ATLAS PROJECT

REGIONAL SRE SURVEY

PREPARED FOR: PRESTON CONSULTING | IMAGE RESOURCES

Spectrum
ECOLOGY & SPATIAL

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EXECUTIVE SUMMARY

Image Resources are planning for the potential development of the Atlas Project, a mineral sands mine located approximately 18 km east of Cervantes in Western Australia (WA). Spectrum Ecology have previously completed basic and detailed terrestrial fauna assessments including short range endemic invertebrate fauna at the Atlas Project. Following the completion of these surveys, fourteen potential SRE invertebrates were recorded from only within the Survey Area. A regional SRE survey was undertaken to provide information on the distribution of potential SRE taxa only recorded from within the Atlas Survey Area.

The regional SRE survey was conducted from September to November 2021. Wet pitfall traps were installed at 16 sites (four traps per site, 2648 trap nights), leaf litter samples were collected from eight sites and foraging was conducted at all sites using sifting trays where appropriate.

Twenty potential SREs were collected during the regional SRE survey: three pseudoscorpions, one snail, nine isopods, four centipedes, one millipede, one flatworm. and one ostracod. A further six taxa were collected that were determined to be widespread or unlikely to be SRE.

Four of the fourteen target potential SREs that were only known from the Survey Area were subsequently recorded in the regional SRE survey – Atemnidae sp., *Austrochthonius* sp., *Buddelundia* '7', and *Laevophiloscia* sp. 24 providing confirmation of their presence beyond the Survey Area.

1. INTRODUCTION

1.1. Project Background

Image Resources (Image) are planning for the potential development of the Atlas Project, a mineral sands mine located approximately 18 km east of Cervantes in Western Australia (Map 1.1). Current project information is as follows:

- One of two mining methods (Dry open pit or dredge) are proposed;
- Mining will progress in stages followed by progressive backfilling and rehabilitation;
- The ore body is 1.4 km to the east of Nambung National Park;
- The northern quarter of the ore body is located on freehold land currently used for stock grazing. The rest of the ore body is located on land predominately covered with native vegetation;
- Clearing of native vegetation will be required for construction of the Project;
- There is a high water table in the vicinity of the ore body (approximately 2 – 5 m depth).

Basic and detailed surveys of the Atlas Project completed by Spectrum Ecology (Spectrum) included SRE invertebrate fauna surveys. Several taxa collected during these surveys were only recorded inside the Survey Area and had not previously been recorded (Table 1.1). These taxa comprise the target potential SREs. Additional information is required to determine their current distribution.

Table 1.1: Potential SREs Only Recorded Inside the Survey Area (Spectrum 2021)

Class/ Order & Family	Bennelongia ID	Alacran ID	Abundance	Site	Survey		SRE Status
					Basic	Detailed	
ARACHNIDA							
Araneae							
Salticidae	*Maratus* `BAR130`	-	1	APSRE5		X	Potential SRE
Pseudoscorpiones							
Atemnidae	Atemnidae sp. 712345*	Atemnidae sp.	1	APSRE7		X	Potential SRE: DDT
Atemnidae	*Oratemnus* `BPS326`	*Oratemnus* sp. 'Nao1'	3	APSRE7		X	Potential SRE: DDT
Chthoniidae	*Austrochthonius* sp. 712610*	*Austrochthonius* sp.	1	APLL8		X	Potential SRE: DDT
Olpiidae	*Beierolpium 8/4 `BPS253`*	-	1	APS17	X		Potential SRE
Olpiidae	*Beierolpium* 8/4 `BPS322`	*Beierolpium* '8/4-NA02'	1	APLL8		X	Potential SRE: DDT
Olpiidae	*Beierolpium* 8/4 `BPS323`	*Beierolpium* '8/4-NA03'	1	APSRE4		X	Potential SRE: DDT
Olpiidae	*Beierolpium* 8/4 `BPS324`	*Beierolpium* '8/4-NA01'	1	APLL8		X	Potential SRE: DDT
Olpiidae	*Beierolpium* 8/2 `BPS325`	*Beierolpium* '8/2-NA04'	1	APLL2		X	Potential SRE: DDT

Class/ Order & Family	Bennelongia ID	Alacran ID	Abundance	Site	Survey		SRE Status
					Basic	Detailed	
Olpiidae	*Beierolpium* sp.	-	1	APS02	X		Potential SRE
Olpiidae	*Euryolpium* `BPS251`	-	1	APS04	X		Potential SRE
Olpiidae	*Olpiidae* sp.	-	1	APS02	X		Potential SRE
ISOPODA							
Armadillidae	*Buddelundia* sp. B38	*Buddelundia* '7'	4	APSRE4, APSRE7, APSRE8		X	Potential SRE: DDG
Philosciidae	*Laevophiloscia* sp. B24	Philosciidae sp. 1	4	APSRE3		X	Potential SRE: DDT

1.2. Scope of Work

Image commissioned Spectrum Ecology to undertake additional regional SRE surveys to provide information on the distribution of potential SRE taxa recorded from the Atlas Survey Area, with particular focus on taxa that have not been recorded outside the Survey Area.

The regional survey was to target taxa from three main groups; Pseudoscorpions, Isopods and Snails with proposed techniques also targeting the jumping spider *Maratus* `BAR130`.

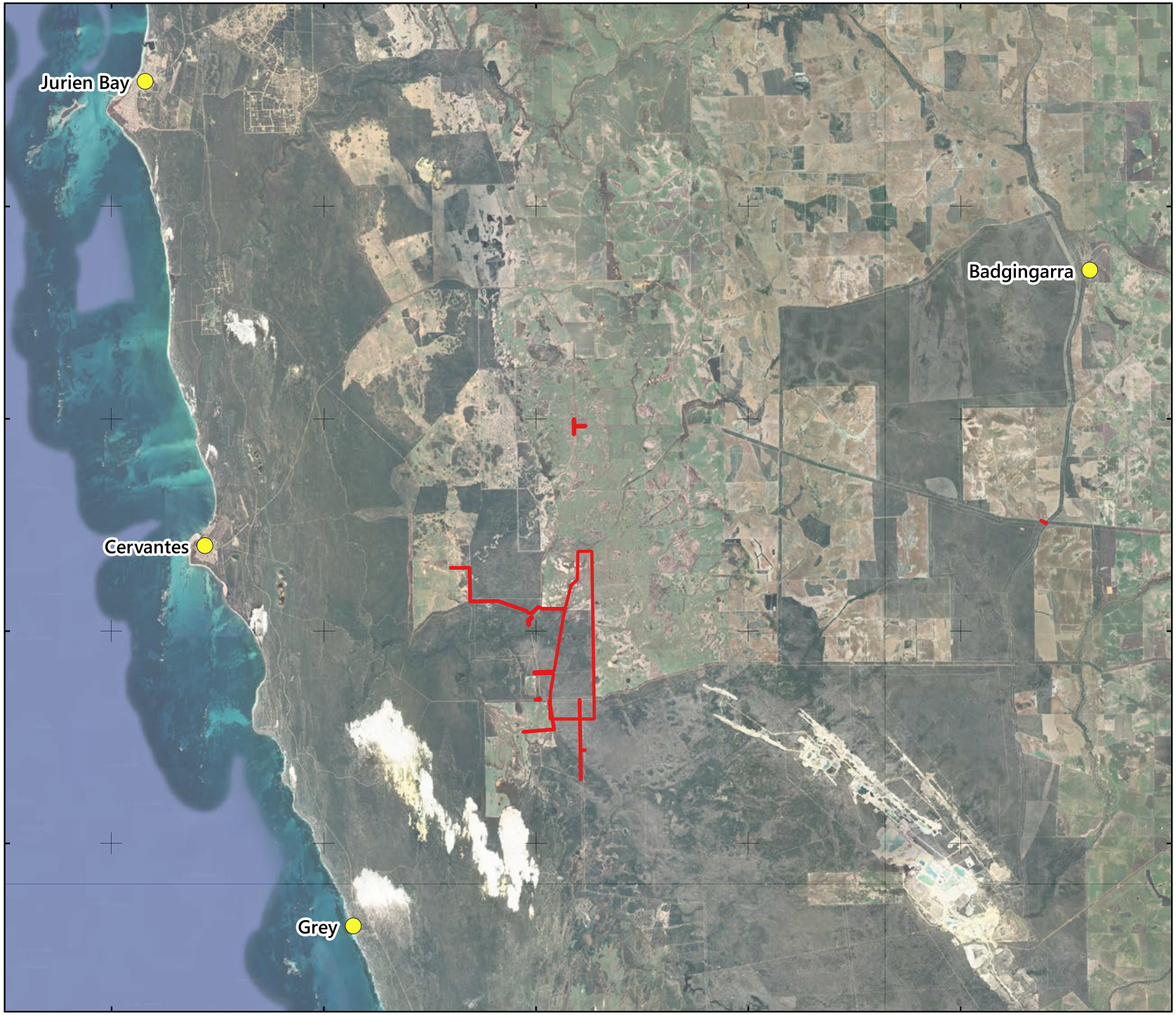
1.3. Legislation & Guidelines

Nationally threatened species (flora and fauna) and ecological communities are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Western Australian *Biodiversity Conservation Act 2016* (BC Act) provides for the conservation, protection and ecologically sustainable use of biodiversity and biodiversity components in Western Australia. Where populations are geographically restricted or threatened by local processes, or where there is insufficient information to formally assign them to threatened fauna categories, conservation significant species are listed by the Department of Biodiversity, Conservation and Attractions (DBCA) as Priority species.

1.3.1. Assessment Guidance

The SRE fauna assessment was conducted in accordance with the following Commonwealth and State legislation, as well as Environmental Protection Authority (EPA) requirements for environmental surveys as outlined below.

- *Biodiversity and Conservation Act 2016 (*BC Act*);*
- *Environmental Protection Act 1986 (*EP Act*);*
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act); and
- Technical Guidance: Sampling of Short Range Endemic Invertebrates (EPA 2016).



Legend

Atlas Project

N

0 3 6 9 km

Scale 1:250,000 @ A4

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

Spectrum ECOLOGY & SPATIAL

Author: NP

Date: 15-02-2022

Location of the Survey Area

Atlas Project

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MAP 1.1

1.4. Short Range Endemic Target Groups

Short range endemic invertebrate species are defined as species with naturally small distributions (<10,000 km^2) that possess ecological, morphological and life history characteristics that limit their range (Harvey, 2002). Poor powers of dispersal, confinement to discontinuous habitats, slow growth rates and low levels of fecundity often result in fragmented or severely restricted distributions. Many species appear to be Gondwanan relicts now isolated in pockets of mesic habitat that was once more widespread and contiguous prior to the aridification of the Australian landscape (Harvey, 2002). A low level of taxonomic resolution, lack of detailed ecological information and difficulties identifying many taxa via morphological means further complicates the assessment of potential SRE species (Harvey *et al.*, 2011). In many taxa, such as *Antichiropus* sp. millipedes, male only characters (e.g. gonopod morphology) are the primary diagnostic features used when identifying species (Wojcieszek, Harvey and Rix, 2010). If female or juvenile specimens are collected, identification to species level or alignment with known undescribed morphospecies using morphological characters is not possible. The use of DNA barcoding is gradually addressing this issue though the database of known sequences is still limited for many taxa (Western Australian Museum, 2014).

The combination of these factors make SRE species particularly vulnerable to threatening processes such as habitat loss, degradation and climate change (Harvey *et al.*, 2011). The taxa detailed in Table 1.2 have been identified as displaying one or more of the characteristics known to cause short range endemism (Harvey, 2002) and as such are targeted during field assessments.

Table 1.2: SRE Target Groups

Phylum or Subphylum	Class	Order	Details
Annelida	Oligochaeta	Haplotaxida	Earthworms.
Chelicerata	Arachnida	Araneae	Spiders, particularly those belonging to the infraorder Mygalomorphae (trapdoor spider).
		Opiliones	Harvestmen.
		Pseudoscorpiones	False scorpion or book scorpion.
		Schizomida	Micro whip scorpions, mostly known from troglobitic species.
		Scorpiones	Scorpions.
Crustacea	Malacostraca	Isopoda	Terrestrial Isopods, also known as slaters or woodlice.
Mollusca	Gastropoda	Stylommatophora	Land snails.
Myriapoda	Chilopoda	Geophilomorpha	Elongate soil centipedes.
		Scolopendromorpha	Centipedes from the family Cryptopidae.
	Diplopoda	Not specified	Millipedes
Onychophora	Udeonychophora	Euonychophora	Velvet worms, family Peripatopsidae.

