1)

The following species have previously been recorded in MML tenements, but a search of the recorded locations could not relocate the populations:

- *Euphorbia sarcostemmoides* (P1)
- *Themeda* sp. Hamersley Station (P3)

It is unlikely that any additional conservation significant species would have been detected with higher intensity searches or with more regularly spaced transects.

2.5.4 *Identification of Plant Taxa*

The expertise employed in the report was sufficient to provide confidence in the results and conclusions:

- the field survey was undertaken Andrew Waters and Dr Shane Chalwell (each individually with more than 15 years experience); and
- identification of plant specimens collected from quadrats, and for all priority species, undertaken by:
  - Frank Obbens, a taxonomist and research associate of the WA Herbarium (where he is a leading expert on *Calandrinia* species) with more than 15 years experience; and
  - where appropriate, experts at the Western Australian herbarium including:
    - Mike Hislop, who confirmed identifications of *Acacia aphanoclada* (P1), *Ptilotus wilsonii* (P1), *Eucalyptus rowleyi* (P3), *Acacia fecunda* (P3), *Acacia acradenia*; and
    - Steve Dillon provided advice on *Atriplex spinulosa* (P1) and a *Maireana* x *Sclerolaena* hybrid.

The observability of Priority Flora may vary according to life stage and seasonal factors. *Atriplex spinulosa* is an annual herb to 20 cm (WA Herbarium, 2015) that can only be reliably surveyed after rain when fruits are present. It requires fruit to be positively identified as it is distinguished by spines arising from fruiting bracteoles. In vegetative appearance, it is similar to *Atriplex semibaccata* (which it may hybridise with in the vicinity of Nullagine) (George 1984). The species can be confused with *Atriplex semilunaris* and requires bracteoles (flowering/fruiting) material to distinguish (WA Herbarium 2015). Throughout the survey period, most material was unsuitable for positive identification but better rainfall in 2017 should allow for appropriate material to be collected.

Goodenia nuda is an annual herb that can only be reliably surveyed after rain when flowers are present. Other similar species are *Goodenia microptera*, which is hairier (although hairiness was found to be variable and flowers were relied upon for confidence in the identification) and *Goodenia triodiophila*, which has rounded rather than flat leaves (Plates 2.1 -2.3).

Most of the perennial shrub taxa are observable and distinguishable throughout the year. The only similar species in the Mosquito Land System to *Acacia aphanoclada* is *Acacia orthocarpa*. "*A. orthocarpa* is readily distinguished by its cylindrical, simple inflorescences (not round heads arranged in racemes as in *Acacia aphanoclada*), nerveless phyllodes which are covered with minute white dots (observe at x10 magnification or higher) and its woody pods" (Maslin & Reid, 2010). The two species can generally be distinguished from a distance in the order of 100 metres because Acacia aphanoclada has a sparser canopy and drooping branches (Plates 2.4 and 2.5). Mature burnt (leafless) plants can also be identified after moderate intensity fires by the drooping stems (Plate 2.6).

Ptilotus wilsonii is a distinctive, readily recognized and reliably surveyed year-round (Plates 2.7 and 2.8). The species could be confused with some chenopods (WA Herbarium, 2015) but all individuals located during the current surveys have distinctly folded leaves, and many had the remnants of flowers spikes and Mike Hislop has confirmed the identification of *Ptilotus wilsonii* from a specimen from the Plantecology Consulting (2016) survey.

Acacia fecunda is also distinctive, readily recognized and can be reliably surveyed year-round (Plates 2.9 and 2.10). *Acacia fecunda* appears most closely related to *A. gonoclada* (which does not occur in the Pilbara) and may superficially resemble *A. elachantha, A. hamersleyensis* and *A. tumida* var. *pilbarensis* (Maslin & Reid, 2010). *A. tumida* occurred in the survey area and is readily distinguished by their habit and phyllodes morphology.

The most similar species in the Mosquito Land System is *Acacia acradenia*. Whilst "[t]here is no *Acacia* species in the Pilbara with which *A. acradenia* is likely to be confused" (Maslin & Reid, 2010), the two species could generally not be distinguished from a distance. The species did not intermingle often and could be differentiated with an inspection of the phyllodes. *Acacia fecunda* often has wide-spreading to ascending falcate phyllodes (though they can also be narrowly elliptic to oblanceolate, or straight and dimidiate), with 2 sub-central nerves more evident than the rest, and a distinct pulvinus (4-5 mm long and orange when fresh). *Acacia acradenia* has obliquely elliptic to narrowly elliptic phyllodes, with 3 or more nerves rather more evident than the rest, minutely hairy (more or less velvety to touch), and terminated by a very short, brown, acute hard point and Mike Hislop has confirmed identifications of *Acacia fecunda* and *Acacia acradenia* specimens that were correctly differentiated in this survey.

Eucalyptus rowleyi (Plates 2.11 and 2.12) was the only mallee species observed in the Mosquito Land System and Mike Hislop has confirmed the identification of *Eucalyptus rowleyi* from specimens from this survey.

Ptilotus mollis is 'distinctive and unlikely to be confused with other members of the genus' (WA Herbarium, 2015). No other species was observed in the Mosquito Land System that was superficially similar (Plate 2.13).

The following specimens have been submitted to the WA Herbarium, along with associated Threatened and Priority Flora Report Forms to DPaW:

- 1 *Ptilotus wilsonii* (P1) specimen;
- 4 *Acacia aphanoclada* (P1) specimens;
- 4 *Eucalyptus rowleyi* (P3) specimens;

- 2 *Acacia fecunda* (P3) specimens; and
- 2 *Acacia acradenia* specimens (to confirm it was being correctly being distinguished from *Acacia fecunda*).

2.5.5 *Timing and Weather*

Whilst the timing of rain events, and the subsequent flowering of plants can be highly variable in the inland Pilbara, the timing of surveys in April, May, June and August 2016, and January 2017, coincided with when most of targeted taxa could typically be expected to be flowering, as indicated in Table 2.3.

The rainfall during the surveys, and in the 12 month period from January 2016, was higher than the long-term median. A comparison of rainfall from 1961 until 1990 (the period used as the climate reference or 'climate normal' by the Bureau of Meteorology) for Nullagine (station 4027, which closed in 2004), with 2015-2017 rainfall from the MML mine site at Golden Eagle shown in Figure 2. The chart shows heavy rainfall in January 2016 followed by low rainfall in the following months, which is not untypical. However, the shallow clay soils of the extensive stony plains appears to dry very quickly and ephemeral species can be difficult to detect if not surveyed within a few weeks of major rain events. As the first survey was undertaken 3 months after the main rains, this limited the ability to survey for annual species and meant that some *Triodia* species did not retain reproductive material for conclusive identification.

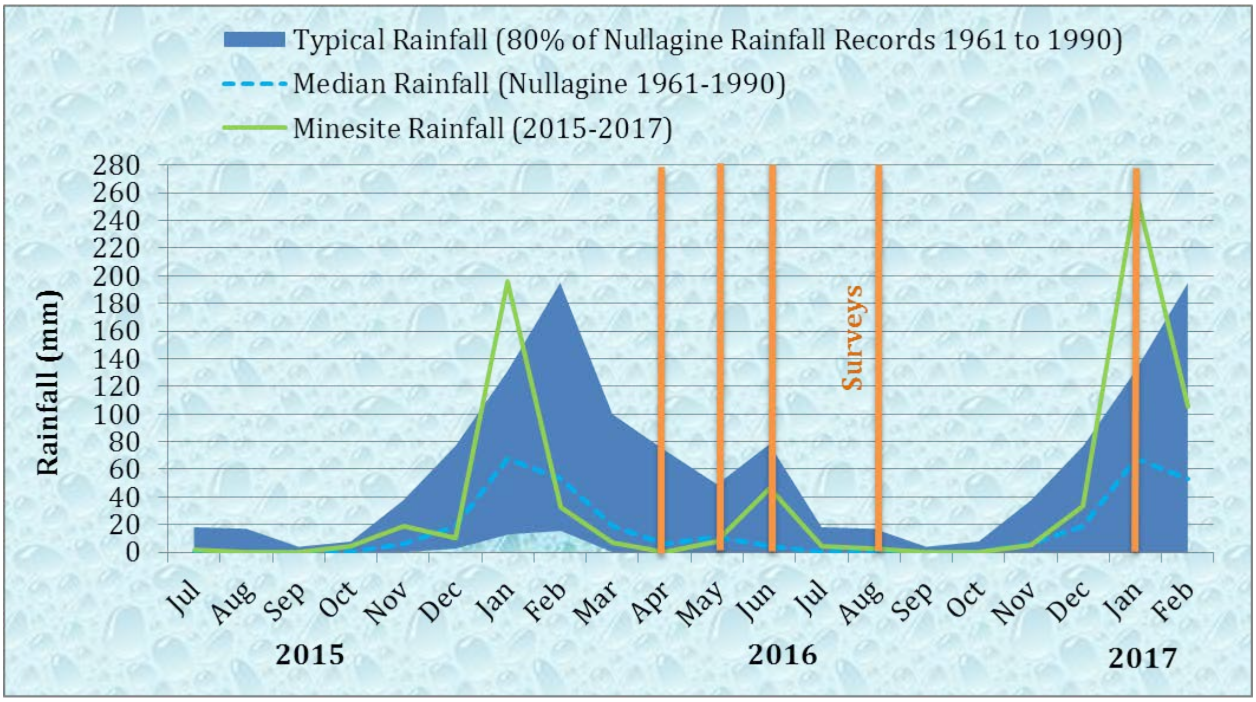

Figure 2.3: Comparison of 2015-2017 Rainfall with 'Climate Normal'

Table 3: Survey Timing in relation to Flowering of Targeted Taxa

Threatened and Priority Species	Lifeform		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Triodia basitricha	Perennial Grass	P3												
Eragrostis crateriformis	Annual Grass	P3												
Eucalyptus rowleyi	Mallee	P3												
Swainsona thompsoniana	Annual Herb	P3												
Acacia cyperophylla var. *omearana*	Tree	P1												
Rostellularia adscendens var. *latifolia*	Shrub	P3												
Nicotiana umbratica	Annual/Perennial Herb	P3												
Stemodia sp. Battle Hill	Shrub	P1												
Goodenia nuda	Annual Herb	P4												
Indigofera ixocarpa	Shrub	P2												
Acacia sp. Nullagine	Shrub	P1												
Ptilotus mollis	Shrub	P4												
Acacia fecunda	Shrub	P3												
Fimbristylis sp. Shay Gap	Annual Sedge	P1												
Themeda sp. Hamersley Station	Perennial Grass	P3				Survey								
Acacia aphanoclada	Shrub	P1				Periods								
Goodenia sp. East Pilbara	Annual/Perennial Herb	P3												
Ptilotus wilsonii	Shrub	P1												
Lepidium catapycnon	Shrub	P4												
Atriplex spinulosa	Annual Herb	P1												
Cochlospermum macnamarae	Shrub	P1												
Euphorbia sarcostemmoides	Shrub	P1												

Source: DPaW (2016)
Flowering time shaded, except for three species for which typical flowering times not documented


Plate 2.1: *G. nuda* flower


Plate 2.2: *G. nuda* leaves


Plate 2.3: *G. nuda* flower


Plate 2.4: *A. orthocarpa* habit


Plate 2.5: *A. aphanoclada* flowers and fruit


Plate 2.6: *A. aphanoclada* stem after fire


Plate 2.7: *P. wilsonii* leaves


Plate 2.8: *P. wilsonii* old inflorescences


Plate 2.9: *A. fecunda* flowering


Plate 2.10: *A. fecunda* nerves on phyllode


Plate 2.11: *E. rowleyi* habit


Plate 2.12: *E. rowleyi* smooth bark


Plate 2.13: *P. mollis* leaves

3. RESULTS

Six taxa of the target Priority Flora were recorded as occurring within the Mosquito Land System (Table 4). Another taxon (*Atriplex spinulosa*) possibly occurs within stony saline plains in the land system, but fruiting material is required before this can be confirmed. Three taxa previously recorded in surveys for the MML tenements (*Lepidium catapycnon, Themeda* sp. Hamersley Station and *Euphorbia sarcostemmoides*) were not re-located during the survey. The remaining target taxa are unlikely to occur in the Mosquito Land System as suitable habitat is absent or degraded through grazing.

