Subterranean Ecology Pty Ltd

Scientific Environmental Services

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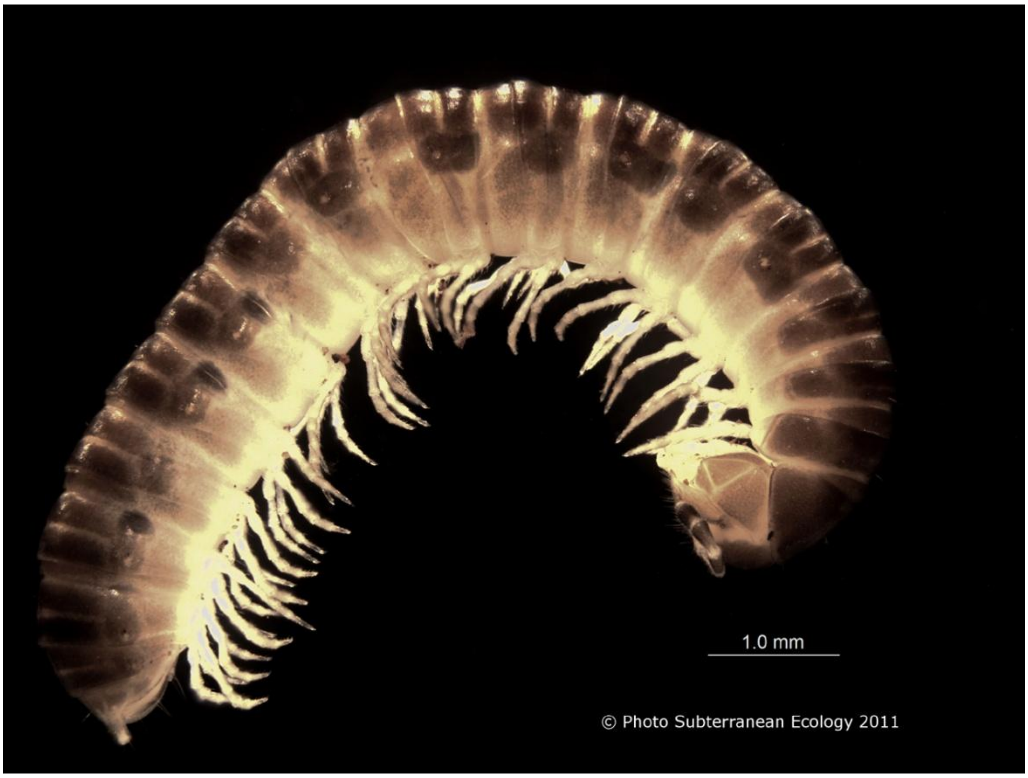
CHRISTMAS CREEK
LIFE OF MINE PROJECT

Terrestrial SRE Invertebrate Survey



Prepared for

Fortescue Metals Group Limited

16 July 2012

CHRISTMAS CREEK
LIFE OF MINE PROJECT
TERRESTRIAL SRE INVERTEBRATE SURVEY
FINAL REVISION 0

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Prepared for
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COVER: Juvenile specimen of *Antichiropus* sp. 'christmas', collected from Christmas Creek. Photo copyright Subterranean Ecology 2011.

LIMITATIONS: This survey was limited to the requirements specified by the client and the extent of information made available to the consultant at the time of undertaking the work. Information not made available to this study, or which subsequently becomes available may alter the conclusions made herein.

VERSION	PREPARED BY	REVIEWED BY	RECIPIENT	DATE
Rev B	S. Callan & S. Danti	R. Keogh (peer review)		15 June 2011
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Executive Summary

Fortescue Metals Group Ltd (Fortescue) proposes to expand its Chichester Hub mining operations in the Pilbara region of Western Australia. As part of the expansion, Fortescue has redefined the 'Life of Mine' (LOM) footprint of the Christmas Creek mine, approximately 110 km north west of the town of Newman. Subterranean Ecology was commissioned to conduct a survey (the Survey) for terrestrial short-range endemic (SRE) invertebrates for the Christmas Creek LOM Expansion Project (the Project). The aims and objectives of the Survey were to:

- Identify and describe prospective SRE habitats within the Survey area;
- Investigate the occurrence of SRE species via field sampling of prospective habitats;
- Identify all target SRE species and assess their conservation (SRE) status; and
- Describe potential impacts to SRE species and habitats which may arise from the Project.

The Survey was undertaken between March and April 2011 (end of wet season) utilising sampling methods such as wet pitfall trapping, active foraging and leaf litter / soil sifting. The sampling methods and survey design have met the recommendations of the EPA (2009) Guidance Statement 20 for terrestrial SRE invertebrates. Twenty-eight (28) sites were chosen for sampling, based on land systems, landforms, drainage, and vegetation types, with the aim of providing representation of potential SRE habitats throughout the Survey area. Within each site, prospective SRE micro-habitats such as leaf litter, tree bark, wood piles and debris, rock cracks and crevices, and rock piles, were targeted for sampling.

The main findings of the Survey were:

- Twenty-seven (27) target taxa from 6 invertebrate orders (spiders, pseudoscorpions, scorpions, myriapods, isopods and snails) were collected;
- Key habitats identified within the Survey area included drainage lines, floodplains, rocky hills and gullies, gorges, and to a lesser extent, isolated groves of Mulga vegetation;
- There is a high level of confidence in the faunal results, for the following reasons:
  - The Survey has met the recommendations of EPA (2009) Guidance Statement 20 for terrestrial SRE fauna;
  - The Survey achieved a high rate of detection, with 76% - 93% of the predicted species richness detected; and
  - The Survey achieved good coverage of vegetation types, land systems, drainage and landforms throughout the Survey area, excluding the Samphire flats surrounding Fortescue Marsh that were inaccessible due to flooding.
- The majority of taxa were widely distributed species (*i.e.* not SRE), that have been recorded outside of the Survey area;
- No conservation listed species were found (under relevant legislation);
- Two (2) species were of potential significance to the Project:
  - *Karaops* sp. 'christmas' (selenopid spider); a potential SRE species, which is also known to occur at Bonney Downs Station, outside of the Survey area to the immediate north; and

  - *Antichiropus* sp. 'christmas' (millipede); a likely SRE species found frequently in most of the habitat types present throughout the Survey area. This species has not been recorded outside of the Survey area to date;

- *Antichiropus* sp. 'christmas' was found in alluvial/ colluvial plains, gorges, rocky hills and gullies, Mulga vegetation groves, and drainage lines. These types of habitats are not locally restricted, and are well represented in the wider local area surrounding the Survey area. Although unconfirmed by sampling data, there is no reason to suggest that this species would not occur in these types of habitats, beyond the boundaries of the Survey area.

Table of Contents

List of Figures

List of Tables

List of Appendices

Glossary

Active foraging – sampling by actively searching (*i.e.* hand collection), using a targeted approach to collect specimens from prospective micro-habitats.

Bioregion – large, geographically distinct areas with similar geology, landforms, climate, and ecology. Australia's bioregions are described in the Interim Biogeographic Regionalisation for Australia (IBRA) (Environment Australia 2000).

Conservation significant - a species (or ecological community) accorded a special conservation status as listed under relevant legislation, due to the level of threat of extinction. This can include endangered, critically endangered, vulnerable and threatened species, species dependent on conservation programs or short-range endemic (SRE) species.

Conservation (SRE) status – status of a target species, in relation to whether it is considered short-range endemic. This is assessed based on the level of taxonomic resolution (certainty) and what is known of the distribution of the species and the tendency of the group to be short-range endemic.

Clade – a defined group within a cladogram (root and branch diagram) that may, at various scales, include closely related sister species, or similar haplotypes within a species (*i.e.* a single 'branch' on the genetic 'tree').

DEC — WA Department of Environment and Conservation

Dispersal limited – species with an inability to disperse widely; *i.e.* sedentary species, species with limited means of dispersal, or with particular micro-habitat requirements such as burrows.