1.4.1. SRE Habitat

Sheltered, isolated, and often relictual mesic habitats such as deep gorges, isolated ranges and outcrops, drainage systems, south-west facing aspects of hillslopes, and fire refuge areas such as cliffs and rock piles have an increased likelihood of hosting SRE taxa (Harvey, 2002; Durrant, 2011; Environmental Protection Authority, 2016). Damp swales, depressions and mound springs may also host SRE fauna in less arid landscapes. Within these features, many SRE species are found in permanently moist, shaded, and sheltered microhabitats. These habitat types are typically limited and isolated by barriers of exposed, dry habitat not

conducive to the dispersal of SRE species. This isolation restricts or eliminates gene flow between populations and may result in speciation via selective pressures, genetic drift, and mutation. Even where speciation has not yet occurred, the geographical distribution of these species has severely contracted and fragmented. Regionally extensive and exposed habitat types with high connectivity are unlikely to host SRE taxa (Durrant, 2011).

1.5. Existing Environment

1.5.1. IBRA Bioregion

The Interim Biogeographic Regionalisation for Australia (IBRA) classifies Australia into regions based on dominant landscape, climate, lithology, geology, landform and vegetation (Thackway and Cresswell, 1995). The Survey Area is located within the northern part of Swan Coastal Plain IBRA (Figure 1.1). The region consists of two subregions, the Perth subregion which is situated along the coast and the Dandaragan Plateau which is located inland and to the northeast.

The Perth subregion (within which the Atlas Project is located) is a low-lying coastal plain covered by woodland. The vegetation of this subregion is characterised by Banksia woodland, Tuart woodland and heath on sandy soils.

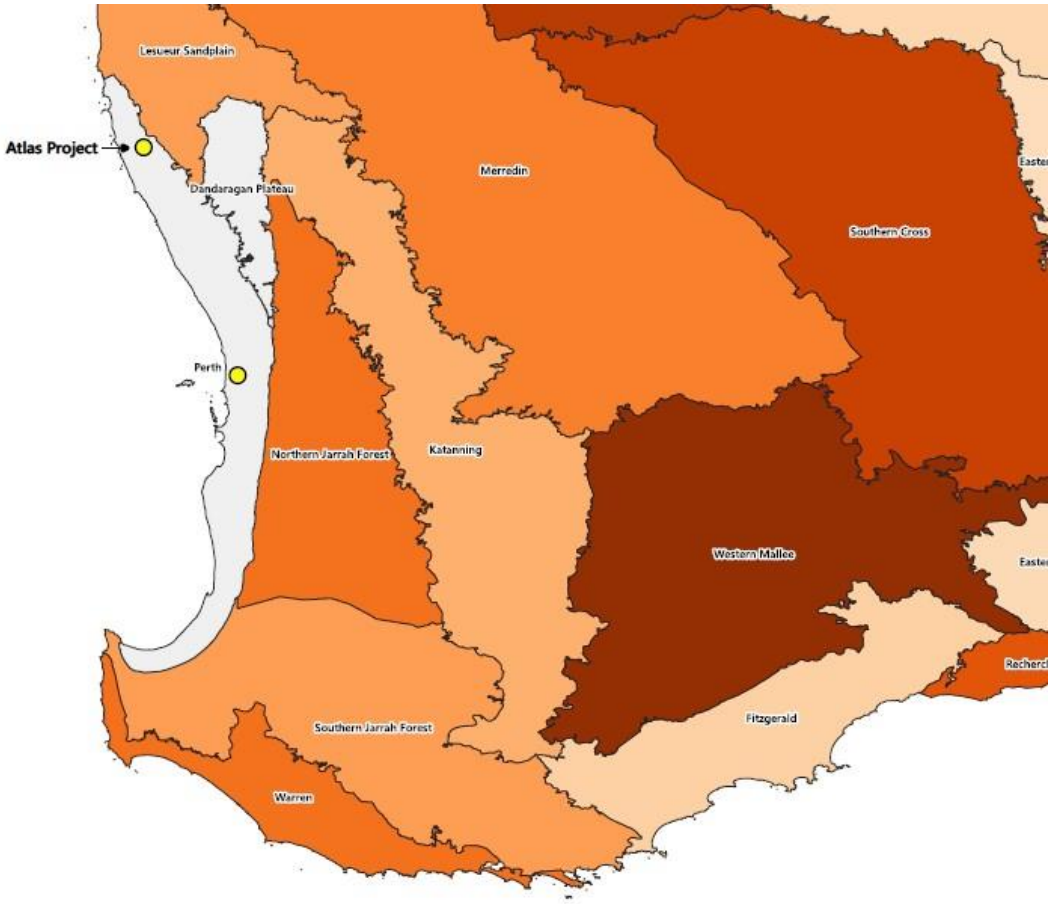


Figure 1.1: IBRA Region

1.5.2. Climate

The climate of the Swan Coastal Plain is described as warm Mediterranean (warm wet winters and hot dry summers) with rainfall ranges between 600mm and 1000mm annually. Nyoongar climatic information

describes six seasons which include long hot dry periods from October to April (Kambarang, Birak & Bunuru) with cooler periods in April-May (Djeran) and August-September (Djilba) on either side of a short wet cold period in June-July (Makuru).

Climate data recorded from the nearest Bureau of Meteorology (BoM) stations (Jurien Bay #9131 and Nambung #9276 BoM station) indicates that the 12 months prior to the survey were much wetter than average recording 290.8 mm above the annual median of 405.4 mm (BoM 2021). This increase in rainfall occurred from May to July and was followed by below average rainfall in August and September (Figure 1.2). Rainfall was high in October 2021 with 51.2 mm above average recorded.

Rainfall data from Nambung weather station was considered more accurate as Jurien Bay records higher rainfall due to its coastal location. Jurien Bay long-term temperature data was used for Figure 1.2 as temperature recorded from Nambung has been sporadic since 2005.

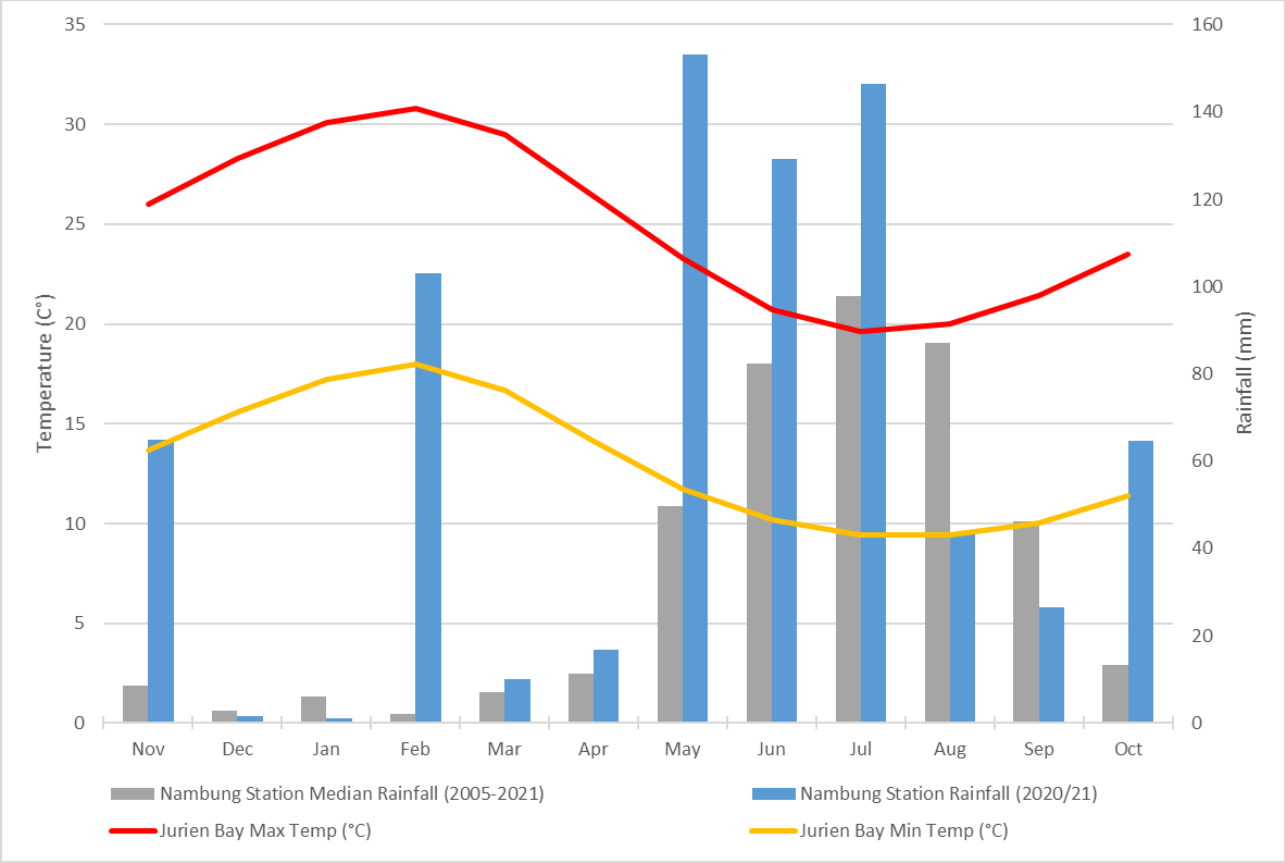


Figure 1.2: Climate Data Associated with the Survey Area

1.5.3. Pre-European Vegetation

Pre-European vegetation mapping was originally undertaken by Beard at various scales across the state and has since been updated to be consistent with the National Vegetation Information System (NVIS) descriptions at a scale of 1:250,000 (DPIRD 2019).

The majority of the Atlas Project occurs within one vegetation unit (1030), described as low Banksia dominated woodland (*Banksia attenuata* & *B. menziesii*) (GoA 2019). Two small sections of the infrastructure corridor occur in two additional vegetation units; 1029 - Banksia mixed open shrubland and 1031 – Banksia Shrubland. Regional sampling for SRE invertebrates was undertaken within vegetation unit 1030 to ensure consistency with previous surveys (Spectrum 2021).

1.5.4. Geology

The geology of Western Australia has been mapped at a scale of 1:50,000, 1:100,000, 1:250,000 and 1:500,000. The Atlas Project occurs across Wedge Island and Hill River 1:100,000 scale geological mapping. It consists of five geological units; Qa, Qe, Qp, Qt, and Czls (Table 1.3). The Qa and Qp units are associated with the drainage system that runs across the northern half of the Survey Area and includes finer alluvium soils associated with the drainage features and ephemeral lakes. The Qe unit consists of accumulated sand forming broad dune features and is associated with areas of Banksia woodland. The Qt units are coastal limestone deposits and the Czls unit corresponds with sandplains associated with low Banksia woodland. Regional sampling for SRE invertebrates was undertaken within the Qa and Qe geological units to ensure consistency with previous survey work (Spectrum 2021).

Table 1.3: Geological Units of the Survey Area (1:100,000)

Code	Description
Qa	Alluvium-sand, silt, and clay
Qe	Non-calcareous sand reworked by eolian processes
Qp	Swamp and lacustrine deposits-clay, silt, and diatomite 1164.71
Qt	TAMALA LIMESTONE: eolian limestone and sandstone with secondary concretionary and residual calcareous deposits; minor fossilferous limestone
Czls	Leached quartz sand associated with laterite

2. METHODS

2.1. Field Survey Methods

2.1.1. Survey Timing

The field survey was completed in Spring 2021 with field survey dates as follows:

- SRE wet pitfall trap installation, foraging and leaf litter collection: 20 – 24 September 2021
- SRE wet pitfall trap collection and foraging: 2 – 4 November 2021

The Survey Area is located within the Southwest Botanical Province as described by Beard (Beard, 1980). The Technical Guidance (EPA 2016) recommends SRE surveys in this region be completed winter to early spring (May – October) to coincide with the presence of adults for key SRE groups and increased activity in otherwise cryptic groups such as land snails. Heavy rain in the region throughout October (Figure 1.2) prolonged optimal conditions for target species.

2.1.2. Site Selection

Sites were pre-selected based on information from previous surveys including the habitats target SRE groups were collected from within the Atlas Project impact area (Spectrum Ecology, 2021), and satellite imagery. Pre-selected sites were ground-truthed and adjusted during the survey to best represent target habitats. The SRE sampling was conducted in three habitat types recorded from the survey area – Banksia Woodland, Melaleuca, and Samphire (Spectrum 2021).

2.1.3. Survey Team and Licenses

The field survey and assessment reporting were completed by the staff listed in Table 2.1. The field surveys were completed under Regulation 27 license BA27000509.