3.1 *Acacia aphanoclada*

Acacia aphanoclada occurs across the entirety of the Mosquito Land System and its distribution is centred around it, in an area approximately 40 km north-south by 65 km east-west, with 56 location records held by DPaW (2016) (Figure 3.1).

The extent of *Acacia aphanoclada* covers geology units (mapped by GSWA at 1:100,000) that cover 89.2% of the Mosquito Land System, and the units that it has not been confirmed on are yet to be surveyed (Figure 3.2). This is consistent with Barker (2007), who found that the density of *Acacia aphanoclada* did not greatly vary across the Mosquito Land System.

The location of every plant was not individually located due to inaccessibility of steeper slopes (>30°) and the large number of plants (>13,000). In comprehensively surveyed areas, the location and number of *Acacia aphanoclada* occurrences were recorded as the number of plants within a 20 metre buffer. Although plants grow to about 3 m tall, the very wispy growth form means individual plants can be difficult to see at a distance greater than this.

Data for areas where plants have been comprehensively counted (Table 5) demonstrates that the species is concentrated on crests and slopes of hills, and infrequently on flats and valley floors (where it is often found near base of hills when present). *Acacia aphanoclada* occurs on all aspects and there is no correlation between density and aspect. Plant records across the land system in relation to slope are shown in Figure 3.3, and a more detailed view is presented for the All Nations prospect in Figure 3.4.

Plant densities and subpopulation/population extents are highly scale dependent as *Acacia aphanoclada* is widespread on hills but highly clustered within hills (Plate 3.1). The occurrence of *Acacia aphanoclada* is also highly correlated to *Triodia wiseana* grasslands on hills, and outcrops of vertically fissured unweathered rocks.

Plate 3.1: *A. aphanoclada* cluster

Table 4: Results of search for conservation-significant taxa recorded in the survey area.

	Priority Species	Habitat	In Land System	Habitat Present	Likely Presence in Survey Area
P1	*Acacia aphanoclada*	Rocky hills, ridges and rises in skeletal stony soils	X	X	Confirmed
	Acacia cyperophylla var. omearana	Stony & gritty alluvium. Along drainage lines.		X	Highly Unlikely highly detectable and not seen
	Acacia sp. Nullagine	Rocky clay, low lying area between rocky hills.		X	
	Cochlospermum macnamarae	Granite boulders.			
	Euphorbia sarcostemmoides	Sandstone ridges, quartzite hills.		X	
P3	*Acacia fecunda*	Associated with quartzite gibbers over grey-red skeletal soil	X	X	Confirmed
	Eucalyptus rowleyi	Red sandy loams on plains and very minor and broad flood-outs	X	X	
P1	*Ptilotus wilsonii*	Stony gravelly soils. Rocky hills.		X	Confirmed
	Stemodia sp. Battle Hill	Cracking clay. Floodplain.			Highly Unlikely detectable and habitat absent
P2	*Indigofera ixiocarpa*	Skeletal red soils over massive ironstone.			
P3	*Rostellularia adscendens var. latifolia*	Ironstone soils. Near creeks, rocky hills.		X	Unlikely Potential habitat grazed but also distinctive and detectable
P4	*Lepidium catapycnon*	Skeletal soils on hillsides.	X	X	Possible Potential habitat but not readily detectable (pioneer ephemeral)
	Ptilotus mollis	Stony hills and screes.		X	Confirmed
P3	*Themeda sp. Hamersley Station*	Claypans	X		Highly Unlikely habitat absent
	Triodia basitricha	Crest of sandstone hill.			
P3	*Eragrostis crateriformis*	Clay-loam or clay. Creek banks, depressions. In Pilbara mainly coastal, also Millstream-Chichester NP (WA Herbarium, 2015)		X	Unlikely Potential habitat degraded by grazing, distinctive culms but annual species
P1	*Atriplex spinulosa*	Footslope of low hill, drainage floor with quartz covered surface, slopes of creek, stony pavement	X	X	Possible Potential habitat but not readily detectable
P3	*Goodenia sp. East Pilbara*	Red-brown clay soil, calcrete pebbles. Low undulating plain, swampy plains			Highly Unlikely Known only from swamp near Mulga Downs homestead (WA Herbarium, 2015)
	Nicotiana umbratica	Shallow soils. Rocky outcrops. Grows in shade of large boulders (WA Herbarium, 2015)			Highly Unlikely Habitat absent (large boulders) and detectable (large distinctive leaves)
	Swainsona thompsoniana	Gibber plains, crabhole plains and gilgai			Highly Unlikely habitat absent
P4	*Goodenia nuda*	Open depression. Brown sandy loam with granite stones.		X	Confirmed
P1	*Fimbristylis sp. Shay Gap*	Edge of small pool in basalt creekline.			Highly Unlikely habitat absent

Table 5: Slope/Aspect Distribution in Comprehensively Surveyed Areas

Slope	N	NE	E	SE	S	SW	W	NW	Total	
Level	49	75	3	21		64	64	80	356	3%
Very Gently Inclined	380	461	238	250	166	63	330	797	2685	22%
Gently Inclined	951	556	881	1184	764	808	923	1328	7395	61%
Moderately Inclined	425		195	139	730	73	107	71	1740	14%
Total	1805	1092	1317	1594	1660	1008	1424	2276	12176	100%
	15%	9%	11%	13%	14%	8%	12%	19%	100%	

NB: under-records proportion of plants on moderate slopes as plants often recorded from top or bottom of inaccessible steep slopes with loose rocks

In the comprehensively surveyed areas the densities and continuity of plants were relatively consistent (Figure 3.5), noting that:

- o the plant densities west of 5 Mile Creek were lower in density as this area had been burnt just before the survey and only larger plants could be counted, and
- o the plants in the All Nations area were more fragmented due to previous clearing;

Acacia aphanoclada plants are highly clustered and discontinuous at scales of less than 50 m, and occurrences are relatively continuous at a scale of greater than 250 m, with each area likely to consist of a single part of much larger population/s if, or when, survey areas are expanded to include surrounding hills (Figure 3.5 and 3.6). Figure 3.7 shows that the number of individual clusters declines slowly with buffer sizes greater than 50 m but the rate of increase in mean cluster extent rises once buffers exceed 250m. This indicates that occurrences of *Acacia aphanoclada* is clumped at fine scales but the population is continuous across the landscape. A similar pattern is seen when using density and mean cluster population sizes (Figure 3.8).

An estimate of *Acacia aphanoclada* abundance for the Mosquito Land System has been calculated using:

- only geology types that the species has been confirmed as occurring on (Figure 3.2);
- slope categories as a surrogate for landform (Figure 3.3);
- for each slope category, presence/absence frequencies (plants within 250 metres of traverse points considered in Figure 3.5); and
- an average plant density of 6.32 plants/ha, based on the 250 metre buffer around clusters (Figure 3.7), which is the same scale as presence/absence and the scale at which occurrences are relatively continuous in the landscape.

An estimate of approximately 530,000 plants is most likely an underestimate because:

- the same density has been applied to all slope categories, but this is not supported by the results from the comprehensively surveyed area and increasing buffer size tends to include a greater proportion of level ground which has lower density (Table 6);
- the geology units that the species has not been confirmed as occurring on have not been surveyed.

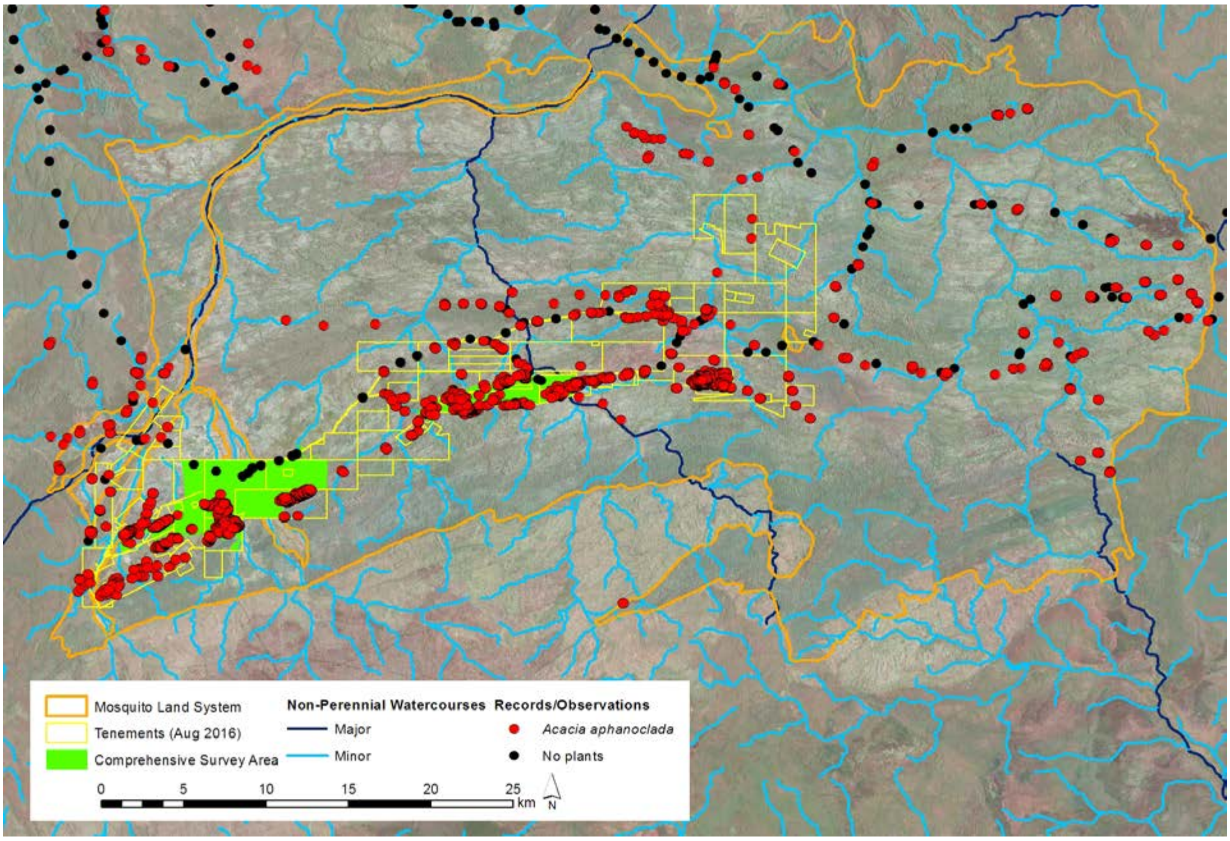

Figure 3.1: Distribution of *Acacia aphanoclada* (P1) in the Mosquito Land System

