

# ACACIA CORUSCA TARGETED SURVEY & SPECIES DISTRIBUTION MODELLING

PREPARED FOR: BHP WAIO



**Spectrum**  
ECOLOGY & SPATIAL



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## EXECUTIVE SUMMARY

Spectrum Ecology & Spatial (Spectrum) was engaged by BHP Western Australian Iron Ore (BHP WAIO) to conduct a targeted survey for the Priority 1 flora taxon *Acacia corusca*, within south-east Pilbara bioregion of Western Australia. *Acacia corusca* is a shrub or small tree that grows on red-brown, sandy-loam soils along crests, ridges, drainage lines and slopes. To date only three populations of *Acacia corusca* have been recorded.

Spectrum performed Species Distribution Modelling (SDM) based on existing *Acacia corusca* locations provided by BHP WAIO and sourced from the Herbarium of Western Australia (Western Australian Herbarium, 2022). The results of this analysis predicts that *Acacia corusca* occurs in close proximity (<12 km) to where the Boolgeeda Banded Iron Formation (BIF) and Woongarra Rhyolite meet. Eroded materials (MrVBF) and Slope Relief Classification were also important in representing the species' preference to drainage, eroded materials, slopes, and ridges.

Informed by the model output, the targeted field survey was undertaken across 17 survey areas from the 3 to 11 August 2022 (18 person days), during which approximately 227.6 km of traverses were surveyed. No additional *Acacia corusca* individuals were recorded. During the targeted survey the Priority 1 flora taxon, *Hibiscus* aff. *campanulatus*, was recorded with approximately 398 individuals from six locations found.

The species distribution model was re-assessed using the confirmed absence data collected during the targeted survey. The reiteration of the model was similar to the original assessment indicating that based on our current knowledge *Acacia corusca* habitat is specific to the junction between the Boolgeeda BIF and the Woongarra Rhyolite. As no additional individuals were recorded during the targeted survey and the model results remained similar before and after the addition of absence data, it's likely that the species distribution cannot be fully explained by the current environmental and landform factors.

Total survey effort was analysed against the revised SDM. Surveys so far have covered 80.6% of the areas classified as having a high probability of occurrence, 61.0% of medium probability of occurrence, and 21.7% low probability of occurrence. Tenure, active mining, and access issues may impede efforts to survey the majority of the remaining high and medium probability of occurrence areas.

## 1. PROJECT INFORMATION

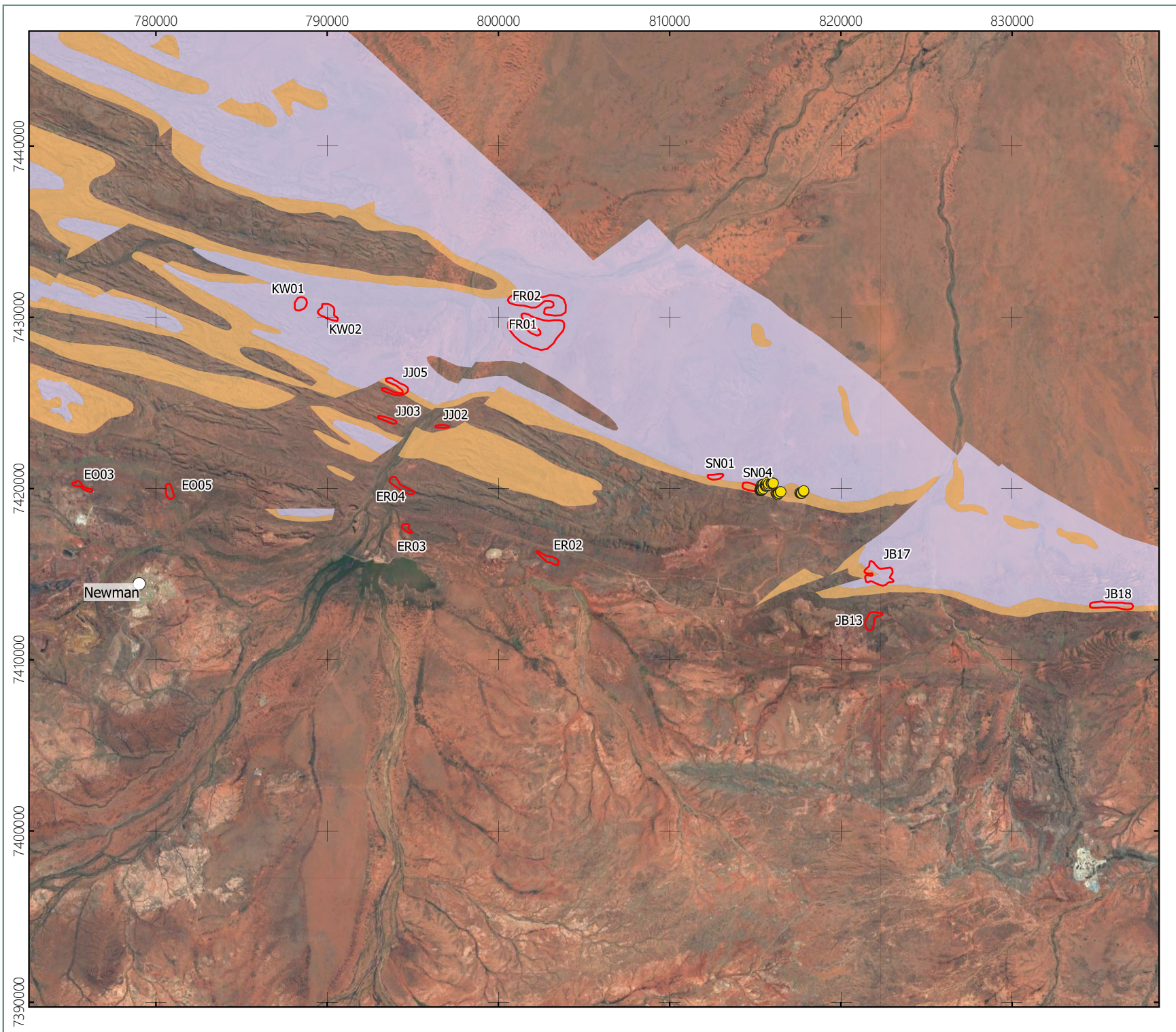
### 1.1. Project Background

*Acacia corusca* was described as a new species in 2019 and is listed as Priority 1 under the Conservation Codes for Western Australia Flora by the Department of Biodiversity Conservation and Attractions (DBCA, Smith & Jones, 2018). The species occurs in the south-east Pilbara bioregion of Western Australia and has been recorded on BHP Western Australian Iron Ore (BHP WAIO) tenements. As there is the potential for proposed future mining operations within the area to impact these restricted populations, BHP WAIO required a targeted survey to identify potential new populations of *Acacia corusca*. Species Distribution Modelling (SDM) was conducted across an 886,6351 ha area (the Study Area), and 17 target polygons (the Survey Area) were identified within 60 km of Newman. The SDM suggested *Acacia corusca* occurs in close proximity to the Boolgeeda Iron formation and is highly specific to Banded Iron Formations (BIF) of the Hamersley Ranges (Spectrum Ecology & Spatial, 2021).

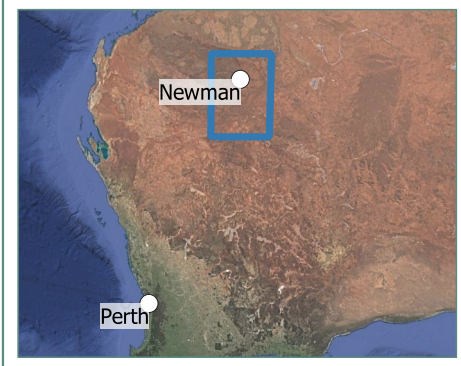
### 1.2. Scope of Work

The scope of works included:

- Undertake a desktop assessment including relevant database searches and a literature review to compile and summarise existing records of *Acacia corusca* (P1) in the vicinity of the Survey Area;
- Use the previously modelled distribution of *Acacia corusca* to inform the search areas in the field assessment;
- Undertake targeted searching for *Acacia corusca* within the Survey Area; and
- Re-assess the SDM model based on the targeted survey results.



- Legend**
- Targeted Survey Area
  - SDM Study Area
  - Acacia corusca records
  - Cities or Towns
  - Associated Geological Units
  - Boolegeeda Iron Formation
  - Woongarra Rhyolite



0   2.5   5   7.5   10 km  
 Scale 1:300,000 @ A4  
Coordinate System: GDA 1994 MGA Zone 50  
 Projection: Transverse Mercator  
 Units: Meter

Author: SM    Approved: MH    Date: 28-11-2022

## Survey Area

Acacia corusca Targeted Survey

## 2. METHODS

### 2.1. Legislation & Guidelines

Flora and vegetation in Western Australia are protected by various legislation, including:

- *Biodiversity Conservation Act 2016* – BC Act (Western Australian Government, 2016);
- *Environmental Protection Act 1986* (Western Australian Government, 1986); and
- *Environment Protection and Biodiversity Conservation Act 1999* - EPBC Act (Australian Government, 1999).

The survey was compliant with survey guidelines, as outlined in:

- EPA Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (Environmental Protection Authority, 2016d);
- EPA Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection (Environmental Protection Authority, 2002);
- EPA Environmental Factor Guideline: Flora and Vegetation (Environmental Protection Authority, 2016a);
- EPA Statement of Environmental Principles, Factors and Objectives (Environmental Protection Authority, 2021);
- DBCA Threatened and Priority Flora Report Form – Field Manual (Department of Biodiversity Conservation and Attractions, 2017b);
- National Vegetation Information System (NVIS) Australian Vegetation Attribute Manual (ESCAVI, 2003);
- Latest version of BHP WAIO's Biological Survey Spatial Data Requirements (SPR-IEN-EMS-015); and
- Latest version of BHP WAIO's Vegetation and Flora Survey Procedure (0124627).

