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ENVIRONMENT

SINOSTEEL MIDWEST CORPORATION

BLUE HILLS

IDIOSOMA NIGRUM TARGETED SURVEY

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TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

ACRONYMS

ANOVA	Analysis of Variance
DEC	Department of Environment and Conservation
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EPA	Environmental Protection Authority
EPBCA	*Environment Protection and Biodiversity Conservation Act 1950*
N	The size of a population
Ne	The effective size of a population
SEM	Standard Error of the Mean
SMC	Sinosteel Midwest Corporation
WC Act	Wildlife Conservation Act 1950

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EXECUTIVE SUMMARY

Sinosteel Midwest Corporation (SMC) is evaluating the opportunity to recommence mining at the Blue Hills tenement (the Survey Area), located approximately 80 kilometres east of Morawa.

SMC has commissioned *ecologia* to undertake a targeted survey of the Shield-back Trapdoor Spider *Idiosoma nigrum,* currently listed as a Schedule 1 species under the *Wildlife Conservation Act 1950*, as part of the evaluation of the proposed mining recommencement at Blue Hills. This survey is part of the environmental approvals process for the Project, which includes an assessment of the potential environmental impacts and subsequent identification of appropriate management strategies.

Regional records of *I. nigrum* were obtained from the WAM arachnid database, the DEC NatureMap database, and seven other invertebrate reports completed in the Midwest.

A survey targeting *I. nigrum* at Blue Hills was undertaken in late October 2012. As survey methods for targeting *I. nigrum* are not discussed in the EPA Guidance Statements No. 20 and 56 or the Position Statement No. 3, the survey methods and sampling design adopted by *ecologia* for this study were developed in consultation with Prof. Barbara Y. Main (University of Western Australia), who originally described the species and is the foremost expert.

Quadrat sites were randomly selected prior to the field survey, and 21 were surveyed. At each site, a 10,000 m^2 (1 ha) quadrat was surveyed by a team of four, each person performing two 100 m transects 12.5 m apart. Where *I. nigrum* burrows were identified, a range of information was recorded, including geographic location, vegetation type, width of burrow trap-door, distance to the nearest shrub, leaf litter coverage (1 m^2 around burrow) and micro-habitat type. A total of 53 burrows were found in 13 of the quadrats surveyed.

The main conclusions of the survey were:

- Specimens from this survey provided new distribution data within the current geographical boundaries of the species;
- The quadrats surveyed covered a variety of vegetation types and landforms, and *I. nigrum* was present at 62% of these;
- Virtually all 53 burrows recorded were identified under either *Acacia ramulosa* var. *ramulosa* or *Acacia caesanura*, in micro-habitats ranging from loamy plains to rocky hillslopes;
- The observed population consisted of two and a half times as many adults to juveniles or emergents – the local population is either in decline, the data collected is skewed, or the dispersal behaviour of *I. nigrum* in the area is atypical;
- Based on the population extrapolation, the Blue Hills tenement contains approximately 2140±0.65 Shield-back Trapdoor Spiders. Approximately 183±0.65 individuals are potentially at risk of impact from the Project, which represents 8.6% of this population; and,
- Indirect impacts on the *I. nigrum* population will likely include an increased risk of fire damage, dust-pollution and surface water run-off potentially encountered in proximity to an operating mine. Grazing and trampling damage may also be caused by introduced species such as rabbits, goats and cows. Management strategies should be put in place to minimise these risks.

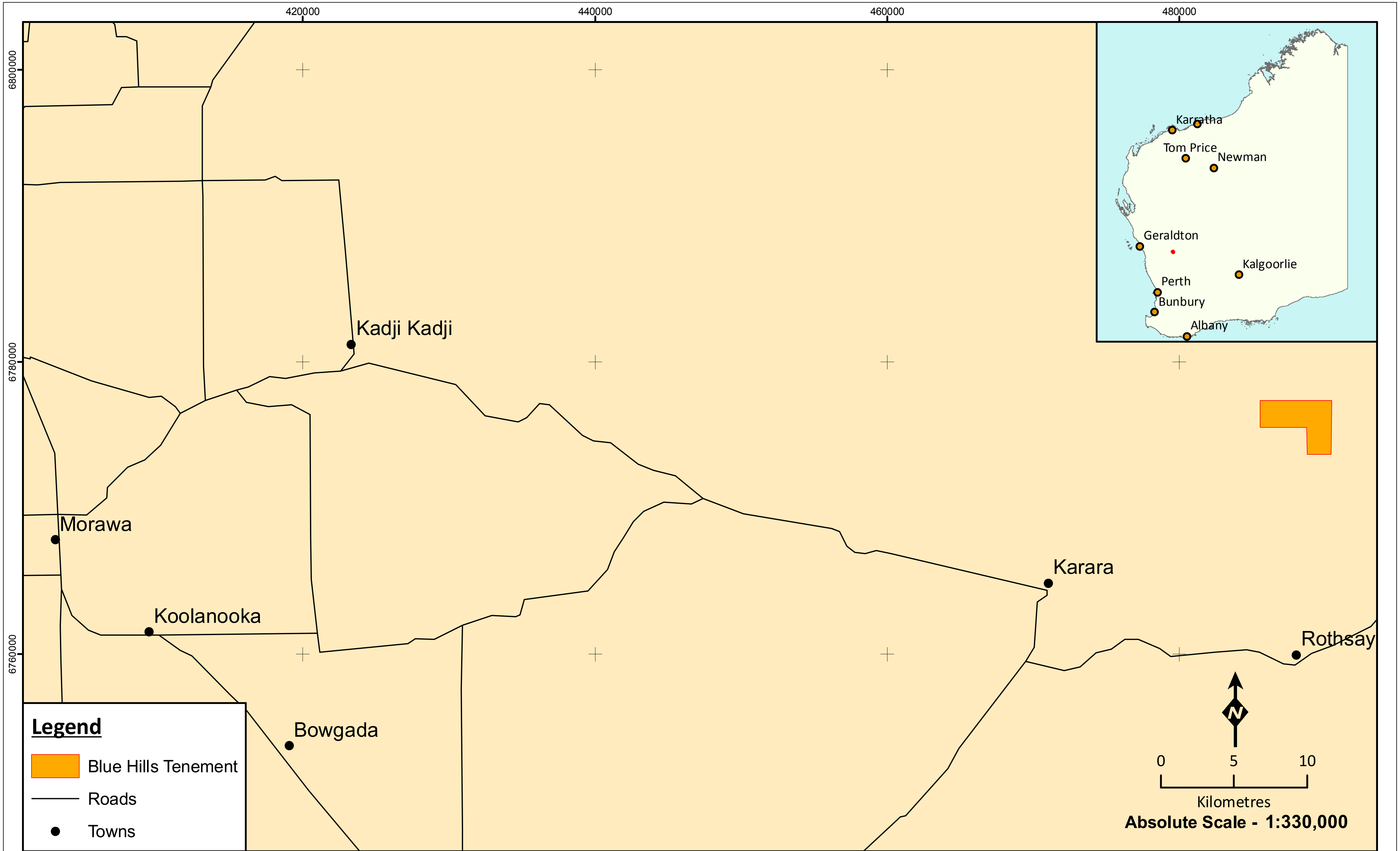
1 INTRODUCTION

1.1 PROJECT BACKGROUND

Sinosteel Midwest Corporation NL (SMC) is considering recommencement of mining at the Blue Hills tenement in the Mid West. SMC's tenure is located approximately 80 kilometres east of Morawa (Figure 1.1), close to the Karara mine and SMC's own Koolanooka mine.

A previous survey conducted by *ecologia* in 2010 identified the presence of the Shield-back Trapdoor Spider *Idiosoma nigrum,* currently listed as a Schedule 1 ("Fauna that is rare or likely to become extinct") species under the *Wildlife Conservation Act 1950* (*WC Act*), and Vulnerable under the *Environment Protection and Biodiversity Conservation Act* (1999). The species has also been recorded nearby in Karara in 2007 (Bamford 2007).

SMC has commissioned *ecologia* to undertake a targeted survey of *I. nigrum* for the proposed evaluation of mining recommencement at Blue Hills. This is a part of the environmental approvals process for the Project, including the assessment of potential environmental impacts and identification of appropriate management strategies.



Location of the Blue Hills Tenement

Figure: 1.1
Project ID: 1483

Drawn: JFH
Date: 18/10/12

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: JFH003

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1.2 LEGISLATIVE FRAMEWORK

Federal and State legislation applicable to the conservation of native fauna includes, but is not limited to, the *Environment Protection and Biodiversity Conservation Act* 1999, the *WC Act* and the *Environmental Protection Act 1986*. Section 4a of the *Environmental Protection Act 1986* requires that developments take into account the following principles applicable to native fauna:

- The Precautionary Principle

– Where there are threats of serious or irreversible damage, a lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

- The Principle of Intergenerational Equity

– The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

- The Principle of the Conservation of Biological Diversity and Ecological Integrity

– Conservation of biological diversity and ecological integrity should be a fundamental consideration.

This document includes background information on the Project, a literature review of *Idiosoma nigrum* in the Mid West subregion, particularly in reference to the habitats and environments of the Project. The conservation significance of fauna in Western Australia is also outlined.

The document was constructed with a view to satisfy the requirements of:

- the EPA Guidance Statement No. 20: Sampling of Short-range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009);
- the EPA Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004); and
- Position Statement No. 3: Terrestrial Biological Surveys As An Element Of Biodiversity Protection

Idiosoma nigrum is listed as Schedule 1 under Commonwealth legislation in the *WC Act*, meaning it is considered “fauna that is rare or likely to become extinct”. It is also listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act* (1999).

1.3 SURVEY OBJECTIVES

SMC commissioned *ecologia* to undertake a targeted survey of the shield-back spider *Idiosoma nigrum* at Blue Hills as part of the Environmental Impact Assessment (EIA) for the Project.

The EPA’s objectives with regards to the management of fauna are to:

- Avoid adverse impacts on biological diversity comprising different plants and animals and the ecosystems they form, at the levels of genetic, species and ecosystem diversity.
- Maintain the abundance, species diversity and geographic distribution of terrestrial invertebrate fauna; and
- Protect Specially Protected (Threatened) fauna, consistent with the provisions of the *WC Act* (1950).

The primary objective of this study was to provide sufficient information to the EPA to assess the impact of the Project on *I. nigrum* at Blue Hills, thereby ensuring that these objectives will be upheld.

Specifically, the objectives of this survey were to undertake a survey that satisfies the requirements documented in EPA’s Guidance Statements numbers 20 and 56, and Position Statement No. 3, providing:

- A review of background information (including literature and database searches);

- A census of *I. nigrum* populations occurring in the Survey Area, incorporating recent published and unpublished records;
- A review of regional and biogeographical significance, including the conservation status of the species recorded in the Survey Area;
- A systematic survey, mapping demography of *I. nigrum* at Blue Hills and collecting information such as population size, population structure and habitat preference in the area; and
- A risk assessment to determine likely impacts of threatening processes on *I. nigrum* within the Survey Area.