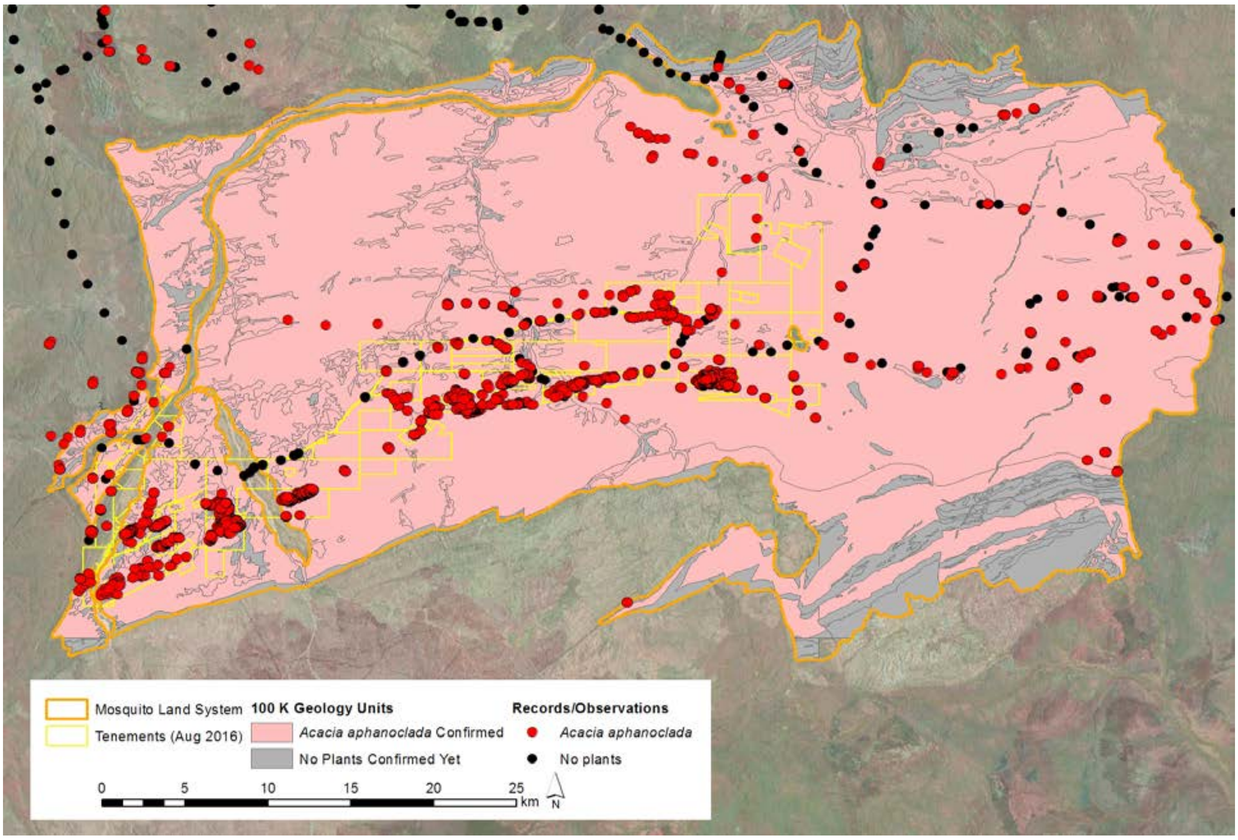

Figure 3.2: Distribution of *Acacia aphanoclada* (P1) in relation to geology units

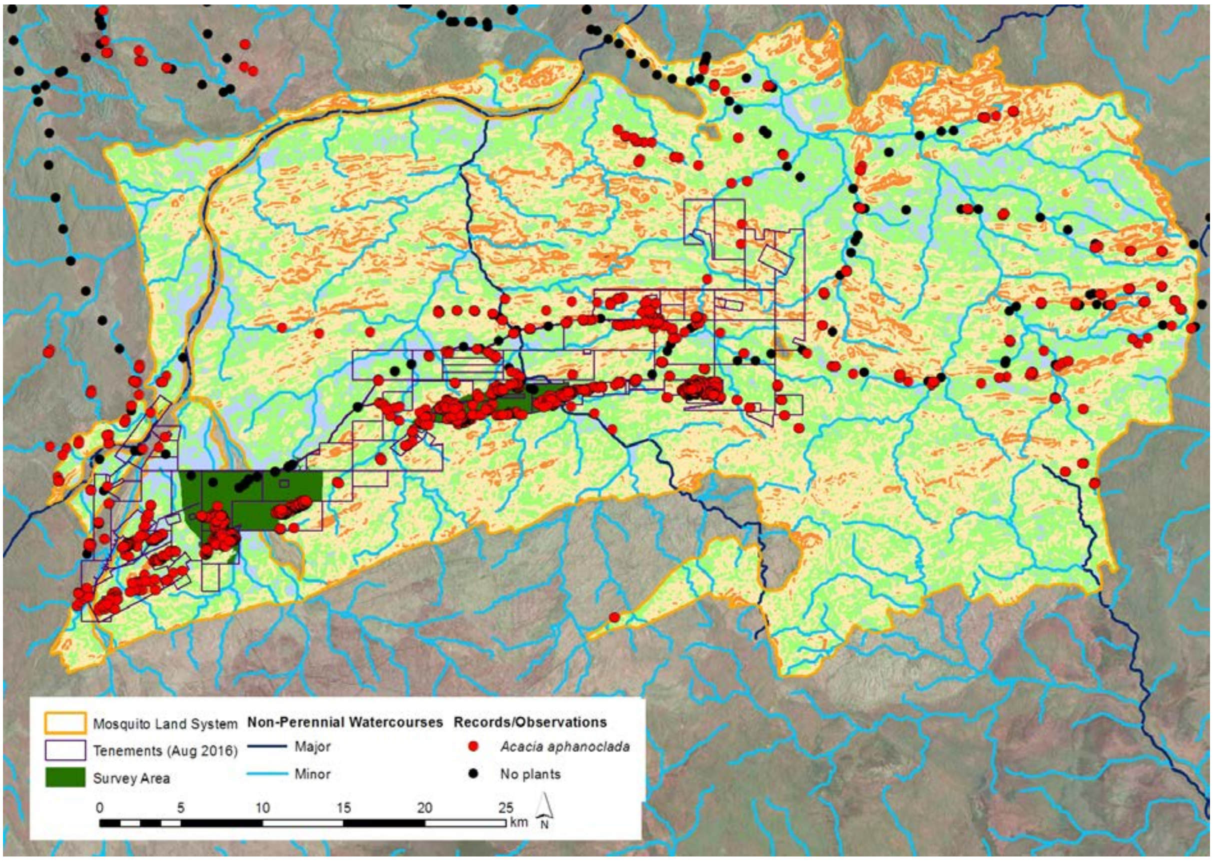

Figure 3.3: Distribution of *Acacia aphanoclada* (P1) in relation to slope

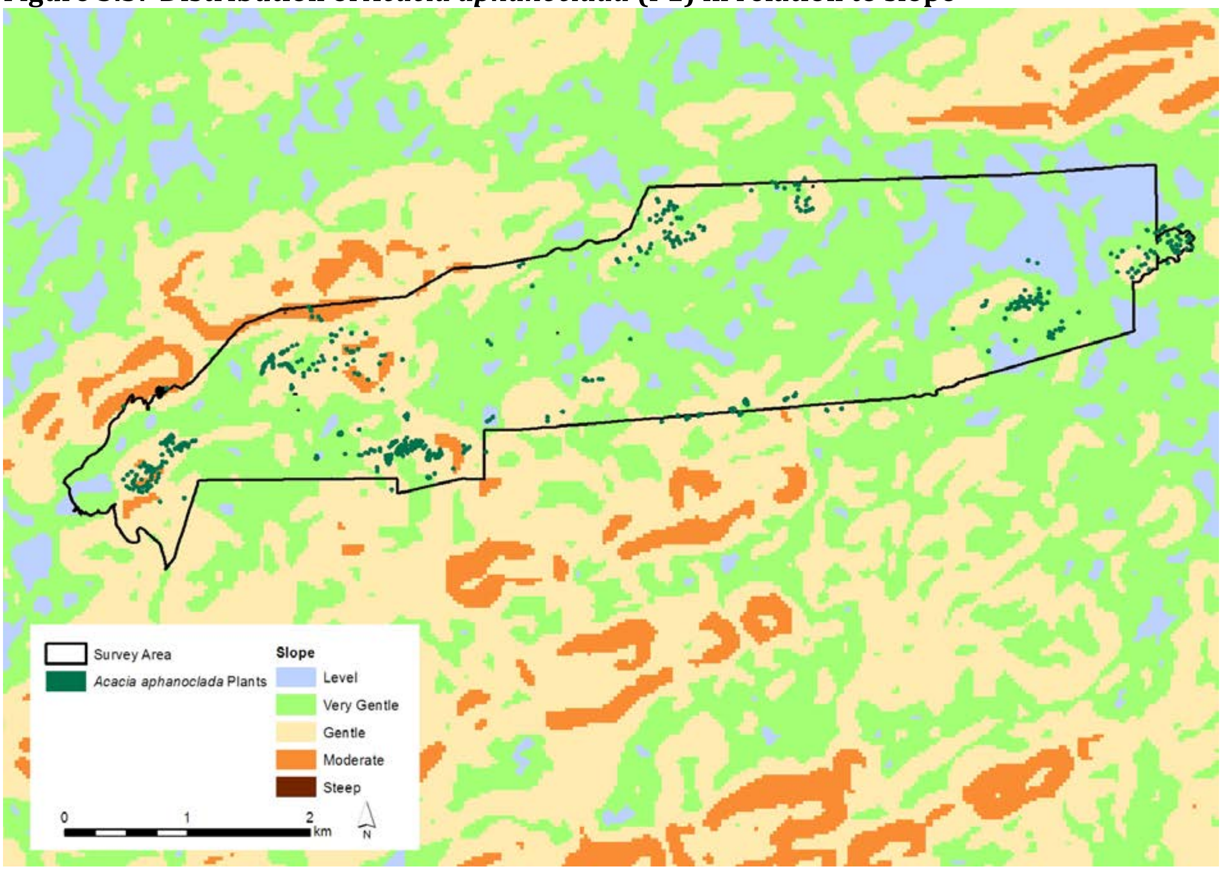

Figure 3.4: Distribution of *Acacia aphanoclada* in relation to slope in the All Nations prospect.