## 2.2. Significant Flora Definitions

Significant flora can include (Environmental Protection Authority, 2016a):

- Being identified as Threatened: Critically Endangered, Endangered, or Vulnerable (state listed Biodiversity conservation - BC Act and/or nationally listed Environment Protection and Biodiversity Conservation - EPBC Act);
- Locally endemic or associated with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems);
- New species or anomalous features that indicate a potential new species;
- Representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- Unusual species, including restricted subspecies, varieties or naturally occurring hybrids; or
- Relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

A detailed description of conservation codes and significance definitions can be found in Appendix A.

## 2.3. Desktop Assessment

### 2.3.1. Biological Database Searches

Database searches of relevant and available biological data sources used during the SDM and on ground assessment phases of this project are presented in Table 2.1 and Map 1.1.

**Table 2.1: Database Searches**

Data Source	Custodian	Records Returned
DBCA Threatened & Priority Flora Databases (TPFL / WA Herbarium)	DBCA	12
BHP WAIO Species Database	BHP WAIO	95

## 2.4. Species Distribution Modelling

The SDM was conducted by Spectrum in 2021 (Spectrum Ecology & Spatial, 2021). The SDM was based on existing *Acacia corusca* locations provided by BHP WAIO and sourced from the Western Australian Herbarium (WAH). Absence data from Onshore Environmental (Onshore Environmental, 2015), were used to construct a bias layer to help inform the model and account for sampling bias and spatial autocorrelation. The modelling included 25 environmental variables that were chosen according to the species' abiotic and biotic interactions with its environment. These included landscape and soil attributes, vegetation indices, and GIS generated predictors from categorical variables of geological attributes. Modelling was implemented using maximum entropy algorithms within the MaxEnt software and parameters were selected for best results as per peer-reviewed literature. The results of this analysis suggested that *Acacia corusca* occurs in close proximity to where the Boolgeeda Iron Formation and Woongarra Rhyolite meet (<12 km). Eroded materials (MrVBF) and Slope Relief Classification were also important in representing the species' preference to drainage, eroded materials, slopes, and ridges. These results indicate that *Acacia corusca* is highly specific to rhyolite and iron formation of the Hamersley Range.

An assessment of the extent of probability of occurrence within the Study Area that was used for the SDM, 88,000 km<sup>2</sup> in the eastern Pilbara (Map 1.1), was performed, with the total predicted extent occupying 91,437 ha (1%). Within the modelled extent, 92% (83,372 ha) was classified as having a low probability of occurrence

for the species to occur. Areas of medium and high probability represented 4,608 ha (5%) and 3,097 ha (3%) of the modelled extent, respectively.

The MaxEnt model analysis depicted likely areas of occurrence at locations within BHP WAIO tenure as well as locations where no mining or exploration tenure exists. These areas were identified as relevant to the species due to the presence of the Woongarra Rhyolite and Boolgeeda Iron Formation, Newman Land System, MrVBF and Slope Relief Classification environmental characteristics.

With the above factors in consideration, 50 sites were identified across low, medium, and high probability areas. Forty-four sites are present within BHP WAIO tenements, with the remaining six sites falling outside of mining tenure. From the 50 sites, 17 areas were selected for an on ground targeted survey based on possibility of the target taxon occurring, accessibility and tenement location (Table 2.2, Map 1.1).

**Table 2.2: Probability of Occurrence for Each Target Area**

Target Area	Polygon ID	Tenure	Area (ha)	Probability
Eastern Ridge	ER02	BHP Tenure	37	High
	ER03	BHP Tenure	18	High
	ER04	BHP Tenure	49	High
Fortescue	FR01	Other Tenure	395	High
	FR02	Other Tenure	223	Medium
Jimblebar	JB13	BHP Tenure	52	High
	JB17	BHP Tenure	146	Medium
	JB18	BHP Tenure	78	Medium
Jimblebar Junction	JJ02	Other Tenure	11	High
	JJ03	Other Tenure	22	Medium
	JJ05	Other Tenure	61	High
Kalgan West	KW01	Other Tenure	43	High
	KW02	Other Tenure	70	High
Ophthalmia East	EO03	BHP Tenure	21	Medium
	EO05	BHP Tenure	30	Medium
Shovelanna North	SN01	Other Tenure	22	High
	SN04	Other Tenure	35	High

## 2.5. Field Assessment

### 2.5.1. Personnel & Licences

Spectrum staff involved with this assessment are listed in Table 2.3, along with their project involvement, years of experience, and relevant licenses.

Table 2.3: Personnel & Licences

Staff	Qualification	Role	Project Tasks	Years of Experience	Flora Licence
Melissa Hay	BSc (Hons)	Principal Botanist	Report review, field planning	16 Years	N/A
Susan Murrey	BSc, MSc	Senior Botanist	Data management, reporting	6 Years	FB62000101-2
Dr. Jason Webb	PhD	Senior Botanist	Field survey	10 Years	FB62000168
Sarah Boys	BSc (Hons)	Botanist	Field survey	4 Years	FB62000386
Chris Parker	BSc	Principal Spatial Ecologist	Species distribution modelling	12 Years	N/A

### 2.5.2. Survey Timing

The targeted survey was undertaken over nine days between 3 and 11 August 2022, following higher rainfall in the preceding three and 12-month periods compared to the long-term median (Figure 2.1). Monthly climate data was sourced from the nearest Bureau of Meteorology (BOM) station with complete data (Newman Airport #7176).

The following rainfall was recorded at Newman Airport prior to the survey:

- The 12 months preceding the field survey (July 2021 to July 2022) recorded 226.8 mm of rainfall, 58.5 mm higher than the sum of the long-term annual median of 168.3 mm; and
- The three-months preceding the field survey (May 2022 to July 2022) recorded 82.2 mm of rainfall, 68.0 mm higher than the sum of the long-term annual median for the same three months (14.2 mm).

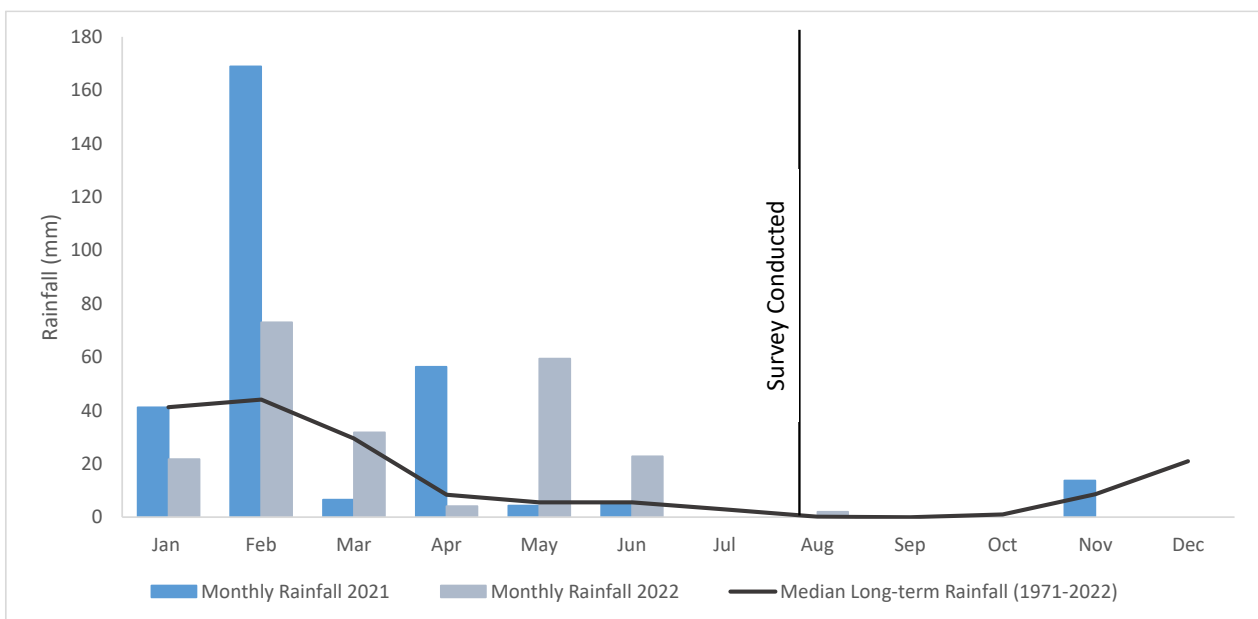


Figure 2.1: Rainfall & Climate Data

### 2.5.3. Field Methods & Sampling Effort

The targeted flora survey was completed by two botanists over a nine-day period (18 person days). Eleven high and six medium likelihood of occurrence target search areas were surveyed, where a total of 227.6 km of traverses were conducted (Map 3.1, Map 3.2, Map 3.3).

To effectively cover the search areas as determined by SDM, the field team was spaced 100-200 m apart (depending on terrain) during each traverse. This spacing was sufficient to cover the target areas with a high confidence level. Where individuals of *Acacia corusca* were deemed more likely to occur the survey intensity increased to search for additional individuals. When other significant flora taxa were encountered (i.e. P1 to P4 and other significant flora as defined by EPA (2016a)), they were opportunistically recorded along the traverse.

*Acacia corusca* or other significant flora were recorded at an individual plant level where possible (i.e. a GPS coordinate for each plant). Where individual counts were not practical, an estimate of the overall population size was taken. Where *Acacia corusca* or significant flora taxa were encountered sufficient information was collected to be compliant with the requirements of the Threatened and Priority Flora report form, and included:

- Observation date;
- Observer, role, organisation;
- Description of location, land tenure;
- GPS coordinates;
- Abundance count; count method;
- Reproductive state (of collected specimens);
- Condition of population;
- Habitat information;
- Vegetation classification; and
- Condition of habitat, fire history etc.

Where required, specimens were submitted to the WAH for formal identification.

## 2.6. Limitations & Constraints

No significant limitations were experienced during this assessment. Survey specific limitations and constraints for the targeted flora assessment are discussed in Table 2.4.