1.4 CURRENT SCIENTIFIC KNOWLEDGE OF *IDIOSOMA NIGRUM*

1.4.1 Biology and Ecology

The Shield-back Trapdoor Spider *Idiosoma nigrum* is one on the most arid-adapted mygalomorph spiders in Australia (Main 1982). This is due to a combination of morphological and behavioural attributes, such as a deep burrow to provide consistent temperature and humidity beneath the surface, and 'twig-lining' of the burrow rim to increase prey foraging area (Figure 1.2). They also have a sclerotised abdominal cuticle which reduces evaporative water loss and blocks the burrow to stop predators entering (Figure 1.2), as well as enlarged eyes which increase visual acuity (Figure 1.2). The spider is long-lived, with females possibly reaching over 20 years of age (B. Y. Main, pers. comm.). Both males and females reach maturity after five or six years, after which males undergo a final moult, then mate and subsequently die. Female spiders are probably capable of reproducing every second year until the age of about 20 (B.Y. Main, pers. comm.). Emergent spiderlings generally establish their burrows within 50 centimetres of the matriarch female, forming a family cluster typical for most mygalomorph spiders, with no aerial dispersal. Gene flow is facilitated by male-biased dispersal (≤ 500 m; (Main 1968)), as males only leave their burrows in search of females, whereas females spend their entire life in their burrow or in its proximity. There is field evidence from other species that females may be capable of storing sperm (B.Y. Main, pers. comm.), although it is unclear whether only virgin females mate or whether adult females mate repeatedly throughout their life. *Idiosoma nigrum* is most active during cooler, wetter periods (Harvey 2002).

The majority of information on the biology and ecology of *I. nigrum* comes from a census study conducted by Main (2003) in the East Yorkrakine Nature Reserve in the Shire of Kellerberrin in WA. In her study, Main established size classes based on measurements of the trapdoor and lumen of burrows, then linked these to age categories (Main 2003). The monitoring of individual burrows within the census area over a six year period resulted in the first data on average mortality of the Shield-back Trapdoor Spider (Table 1.2; Main 2003), as well as its transition success between age classes (Table 1.3; Main, unpublished data).

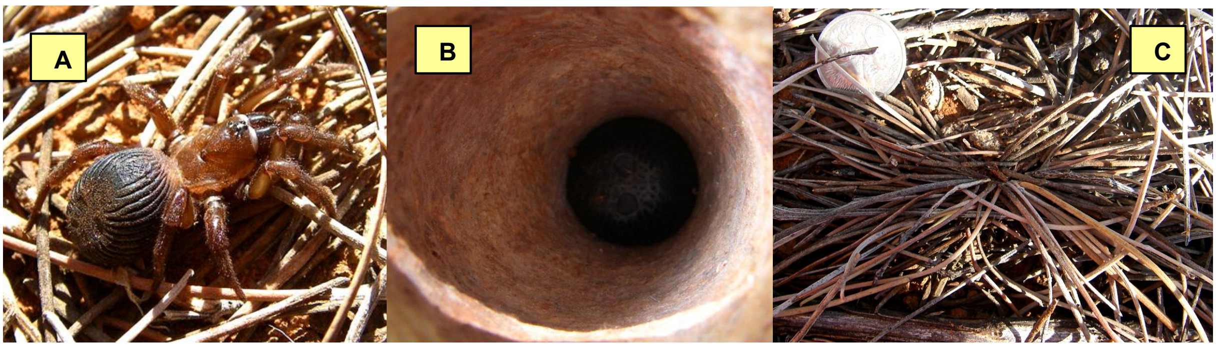


Figure 1.2 – (A) The Shield-Back Trapdoor Spider *Idiosoma nigrum*; (B) adult female spider blocking the burrow lumen with its sclerotised abdomen; (C) trap-door with twig-lining (5 cent coin shown for scale).

Table 1.1 – Size classes (After Main 2003)

	Emergents	Juveniles	Adults
Door (cm)	≤ 1.4	1.5 - 2.0	≥ 2.1
Age (years)	< 1	1 - 5 or 6	> 5 or 6

Table 1.2 – Percentage mortality (After Main 2003)

	1989/1990	1990/1991	1991/1992	1992/1993	1993/1994	Mean
Emergents	85%	65%	25%	57%	50%	56%
Juveniles	30%	36%	77%	39%	33%	43%
Adults	30%	36%	19%	40%	20%	29%

Table 1.3 – Percentage survival in age class transition (Main, unpublished data)

	1989/1990	1990/1991	1991/1992	1992/1993	1993/1994	Mean
Emergents to Juveniles	15%	35%	50%	35%	50%	37%
Juveniles to Adults	22%	9%	15%	33%	30%	22%

1.4.2 Effective population size

Effective population size (Ne) is defined as the number of individuals within a population that can contribute genes equally to the next generation (Allendorf and Luikart 2007). Thus, the effective population size is usually smaller than the actual size of the population (N). This is mainly due to factors such as reproductive maturity (e.g. juveniles cannot reproduce), reproductive availability (e.g. females can only raise one clutch of spiderlings at a time), reproductive success (e.g. dominant males have higher chance of reproduction than sub-dominant males), mating systems (e.g. long-term monogamy versus polygamy) and many others.

Effective population size can be determined accurately by constant monitoring of all individuals within a population – recording mating events, parental success, offspring dispersal, and so on. Sensitive molecular techniques (i.e. micro-satellites) can also be used to identify individuals and their relatives within the population and thus quantify Ne. Alternatively, if no such information is available, estimates of Ne can be made where accurate knowledge of a species' biology and life cycle exists. This is the process by which this report will estimate the effective population size of *I. nigrum* in the Blue Hills tenement.

For isolated populations of threatened species, estimation of Ne is especially important because it can highlight any propensity for genetic inbreeding and subsequent inbreeding depression. Franklin (1980) introduced what is termed the '50/500 rule', which states that "in the short term, Ne should not be less than 50 individuals, and in the long term Ne should not be less than 500". Even though there are many problems with the use of simple rules such as this, due to the fact that the loss of genetic diversity is a continuous process and thus no universal thresholds really exist (Allendorf and Luikart 2007), the 50/500 rule can still be used as a useful guideline analogous to a warning sign.

For the Shield-back Trapdoor Spider, important factors influencing their effective population size are:

1. The total number of adults;
2. 50% female availability (female capability of reproduction every second year);
3. Two potential mating systems:

    a) Single matings of virgin females only, followed by sperm storage. This effectively equals monogamy, therefore sex ratio is equal (number of Females = number of Males);

b) Multiple matings of all adult females over number of years. As all males die after a single mating season, males are constantly taken out of the gene pool by the time they reach 5 or 6 years of age. This creates a deficit of males and sex ratio is always unequal. Assuming that population growth is exponential, sex ratio at birth is 50:50 and mortality is equal for both sexes during emergent and juvenile stage, the sex ratio should be approximately 53% Females to 47% of Males; and,

4. Stochastic events - approximately 6% of all adults within any population do not reproduce (Allendorf and Luikart 2007).

1.4.3 Historical data

Idiosoma nigrum was first described in 1952 (Main 1952) when its known geographic distribution occurred throughout what is now the central and northern wheatbelt, and across to areas north of the Murchison River. The spider typically inhabited the clay soils of eucalypt woodlands and *Acacia* vegetation (Main 1996, 2003). However, broad-scale clearing of woodlands for agricultural purposes destroyed the majority of its habitat during the last century, thereby reducing the population to small sub-sets confined to bushland in nature reserves and private remnants (Main 2003). Populations in many of these remaining sites then further declined or became extinct due to secondary dry-land salinisation – a process which continues today. As a result of these threatening processes, the remaining populations of *Idiosoma nigrum* are small, fragmented and extremely isolated, making them particularly vulnerable to both large- and small-scale disturbance (e.g. bushfire or vegetation clearing) as well as inbreeding depression. Populations remaining in the wheatbelt area to date include a population in the East Yorkrakine Reserve, currently monitored by Prof B. Y. Main (B. Y. Main, pers. comm.). Recent environmental surveying in the Mid West has identified additional populations of *Idiosoma nigrum* further north at Jack Hills (*ecologia* 2009a) and Weld Range (*ecologia* 2009b), further east at Mount Magnet (*ecologia* 2012), and nearby at the Karara mine (Bamford 2007).

2 BIOPHYSICAL ENVIRONMENT

2.1 CLIMATE

The tenement is located in the Yalgoo biogeographic region of Western Australia, where the climate is arid and has two distinct seasons – a hot summer (October to April) and a mild to cool winter (May to September). Rainfall in the area occurs predominantly during winter; however, due to cyclonic activity in the Pilbara to the north, rainfall peaks are also experienced in late summer.

Average rainfall and temperature data for the Survey Area were obtained from the Bureau of Meteorology Morawa Airport weather station (station number 8296), located at -29.21° S, 116.01° E (BoM 2012). The weather station is located approximately 80 km west of the Survey Area.

Mean total annual rainfall for the Survey Area is 287.5 mm. The average rainfall in the five years prior to the survey was slightly above average (Table 2.1). Figure 2.1 shows that May, June and July produce the highest average rainfall, with an additional peak in January due to cyclonic activity in the north. In the months preceding the survey in October, below-average rainfall occurred in the Survey Area, with August and September receiving respective totals of 20.8 and 16.4 mm (Table 2.2).

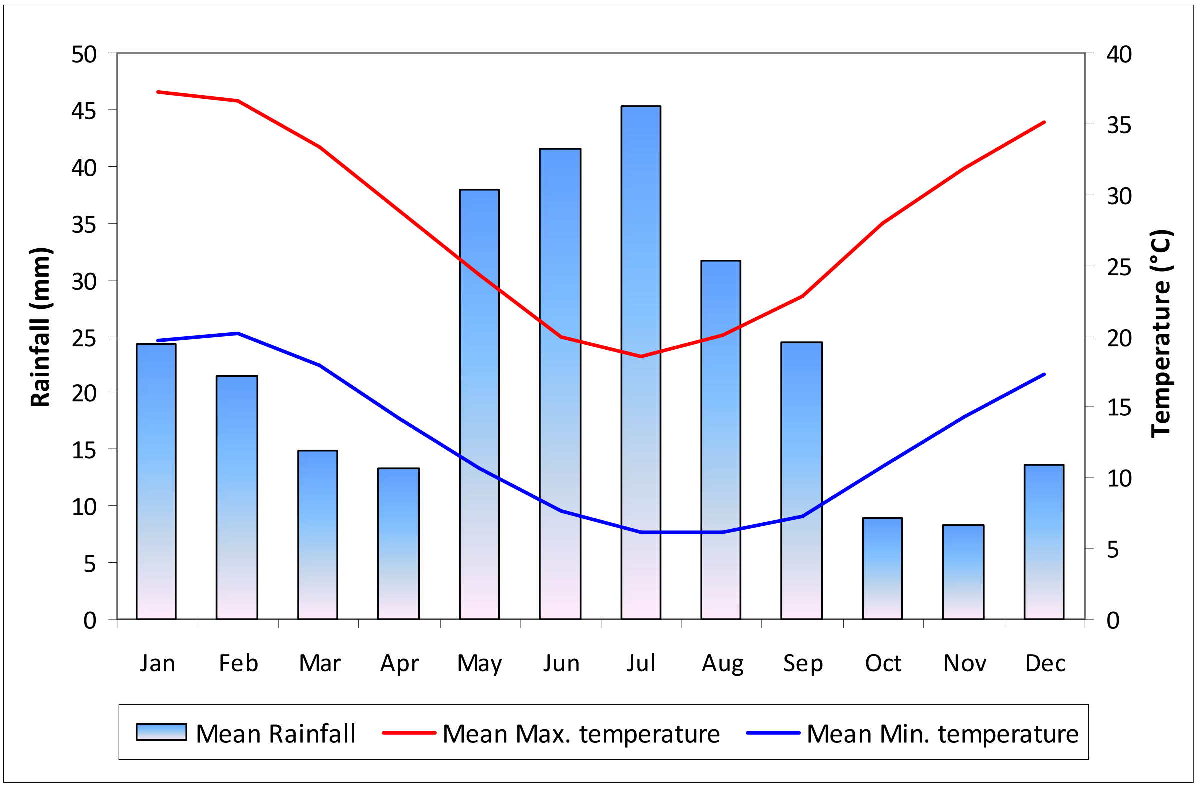


Figure 2.1 – Climate Statistics for Morawa Airport (Temperature and Rainfall 1997-2012, BoM 2012)

