Millennium Minerals Ltd
Priority Flora
Nullagine Census Update
June 2018

JUNE 2018

Plantecology CONSULTING

Woodgis
ENVIRONMENTAL ASSESSMENT & MANAGEMENT

Plantecology Consulting
ABN 18 849 210 133
50 New Cross Rd
Kingsley WA 6026
Telephone: 0429 061 094
shane@plantecology.com.au

Woodgis
ABN 47 085 106 428
PO Box 1130
Willagee WA 6156
Telephone: 0403318284
andrew@woodgis.com.au

Recommended Citation:

Woodgis (2018) *Millennium Minerals Ltd – Nullagine Priority Flora Census Update, June 2018*, unpublished report by Woodgis and Plantecology for Millennium Minerals Ltd.

Executive Summary

This report updates the priority flora data for surveys across Millennium Minerals Ltd tenements near Nullagine, from April 2016 until June 2018, and provides a basis for priority flora impact assessments in the northern occurrence of the Mosquito Land System.

Since 2016, flora and vegetation field surveys have been conducted across 200 field days, with an additional 35 field days dedicated to the characterization of soil-plant-vegetation-landform relationships. The focus of the surveys was within the 5,670 hectares where 1:10,000 vegetation mapping (and more than 33,000 unique flora/vegetation observations) has been undertaken. This detailed mapping includes approximately 50% of the east-west extent, and 3% of the area, of the 184,000 ha Mosquito Land System, and it is estimated that 92-99% of the flora in the mapped area has been recorded (based on estimates from 228 quadrats).

In addition to the data collected for detailed vegetation mapping, flora/vegetation/landform patterns have been observed along more than 700 km of road and tracks in and around the Mosquito Land System, including approximately 475 km of priority flora traverses (the presence/absence of *Acacia aphanoclada* was recorded at 245 sites, and the presence/absence of *Acacia fecunda* and *Eucalyptus rowleyi* were recorded at 339 sites).

Surveys were undertaken by Andrew Waters and Dr Shane Chalwell, each with approximately 20 years experience. Identifications were verified by Frank Obbens, a research associate of the WA Herbarium, and Andrew Mitchell was consulted on *Solanum* sp. Mosquito Creek (A.A. Mitchell et al. AAM 10795). Threatened and Priority Flora Report Forms have been submitted to DBCA, and plant specimens lodged with the WA Herbarium.

The Mosquito Land System (MLS) is a centre of local endemism, and half of the priority flora recorded are abundant in the land system but not regionally widespread:

- *Ptilotus wilsonii* (P1) appears to be neither locally abundant, nor regionally widespread;
- *Acacia aphanoclada* (P1), *Acacia fecunda* (P1), *Atriplex spinulosa* (P1) and *Solanum* sp. Mosquito Creek (P1) are abundant local endemics that are favoured by disturbance;
- *Eucalyptus rowleyi* (P3) is scattered across the southeast Pilbara; and
- *Goodenia nuda* (P4) and *Ptilotus mollis* (P4) are scattered throughout the Pilbara.

The appropriate basis for impact assessments are:

- Individual plants
  - *Ptilotus wilsonii* (P1) and *Ptilotus mollis* (P4) are small shrubs that are not locally abundant
- Habitat Extent (Length of Drainagelines)
  - *Acacia fecunda* (P1) and *Eucalyptus rowleyi* (P3) are abundant shrubs/trees that form monocultures/large stands along creeks
  - *Goodenia nuda* (P4) is a widespread annual herb that occurs in variable densities but with highest densities in disturbed areas. It cannot be reliably detected in all seasons but its habitat can be mapped.
- Habitat Extent (Area of Vegetation Units)
  - *Atriplex spinulosa* (P1) and *Solanum* sp. Mosquito Creek (P1) are highly abundant locally endemic shrubs that are associated with specific vegetation units, and occur in variable densities but with highest densities in disturbed areas.
- Habitat Extent (Area of Landforms)
  - *Acacia aphanoclada* (P1) is a highly abundant locally endemic shrub whose density is highly correlated with steepness of slopes.

Table of Contents

LIST OF FIGURES

List of Tables

1 INTRODUCTION

Objective

This report updates priority flora data collected for Millennium Minerals Ltd as of 01 June 2018.

2 METHODS

Field Surveys

Since 2016, flora and vegetation field surveys have been conducted across 200 field days, with an additional 35 field days dedicated to the characterization of soil-plant-vegetation-landform relationships. These surveys were undertaken across all seasons and over a number of years. Surveys were undertaken on the following dates:

- 12-21 April 2016
- 11-16 May 2016
- 02-09 June 2016
- 03-18 August 2016
- 12-20 January 2017
- 17-23 February 2017
- 13-23 March 2017
- 06-13 April 2017
- 20-27 April 2017
- 18-25 May 2017
- 21-28 September 2017
- 06-13 October 2017
- 02-09 November 2017
- 09-16 April 2018
- 10-17 May 2018

The focus of the surveys was within the 5,670 hectares where 1:10,000 vegetation mapping has been undertaken (Figure 1). This area has been comprehensively surveyed, with more than 18,000 vegetation observations and 15,000 priority flora observations being made at unique locations. It is estimated that 92-99% of the flora in the mapped area has been recorded (based on chao, jackknife1, jackknife2 and bootstrap estimates from 228 quadrats). Densities of *Atriplex spinulosa* were recorded in 1 m x 60 m areas within quadrats it was recorded in.

The detailed mapping covers approximately 50% of the east-west extent, and 3% of the area, of the 184,000 ha Mosquito Land System (MLS).

Flora/vegetation/landform patterns also have been observed along more than 700 km of roads and tracks in and around the Mosquito Land System during surveys, including approximately 475 km of traverses undertaken for three priority species (Figure 2):

- *Acacia aphanoclada* was surveyed at 245 sites along roads and tracks at intervals of 1 km in, and 2 km outside of, Millennium Minerals tenements, with the following recorded:
  - the distance to the closest plant and the plant closest to it,
  - the species as absent where no plants were within 250 m of the site.
- *Acacia fecunda* and *Eucalyptus rowleyi,* the presence/absence within 50 metres of drainageline crossings was recorded at 325 minor/intermediate channels surveyed, and 14 major channels across the Mosquito Land System.

Field surveys were undertaken by Andrew Waters and Dr Shane Chalwell, each with approximately 20 years professional experience. Priority flora identifications were verified by Frank Obbens, a research associate of the Western Australian Herbarium where he is a leading expert on the genus *Calandrinia*. *Solanum* sp. Mosquito Creek was listed as Priority flora in November 2017, and Andrew Mitchell was consulted on its identification / habitat.

Dr Shane Chalwell has lodged plant specimens with the WA Herbarium for:

- *Atriplex spinulosa*
- *Acacia aphanoclada*
- *Acacia fecunda*
- *Eucalyptus rowleyi*
- *Ptilotus wilsonii*
- *Solanum* sp. Mosquito Creek

Andrew Waters submitted Threatened and Priority Flora Report Forms, with associated shapefiles, to DBCA on 13/12/2017 for:

- *Atriplex spinulosa*
- *Acacia aphanoclada*
- *Acacia fecunda*
- *Eucalyptus rowleyi*
- *Goodenia nuda*
- *Ptilotus mollis*
- *Ptilotus wilsonii*

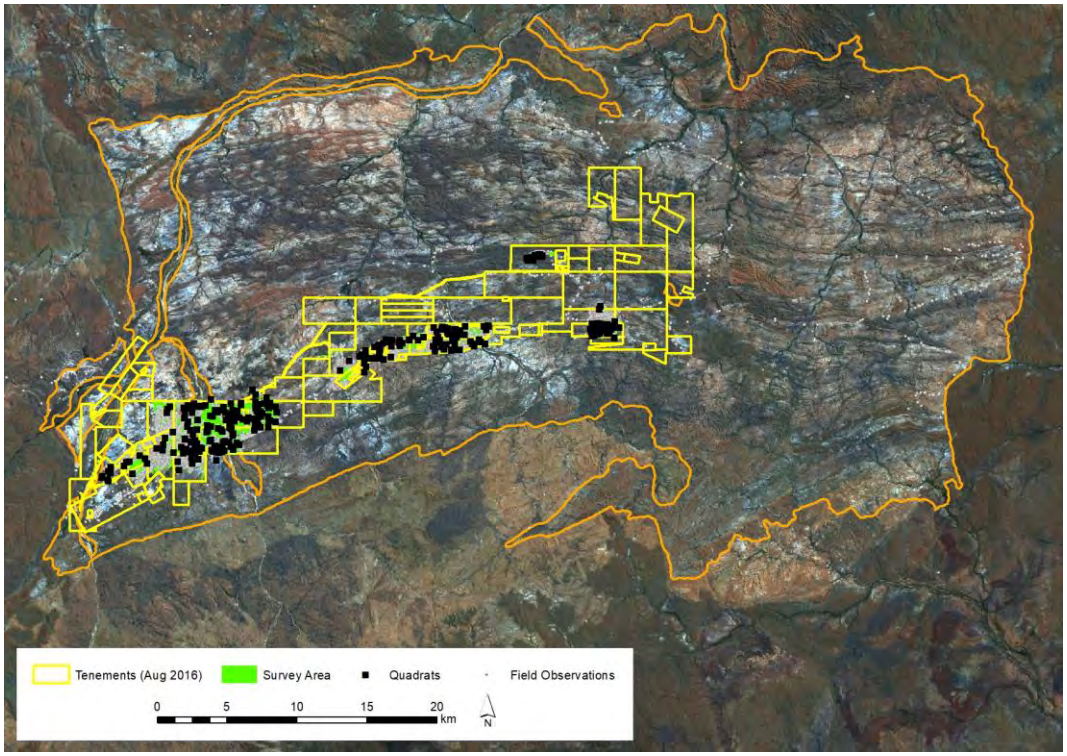


Figure 1: Census Extents

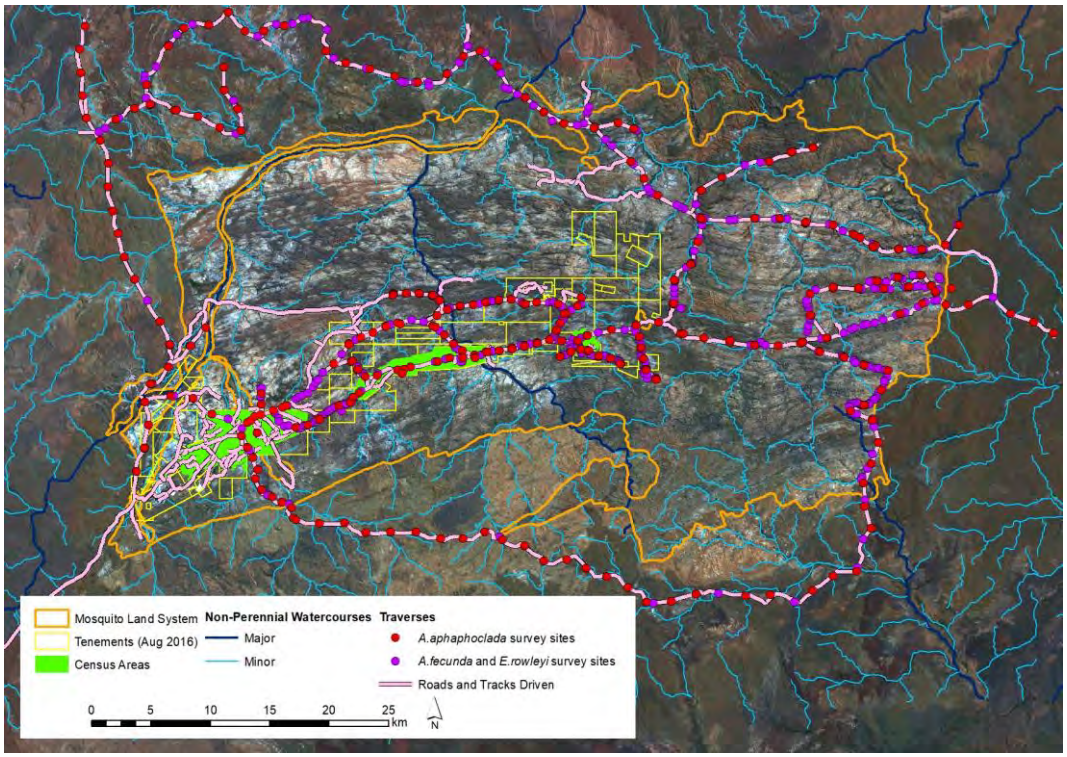


Figure 2: Survey Traverse Extents

The flora taxa targeted in the surveys are summarised in Table 1.