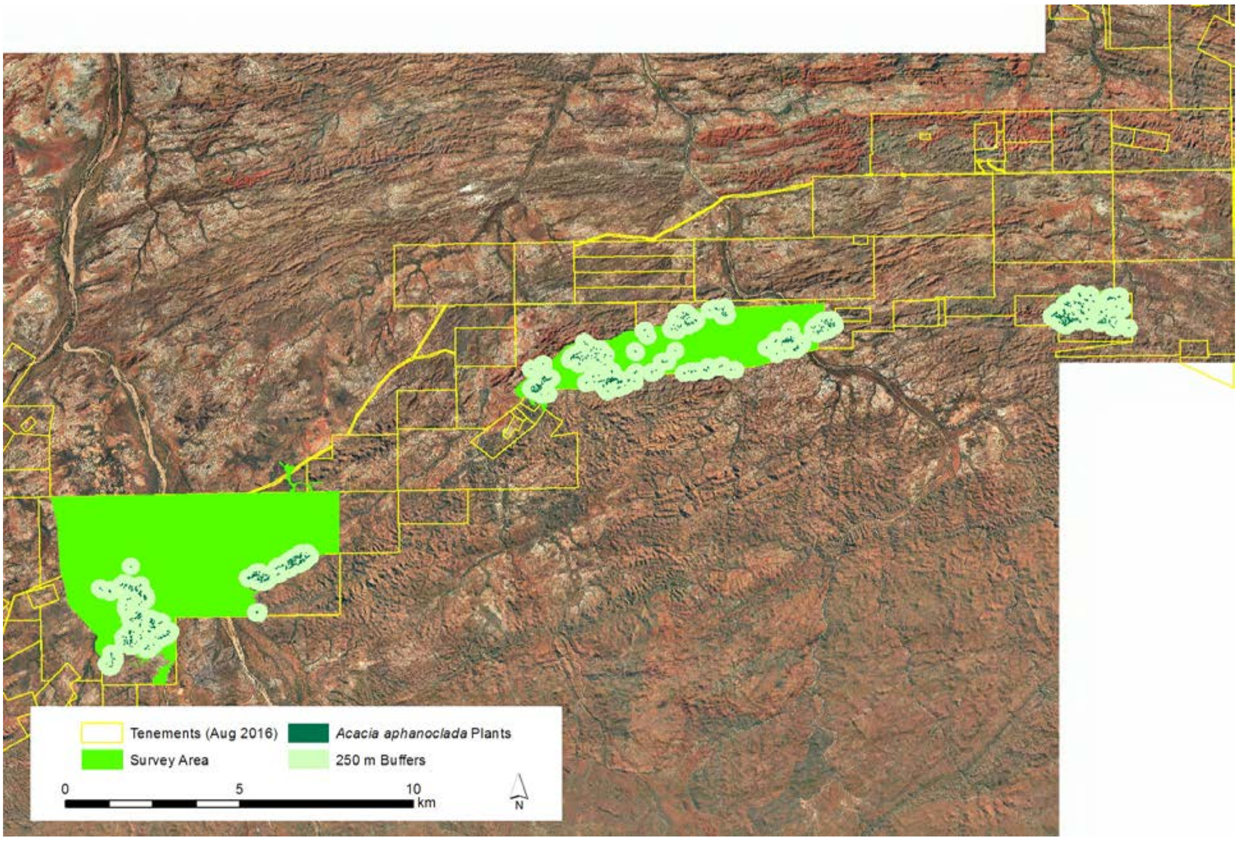

Figure 3.5: Continuity of *Acacia aphanoclada* occurrences in survey areas

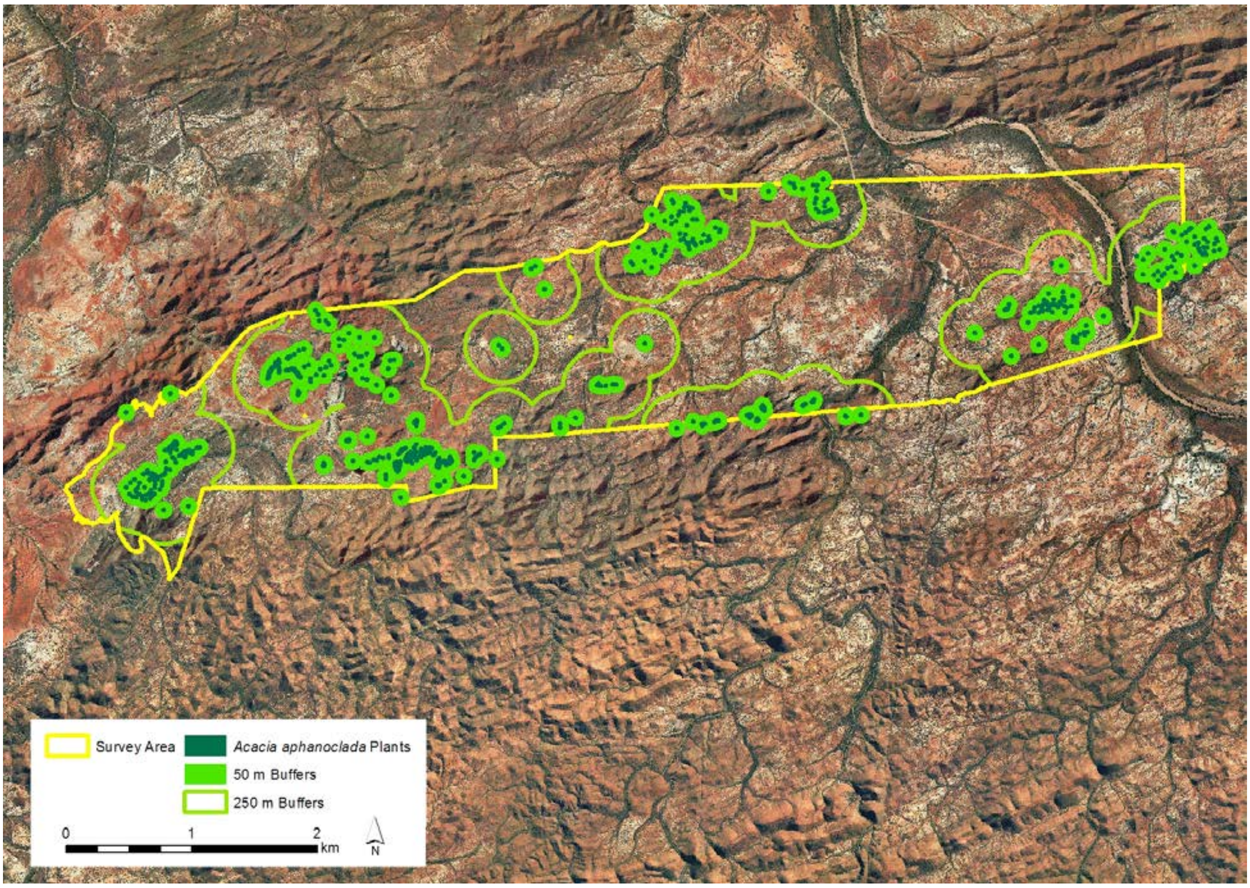

Figure 3.6: Continuity of *Acacia aphanoclada* occurrences in All nations prospect.

Table 6: Abundance Estimate for Confirmed Geology Units in Mosquito Land System

	Level	Very Gently Inclined	Gently Inclined	Moderately Inclined	Total
Extent of Slope Category	15,179 ha	61,102 ha	67,148 ha	12,090 ha	155,519 ha
Frequency of Plant Occurrence	15%	28%	47%	100%	-
Area Potentially Occupied	2,291 ha	17,152 ha	31,408 ha	12,090 ha	62,941 ha
Number of Plants	19,452	145,617	266,654	102,644	534,366 plants

Another estimate of *Acacia aphanoclada* abundance was calculated by extrapolating the complete counts obtained from the comprehensively surveyed area to the whole of the Mosquito Land System (Table 7). This density-based estimate used:

- the extents of each slope category across the entire Mosquito Land System (Figure 3.3); and
- plant densities across the entirety of each slope category in the comprehensively surveyed area (Figure 3.8).

The estimate of approximately 1,360,000 plants is supported by the following observations:

- the geology units that the species has not been confirmed on have not been surveyed and these are also hills;
- the comprehensively surveyed area consisted of three non-contiguous areas spread over 30km and accounts for approximately 2% of the land system; and
- densities of plants are consistent across the Mosquito Land System, and the densities for each division of the comprehensively surveyed area are relatively consistent. Also (Barker (2007) reported no significant variation in the densities of *Acacia aphanoclada* across the Mosquito Land System.

Table 7: Abundance Estimate based on densities by landform

	Level	Very Gently Incline	Gently Inclined	Moderately Inclined	Total
Extent of Slope Category	15,179 ha	61,102 ha	67,148 ha	12,090 ha	155,519 ha
Density of Plants	0.36	1.28	9.23	54.46	-
Number of Plants	5,494	78,483	619,639	658,472	1,362,088 plants