Table 2.1 – Mean rainfall record at Morawa Airport over previous five years (BoM 2012)

	2007	2008	2009	2010	2011
Rainfall (mm)	173.2	311	328.8	253.6	460
± mean (mm)	-114.3	23.5	41.3	-33.9	172.5

Table 2.2 – Rainfall record for Morawa Airport preceding the survey (BoM 2012)

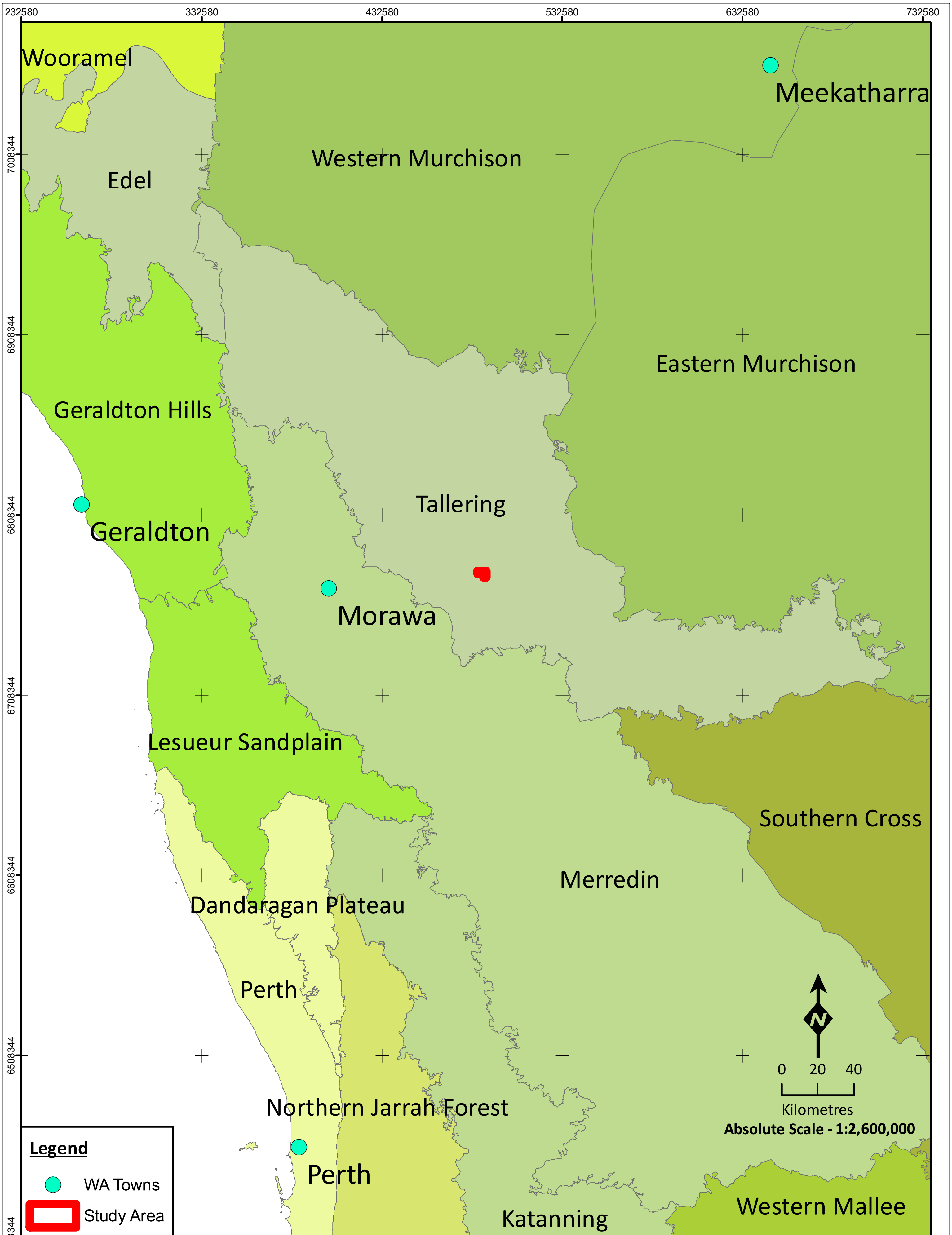
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.
Monthly Totals in 2011-12 (mm)	22.6	13.6	10.8	14.0	6.8	2.4	4.4	10.2	97.2	32.0	20.8	16.4
Historical Monthly Means for 1997-2012 (mm)	8.9	8.3	13.6	24.3	21.5	14.9	13.4	37.9	41.5	45.3	31.7	24.5

2.2 BIOGEOGRAPHY

The Interim Biogeographic Regionalisation for Australia (IBRA) classifies the Australian continent into regions (bioregions) of similar geology, landform, vegetation, fauna and climate characteristics (DSEWPaC 2010). According to IBRA (version 6.1), the Survey Area is located in the Tallering (YAL2) subregion of the larger Yalgoo (YAL) bioregion (Figure 2.2).

The Tallering subregion is dominated by the red earth to sandy-earth plains of the Western Yilgarn Craton. The predominant land use in the Yalgoo bioregion is grazing on native pastures (approximately 77%) (Payne *et al.* 1998), as it represents the westernmost section of a large area mainly used for pastoral purposes. The Yalgoo bioregion is also an interzone between the south-western bioregions and the Murchison bioregion (Desmond and Chant 2001).

The vegetation of the Yalgoo bioregion is characterised by low to open woodlands and scrubs of Mulga, *Eucalyptus*, *Acacia* and *Callitris* species (Desmond and Chant 2001). Ephemeral species are also particularly abundant in this bioregion.



IBRA Subregions of the Survey Area

Figure: 2.2
Project ID: 1483

Drawn: JFH
Date: 23/11/12

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: JFH009

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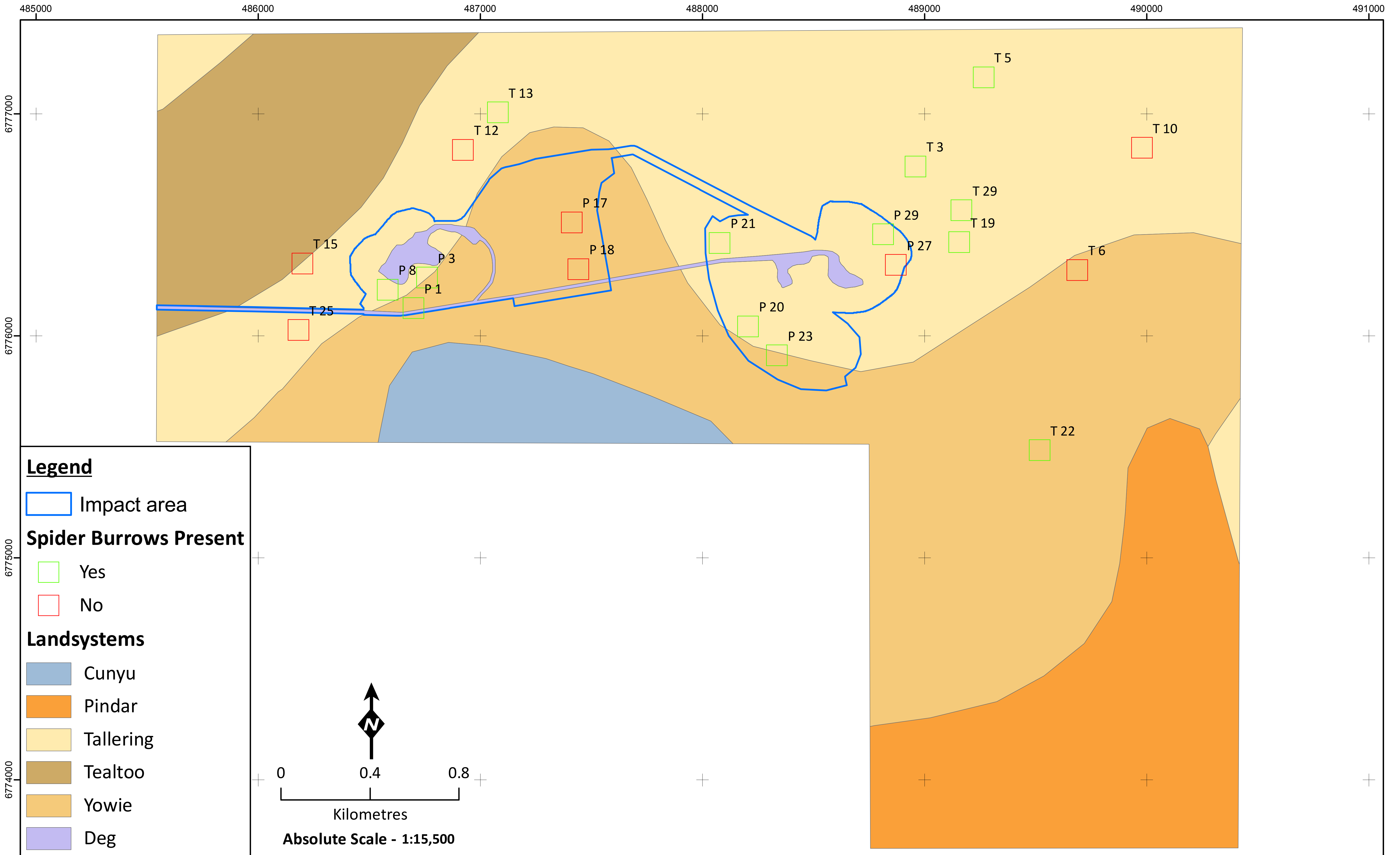
2.3 LAND SYSTEMS

Land systems are described using the biophysical characteristics of geology, landforms, vegetation and soils (Curry *et al.* 1994; Payne *et al.* 1998). The Survey Area covers five land systems; Tallering, Yowie, Tealtoo, Pindar and Cunyu – the first two of which cover most of the Survey Area. Three land systems are present within the proposed impact area; Tallering, Yowie and Tealtoo. These are described in Table 2.3, and shown in Figure 2.3 below.

Table 2.3 – Land systems of the Survey Area.