Table 1: Priority Flora Targeted in Surveys

Lifeform	Priority	Species	Habitat	In Land System	Habitat Present	Likely Presence in Census Areas
Trees, Mallees and Shrub >1m	P1	*Acacia aphanoclada*	Rocky hills, ridges and rises in skeletal stony soils	X	X	Confirmed
	P1	*Acacia cyperophylla* var. *omearana*	Stony & gritty alluvium. Along drainage lines.		X	Highly Unlikely highly detectable and not seen
	P1	*Acacia* sp. Nullagine	Rocky clay, low lying area between rocky hills.		X	
	P1	*Cochlospermum macnamarae*	Granite boulders.			
	P1	*Euphorbia sarcostemmoides*	Sandstone ridges, quartzite hills.		X	
	P3	*Acacia fecunda*	Associated with quartzite gibbers over grey-red skeletal soil	X	X	Confirmed
	P3	*Eucalyptus rowleyi*	Red sandy loams on plains and very minor and broad flood-outs	X	X	
Shrubs < 1m	P1	*Ptilotus wilsonii*	Stony gravelly soils. Rocky hills.	X	X	
	P1	*Solanum* sp. Mosquito Creek	Alluvial clays and clay loams	X	X	
	P1	*Stemodia* sp. Battle Hill	Cracking clay. Floodplain.			Highly Unlikely detectable and habitat absent
	P2	*Indigofera ixocarpa*	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)
	P4	*Ptilotus mollis*	Stony hills and screes.	X	X	Confirmed
Perennial Grass < 1m	P3	*Themeda* sp. Hamersley Station	Claypans	X		Highly Unlikely habitat absent
	P3	*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)		X	Unlikely Potential habitat degraded by grazing, distinctive culms but annual species
Annual Herb < 1m	P1	*Atriplex spinulosa*	Footslope of low hill, drainage floor with quartz covered surface, slopes of creek, stony pavement	X	X	Confirmed
	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)
	P3	*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)
	P3	*Swainsona thompsoniana*	Gibber plains, crabhole plains and gilai			Highly Unlikely habitat absent
	P4	*Goodenia nuda*	Open depression. Brown sandy loam with granite stones.	X	X	Confirmed
Annual Sedge < 1m	P1	*Fimbristylis* sp. Shay Gap	Edge of small pool in basalt creekline.			Highly Unlikely habitat absent

3 SPECIES RECORDS / DISTRIBUTIONS

Acacia aphanoclada (P1)

Acacia aphanoclada is a shrub (Plate 1) that is a local endemic (Figure 3) that is widespread and abundant in the Mosquito Land System (Figure 4 and Figure 5).

Plate 1: *Acacia aphanoclada*

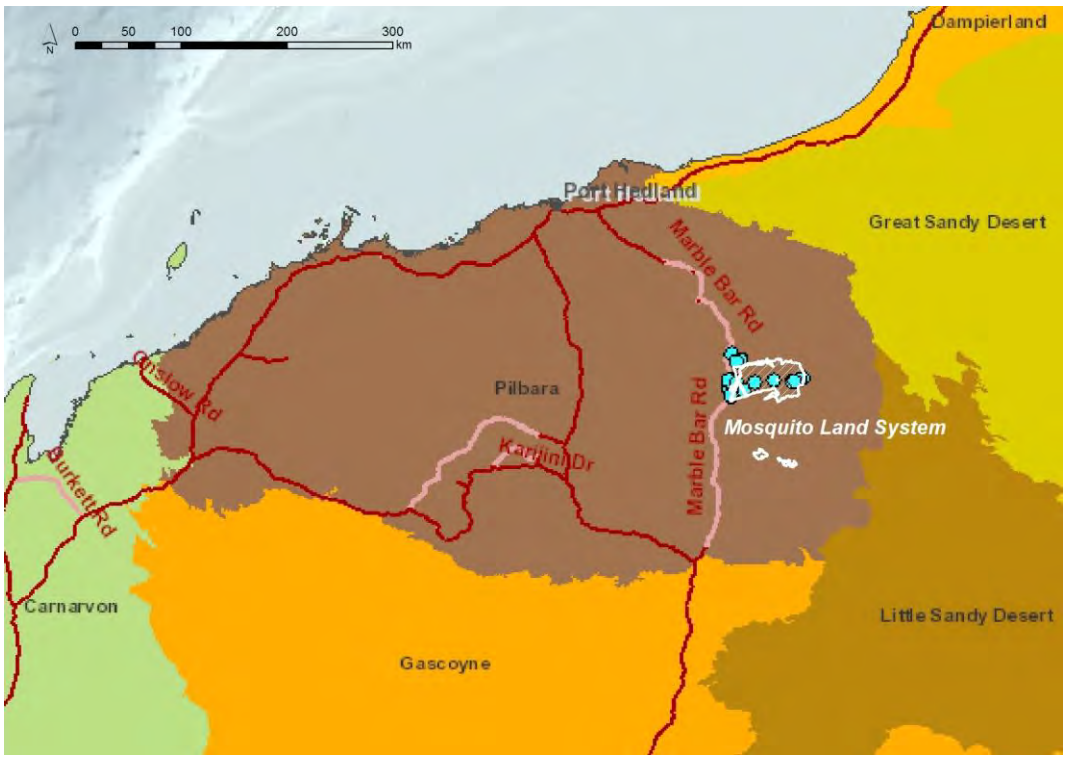


Figure 3: Records of *Acacia aphanoclada* (P1) in the Pilbara Bioregion

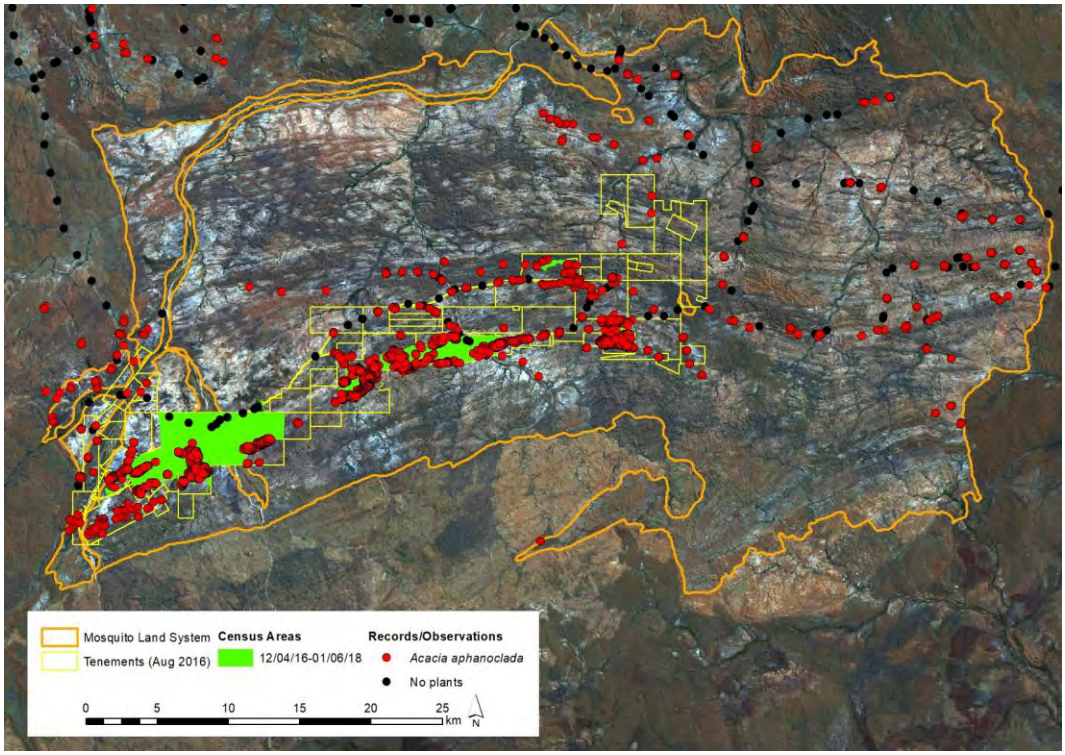


Figure 4: Records of *Acacia aphanoclada* (P1) in the Mosquito Land System

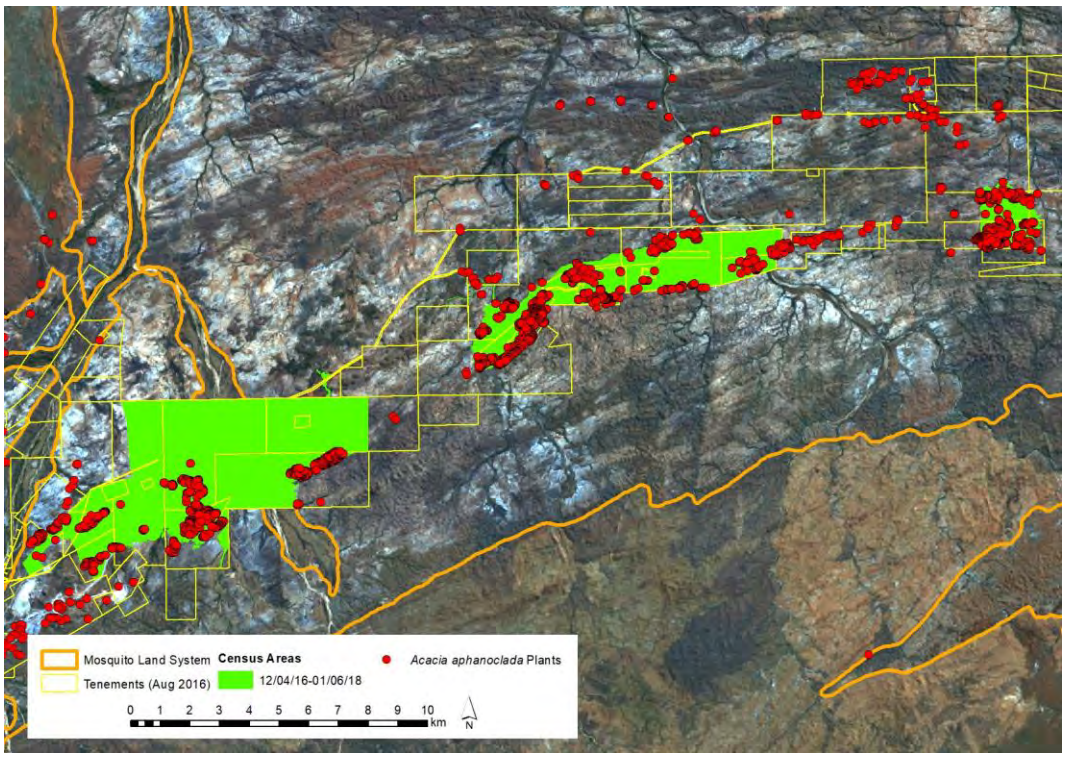


Figure 5: Records of *Acacia aphanoclada* (P1) in the Census Areas

Acacia aphanoclada is indicative of ridges and hills in the Mosquito Land System (Vreeswyk, Payne, Leighton, & Hennig, 2004) (Plate 2) and occurs on:

- skeletal stony soils, rocky hills, ridges & rises (DPaW, 2016);
- predominantly rocky hills and outcrops, 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);
- rocky "spinifex" (Triodia spp.) hills with scattered eucalypts and acacias on Mosquito Creek sediments and conglomerates (Maslin B. , 1998);
- narrowly fissured vertical rock (Plate 3); and
- disturbed areas (Plate 4).

Acacia aphanoclada:

- appears to readily germinate from seed;
- resprouts after fire (Maslin & Reid, 2010) (Plate 5); and
- does not appear to be grazed by cattle (and its prime habitat is inaccessible to cattle).

Plate 2: *A. aphanoclada* on typical slopes

Plate 4: *A. aphanoclada* in disturbance

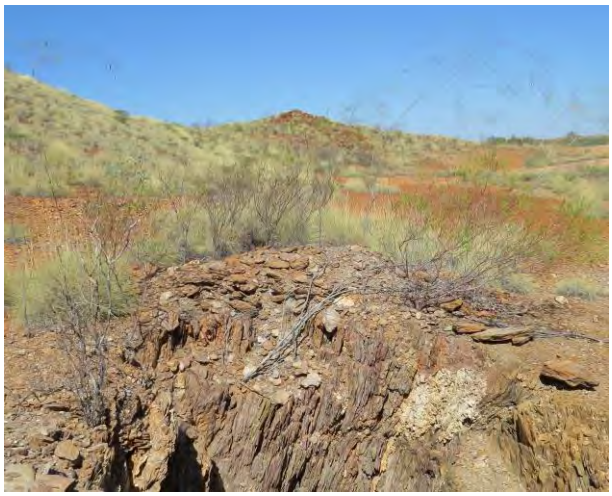


Plate 3: *A. aphanoclada* on typical soils

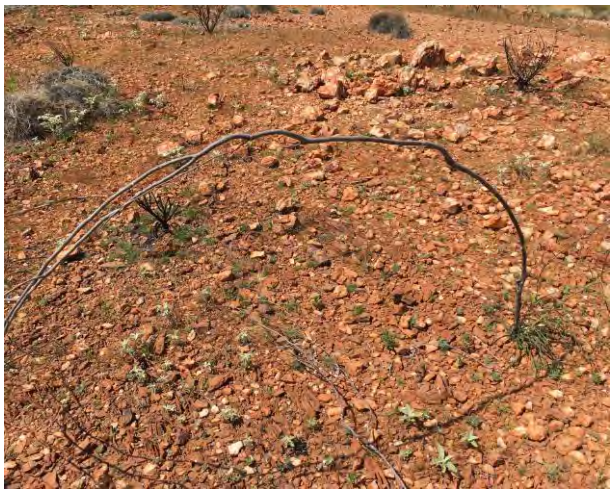


Plate 5: *A. aphanoclada* resprouting after fire

Table 2 shows (for the approximately 5,602 ha area censused up until 01 June 2018) 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); and
- occurs on all aspects, with no correlation between density and aspect.