Table 2.1: Project team

Staff	Role	Years of Experience
Fauna		
Damien Cancilla	Principal Zoologist (field survey and reporting)	15 years
Erica MacIntyre	Senior Zoologist (field survey)	10 years
Lachlan Petersen	Zoologist (field survey, specimen sorting and reporting)	3 years
Melinda Henderson	Zoologist (field survey)	2 years
Nicola Palmer	Senior Zoologist (reporting)	7 years

2.1.4. Animal Ethics

Any disturbance of animals by the capture or sampling methods involved followed the state and federal legislation and guidelines listed in Section 1.3. Any potential SRE invertebrates collected during the field survey were humanely euthanized by chilling them in a refrigerator before inserting into a vial of chilled 100% ethanol. Wet pitfall trapping techniques followed the most recent available guidelines to limit the by-catch collected as much as possible (DBCA, 2017).

2.1.5. Systematic Sampling

SRE invertebrate sampling was completed using a variety of techniques to maximise the likelihood of capturing all target taxa. Sixteen SRE invertebrate sampling sites were established - wet pitfall traps were

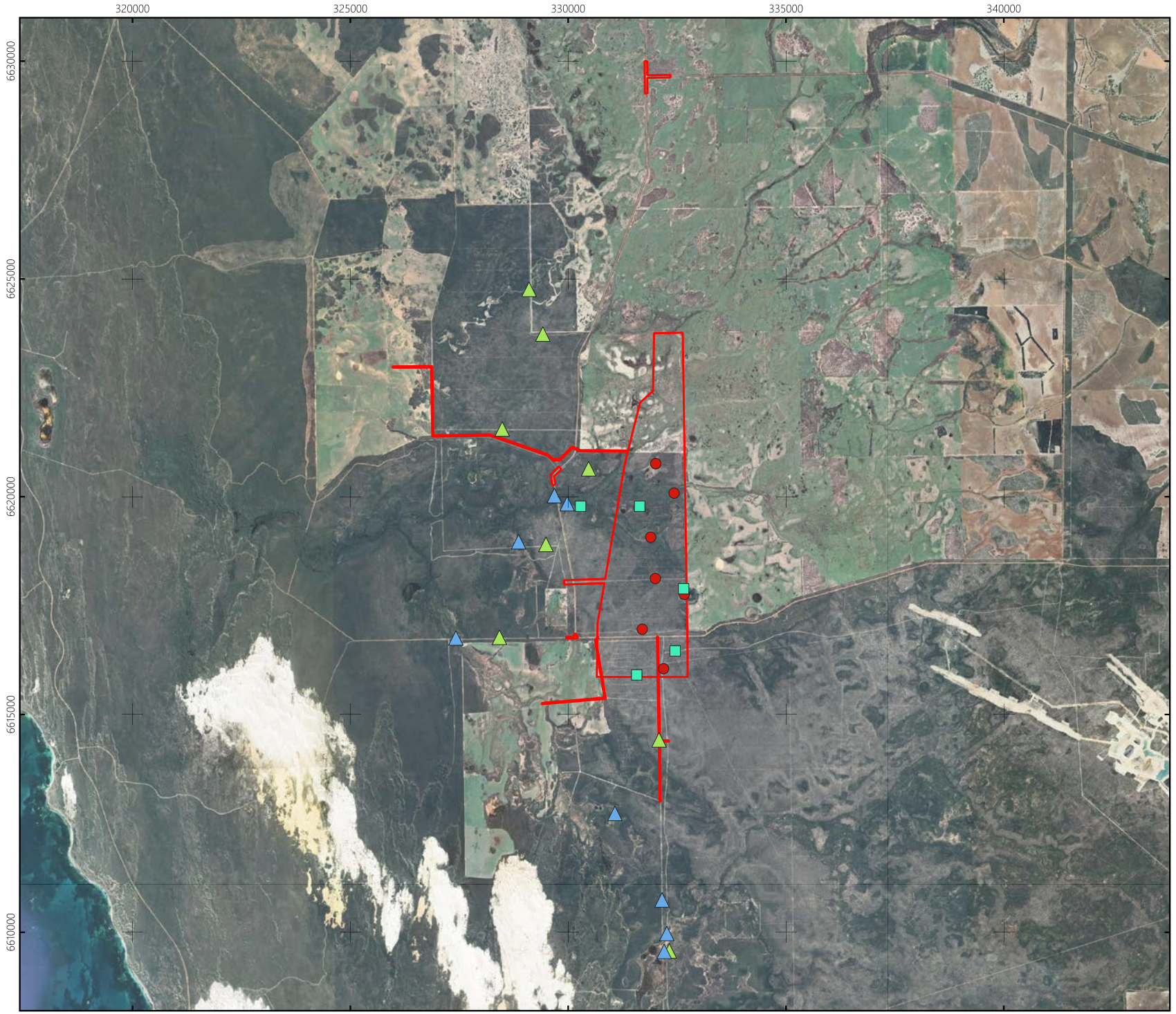
installed at all sites (four traps per site; 2648 trap nights), leaf litter was collected from eight sites (three samples per site) and foraging was conducted at all sites, using sifting trays where appropriate (Map 2.1).

Details of the methods used during the SRE invertebrate fauna surveys are described below.

- Wet pitfall trapping: Wet pitfall traps consisted of a 120 mL plastic jar containing 110 mL of mixed preserving solution (active ingredients: Propylene-Glycol and Ethanol). All wet pitfall traps were covered with a bucket lid positioned approximately 1-2 cm above the surface of the ground to prohibit large vertebrate species from being trapped. Each wet pitfall site comprised four wet pitfall traps which were established in suitable microhabitats and left in-situ for 40 days.
- Leaf litter collection: Three 1 m^2 quadrats were collected from eight sites containing suitable leaf litter or soil. The samples were initially processed using a leaf litter reducer, with the smaller leaf litter components placed into plastic zip-lock bags and transported back to Perth where they were placed under Tullgren funnels to extract the invertebrates.
- Foraging: Foraging was completed in microhabitats suitable for invertebrates that potentially represent SRE species. Leaf litter and the underside of rocks and logs were closely searched for molluscs, millipedes, isopods, pseudoscorpions and arachnids. Small quantities of soil and leaf litter from the base of trees, shrubs and roots were sifted through graduated geology sieves and thoroughly searched for specimens. Each separated size class of particles was also searched simultaneously for relevant SRE taxa (e.g. snails and large spiders in the large particle class, and pseudoscorpions in the smaller particle class). If encountered, live snails were also collected from vegetation and trapdoor spider burrows were excavated.

Leaf litter samples were processed by Spectrum in Tullgren funnels immediately following the field survey to ensure maximum survivorship (Figure 2.1).

Figure 2.1: Tullgren funnel set-up



Legend

- Survey Area

Regional SRE sampling sites

- Wet pitfall, foraging
- Wet pitfall, foraging, leaf litter

Atlas Project Detailed Survey SRE sampling sites

- Leaf litter
- Wet pitfall, leaf litter

Atlas Project Basic Survey SRE sampling sites

- Leaf Litter

N

0 1.5 3 4.5 km

Scale 1:120,000 @ A4

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

Spectrum ECOLOGY & SPATIAL

Author: NP

Date: 13-05-2022

Survey Site Locations

Atlas Project

Prepared for
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MAP 2.1

2.2. SRE Invertebrate Fauna Identification

Invertebrate fauna specimens collected during the current survey were sorted and labelled by Spectrum before provision to Alacran Environmental Consultants (Alacran), where they were identified to the lowest possible taxonomic level. Alacran collaborate with WA Museum, which results in the taxa identification aligning with the Museum collection. Invertebrate fauna specimens collected during the Atlas Project Detailed Fauna Assessment (Spectrum Ecology, 2021) were identified by Bennelongia Environmental Consultants (Bennelongia). These specimens were reclassified by Alacran to ensure continuity of identification, and alignment with the WA Museum collection.

2.2.1. Determination of SRE Status

The SRE status of invertebrates is based on categories which were developed by the Western Australian Museum (WAM). In an effort to further clarify the status of specimens collected during field assessments, the system employed by the WAM has been expanded to include likely and unlikely SRE sub-categories that fall within the larger potential SRE category (Table 2.2). To assign a species to one of these sub-categories, the habitat associated with the record is assessed to determine its likelihood of hosting SRE species. Further to this, related species at a generic or family level are examined to identify any confirmed SRE species within the group. The combination of habitat preference and prevalence of short range endemism in closely related species can be indicators as to a species likelihood of being an SRE. Following the Precautionary Principle, all data deficient species from known SRE target groups are regarded as potential short range endemics.

Table 2.2: SRE Categories

Categories	Defining Characteristics
Confirmed SRE	• Known distribution of <10,000 km^2. • Taxonomy is well understood. • Species is well represented in collections. • Region of occurrence has been comprehensively sampled.
Potential SRE	• Limited sampling has resulted in incomplete knowledge of the species distribution. • Poor or limited taxonomic resolution. Species not well represented in collections.
Not SRE	• Known distribution of >10,000 km^2. • Taxonomy is well understood. • Species is well represented in collections. • Region of occurrence has been comprehensively sampled.

In order to align with sub-categories used by the WAM, the following sub-categories are also be included to further clarify a species ranking as a potential SRE.

Table 2.3: WAM Sub-Categories Used to Justify Potential SRE Status

Sub-Category	Description
A: Data Deficient (DD)	• There is insufficient data available to determine SRE status. • Factors that fall under this category include: - Lack of geographic information (DDG); - Lack of taxonomic information (DDT); - The group may be poorly represented in collections; and - The individuals sampled (e.g., juveniles) may prevent identification to species level.
B: Habitat Indicators (H)	• It is becoming increasingly clear that habitat data can elucidate SRE status; and • Where habitat is known to be associated with SRE taxa and vice versa, it will be noted here.

C: Morphology Indicators (M)	• A suite of morphological characters are characteristic of SRE taxa; and • Where morphological characters are known to be associated with SRE taxa and vice- versa, it will be noted here.
D: Molecular Evidence (M)	• If molecular work has been done on this taxon (or a close relative), it may reveal patterns congruent or incongruent with SRE status.
E: Unpublished Research & Expertise (U)	• Previous research and/ or WAM expertise elucidates taxon SRE status; and • This category takes into account the expert knowledge held within the WAM.

2.3. Survey Limitations

Survey limitations are unforeseen events that can limit the effectiveness of the field survey to achieve the required objectives. Overall, no significant limitations were experienced during the field survey. Specific potential limitations are addressed below in Table 2.4.

Table 2.4: Survey Limitations

Limitation	Constraint	Comment
Competency/experience of the consultant carrying out the survey.	No	The zoologists that completed the field survey were highly experienced conducting short range endemic invertebrate surveys in the south west region.
Scope (what faunal groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions).	No	Sampling techniques were designed for a short range invertebrate fauna survey. No survey constraints were experienced that limited sampling of specific SRE groups.
Proportion of fauna identified, recorded and/or collected.	No	Invertebrate fauna specimens were collected for identification by Alacran taxonomists. Taxonomic resolution is limited by current knowledge of invertebrate species/taxa.
Sources of information.	No	Database searches and previous survey reports provided a sufficient level of information, adequate to guide field survey design and effort.
The proportion of the task achieved and further work which might be needed.	No	All components of a regional SRE assessment were completed during the field survey. The combination of previous and current survey work gives a comprehensive understanding of the SRE invertebrate assemblage of the Survey Area.
Timing/weather/season/cycle.	No	The field survey was conducted during the optimal survey period for SRE taxa in the south west region. Wet pitfall traps were collected just outside the recommended period however above average rainfall in the months preceding the survey is likely to have led to increased invertebrate activity throughout the period of wet pitfall trapping.
Disturbances (e.g. fire, flood, accidental human intervention) which affected results of survey.	No	No disturbances were recorded during the survey.
Intensity (in retrospect, was the intensity adequate).	No	The completed assessment was adequate to identify the SRE invertebrate fauna assemblage within and surrounding the Survey Area. Sufficient targeted searches for SRE species were completed within areas of suitable habitat.
Completeness (was the relevant area fully surveyed).	No	All major fauna habitat types were sampled.
Resources (degree of expertise available in animal identification to taxon level).	No	The experience level of the zoologists present was sufficient to sample all species and Alacran taxonomists were able to identify specimens

Limitation	Constraint	Comment
		accurately. Resources available were adequate and did not compromise the outcome of the survey.
Remoteness and/or access problems.	No	No issues were encountered in accessing the site and suitable access tracks were available throughout.
Availability of contextual (e.g. biogeographic) information on the region.	No	Background information about the region was available and sufficient.

2.4. Data for the Index of Biodiversity Surveys for Assessment (IBSA)

The Environmental Protection Authority (EPA) has given instruction that all biological surveys collecting data on biodiversity submit the report and associated raw data to IBSA as an IBSA data package. All survey data collected at the Project was provided electronically following the completion of the surveys to comply with IBSA data standards.