Land System	Description	Total Area in WA (km2)	Area within Project Area (ha)	Percent of Total Land System (%)	Percent of Survey Area (%)
Land type 1 – Hills and ranges with Acacia shrublands					
Tallering	Prominent ridges and hills of banded ironstone, dolerite and sedimentary rocks supporting bowgada and other *Acacia* shrublands.	32 949	456.41	1.39	37.72
Land type 29 – Sandy plains with Acacia shrublands and wanderrie grasses					
Tealtoo	Level to gently undulating loamy plains with fine ironstone lag gravel supporting dense *Acacia* shrublands.	69 343	115.14	0.17	9.52
Yowie	Sandy plains supporting shrublands of mulga and bowgada with patchy wanderrie grasses.	1 620 859	401.42	0.02	33.18
Land type 30 – Plains with eucalypt woodlands with non-halophytic undershrubs					
Pindar	Loamy plains surrounded by sandplain supporting York gum woodlands and *Acacia* shrublands.	151 876	176.30	0.12	14.57
Land type 40 – Calcrete plains with Acacia shrublands					
Cunyu	Calcrete platforms and intervening alluvial floors and minor areas of alluvial plains, including channels with *Acacia* shrublands and minor halophytic shrublands.	329 933	48.70	0.01	4.03



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Land Systems of the Survey Area

Figure: 2.3
Project ID: 1483

Drawn: JFH
Date: 24/11/12

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: JFH010

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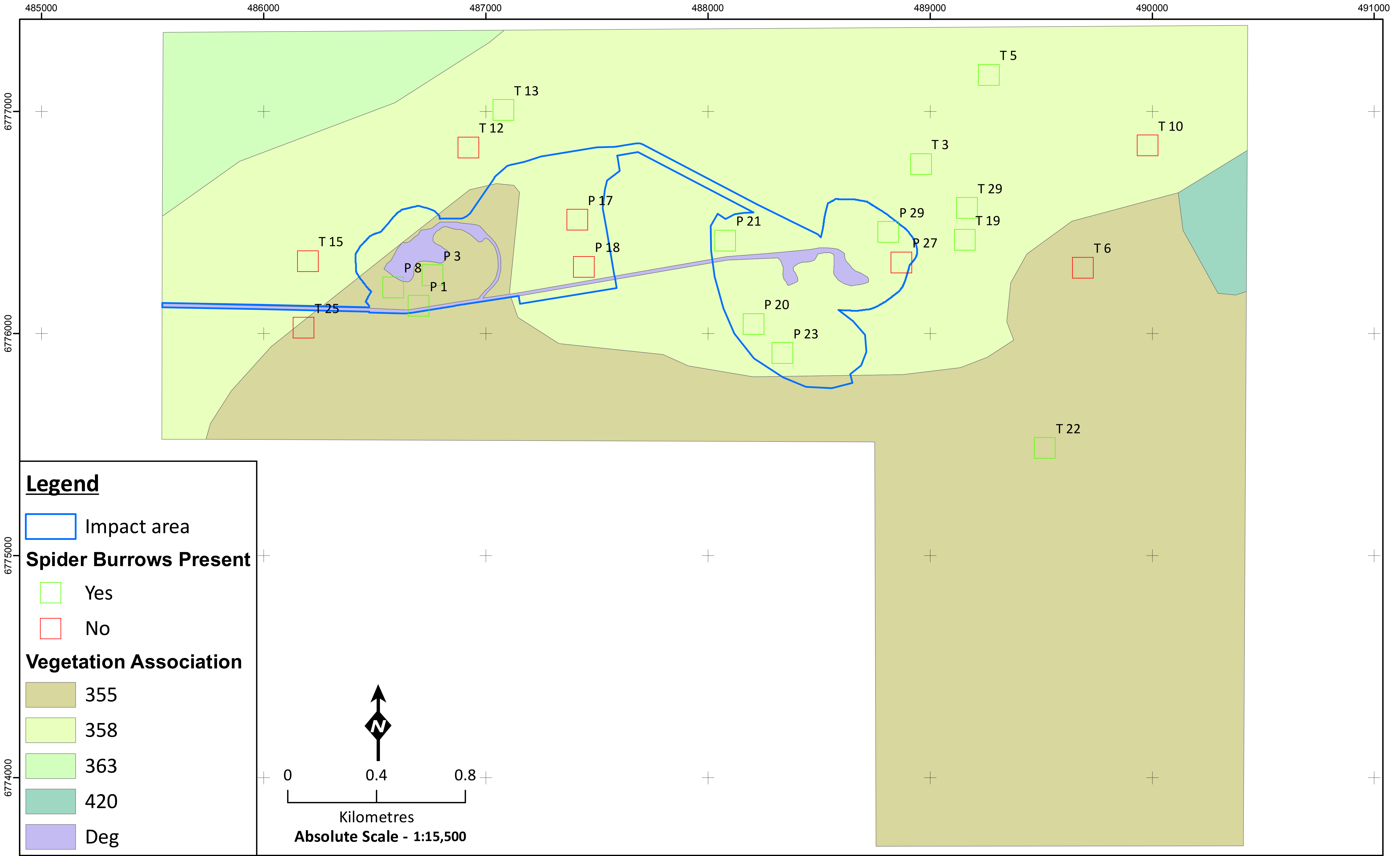
2.4 VEGETATION ASSOCIATIONS

The Survey Area lies within the Eremaean Botanical Province of Western Australia (Thackway and Cresswell 1995). Four vegetation associations mapped by Shepherd (2001) occur within the tenement (Table 2.4, Figure 2.4). The area consists entirely of *Acacia* shrublands with a variety of dominant tree species such as Eucalypt, Allocasuarina and Callitris. All four vegetation association types are reasonably widespread in WA, and no more than 1% of each is represented within the Survey Area.

Table 2.4 – Vegetation associations within the Survey Area

Vegetation Association	Shepherd Vegetation Description	Equivalent Beard Unit	Current Extent in WA (ha)	% Pre-European Extent Remaining	ha within Survey Area (% of WA extent)	% of Survey Area
355	*Acacia* shrublands; bowgada and jam scrub with scattered York gum and red mallee.	e6, 22Lr a9, 19Si	58 060	94.13	575.00 (0.97)	47.52
358	*Acacia* shrublands; bowgada and *Acacia quadrimarginea* on stony ridges.	a9, 14Si	59 645	99.88	544.58 (0.88)	45.02
363	*Acacia* shrublands; bowgada scrub with scattered cypress pine.	cLr a9Si	247 655	100	64.51 (0.03)	5.33
420	*Acacia* shrublands; bowgada and jam scrub.	a9,19Si	830 931	96.66	13.93 (0.002)	1.15



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Vegetation Associations of the Survey Area

Figure: 2.4
Project ID: 1483

Drawn: JFH
Date: 24/11/12

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: JFH011

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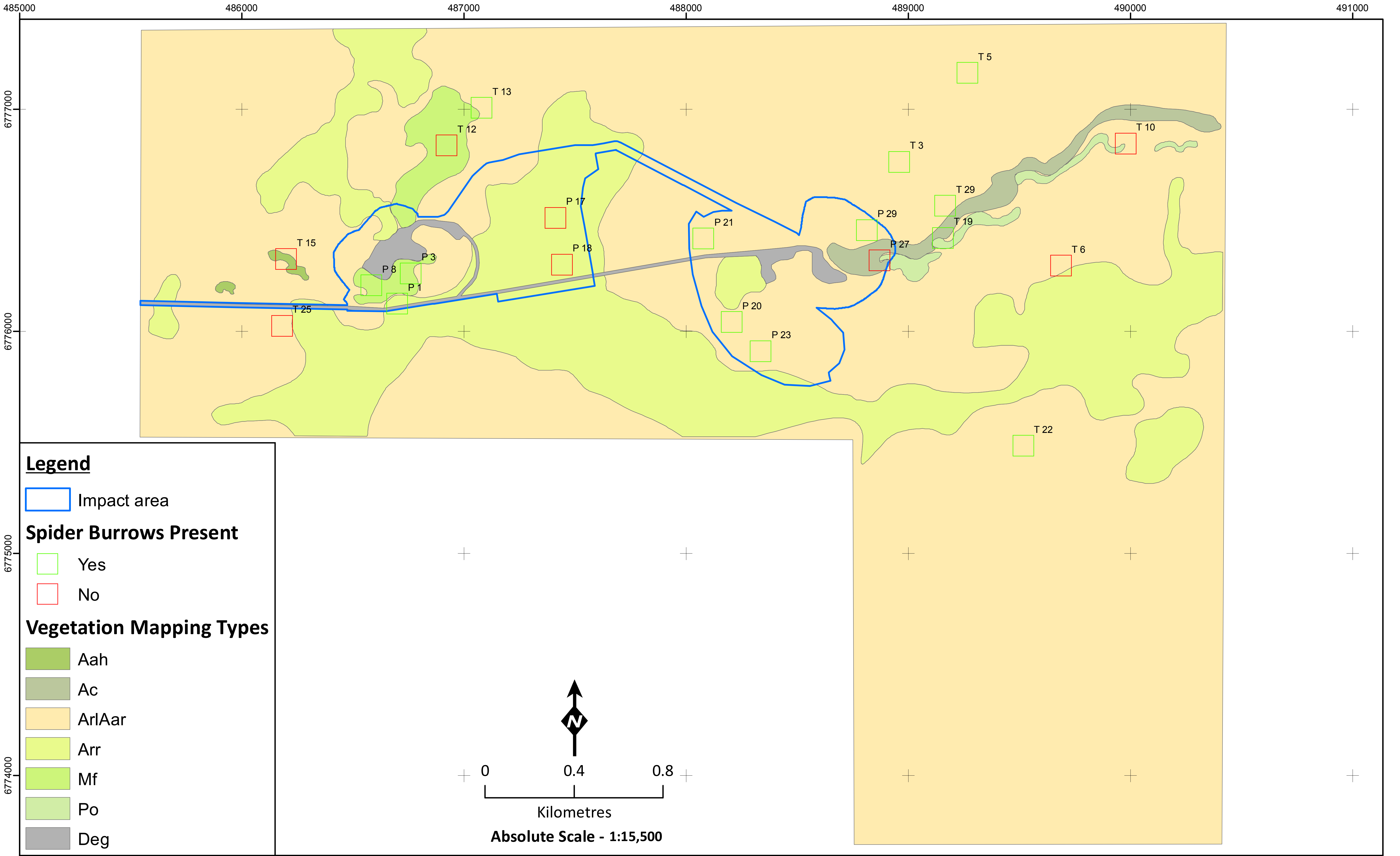
2.5 LOCAL VEGETATION

A flora and vegetation survey was initially undertaken in 2007 (*ecologia* 2008) to assess and map the vegetation within the Blue Hills Survey Area. Fourteen vegetation communities were described at the time (Appendix A), which included an analysis of grass and tree species. However, *I. nigrum* distribution is primarily dependent on the type and density of *Acacia* shrubs present, so the original mapping was adapted into broader habitat-based categories. These are shown below in Table 2.5 and Figure 2.5.

Table 2.5 – *Ecologia* vegetation communities recorded within the Survey Area

Vegetation Unit	Vegetation Description	Area Within Impact Area (ha)	Area Outside Impact Area (ha)	Total Area (ha)
ArlAar	Tall shrubland of *Acacia ramulosa* var. *ramulosa* and *Acacia ramulosa* var. *linophylla* over *Aluta aspera* subsp. *hesperia*.	61.24 (52.43%)	863.05 (78.96%)	924.31 (76.4%)
Arr	Low open woodland of *Eucalyptus loxophleba* subsp. *supralaevis* over tall shrubland of *Acacia ramulosa* var. *ramulosa*.	36.18 (30.97%)	201.12 (18.40%)	237.30 (19.61%)
Ac	Tall shrubland of *Acacia caesaneura* and *Acacia ramulosa* var. *linophylla*.	3.29 (2.81%)	10.29 (0.94%)	13.58 (1.12%)
Mf*	Tall shrubland of *Acacia assimilis* subsp. *assimilis*, *Acacia ramulosa* var. *linophylla* and *Melaleuca filifolia*.	4.73 (4.05%)	10.97 (1%)	15.70 (1.30%)
Po*	Low shrubland of *Ptilotus obovatus* and *Eremophila clarkei*.	0.15 (0.13%)	5.74 (0.53%)	5.90 (0.49%)
Aah*	Scattered *Melaleuca filifolia* and *Acacia assimilis* subsp. *assimilis* over low shrubland of *Aluta aspera* subsp. *hesperia*.	-	1.20 (0.11%)	1.20 (0.10%)
Deg*	Degraded or cleared.	11.22 (9.61%)	0.65 (0.06%)	11.85 (0.98%)
Total		**116.81 (9.66%)**	**1093.03 (90.34%)**	**1209.83**

*Unsuitable habitat for *I. nigrum*.