Table 2: Number of Plants by Slope and Aspect in Targeted Surveys (up till 01 June 2018)

	N	NE	E	SE	S	SW	W	NW	Total	
Level	27	112	81	126	38	28	136	24	572	3%
Very Gently Inclined	933	526	566	326	109	522	582	709	4,273	20%
Gently Inclined	1,536	1,120	1,350	2,109	1,481	1,190	1,712	2,246	12,744	60%
Moderately Inclined	710	93	131	769	132	305	424	1,066	3,630	17%
Total	3,206	1,851	2,128	3,330	1,760	2,045	2,854	4,045	21,219	100%
	15%	9%	10%	16%	8%	10%	13%	19%	100%	

NB: under records plants on moderate slopes as plants often recorded from top or bottom of inaccessible slopes

The estimate of *Acacia aphanoclada* abundance in Table 3 was based on:

- plant densities across the entirety of the comprehensively surveyed area; and
- the extents of slope categories across the northern Mosquito Land System, but only for geology types that the species has been confirmed as occurring on (as listed in Appendix 1).

Table 3: Abundance Estimate based on densities by landform (01 June 2018)

	Level	Very Gently Inclined	Gently Inclined	Moderately Inclined	Steep or Very Steep	Total
Extent of Slope Category	19,223 ha	56,016 ha	65,323 ha	17,119 ha	585 ha	158,274 ha
Density (Plants/ha)	0.48	1.79	10.18	45.29	Not recorded	-
Number of Plants	9,155	100,248	665,219	775,365	Not calculated	1,549,987

The extrapolated density distribution is shown in Figure 6.

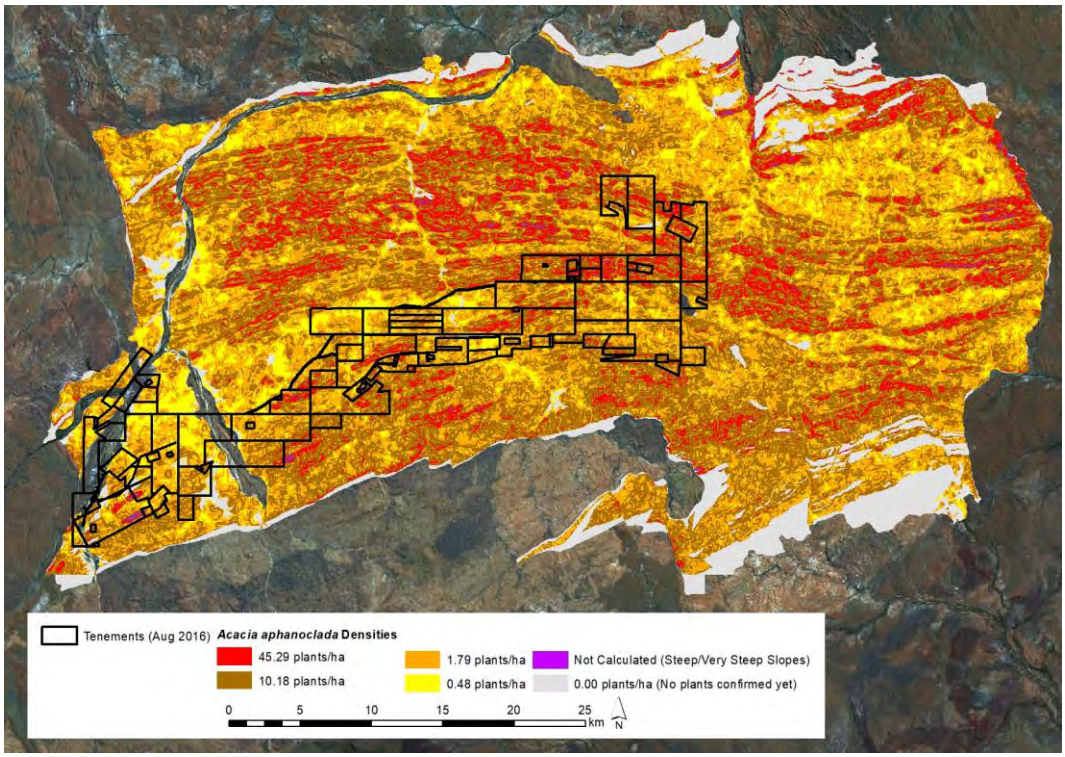


Figure 6: Density of *Acacia aphanoclada* (P1) across the Mosquito Land System

Acacia fecunda (P1)

Acacia fecunda is a tall shrub (Plate 6) that is a local endemic (Figure 7) and is abundant, occurring across much of the MLS (Figure 8 and Figure 9).

Plate 6: *Acacia fecunda*

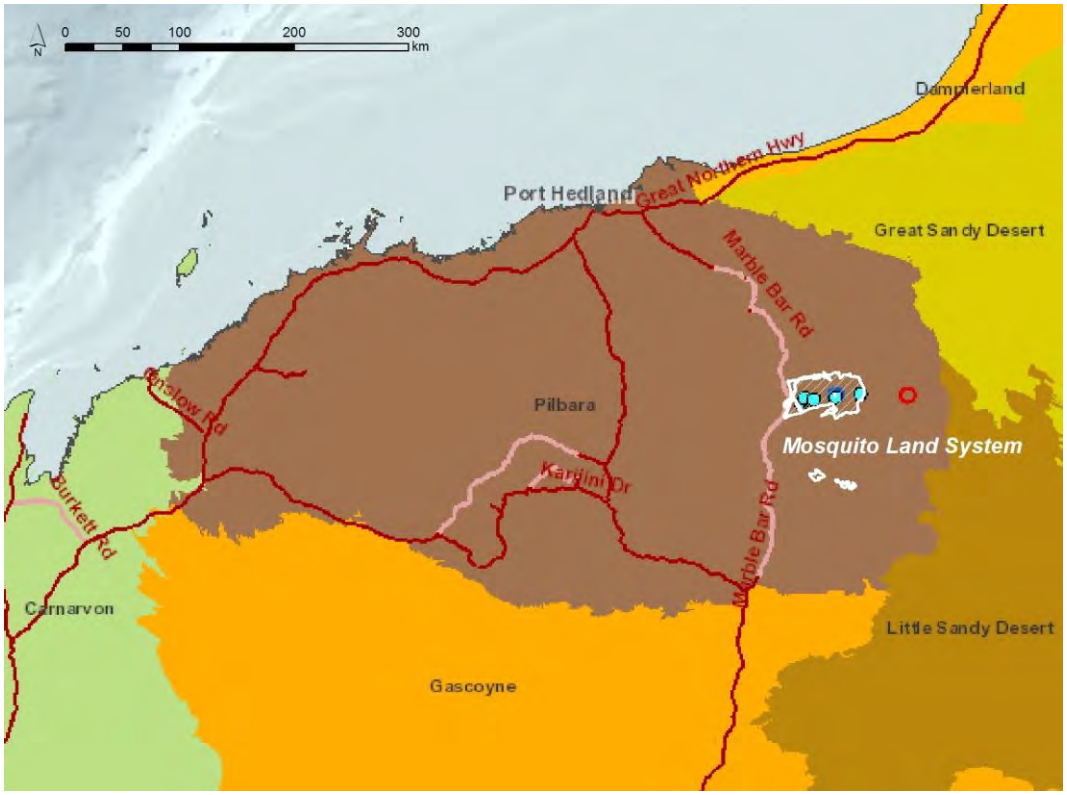


Figure 7: Distribution of *Acacia fecunda* (P1) in the Pilbara Bioregion

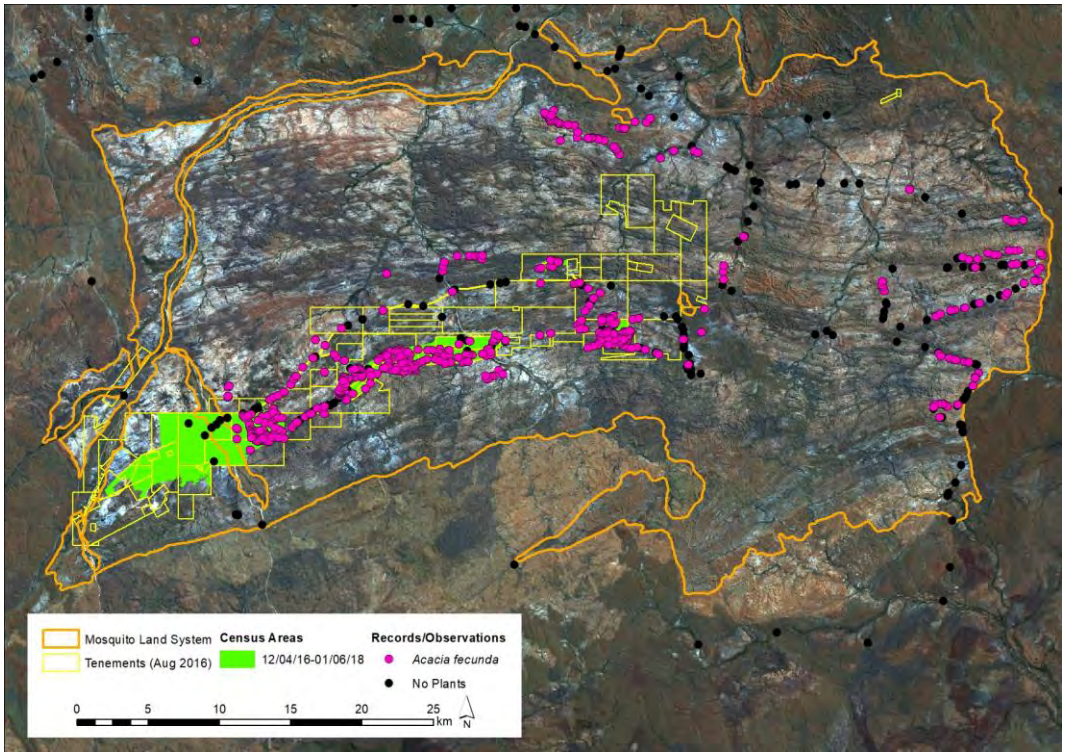


Figure 8: Records of *Acacia fecunda* (P1) in the Mosquito Land System

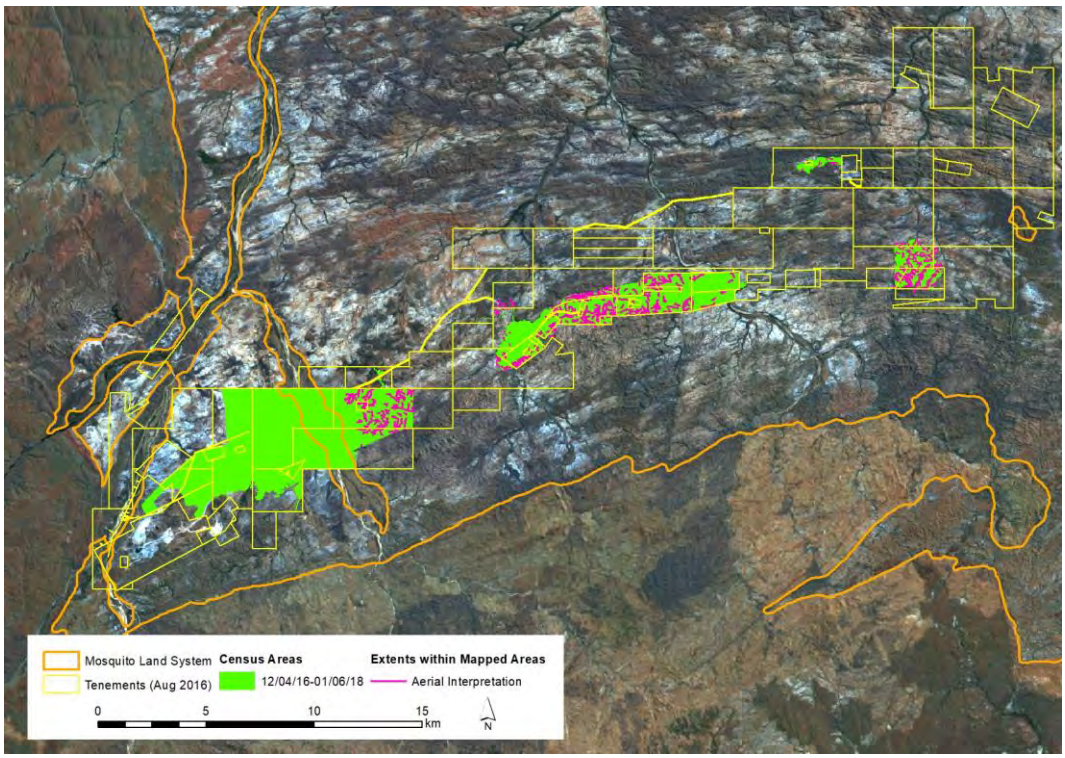


Figure 9: Distribution of *Acacia fecunda* (P1) in the Census Areas

Acacia fecunda:

- tends to form monocultures on drainagelines (Plate 7 and Plate 8);
- is often common in the places where it occurs and it favours water-gaining sites (Maslin & van Leeuwen, 2008); 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
- is likely to be resilient to some disturbance given:
    - it regenerates from seed following fire or other disturbance (may form dense roadside populations) (Maslin & van Leeuwen, 2008); and
    - plants flower from age of about 1 year old (Maslin & van Leeuwen, 2008)

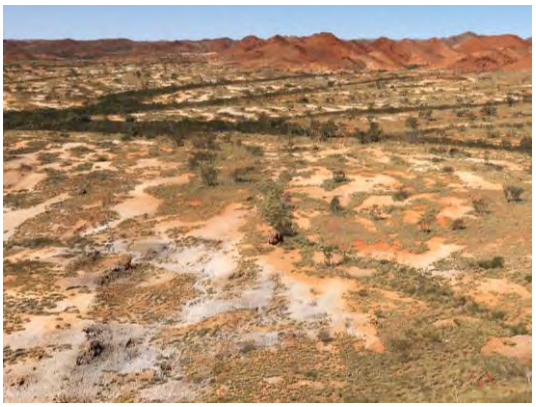


Plate 7: *A. fecunda* drainageline monoculture Example 1

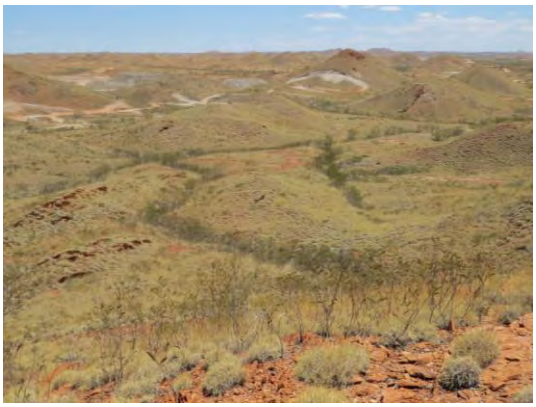


Plate 8: *A. fecunda* drainageline monoculture Example 2

Atriplex spinulosa (P1)

Atriplex spinulosa is an annual/short-lived perennial herb/subshrub (Plate 9) that is a local endemic (Figure 10) and is ubiquitous across the stony saline plains of the Mosquito Land System (Figure 11 and Figure 12).