3. RESULTS & DISCUSSION

3.1. SRE Fauna Assemblage

Twenty potential SRE taxa were collected during the regional SRE survey: three pseudoscorpions, one snail, nine isopods, four centipedes, one millipede, one flatworm, and one ostracod. A further six taxa were collected that were determined to be widespread or unlikely to be SRE. Full details of all taxa recorded are provided in Appendix B.

Four of the fourteen target potential SREs that were only known from the Survey Area (Table 1.1) were subsequently recorded in the regional SRE survey (Table 3.1;Map 3.1) – Atemnidae sp., *Austrochthonius* sp., *Buddelundia* '7', and *Laevophiloscia* sp. 24.

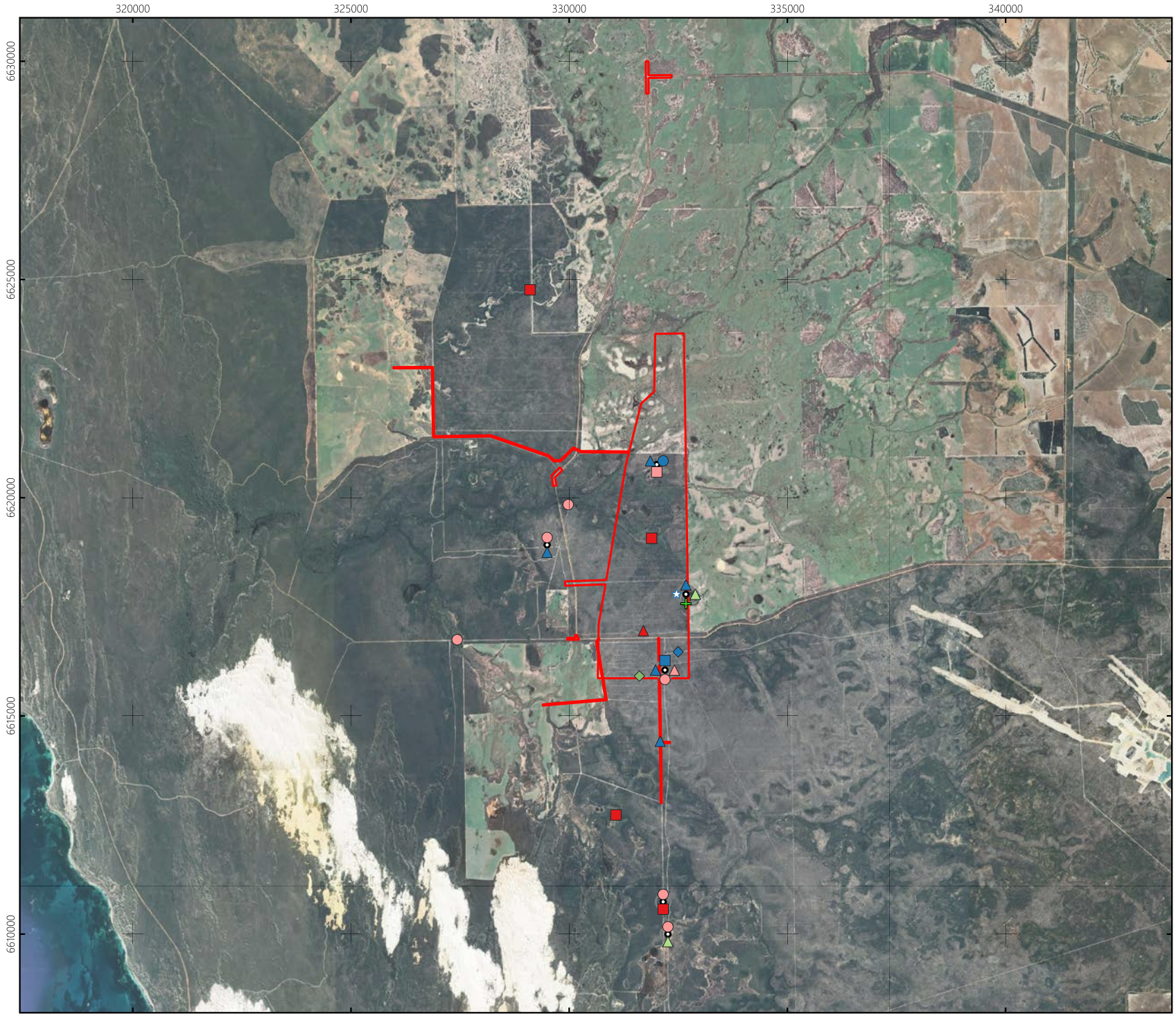
Due to the change in taxonomists and reference collections between the basic and detailed SRE surveys (Bennelongia) and the regional survey (Alacran), undescribed SRE taxa are sometimes given different phrase names (e.g. *Beierolpium* 8/4 `BPS322` and *Beierolpium* sp. '8/4-NA02'; Table 3.1). Where possible specimens were compared to WAM's reference collection, with additional private collections accessed where required. Overall, more credence has been given to Alacran's identification and phrase names due to the collaboration with the WA Museum unless previous work completed by Bennelongia provided more detail or context (such as DNA sequencing).

Table 3.1: Target Potential SRE Invertebrate Fauna

Class/ Order & Family	Bennelongia ID	Alacran ID	Abundance	Site	Details	Inside and/or Outside Survey Area	Survey			SRE Status
							Basic	Detailed	Regional	
ARACHNIDA										
Araneae										
Salticidae	*Maratus* `BAR130`	-	1	APSRE5	DNA recommended as is an unusual animal and suspected to be a new species. Specimen submitted to WA Museum following Bennelongia identification, not classified by Alacran	Inside		X		Potential SRE
Pseudoscorpiones										
Atemnidae	Atemnidae sp. 712345*	Atemnidae sp.	2	APSRE7 SRE12	Juveniles, unable to identify further. DNA recommended to compare all Atemnid specimens.	Inside/ outside		X	X	Potential SRE: DDT
Atemnidae	*Oratemnus* `BPS326`	*Oratemnus* sp. 'Na01'	3	APSRE7	DNA recommended to compare all Atemnid specimens.	Inside		X		Potential SRE: DDT
Chthoniidae	*Austrochthonius* sp. 712610*	*Austrochthonius* sp.	22	APLL8 SRE12 SRE13 SRE15 SRE16 SRE9	DNA recommended to investigate if all specimens are the same species, and compare with individuals collected from Cooljarloo, 10 km south.	Inside/ outside		X	X	Potential SRE: DDT
Olpiidae	*Beierolpium* 8/4 `BPS253`	-	1	APS17	Male and juvenile compared to sp. B08 from Cooljarloo West approx. 8km south, specimens do not appear be the same.	Inside	X			Potential SRE

Class/ Order & Family	Bennelongia ID	Alacran ID	Abundance	Site	Details	Inside and/or Outside Survey Area	Survey			SRE Status
							Basic	Detailed	Regional	
Olpiidae	*Beierolpium* 8/4 `BPS322`	*Beierolpium* sp. '8/4-NA02'	1	APLL8	Comparisons to other specimens collected in the area indicate a distinct species. Closely resembles *Beierolpium* sp. '8/4' recorded in the regional survey however DNA sequencing is recommended for clear resolution.	Inside		X		Potential SRE: DDT
Olpiidae	*Beierolpium* 8/4 `BPS323`	*Beierolpium* sp. '8/4-NA03'	1	APSRE4	Comparisons to other specimens collected in the area indicate a distinct species.	Inside		X		Potential SRE: DDT
Olpiidae	*Beierolpium* 8/4 `BPS324`	*Beierolpium* sp. '8/4-NA01'	1	APLL8	Comparisons to other specimens collected in the area indicate a distinct species. Did not align genetically with any previously recorded species.	Inside		X		Potential SRE: DDT
Olpiidae	*Beierolpium* 8/2 `BPS325`	*Beierolpium* sp. '8/4-NA04'	1	APLL2	Comparisons to other specimens collected in the area indicate a distinct species.	Inside		X		Potential SRE: DDT
Olpiidae	*Beierolpium* sp.	-	1	APS02	1 juvenile, unable to ID further.	Inside	X			Potential SRE
Olpiidae	*Euryolpium* `BPS251`	-		APS04	Compared to sp. B05 from Cooljarloo West and BPS252 has fatter bigger chela.	Inside	X			Potential SRE
Olpiidae	Olpiidae sp.	-		APS02	Juvenile specimen, cannot ID further.	Inside	X			Potential SRE

Class/ Order & Family	Bennelongia ID	Alacran ID	Abundance	Site	Details	Inside and/or Outside Survey Area	Survey			SRE Status
							Basic	Detailed	Regional	
ISOPODA										
Armadillidae	*Buddelundia* sp. B38	*Buddelundia* '7'	8	APSRE4 APSRE7 APSRE8 SRE8 SRE16	DNA recommended to confirm animal is the same species as collected elsewhere. May be conspecific with *Buddelundia subinermis* however further work would be required to confirm this.	Inside/ Outside		X	X	Potential SRE: DDG
Philosciidae	*Laevophiloscia* sp. B24	Philosciidae sp. 1	17	APSRE3 SRE2 SRE7 SRE9	Distinctly different from *Laevophiloscia* sp. B23. Sequencing was unsuccessful though due to the failure of the Cooljarloo specimens, no sequence was available for comparison.	Inside/ outside		X	X	Potential SRE: DDT



Legend

- Survey Area

Target Potential SRE Records

- Olpiidae sp.
- Atemnidae sp.
- Beierolpium 8/4 `BPS253`
- Austrochthonius sp.
- Beierolpium sp. '8/2-Na04'
- Beierolpium sp. '8/4-Na02'
- Beierolpium sp. '8/4-Na01'
- Beierolpium sp. '8/4-Na03'
- Buddelundia '7'
- Euryolpium `BPS251`
- Maratus `BAR130`
- Laevophiloscia sp. B24
- Oratemnus sp. 'Na01'

N

0 1.5 3 4.5 km

Scale 1:120,000 @ A4

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

Spectrum ECOLOGY & SPATIAL

Author: NP

Date: 13-05-2022

Target Potential SRE Locations

Atlas Project

Prepared for
Preston Consulting | Image Resources

MAP 3.1

3.2. Target Potential SRE Taxa

Those taxa that were only recorded inside the Survey Area during the basic and detailed fauna surveys are discussed below.

3.2.1. Araneae (Spiders)

The specimen *Maratus* 'BAR130' collected at wet pitfall site APSRE5 in Banksia Woodland habitat during the detailed survey appears to be an undescribed species. The genus *Maratus* (Karsch 1878) is comprised of 86 species, 47 of which could be considered short range endemics based on the current understanding of their distributions (Schubert, 2020). As for many potential SRE taxa, further targeted survey effort and taxonomic resolution may show these species to have larger distributions than once thought. At this time *Maratus* 'BAR130' is considered a potential SRE in accordance with the Precautionary Principle. Bennelongia Environmental Consultants (Bennelongia) taxonomists recommended genetic sequencing for comparison with known species to determine the species identity.

No further specimens of the *Maratus* genus were collected during the regional SRE survey.

3.2.2. Pseudoscorpions

Pseudoscorpions are small arachnids that resemble small scorpions; however, they do not have an elongated tail. Pseudoscorpions are often associated with vegetated habitats where they are recorded from under bark and from within leaf litter. Morphospecies Atemnidae sp., *Austrochthonius* sp., *Beierolpium 8/4 `BPS253`*, *Beierolpium* '8/2 Na04`, *Beierolpium* '8/4 Na02`, *Beierolpium* `8/4 Na03`, *Beierolpium* '8/4 Na01`, *Beierolpium* sp., Olpiidae sp., *Euryolpium* `BPS251` and *Oratemnus* sp. 'Na01' were collected only from within the Survey Area during the basic and detailed surveys and were not known from any other locations.

Following the detailed survey, genetic sequencing was completed by Bennelongia on two morphospecies in an effort to align them with those recorded outside of the Survey Area. Sequencing failed for the single *Beierolpium* `8/4 Na03` specimen available, likely due to its small size. *Beierolpium* '8/2 Na04` was sequenced successfully though did not align with any previously recorded species.

A single specimen of Atemnidae sp. was collected during the regional SRE survey (Map 3.1). Specimens from this and previous surveys are juvenile, and DNA sequencing is recommended if further taxonomic resolution is required (Table 3.1). Several specimens of *Austrochthonius* sp. were recorded in the regional SRE survey (Map 3.1). The taxonomy of this group is unresolved with numerous undescribed morphospecies known. However, most *Austrochthonius* morphospecies appear to be widespread (Alacran 2022).