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SINOSTEEL SMC

Vegetation Mapping of the Survey Area

Figure: 2.5
Project ID: 1483

Drawn: JFH
Date: 24/11/12

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: JFH012

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3 METHODS

3.1 LITERATURE REVIEW AND DATABASE SEARCHES

Previous records of *I. nigrum* were collected from the WAM arachnid database and the DEC NatureMap database. *Idiosoma nigrum* has been also recorded by *ecologia* in the Mid West, and six *ecologia* and one other company's reports were referenced for the locations of *I. nigrum* near Blue Hills (Bamford 2007; *ecologia* 2007, 2009a, 2010a, c, 2011, 2012).

3.2 EXPERIMENTAL DESIGN

The survey methods and sampling design adopted by *ecologia* for this study were developed in consultation with Prof. Barbara Y. Main (University of Western Australia), who described the species and is the foremost expert. The EPA's Guidance Statements Nos. 20 and 56 (EPA 2004, 2009) and Position Statement 3 (EPA 2002) currently provide no specific instructions on the expected design of *I. nigrum* surveys.

A total of 21 sites were methodically searched during the survey; 10 within the impact areas and 11 outside (Table 3.1, Figure 4.1). These sites were randomly selected from two larger pools of 30 sites each – one pool within the impact areas and one outside. Sites chosen for each pool covered the range of previously identified vegetation communities found within the impact areas (*ecologia* 2008), in order to survey each potentially disturbed *I. nigrum* habitat. Furthermore, site selection within each vegetation community focused on areas with greater shrub densities, as *I. nigrum* burrows are almost exclusively found under *Acacia* shrubs.

At each site, a 10,000 m^2 (one hectare) quadrat was searched for *I. nigrum* burrows by a team of four, with each person performing two 100 m transects 12.5 m apart. In order to provide detailed habitat analysis, the landform and substrate type within each quadrat was recorded whilst a botanist documented the flora present. A range of information was also recorded regarding each burrow that was found, including geographic location, width of the burrow trap-door, distance to the nearest shrub, leaf litter coverage (1 m^2 around burrow) and micro-habitat type (e.g. Appendix C).

Table 3.1 – Quadrat locations (coordinates represent the top-left corner of each quadrat)

Site Name	Easting	Northing	No. Burrows Found	No. Adults
P 1	486648	6776175	1	1
P 3	486710	6776312	11	4
P 8	486532	6776258	2	-
P 17	487361	6776562	-	-
P 18	487391	6776351	-	-
P 20	488155	6776093	3	2
P 21	488028	6776469	1	-
P 23	488286	6775962	5	3
P 27	488821	6776370	-	-
P 29	488763	6776507	1	1
T 3	488909	6776814	15	11
T 5	489216	6777215	2	1
T 6	489638	6776347	-	-
T 10	489929	6776897	-	-
T 12	486872	6776888	-	-
T 13	487029	6777057	2	1
T 15	486149	6776376	-	-
T 19	489107	6776472	2	1
T 22	489468	6775535	6	3
T 25	486130	6776076	-	-
T 29	489117	6776616	2	1

Datum: WGS 84
Zone: 50 J

3.3 DATA ANALYSIS

3.3.1 Distribution and habitat preference

Differences in the numbers of spider burrows within and outside the impact areas were first tested using the Ryan-Joiner method, a correlation based test for normally distributed data. A one-way analysis of variance (one-way ANOVA) test was then performed to compare the two burrow distributions. Statistical analysis was performed using the software package Minitab 16. Micro-habitat preference was determined for each burrow, along with more general information on the vegetation and landform of each quadrat.

3.3.2 Size/ age classes

The age classes of adults, juveniles and emergents were determined from the measurements of trap doors, using a method suggested by Main (2003) (Table 1.1).

3.3.3 Total population size and effective population size

Estimates of total population size (N) were calculated using the mean number of individuals per hectare determined from the survey, and multiplied by the number of hectares in the tenement. The estimated number of adults in the population was similarly extrapolated from the number of burrow observations with regard to each age class. The effective population size (Ne) was calculated based on the number of adults, using the scenario of equal sex ratio. The calculation of Ne also accounted for the fact that only half of female Shield-back Trapdoor Spiders can breed each year, and that population estimates must include a general reduction of 6% due to stochastic events.

Population estimates for N and Ne were then also calculated for either within or outside the impact areas based on suitable habitat.

3.3.4 Vegetation mapping and habitat selection

Plant specimens were collected from each quadrat surveyed and subsequently identified to species level. This enabled the vegetation mapping from *ecologia*'s prior flora survey at Blue Hills to be modified into broader categories based on the dominant shrub and tree species (Table 2.5). It was then possible to distinguish between suitable and unsuitable *I. nigrum* habitat.

3.4 SURVEY TIMING

The survey took place during spring, from the 26th to the 30th October 2012.

3.5 TAXONOMY AND NOMENCLATURE

Taxonomic identifications were performed by Mark Castalanelli, the Short-range Endemic Curator at the WA Museum. All three spider specimens collected were confirmed to be *I. nigrum*.

3.6 SURVEY TEAM

Survey team members are listed in Table 3.2.

Table 3.2 – *ecologia* staff involved with the survey

Team Member	Qualification	Experience (years)
Magdalena Davis	PhD in Zoology	11
Lazaro Roque-Albelo	PhD in Zoology	18
Farhan Bokhari	PhD candidate in Zoology	4
Sean White	BSc	4
Jesse Forbes-Harper	BA, BSc (Hons)	3
Renee Young	PhD in Botany	6

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4 RESULTS

4.1 LITERATURE REVIEW AND DATABASE SEARCHES

Idiosoma nigrum was recorded on a previous survey at Blue Hills (*ecologia* 2010b), but was not present in the Western Australian Museum Arachnid Database within a 50 km radius of the Survey Area. Additionally, *ecologia* (2007) identified *I. nigrum* populations approximately 100 km north-east of the Survey Area at Mount Magnet, 280 km north-north-east at Weld Range (*ecologia* 2010c), 340 km north at Jack Hills (*ecologia* 2009a) and 370 km north-east at Yeelirrie (*ecologia* 2010a).

The Department of Environment and Conservation's (DEC) NatureMap database indicates records of *I. nigrum* within a 40 km radius; however, a 50 km radius search of the WA Museum's SRE database did not return a result for *I. nigrum*.

4.2 SURVEY AREA AND DISTRIBUTION

A total area of 21 hectares was surveyed for *I. nigrum*, and 53 burrows were found. *Idiosoma nigrum* was present in 13 hectares (62%) of the area surveyed (Figure 4.1). The mean number of burrows per hectare was 4.08, and the standard error of the mean (SEM) was calculated at 0.94 (Table 4.1).

Table 4.1 – Summary of survey results

Area surveyed (ha)	Number of burrows found	Mean number of burrows per quadrat	SEM
21	53	4.08	0.94

4.3 HABITAT PREFERENCE

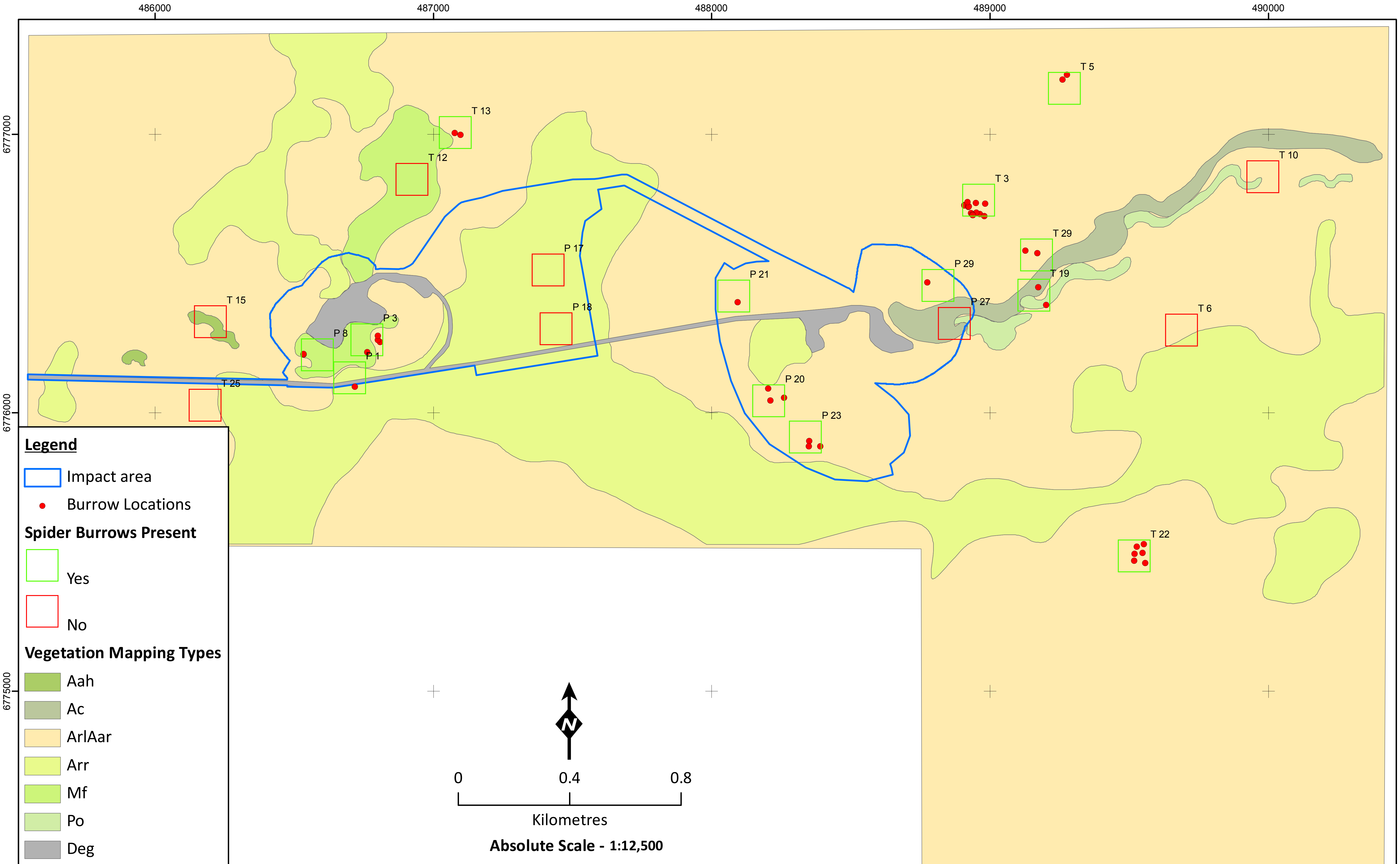
Of the 53 burrows detected, 58.5% were found on plains and 41.5% occurred on hillslopes (Table 4.2). The micro-habitat that harboured the highest number of burrows was rocky or stony substrate on hillslope; however, a greater number of burrows overall were found on plains in a variety of substrates (Appendix B). The leaf litter cover (1 m^2 around *I. nigrum* burrows) ranged from 25 – 98%, with an average of 63%.