Plate 9: *Atriplex spinulosa* (P1)

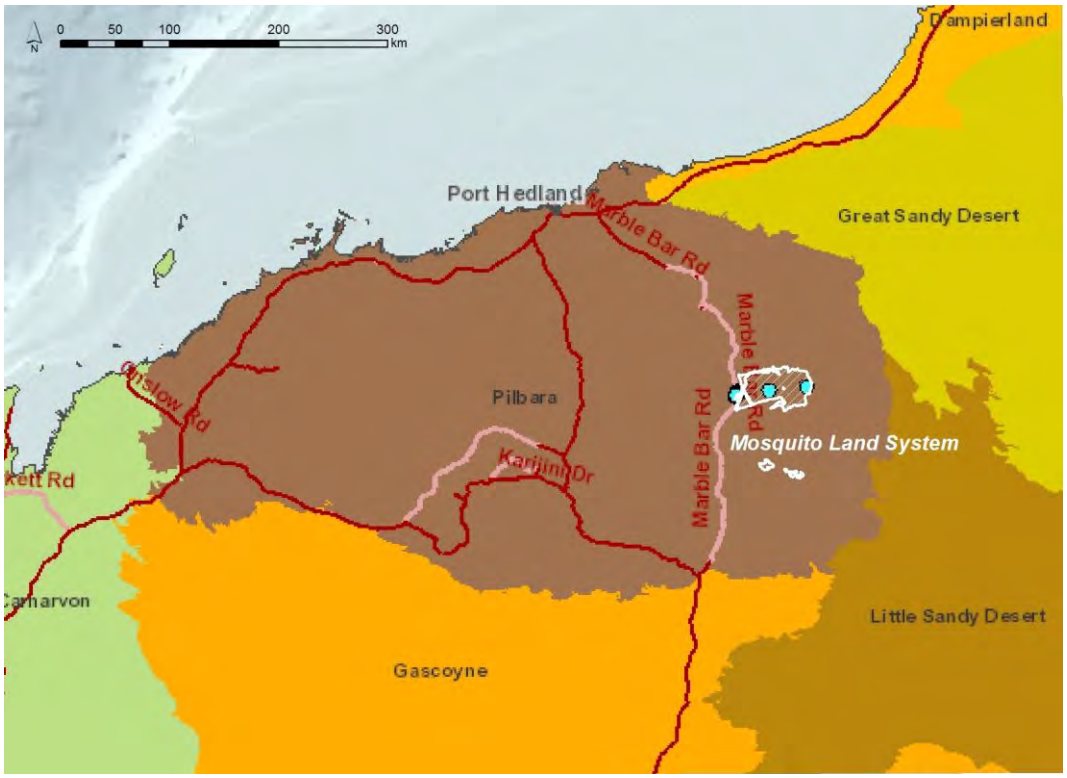


Figure 10: *Records of Atriplex spinulosa* (P1) in the Pilbara Bioregion

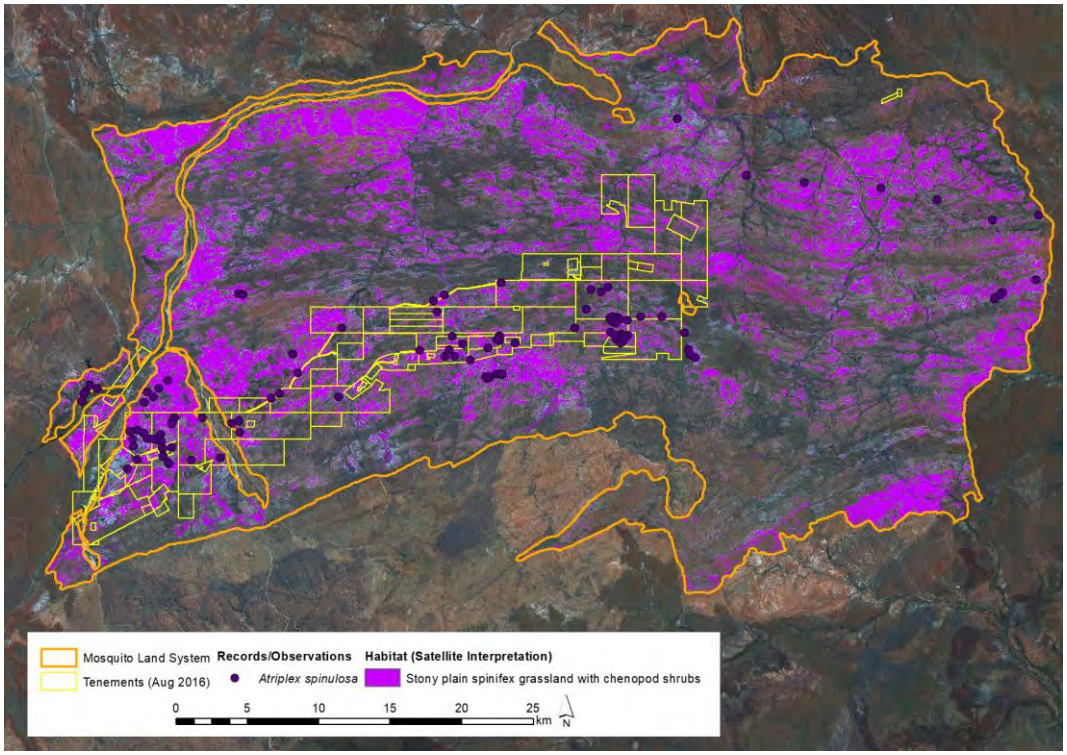


Figure 11: Records of *Atriplex spinulosa* (P1) in the Mosquito Land System

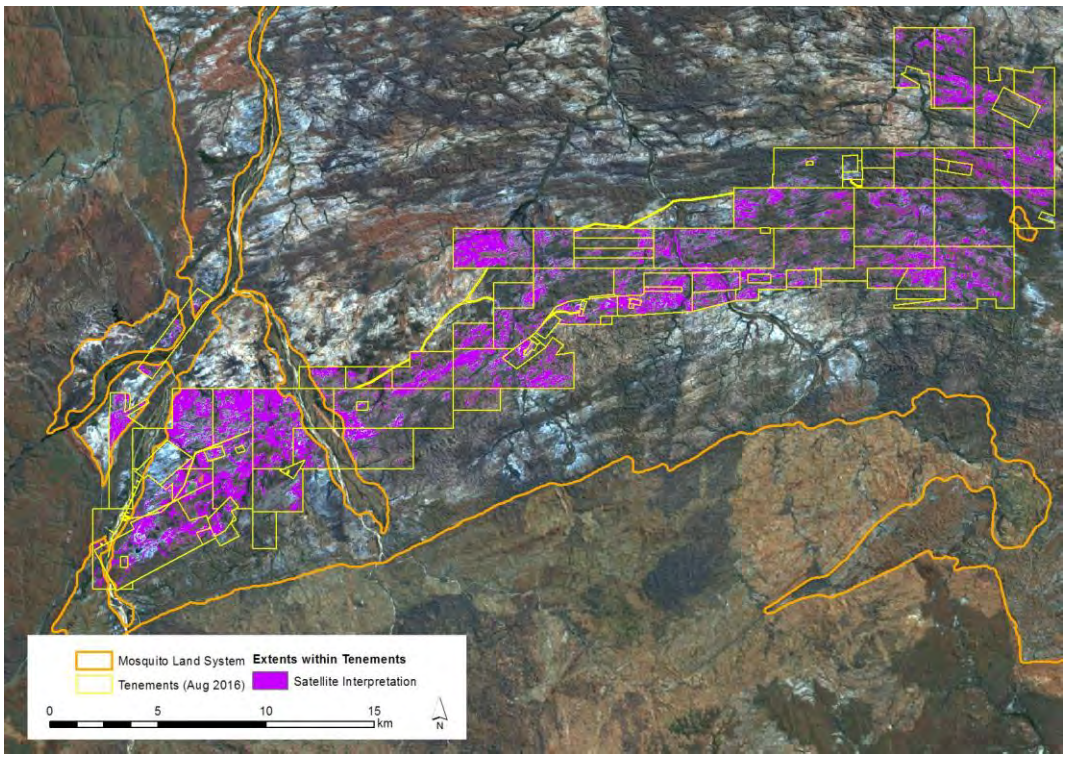


Figure 12: Distribution of *Atriplex spinulosa* (P1) in MML's Nullagine tenements

Atriplex spinulosa was previously recorded as often common where it occurs, and growing amongst hummock grasses on gibber plains on Mosquito Creek Series metasediments or along drainagelines (WA Herbarium, 2015).

Atriplex spinulosa is ubiquitous on the stony saline plains of the Mosquito Land System (Plate 10). An average density of 5,700 plants / hectare was recorded on stony saline plains (in 18 quadrats where it was present (see Appendix 2).

Atriplex spinulosa can be more abundant in disturbed areas (Plate 11). Densities up to 46,300 plants / hectare were recorded along windrows in comparison to densities up to 30,500 plants / hectare recorded on undisturbed areas (see Appendix 2).

Plate 10: *A. spinulosa* in typical habitat

Plate 11: Abundant *A. spinulosa* along windrow

Ptilotus wilsonii (P1)

Ptilotus wilsonii is a small shrub (Plate 12) with disjunct populations in the Mosquito Land System and the Little Sandy Desert (Figure 13). *Ptilotus wilsonii* is scattered across the stony saline plains of the Mosquito Land System (Figure 14 and Figure 15).

Plate 12: *Ptilotus wilsonii* (P1)