No further specimens of *Beierolpium 8/4 `BPS253`*, *Beierolpium* '8/2 Na04`, *Beierolpium* '8/4 Na02`, *Beierolpium* `8/4 Na03`, *Beierolpium* '8/4 Na01`, *Beierolpium* sp., Olpiidae sp., *Euryolpium* `BPS251` or *Oratemnus* sp. 'Na01 were recorded during the regional SRE survey.

3.2.3. Isopoda (Wood Lice)

Isopods are crustaceans found in marine, freshwater, and terrestrial environments. Terrestrial isopods (superfamily Oniscoidea) have segmented exoskeletons, seven pairs of legs and are often associated with decaying wood leading to the common name wood louse. Two potential SRE isopods were only confirmed from within the Survey Area during the basic and detailed surveys - *Buddelundia* '7', and *Laevophiloscia* sp. B24.

Following the detailed survey, genetic sequencing was attempted to align *Laevophiloscia* sp. B24 with specimens previously recorded from approximately 10 km southeast of the Survey Area at Cooljarloo.

Unfortunately, the sequencing of *Laevophiloscia* sp. B24 specimens from Cooljarloo failed and could not be compared to specimens collected within the proposed Atlas Project Survey Area. The failure was attributed to preservation techniques used in 2012 when the specimens were collected.

Four specimens of *Buddelundia* '7' were recorded from two locations during the regional SRE survey, while twelve specimens of *Laevophiloscia* sp. B24 were recorded from three locations (Map 3.1).

4. CONCLUSION

The regional SRE survey recorded twenty potential SREs: three pseudoscorpions, one snail, nine isopods, four centipedes, one millipede, one flatworm and one ostracod. A further six taxa were collected that were determined to be widespread or unlikely to be SRE.

Four taxa provided additional regional records of the target potential SRE species that had not been previously confirmed outside of the Atlas Project Survey Area – Atemnidae sp., *Austrochthonius* sp., *Buddelundia* '7', and *Laevophiloscia* sp. 24.

Ten of the target potential SREs were not recorded during the Regional SRE survey and remain known only from inside the Survey Area - *Maratus* 'BAR130', *Beierolpium* 8/4 `BPS253`, *Beierolpium* '8/2 Na04`, *Beierolpium* '8/4 Na02`, *Beierolpium* `8/4 Na03`, *Beierolpium* '8/4 Na01`, *Beierolpium* sp., Olpiidae sp., *Euryolpium* `BPS251`, and *Oratemnus* sp. 'Na01'.

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Appendix A: Site Details

Regional SRE Wet Pitfall Site Details

Site name	Habitat Type	Zone	Easting	Northing	Site Type	Photo
SRE1	Banksia Woodland	50 S	329417	6623763	SRE wet pitfall, foraging	
SRE2	Melaleuca	50 S	329103	6624763	SRE wet pitfall, foraging	
SRE3	Banksia Woodland	50 S	328483	6621537	SRE wet pitfall, foraging	
SRE4	Melaleuca	50 S	330470	6620640	SRE wet pitfall, foraging	

SRE5	Samphire	50 S	329710	6620077	SRE wet pitfall, foraging, leaf litter	
SRE6	Samphire	50 S	328897	6618883	SRE wet pitfall, foraging, leaf litter	
SRE7	Samphire	50 S	331073	6612730	SRE wet pitfall, foraging, leaf litter	
SRE8	Banksia Woodland	50 S	332087	6614417	SRE wet pitfall, foraging	
SRE9	Melaleuca	50 S	332156	6610739	SRE wet pitfall, foraging, leaf litter	

SRE10	Samphire	50 S	332323	6609569	SRE wet pitfall, foraging	
SRE11	Samphire	50 S	332206	6609558	SRE wet pitfall, foraging, leaf litter	
SRE12	Melaleuca	50 S	332265	6609996	SRE wet pitfall, foraging, leaf litter	
SRE13	Melaleuca	50 S	327435	6616745	SRE wet pitfall, foraging, leaf litter	
SRE14	Banksia Woodland	50 S	328423	6616773	SRE wet pitfall, foraging	

SRE15	Melaleuca	50 S	329980	6619842	SRE wet pitfall, foraging, leaf litter	
SRE16	Banksia Woodland	50 S	329496	6618918	SRE wet pitfall, foraging	

Appendix B: Taxa from SRE Target Groups Recorded during the Basic, Detailed and Regional Surveys

Class/ Order & Family	Bennelongia ID	Alacran ID	Abundance	Site	Details	Inside and/or Outside Survey Area	Survey			SRE Status
							Basic	Detailed	Regional	
ARACHNIDA										
Araneae										
Salticidae	*Maratus* `BAR130`	-	1	APSRE5	DNA recommended as is an unusual animal and suspected to be a new species. Specimen submitted to WA Museum following Bennelongia identification, not classified by Alacran	Inside		X		Potential SRE
Salticidae		Salticidae sp.	1	SRE10		Outside			X	
Pseudoscorpiones										
Atemnidae	Atemnidae sp. 712345*	Atemnidae sp.	2	APSRE7 SRE12	Juveniles, unable to identify further. DNA recommended to compare all Atemnid specimens.	Inside/ outside		X	X	Potential SRE: DDT
Atemnidae	*Oratemnus* `BPS326`	*Oratemnus* sp. 'Na01'	3	APSRE7	DNA recommended to compare all Atemnid specimens.	Inside		X		Potential SRE: DDT
Chthoniidae	*Austrochthonius* sp. 712610*	*Austrochthonius* sp.	1	APLL8 SRE12 SRE13 SRE15 SRE16 SRE9	DNA recommended to investigate if all are the same species, and compare with individuals collected from Cooljarloo, 10 km south.	Inside/ outside		X	X	Potential SRE: DDT
Olpiidae	*Beierolpium 8/4 `BPS253`*	-	1	APS17	Male and juv compared to sp B08 from Cooljarloo West appox 8km south and not same cheala size and tricobothria pattern different.	Inside	X			Potential SRE

Class/ Order & Family	Bennelongia ID	Alacran ID	Abundance	Site	Details	Inside and/or Outside Survey Area	Survey			SRE Status
							Basic	Detailed	Regional	
Olpiidae	*Beierolpium* sp.	-	1	APS02		Inside	X			Potential SRE
Olpiidae	-	*Beierolpium* '8/4'	1	SRE14	Closely resembles *Beierolpium* sp. '8/4-NA02' however DNA sequencing recommended for clear resolution.	Outside			X	Potential SRE: DDT
Olpiidae	*Beierolpium* 8/4 `BPS322`	*Beierolpium* sp. '8/4-NA02'	1	APLL8	Comparisons to other specimens collected in the area indicate a distinct species.	Inside		X		Potential SRE: DDT
Olpiidae	*Beierolpium* 8/4 `BPS323`	*Beierolpium* sp. '8/4-NA03'	1	APSRE4	Comparisons to other specimens collected in the area indicate a distinct species.	Inside		X		Potential SRE: DDT
Olpiidae	*Beierolpium* 8/4 `BPS324`	*Beierolpium* sp. '8/4-NA01'	1	APLL8	Comparisons to other specimens collected in the area indicate a distinct species. Did not align genetically with any previously recorded species.	Inside		X		Potential SRE: DDT
Olpiidae	*Beierolpium* 8/2 `BPS325`	*Beierolpium* sp. '8/4-NA04'	1	APLL2	Comparisons to other specimens collected in the area indicate a distinct species.	Inside		X		Potential SRE: DDT
Olpiidae	*Euryolpium* `BPS251`	-		APS04	Compared to sp. B05 from Cooljarloo West and BPS252 has fatter bigger chela.	Inside	X			Potential SRE
Olpiidae	*Euryolpium* `BPS252`	-		APS18	Compared to BPS251 and B05 from Cooljarloo West, not the same size of cheala different	Outside	X			Potential SRE

Class/ Order & Family	Bennelongia ID	Alacran ID	Abundance	Site	Details	Inside and/or Outside Survey Area	Survey			SRE Status
							Basic	Detailed	Regional	
Olpiidae	*Euryolpium* sp.	-		APS18	-	Outside	X			Potential SRE
Olpiidae	Olpiidae sp.	-		APS02	Juvenile specimen, cannot ID further.	Inside	X			Potential SRE
GASTROPODA										
Eupulmonata										
Planorbidae	-	Planorbidae sp.	8	SRE5 SRE15	Dead shells and preserved specimen, unable to ID further	Outside			X	
Stylommatophora										
Punctidae	*Westralaoma* cf. *aprica*	*Westralaoma expicta*	3	APLL6 APS18	Shell only. Compared to shells collected 10km SE and believe they are the same. Would need DNA to confirm but cannot do so with shells.	Inside/ Outside	X	X		Potential SRE
Punctidae	-	*Westralaoma* sp.	4	SRE9 SRE10 SRE12 SRE14	Shells only, unable to ID further	Outside			X	Not SRE
ISOPODA										
Amphisopodidae	-	*Paramphisopus palustris*	77	SRE5	Aquatic species, likely to be SRE.	Outside			X	Potential SRE: DDG

Class/ Order & Family	Bennelongia ID	Alacran ID	Abundance	Site	Details	Inside and/or Outside Survey Area	Survey			SRE Status
							Basic	Detailed	Regional	
Armadillidae	*Buddelundia* sp. B38	*Buddelundia* '7'	8	APSRE4 APSRE7 APSRE8 SRE8 SRE16	DNA recommended to confirm animal is the same species as collected elsewhere. May be conspecific with *Buddelundia subinermis* however further work would be required to confirm this.	Inside/ Outside		X	X	Potential SRE: DDG
Armadillidae	-	*Buddelundia cinerascens*	3	SRE5 SRE6	Smaller specimens match voucher speciemens for the species collected at Drovers Cave.	Outside			X	Potential SRE: DDT
Armadillidae	-	*Pseudodiploexochus sp.*	32	SRE9 SRE12	Compared to other specimens collected from the Swan Coastal Plain and found to be morphologically distinct.	Outside			X	Potential SRE: DDT
Armadillidae	-	*Spherillo* '2'	21	SRE9 SRE13	Specimens are typical of the *Spherillo* species complex. DNA sequencing recommended if greater resolution is required.	Outside			X	Potential SRE: DDG
Philosciidae	*Laevophiloscia* sp. B23	*Laevophiloscia* sp. 1	46	APSRE1 APSRE6 APSRE7	Genetic sequencing confirmed the species is conspecific with *Laevophiloscia* sp. B23 recorded at Cooljarloo.	Inside/ Outside		X		Potential SRE: DDT

Class/ Order & Family	Bennelongia ID	Alacran ID	Abundance	Site	Details	Inside and/or Outside Survey Area	Survey			SRE Status
							Basic	Detailed	Regional	
Philosciidae	-	*Laevophiloscia* 'Na01A'	91	SRE1 SRE2 SRE4 SRE5 SRE7 SRE9 SRE12 SRE13	'Typical' form of *Laevophiloscia*. Taxonomy of the groups is poorly known and DNA sequencing is recommended if further resolution is required.	Outside			X	Potential SRE: DDT
Philosciidae	-	*Laevophiloscia* 'NA01B'	11	SRE5 SRE13 SRE14	'Typical' form of *Laevophiloscia*. Taxonomy of the groups is poorly known and DNA sequencing is recommended if further resolution is required.	Outside			X	Potential SRE: DDT
Philosciidae	*Laevophiloscia* sp. B24	Philosciidae sp. 1	17	APSRE3 SRE2 SRE7 SRE9	Distinctly different from *Laevophiloscia* sp. B23. Sequencing was successful though due to the failure of the Cooljarloo specimens, no sequence was available for comparison.	Inside		X	X	Potential SRE: DDT
Porcellionidae	*Porcellionides pruinosus*	*Porcellionides pruinosus*	3	APSRE7	Introduced species.	Inside		X		Not SRE.
Styloniscidae	-	*Styloniscus* sp.	2	SRE13	Wet forest group known to contain many SRE species. DNA sequencing is recommended if further resolution is required.	Outside			X	Potential SRE: DDT

Class/ Order & Family	Bennelongia ID	Alacran ID	Abundance	Site	Details	Inside and/or Outside Survey Area	Survey			SRE Status
							Basic	Detailed	Regional	
MYRIAPODA										
Lithobiomorpha										
Henicopidae	*Lamyctes* nr *africanus*	*Lithobiomorpha* sp. *Lamyctes africanus*	9	APSRE5 APSRE7 SRE8 SRE9 SRE16	Keys to *Lamyctes africanus* from Centipedes of Australia however the range distance is challenging. DNA not recommended as rock centipedes are not usually potential SREs.	Inside/outside		X	X	Not SRE
Polydesmida										
Paradoxosomatidae	*Antichiropus sulcatus*	*Antichiropus* sp.	3	APSRE4	Genetically aligns with *Antichiropus sulcatus*.	Inside/ Outside		X		Potential SRE: DDT
Paradoxosomatidae	*Antichiropus whistleri*	*Antichiropus* sp. *Antichiropus whistleri*	2	APSRE5 APSRE8 SRE16	Genetically aligns with *Antichiropus whistleri*.	Inside/ Outside		X	X	Not SRE
Paradoxosomatidae	-	*Antichiropus* sp.	42	SRE16 SRE13 SRE8 SRE12 SRE2 SRE3	Female and juvenile specimens could not be identified to species level. DNA sequencing is recommended if further resolution is required.	Outside			X	Potential SRE: DDT