Distribution range – the known spatial range of occurrence for a species or organism. Also 'distribution'.

Endangered — a native species is endangered if:

(a) It is not critically endangered; and,

(b) It is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria (*EPBC Act 1999*).

Endemic (Endemism) — the ecological state of being unique, or restricted, to a defined location such as an island, nation or any other pre-defined zone (Allen *et al.* 2002). Organisms are considered endemic to a place if they only occur in that place, and nowhere else.

EIA — Environmental Impact Assessment

EPBC Act 1999 — *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)

EPA — WA Environmental Protection Authority

EP Act 1986 — Environmental Protection Act 1986 (WA)

km / km^2 – Kilometres / square kilometres

Land System – an area or group of areas throughout which there is a recurring pattern or similarity of broad terrestrial environmental characteristics. Land Systems throughout WA were broadly mapped by Van Vreeswyk and WA Dept of Agriculture 2004, based on landforms, soil types and vegetation associations.

Life of Mine (LOM) footprint — The anticipated spatial area of physical disturbance during the currently anticipated economic life of the resource for a project.

Micro-habitat – small scale habitat within larger habitat types utilized by particular species or types of species. For SRE taxa micro-habitats can include leaf litter, wood piles and woody debris, rock cracks and crevices, the undersides of bark, and burrows.

Morphology – the physical features or structures which distinguish one organism from another.

Morpho-species — species distinguished from others only by observable morphology. This designation is typically used during parataxonomic sorting for specimens in unsuitable condition for taxonomic characters to be observed, for new / undescribed organisms, or for organisms where the taxonomic knowledge is insufficient or non-existent.

Parataxonomy — sorting of specimens into recognizable taxonomic units (*e.g.* higher taxonomic levels such as family or order, or morpho-species) based upon morphology, without the use of taxonomic keys or expert knowledge.

Prospective habitat – habitat considered suitable for specific types or groups of taxa.

Range-restricted – species only known from, or known to be limited to, a certain, narrow range (*i.e.* not widespread). This term has the same intent as 'short-range endemic', but is not contingent upon a particular range criterion.

Short-range Endemic (SRE) — SRE species have highly restricted distribution ranges, therefore endemic to relatively small or localised areas. Harvey (2002) proposed a distribution range criterion (nominal limit) of < 10,000 square kilometres (km^2) for SRE invertebrates, while Eberhard *et al.* (2009), proposed a distribution range criterion of < 1,000 km^2 for SRE stygofauna. The occurrence of SRE species (as defined by distribution range criteria) has recently emerged as a potential issue for Environmental Impact Assessment in Western Australia (EPA 2009).

Species accumulation curve – The plot of the cumulative number of species, collected against a measure of the sampling effort.

Species richness – the number of species recorded in a given area.

SRE status categories – categories designed to clarify the current status of individual target SRE taxa. In some instances it is not yet clear whether a species is or is not SRE. In these cases it is useful to use categories such as 'likely SRE' or 'potential SRE' to indicate the degree to classify the likelihood that these species might be SRE (Refer Section 3.5).

Target SRE taxa – Higher taxonomic groups that are known to contain SRE species (*e.g.* Mygalomorphae, Pseudoscorpiones, Scorpiones *etc*). Not all of the species within these taxa are necessarily SRE, although these are generally the taxonomic groups targeted for sampling.

Survey area – the area outlined by the proponent as being the location / boundary inside which the survey is intended to occur.

Sub-regional search area – the area, surrounding the survey area, used to search for previous records of SRE fauna.

Taxonomy – the science of identifying, grouping and naming organisms according to the closeness of their natural / evolutionary relationships.

WAM – Western Australian Museum

WA – Western Australia

1 INTRODUCTION

Fortescue Metals Group's (Fortescue) Christmas Creek mine is located in the Pilbara region of Western Australia and is approximately 110 km north-west of the town of Newman (Figure 1). Fortescue proposes to expand its Chichester Hub mining operations at Christmas Creek. The combined production rate of the Chichester Hub is currently approximately 55 Mtpa, with a medium term expansion target of 95 Mtpa.

As part of the proposed expansion of the Christmas Creek mine, Fortescue commissioned Subterranean Ecology to conduct a survey (the Survey) for terrestrial short-range endemic (SRE) invertebrates for the Christmas Creek Life of Mine (LOM) Expansion Project (the Project). The Survey included field sampling and habitat assessment of areas of relevance to the Project.

1.1 Aims and Objectives

The primary objective of the Survey was to investigate the occurrence of SRE invertebrate species and habitats within the Survey area using existing information and field sampling, to meet EPA (2009) requirements for a level 2 (baseline) survey. The specific aims of the Survey were to:

- Identify and describe prospective SRE habitats within the Survey area;
- Investigate the occurrence of SRE species via field sampling of prospective habitats;
- Identify all target SRE species and assess their conservation (SRE) status; and
- Describe potential impacts to SRE species and habitats which may arise from the Project.
- Investigate the degree to which the target species and habitats found within the Survey area are known occur / extend outside of the Survey area.

1.2 Location and Survey Area

The Survey area for the Project is located in the Fortescue Plains and is immediately adjacent to the north eastern margin of Fortescue Marsh, approximately 140 km south of the town of Marble Bar and 110 km north west of Newman (Figure 1).

The Survey area covers approximately 49,000 ha, extending from the foothills of the Chichester Ranges in the north, to the fringe of Fortescue Marsh in the south (Figure 1). The Survey area ranges east-west over approximately 35 km, between the Newman- Marble Bar Road to the east and Fortescue's Cloudbreak mine to the west.