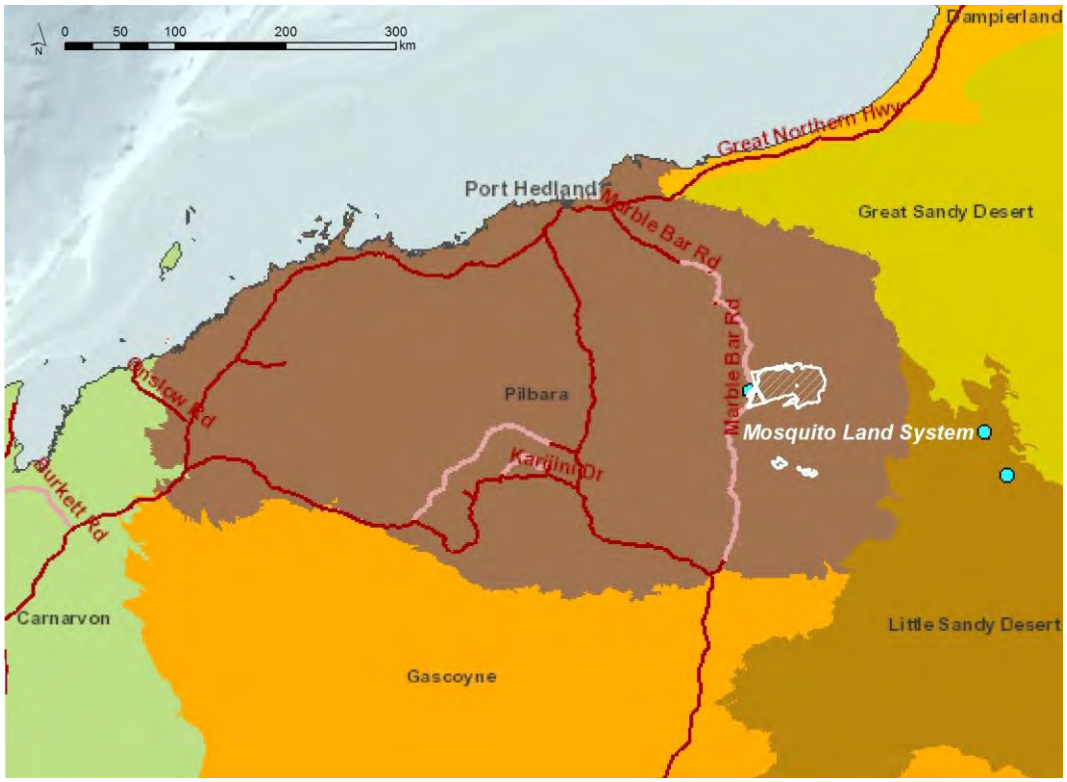


Figure 13: Records of *Ptilotus wilsonii* (P1) in the Pilbara Bioregion

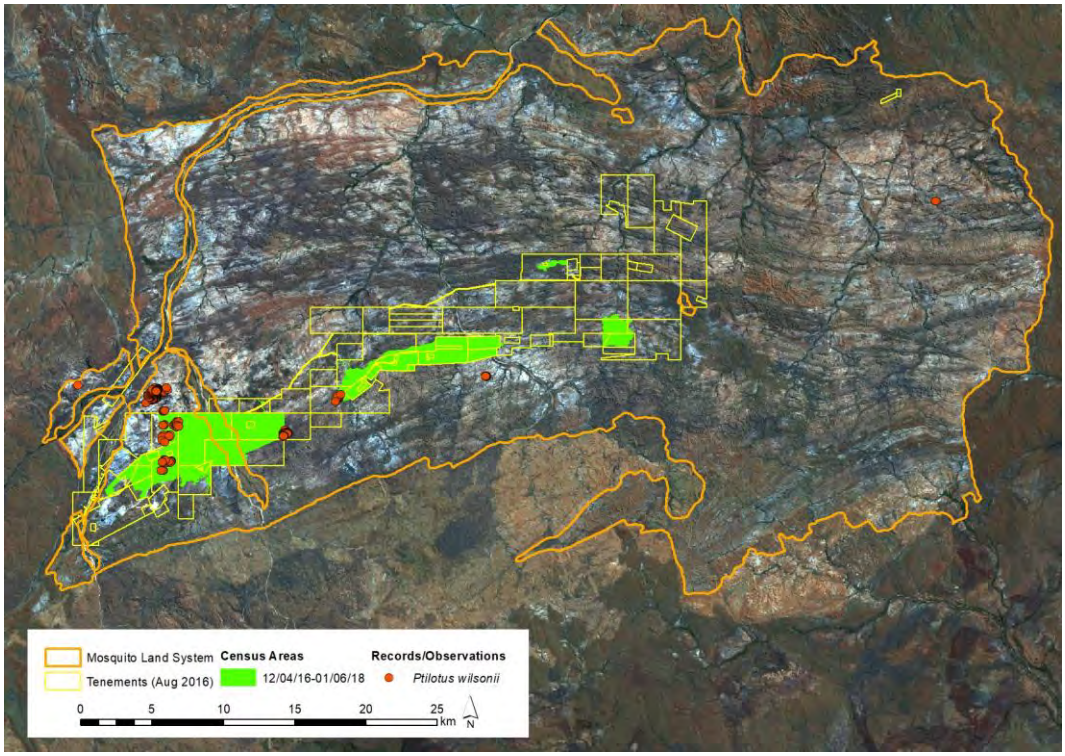


Figure 14: Records of *Ptilotus wilsonii* (P1) in the Mosquito Land System

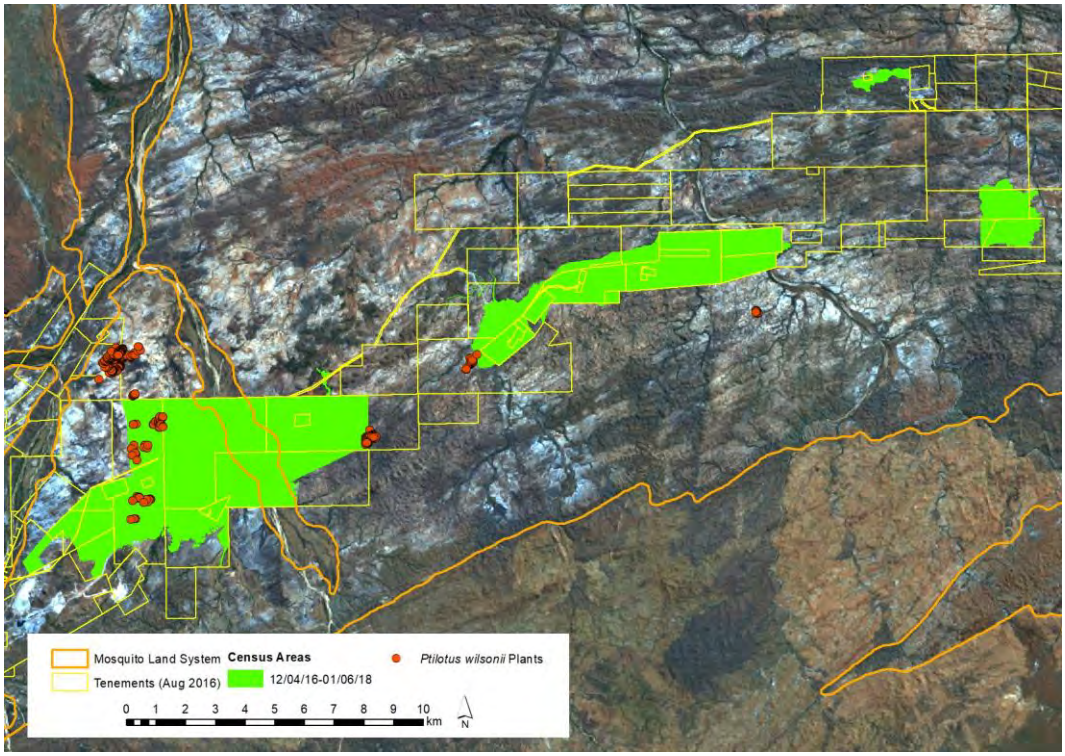


Figure 15: Records of *Ptilotus wilsonii* (P1) in the Census Areas

Ptilotus wilsonii generally occurs on the more elevated parts of the stony saline plains. *Ptilotus wilsonii* was previously recorded growing on or near the base of gently sloping rocky hills (WA Herbarium, 2015),which matches the population shown in Plate 13. Soil profiles at two sites where it occurs (Plates 14 and 15) are different to those of the surrounding stony saline plains, 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).

Plate 13: *P. wilsonii* in hillside habitat

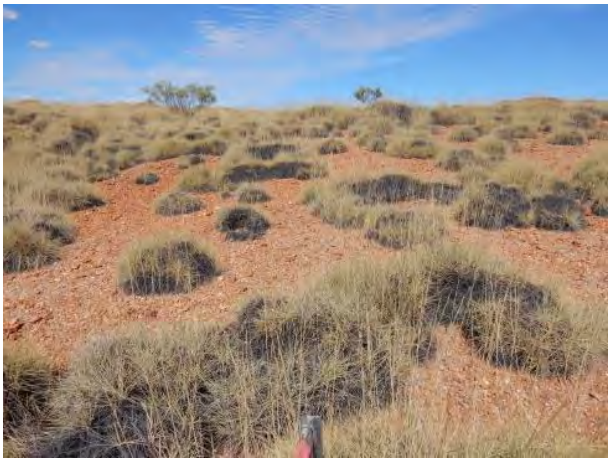


Plate 15: *P. wilsonii* habitat - Quadrat 22

Plate 14: *P. wilsonii* in typical habitat

Solanum sp. Mosquito Creek (A.A. Mitchell et al. AAM 10795) (P1)

Solanum sp. Mosquito Creek is a small shrub (Plate 16) that was listed as Priority flora in November 2017. Andrew Mitchell was consulted on its identification / habitat. It is a local endemic (Figure 16) that is scattered across alluvial clays and clay loams of the Mosquito Land System (Figure 17 and Figure 18).

Plate 16: *Solanum* sp. Mosquito Creek (P1)

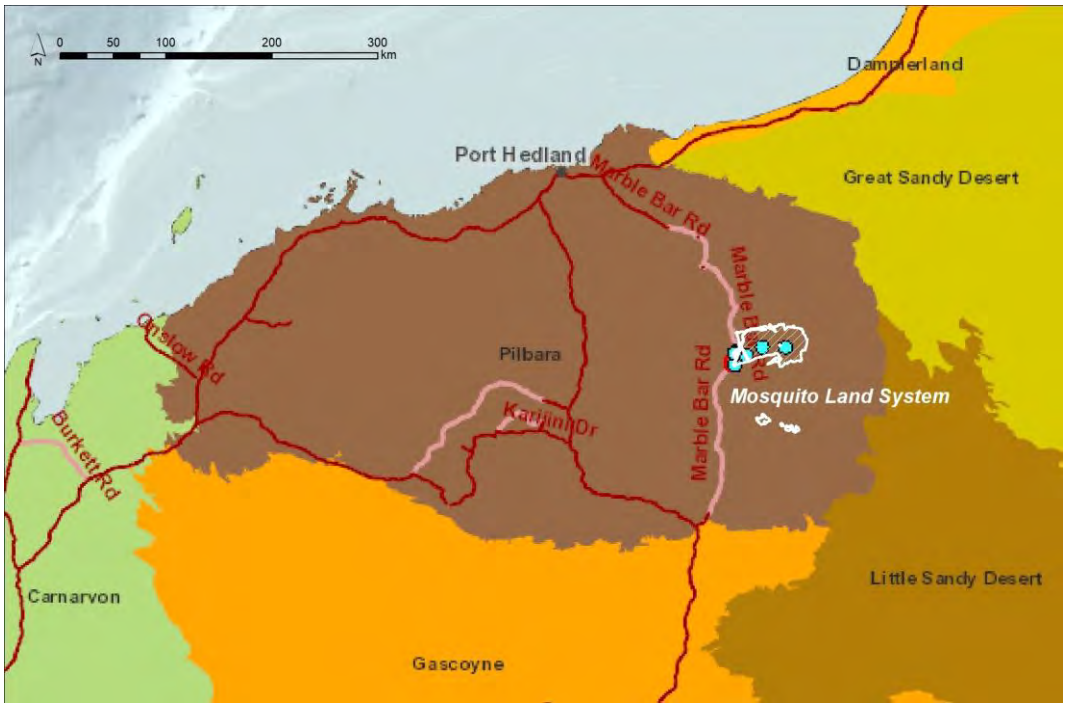


Figure 16: Records of *Solanum* sp. Mosquito Creek (P1) in the Pilbara Bioregion

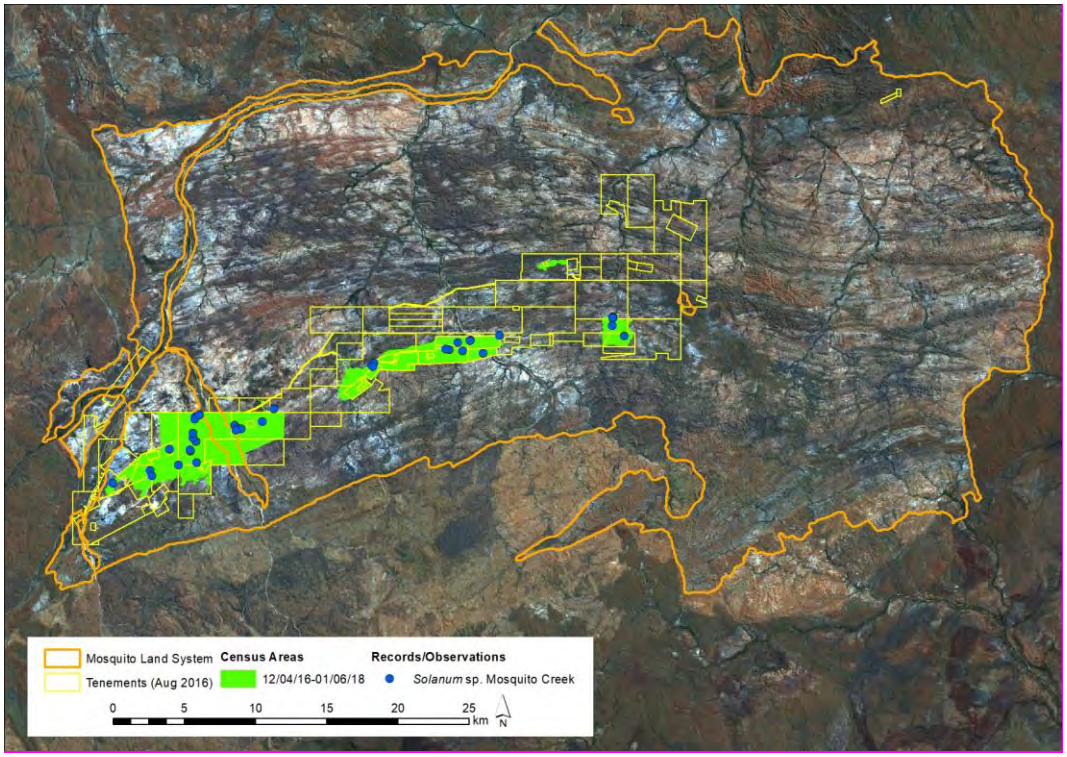


Figure 17: Records of *Solanum* sp. Mosquito Creek (P1) in the Mosquito Land System