Class/ Order & Family	Bennelongia ID	Alacran ID	Abundance	Site	Details	Inside and/or Outside Survey Area	Survey			SRE Status
							Basic	Detailed	Regional	
Scolopendrida										
Scolopendridae	Scolopendrinae `BSCOL071`	*Cormocephalus* sp.	1	APSRE3	Does not key to *Cormocephalus* or Scolopendrinae, unusual animal. Spines on all tarsus. Broad large process. 19 segment antennae, large porous area extending over processes. DNA recommended to investigate genus and species.	Inside		X		Unlikely SRE
Polyxenida										
Polyxenidae	*Unixenus* sp.	Polyxenidae sp.	5	APLL5 APLL8		Inside		X		Not SRE
Synxenidae	*Phryssonotus novaehollandiae*	Synxenidae sp.	17	APLL4 APLL5 APLL6 APLL7 APLL8		Inside		X		Not SRE
Geophilomorpha										
Geophilidae	-	*Sepedonophilus* sp.	2	SRE7 SRE9	DNA sequencing is required to identify to species level. Most W.A. *Sependonophilus* morphospecies are SRE.	Outside			X	Potential SRE: DDT

Class/ Order & Family	Bennelongia ID	Alacran ID	Abundance	Site	Details	Inside and/or Outside Survey Area	Survey			SRE Status
							Basic	Detailed	Regional	
Mecistocephalidae	-	*Mecistocephalus* sp.	2	SRE15	DNA sequencing is required to identify to species level. Most W.A. *Mecistocephalus* morphospecies are SRE.	Outside			X	Potential SRE: DDT
Oryidae	-	*Orphnaeus* sp.	2	SRE9	DNA sequencing is required to identify to species level. Most W.A. *Orphnaeus* morphospecies are SRE.	Outside			X	Potential SRE: DDT
Symphyla										
		Symphyla sp.	17	SRE9 SRE12	Taxonomy of this group is poorly known and determination of W.A. species requires DNA sequencing.	Outside			X	Potential SRE: DDT
ANNELIDA										
Clitellata										
Oligochaeta	-	Oligochaeta sp.	1	SRE15		Outside			X	
TRICLADIDA										
Geoplanoidea										
Geoplanidae	-	Geoplanidae sp.	1	SRE3	Taxonomy of this group is poorly known and determination of W.A. species requires DNA sequencing.	Outside			X	Potential SRE: DDT

Appendix C: SRE Identification Reports (Alacran)

Alacran Environmental Science

Report No. 2136-B

Identification and Short-range endemic assessment of Invertebrates for the Atlas Project

Prepared for

Spectrum Ecology

Beierolpium '8/4 complex'

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EXECUTIVE SUMMARY

During 2021 Spectrum Ecology provided a collection of invertebrates from the Atlas project (Northern Swan Coastal Plain) for taxonomic identification and conservation assessment. In total, the collection contained 47 samples, representing 17 different taxa. Of these taxa, 12 belonged to SRE categories and two was widespread. One widespread (introduced) species was described, and the remainder were represented by morphospecies or ambiguous (sp.) identifications.

Of the morphospecies identified from this collection two (Philosciidae sp. 1 and Laevophiloscia sp. 1) were also represented in Alacran (2021).

The pseudoscorpion *Beierolpium* sp. '8/4-Na02' may be conspecific with *Beierolpium* sp. 'CO1' from Alacran (2021); however, that relationship should be confirmed using DNA sequence data because the species boundaries within *Beierolpium* are hampered by the poor state of its taxonomy.

The pseudoscorpion *Austrochthonius* sp. in the present collection may be conspecific with either of the three (possibly four) *Austrochthonius* morphospecies from Alacran (2021): *Austrochthonius* 'CO1', *Austrochthonius* 'CO2', *Austrochthonius* 'CO3' and *Austrochthonius* sp.. The specimen from this collection is a juvenile therefore morphological identification was impossible; however, its relationship to those in Alacran (2021) may be resolved with the DNA sequence data.

Antichiropus sp. was present in both this collection and Alacran (2021); however, none of these samples was adult male and species relationships between each other or known species and morphospecies is ambiguous. The only way to assess these relationships is by analysing their DNA sequences.

Lithobiomorpha sp. was present in this collection and Alacran (2021); however, the relationship of these samples should be verified using DNA sequence data.

***Alacran* Environmental Science**

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SCOPE

During 2022 Spectrum Ecology provided several samples of invertebrates from the Atlas project on the Northern Swan Coastal Plain for taxonomic identification and conservation assessment. Spectrum requested taxonomic identifications and assessment of SRE and other conservation categories for these invertebrate species. Spectrum also requested an assessment of the relationship between species from this collection and those previously reported on by Alacran (2021).

BACKGROUND

SHORT-RANGE ENDEMISM

Short-range endemics (SREs) are organisms with small geographic distributions (Harvey 2002; Ponder *et al.* 2002), nominally less than 10,000 km^2(Harvey 2002). These organisms are typically characterised by one or more of the following features:

- limited dispersal capabilities,
- seasonal activity (cooler or wetter periods),
- slow growth, and
- low levels of fecundity.

Their limited dispersal capabilities result in small populations being isolated from each other by inhospitable geographic features such as rivers, rocky ridges or plains. Prolonged isolation between populations eventually results in speciation, with each population becoming genetically and, or morphologically distinct over time. Two types of short-range endemism have been recognised: Relictual Endemism and Habitat Specialist Endemism (Harvey 2002; Ponder *et al.* 2002).

Relictual SREs result when speciation occurs following the fragmentation of continuous habitat into two or more refugia. In Australia, the primary driver of this over the last 65 million years has been aridification, which acted to isolate formerly widespread species living in mesic forests to small patches of mesic refugia. Relictual SREs include scorpions in the genus *Aops* (Volschenk et al. 2008), pseudoscorpions in the genera *Tyrannochthonius* (Harvey 1991; Edward et al. 2008), *Indohya* (Harvey 1993b; Harvey *et al.* 2007) and *Idioblothrus* (Muchmore 1982; Harvey 1993a; Harvey *et al.* 2008) and millipedes in the genus *Antichiropus* (Car *et al.* 2013; Car *et al.* 2014).

Habitat specialist SREs are species that have adapted to very specific environment types, including those found in arid environments (*e.g.* rocky outcrops, isolated dune systems and salt lakes). These habitats are often relatively young (<10 million years) and therefore are not refugial. Examples of habitat specialist SREs include spiders in the family Selenopidae, pseudoscorpions in the genus *Synsphyronus* (Harvey 2011, 2012), scorpions in the genera *Lychas* and *Urodacus* and tiger beetles in the genus *Pseudotetracha* (Lopez-Lopez et al. 2016)

METHODS

ASSESSMENT OF SHORT-RANGE ENDEMISM

Assessment of short-range endemism can be challenging when data for evaluation are absent or limited. Limitations may include any of the following:

- **Poor survey coverage,** e.g. the fauna of an area has not been sampled extensively enough to enable assessment of species distributions. The absence of a species from survey records may not mean that it is absent from the area.
- **Poor taxonomic resolution,** e.g. a species has not been subject to systematic investigation, and/or the identity is either difficult or impossible to determine. Good taxonomic resolution does not necessarily need to be in the form of published revisions, as it can be facilitated by any of the following:
  - a researcher actively working on the group who can authorise identifications,
  - a publicly accessible reference collection, and/or;
  - assessment of species boundaries using genomic methods such as DNA barcoding (Hebert et al. 2003a; Hebert et al. 2003b).
- **Identification issues**, e.g. surveys sampled life stages of SREs that are impossible to identify based on morphological characters. Examples of relevant taxa include juvenile or female millipedes, mygalomorph spiders and *Urodacus* scorpions.

There are no published systems for assessing the SRE potential for a species. The W.A. Museum previously employed the following system to assess SRE-status of invertebrates:

- **Confirmed SRE:** This category applies when the identity of the taxon is unambiguous and its distribution is less than 10 000 km^2 based on publicly available vouchered records. Supporting data can be either genomic (from DNA sequences) or morphological, ideally both.
- **Potential SRE:** This category applies to situations where there are knowledge gaps for the taxon. The following sub-categories further elucidate this status:
  - **Data Deficiency (DD):** This category covers taxa for which there is insufficient data available to determine SRE status. Factors that fall under this category include:
    - insufficient geographic information (DDG),
    - insufficient taxonomic information (DDT), and/or
    - inappropriate life stages prevent identification to species level.
  - **Habitat Indicators (H):** This category employs habitat characteristics to evaluate SRE status when habitats are known to support SRE taxa. For example, many species sampled from subterranean habitats are known to be range restricted; a new species discovered from such habitat therefore has greater potential to be range restricted (i.e. a SRE) than widespread.

- **Morphological Evidence (M):** This category uses one or more morphological characters that are characteristic of SRE taxa inhabiting restricted environments, e.g. the specialised morphological features of animals adapted to subterranean habitats, including body markings that are absent or significantly paler than surface dwelling relatives, eyes that are absent or significantly reduced, and/or longer appendages (legs and antennae) than surface relatives.

— **Unpublished Research & Expertise (U):** This category relies on unpublished research or expertise to develop SRE status. **Widespread (not an SRE)**: This category applies when vouchered evidence demonstrates a distribution greater than 10,000 km^2.

TAXONOMY

The taxonomic nomenclature of invertebrates follows the references detailed in Table 2.2. Morphospecies designations follow the parataxonomy of the scientist(s) working on the group; these informal names are written between single quotation marks rather than being italicised as they are not valid under the International Code of Zoological Nomenclature (1999).

In defining morphospecies, Alacran follows the "Phylogenetic Species Concept" (Cracraft 1983):

> "A species is the smallest **diagnosable** cluster of individual organisms within which there is a parental pattern of ancestry and descent."

Morphological Identification (Traditional Taxonomy)

For this report, all identifications were carried out by the Dr Erich Volschenk. The references used for species determination are summarised in Table 2.2.

Table 2.1. The following references and collections were used to assist with morphospecies designations.

Order	Taxonomic reference	Morphospecies and reference
Pseudoscorpiones	(Harvey 1992; Murienne *et al.* 2008; Harvey 2012, 2013)	W.A. Museum reference collection.
Araneae (Mygalomorphae)	(Castalanelli *et al.* 2014; Rix *et al.* 2017; Harvey *et al.* 2018; Rix *et al.* 2018a; Rix *et al.* 2018b; Rix *et al.* 2018c)	WA Museum reference collection
Scorpiones	(Glauert 1925b, a; Acosta 1990; Kovařík 1997; Fet et al. 2000; Volschenk et al. 2000; Volschenk et al. 2008; Volschenk et al. 2010)	Morphospecies designation by Dr Erich S Volschenk, W.A. Museum reference collection.
Chilopoda	(Koch 1983b, a, c, 1984; Koch *et al.* 1984; Koch 1985; Colloff *et al.* 2005; Bonato *et al.* 2014)	W.A. Museum reference collection.
Eupulmonata	(Solem 1985, 1988, 1997; Whisson *et al.* 2012; Whisson *et al.* 2014; Stanisic *et al.* 2017)	W.A. Museum reference collection.

Isopoda	(Judd *et al.* 2003; Judd *et al.* 2013; Javidkar *et al.* 2015; Javidkar *et al.* 2016; Javidkar *et al.* 2017a; Javidkar *et al.* 2017b)	Dr Simon Judd Reference Collection

RESULTS

The collection contained 47 samples, representing 17 different taxa. Of these taxa, 20 belonged to SRE categories, two were widespread species and two were non-target species. One species was described formally (the introduced species *Porcellionides pruinosus*) and 16 were represented by morphospecies or ambiguous (sp.) identifications. A taxonomic summary of the SRE species (with corresponding SRE categories) are summarised in Table 1. The list of representative samples for this and the previous Atlas collections (Alacran 2021) are provided in Appendix 1.

Table 2. List of species present in this collection with assigned SRE categories.