Table 2.4: Limitations & Constraints

Limitation	Constraint	Comment
Availability of contextual information at a regional and local scale.	No	Background information for the region was available and sufficient. Locations of previously recorded individuals was supplied by BHP WAIO prior to the survey.
Competency/experience of the team carrying out the survey, including experience in the bioregion surveyed.	No	Field survey team lead, Jason Webb, has 10 years' experience as an environmental scientist including three years of conducting flora surveys in the Pilbara region of Western Australia. The field team initially familiarised themselves with the target species from a previously known location during the survey.
Restrictions to, or functionality of survey equipment and tools to complete the flora and vegetation assessment.	No	Equipment supplied was sufficient for the survey and there were no functionality or access issues with equipment and tools used during the survey.
Proportion of flora recorded and/or collected, any identification issues.	No	There was adequate floristic material available for identification of <i>Acacia corusca</i> , however, the species can be identified without flowering or fruiting material.
Survey effort and extent.	No	Seventeen areas were selected for the on ground targeted assessment, of which all were surveyed thoroughly during the assessment. There were an additional 33 areas that were determined as low, medium or high likelihood of occurrence areas that were not surveyed, however this was not part of the scope of works.
Access restrictions within the Survey Area.	No	Access to the west of site JB18 was limited, however assessment of the east of the polygon showed a lack of appropriate habitat for <i>Acacia corusca</i> and aerial imagery shows the west is a continuation of this landform. Steep slopes that were inaccessible at EO05 and KW02 were surveyed with binoculars.
Survey timing, rainfall, season of survey.	No	The survey was conducted after above median rainfall, creating optimal survey conditions, however, the species can be identified without flowering or fruiting material.
Disturbance that may have affected the results of survey such as fire, flood or clearing.	Minor	Small patches of Survey Area polygons ER04 and KW02 were burnt within the last 2-3 years. Re-growth of trees and shrubs was sufficient to determine that <i>Acacia corusca</i> was not currently growing within the polygon. No other disturbances were noted.

### 3. RESULTS & DISCUSSION

#### 3.1. Desktop Assessment

##### 3.1.1. Previously Conducted Biological Assessments

*Acacia corusca* was first recorded during a detailed flora and vegetation survey at Orebody 31 (Onshore Environmental, 2014), where three records were found. Additional targeted searches by Onshore Environmental (Onshore Environmental, 2015) found an additional 564 records (Map 1.1, Table 3.1). To date, only three populations of *A. corusca* have been recorded, separated by approximately one kilometre.

Table 3.1: Previously Conducted Assessments

Data Source	Survey Type	Details	Records
DBCA	N/A	DBCA Threatened & Priority Flora Databases (TPFL / WA Herbarium)	12
Onshore Environmental	Detailed	Orebody 31 Level 2 Flora and Vegetation Survey	3
Onshore Environmental	Targeted	Orebody 31 - Targeted Significant Flora Survey June 2014	567

##### 3.1.2. Description & Habitat Preferences



Plate 3.1: *Acacia corusca*

*Acacia corusca* is a shrub or small tree from the south-east Pilbara bioregion of north-western Australia. The taxon is a broadly rounded, multi-stemmed shrub to small tree with smooth grey to dark grey bark (Plate 3.1).

Branchlets are terete and can be slightly angled at the ends, with youngest branchlets ribbed and with a dense indumentum. New shoots are resinous and young phyllodes have a noticeable marginal nerve with dense red-brown, glandular hairs. *Acacia corusca* can be differentiated from similar taxa by:

- Phyllodes with 1-3 longitudinal nerves that are slightly more prominent than the minor nerves and with many anastomosing minor nerves;
- Distant gland from the pulvinus resulting in a kink in the phyllode;
- The presence of red-brown glandular hairs on new growth along the margins of the phyllode; and

- Cylindrical inflorescence.

This taxon is known to occur in red-brown, sandy-loam soils, crests, ridges, drainage lines and slopes of less than 20 degrees. Three known populations of the species exist within an 8 ha extent on breakaway slopes of low hills and adjacent drainage lines, along the intersection of the Boolgeeda BIF and Woongarra Rhyolite (Map 1.1, Bull, Dillion and Brearley, 2019). The largest population was found where the Boolgeeda BIF was heavily eroded exposing the underlying Woongarra Rhyolite, and was less common on nearby hill crests and larger incised drainage lines supporting Mulga (Onshore Environmental, 2015). The species is associated with spinifex hummock grassland dominated by *Triodia pungens*, *Triodia vanleeuwenii* and scattered *Eucalyptus leucophloia* subsp. *leucophloia*, in open shrublands of *Grevillea wickhamii* subsp. *hispidula*, *Senna glutinosa* and *Acacia marramamba* (Bull, Dillion and Brearley, 2019).



Plate 3.2: *Acacia corusca* Habitat



## 3.2. Field Assessment



### 3.2.1. *Acacia corusca*



No *Acacia corusca* individuals were recorded during the field assessment. Target areas were searched, and habitat notes were taken. The dominant habitat types of each survey polygon and habitat suitability are shown in Table 3.2 and the survey effort is displayed on Map 3.1 - Map 3.3. All polygons except JJ03 and JB18 contained areas with the correct habitat for *Acacia corusca*. SDM variable for each polygon is shown in Appendix C.



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Table 3.2: Target Area Polygon Site Descriptions and habitat assessment



Habitat Type	Polygon	Suitable Habitat Within Polygon	Photo
<b>Eastern Ridge</b>			
<p><i>Triodia</i> hummock grassland with <i>Eucalyptus leucophloia</i> low open woodland over <i>Acacia bivenosa</i>, <i>Senna artemisioides</i> subsp. <i>oligophylla</i> and (+/-) <i>Grevillia wickhamii</i> mid open shrubland on rocky slopes</p>	ER02	Suitable habitat recorded to the south of ridgeline dissecting the polygon along rocky slopes and within valleys. Polygon occurs on the Marra Mamba Iron Formation and the Newman Land system.	
	ER03	Small areas of suitable habitat occur on rocky breakaway slopes and the valleys and drainage lines below these slopes. Polygon occurs on the Marra Mamba Iron Formation 200m south of the Boolgeeda Iron Formation.	



Habitat Type	Polygon	Suitable Habitat Within Polygon	Photo
	ER04	Suitable habitat recorded along rocky slope and valleys in the middle and towards the north of the polygon predominantly on Brockman Iron Formation, landscape too steep heading further northeast. Polygon occurs on the Brockman Iron Formation and Mount McRae Shale and Mount Sylvia Formation within the Newman Land system.	
	EO03	Suitable habitat recorded on breakaways and low undulating hills. Majority of polygon occurs on the Marra Mamba Iron Formation within the Newman Land system.	


Habitat Type	Polygon	Suitable Habitat Within Polygon	Photo
	EO05	Suitable habitat recorded toward the north of the polygon with breakaway slopes and low undulating hills. South of the polygon was too steep and not suitable. Polygon occurs on the Brockman and Marra Mamba Iron Formation within the Newman land system.	
<b>Fortescue</b>			
<p>hummock grassland with <i>Eucalyptus leucophloia</i> low open woodland over <i>Acacia bivenosa</i>, <i>Senna artemisioides</i> subsp. <i>oligophylla</i> and (+/-) <i>Grevillia wickhamii</i> mid open shrubland on rocky slopes</p>	FR01	Suitable habitat recorded on ridgeline breakaways, slopes, and minor drainage lines dissecting rocky hills. Polygon occurs on the Boolgeeda Iron Formation within the Newman Land system.	

Habitat Type	Polygon	Suitable Habitat Within Polygon	Photo
	FR02	Suitable habitat recorded on ridgeline breakaways, slopes, and minor drainage lines dissecting rocky hills. Polygon occurs on the Boolgeeda Iron Formation within the Newman Land system.	No photo
<b>Shovelanna North</b>			
hummock grassland with <i>Eucalyptus leucophloia</i> low open woodland over <i>Acacia bivenosa</i> , <i>Senna artemisioides</i> subsp. <i>oligophylla</i> and (+/-) <i>Grevillia wickhamii</i> mid open shrubland on rocky slopes	SN01	Suitable habitat recorded on breakaways and low undulating hills to the north of the ridgeline dissecting the polygon. Polygon is 2km west of known population and occurs on the Boolgeeda Iron Formation and Wongarra Rhyolite within the Newman Land.	
	SN04	Suitable habitat recorded on breakaways and low undulating hills to the north of the ridgeline dissecting the polygon. Polygon borders known population and occurs on Wongarra Rhyolite geology within the Newman Land.	

Habitat Type	Polygon	Suitable Habitat Within Polygon	Photo
<b>Jimblebar</b>			
hummock grassland with <i>Eucalyptus leucophloia</i> low open woodland over <i>Acacia bivenosa</i> , <i>Senna artemisioides</i> subsp. <i>oligophylla</i> and (+/-) <i>Grevillia wickhamii</i> mid open shrubland on rocky slopes	JB13	Some sections of suitable habitat on slopes on the east of the polygon. Flat <i>Triodia</i> plains to the west and south of the polygon not suitable habitat. Polygon occurs on the Brockman Iron formation within the Newman Land system.	
	JB17	Some suitable habitat to the southwest of polygon on Boolgeeda iron formation and Wongarra Rhyolite within the Newman Landsystem.  Eastern and northern areas not considered suitable; Eastern side was dominated by low <i>Triodia</i> hummock slopes with no breakaways and Eastern and northern areas affected by heavy grazing from camels.	
	JJ02,	Suitable habitat recorded. Occurs on the Weeli Wolli Formation near Wongarra Rhyolite geology within the Newman Land system. Suitable habitat with multiple breakaways and undulating slopes across the polygon.	No photo

Habitat Type	Polygon	Suitable Habitat Within Polygon	Photo
	JJ05	Suitable habitat recorded. Occurs on Boolgeeda and Wongarra Rhyolite within the Newman Landsystem. Suitable habitat throughout the polygon with breakaway ridgelines and undulating slopes.	
Acacia (Mulga) woodlands, with <i>Triodia</i> hummock grassland on flat plains	JB18	No suitable habitat. Occurs on Boolgeeda and Wongarra Rhyolite geology, however the landform was flat mulga dominated plains with minor drainage lines.	