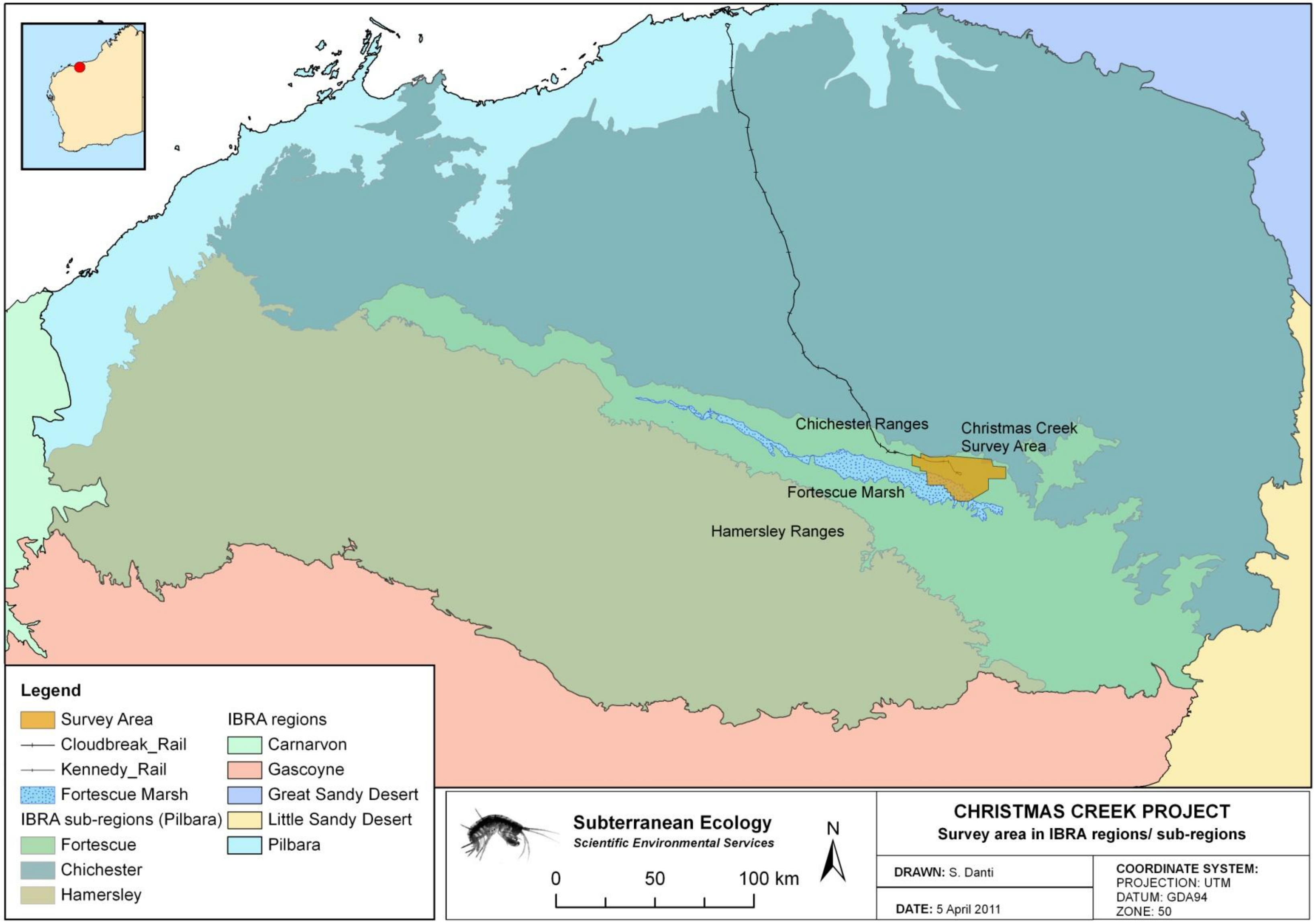


Figure 1. Location map of the Christmas Creek survey area, within IBRA sub-regions

2 LEGISLATIVE FRAMEWORK

In undertaking an Environmental Impact Assessment (EIA) of proposed developments, the Environmental Protection Agency (EPA) and Department of Environment and Conservation (DEC) are required to meet the following objectives in regard to terrestrial SRE fauna:

> *...to ensure the protection of key habitats for SRE species; maintain the distribution, abundance and productivity of populations of SRE taxa; and ensure that the conservation status of SRE taxa is not adversely changed as a result of development proposals* (EPA 2009).

Consideration is given to relevant State and Federal legislation, including (but not limited to):

- *Environmental Protection Act 1986* (*EP Act 1986*) (WA);
- *Wildlife Conservation Act 1950* (*WC Act 1950*) (WA); and
- *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act 1999*) (Commonwealth).

Some terrestrial invertebrate species are listed as threatened, vulnerable or endangered under State or Federal legislation, including:

- Species and Threatened Ecological Communities listed under the *EPBC Act 1999*;
- Scheduled species listed under *WC Act 1950*; and
- Threatened or Priority Ecological Communities as listed by the DEC.

However, the majority of SRE species have no specific legislative protection, due to a lack of taxonomic and ecological knowledge. The assessment of conservation status / SRE status for target species in this Survey follows a precautionary approach which aligns with the intent of the *EP Act 1986.* The designation of conservation significance for SRE species and habitats was not limited to listed or protected species only.

The Survey design and methods were developed to meet the following EPA guidelines:

- **EPA (2009) Guidance Statement No. 20** – Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia;
- **EPA (2004) Guidance Statement No. 56** – Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia; and
- **EPA (2002) Position Statement No. 3** – Terrestrial Biological Surveys as an element of biodiversity protection.

3 SHORT-RANGE ENDEMISM

3.1 Definitions and Criteria

Endemism is the ecological state of being unique, or restricted, to a defined location (such as an island, nation or any other pre-defined zone) (Allen *et al.* 2002). Organisms that are indigenous (or native) to a location are not necessarily endemic if they are also found widely elsewhere (Raven and Stumkat 2005). Endemism is intrinsically linked to a species' distribution range; the area within which a species has been recorded, or is known to occur.

SRE species have highly restricted distribution ranges, and are therefore endemic to small or localised areas. Harvey (2002) proposed distribution ranges of < 10,000 km^2 as a criterion for short-range endemism. Eberhard *et al.* (2009), suggested < 1,000 km^2 may be a more suitable threshold for SRE stygofauna (aquatic subterranean fauna).

Range-restricted or dispersal-limited species often share similar biological, behavioural and life-history traits that form the basis for short-range endemism. SRE species are generally sedentary and have limited means of dispersal, or occupy small, fixed home territories and micro-habitat niches (*e.g*. burrows and under logs). SRE species are often long-lived, active only during certain seasons or in certain conditions (*e.g*. following rainfall), and have low growth rates and low fecundity, compared to the more wide-ranging species (Harvey 2002). Many SREs are relictual species that are now confined to fragmented, restricted and isolated habitats or micro-habitats where suitable environmental conditions persist.

Due to these behavioural and life-history traits, SRE fauna may be at greater conservation risk as a result of threatening processes (Harvey 2002, EPA 2009). Localised and / or isolated habitats are considered more vulnerable to impacts than widespread or continuous habitats. Impact assessment of SRE species requires assessment of the potential distribution range and prospective habitats of the species, relative to potential impact areas. The understanding of Western Australia's SRE invertebrate fauna is still in development; therefore assessment of SRE status is often putative, dependent upon advice from taxonomic specialists and information regarding closely related taxa.

3.2 Origins and Processes

It is thought that many Western Australian SRE invertebrates have Gondwanan origins; relictual taxa that were previously more widespread throughout the great southern continent. The separation and northward drift of the Australian continent (*ca.* 80-40 mya) following the break-up of Gondwana, resulted in changes to climate and sea levels. Increasing aridity and intensification of seasonality resulted in the fragmentation and retreat of mesic terrestrial habitats in Archean Western Australian landscapes such as the Pilbara (Hill 1994).

Currently, mesic habitats in the Pilbara are generally scarce, fragmented, isolated, and characterised by shade and soil types which allow moisture to persist after rainfall (Harvey 2002). Relictual taxa are able to persist by occupying micro-habitat niches (*e.g.* burrows, caves, rock piles), within such habitat remnants. Such species exhibit highly restricted ranges and very particular habitat requirements which have limited their potential to occur widely (Harvey 2002). Habitat fragmentation, isolation, and poor dispersal powers have promoted speciation and differentiation within these range-restricted, relictual taxa (Ponder and Colgan 2002).

3.3 Target SRE Taxa

Based on current knowledge (broadly following Harvey 2002 and EPA 2009), the main invertebrate taxa that are known to include terrestrial SRE species in the Pilbara region are:

- Terrestrial molluscs (Pulmonata);
- Millipedes (Diplopoda);
- Spiders (particularly Mygalomorphae, plus certain other taxa such as Selenopidae);
- Scorpions (Scorpiones);
- Pseudoscorpions (Pseudoscorpiones); and
- Terrestrial slaters (Isopoda).

These taxonomic groups, henceforth referred to as 'target SRE taxa', formed the subject of the current Survey. The above list is indicative only and is based on current knowledge, which is still in development. Not all of the species within these groups are considered SRE by default; SRE status is assessed on a case by case basis, following advice from taxonomic specialists where necessary. A detailed description of the SRE status categories used in the Survey is given in section 3.5.

3.4 Target SRE Habitats

Terrestrial SRE invertebrate species (excluding subterranean fauna) are often found to inhabit:

- Mountainous terrains including rocky outcrops, mesas, breakaways, gullies, gorges and sheltered slopes (*e.g*. south facing) (EPA 2009; Harvey 2002);
- Sheltered / protected vegetation types receiving run-off or capable of storing soil moisture (Morton *et al.* 1995);
- Forest / Rainforest patches and isolated groves of dense, shady vegetation;
- Freshwater habitats (*e.g.* ephemeral or permanent rivers, streams, pools, springs, and wetlands) (Ponder and Colgan 2002); and
- Islands (*e.g.* Barrow Island) (Morton *et al.* 1995).

Within these broad landscape-scale habitat types, there are a variety of micro-habitats which may be inhabited by SRE species. Such micro-habitats generally include:

- Deep, moist leaf litter and soil;
- Fallen logs, bark and woody debris;
- Rock piles, stone piles, and scree;
- Rocky outcrop, caves, cracks and crevices; and
- Various soil types that can support invertebrate burrows.