Table 4.2 – Micro-habitat types where burrows were found

Micro-habitat Type	Number of burrows found	%
Plain: Rocks/ stones	6	11.3
Plain: Pebbles/ loam	8	15.1
Plain: Soil/ clay	17	32.1
Hillslope: Rocks/ stones	20	37.7
Hillslope: Pebbles/ sand	2	3.8

On all occasions, *I. nigrum* burrows were found underneath *Acacia* shrubs, almost exclusively either *Acacia ramulosa* var. *ramulosa* or *Acacia caesanura*. These two *Acacia* species are found primarily in three of the six vegetation types mapped; 'ArlAar', 'Arr' and 'Ac' (Table 2.5, Figure 4.1). In order to simplify the process of population extrapolation estimates, the six vegetation types were grouped by whether or not they were suitable habitat for *I. nigrum* (Figure 4.2).

The two theoretical populations within and outside the impact areas were shown to follow a normal distribution according to the Ryan-Joiner test ($p < 0.02$). A subsequent one-way ANOVA test indicated there is no significant difference between the mean number of burrows in potentially impacted areas and outside them ($p = 0.89$). This indicates that spider density is not dependent on the habitat located inside the impact areas.



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Vegetation Mapping, quadrats surveyed and burrow locations

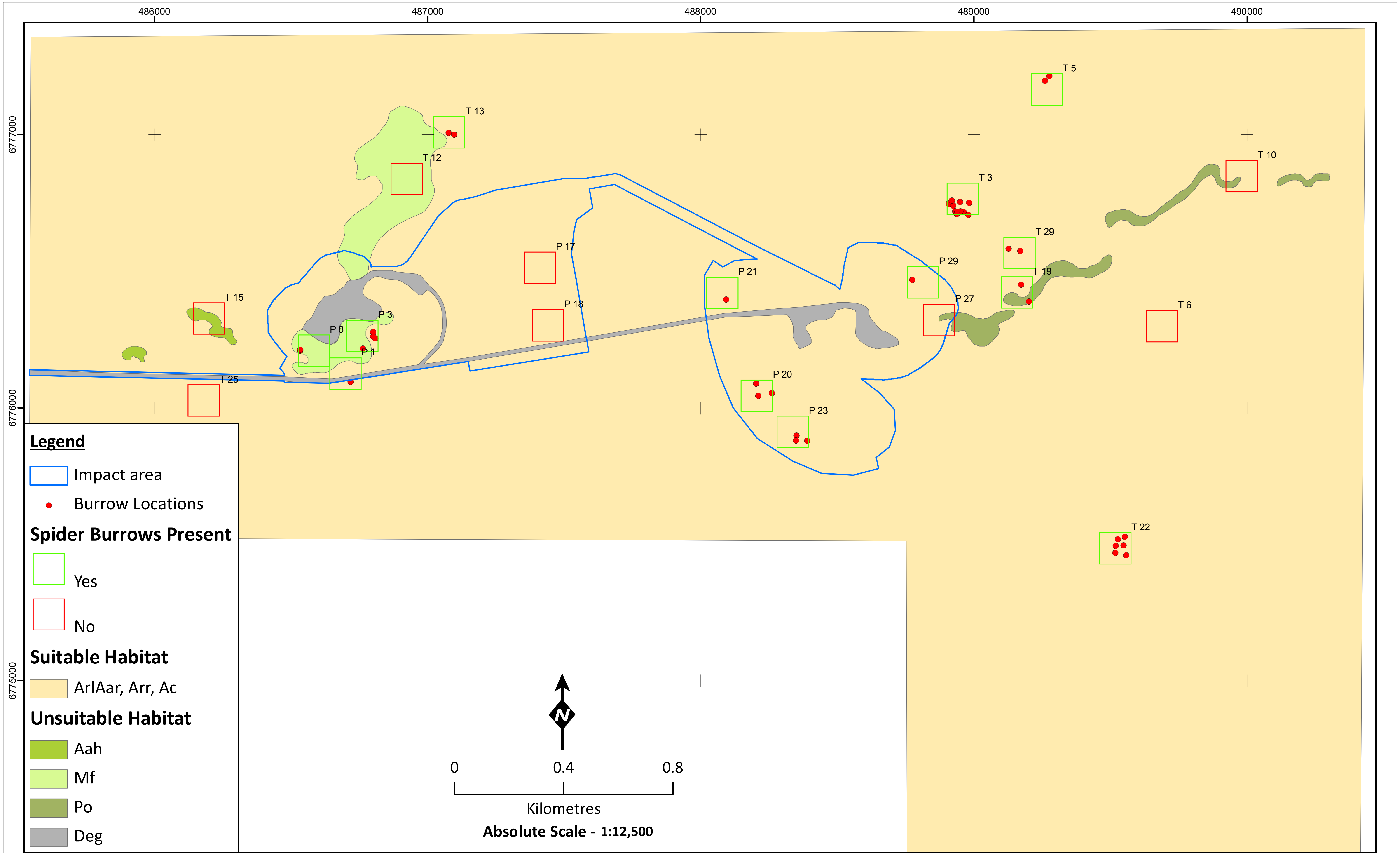
Figure: 4.1
Project ID: 1483

Drawn: JFH
Date: 24/11/12

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: JFH013

A3



Vegetation Mapping grouped by habitat suitability

Figure: 4.2
Project ID: 1483

Drawn: JFH
Date: 24/11/12

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: JFH014

A3

4.4 POPULATION STRUCTURE

The population of *I. nigrum* at Blue Hills was found to have roughly equal proportions of emergents to juveniles (1:1 ratio), and two and a half times the number of adults to juveniles (2.6:1 ratio, Table 4.3). These ratios appear insufficient to achieve the observed amount in each subsequent age class (Figure 4.3), based upon percentage survival rates between classes (Main, unpublished data, Table 1.3).

Table 4.3 - Age Classes Determined By Measurements of the Trap Doors (After Main 2003)

	Emergents	Juveniles	Adults	Total
Survey Area	13	11	29	53

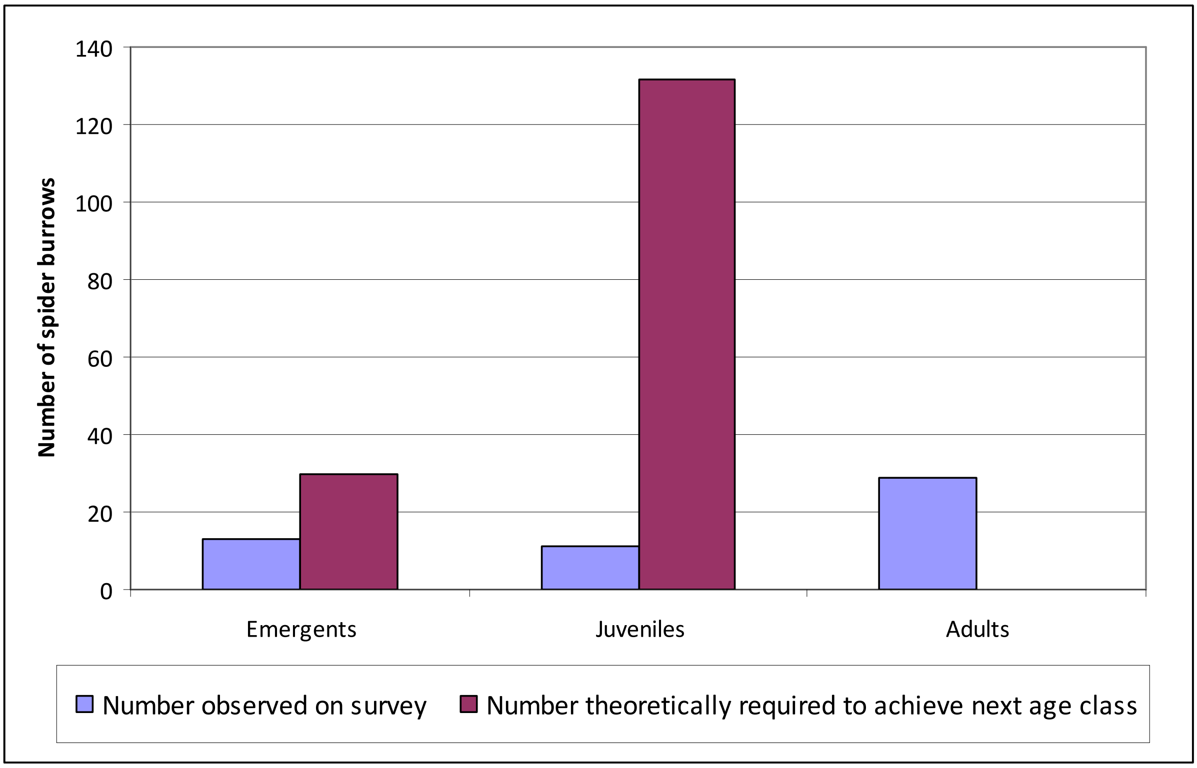


Figure 4.3 – Numbers needed to achieve size classes based on inter-class mortality (after Main, unpub. data)

4.5 AREA EXTRAPOLATION, POPULATION SIZE AND EFFECTIVE POPULATION SIZE

The mean number of burrows per hectare (4.08±0.94) was used for the extrapolation estimate of the total population size (N). The mean number of adults (2.64±0.65) was similarly used to calculate the effective population size (Ne) within the tenement, both within and outside the impact areas (Table 4.4). The effective population size in the Blue Hills tenement was calculated at 2140±0.65, with only 8.6% (183±0.65) occurring within the impact areas.

Table 4.4 – Extrapolation of population size (N) and effective population size (Ne)

Suitable Habitat	Size (ha)	N (Mean±SE)	Adults (Mean±SE)	Estimated Ne	% of total
Within impact area	100.71	411±0.94	266±0.65	183±0.65	8.55
Outside impact area	1074.46	4384±0.94	2837±0.65	1957±0.65	91.45
Total	1175.17	4795±0.94	3103±0.65	2140±0.65	

4.6 SURVEY LIMITATIONS AND CONSTRAINTS

Table 4.5 – Limitations for the *Idiosoma nigrum* survey at Blue Hills

Aspect	Limitation	Comment
Survey Adequacy	No	Given the relatively small Survey Area and the number of sites sampled, which identified the presence of *Idiosoma nigrum*, survey adequacy was not a limitation.
Method Efficiency	No	Survey methods utilised were efficient at identifying burrows of *Idiosoma nigrum*.
Seasonality	No	The survey occurred outside of the wet season as defined by the EPA Guidance Statement 20. However, the burrows were clearly discernable at the time of the survey.
Field Personnel Experience	No	All personnel had sufficient experience for their roles in the survey.
Species Identification Resolution	No	Taxonomic knowledge of *Idiosoma nigrum* is well documented, so identification of specimens and burrows was not a limitation.

5 DISCUSSION

This targeted survey of the Shield-back Trapdoor Spider (*I. nigrum*) at Blue Hills provided new data on the species. In particular, the survey determined the spider's demography, population structure and preference for habitat, and allowed for estimation of the total and effective population sizes. A total of 53 burrows were recorded, almost entirely under either *Acacia ramulosa* var. *ramulosa* or *Acacia caesanura*. The habitats from which the burrows were recorded partly matched the expected habitats based on regional records (*ecologia* 2009a, b, 2010a, 2012) of *I. nigrum* (a rocky substrate on clay or coarse sand) and partly new habitats (almost entirely rocks and stones).