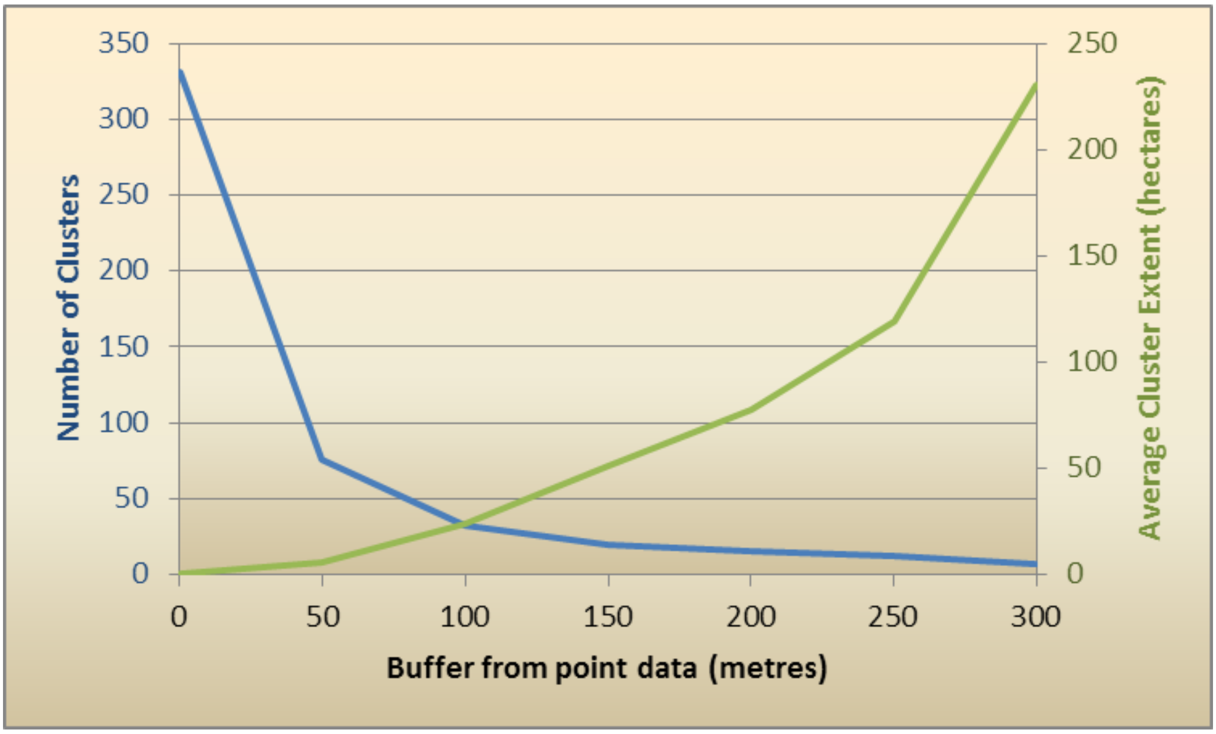

Figure 3.7: Scale-dependent continuity of *Acacia aphanoclada* occurrences

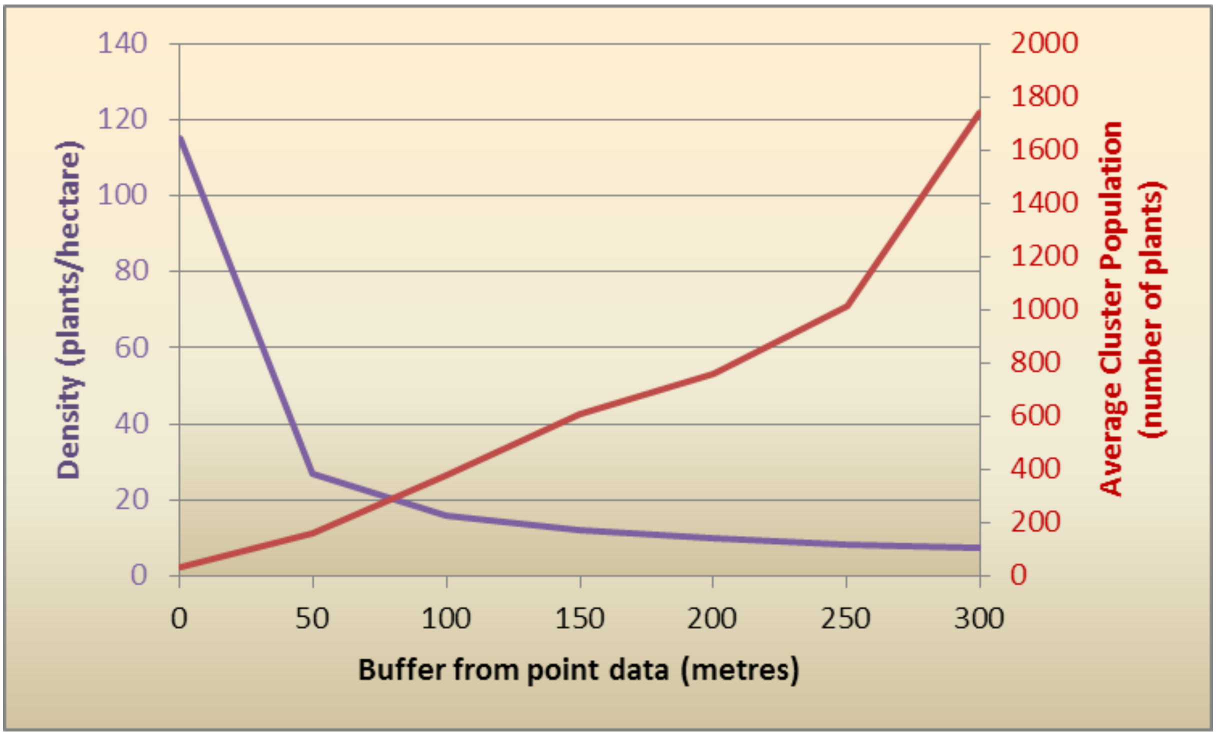

Figure 3.8: Scale-dependent densities of *Acacia aphanoclada* occurrences

3.2 *Atriplex spinulosa*

The locations in the Mosquito Land System are shown in Figure 3.9. No population counts were made in the current survey as it is an annual and only readily identifiable after appropriate rains. As an annual, population sizes may vary year-on-year, but it is often common where it occurs (WA Herbarium, 2015). Within the comprehensive survey area, *Atriplex spinulosa* occurs on the stony saline plains in association with *Triodia longiceps.* However, determination of its precise distribution will require adequate fruiting material to distinguish the species from closely related taxa (i.e. *Atriplex codonocarpa*), or if there are variants within the species.

Atriplex spinulosa:

- can only be reliably surveyed after rain when fruits are present; and
- will likely need to be managed based on habitat (vegetation polygons) given the difficulties surrounding its identification and annual habit.

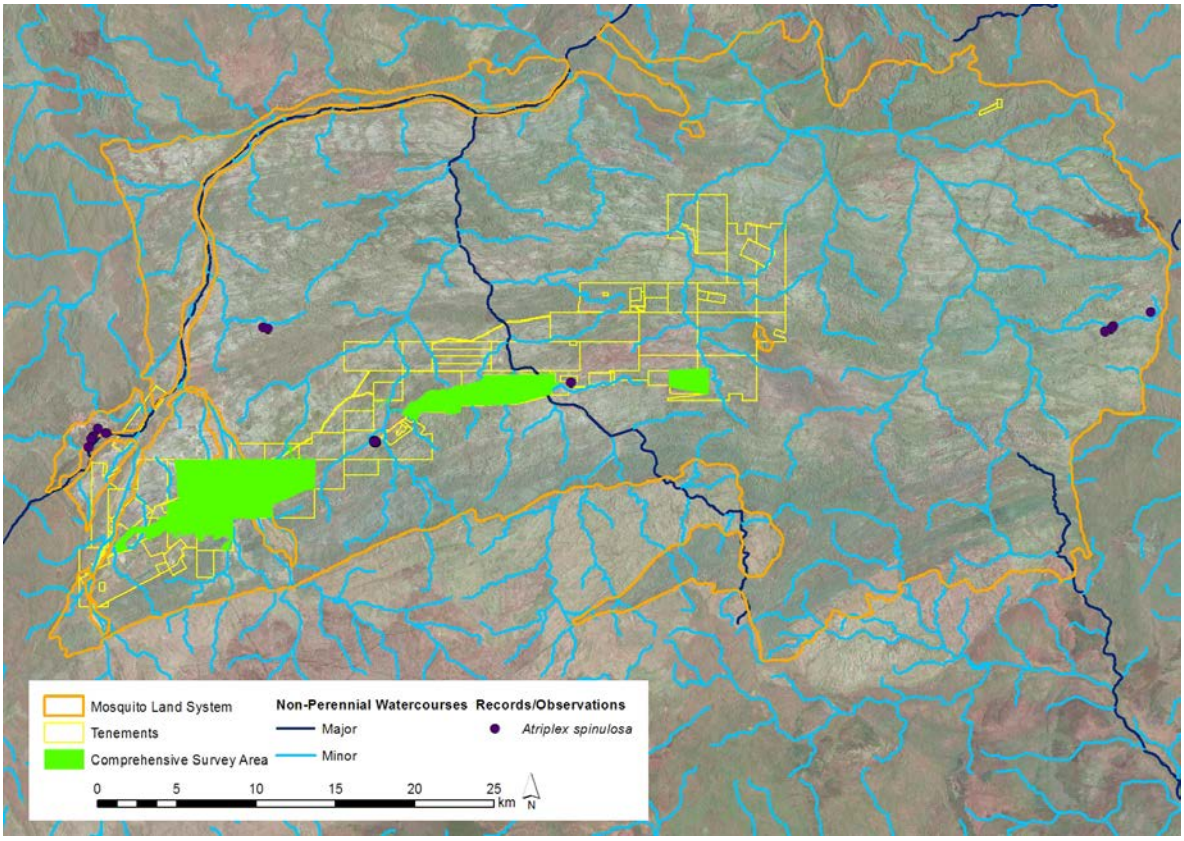

Figure 3.9: Distribution of *Atriplex spinulosa* (P1) in Mosquito Land System

3.3 *Ptilotus wilsonii*

Four populations have now been recorded in MML tenements (Figure 3.10). The population sizes are:

- approximately 6,000 (estimated plants over an area of 400 m x 400m);
- 214 counted plants;
- 64 counted plants; and
- 1 counted plant

The species appears to be locally restricted but scattered over a large range on some of the slightly more elevated parts of the stony saline plains of the Mosquito Land System. Soil profiles at two sites where it occurs are different to the surrounding stony saline plains in which the sites are located, with *Ptilotus wilsonii* appearing to grow where there is shallow consolidated parent material (i.e. hard rock) rather than unconsolidated parent material (i.e. soft/crumbly weathered material).

Ptilotus wilsonii was previously recorded growing on or near the base of gently sloping rocky hills (WA Herbarium, 2015) (which matches population shown in plate 1.13).