These micro-habitats can occur in relatively widespread or continuous landscapes, although more restricted or fragmented habitat types would be expected to be more conducive to short-range endemism, as described above in sections 3.1 and 3.2.

3.5 SRE Status

The categories below were applied to target SRE taxa in relation to their SRE status, based on current knowledge and advice from taxonomic specialists. For consistency, the categories broadly follow Ecologia's (2010a) SRE survey for the Cloudbreak Project, as follows:

- **Not SRE** – species is not considered a SRE;
- **Confirmed SRE** – identification well-resolved, species is considered a SRE;
- **Likely SRE** – taxon belongs to a known SRE group or highly likely to be a SRE, but status cannot be confirmed based on current knowledge (*e.g.* unidentifiable juveniles of SRE taxa);
- **Potential SRE** – identification or distribution range is poorly resolved, but there is a possibility that the taxon may be a SRE (*e.g.* family-level morpho-species, singletons).

4 REVIEW OF EXISTING KNOWLEDGE

There have been several previous SRE surveys conducted in the local / sub-regional area of the Project. There has been a desktop assessment of SRE fauna at the Christmas Creek Mine (Ecologia 2010a), and a desktop assessment and multiple field surveys at the Cloudbreak mine, approximately 40 km to the east (Biota 2005b, Ecologia 2010b, 2011, Harvey 2006). The nearby Roy Hill mine (operated by Roy Hill Iron Ore Pty Ltd), located approximately 35 km to the south of Christmas Creek, has also been surveyed (Ecologia 2006, 2008). The Fortescue Marshes / Eastern Chichester ranges were sampled for terrestrial invertebrates as part of DEC's Pilbara Regional Biodiversity Surveys 2002-2007 (Volschenk *et al.* 2010, Durrant *et al.* 2010). A brief synopsis of the key results of these investigations follows:

Christmas Creek Desktop Assessment (Ecologia 2010a)

- A search of WA Museum (WAM) invertebrate databases was conducted for the local / sub-regional area surrounding the Project. (22°55'08" S to 22°54'32" S and 118°48'40" E to 120°02'52" E);
- At the time of the search, the WAM databases contained records of:
    - two confirmed SRE taxa; *Synsphyronus gracilis* (pseudoscorpion) and *Antichiropus sp.* (millipedes);
    - 25 potential SRE taxa, including mygalomorph spiders, scorpions and snails;
- Four (4) broad habitat classes were identified, based on landforms and broad vegetation types (spinifex hills, Mulga shrubland, creeklines, and halophytic shrubland) (refer Figure 2 from Ecologia 2010a);
- The majority of SRE / potential SRE species were known to occur in spinifex hills and drainage line habitats in the nearby local area;
- Environmental degradation by fire and pastoralism (grazing) was seen as a possible reason for low capture rates of SRE invertebrates in the nearby local area; and
- It was recommended that field surveys should be conducted to collect representative target SRE taxa in order to obtain information regarding distribution and habitat associations.

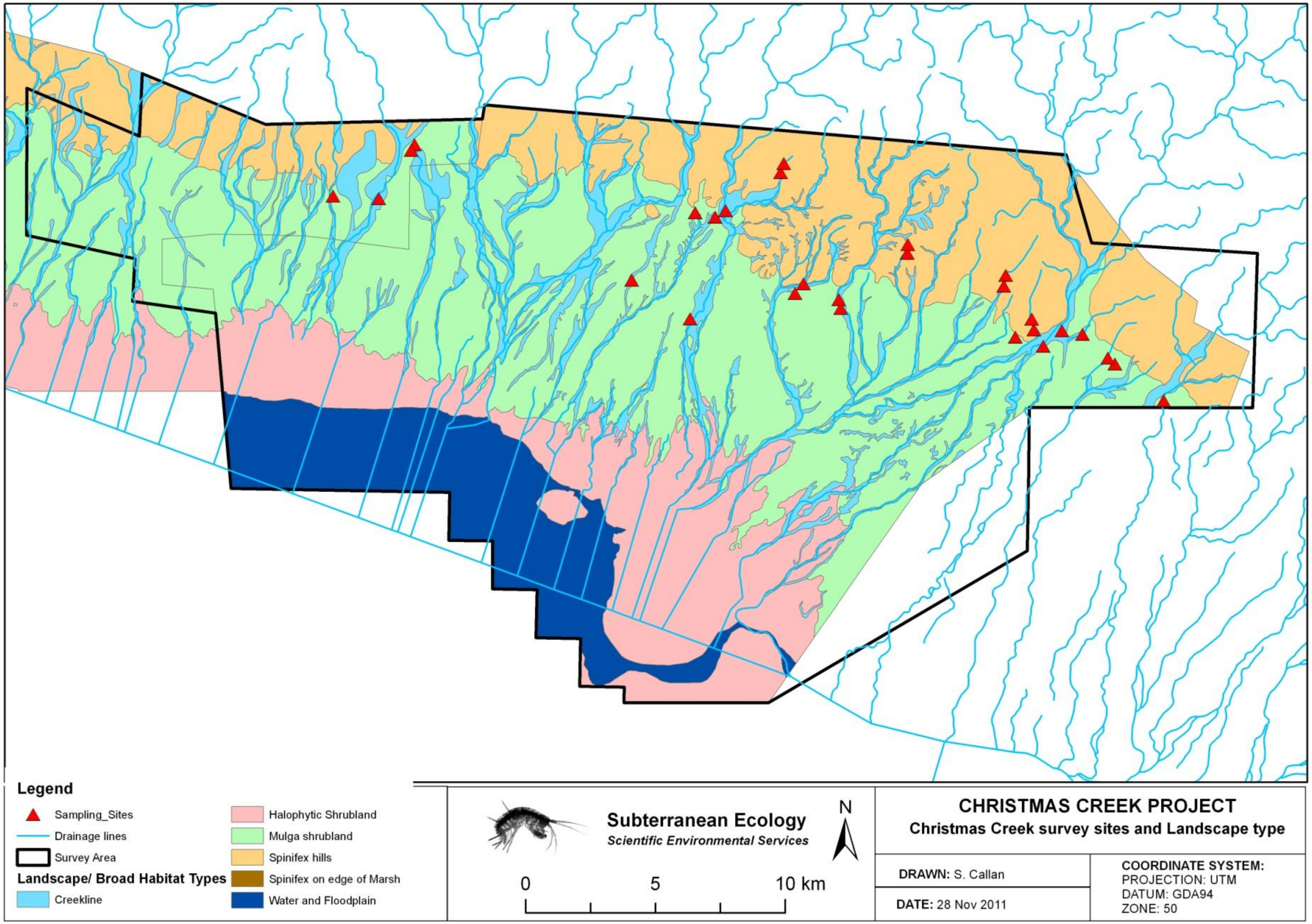


Figure 2. Sampling sites for the current Survey, in relation to broad, landscape-scale SRE habitat types, as defined by Ecologia 2010a

Cloudbreak Desktop Assessment and SRE Survey (Ecologia 2010b, 2011)

- Sampling was conducted in November utilising pitfall trapping and litter extraction;
- Broad habitat types sampled included creek lines, Spinifex-covered hills, snakewood and Mulga woodland, hummock grassland fringing Fortescue Marsh, and halophytic shrubs (these broadly align to similar habitats at Christmas Creek, refer Figure 2);
- 26 target species were collected from 685 specimens (including spiders, pseudoscorpions, scorpions, myriapods, isopods);
    - one species of confirmed SRE (*Antichiropus* sp. 'Cloudbreak', recorded from creek line);
    - one species of likely SRE (*Linnaeolpium* sp., recorded from woodland);
    - five species of potential SRE (*Conothele* sp., *Aname* sp. 'MYG001', *Urodacus* sp., *Austrohorus* sp., and *Beierolpium* sp. 8/2);
- Analyses showed no relationship between broad scale habitats and SRE distribution. The effects of microhabitats were unable to be analysed with the available information; and
- All habitat types present within the impact area were considered likely to extend outside the impact area.