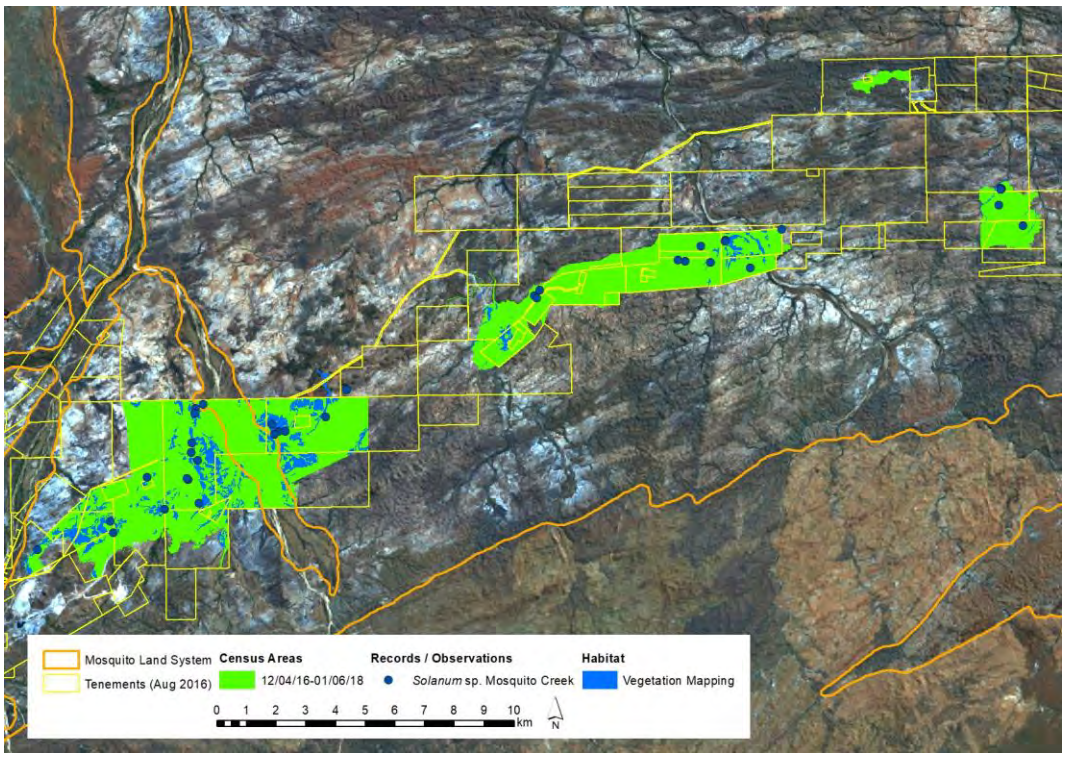


Figure 18: Distribution of *Solanum* sp. Mosquito Creek (P1) in the Census Areas

Solanum sp. Mosquito Creek is widespread but in variable densities across northern Mosquito Land System. Solanum sp. Mosquito Creek is consistently present on alluvial plains of *Triodia longiceps-Pluchea ferdinand-muelleri* (Plate 17) where a mean of 55 plants/hectare and a maximum of 544 plants/hectare has been recorded. It is also favoured by disturbance (Plate 18) (where up to 1,325 plants/hectare have been recorded) and fire (where up to 2,044 plants/hectare have been recorded)

Plate 17: *Solanum* sp. Mosquito Creek germinants in typical habitat

Plate 18: *Solanum* sp. Mosquito Creek in graded area

Eucalyptus rowleyi (P3)

Eucalyptus rowleyi is a mallee (Plate 19) that occurs across the southeast of the Pilbara (Figure 19) and is abundant across the Mosquito Land System (Figure 20 and Figure 21).

Plate 19: *Eucalyptus rowleyi* (P3)

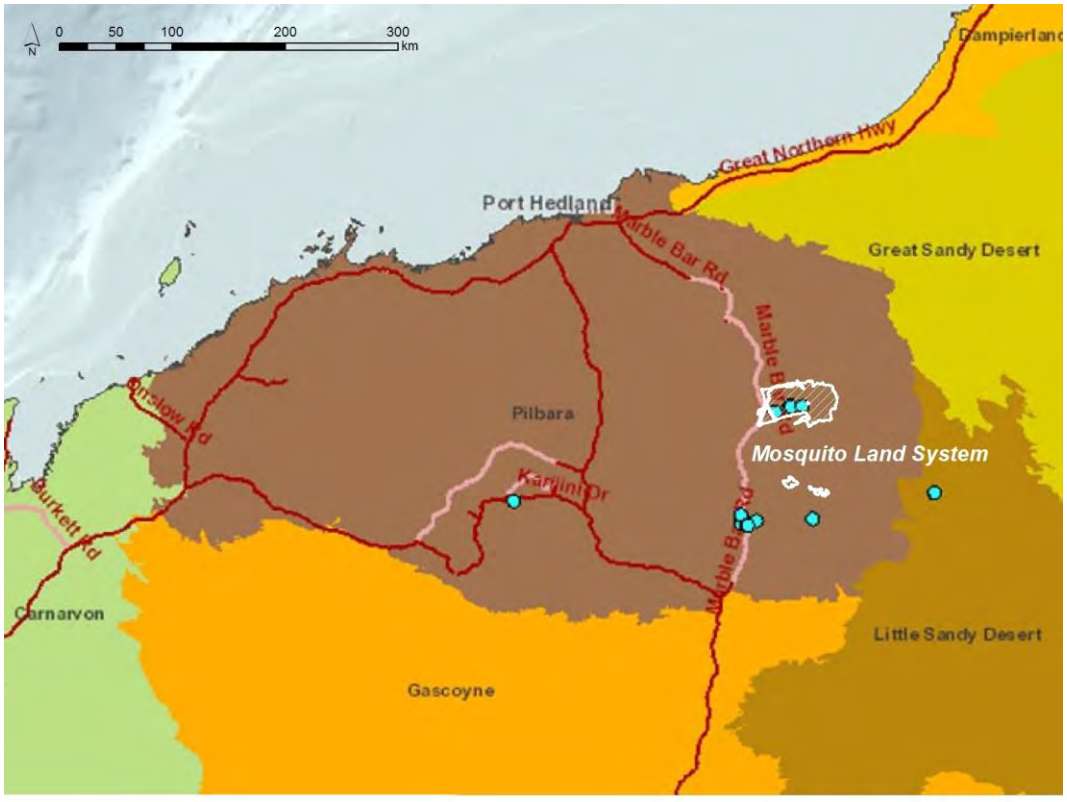


Figure 19: Records of *Eucalyptus rowleyi* (P3) in the Pilbara Bioregion

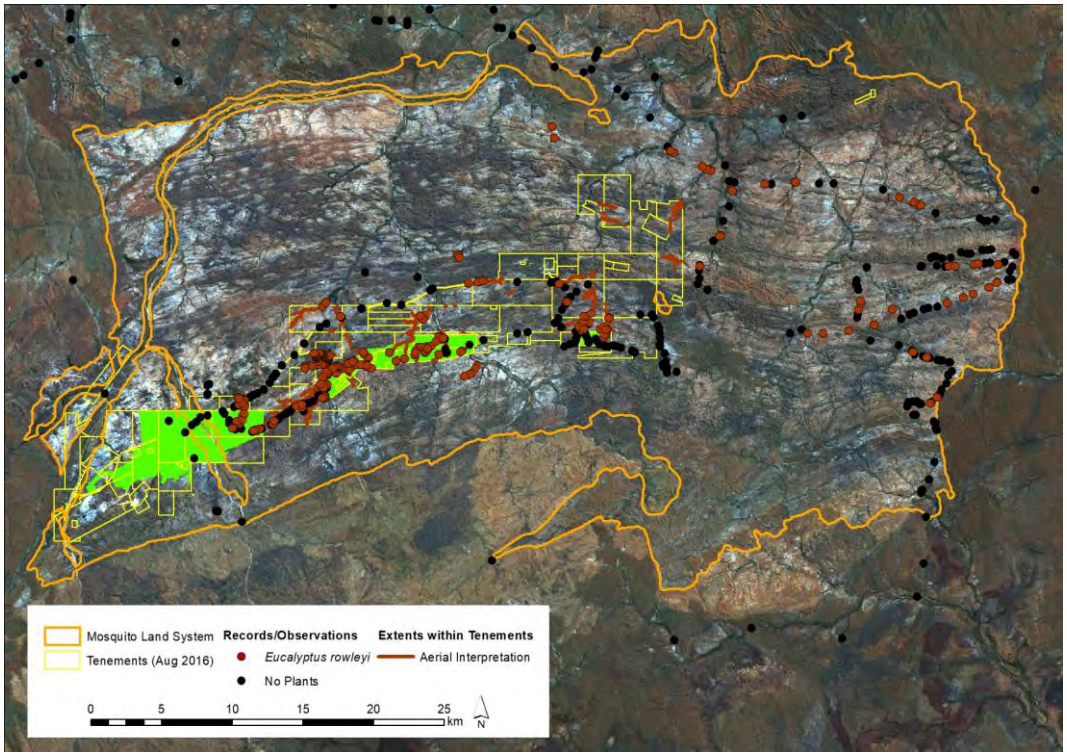


Figure 20: Records of *Eucalyptus rowleyi* (P3) in the Mosquito Land System

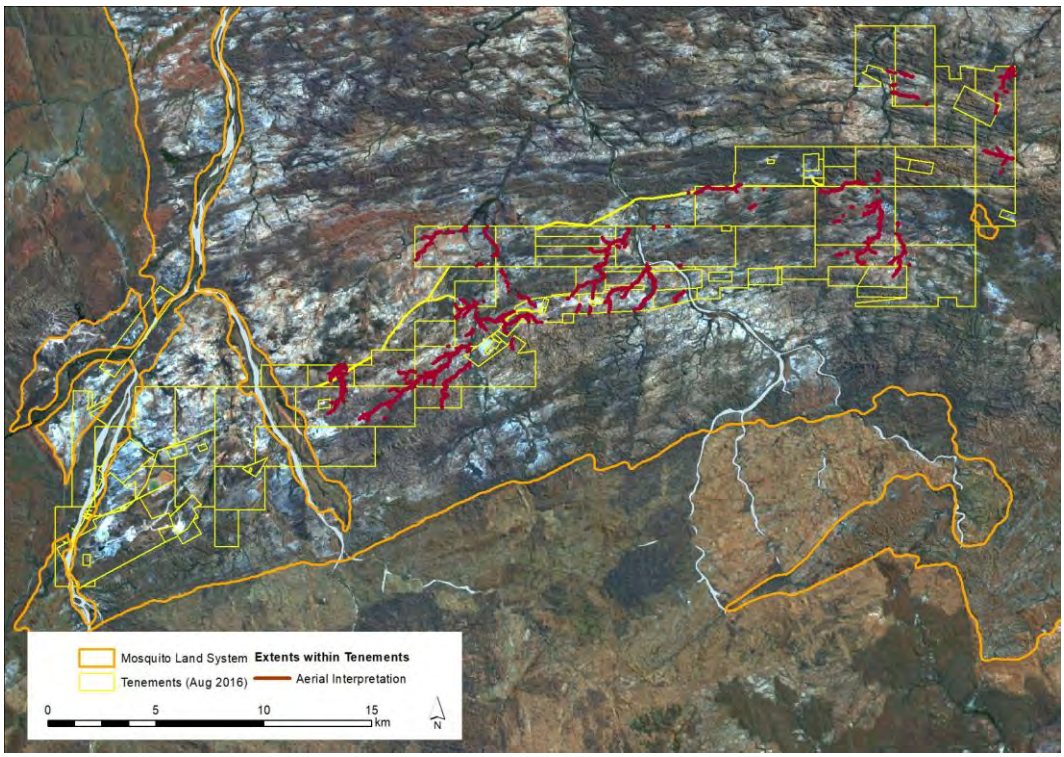


Figure 21: Distribution of *Eucalyptus rowleyi* (P3) across MML's Nullagine tenements

Eucalyptus rowleyi:

- 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);
- 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; and
- was comprehensively mapped in MML's tenements on the basis of aerial photo interpretation, where it tends to form monocultures on clay flats and drainagelines (Plate 20 and 21).

Plate 20: *E. rowleyi* monoculture

Plate 21: *E. rowleyi* in clay along creek

Goodenia nuda (P4)

Goodenia nuda is an annual herb (Plate 22) scattered throughout the Pilbara (Figure 22).