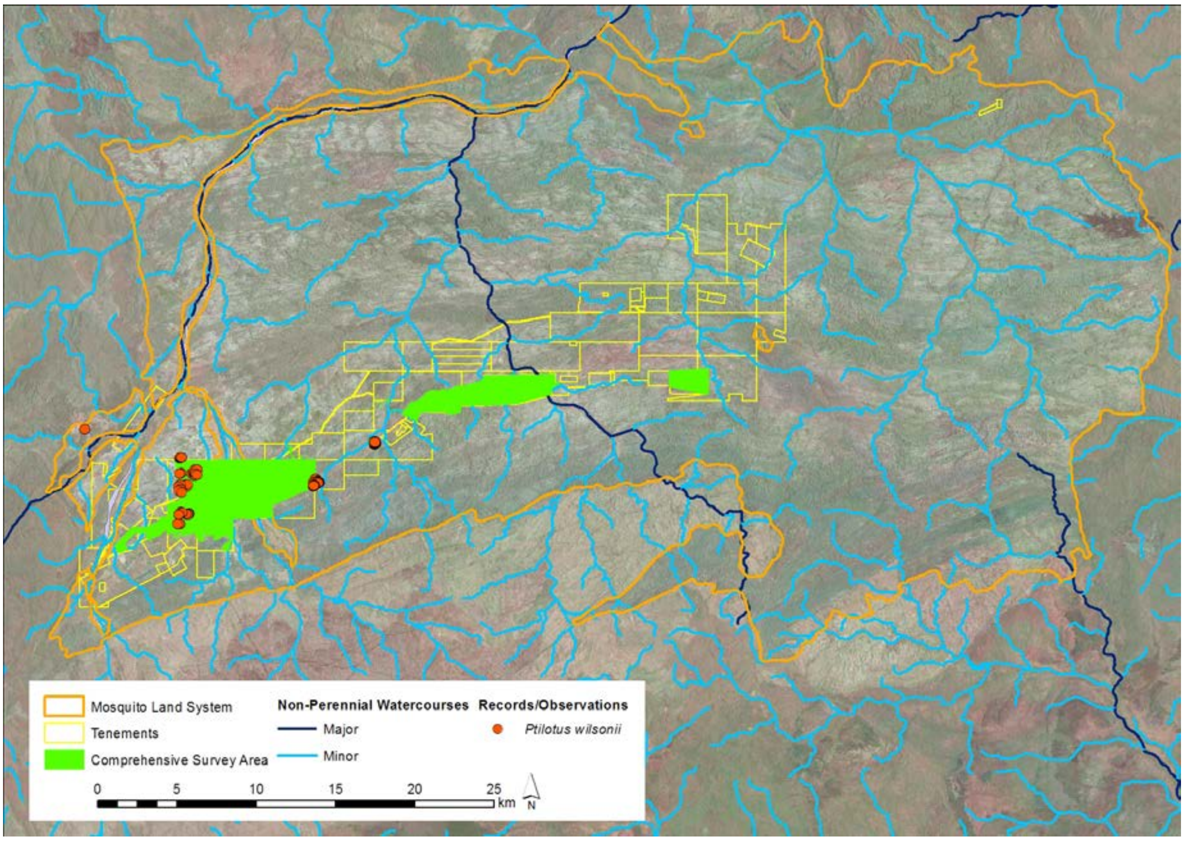

Figure 3.10: Distribution of *Ptilotus wilsonii* (P1) in the Mosquito Land System

3.4 *Acacia fecunda*

Acacia fecunda occurs across the much of the Mosquito Land System east of 5 Mile Creek and was recorded on approximately 50% of the 325 minor/intermediate channels surveyed and none of the 14 major channels across the Mosquito Land System (Figure 3.11). It tends to form monocultures on minor drainage lines and is often the dominant shrub (Plates 3.2 and 3.3). Although largely restricted to drainage lines higher in the landscape, *Acacia fecunda* tends to favour water-gaining sites and this may also include areas on flats and low rises.

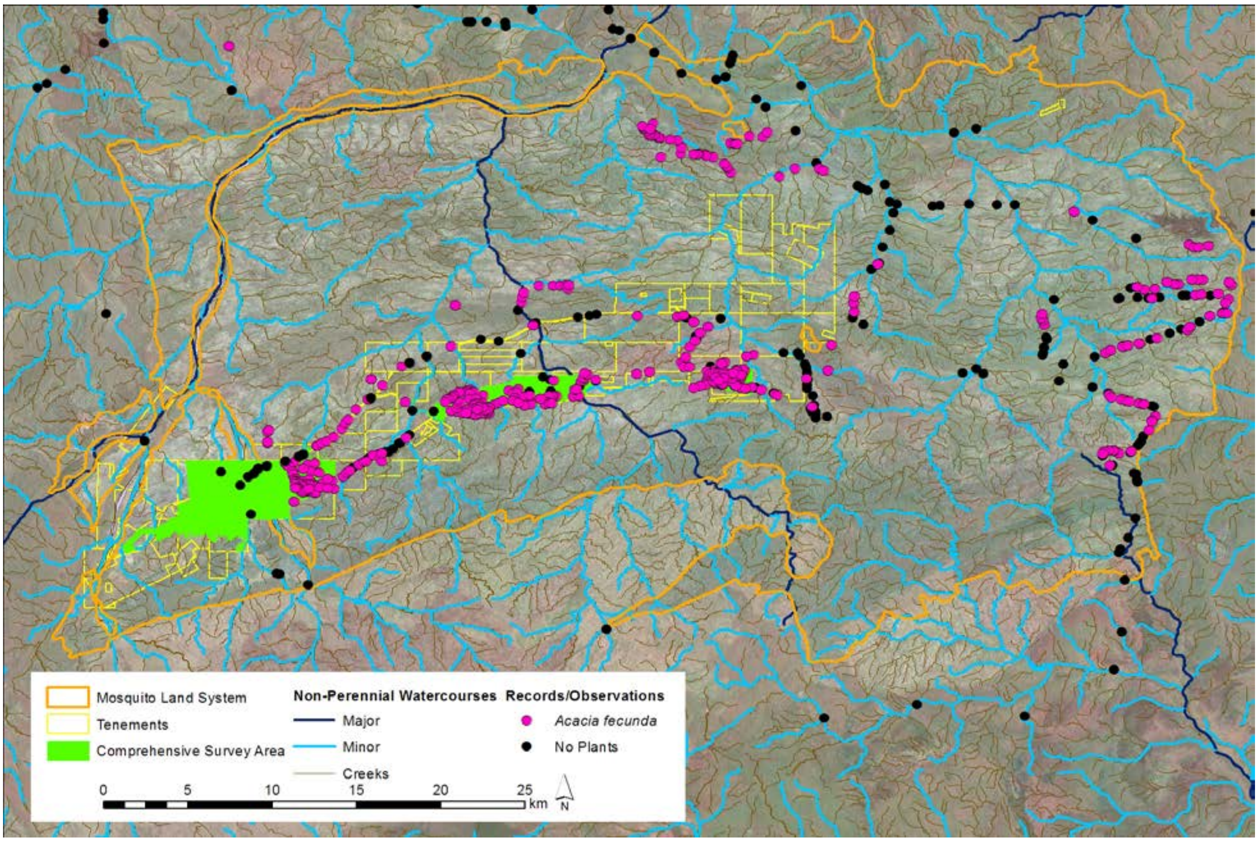

Figure 3.11: Distribution of *Acacia fecunda* (P3) in the Mosquito Land System

Plate 3.2: *A. fecunda* drainage lines in stony saline plains

Plate 3.3: *A. fecunda* drainage lines in foothills

3.5 *Eucalyptus rowleyi*

Eucalyptus rowleyi occurs across much of the Mosquito Land System on flats and intermediate drainage lines where clay is present (Figure 3.12). It is abundant (forming dominant monocultures in the tree strata) to the east of 5 Mile Creek, but rarely occurs west of here in the Mosquito Land System. *Eucalyptus rowleyi* was recorded at 7 flats, approximately 28% of the 325 minor/intermediate channels surveyed, and none of the 14 major channels surveyed across the Mosquito Land System. A single near continuous occurrence was recorded along 7 km of creeks feeding into Middle Creek, with scattered pockets along at least 10 km of Middle Creek, and individual occurrences on washout flats have been mapped up to 10.8 ha.

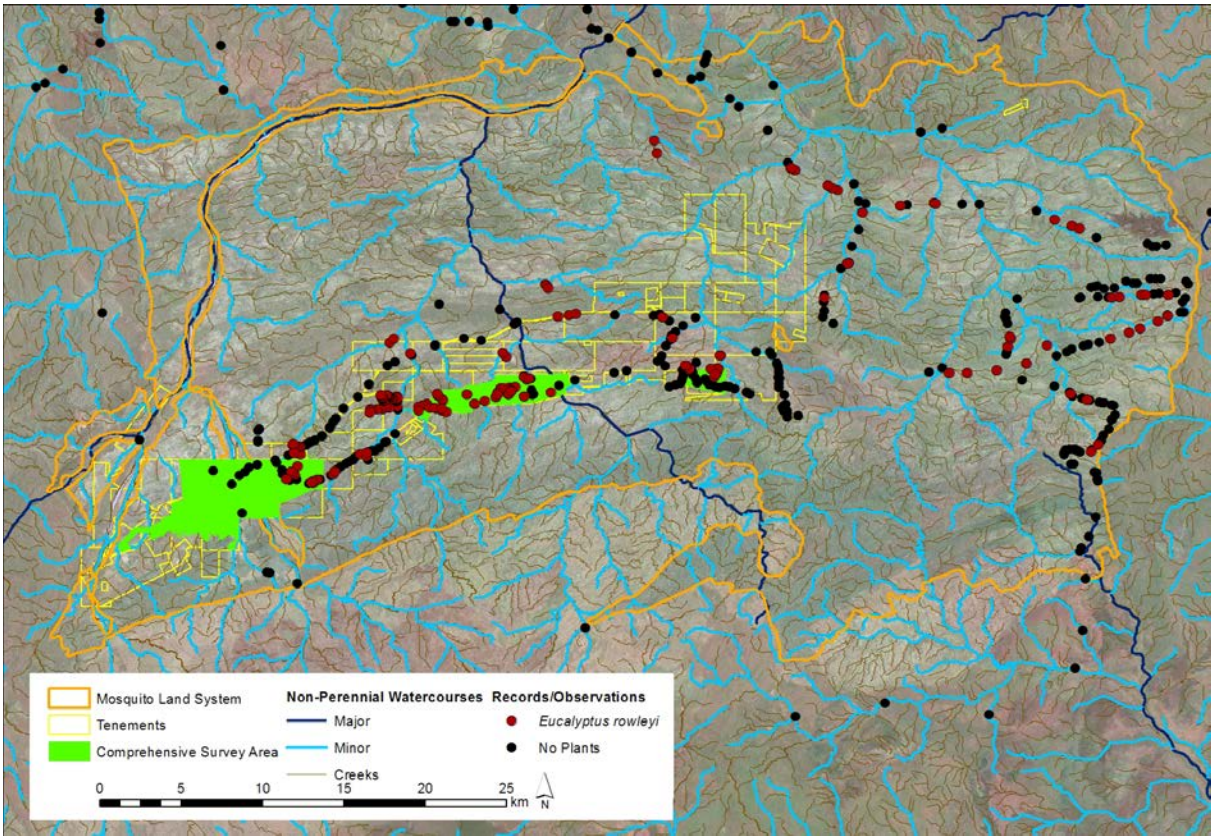

Figure 3.12: Distribution of *Eucalyptus rowleyi* (P3) in the Mosquito Land System

3.6 *Goodenia nuda*

Records in the Mosquito Land System were all associated with the banks either side of 5 Mile Creek (Figure 3.13). *Goodenia nuda* was recorded growing in sandy soils overlaying red-brown clays (Plates 3.4 and 3.5).