FMG Stage B Fauna Survey (Biota 2005b)

- SRE sampling conducted in April 2005 utilising pitfall trapping, foraging and litter sifting;
- Fauna habitat classification was based upon land systems and vegetation types;
- Two potential SRE mygalomorph spiders (*Aganippe* sp. and *Synothele* sp.) were recorded from hill slopes and stony plains; and
- The remaining invertebrates collected were not considered to be SRE species.

Roy Hill Iron Ore Mine SRE Surveys (Ecologia 2006, 2008)

- Initial sampling was conducted in June 2006, utilising pitfall trapping and foraging methods;
- Three habitat types were sampled, including drainage lines, southern facing slopes and Mulga plains;
- Ten target species collected, no confirmed SRE species;
- Additional SRE sampling in October 2008 by foraging in creek lines;
- One potential SRE species was recorded (*Conothele* sp.); and
- Further sampling was recommended in order to confirm the SRE status of *Conothele* sp.

The above studies confirm that a number of SRE species are known to occur in the local / sub-regional area of the Project. The key habitats for target SRE species in the local area include drainage lines, slopes and outcrop, gullies and gorges, and dense vegetation groves (*e.g.* Mulga groves). Although the occurrence of suitable SRE micro-habitats within each of the broader habitat types was noted, there was no statistically significant relationship between SRE species and broad habitat type in the Cloudbreak SRE survey (Ecologia 2011). Taxa that would be expected to occur within the Survey area include the regular target SRE taxa known from the region (*i.e.* mygalomorph spiders, pseudoscorpions, scorpions, millipedes, and snails). Following the EPA (2009) Guidance, sampling within prospective SRE habitats via pitfall trapping, active foraging and leaf litter sifting would be suitable for detection of these taxa.

4.1 Conservation Significant Fauna

A search of DEC Declared Threatened Fauna lists and the Notices of the *WC Act 1950* (DEC 2010) found no listed terrestrial invertebrate species from within the Survey area (Ecologia 2010a). Ecologia (2010a) found that Fortescue Marsh may contain prospective habitat for the following three invertebrate species, which are listed by DEC as Priority 2 Priority Fauna species occurring in the Pilbara region;

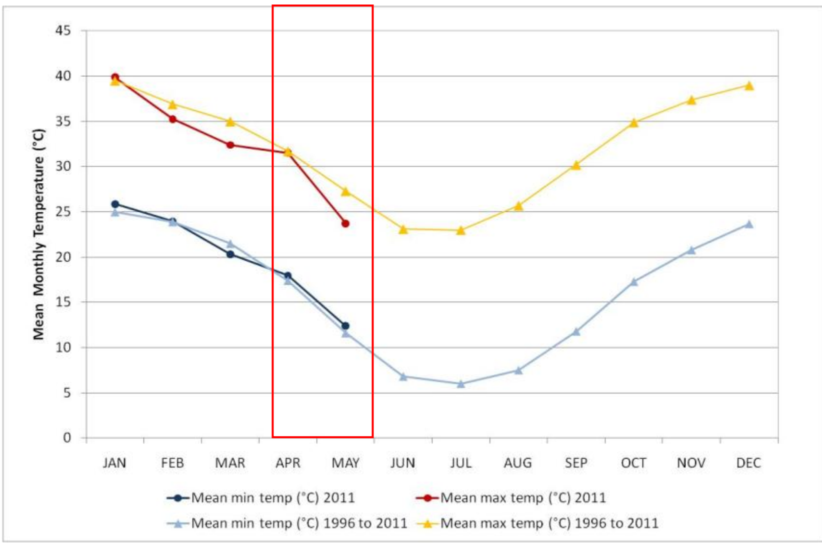
- *Antipodogomphus hodgkini* (dragonfly);
- *Nosostica pilbara* (dragonfly); and
- *Dupucharopa millestriata* (snail).

Although the two dragonfly species, *A. hodgkini* and *N. pilbara,* are associated with the springs and streams of the Fortescue river basin (Watson 1974), they do not belong to typical SRE taxa (as defined in Harvey 2002). While it may be possible that these species occur at Fortescue Marsh, they would not be expected to be restricted to the Survey area. In addition, the type locality for the snail (*D. millestriata*) is Dupuch Island, off the northern Pilbara coast, and to date it has not been recorded from Fortescue Marsh (C. Whisson, WAM pers. comm. 2011). Despite the potential occurrence of suitable habitat for these Priority 2 Fauna species at Fortescue Marsh, their presence within the Survey area has not been confirmed by collection records, and as such, they are not considered to be of relevance to the current assessment.

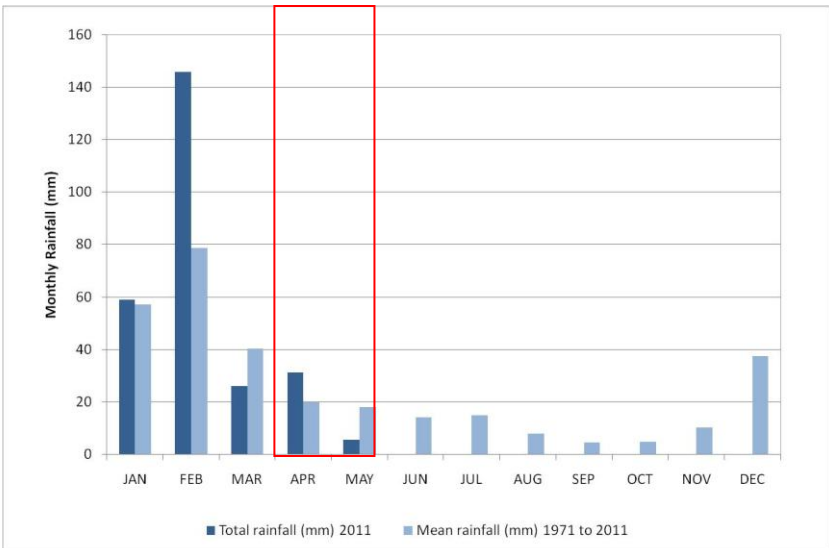
5 SURVEY AREA

5.1 Climate

The Project area experiences a semi-tropical, arid climate with hot, humid summers and mild, dry winters (Beard 1975). Average annual rainfall is approximately 312 mm, as measured at Newman airport, approximately 110 km to the south. Figure 3 shows the mean monthly temperatures (A) and mean rainfall (B) for the period 1971-2011, compared to observations from January to May 2011 (data from Bureau of Meteorology (BOM) 2011).



(A)



(B)

Figure 3. Long-term climate statistics for Newman Airport (1971-2011), plotted against monthly observations from Jan- May 2011; A) max. and min. temperatures (°C), and B) mean rainfall (mm) (BOM 2011). Dark colours represent 2011 observations. The survey period is indicated by red boxes.

Rainfall in the semi-arid Pilbara region is irregular and average annual evaporation (approximately 2,500 mm) exceeds average annual rainfall in most years (Australian Natural Resources Atlas 2010, Beard 1975). In these arid environments, SRE species are limited to cool, moist, sheltered micro-habitats for most of the year (Harvey 2002). However, periods of humid weather before and after significant rainfall events (such as tropical storms and cyclones), can produce optimal conditions for invertebrate activity, allowing SRE species to become more active on the surface, and triggering foraging and reproductive behaviours (Harvey 2002).

Weather conditions at the time of the survey and in the months preceding were optimal for SRE invertebrate activity and sampling. Figure 3(b) shows that the summer months (Jan-Apr) received above average rainfall, and temperatures were warm, within the average temperature range. The Survey commenced in April, at the end of an exceptionally wet summer, which produced high productivity in the vegetation and high invertebrate activity levels (personal observations). Prior to retrieval of pitfall traps in April, steady rainfall occurred over two consecutive nights (approx. 4 mm recorded at Newman Airport) (BOM 2011). The majority of foraging took place when conditions were humid, overcast and warm (average temperatures 19-30°C), which is likely to have produced high activity levels of most target SRE taxa.