5.1 VALIDATION OF SAMPLING METHOD

Measuring trap-door spider populations in nature is inherently difficult. The traditional sampling method, pitfall trapping, is at best semi-quantitative and is not a robust or reliable measure of spider abundance. Typically, only male trap-door spiders leave their burrows in search of females to mate, usually after specific weather conditions such as humid or wet nights. Pitfall trapping is therefore unlikely to provide sufficient or useful data on *I. nigrum* density, because of the unpredictability of weather conditions.

The sampling design used in this study was based on a random selection of quadrat plots from a wider pool. This pool targeted the potentially impacted vegetation types mapped on a previous survey (*ecologia* 2008)(Appendix A), and allowed for roughly equal survey effort both within and outside the impact areas. The randomised sampling also removed potential bias towards micro-habitats (e.g. denser vegetation), making the collected data more robust in that it accounts for variation in vegetation density across the tenement. This proved to be an effective method for extrapolating the population size of *I. nigrum* at Blue Hills. Similar sampling design has been applied to spider populations in other parts of the world (Carrel 2003), demonstrating this to be an efficient method for monitoring spider populations in large areas.

Although based on a relatively small amount of data, a one-way ANOVA comparing the spider populations within and outside the impact areas indicated that there is no difference in their distribution. This suggests that areas of suitable habitat either within or outside the impact areas are equally capable of supporting *I. nigrum*, lending credibility to comparisons of population extrapolations between the two areas.

One of the critical points when censuring animal populations in nature is the ability to differentiate morphologically similar species via other characteristics such as burrow shape, size and ornamentation. Fortunately, much is known about the ecology of *I. nigrum* through the extensive demographic studies conducted by Prof. Barbara Y. Main (Main 2003), complemented by background studies performed by *ecologia* in other areas of the Mid West. *Idiosoma nigrum* construct burrows with camouflaged trap-doors, making their detection difficult. Results from these various studies demonstrated that a well-trained team systematically searching for burrows is an effective method for detecting, and subsequently estimating, population densities of *I. nigrum*. However, special care is recommended in areas where other trapdoor spiders such as *Anidiops* and *Aganippe* are sympatric to the species. The survey team was informed of the potential presence of the Tree-stem Trapdoor Spider (*Aganippe castellum*) at Blue Hills, although no potential burrows were found.

5.2 DISTRIBUTION AND HABITAT PREFERENCES

One of the main purposes of this survey was to determine the distribution and habitat preferences of *I. nigrum* at Blue Hills. The spider occurs widely within the tenement area, and its distribution does not appear to be heavily dependent on any one micro-habitat or vegetation type. The two most dissimilar micro-habitat types are the two that were most utilised – clay plains, and rocky slopes. The leaf litter coverage surrounding each burrow also varied by 73%. Previous studies confirm this habitat flexibility, with some populations preferring rocky slopes and foothills (*ecologia* 2009a, b), and others favouring sandy plains (*ecologia* 2012).

Although vegetation density varied between vegetation types of suitable habitat, it did not necessarily correlate with *Acacia* shrub density. This is why the north-east region of the tenement was classified as the same vegetation type (ArlAar) as most of the rest of the Survey Area despite the generally higher vegetation density, because both the dominant *Acacia* species and their distribution were similar. The density of the two most favoured *Acacia* species did have an impact on burrow density, as indicated by the two quadrats where the highest numbers of burrows were found (T 3 and T 22, Figure 4.2, Appendix B). Alternatively, even though the vegetation type 'Arr' is suitable habitat for *I. nigrum*, only one burrow was found within it, likely due to its typically lower shrub density. Denser areas of *Acacia* provide more shade and increase potential for the harvesting of moisture. The preference of *I. nigrum* for this microhabitat type may be an expression of a behavioural adaptation to arid environments (Main 2003).

5.3 POPULATION SIZE AND STRUCTURE

Overall analysis of the *I. nigrum* burrows at Blue Hills indicates that a viable population exists there, with regions of abundance across different vegetation types and micro-habitats. The total effective population size (Ne) is estimated to be 2140±0.65. According to the 50/500 rule (Allendorf and Luikart 2007), the population is currently not prone to genetic inbreeding in the short- or long–term, since the Ne is well above 500 individuals even after proposed impacts are accounted for (1957±0.65 individuals). These estimates are realistic, given the large extent of the vegetation association types present in the Survey Area (Table 2.4), which provide continuous habitat for *I. nigrum* beyond the boundary of the tenement.

However, analysis of the apparent population structure is more problematic. The proportions of each age class relative to the subsequent one are much lower than expected. Taking into account high mortality rates between classes (Table 1.3), this suggests that the *I. nigrum* population at Blue Hills is in decline, with insufficient spiderlings being produced to maintain the population size (Figure 4.3). Without long-term monitoring, it is not possible to determine whether this is caused by a recent change in environmental conditions, or a general, long-term decline in the local population. Since rainfall in the region has been favourable over the past five years (Table 2.1), the cause cannot be explained by unfavourable climatic conditions. However, it is also possible that the data recorded provides a poor representation of the *I. nigrum* population structure at Blue Hills, or that the spiders in the area exhibit atypical dispersal behaviour by clustering in family groups less often.

5.4 IMPACT

Mining activities at Blue Hills have the potential to impact 183±0.65 individuals, which make up 8.6% of the projected population within the tenement. This estimation takes into account the fact that 13.8% of the impact area is already unsuitable habitat for *I. nigrum*, whilst only 1.7% of the outside region is unsuitable. Although vegetation mapping cannot exactly determine where *I. nigrum* may or may not inhabit, it still provides a reliable estimation.

If the planned impact areas are modified at a later date, the current data can be utilised to extrapolate a new projection of potential impact on *I. nigrum* in the tenement.

Indirect future impacts on the *I. nigrum* population will likely include an increased risk of the fire damage, dust-pollution and surface water run-off encountered in proximity to an operating mine. Another threatening process is the grazing and trampling damage caused by introduced species, such as rabbits, goats and cows. Management strategies should be put in place to minimise these risks.

6 CONCLUSIONS

The main conclusions of the survey were:

- Specimens from this survey provided new distribution data within the current geographical boundaries of the species;
- The quadrats surveyed covered a variety of vegetation types and landforms, and *I. nigrum* was present at 62% of these;
- Virtually all 53 burrows recorded were identified under either *Acacia ramulosa* var. *ramulosa* or *Acacia caesanura*, in micro-habitats ranging from loamy plains to rocky hillslopes;
- The observed population consisted of two and a half times as many adults to juveniles or emergents – the local population is either in decline, the data collected is skewed, or the dispersal behaviour of *I. nigrum* in the area is atypical;
- Based on the population extrapolation, the Blue Hills tenement contains approximately 2140±0.65 Shield-back Trapdoor Spiders. Approximately 183±0.65 individuals are potentially at risk of impact from the Project, which represents 8.6% of this population; and,
- Indirect impacts on the *I. nigrum* population will likely include an increased risk of the fire damage, dust-pollution and surface water run-off encountered in proximity to an operating mine, as well as grazing and trampling damage caused by introduced species such as rabbits, goats and cows. Management strategies should be put in place to minimise these risks.

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7 REFERENCES

Allendorf, F. W. and Luikart, G. 2007. Conservation and the Genetics of Populations. Blackwell Publishing.

Bamford Consulting Ecologists. 2007. Investigations into the distribution of the Shield-backed Trapdoor Spider (*Idiosoma nigrum*) and Woolley's Pseudantechinus (*Pseudantechinus woolleyae*) in the Karara/Mungada area, July 2007. Report Prepared for Gindalbie Metals. Kingsley, W.A.

BoM. 2012. Climate Data Online. Accessed http://www.bom.gov.au/climate/data/.

Carrel, J. E. 2003. Ecology of two burrowing wolf spiders (Araneae: Lycosidae) syntopic in Florida scrub: burrow/body size relationships and habitat preference. Journal of the Kansas Entomological Society 76(1): 16-30.

Curry, P. J., Payne, A. L., Leighton, K. A., Hennig, P., and Blood, D. A. 1994. An inventory and condition survey of the Murchison River Catchment, Western Australia. Technical Bulletin No. 84. Department of Agriculture, Western Australia.

Desmond, A. J. and Chant, A. 2001. Yalgoo. A Biodiversity Audit of Western Australia's 53 Biogeographic Subregions 2002. CALM, Perth, WA.

Department of Sustainability, Environment, Water, Population and Communities. 2010. Maps: Australia's bioregions (IBRA).

ecologia Environment. 2007. Koolanooka/ Blue Hills DSO Mining Project Short-Range Endemic Biological Assessment. Report Prepared for Sinosteel Midwest Corporation.

ecologia Environment. 2008. Koolanooka Hills/ Blue Hills Flora and Vegetation Survey. Report Prepared for Sinosteel Midwest Corporation.

ecologia Environment. 2009a. Jack Hills Project. Shield-back Spider *Idiosoma nigrum* Survey. Report Prepared for Sinosteel Midwest Corporation.

ecologia Environment. 2009b. Weld Range Iron Ore Project. Shield-back spider *Idiosoma nigrum* Survey. Report Prepared for Sinosteel Midwest Corporation.

ecologia Environment. 2010a. BHPB Uranium Yeelirrie Project – Yeelirrie Playa Short-Range Endemic Invertebrate Survey. Report Prepared for URS Corporation.

ecologia Environment. 2010b. Blue Hills Short-Range Endemic Invertebrate Survey. Unpublished report for Sinosteel Midwest Corporation.

ecologia Environment. 2010c. Weld Range Project. The Shield-back Spider *Idiosoma nigrum* Clearance Survey.

ecologia. 2011. Mount Magnet South Kirkalocka Gold Mine Project Short Range Endemic Baseline Study.

ecologia Environment. 2012. Kirkalocka Gold Mine Project *Idiosoma nigrum* Targeted Survey. Unpublished report for Mount Magnet South.

Environmental Protection Authority. 2002. Position Statement No. 3 Terrestrial Biological Surveys as an element of Biodiversity Protection. Perth.

Environmental Protection Authority. 2004. Guidance for the Assessment of Environmental Factors No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia. Perth.

Environmental Protection Authority. 2009. Guidance for the Assessment of Environmental Factors, Statement No. 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia.

Franklin, I. R. 1980. Evolutionary changes in small populations *in* Soule, M., and Franklin, I. R., eds. Conservation Biology: an Evolutionary-Ecological Perspective. Sinauer, Sunderland, MA.

Harvey, M. S. 2002. Short-range endemism among the Australian fauna: some examples from non-marine environments. Invertebrate Systematics 16: 555 - 570.

Main, B. Y. 1952. Notes of the genus *Idiosoma*, a supposedly rare Western Australian trap-door spider. The Western Australian Naturalist 3(6): 130-137.

Main, B. Y. 1968. Distribution and adaptive diversity of trapdoor spider. Australian Natural History 16(2): 49-53.

Main, B. Y. 1982. Adaptations to arid habitats by mygalomorph spiders *in* Barker, W. R., and Greenslade, P. J. M., eds. Evolution of the Flora and Fauna of Arid Australia. Peacock Publications.

Main, B. Y. 1996. Microcosmic biogeography: trapdoor spiders in a time warp at Durokoppin. pp. 163-171 *in* Hopper, S. D., ed. Gondwanan Heritage: Past, Present and Future of the Western Australian Biota. Surrey Beatty & Sons, Chipping Norton.