Plate 22: *Goodenia nuda* (P4)

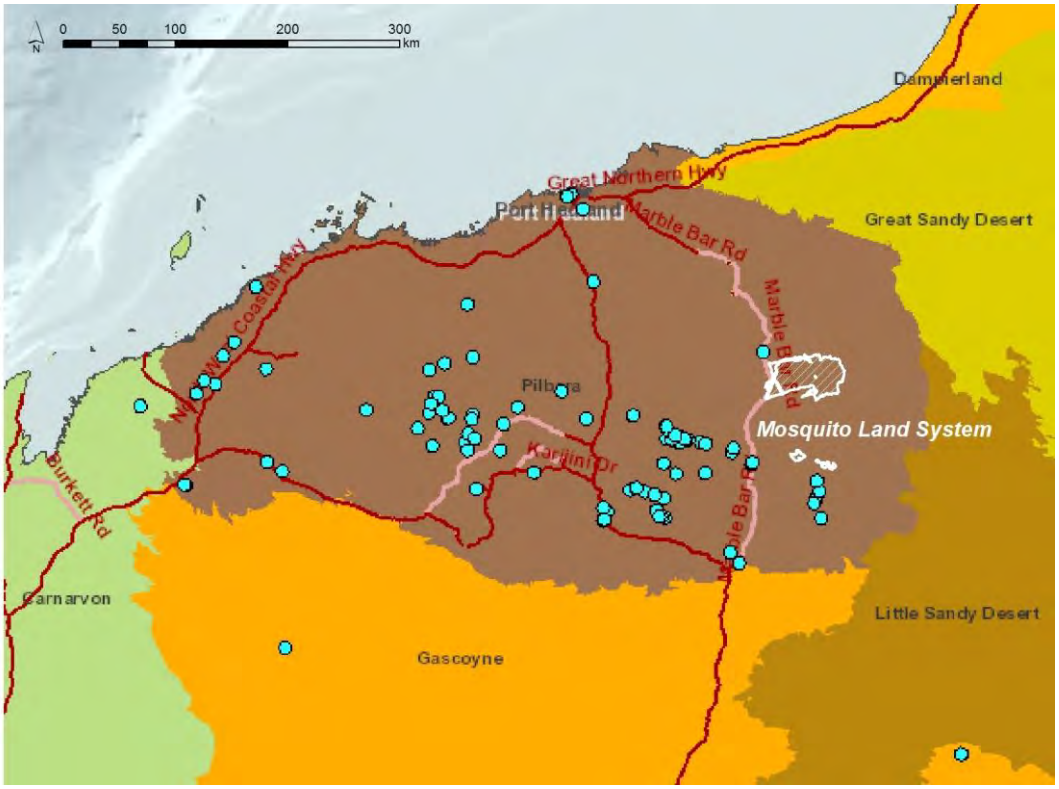


Figure 22: Records of *Goodenia nuda* (P4) in the Pilbara Bioregion

No attempt was made to document all occurrences of this annual herb but its habitat appears to be the sandy banks of major rivers / creeks (Figure 23).

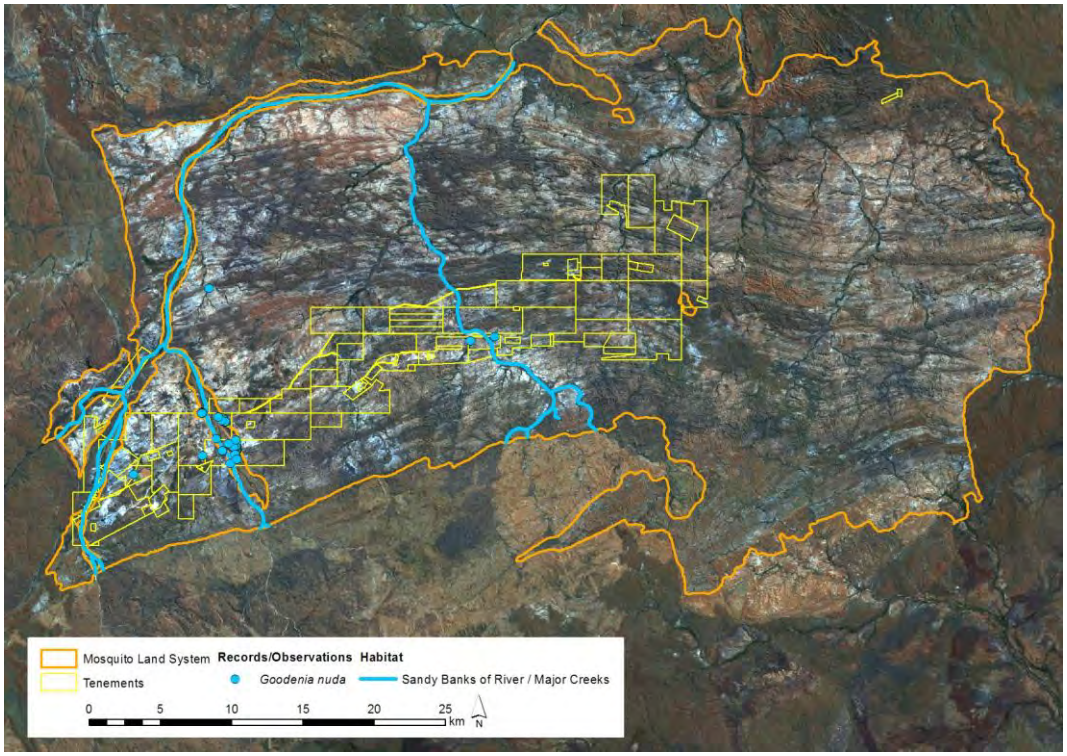


Figure 23: Records of *Goodenia nuda* (P4) in the Mosquito Land System

Many *Goodenia* prefer water-gaining sites, the margins of watercourses, or depressions (Sage & Pigott, 2003)

Goodenia nuda is:

- associated with the banks of low-lying areas along major creeks in the Census Area (Plate 23);
- 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);
- appears to thrive in disturbed areas (Plate 24) and many *Goodenia* are highly responsive to disturbance (Sage & Pigott, 2003); and

Plate 23: *G. nuda* in typical habitat

Plate 24: *G. nuda* in centre of track

Ptilotus mollis (P4)

Ptilotus mollis is a small shrub (Plate 25) scattered throughout the Pilbara (Figure 24) and the Mosquito Land System (Figure 25 and Figure 26).

Plate 25: *Ptilotus mollis* (P4)

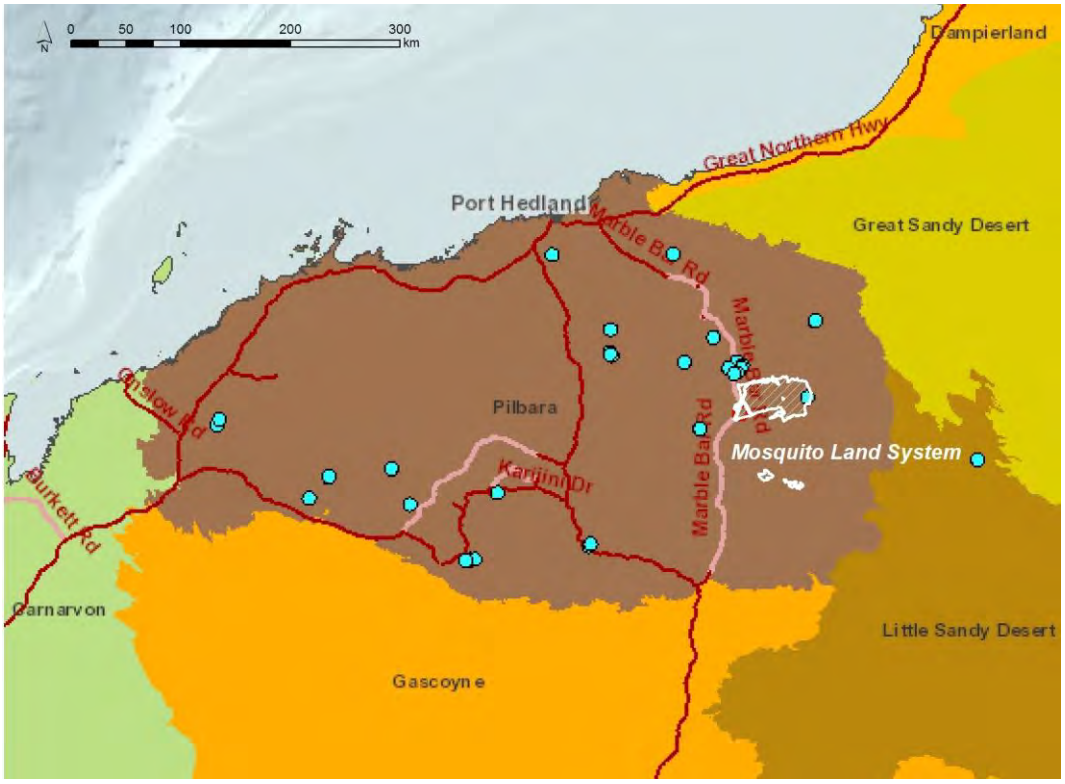


Figure 24: Records of *Ptilotus mollis* (P4) in the Pilbara Bioregion

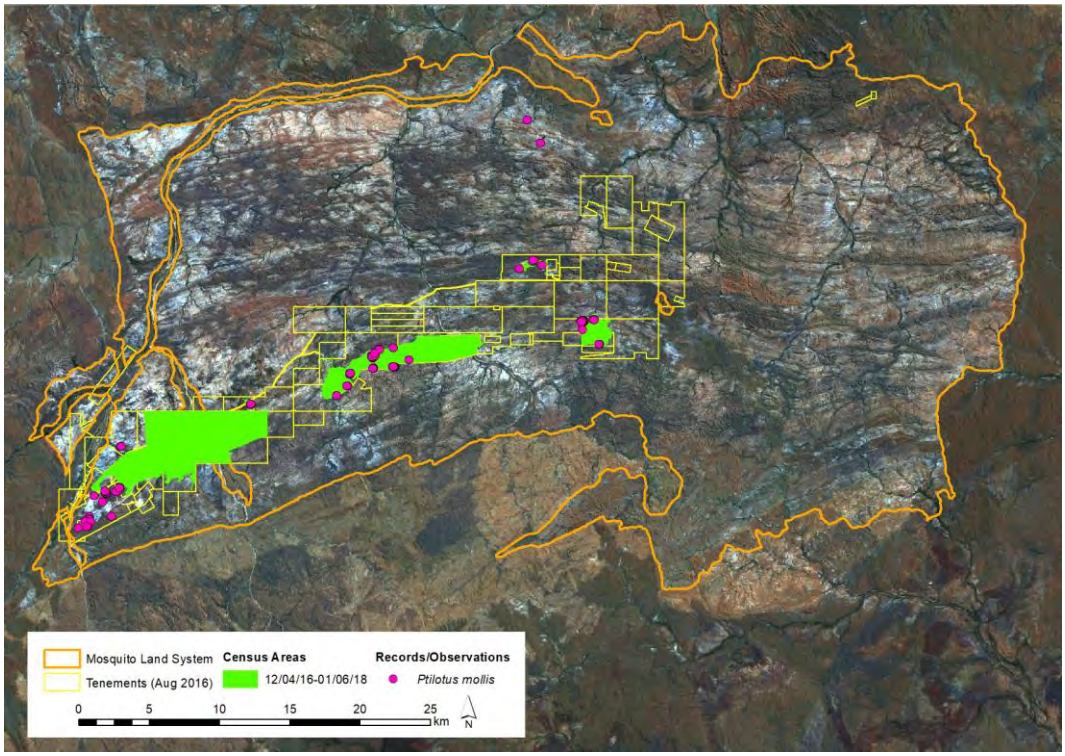


Figure 25: Records of *Ptilotus mollis* (P4) in the Mosquito Land System

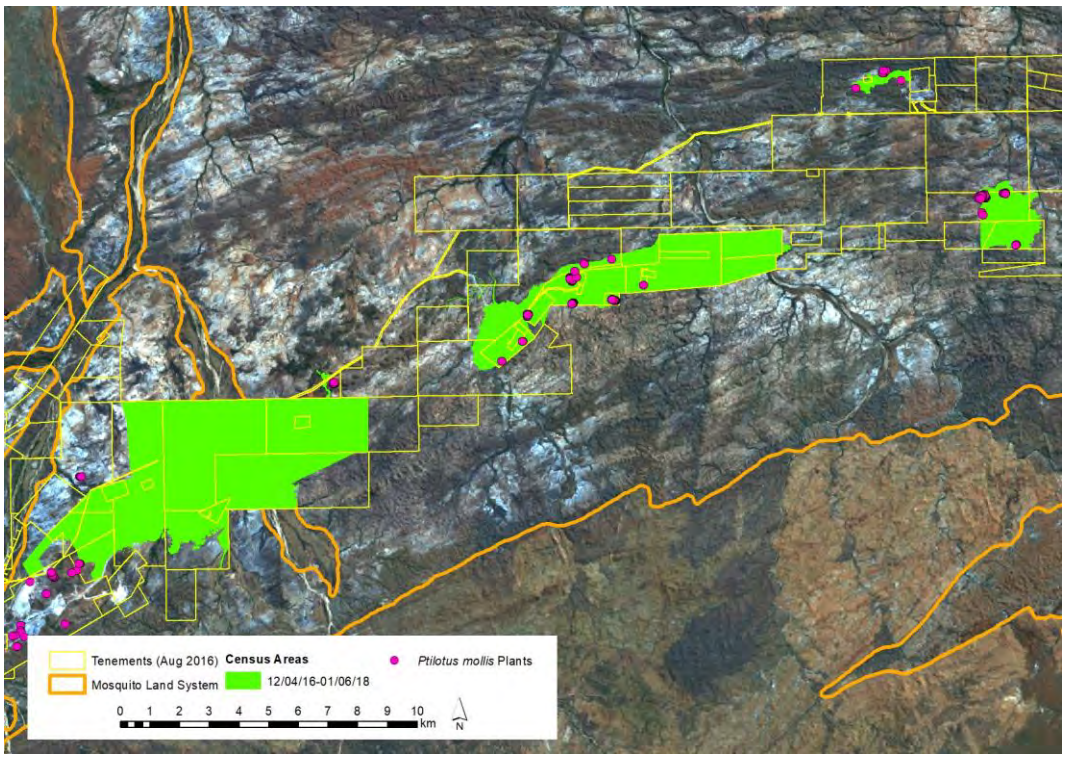


Figure 26: Records of *Ptilotus mollis* (P4) in the Census Areas

Ptilotus mollis typically occurs on steep rocky slopes, usually in full sun on massive ironstone formations (WA Herbarium, 2015), and this is where it occurred in the Mosquito Land System (Plate 26 and 27).