5.2 Biogeography

The Interim Biogeographic Regionalisation for Australia (IBRA) positions the survey area in the Fortescue Plain subregion of the Pilbara bioregion, which covers approximately 11 % of the Pilbara region (refer Figure 1) (Thackway and Cresswell 1995). The northern boundaries of the survey area run along the edge of the Chichester subregion and are characterised by steep ridges and gorges that contain Archean granite, basalt and Banded Iron Formations (BIF). The southern section of the survey area is characterised by vast arrays of alluvial plains which extend from drainage lines surrounded by River Gum / Coolibah (*Eucalyptus camaldulensis and E. victrix*) woodland (Ecologia 2010a).

5.3 Land Systems

Land systems represent broad-scale characteristic landforms incorporating geomorphology, soil and vegetation types. Nine land systems occur within the survey area; Newman, McKay, Boolgeeda, Jamindie, Turee, Cowra, Warri, Calcrete and Marsh (Figure 4) (Van Vreeswyk and Western Australia Dept. of Agriculture 2004). Six of these land systems are well represented in the Pilbara region with less than 10% of their total area occurring within the survey area (Table 2) (ENV 2010). The remaining three land systems (Turee, Cowra, and Marsh) have less than 30% of their total area occurring within the survey area (Table 1). These consist of Spinifex (*Triodia* spp.) tussock grassland, Mulga (*Acacia aneura*) shrubland / woodland and halophytic vegetation that fringes Fortescue Marsh.

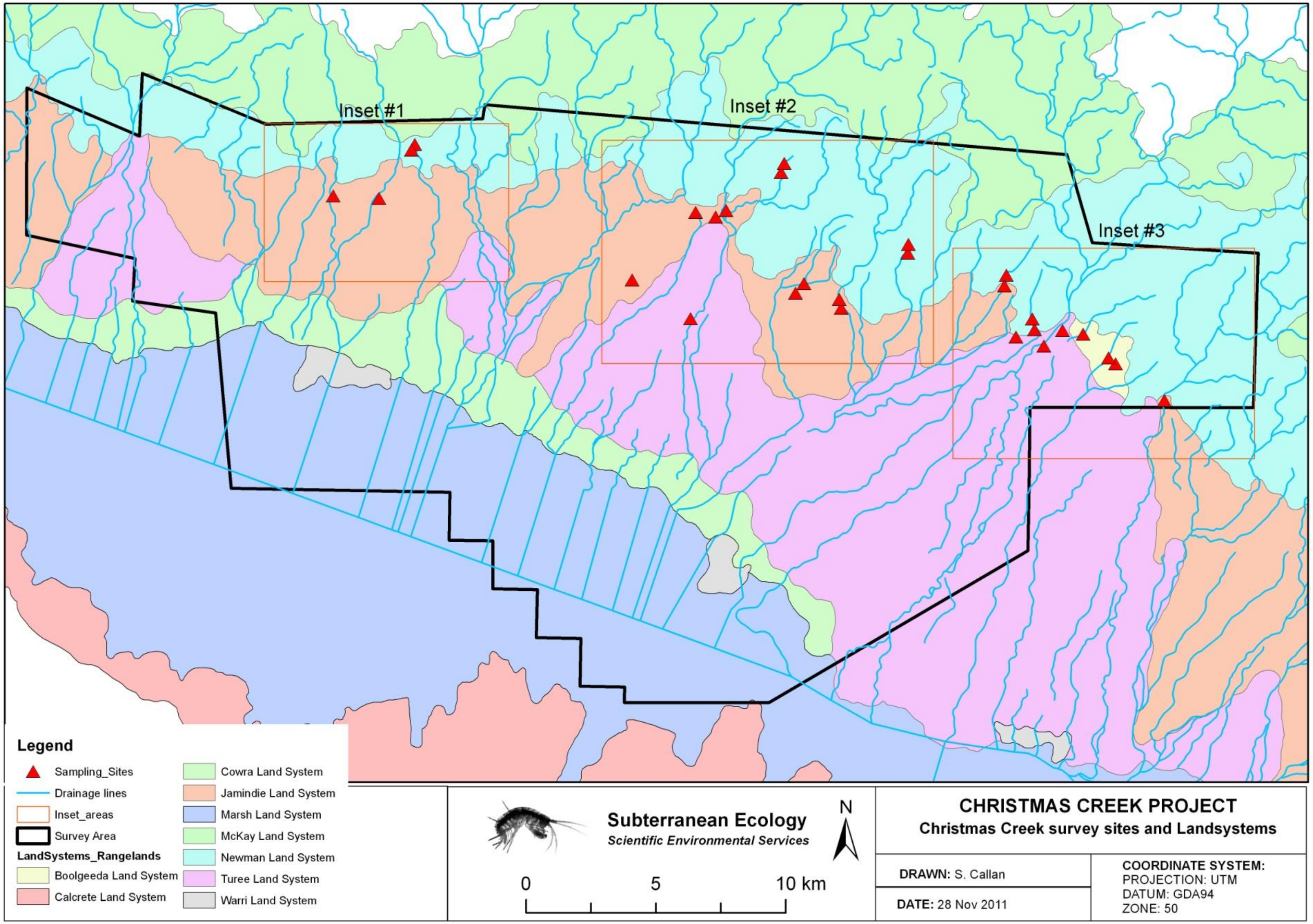


Figure 4. Land systems in the Christmas Creek survey area.

Table 1. Description of land systems and their areas in the Christmas Creek survey area (ENV 2010)

Land system	Description	Area in Survey area (km²)	% of total area occurring in Survey area
Newman	Rugged jaspilite plateaux, ridges and mountains supporting hard Spinifex grasslands	145.54	1.00%
McKay	Hills, ridges, plateau remnants and breakaways of meta sedimentary and sedimentary rocks supporting hard Spinifex grasslands	21.49	0.51%
Boolgeeda	Stony lower slopes and plains below hills systems supporting hard and soft Spinifex grasslands and Mulga shrublands	4.06	0.05%
Jamindie	Stony hardpan plains and rises supporting groved Mulga shrublands, occasionally with Spinifex understory	139.85	6.74%
Turee	Stony alluvial plains with gilgaied and non-gilgaied surfaces supporting tussock grasslands and grassy shrublands	166.11	28.59%
Cowra	Plains fringing the Marsh land system and supporting snakewood and Mulga shrublands with some halophytic undershrubs	47.7	23.53%
Warri	Low calcrete platforms and plains supporting Mulga and cassia shrubs	6.75	2.21%
Calcrete	Low calcrete platforms and plains supporting shrubby hard Spinifex grasslands	0.02	0.001%
Marsh	Lakebeds and floodplains subject to regular inundation, supporting Samphire shrubland, saltwater couch grasslands and halophytic shrubland	126.43	12.94%

5.4 Vegetation

The vegetation and flora of the Survey area was characterised by ENV Australia (ENV 2010), building on previous survey work undertaken by Mattiske (2005, 2007) and Biota (2004, 2005a). ENV Australia (2010) found four broad floristic formations corresponding to landforms that occur throughout the Survey area:

- Creeks and Drainage lines (vegetation types 1, 2 and 8), covering approx. 13% of Survey area;
- Ranges, Hills and Hill Slopes (vegetation types 16 and 17), covering approx. 33% of Survey area;
- Flats and Broad Plains (vegetation types 3, 4, 10 and 30), covering approx. 12% of Survey area; and
- Fringes of Samphire Flats (vegetation types 13, 22, 26, 31, 32, 33, 34 and 35), covering approx. 32% of Survey area;

The remaining 10% of the Survey area comprised bare ground, infrastructure or burnt areas (ENV 2010). Table 2 contains a detailed description of the vegetation types defined by ENV (2010).

Table 2. Vegetation units found in the Christmas Creek survey area (ENV 2010).