Habitat Type	Polygon	Suitable Habitat Within Polygon	Photo
<p><i>Triodia</i> hummock grassland on steep rocky slopes</p>	<p>JJ03</p>	<p>No suitable habitat. Slopes too steep, with no rocky outcrops and dominated by <i>Triodia</i> hummock grassland. Occurs on the Weeli Wolli Formation near Wongarra Rhyolite geology within the Newman Land system.</p>	
<p>Kalgans West</p>			
<p>hummock grassland with <i>Eucalyptus leucophloia</i> low open woodland over <i>Acacia bivenosa</i>, <i>Senna artemisioides</i> subsp. <i>oligophylla</i> and (+/-) <i>Grevillia wickhamii</i> mid open shrubland on rocky slopes</p>	<p>KW01</p>	<p>Suitable habitat recorded. Occurs on the Boolgeeda iron formation within the Newman Land system. Suitable habitat with multiple breakaways and undulating slopes across the polygon.</p>	

Habitat Type	Polygon	Suitable Habitat Within Polygon	Photo
	KW02	Suitable habitat recorded. Occurs on the Boolgeeda iron formation within the Newman Land system. Suitable habitat with multiple breakaways and undulating slopes across the polygon.	

### 3.2.2. *Hibiscus aff. campanulatus*

*Hibiscus aff. campanulatus* was recorded opportunistically with approximately 248 individuals from five locations recorded (Map 3.4) This species has been recently discovered and is likely to be raised as a phrase-name entity and assigned a Priority Flora status in the near future. *Hibiscus aff. campanulatus* was found in shaded areas, such as, gullies, crevasses, and drainage lines on rocky substrates as well as along tracks.

775000 776000 777000 778000 779000 780000 781000

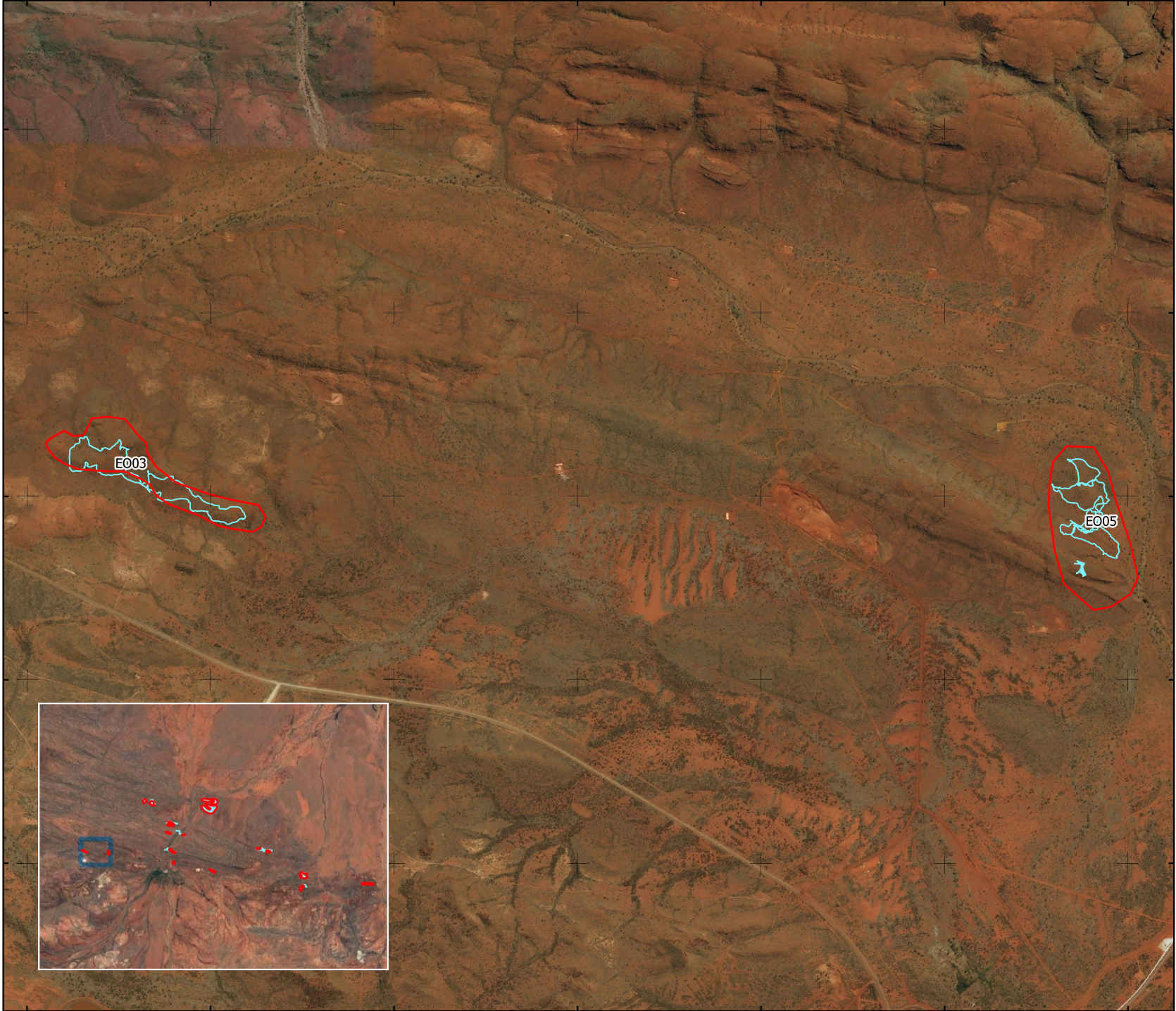
7422000

7421000



7420000

7419000

7418000



### Legend

-  Survey Area
-  Traverses



0 0.5 1 km

Scale 1:29,000 @ A4

Coordinate System: GDA 1994 MGA Zone 50  
 Projection: Transverse Mercator  
 Units: Meter



Author: SM Approved: MH Date: 13-03-2023

## Sampling Effort

Acacia corusca Targeted Survey

MAP

3.1

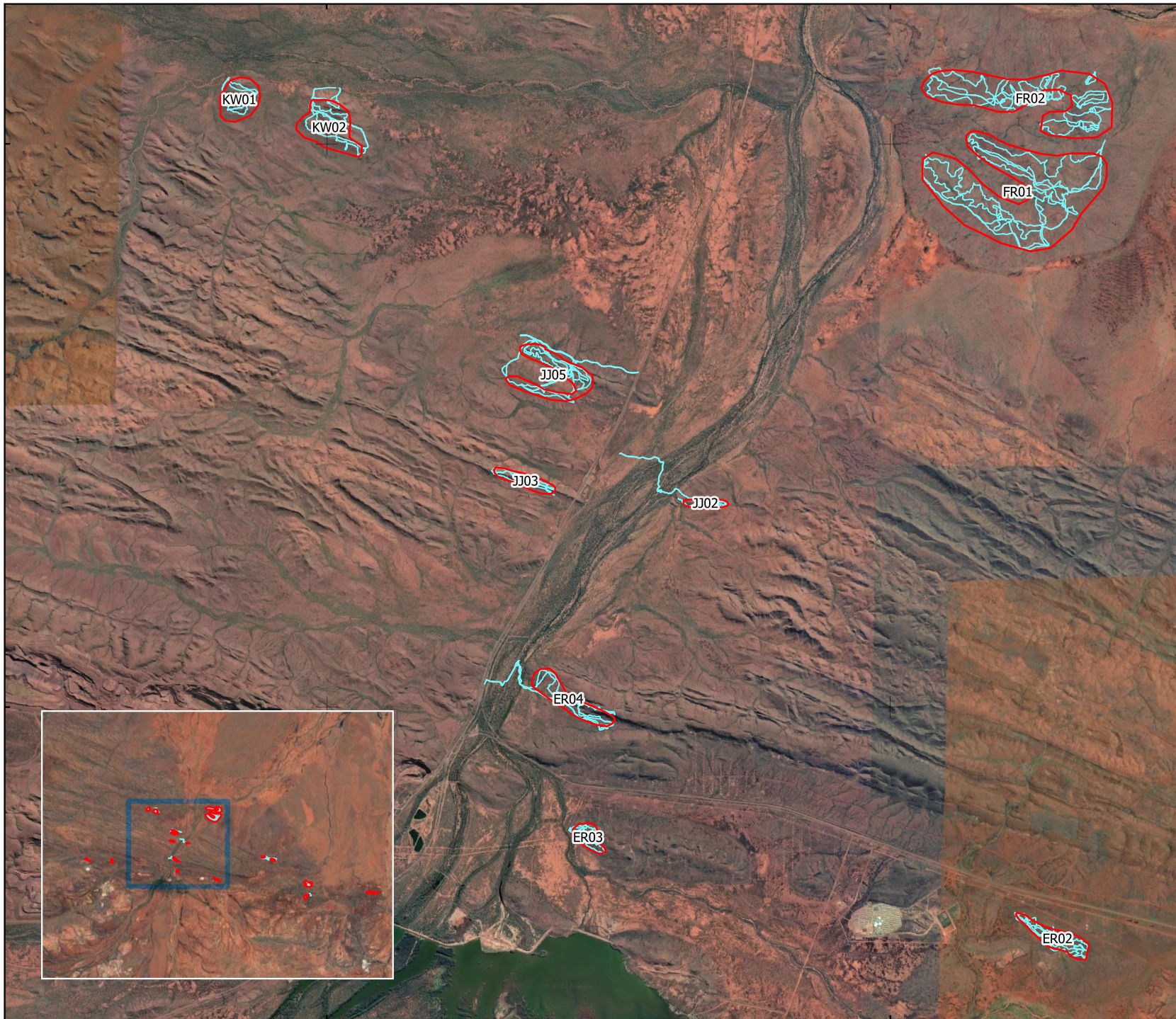
Prepared for  
BHP WAIO

790000

800000

7430000

7420000



### Legend

- Survey Area
- Traverses



0 1 2 3 km  
 Scale 1:95,000 @ A4

Coordinate System: GDA 1994 MGA Zone 50  
 Projection: Transverse Mercator  
 Units: Meter