CLASS	ORDER	FAMILY	SPECIES/morphospecies	SRE
Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius* sp.	Potential SRE: DDT
Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium* '8/4-Na01'	Potential SRE: DDT
Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium* '8/4-Na02'	Potential SRE: DDT
Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium* '8/4-Na03'	Potential SRE: DDT
Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium* '8/2-Na04'	Potential SRE: DDT
Arachnida	Pseudoscorpiones	Atemnidae	*Oratemnus* 'Na04'	Potential SRE: DDT
Arachnida	Pseudoscorpiones	Atemnidae	*Atemnidae* sp.	Potential SRE: DDT
Chilopoda	Lithobiomorpha		Lithobiomorpha sp.	Potential SRE: DDT
Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus* sp.	Potential SRE: DDT
Malacostraca	Isopoda	Philosciidae	*Laevophiloscia* 'sp. 1'	Potential SRE: DDT
Malacostraca	Isopoda	Philosciidae	Philosciidae 'sp. 1'	Potential SRE: DDT
Malacostraca	Isopoda	Porcellionidae	*Porcellionides pruinosus*	Widespread/Introduced
Gastropoda	Eupulmonata	Punctidae	*Westralaoma expicta*	Widespread

DISCUSSION

Species identifications and SRE justification for each taxon are discussed below.

ARACHNIDA

Pseudoscorpiones

Family Atemnidae

***Oratemnus* 'Na01' and Atemnidae sp.**

Two samples of *Oratemnus* 'Na01' were present in this collection as was a single sample of Atemnidae sp., a sample that could not be identified as it is juvenile. This family was absent from Alacran (2021). In the absence of clear species data, both of these taxa are potential SRE owing to taxonomic data deficiency. The relationship of these samples to one another as well as other species of Atemnidae from the region may be further resolved by analysing their DNA sequences.

Family Chthoniidae

***Austrochthonius* sp.**

A single sample of this taxon was present in this collection. The specimen is juvenile so species or morphospecies relationships could not be determined. Many undescribed species of Austrochthonius are known from W.A and three potential morphospecies were identified in Alacran (2021). Further relationships between those taxa and the specimen in this collection may be determined by analysing their DNA sequences.

Most *Austrochthonius* species appear to be relatively widespread and multiple species are also known to occur in sympatry; however, in the absence of more detailed taxonomic information about this specimen it is a potential SREs owing to taxonomic data deficiency.

Family Olpiidae

***Beierolpium* '8/4 Na01', *Beierolpium* '8/4 Na02', *Beierolpium* '8/3 Na01' and *Beierolpium* '8/2 Na04'**

Four putative species of *Beierolpium* were identified from this collection belonging to the '8/4' and '8/2' species groups. Each morphospecies was represented by a single sample. These groups are generally diagnosable based on trichobothrial patterns, and these led to the W.A. Museum's morphospecies notation of "8/4" , "8/2" etc. Assessment of the DNA sequences from specimens within these groups has revealed the presence of numerous undescribed species; therefore, what was thought to represent species is indicative of species complexes and species groups. Unambiguous species identification of *Beierolpium* species requires an assessment of their DNA sequences. The four morphospecies identified in this collection appear to be morphologically distinct. These four morphospecies are potential SRE's owing to taxonomic and geographical data deficiency. Greater taxonomic and geographical resolution will require assessment of the DNA sequences of these and other regional *Beierolpium* species.

Beierolpium '8/4 Na01' appears to be morphologically similar to *Beierolpium* 'CO1' in Alacran (2021). The relationship between these morphospecies should be verified by analysing their DNA sequences.

CHILOPODA

Lithobiomorpha

Lithobiomorpha sp.

Four samples of this order were present in the collection and are morphologically similar to *Lamyctes africanus*. No Lithobiomorpha are currently regarded as SRE however the taxonomy of this order is poorly known. They are cautiously considered potential SREs pending molecular review of the species in WA.

This taxon was also present in Alacran (2021) and its relationship with those samples should be explored using DNA sequences.

DIPLOPODA

Polydesmida

Family Paradoxosomatidae

***Antichiropus* sp.**

Five samples contained representatives of *Antichiropus*. Adult male specimens are required to identify *Antichiropus* specimens, but none were present in this collection. Further complicating matters is the regular occurrence of two or more species in sympatry. Most *Antichiropus* species appear to be SREs (Car *et al.* 2013; Car *et al.* 2014; Car *et al.* 2019). The only way to obtain identifications of these specimens is with the use of DNA sequences. This taxon is a potential SRE owing to taxonomic data deficiency and more than one species may be represented.

Alacran (2021) also contained unresolved specimens of *Antichiropus*. The only way to assess these samples is by comparisons of their DNA sequences.

MALACOSTRACA

Isopoda

Family Armadillidae

Buddelundia '7'

This morphospecies is known from the northern part of the Swan Coastal Plain (Perth area), the area of this study and possibly Geraldton. This is a **potential SRE** species since its wider distribution is yet to be confirmed. It is likely conspecific with *Buddelundia subinermis* Budde-Lund 1912, but further work is needed to confirm this.

Family Philosciidae

***Laevophiloscia* sp. 1**

This is a typical form of *Laevophiloscia* found in drier regions. The specimens in this batch were morphologically the same as those present in Alacran (2021). This morphospecies is a potential SRE owing to taxonomic data deficiency. Sequencing is the most cost effective and practical method of verifying the identity of Philosciidae.

Philosciidae sp. 1.

This is an unusual morphospecies of Philosciidae. The genus is unknown, but it is markedly different to *Laevophiloscia* and has highly distinctive dorsal setae. Specimens of this genus have been collected from northern parts of the Swan Coastal Plain and from the wetter areas of the Jarrah Forest. No morphological comparison with previous material was undertaken. Since the genus is known only from a few records in the areas stated, and it is unclear whether they are the same species. It is a potential SRE owing to taxonomic data deficiency. This species was also present in Alacran (2021) but was only identified as Philosciidae sp.

Family Porcellionidae

***Porcellionides pruinosus* (Brandt, 1833)**

This is the most widespread introduced species in Western Australia and has been collected previously from this area.

GASTROPODA

Eupulmonata

Family Punctidae

Westralaoma expicta

Three samples were identified to *Westralaoma* expicta. This is a widespread species found in the southern Murchison and through the WA Goldfields.

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Appendix 1 (attached file): 2136-B_Spectrum_Atlas_SRE-Data.xlsx

Alacran Environmental Science

Report No. 2144

Identification and SRE Assessment for Invertebrates from the Nambung Area

Prepared for

Spectrum Ecology

***Beierolpium* '8/2-Na05'**

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EXECUTIVE SUMMARY

Spectrum Ecology requested taxonomic identification and SRE assessment of a collection of invertebrates from Spectrum Ecology. Subsequently to scope was refined to specific comparisons and confirmation if the following morphospecies were present: *Beierolpium* '8/4-Na03', (BPS323); *Beierolpium* '8/2-Na04', (BPS325); and *Laevophiloscia* 'B24'

The collection contained 107 samples, comprising 20 different taxa belonged to SRE target groups. Of the target groups, a single species of *Beierolpium* was identified and three species of *Philosciidae* were present. The species in this collection could not be confirmed against the target samples based on morphology because both of these groups are taxonomically challenging and require species level identification to be verified with DNA sequences.

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SCOPE

Spectrum Ecology (Spectrum) requested identification of a collection of invertebrate samples from the Nambung area in Western Australia. Specific comparisons with the following morphospecies was requested:

- *Beierolpium* '8/4-Na03', (BPS323)
- *Beierolpium* '8/2-Na04', (BPS325)
- *Laevophiloscia* 'B24'

BACKGROUND

SHORT-RANGE ENDEMISM

Short-range endemics (SREs) are organisms with small geographic distributions (Harvey 2002; Ponder *et al.* 2002), nominally less than 10,000 km^2(Harvey 2002). These organisms are typically characterised by one or more of the following features:

- limited dispersal capabilities,
- seasonal activity (cooler or wetter periods),
- slow growth, and
- low levels of fecundity.

Their limited dispersal capabilities result in small populations being isolated from each other by inhospitable geographic features such as rivers, rocky ridges or plains. Prolonged isolation between populations eventually results in speciation, with each population becoming genetically and, or morphologically distinct over time. Two types of short-range endemism have been recognised: Relictual Endemism and Habitat Specialist Endemism (Harvey 2002; Ponder *et al.* 2002).

Relictual SREs result when speciation occurs following the fragmentation of continuous habitat into two or more refugia. In Australia, the primary driver of this over the last 65 million years has been aridification, which acted to isolate formerly widespread species living in mesic forests to small patches of mesic refugia. Relictual SREs include scorpions in the genus *Aops* (Volschenk et al. 2008), pseudoscorpions in the genera *Tyrannochthonius* (Harvey 1991; Edward et al. 2008), *Indohya* (Harvey 1993b; Harvey *et al.* 2007) and *Idioblothrus* (Muchmore 1982; Harvey 1993a; Harvey *et al.* 2008) and millipedes in the genus *Antichiropus* (Car *et al.* 2013; Car *et al.* 2014).

Habitat specialist SREs are species that have adapted to very specific environment types, including those found in arid environments (*e.g.* rocky outcrops, isolated dune systems and salt lakes). These habitats are often relatively young (<10 million years) and therefore are not refugial. Examples of habitat specialist SREs include spiders in the family Selenopidae, pseudoscorpions in the genus *Synsphyronus* (Harvey 2011, 2012), scorpions in the genera *Lychas* and *Urodacus* and tiger beetles in the genus *Pseudotetracha* (Lopez-Lopez et al. 2016)

METHODS

ASSESSMENT OF SHORT-RANGE ENDEMISM

Assessment of short-range endemism can be challenging when data for evaluation are absent or limited. Limitations may include any of the following:

- **Poor survey coverage,** e.g. the fauna of an area has not been sampled extensively enough to enable assessment of species distributions. The absence of a species from survey records may not mean that it is absent from the area.
- **Poor taxonomic resolution,** e.g. a species has not been subject to systematic investigation, and/or the identity is either difficult or impossible to determine. Good taxonomic resolution does not necessarily need to be in the form of published revisions, as it can be facilitated by any of the following:
  - a researcher actively working on the group who can authorise identifications,
  - a publicly accessible reference collection, and/or;
  - assessment of species boundaries using genomic methods such as DNA barcoding (Hebert et al. 2003a; Hebert et al. 2003b).
- **Identification issues**, e.g. surveys sampled life stages of SREs that are impossible to identify based on morphological characters. Examples of relevant taxa include juvenile or female millipedes, mygalomorph spiders and *Urodacus* scorpions.

There are no published systems for assessing the SRE potential for a species. The W.A. Museum previously employed the following system to assess SRE-status of invertebrates:

- **Confirmed SRE:** This category applies when the identity of the taxon is unambiguous and its distribution is less than 10 000 km^2 based on publicly available vouchered records. Supporting data can be either genomic (from DNA sequences) or morphological, ideally both.
- **Potential SRE:** This category applies to situations where there are knowledge gaps for the taxon. The following sub-categories further elucidate this status:
  - **Data Deficiency (DD):** This category covers taxa for which there is insufficient data available to determine SRE status. Factors that fall under this category include:
    - insufficient geographic information (DDG),
    - insufficient taxonomic information (DDT), and/or
    - inappropriate life stages prevent identification to species level.
  - **Habitat Indicators (H):** This category employs habitat characteristics to evaluate SRE status when habitats are known to support SRE taxa. For example, many species sampled from subterranean habitats are known to be range restricted; a new species discovered from such habitat therefore has greater potential to be range restricted (i.e. a SRE) than widespread.
  - **Morphological Evidence (M):** This category uses one or more morphological characters that are characteristic of SRE taxa inhabiting restricted environments,

e.g. the specialised morphological features of animals adapted to subterranean habitats, including body markings that are absent or significantly paler than surface dwelling relatives, eyes that are absent or significantly reduced, and/or longer appendages (legs and antennae) than surface relatives.

— **Unpublished Research & Expertise (U):** This category relies on unpublished research or expertise to develop SRE status. **Widespread (not an SRE)**: This category applies when vouchered evidence demonstrates a distribution greater than 10,000 km^2.

TAXONOMY

The taxonomic nomenclature of invertebrates follows the references detailed in Table 0.1. Morphospecies designations follow the parataxonomy of the scientist(s) working on the group; these informal names are written between single quotation marks rather than being italicised as they are not valid under the International Code of Zoological Nomenclature (1999).

In defining morphospecies, Alacran follows the "Phylogenetic Species Concept" (Cracraft 1983):

> "A species is the smallest **diagnosable** cluster of individual organisms within which there is a parental pattern of ancestry and descent."

Morphological Identification (Traditional Taxonomy)

For this report, all Isopods were identified by Dr Simon Judd and all remaining taxa were identified by Dr Erich Volschenk. The references used for species determination are summarised in Table 0.1.