Main, B. Y. 2003. Demography of the Shield-Back Trapdoor Spider *Idiosoma nigrum* Main in Remnant Vegetation of the Western Australian Wheatbelt. Records of the South Australian Museum Monograph Series 7: 179 - 185.

Payne, A. L., Van Vreeswyk, A. M. E., Pringle, H. J. R., Leighton, K. A., and Hennig, P. 1998. An inventory and condition survey of the Sandstone-Yalgoo-Paynes Find area, Western Australia. Technical Bulletin No. 90. Agriculture Western Australia, Perth.

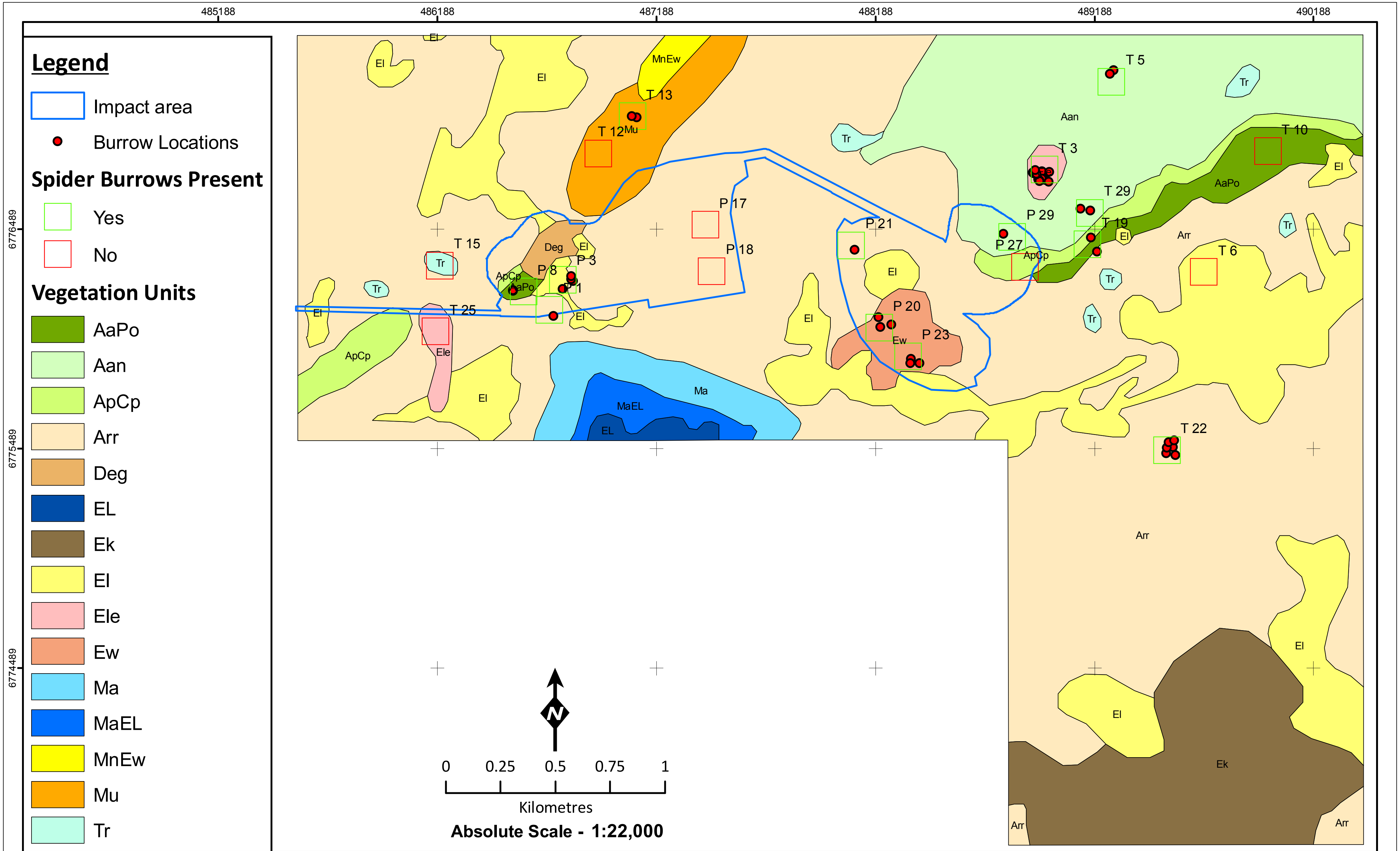
Shepherd, D. P., Beeston, G. R., and Hopkins, A. J. M. 2001. Native vegetation in Western Australia: Extent, type and status. Technical Report 249. Department of Agriculture, South Perth.

Thackway, R. and Cresswell, I. D. 1995. An Interim Biogeographic Regionalisation for Australia. Australian Nature Conservation Agency, Canberra.

APPENDIX A VEGETATION TYPES MAPPED ON PRIOR FLORA SURVEY

Appendix A1 – Descriptions of vegetation types mapped on prior flora survey (*ecologia* 2008).

Vegetation Type	Description
AaPo	Tall open scrub of mixed species, typically *Acacia assimilis* var. *assimilis* and *Melaleuca nematophylla* over a low open shrubland to open low heath of *Ptilotus obovatus* var. *obovatus* over a herbland of annual daisies.
Aan	Tall open scrub of mixed *Acacia* species, including *Acacia aneura* over a low open shrubland dominated by *Philotheca sericea* and a herbland with large areas of bare ground.
ApCp	Tall open scrub of mixed species typically *Allocasuarina acutivalvis* subsp. *prinsepiana*, *Calycopepus pauciflorus*, *Melaleuca nematophylla* and *Acacia* species over a very open herbland/ grassland or BIF rocks.
Arr	Tall shrubland of *Acacia* species typically dominated by *Acacia ramulosa* subsp. *ramulosa* over a low open shrubland dominated by *Philotheca sericea* over an open herbland of annual daisies and/ or bare ground.
Deg	Degraded areas, mined previously.
EL	Low open woodland to woodland of *Eucalyptus loxophleba* subsp. *loxophleba* over a closed low heath of *Logania* sp. and bare ground.
Ek	Tree Mallee of *Eucalyptus kochii* subsp. *plenissima* and shrub mallee of *Eucalyptus ewartiana* over a tall shrubland dominated by *Acacia ramulosa* subsp. *ramulosa* over very open herbland or annual daisies and bare ground.
El	Low woodland to low open forest of *Eucalyptus loxophleba* subsp. *loxophleba* over a low shrubland often dominated by *Chenopodiaceae* over a very open herbland and bare ground.
Ele	Open shrub mallee of *Eucalyptus leptopoda* over a tall open scrub of *Acacia ramulosa* subsp. *ramulosa* or *Acacia aneura* over an open herbland or bare ground.
Ew	Open shrub mallee of *Eucalyptus ewartiana* over a tall open scrub of *Acacia ramulosa* subsp. *ramulosa* over an open herbland of annual daisies and/ or bare ground.
Ma	Tall open shrubland to closed tall scrub of *Melaleuca* affin. *Acuminata* subsp. *websteri* over a herbland of mixed species and/ or bare ground.
MaEL	Tall shrubland of *Melaleuca* affin. *Acuminata* subsp. *websteri* with emergent *Eucalyptus loxophleba* subsp. *loxophleba* over an open gralland/ herbland and bare ground.
MnEw	Tall shrubland of mixed species dominated by *Melaleuca nematophylla* and *Acacia ramulosa* subsp. *ramulosa* with emergent *Eucalyptus ewartiana* over a low shrubland dominated by *Philotheca sericea* over a herbland of annual daisies and/ or bare ground.
Mu	Tall shrubland of *Acacia ramulosa*, *Acacia burkittii*, *Melaleuca leiocarpa* and *Melaleuca uncinata* over an open herbland of annual daisies, leaf litter and bare rocks.
Tr	Closed low heath of *Thryptomene ramulosa* with emergent *Acacia* species over annual species or bare ground on the lower slopes.



Vegetation Mapping from prior flora survey

Appendix A2
Project ID: 1483

Drawn: JFH
Date: 24/11/12

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: JFH015

A4

APPENDIX B QUADRAT INFORMATION

Appendix B1 – Quadrat information

Quadrat Information	Photo
P 1 Dominant vegetation type: ArlAar Dominant micro-habitat: Soil or clay plain Burrows found: 1	
P 3 Dominant vegetation type: Mf Dominant micro-habitat: Soil or clay plain Burrows found: 11	

P 8 Dominant vegetation type: Mf Dominant micro-habitat: Rocky/ stony slope Burrows found: 2	
P 17 Dominant vegetation type: Arr Dominant micro-habitat: Soil or clay plain Burrows found: None.	
P 18 Dominant vegetation type: Arr Dominant micro-habitat: Soil or clay plain Burrows found: None	

P 20 Dominant vegetation type: ArlAar Dominant micro-habitat: Pebbly loam plain Burrows found: 3	
P 21 Dominant vegetation type: ArlAar Dominant micro-habitat: Rocky or stony plain Burrows found: 1	
P 23 Dominant vegetation type: ArlAar Dominant micro-habitat: Pebbly loam plain Burrows found: 5	

P 27 Dominant vegetation type: Ac Dominant micro-habitat: Rocky or stony slope Burrows found: None	
P 29 Dominant vegetation type: ArlAar Dominant micro-habitat: Rocky or stony slope Burrows found: 1	

T 3 Dominant vegetation type: ArlAar Dominant micro-habitat: Pebbly loam slope Burrows found: 15	
T 5 Dominant vegetation type: ArlAar Dominant micro-habitat: Pebbly loam plain Burrows found: 2	
T 6 Dominant vegetation type: ArlAar Dominant micro-habitat: Pebbly loam plain Burrows found: None	

T 10 Dominant vegetation type: ArlAar Dominant micro-habitat: Rocky or stony slope Burrows found: None	
T 12 Dominant vegetation type: Mf Dominant micro-habitat: Rocky or stony hilltop Burrows found: None	
T 13 Dominant vegetation type: ArlAar Dominant micro-habitat: Rocky or stony plain Burrows found: 2	

T 15 Dominant vegetation type: Aah Dominant micro-habitat: Pebbly loam plain Burrows found: None	
T 19 Dominant vegetation type: Ac Dominant micro-habitat: Rocky or stony slope Burrows found: 2	
T 22 Dominant vegetation type: ArlAar Dominant micro-habitat: Soil or clay plain Burrows found: 6	

T 25 Dominant vegetation type: ArlAar Dominant micro-habitat: Pebbly or sandy slope Burrows found: None	
T 29 Dominant vegetation type: ArlAar Dominant micro-habitat: Rocky or stony slope Burrows found: 2	

APPENDIX C EXAMPLE OF FIELD SURVEY DATA COLLECTION SHEET

Appendix C1 – Example of field survey data collection sheet

Site:			Initials:								
Code	GPS		Burrow characteristics			Micro-habitat type	Litter Cover (%)	Pictures #		Comments
	E	N	No.	Lid diam. (mm)	Distance to nearest shrub			Macro	Landscape	

1: Plain - rocks/stones	**5: Slope - pebbles/sand**	**9: Hilltop - soil/clay**
2: Plain - pebbles/sand	**6: Slope - soil/clay**	**10: Drainage line - rocks/stones**
3: Plain - soil/clay	**7: Hilltop - rocks/stones**	**11: Drainage line - pebbles/sand**
4: Slope - rocks/stones	**8: Hilltop - pebbles/sand**	**12: Drainage line - soil/clay**