Author: SM Approved: MH Date: 28-11-2022

## Sampling Effort - B

Acacia corusca Targeted Survey

MAP

3.2

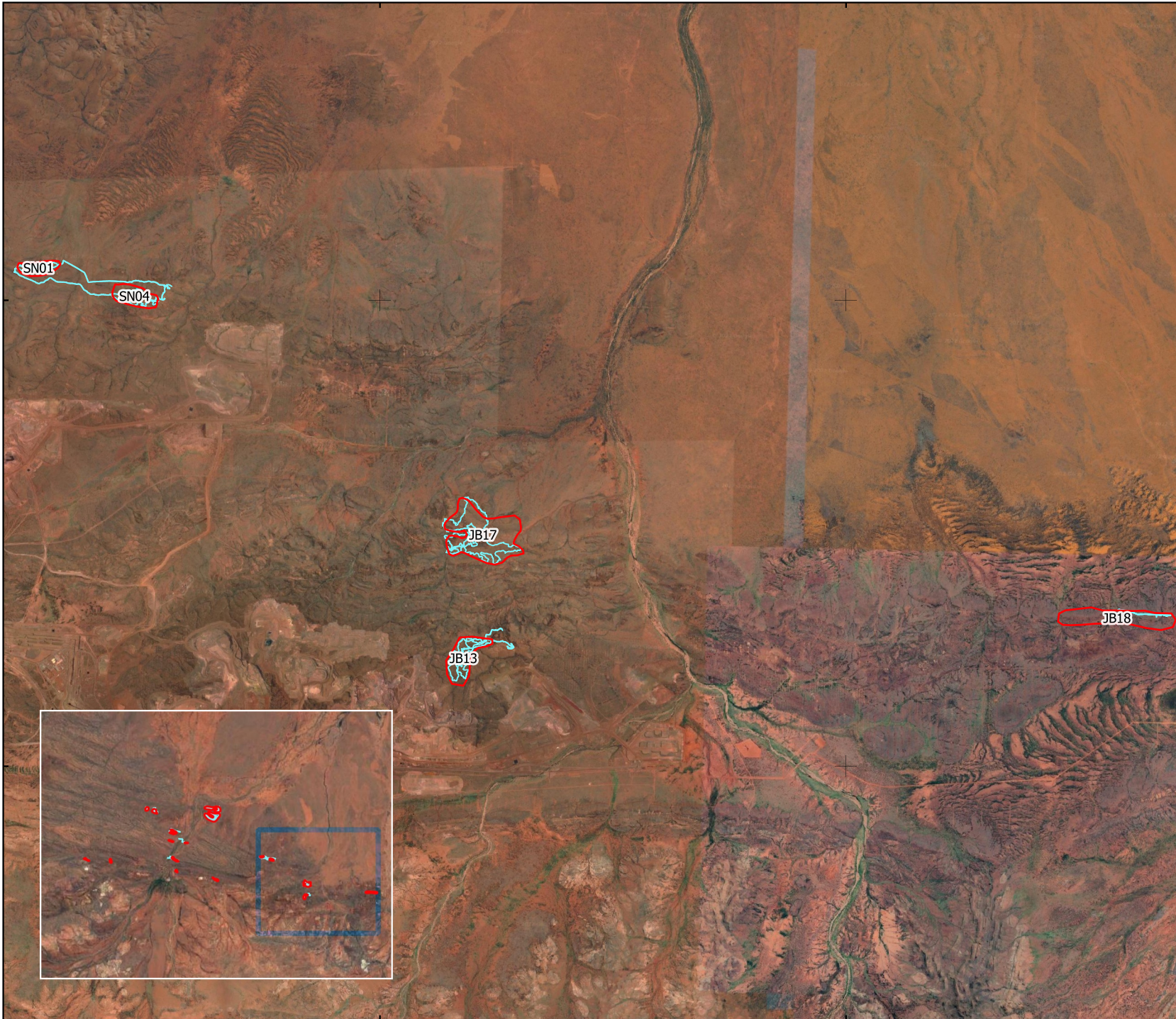
Prepared for  
 BHP WAIO

820000

830000

7420000

7400000



### Legend

- Survey Area
- Traverses



0 1 2 3 km

Scale 1:115,000 @ A4

Coordinate System: GDA 1994 MGA Zone 50  
 Projection: Transverse Mercator  
 Units: Meter



Author: SM Approved: MH Date: 28-11-2022

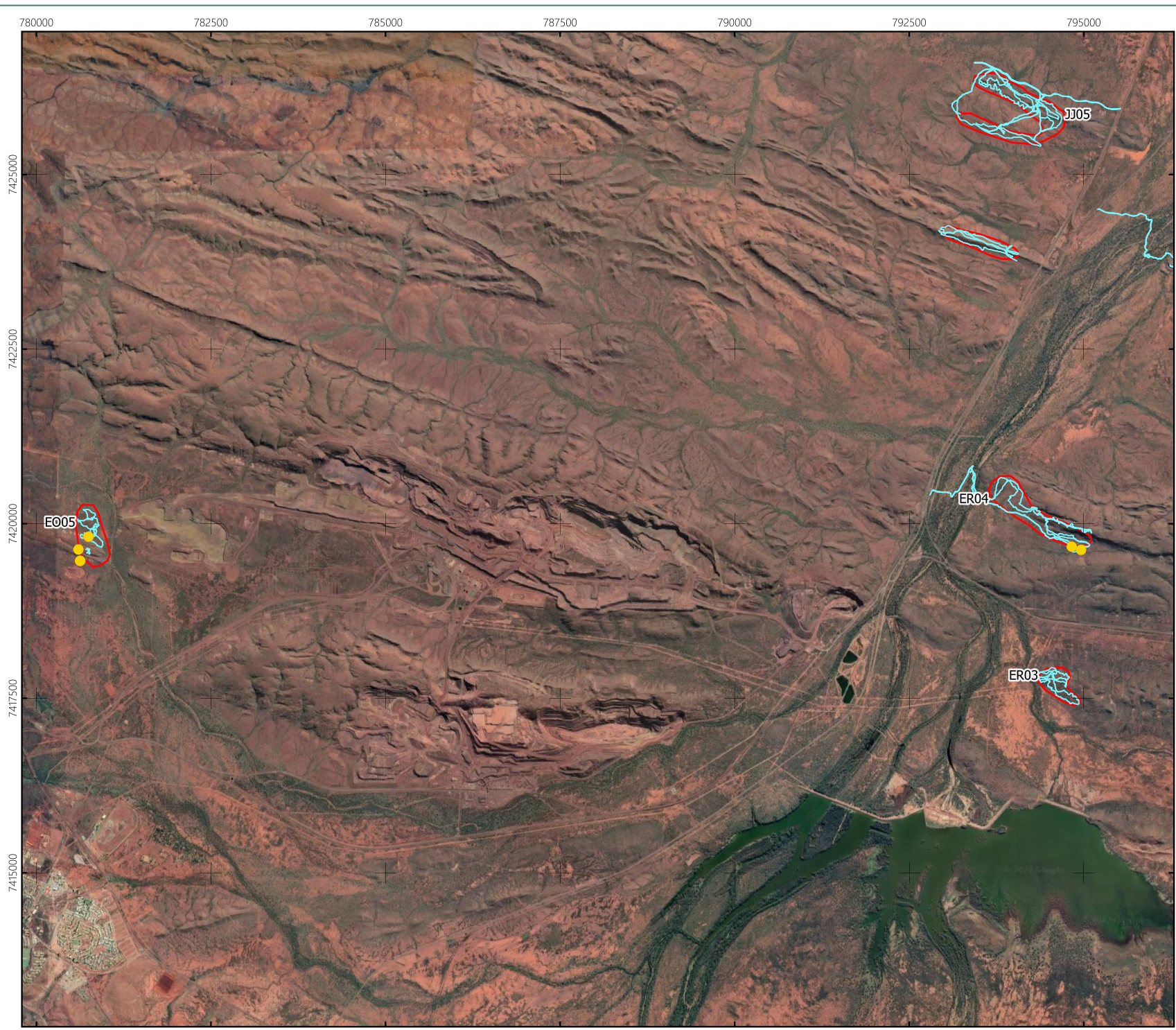
## Sampling Effort - C

Acacia corusca Targeted Survey

MAP

# 3.3

Prepared for  
BHP WAIO



**Legend**

- Survey Area
- Hibiscus aff. campanulatus
- Traverses

0 1 2 3 km  
Scale 1:75,000 @ A4

Coordinate System: GDA 1994 MGA Zone 50  
Projection: Transverse Mercator  
Units: Meter

Author: SM Approved: MH Date: 11-10-2022

# Recorded Hibiscus aff. campanulatus

Acacia corusca Targeted Survey

### 3.3. Species Distribution Modelling Results

#### 3.3.1. Correlation Test Amongst Environmental Predictors

The correlation test amongst environmental predictor variables for the Study Area revealed that they are not independent. Slope, Topographic Wetness Index, and the July Net Radiation showed correlation above 0.7. Furthermore, the correlation test between environmental variables in the locations of previous records found dependencies amongst same variables. These variables were then removed, and the correlation test process was iterated until all variables resulted in a correlation lower than 0.7. The final selected variables to feed the model are shown in in Appendix B.

#### 3.3.2. Maximum Entropy Model Performance

Twenty-eight models were tested in the selection process, choosing the best model that presented a very high performance with an AUC of 0.99. This means that the model was highly efficient measuring presences and pseudo-absences. However, the omission rate (the proportion of test presences incorrectly predicted) is lower than expected randomly. This means that the model is very good at distinguishing absences from presences, but as the chance of finding an individual increases, the model is less accurate as would be expected by chance (Figure 3.1). This suggests that although the model's performance was very high, overfitting, although reduced, was present due to the spatial closeness between the records. These findings were somewhat expected, since modelling species with known records in close vicinity is often challenging, especially when extrapolating to larger extents (Fois *et al.*, 2018).