Table 0.1. The following references and collections were used to assist with morphospecies designations.

Order	Taxonomic reference	Morphospecies and reference
Pseudoscorpiones	(Harvey 1992; Murienne *et al.* 2008; Harvey 2012, 2013)	W.A. Museum reference collection.
Chilopoda	(Koch 1983b, a, c, 1984; Koch *et al.* 1984; Koch 1985; Colloff *et al.* 2005)	W.A. Museum reference collection.
Diplopoda	(Framenau *et al.* 2008; Edward *et al.* 2010; Car *et al.* 2013; Car *et al.* 2014)	W.A. Museum reference collection.
Eupulmonata	(Solem 1985, 1988, 1997; Whisson *et al.* 2012; Whisson *et al.* 2014; Stanisic *et al.* 2017)	W.A. Museum reference collection.
Tricladida	(Cannon 1986; Winsor 2003; Sluys *et al.* 2009)	Alacran and Genbank DNA sequences

RESULTS

The collection contained 107 samples, comprising 20 different taxa belonged to SRE target groups. Of the target groups, a single species of Beierolpium was identified and three species of Philosciidae were present. The species in this collection could not be confirmed against the target samples based on morphology because both of these groups are taxonomically challenging and require species level identification to be verified with DNA sequences.

A taxonomic summary of the SRE species (with corresponding SRE categories) are summarised in Table 2. The list of representative samples for these taxa are provided in Appendix 1.

Table 2. List of species present in this collection with assigned SRE categories.

Order	Family	Species	SRE category
Pseudoscorpiones	Atemnidae	Atemnidae sp.	Potential SRE: DDT
Pseudoscorpiones	Chthoniidae	*Austrochthonius* sp.	Potential SRE: DDT
Pseudoscorpiones	Olpiidae	*Beierolpium* '8/4-Na05'	Potential SRE: DDG
Geophilomorpha	Geophilidae	*Sepedonophilus* sp.	Potential SRE: DDT
Geophilomorpha	Mecistocephalidae	*Mecistocephalus* sp.	Potential SRE: DDT
Geophilomorpha	Oryidae	*Orphnaeus* sp.	Potential SRE: DDT
Polydesmida	Paradoxosomatidae	*Antichiropus whistleri*	Widespread
Polydesmida	Paradoxosomatidae	*Antichiropus* sp.	Potential SRE: DDT
Isopoda	Amphisopodidae	*Paramphisopus palustris*	Potential SRE: DDG
Isopoda	Armadillidae	*Buddelundia* '7'	Potential SRE: DDT
Isopoda	Armadillidae	*Buddelundia cinerascens*	Potential SRE: DDT
Isopoda	Armadillidae	*Pseudodiploexochus* sp.	Potential SRE: DDT
Isopoda	Armadillidae	*Spherillo* '2'	Potential SRE: DDT
Isopoda	Philosciidae	*Laevophiloscia* 'Na01A'	Potential SRE: DDG
Isopoda	Philosciidae	*Laevophiloscia* 'Na01B'	Potential SRE: DDG
Isopoda	Philosciidae	Philosciidae '1'	Potential SRE: DDT
Isopoda	Styloniscidae	*Styloniscus* sp.	Potential SRE: DDT
Symphyla		Symphyla sp.	Potential SRE: DDT
Tricladida	Geoplanidae	Geoplanidae sp.	Potential SRE: DDT
Stylommatophora	Succiniidae	*Austrosuccinea* sp.	Potential SRE: DDT

DISCUSSION

Species identifications and SRE justification for each taxon are discussed below.

ARACHNIDA

Pseudoscorpiones

Family Atemnidae

***Oratemnus* sp.**

This taxon was represented by a single juvenile sample. The taxonomy of this genus (and family) is complicated, and several undescribed species are known in W.A. These include both widespread and SRE (potential SRE) species. Most unambiguous identifications of *Oratemnus* species require assessment of their DNA sequences owing to the poor state of their taxonomy. This is a potential SRE owing to taxonomic data deficiency. Greater taxonomic resolution and regional context may be achieved for this species following assessment of its DNA sequences.

Family Chthoniidae

***Austrochthonius* sp.**

This morphospecies was represented by 14 samples. The taxonomy of this group is unresolved and numerous undescribed morphospecies are known. Species level identity was not attempted since this genus was not among the targeted species to assess. Most *Austrochthonius* morphospecies appear to be widespread.

Family Olpiidae

***Beierolpium* '8/4-Na05'**

This morphospecies was represented by a single male specimen. This specimen closely resembles *Beierolpium* '8/4-Na02'; however, the taxonomy of Beierolpium is complicated by many undescribed species and this relationship would need to be explored using DNA sequence data.

This species does not resemble *Beierolpium* '8/4-Na03' morphologically and is unlikely to represent that species; however, this should be confirmed using DNA sequence data owing to the challenging morphological system of this genus.

The trichobothrial arrangement (8/4) indicates that *Beierolpium* '8/4-Na05' is a different species to *Beierolpium* '8/2-Na04', which has 8/2 trichobothrial arrangement.

CHILOPODA

Geophilomorpha

Family Geophilidae

***Sepedonophilus* sp.**

This taxon was represented by two samples. The taxonomy of this group is very poorly known and numerous undescribed morphospecies are known. Species level identity for W.A. representatives of this family can only be achieved with the aid of DNA sequences. Most W.A. *Sepedonophilus* morphospecies appear to be SREs.

Family Mecistocephalidae

***Mecistocephalus* sp.**

This taxon was represented by two samples. The taxonomy of this group is very poorly known and numerous undescribed morphospecies are known. Species level identity for W.A. representatives of this family can only be achieved with the aid of DNA sequences. Most W.A. *Mecistocephalus* morphospecies appear to be SREs.

Family Oryidae

***Orphnaeus* sp.**

This taxon was represented by two samples. The taxonomy of this group is very poorly known and numerous undescribed morphospecies are known. Species level identity for W.A. representatives of this family can only be achieved with the aid of DNA sequences. Most W.A. *Orphnaeus* morphospecies appear to be SREs.

DIPLOPODA

Polydesmida

Family Paradoxosomatidae

***Antichiropus whistleri* and *Antichiropus* sp.**

A single male specimen of *Antichiropus* was identified to *Antichiropus whistleri*, a widespread species (Car *et al.* 2013).

Antichiropus sp. was represented by 14 samples containing female and juvenile specimens. Species level identification is not possible for these samples; however, multiple species of *Antichiropus* can occur sympatricaly so it could not be assumed that they would all be *Antichiropus whistleri*. Female and juvenile Antichiropus specimens can only be determined by assessing their DNA sequences. This taxon is Potential SRE owing to taxonomic data deficiency.

MALACOSTRACA

Isopoda

All of the Isopod identifications for this report were undertaken by Dr Simon Judd. The descriptions provided below are based on his advice.

Family Amphisopodidae (Suborder Phreatoicidae)

***Paramphisopus palustris* (Glauert 1925)**

This is an aquatic species that is only known from the Swan Coastal Plain. It is likely to be SRE but typically not sampled since SRE surveys typically restrict surveying to terrestrial habitats.

Family Armadillidae

***Buddelundia* '7'**

This morphospecies is known from the Perth area of the northern part of the Swan Coastal Plain and the area of this study. This morphospecies may be conspecific with *Buddelundia subinermis* Budde-Lund 1912 described form the Geraldton area, but further work is needed to confirm this. This is a potential SRE owing to geographical data deficiency.

Buddelundia cinerascens

This species occurs in coastal limestone areas of the northern Swan Coastal Plain. Three additional species are described from such areas between Fremantle and Geraldton and the other two are *B. inaequalis* and *B. bipartita.* None of the three species can be determined from the literature and there is considerable morphological variation within sets of specimens of these species. Juveniles also look different to adults. The three species may be conspecific; however, more work is required to resolve this problem. The smaller specimens from this collection matched voucher specimens of *Buddelundia cinerascens* from Drovers Cave National Park which is 30-40 kilometres to the north of this study. This species is a potential SRE owing to taxonomic data deficiency.

Pseudodiploexochus sp.

This taxon was collected from two sites in damp areas. There were relatively large numbers of specimens collected. A single specimen (AES211150) was collected at another nearby location in Alacran project 2136. The specimens from this project were compared to this specimen and there are a number of small morphological differences indicating that they may be different species. Sequencing is recommended to inform this hypothesis. The genus is found all over southern W.A., but they are not common on the Swan Coastal Plain where they may be associated with Melaleuca wetlands and damplands. There is likely to be numerous SRE species (undescribed) in W.A. This taxon is a potential SRE owing to geographical data deficiency.

Spherillo '2'

This taxon is a species complex and occurs in the northern Jarrah Forest and northern Swan Coastal Plain regions. These would not determine these as *Spherillo* now; however, the name is used to preserve relationships with samples elsewhere (W.A. Museum) with this name. These specimens were typical of those found on the northern Swan Coastal Plain and matched AES 211157 from Alacran Project 2136 determined as *Spherillo* '2B'. Sequencing should be undertaken if greater resolution is required. This taxon is a potential SRE owing to taxonomic data deficiency.

Family Philosciidae

***Laevophiloscia* 'Na01A' and *Laevophiloscia* 'Na01B'**

Both of these morphospecies represent 'typical' forms of *Laevophiloscia* and the most common type of Philosciidae in the south-west. The taxonomy of this group is very poorly known. They must be sequenced for greater resolution. The males are morphologically different to the females, so it is not possible to know whether males and females present in the same sample are the same species. Two species were tentatively identified from this collection. No comparisons were made with previous since the only reliable means of determining species levels is by assessing their DNA sequences. Both of these morphospecies are potential SRE owing to taxonomic data deficiencies. Sequencing is the most cost effective and practical method to confirm a wider distribution should it be necessary.

Philosciidae '1'

This is an unusual morphospecies of Philosciidae and has also been referred to as Philosciidae 'S'. The genus is unknown, but it is markedly different to *Laevophiloscia* and has highly distinctive dorsal setae. Specimens of this genus have been collected from northern parts of the Swan Coastal Plain and from the wetter areas of the Jarrah Forest. No morphological comparison with previous material was undertaken since the genus is known only from a few records in the areas stated, and species boundaries are unresolved. This species is a potential SRE owing to taxonomic data deficiency.

Family Styloniscidae

***Styloniscus* sp.**

Styloniscus is a principally wet forest group of species likely to contain many cryptic SRE species. This form of *Styloniscus* (also referred to as *Styloniscus* '7') has a high potential for SREs (Judd & Horwitz, 2003). There is plenty of available comparable material from the south-west should sequencing be required. This is most likely the same species collected in Alacran Project 2129. The specimens here should be considered Potential SREs owing to taxonomic data deficiency. Representatives of Styloniscus are rarely found on the Swan Coastal Plain.

SYMPHYLA

Symphyla sp.

This taxon was represented by six samples. Symphylans are very poorly known taxonomically. Species determination of W.A. species requires assessment of DNA sequences. No attempt was made to identify these

samples to species level since they do not represent the target group and were not present in previous surveys of the area. This is a potential SRE owing to taxonomic data deficiency.

RHABDITOPHORA (FLAT WORMS)

Tricladida

Family Geoplanidae

***Geoplanidae* sp.**

This taxon was represented by a single sample. The W.A. fauna of Geoplanidae is very poorly known taxonomically. They possess biological characteristics (low vagility, and soft, wet bodies) which suggest that there are likely to be SRE representatives (Harvey 2002). This taxon is a potential SRE owing to taxonomic and geographical data deficiency.

GASTROPODA

Stylommatophora

Family Succiniidae

***Austrosuccinea* sp.**

This taxon was represented by six samples, representing 3 vials of dead shells and three vials with live preserved specimens. Species determination of most W.A. Succiniidae requires assessment of their DNA sequences Currently specimens represented by dead shells cannot be identified to species.

DISCUSSION

The primary focus of this study was to determine if any of the following species were present among the samples in this collection: *Beierolpium* '8/4-Na03', (BPS323), *Beierolpium* '8/2-Na04', (BPS325) or *Laevophiloscia* 'B24'. Only one specimen of *Beierolpium* was present in this collection and it could not be confidently matched with either for the above target species. *Beierolpium* taxonomy is extremely challenging and morphological assessments should always be verified using DNA sequences.

Species level assessment of Philosciidae is challenging and species determination should be based on DNA sequences. Isopods in this collection were identified to morphospecies level and representatives of *Laevophiloscia* 'Na01A' and *Laevophiloscia* 'Na01B' should be sequenced for comparison with *Laevophiloscia* 'B24'.

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Appendix 1 (Attachment) 2144-Spectrum-NambungSRE.xlsx