Vegetation unit	Description (from ENV 2010)
Creekline and Drainage Lines	
1 ^	Open Woodland of *Eucalyptus victrix*, *Eucalyptus camaldulensis* with pockets of *Acacia coriacea* subsp. *pendens* over *Grevillea wickhamii* subsp. *aprica*, *Petalostylis labicheoides*, *Acacia tumida* over *Triodia longiceps*, *Chrysopogon fallax*, *Themeda triandra* and *Aristida* species.
2	Low Woodland to Low Open Forest of *Acacia aneura* var. *aneura*, *Acacia* cit *rinovirirdis*, *Acacia pruinocarpa* over *Acacia tetragonophylla* and *Psydrax latifolia* over *Chrysopogon fallax*, *Stemodia viscosa*, *Blumea tenella*, *Themeda triandra* and species of *Triodia* and *Aristida*.
8	Closed Scrub to Tall Shrubland of *Acacia pruinocarpa*, *Acacia tumida*, *Acacia ancistrocarpa*, *Acacia maitlandii*, *Acacia kempeana*, *Acacia tetragonophylla* with occasional *Eucalyptus gamophylla* and *Corymbia deserticola* over *Triodia epactia*, *Themeda triandra* and *Aristida* species.
Flats and Broad plains	
3 †	Low Woodland to Low Open Forest of *Acacia aneura* var. *aneura*, *Acacia pruinocarpa*, *Acacia tetragonophylla*, *Acacia* tenuissima, *Grevillea wickhamii* subsp. *aprica*, *Psydrax latifolia* over *Dodonaea petiolaris* and species of *Triodia* and *Aristida.*
4 †	Low Open Woodland of *Acacia aneura* var. *aneura*, *Acacia pruinocarpa*, *Acacia xiphophylla*, *Acacia victoriae* over *Acacia tetragonophylla*, *Psydrax latifolia* and *Psydrax suaveolens* over *Ptilotus obovatus* and mixed species of *Maireana* and *Sclerolaena*.
10 †	Low Open Woodland of *Acacia xiphophylla*, *Acacia victoriae*, *Acacia aneura* var. *aneura* over *Acacia tetragonophylla*, *Ptilotus obovatus*, *Senna* species and mixed species of *Maireana* and *Sclerolaena*.
30	High open Shrubland of *Acacia synchronicia* with *Senna glaucifolia* over *Aristida* sp.
Ranges, Hills and Hill slopes	
16	Hummock Grassland of *Triodia basedowii* with pockets of *Triodia epactia* and *Triodia lanigera* with emergent patches of *Eucalyptus leucophloia*, *Corymbia deserticola* over *Acacia ancistrocarpa*, *Acacia hilliana*, *Acacia acradenia*, *Acacia pyrifolia*, *Hakea lorea* subsp. *lorea* over *Goodenia stobbsiana* and mixed *Senna* species.
17	Hummock Grassland of *Triodia basedowii* with pockets of *Triodia epactia* and *Triodia lanigera* with emergent patches of *Eucalyptus leucophloia*, *Corymbia deserticola* over *Acacia ancistrocarpa*, *Acacia pyrifolia*, *Hakea lorea* subsp. *lorea* over *Goodenia stobbsiana* and mixed *Senna* and *Ptilotus* species.
Fringes of Samphire Flats	
13 *	Low Halophytic Shrubland of *Tecticornia auriculata*, *T. indica* subsp. *leiostachya*, *T. halocnemoides* subsp. *tenuis* with patches of *Frankenia* species.
22 *	Low Shrubland of *Tecticornia indica* subsp. *bidens* and *Nicotiana occidentalis* over grasses with occasional stands of *Sesbania cannabina* and *Cullen cinereum*.
26 *	Low Shrubland of *Muellerolimon salicorniaceum* and *Tecticornia indica* subsp. *bidens.*
31 *	Low Shrubland of *Tecticornia indica* subsp. *bidens*, *Tecticornia auriculata* and *Tecticornia indica* subsp. *leiostachya* with *Tecticornia* sp. Christmas Creek, (K.A. Shepherd & T. Colmer et al. KS 1063), *Tecticornia* sp. Denny's Crossing (K.A. Shepherd & J. English KS 552), *Tecticornia* sp. Fortescue Marsh (K.A. Shepherd et al. KS 1055) and *Tecticornia* sp. Roy Hill (H. Pringle 62).
32 *	Low Shrubland of *Muellerolimon salicorniaceum* over *Tecticornia indica* subsp. *bidens* and *Tecticornia indica* subsp. *leiostachya* with *Tecticornia* sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063), and *Tecticornia* sp. Denny's Crossing (K.A. Shepherd & J. English KS 552) with *Euphorbia* species.
33 *	Low Shrubland of *Tecticornia indica* subsp. *bidens* and *Scaevola spinescens* with *Acacia synchronicia*.
34 *	Low Shrubland of *Muellerolimon salicorniaceum* over *Tecticornia indica* subsp. *bidens* and *T. auriculata* with *Heliotropium curassavicum* and *Atriplex flabelliformis*.
35 *	Low Shrubland of *Muellerolimon salicorniaceum* over *Tecticornia auriculata*, *Tecticornia* sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063), and *Tecticornia* sp. Denny's Crossing (K.A. Shepherd & J. English KS 552) with *Euphorbia* species.

Vegetation unit	Description (from ENV 2010)
Other	
Bare Ground	Bare Ground
Burnt	Burnt areas
Infrastructure	Infrastructure / mine areas

Note: Dagger † indicates Mulga-associated vegetation type, Asterisk * indicates Samphire-associated vegetation type, Caret ^ indicates Coolibah and River Gum woodland.

Each of the broad floristic formations occurring in the Survey area are known to extend beyond the Survey area to varying degrees. The proportion of the total (mapped) extent of each floristic formation that occurs within the Survey area is:

- Creeks and Drainage lines, approx. 30%;
- Ranges, Hills and Hill Slopes approx. 29%;
- Flats and Broad Plains approx. 22%; and
- Fringes of Samphire Flats approx. 47% (source: ENV 2010).

The Samphire vegetation types form part of the locally and nationally significant Fortescue Marsh (Priority 1) Priority Ecological Community (ENV 2010). The Samphire vegetation types associated with Fortescue Marsh are considered regionally unique, although within the Christmas Creek Survey area, they are relatively extensive at the margins of the marsh. Samphire vegetation types are structurally different than the other Mulga and Spinifex dominated vegetation types.

Mulga vegetation types (3, 4, and 10) were also considered regionally significant, as the Chichester Range is recognised as the northern extent of Mulga in Western Australia (ENV 2010). Within the Survey area, Mulga often occurs in dense, sheltered groves or bands, which are often isolated by bare ground or other structurally different vegetation types (*e.g. Triodia* hummock grassland) (ENV 2010). Mulga vegetation types make up a large proportion of the Survey area (approx. 30%), particularly along minor drainage lines and in frequent groves throughout the alluvial plains. Figure 5 shows the vegetation types throughout the Survey area, as mapped by ENV (2010).