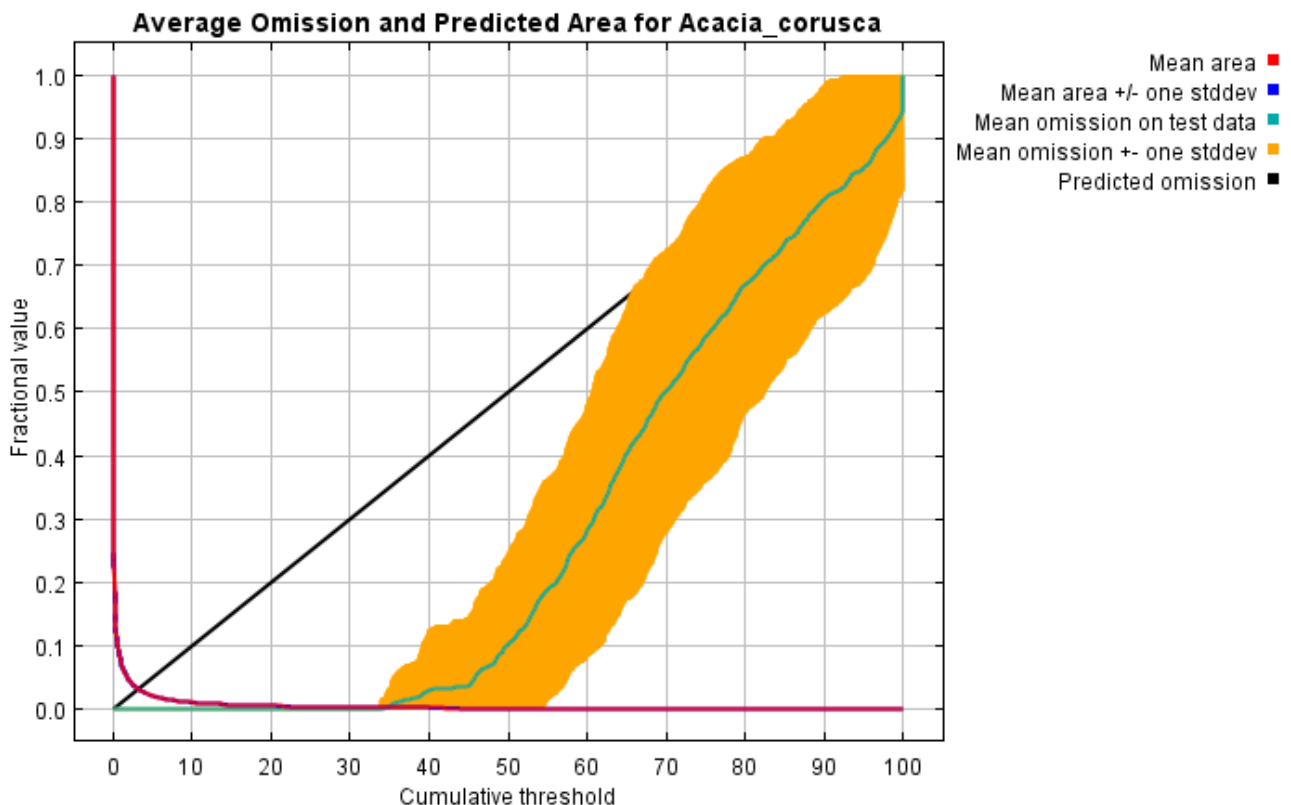


Figure 3.1: Average Omission & Predicted Area for *Acacia corusca*

### 3.3.3. Species Distribution Model Revision

The model was run using the same method presented in the original SDM (Spectrum Ecology & Spatial, 2021) with the addition of known absence locations from the targeted survey. The same 17 unique predictor variables were tested from the original iteration of the SDM with the additional known absence locations added to the pseudo absence locations. The resulting influential environmental factors found that the same nine factors were still influencing the model output with slight changes to the percent contributions and permutation importance. Additionally, the high likelihood cut off value increased from 80.0% to 85.0%. The medium and low cut off values remained the same.

### 3.3.4. Environmental Variable Importance & Contribution

Amongst the 17 unique predictor variables tested, nine were the most influential when explaining the distribution of *Acacia corusca* (Table 3.3). Land systems (Newman System) and the distance to the Boolgeeda BIF and Woongarra Rhyolite remain the most influential predictors, however, percentage contribution from the land systems variable increased (27.9 to 31.5) and distance to the Boolgeeda BIF and Woongarra Rhyolite decreased (24.8 to 23.6). Of these two variables, distance to Boolgeeda BIF and the Woongarra Rhyolite was still the most important variable (86.3%).

This result was similar to the initial model selected, indicating that based on our current knowledge *Acacia corusca* habitat is specific to the junction between the Boolgeeda BIF and the Woongarra Rhyolite. As no additional individuals were recorded during the target survey and the model results remained similar before and after the addition of absence data, it's likely that the species distribution cannot be fully explained by the current environmental and landform factors.

**Table 3.3: Variable Importance of the Best Performing Model**

Variable	Original Model		Revised Model	
	Percent Contribution	Permutation Importance	Percent Contribution	Permutation Importance
Land Systems	27.9	0.4	31.5	0.2
Distance to Boolgeeda Iron Formation and Woongarra Rhyolite	24.8	87.2	23.6	86.3
MrVBF Classified	17.8	3.8	18.1	2.7
Soil Atlas	14.4	0.4	13.3	0.6
Slope Relief Classification	5.3	0.1	5.9	0.1
Soil Sand (%)	4.3	6.8	1.7	6
Digital Elevation Model	2.4	0.9	1.7	1.5
Soil Organic Carbon	2.3	0	2.7	0.2
MSAVI	0.8	0.5	1.5	2.4

### 3.3.5. Representation of Predicted Areas within the Study Area

An assessment of the extent of probability of occurrence within the Study Area was performed, with the total predicted extent occupying 70,064 ha (0.8%) of the Study Area, 21,350 ha less than the original model. Within the modelled extent, 89.8% (62,919 ha) was classified as having a low probability of occurrence of the species. Areas of medium and high probability represented 4,901 ha (7%) and 2,244 ha (3.2%) of the modelled extent, respectively (Table 3.4).

Much of the total modelled extent of *Acacia corusca* (82.6%) occurs outside of BHP tenements (Table 3.4). Of the total classified model extent, areas categorised as having a medium or high probability of occurrence within BHP tenements, occupied 2.0% and 1.1%, respectively.

**Table 3.4: Probability of Occurrence in Study Area & BHP WAIO Tenements**

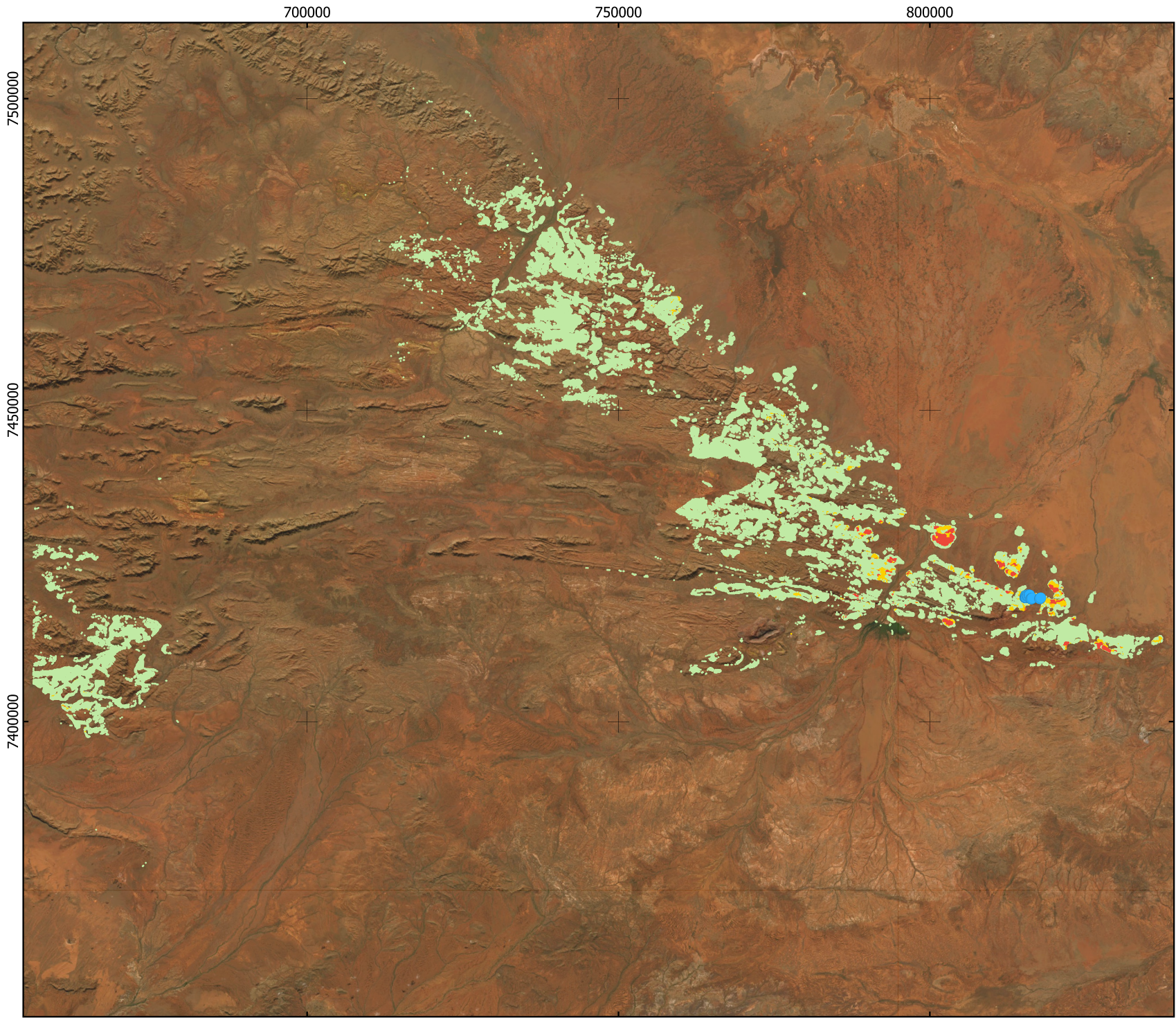
Site	Low		Medium		High	
	Ha	%	Ha	%	Ha	%
Outside Mining Tenements	43,497	62.1	1,378	2.0	254	0.4
Other Tenements	9,380	13.4	2,151	3.1	1,213	1.7
BHP WAIO tenements	10,043	14.3	1,372	2.0	777	1.1
<b>Total</b>	<b>62,919</b>	<b>89.8</b>	<b>4,901</b>	<b>7.0</b>	<b>2,244</b>	<b>3.2</b>

### 3.3.6. Total Survey Effort across the Revised SDM

The Survey Area assessed by Onshore Environmental (Onshore Environmental, 2015) and the current Spectrum targeted survey was analysed against the revised SDM (Table 3.5; Map 3.6). Of the areas classified as having a high probability of occurrence, 80.6% fall within the Onshore or Spectrum Survey areas. Areas with a medium and low probability of occurrence have 61.0%, and 21.7% of their extent, respectively, within the Survey Areas. There remain areas of high probability of occurrence areas across FMG tenure and Ethel Creek Station to the north of East Ophthalmia Mine, and near an actively mined area at Eastern Ridge.