Plate 26: *P. mollis* in typical habitat

Plate 27: *P. mollis* habitat - exposed rock on hill

4 FRAMEWORKS FOR IMPACT ASSESSMENTS

The Mosquito Land System is a centre of local endemism, and half of the priority flora recorded are abundant in the land system but not regionally widespread.

Eight priority flora taxa were confirmed in surveys:

- *Ptilotus wilsonii* (P1) appears to be neither locally abundant, nor regionally widespread;
- *Acacia aphanoclada* (P1), *Acacia fecunda* (P1), *Atriplex spinulosa* (P1) and *Solanum* sp. Mosquito Creek are abundant local endemics that are favoured by disturbance;
- *Eucalyptus rowleyi* (P3) is scattered through the southeast Pilbara; and
- *Goodenia nuda* (P4) and *Ptilotus mollis* (P4) are scattered throughout the Pilbara.

Impacts on priority flora species in MML's Nullagine tenements can be placed in context by quantifying the proportion of population/s in the northern occurrence of the Mosquito Land System being impacted upon, according to Table 4 and Table 5.

The appropriate basis for impact assessments are:

- Individual plants
    - *Ptilotus wilsonii* (P1) and *Ptilotus mollis* (P4) are small shrubs that are not locally abundant
- Habitat Extent (Length of Drainagelines)
    - *Acacia fecunda* (P1) and *Eucalyptus rowleyi* (P3) are abundant shrubs/trees that form monocultures/large stands along creeks
    - *Goodenia nuda* (P4) is a widespread annual herb that occurs in variable densities but with highest densities in disturbed areas. It cannot be reliably detected in all seasons but its habitat can be mapped.
- Habitat Extent (Area of Vegetation Units)
    - *Atriplex spinulosa* (P1) and *Solanum* sp. Mosquito Creek (P1) are highly abundant locally endemic shrubs that are associated with specific vegetation units, and occur in variable densities but with highest densities in disturbed areas.
- Habitat Extent (Area of Landforms)
    - *Acacia aphanoclada* (P1) is a highly abundant locally endemic shrub whose density is highly correlated with steepness of slopes.

Table 4: Population Measurements / Estimates for Priority 1 Taxa (01/06/2018)

Priority Species	Population/s in Census Area (5,670 hectares)	Population/s in Tenements (25,875 hectares)	Additional / Opportunistic Records	Population/s in northern MLS (174,464 hectares)	Regional Extent[1]
Acacia aphanoclada P1	21,223 plants (complete count for 5,602 hectares of census area)	Estimate of 203,281 plants based on densities by slope categories for geology units confirmed on	4,636 plants Present at approx. 32% of 245 sites inspected at regular intervals in and around the northern MLS	Estimate of **1,550,000 plants** based on densities by slope categories for geology units confirmed on	40 km north-south 65 km east-west
Acacia fecunda P1	106 km of creeklines aerial photo interpretation with 358 points confirmed	Not Quantified Extensive aerial photo interpretation not reliable without intensive ground truthing with 425 points confirmed	Present at approx. 50% of 325 minor/ intermediate channels inspected across MLS	Not Quantified **>106 km of creeklines** Extensive	100 km north-south 50 km east-west
Atriplex spinulosa P1	1,626 ha of Stony Saline Plains aerial photo interpretation with 58 points confirmed	5,138 ha of Stony Saline Plains satellite interpretation of entire tenements with 87 points confirmed	Ubiquitous but variable densities on stony saline plains across northern MLS Where present 5,700 plants/ha (mean) 30,500 plants/ha (max.)	Estimate of **36,000 hectares** of Stony Saline based on satellite interpretation	40 km north-south 65 km east-west
Ptilotus wilsonii P1	1,070 plants (complete count for 5,670 hectares of census area)	Not Quantified >2,731 plants Complete counts where located Likely Limited	433 plants Widespread but restricted occurrences across northern MLS	Not Quantified **>3,164 plants** Likely Limited	70 km north-south 220 km east-west
Solanum sp. Mosquito Creek P1	693 ha of *Triodia longiceps - Pluchea ferdinand-muelleri* alluvial plains and *Eucalyptus rowleyi-Acacia trachycarpa* drainagelines aerial photo interpretation with 71 points confirmed	Not Quantified Likely Abundant but of Limited Extent	Widespread but variable across northern MLS (Predominately 2 vegetation types but present in 5 site types) *T. longiceps-P. ferdinand-muelleri* (consistently present) 55 plants/ha (mean) 544 plants/ha (max.) *E. rowleyi-A. trachycarpa* (present where loams deeper) 25 plants/ha (mean) 50 plants/ha (max.) Other vegetation types, abundant where burnt (544-2,044 plants/ha) abundant where disturbed (1,325 plants/ha)	Not Quantified **>693 hectares** Extensive	20 km north-south 50 km east-west

1 DPaW (2016) MLS = Mosquito Land System

Table 5: Population Measurements / Estimates for Priority 3 and 4 Taxa (01/06/2018)

Priority Species	**Population/s in Census Area** (5,670 hectares)	**Population/s in Tenements** (25,875 hectares)	**Additional / Opportunistic Records**	**Population/s in northern MLS** (174,464 hectares)	**Regional Extent[1]**
Eucalyptus rowleyi P3	34 km of creeklines aerial photo interpretation with 195 points confirmed	90 km of creeklines aerial photo interpretation with 209 points confirmed	Present at approx. 28% of 325 minor/ intermediate channels, and 7 flats inspected across MLS	Not Quantified **>90 km of creeklines** Extensive	100 km north-south 350 km east-west
Goodenia nuda P4	No Census Undertaken 82 plants recorded	>27 km of creeklines length of Nullagine River, Five Mile Creek, Twenty Mile Creek	Widespread along sandy / alluvial banks of rivers and major creeks	Not Quantified **>124 km of creeklines** Extensive	300 km north-south 600 km east-west (outliers 300 km further east and 200 km south)
Ptilotus mollis P4	664 plants	Not Quantified >975 plants Likely Limited	119 plants Widespread but scattered across northern MLS	Not Quantified **>1,094 plants** Likely Limited	300 km north-south 650 km east-west

1 DPaW (2016)

MLS = Mosquito Land System

5 REFERENCES

Barker, A. (2007). *Distribution of Acacia aphanoclada and the Effect of Soil Mineralogy and Water Availability on Habitat Preference.* Perth: University of Notre Dame.

DPaW. (2016, 03 14). *FloraBase*. Retrieved 05 09, 2016, from Florabase: http://florabase.calm.wa.gov.au/

DPaW. (2016). *NatureMap: Mapping Western Australia's Biodiversity*. Retrieved July 1, 2016, from http://naturemap.dpaw.wa.gov.au/

Maslin, B. (1998). Acacia Miscellany 6. Review of Acacia victoriae and related species (Leguminosae: Mimosoideae: Section Phyllodineae). *Nuytsia, 8*(2), 285-309.

Maslin, B. L., & Reid, J. (2010). *Wattles of the Pilbara. CD-ROM, Version 1.0.* Perth: Department of Environment and Conservation.

Maslin, B., & van Leeuwen, S. (2008). New taxa of Acacia (Leguminosae: Mimosoideae) and notes on other species from the Pilbara and adjacent desert regions of Western Australia. *Nuytsia, 18*, 139-188.

Nicolle, D., & French, M. (2012). Two new mallee box species (Eucalyptus sect. Adnataria ser. Lucasianae; Myrtaceae) from the Pilbara region of Western Australia. *Nuytsia, 22*(I), 17-29.

Sage, L., & Pigott, J. (2003). Conservation status of Goodenia (Goodeniaceae) in Western Australia, including a review of threatened, rare and poorly known species. *Journal of the Royal Society of Western Australia, 86*, 123-132.

Vreeswyk, A. V., Payne, A., Leighton, K., & Hennig, P. (2004). *Technical Bulletin No. 92 - An inventory and condition survey of the Pilbara region, Western Australia.* Perth: Department of Agriculture.

WA Herbarium. (2015). *Rare and Priority Plans of the Pilbara.* Brisbane: LucidMobile.

Waters, A., & Chalwell, S. (2017). *Priority Flora of the Mosquito Land System, version 3.0.* Perth: unpublished report by Woodgis and Plantecology Consulting for Millennium Minerals Ltd.

APPENDIX 1: *Acacia aphanoclada* data

Table 6: Geology Units *Acacia aphanoclada* recorded on

Geology Units	Extent (ha)
ADnss	9,539
ADqs	124,742
ADqsc	778
ADqsl	3,288
Czc	2,899
Czrf	458
Qaa	6,431
Qc	7,388
Total	**155,522**

Table 7: Other Geology Units

Geology Units	Extent (ha)
_A1c	0
Ab	203
Aba	701
Abk	458
ADnb	14
ADnba	228
ADnbk	12
ADncc	9
ADnfv	8
ADnlb	2,833
ADnlbn	176
ADnog	967
ADnsl	2,181
ADnst	410
ADnstb	254
ADnstbc	524
ADnu	30
ADnup	45
ADnur	7
ADqss	631
ADqst	859
Aeb	16
AFdb	334
AFh	244
AFhb	5
AFhe	42
AFhs	29
AFhsw	46
AFj	1
AFk	3
AFkbi	59
AFkbk	97
AFmbk	9
A-FOk-bb	17
A-FOk-bng	2
AFr	84
AFrsc	30
AFt	145
Agd	3
AgKbd	1,153
AgKbdn	27
AgKge	1,332
A-MBge-mgtn	7
A-NUc-mhc	90
A-NUc-mls	112
A-NUc-mog	4
A-NUc-xms-mwa	101
A-NUq-mh	28
Aog	22
A-SRbo-gmm	12
Aus	534
AW(bk)	92
AWeb	113
AWebk	33
AWpfa	1
AWwb	363
AWwcc	21
AWwssz	220
Czaf	65
d	226
P_gBmh	116
PLgBgh	184
q	1
Qao	1,810
Qw	411
Total	**18,794**

NB 378 ha of MLS not covered by 100K geology map sheets

APPENDIX 2: *Atriplex spinulosa* data

Table 8: *Atriplex spinulosa* density measurements

Quadrat/Site	Easting	Northing	Plants/ha
Tb10	235447	7581768	1,333
TLMm08	235715	7581608	7,500
TbTL19	235845	7581298	-
TLMm05	235940	7581447	333
TbTL20	236125	7581417	667
TbTL24	236202	7581423	-
TbTL12	236057	7581197	167
TbTL23	236101	7581047	-
TLMm22	236267	7581158	-
TLMm73	236378	7581367	-
TLMm06	236138	7581690	30,500
TLMm63	228056	7581162	6,333
TLMm17	228180	7581403	9,333
TLMm25	228231	7581395	833

Quadrat/Site	Easting	Northing	Plants/ha
TLMm56	226348	7579700	15,000
TLMm57	225809	7580822	-
TLMm51	206737	7572206	333
TLMm36	207154	7575328	3,167
TLMm48	206997	7575135	4,667
TbTL01	206984	7574893	1,500
TLMm26	211345	7575164	-
TLMm42	225140	7581312	6,000
TLMm70	224930	7580381	-
TLMm68	224665	7579916	333
TLMm38	225303	7579929	18,333
Windrow01	236335	7581540	46,333
Windrow02	206099	7575204	3,500
Windrow03	206369	7573151	4,667

Tb10

TbTL19

TLMm08

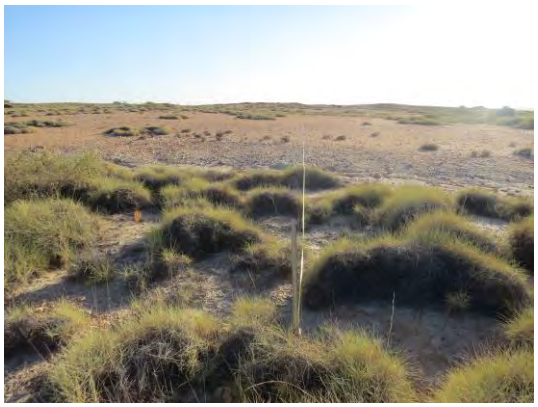
TLMm05

TbTL20

TLMm22

TbTL24

TLMm73



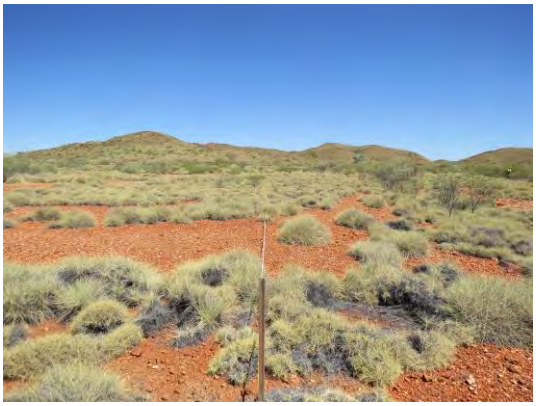
TbTL12

TLMm06

TbTL23

TLMm63

TLMm17



TLMm51

TLMm25

TLMm36

TLMm56

TLMm48

TLMm57

TbTL01

TLMm26

TLMm38

TLMm42

Windrow 01

TLMm70

Windrow 02

TLMm68

Windrow 03