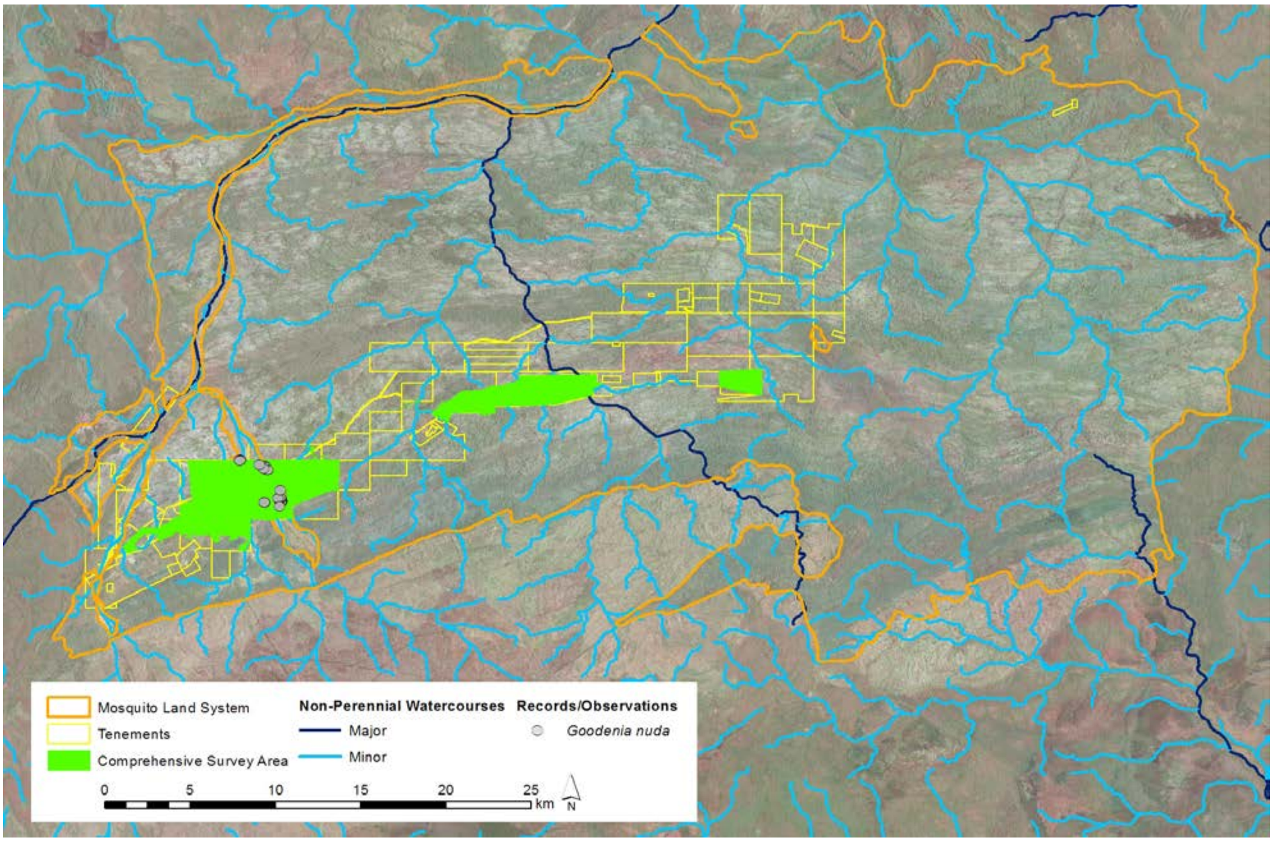

Figure 3.13: Distribution of *Goodenia nuda* (P4) in the Mosquito Land System

Plate 3.4: *Goodenia nuda* habitat - Quadrat 31

Plate 3.5: *Goodenia nuda* growing on track

3.7 *Ptilotus mollis*

Ptilotus mollis occurs in scattered small populations within the Mosquito Land System (Figure 3.44), with a total of only 236 plants being recorded thus far. The habitat observed within the Mosquito Land System was exposed weathered clays, which is consistent with other records from the Pilbara (Plates 3.6 and 3.7).

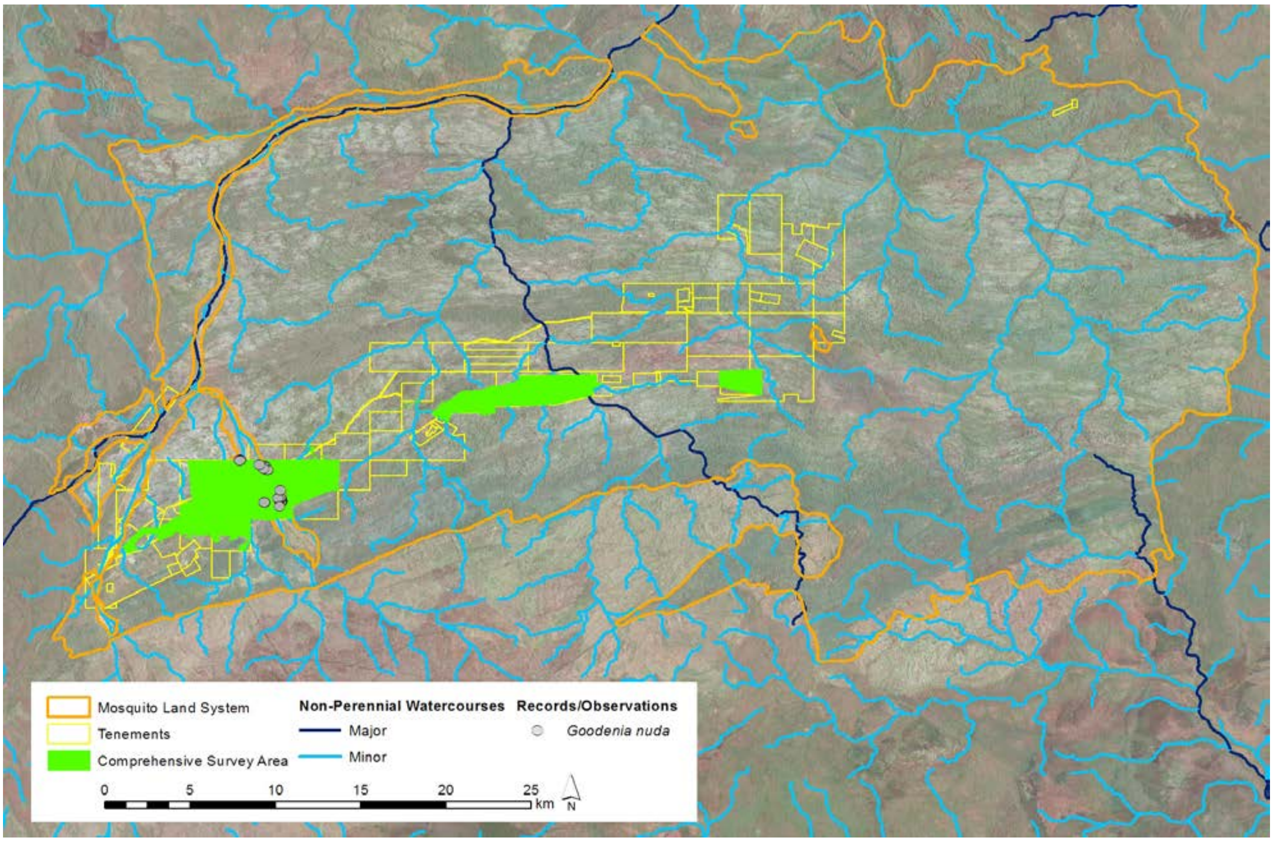

Figure 3.44: Distribution of *Ptilotus mollis* (P4) in the Mosquito Land System

Plate 3.6: *P. mollis* habitat

Plate 3.7: *P. mollis* habitat on exposed rock

3.8 Other Priority Taxa

Three other priority taxa (*Euphorbia sarcostemmoides* (P1), *Themeda* sp. Hamersley Station (P3); and *Lepidium catapycnon* (P4)) have been previously recorded in the vicinity, but were not relocated during the current surveys.

3.8.1 *Euphorbia sarcostemmoides (P1)*

Euphorbia sarcostemmoides (P1) was previously recorded by Mattiske Consulting Pty Ltd (2012) but could not be relocated at the co-ordinates recorded and it is unclear whether it was a misidentification, as the similar species *Euphorbia tannensis* and *Sarcostemma viminale* were located elsewhere in the survey area. *Sarcostemma viminale* is widespread throughout the northern two thirds of Western Australia but never common (Mitchell & Wilcox, 1998).

3.8.2 *Themeda sp. Hamersley Station (P3)*

Themeda sp. Hamersley Station (P3) was previously recorded around the Golden Eagle pit by Mattiske Consulting Pty Ltd (2012) (Figure 3.15). This taxon appears to be concentrated around the Hamersley Range with 30 records between Karratha, Newman, and Nullagine, spread over an area 250 km north-south by 350 km east-west (DPaW, 2016). It occupies the calcareous cracking clay soil of the Hamersley Plain. It also occurs on the Hamersley plateau and Fortescue floodplain where there are calcareous cracking clay soils and limestone boulders (Clunies-Ross & Mitchell, 2014).

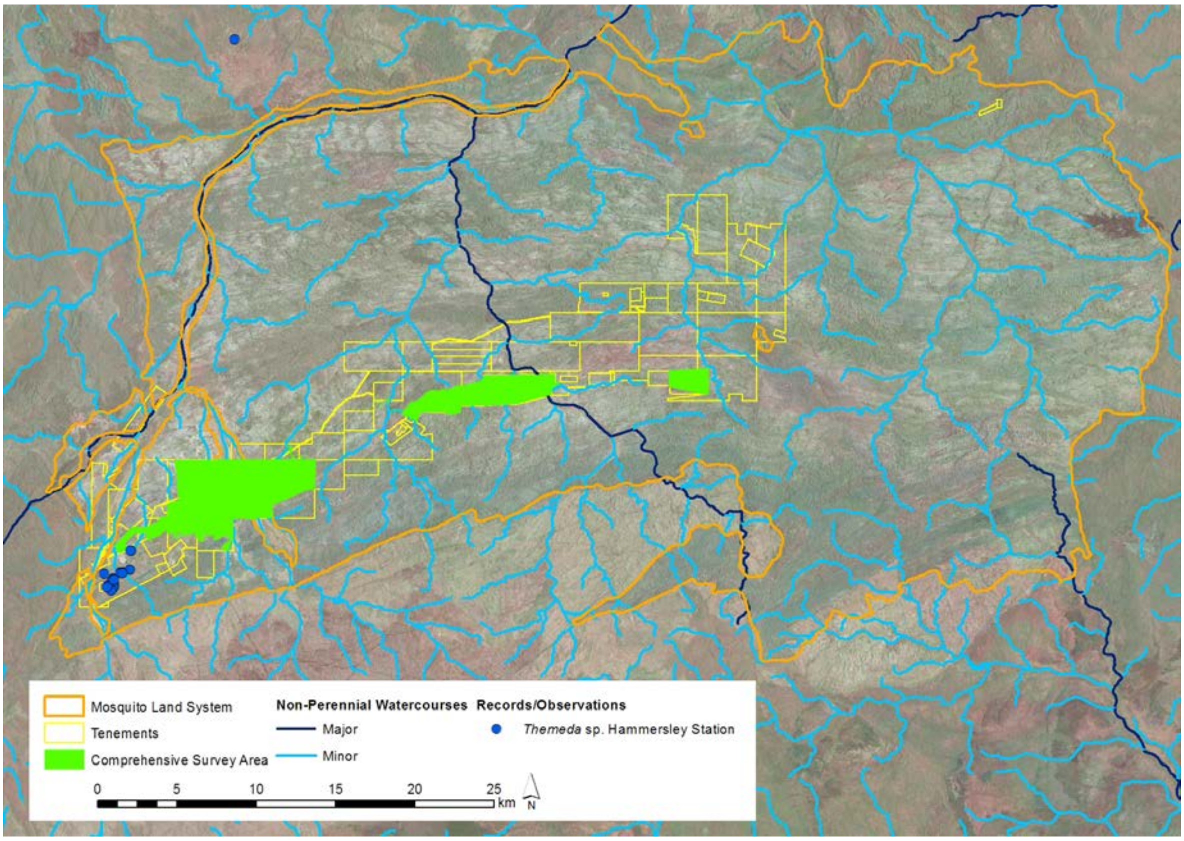

Figure 3.15: Distribution of *Themeda* sp. Hamersley Station (P3) in Land System

3.8.3 *Lepidium catapycnon (P4).*

Whilst *Lepidium catapycnon* is listed as P4 by DPaW, it is also listed as Vulnerable under EPBC Act. It was recorded at three points in the 'Barton lease' area, but population abundance and extent were not documented by Mattiske Consulting Pty Ltd (2005) (Figure 3.16). It was not located subsequent surveys of the 'Barton lease' area (George, 2015). The species is not always detectable as it is a:

- short-lived perennial herb or shrub to 40 cm (Department of the Environment, 2016);
- a pioneer ephemeral that re-appears after fire (WA Herbarium, 2015);
- a disturbance opportunist along tracks (Mattiske Consulting Pty Ltd, 2005); and
- appears to be concentrated around the Hamersley Range;
    - o 86 records between Newman, Tom Price and Nullagine, 160 km north-south by 300 km east-west, with most records in Hamersley Range (DPaW, 2016);

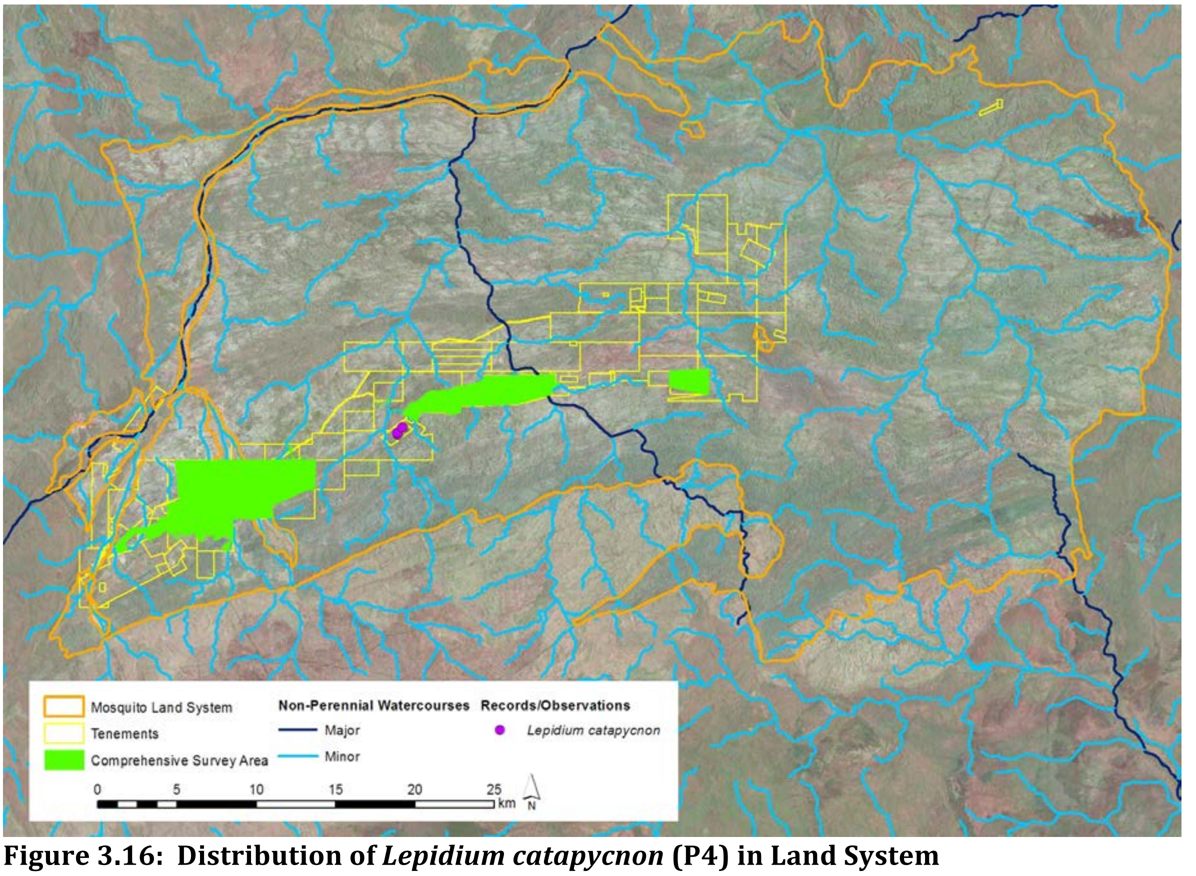

Figure 3.16: Distribution of *Lepidium catapycnon* (P4) in Land System

3.9 Other Taxa of Interest

Material from a hybrid between *Maireana melanocoma* and a species of *Sclerolaena* was submitted to Steve Dillon at the WA Herbarium.

This hybrid has previously been collected from the other (eastern) end of the Mosquito Land System. Both specimens were identical (with the fruiting perianth having both spines and a wing), and both "populations" consisted of one plant (Dillon, 2017). Other hybrids between genera in the same group have already been recorded (e.g. *Enchylaena* × *Maireana*) (Dillon, 2017).

4. Discussion

Acacia aphanoclada occurs across the entirety of the Mosquito Land System, where it is abundant on crests and slopes (of all aspects) of hills, and in low density and scattered on flats and valley floors (often near base of hills where present). However, it is restricted to the Mosquito Land System and its immediate surrounds and is highly correlated with *Triodia wiseana* grasslands on hills (Vreeswyk et al., 2004).

The results of this study are consistent previous surveys and with the findings of Barker (2007) who recorded the species occurring across the Mosquito Land System at relatively consistent densities. Two estimates of the total population size was obtained in this study. The lower estimate (approximately 530 000 plants) still indicates a significant number of plants extant across the Mosquito Land System. This result is likely to under-estimate the total population size as it oversamples parts of the landscape where the species is uncommon (i.e. plains). The higher estimate (approximately 1 360 000 plants) is likely to be a more accurate result as it is extrapolated from complete counts of plants (13,164 plants have been directly counted) over approximately 2% of the Mosquito Land System. Although the species has a restricted distribution, localised disturbances are unlikely to represent a significant threat to local populations or the species.

Occurrences of *Acacia aphanoclada* are clumped at fine scales within hills but is relatively continuous throughout its habitat. The DPaW's guideline in its *Threatened and Priority Flora Report Form - Field Manual* is to include plants within 500 m of a known population as part of that population (Stack, 2010). This default position appears appropriate for *Acacia aphanoclada* and would likely result in a few very extensive populations across the Mosquito Land System if it were comprehensively surveyed.

Atriplex spinulosa appears to be largely restricted to the Mosquito Land System with 31 records, mostly between Nullagine and Twenty Mile (Sandy) Creek 60 km east to the east (DPaW, 2016). Outliers have been recorded from Carnarvon and Geraldton (DPaW, 2016) but these outliers are no longer considered same taxa (WA Herbarium, 2015). An accurate count of population sizes is not yet possible as fruiting material is required to distinguish it from similar taxa, and appropriate material was not available throughout 2016. Subsequent surveys during the 2017 wet season should provide more information regarding its extent in the Mosquito Land System.

Ptilotus wilsonii is a poorly documented species that occurs in the Pilbara and Little Stony Desert, including in Rudall River National Park (WA Herbarium, 2015). However, there are only 4 records from Nullagine to the Throssell Range, representing an area 70 km north-south by 220 km east-west (DPaW, 2016). The four occurrences recorded in the MML tenements should not be disturbed as each one is very restricted in area and represents a limited number of plants.

Acacia fecunda is a local endemic centred around Mosquito Land System with 19 records across an area approximately 100 km north-south by 50 km east-west (DPaW, 2016). It was recorded from 50% of minor drainage lines crossed during the land-system wide survey and is locally very abundant. It is often the dominant species where it is located. Although it is not expected that this species has a particularly extensive geographic range (Maslin & van Leeuwen, 2008), the population size and extent indicates that is not threatened by localised disturbances. It is likely to be resilient to such disturbances given that it regenerates from seed following disturbance and plants flower from about the age of 1 year (Maslin & van Leeuwen, 2008).

Similarly, *Eucalyptus rowleyi* is widespread and locally abundant. It occurs on the plains of the upper De Grey River system, north-east of the Hamersley Range in the area bounded by Marble Bar, Newman and the Rudall River National Park, with three main populations known east of Nullagine, south of Roy Hill and to the north-east of Balfour Downs Station (Nicolle & French, 2012). There are 29 records over an area approximately 100 km north-south by 350 km east-west (DPaW, 2016). This species would not have been targeted in surveys prior to 2012 (at which time *Eucalyptus rowleyi* was separated from *Eucalyptus lucasii*) and it is likely more populations will be found with further surveys. Local disturbances are not considered to represent a threat in the short-term, although there are no populations known from the conservation estate (Nicolle & French, 2012).

Goodenia nuda and *Ptilotus mollis* are both widespread species in the region. *Goodenia nuda* occurs mostly between Port Hedland, Onslow and Newman over an area of 300 km north-south by 600 km east-west, but there are also outliers 300 km farther east and 200 km south (DPaW, 2016). The species is likely under-reported as it can only be reliably surveyed after rain when flowers are present and it appears to thrive in disturbed areas. This trait is similar to many *Goodenia* that are highly responsive to disturbance (Sage & Pigott, 2003). *Ptilotus mollis* only appears to occur in scattered small populations within the Mosquito Land System. The habitat that it was recorded in this survey (rocky areas with exposed weathered clay) is typical for the species and suggests that habitat type is uncommon in the Mosquito Land System.

5. Summary

The main targeted species in this study (*Acacia aphanoclada, Acacia fecunda* and *Eucalyptus rowleyi*) are widespread and abundant within the Mosquito Land System. Localised disturbances are unlikely to represent a significant impact to the viability of the local populations or the species. *Ptilotus wilsonii,* however, is very restricted within the Mosquito Land System and most occurrences represent only a few individuals.

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