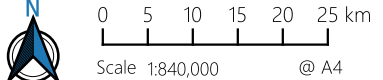
**Table 3.5: Total Survey Area Across Probability of Occurrence**

Site	Total Ha	Total Survey Extent	
		Ha	%
Low	62,919	13,658	21.7
Medium	4,901	2,990	61.0
High	2,244	1,809	80.6
<b>Total</b>	<b>70,064</b>	<b>18,457</b>	<b>26.3</b>



**Legend**

- *Acacia corusca*
- Revised Model Output
  - Low
  - Medium
  - High



Coordinate System: GDA 1994 MGA Zone 50  
Projection: Transverse Mercator  
Units: Meter



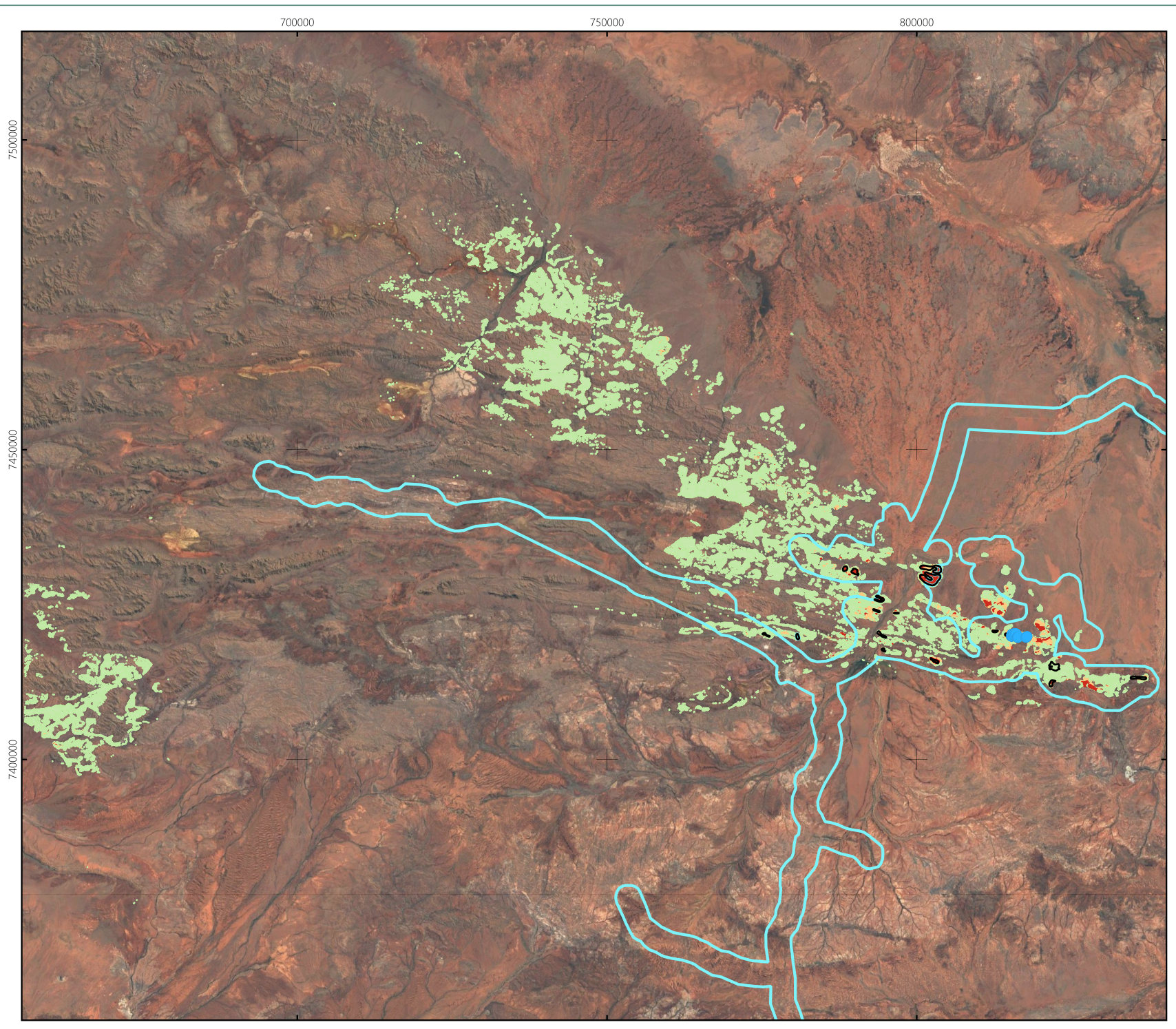
Author: SM    Approved: MH    Date: 30-11-2022

# Species Distribution Model Revision

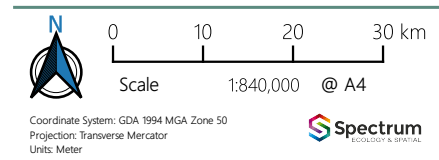
*Acacia corusca* Targeted Survey

Prepared for  
BHP WAIO

MAP  
**3.5**



- Legend**
- Acacia Corusca
  - Survey Area
  - Onshore Survey Buffer
- Revised Model Output**
- High
  - Medium
  - Low



Author: SM    Approved: MH    Date: 13-03-2023

## Total Survey Effort Across Revised SDM

Acacia corusca Targeted Survey

Prepared for  
BHP WAIO

**MAP**  
**3.6**

## 4. CONCLUSIONS

*Acacia corusca* was described as a new species in 2019 and is listed as Priority 1 under the Conservation Codes for Western Australia Flora by the Department of Biodiversity Conservation and Attractions (DBCA, Smith & Jones, 2018). As there is the potential for proposed future mining operations within the area to impact localised populations, a targeted field survey was undertaken to identify additional populations of the species using the results of a SDM. The targeted field survey was undertaken from the 3 to 11 August 2022, during which approximately 227.6 km of traverses were surveyed. No additional individuals of *Acacia corusca* were found.

The SDM was then re-assessed using the confirmed absence data collected during the survey. The revised extent of probability of occurrence within the Study Area was performed, with the total predicted extent occupying 70,064 ha (0.8%) of the Study Area, 21,350 ha less than the original model. Within the modelled extent, 89.8% (62,919 ha) was classified as having a low probability of occurrence of the species. Areas of medium and high probability represented 4,901 ha (7%) and 2,244 ha (3.2%) of the modelled extent, respectively.

Total survey effort was mapped against the revised SDM. Surveys so far have covered 80.6% of the areas classified as having a high probability of occurrence, 61.0% of medium probability of occurrence, and 21.7% low probability of occurrence. Tenure, active mining, and access issues may impede efforts to survey the majority of the remaining high and medium probability of occurrence areas.

The reiteration of the model was similar to the original assessment indicating that based on our current knowledge *Acacia corusca* habitat is specific to the junction between the Boolgeeda BIF and the Woongarra Rhyolite. As no additional individuals were recorded during the target survey and the model results remained similar before and after the addition of absence data, it's likely that the species distribution cannot be fully explained by the current environmental and landform factors.

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## Appendix A: Conservation Codes & Significant Definitions



Appendix A1: Definitions of Conservation Categories under the EPBC Act

Category	Definition
<b>Extinct</b>	A native species is eligible to be included in the extinct category at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.
<b>Extinct in the Wild</b>	A native species is eligible to be included in the extinct in the wild category at a particular time if, at that time: (a) it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
<b>Critically Endangered</b>	A native species is eligible to be included in the critically endangered category at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
<b>Endangered</b>	A native species is eligible to be included in the endangered category at a particular time if, at that time: (a) it is not critically endangered; and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
<b>Vulnerable</b>	A native species is eligible to be included in the vulnerable category at a particular time if, at that time: (a) it is not critically endangered or endangered; and (b) it is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
<b>Conservation Dependent</b>	A native species is eligible to be included in the conservation dependent category at a particular time if, at that time: (a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered, or critically endangered; or (b) the following subparagraphs are satisfied: (i) the species is a species of fish; (ii) the species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long-term survival in nature are maximised; (iii) the plan of management is in force under a law of the Commonwealth or of a State or Territory; (iv) cessation of the plan of management would adversely affect the conservation status of the species.

## Appendix A2: Definitions of Priority Species Classification (DBCA 2019)

**Priority species:** Possibly Threatened species that do not meet the criteria for listing under the BC Act due to insufficient survey or otherwise data deficient, are added to the Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as Threatened flora.

Species that are adequately known, are rare but not Threatened, or meet criteria for near Threatened, or that have been recently removed from the Threatened species, are placed in Priority 4. These species require regular monitoring.

Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.

Category	Definition
P1	<p><b>Priority 1: Poorly-known species</b></p> <p>Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.</p>
P2	<p><b>Priority 2: Poorly-known species</b></p> <p>Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.</p>
P3	<p><b>Priority 3: Poorly-known species</b></p> <p>Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.</p>
P4	<p><b>Priority 4: Rare, Near Threatened and other species in need of monitoring</b></p> <p>(a) Rare. Species 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 species are usually represented on conservation lands.</p> <p>(b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as Conservation Dependent.</p> <p>(c) Species that have been removed from the list of Threatened species during the past five years for reasons other than taxonomy</p>

### Appendix A3: Significant Flora & Vegetation Definitions

Significant flora can include (EPA, 2016b):

- Being identified as Threatened: Critically Endangered, Endangered or Vulnerable (state listed BC Act and/or nationally listed EPBC Act);
- Being identified as Priority Flora species: Priority 1 to 4 (DBCA, 2019);
- Locally endemic or association with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems);
- New species or anomalous features that indicate a potential new species;
- Representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- Unusual species, including restricted subspecies, varieties or naturally occurring hybrids; or
- Relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

Significant vegetation can include (Environmental Protection Authority, 2016c):

- Threatened Ecological Community (TEC): Critically Endangered, Endangered or Vulnerable (state listed BC Act and/or nationally listed EPBC Act);
- Priority Ecological Community (PEC): Priority 1 to 5 (DBCA, 2017a);
- Restricted distribution;
- Degree of historical impact from threatening processes;
- A role as a refuge; or
- Providing an important function required to maintain ecological integrity of a significant ecosystem.

## Appendix B: Correlation Test



Appendix BA: Selected Variables after Correlation Test

Environmental Variable		Description	Source	Type
Landscape Attributes	Depth of Regolith	Metres of <i>in situ</i> and transported material overlying unweathered bedrock	CSIRO	Numeric
	MrVBF	MrVBF is a topographic index designed to identify areas of deposited material at a range of scales based on the observations that valley bottoms are low and flat relative to their surroundings and that large valley bottoms are flatter than smaller ones. This dataset was classified into five categories based on the Jenks Natural breaks classification.		Numeric
	Slope Relief Classification	Soil relief landform pattern classification based on Speight (2009).		Categorical
Soil Attributes	Soil Bulk Density	Bulk density of the whole soil (including coarse fragments) in mass per unit volume	CSIRO	Numeric
	Soil Organic Carbon	Mass fraction of carbon by weight in the < 2 mm soil material as determined by dry combustion at 900 Celsius		Numeric
	Soil Sand (%)	Percentage of sand content of the soil at a depth of 0-5 cm		Numeric
	Soil Depth	Depth of soil (A & B horizons) to 2m		Numeric
	Soil Total Phosphorus	Percentage of phosphorus content of the soil at a depth of 0-5 cm		Numeric
	Effective Cation Exchange Capacity	Cations extracted using barium chloride (BaCl <sub>2</sub> ) plus exchangeable H + Al		Numeric
Geology & GIS	Atlas of Australian Soils	Digitalised soil landscapes from Northcote et al. (1960-1968)	Bureau of Rural Sciences	Categorical
	Pre-European Vegetation	Pre-European Vegetation of Western Australia (DPIRD-006) (ID:7)	DPIRD	Categorical
	Land Systems	Soil Landscape systems	DPIRD	Categorical
	Distance to Boolgeeda Iron Formation and Woongarra Rhyolite	Combined Euclidean Distance from the Boolgeeda Iron Formation and Woongarra Rhyolite (Surface Geology from Geoscience Australia) calculated in ArcMap	Calculated by Spectrum	Numeric
Vegetation Indices	MSAVI	Modified Soil Vegetation Index from Landsat 8 Imagery	Landsat 8	Numeric
	NDWI	Normalized Wetness Index from Landsat 8 Imagery	Landsat 8	Numeric
Bioclimatic	Bioclim1	Annual Mean Temperature	Hijmans 2005	Numeric
	Bioclim12	Annual Precipitation	Hijmans 2005	Numeric

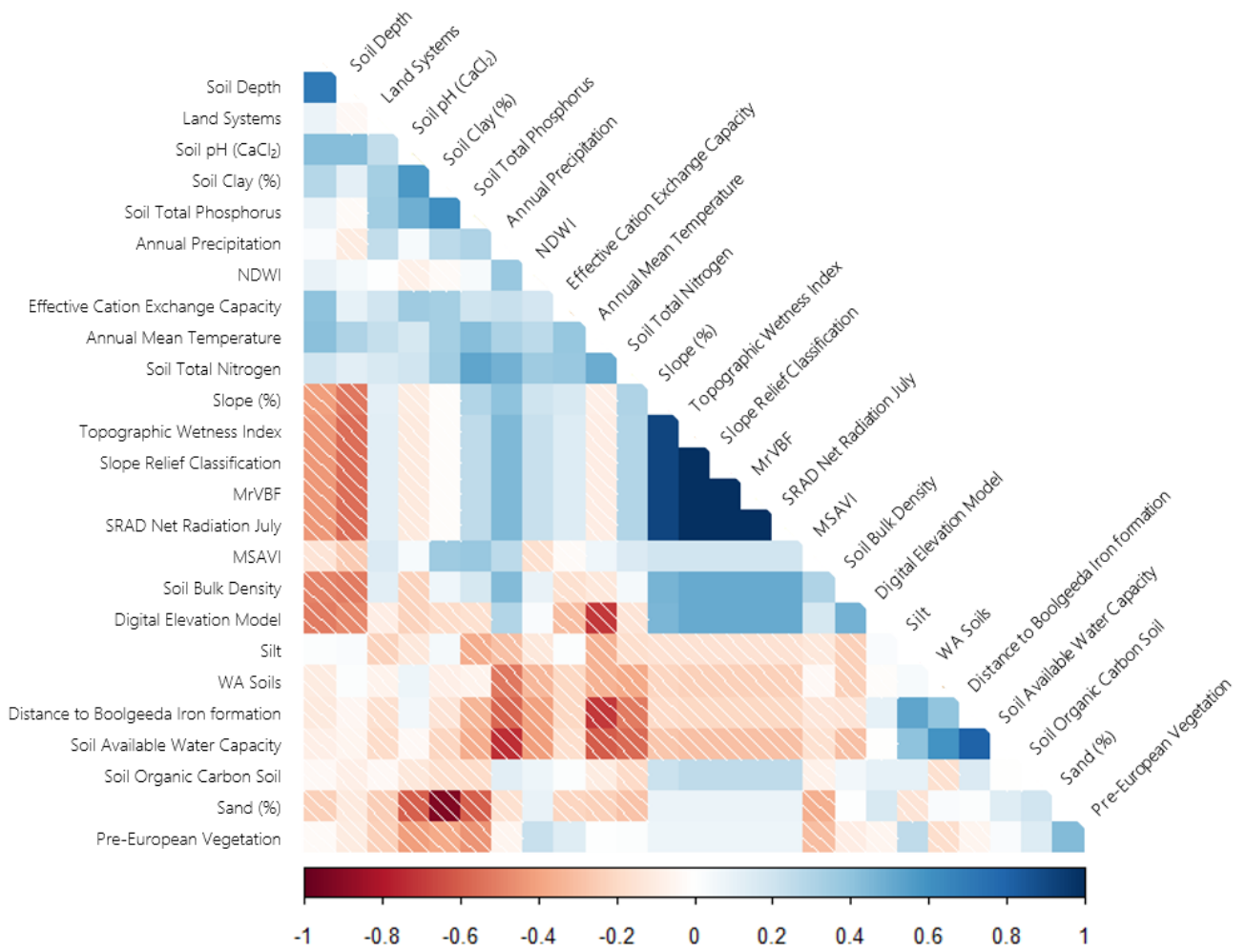


Figure 5.1: Correlation Test of Environmental Predictors.

## Appendix C: Target Area Polygons SDM Factors



Polygon	Soil	Elevation (m)	Sand (%)	Slope (%)	MrVBF Index	Land System
ER02	Fa13	539-562	81.5 – 83.0	2.2 - 11	0,2,3	Newman System -
ER03	Fa13 (northern section of polygon) and BE6	506 -535	82.0 – 83.0	4.1 – 11.3	0,2	Newman System -
ER04	Fa13 (Primarily) & Mz25 9 (northwest section)	506 -578	76.1 – 83.3	1.3 – 38.6	0,2,3	Newman System
EO03	Fa13	572-593	82.0 – 83.0	2.8 – 10.2	0,2,3 (Mainly 0)	Newman System
EO05	Fa13 and BE6 (small southern portion)	541-584	78.9 – 83.8	1.3 – 20.6	0,2,3 (Mainly 0)	Newman System (Primarily) and River System (Partial):
FR01	Fa13	497-540	76.4-83.1	1.6 – 12.0	0,2,3 (Mainly 0)	Newman System
FR02	Fa13	489-519	75.0 - 82.9	1.0 – 8.5	0,2,3 (good mix)	Newman System
SN01	Fa13	523-548	80.0 – 83.2	1.2 – 11.6	0,2,3 (Mainly 0)	Newman System
SN04	Fa13	528-564	81.6 - 83.4	2.8 – 14.9	0,2,3 (Mainly 0)	Newman System
JB13	Fa13	567 -609	80.4 – 85.3	1.3 – 9.5	0,2,3	Newman System
JB17	Fa13	520-561	77.2 – 83.2	1.2 – 11.6	0,2,3 (good mix)	Newman System
JJ02	Fa13	500-519	82.5-82.9	3.2 – 6.3	0,2 (mainly 2)	Newman System
JJ05	Fa13	503-532	81.2-83.0	1.4 – 9.9	0,2,3	Newman System
JB18	Fa13	512-537	73.9-82.8	0.6 – 4.7	0,2,3,4 (Mainly 0), 4 located in central area – in conjunction with the Jamindie System	Newman System and Jamindie System (central portion)
JJ03	Fa13	507-556	82.2-83.0	5.5 – 16.8	0-2 (Mainly 0)	Newman System
KW01	Fa13	513-545	81.3-83.4	2.1 – 9.2	0,2,3 (Mainly 0)	Newman System
KW02	Fa13	508-552	81.3-83.4	1.9 – 11.7	0,2,3 (Mainly 0)	Newman System