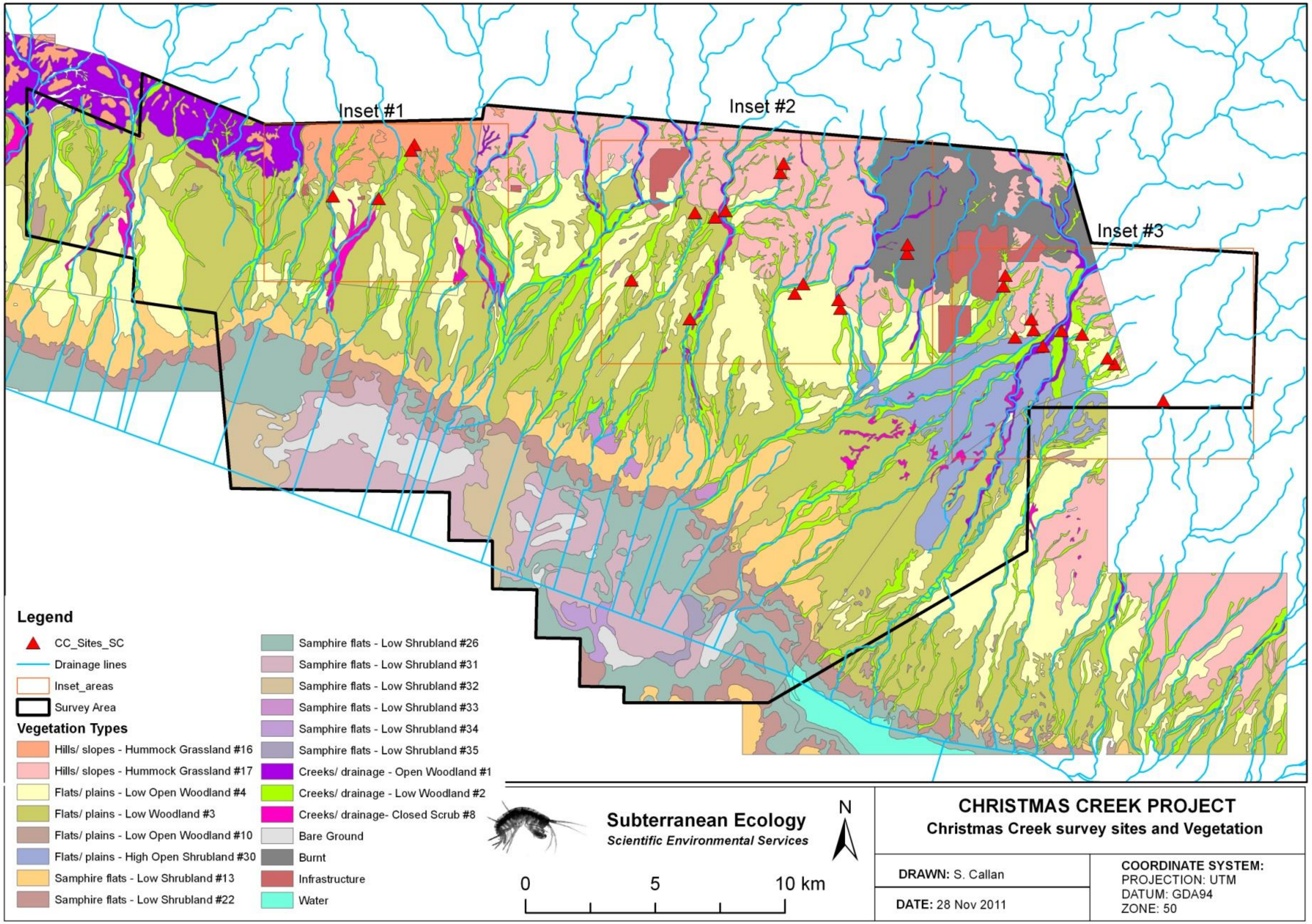


Figure 5. Vegetation types (ENV 2010) and SRE sites within the Survey area. Refer Appendix 8 for map insets.

6 METHODS

The methods and layout of sampling sites for the current Survey have been designed to meet EPA (2009) recommendations for assessment of SRE fauna.

6.1 Site Selection

Site selection was based on land systems, topography, drainage, vegetation and on-site habitat assessment. Broad, landscape scale information (such as land systems and drainage) was combined with vegetation mapping (Biota 2005a) and topography to short-list potential sites for sampling, prior to deployment (Figure 5). Fine scale vegetation information was subsequently updated using ENV 2010. Sites were chosen to achieve adequate representation of land systems and vegetation types (taking particular note of any restricted vegetation types) throughout the Survey area, within the practical limitations of site accessibility. Site layout was verified by on-site, visual assessment of potential SRE micro-habitats within each site. Table 3 shows the range of habitat characteristics used to plan the location of each site.

The habitat assessment (results shown in section 7.1) used the following categories to describe various site characteristics:

- Soils – Sand, Loam, Clay, Gravel, Scree (or combinations thereof);
- Slope – Negligible, Low, Moderate, Steep (plus direction);
- Leaf litter depth – Shallow (<1cm), Moderate (1 – 5cm), Deep (>5cm);
- Leaf litter coverage – Negligible, Sparse, Moderate, Dense (relative coverage of leaf litter);
- Wood litter / debris - Negligible, Low, Moderate, High (relative abundance of debris).
- Disturbance, including:
    - Weeds – Negligible, Low, Moderate, High (qualitative assessment of weed coverage / density);
    - Fire – Recent (within 1 year), Young (3-5 years), Moderate (5-10 years), Old (>10 years); and
    - Grazing - Negligible, Low, Moderate, High (qualitative assessment of visible impacts of grazing)
- In terms of habitat type, drainage lines were either judged present or absent, while ‘floodplain’ sites were sites occurring within the riparian flood zone, without having an actual drainage line present on-site.

Table 3 Broad scale habitat characteristics used for site selection.

Site	Land system	Vegetation type (ENV 2010)	Slope	Drainage	Disturbance*
XC01	Turee	Creeks/drainage – Low woodland #2	Low	Present	Mod. weeds, mod. grazing
XC02	Newman	Creeks/drainage – Low woodland #2	Low	Absent	Neg.
XC05	Turee	Creeks/drainage – Low woodland #2	Neg.	Floodplain	High weeds, low grazing
XC06	Turee	Creeks/drainage – Open woodland #1	Neg.	Floodplain	High weeds, mod. grazing
XC07	Newman	Creeks/drainage – Low woodland #2	Low	Present	Mod fire, low weeds, mod. grazing
XC08	Jamindie	Creeks/drainage – Low woodland #2	Neg.	Floodplain	Young fire, high weeds, mod. grazing
XC09	Jamindie	Creeks/drainage – Low woodland #2	Neg.	Absent	High weeds
XC10	Jamindie	Creeks/drainage – Low woodland #2	Neg.	Absent	Mod. fire, low weeds
XC11	Jamindie	Creeks/drainage – Low woodland #2	Neg.	Absent	Mod. weeds, clearing nearby
XC12	Jamindie	Flats/plains - Low open woodland #4	Neg.	Absent	Low weeds, clearing nearby
XC13	Turee	Flats/plains – Low woodland #3	Neg.	Absent	Low weeds, low grazing
XC14	Boolgeeda	Creeks/drainage – Low woodland #2	Neg.	Absent	High weeds, low grazing
XC15	Jamindie	Creeks/drainage – Low woodland #2	Low	Floodplain	Mod. fire, high weeds, mod. grazing
XC17	Jamindie	Flats/plains – Low woodland #3	Neg.	Absent	High weeds, mod. grazing
XC18	Jamindie	Flats/plains – Low woodland #3	Neg.	Absent	Mod. fire, low weeds, mod. grazing
XC19	Jamindie	Creeks/drainage – Closed scrub #8	Neg.	Absent	Mod. fire, mod. weeds
XC24	Boolgeeda	Creeks/drainage – Low woodland #2	Neg.	Absent	Low weeds, mod. grazing
XC25	Boolgeeda	Creeks/drainage – Low woodland #2	Low	Absent	Low weeds, mod. grazing
XC27	Jamindie	Flats/plains – Low open woodland #4	Neg.	Absent	Low weeds, low grazing
XC28	Jamindie	Creeks/drainage – Low woodland #2	Neg.	Absent	High weeds, mod. grazing
XC30	Newman	Hills/slopes – Hummock grassland #16	Mod.	Absent	Young fire
XC31	Newman	Hills/slopes – Hummock grassland #16	Mod.	Absent	Neg.
XC32	Newman	Hills/slopes – Hummock grassland #16	Steep	Absent	Clearing nearby
XC33	Newman	Hills/slopes – Hummock grassland #16	Steep	Absent	Low weeds
XC34	Newman	Burnt	Mod.	Absent	Recent fire
XC35	Newman	Burnt	Steep	Absent	Recent fire nearby
XC36	Jamindie	Creeks/drainage – Low woodland #2	Low	Absent	Low weeds, mod. grazing
XC37	Turee	Creeks/drainage – Open woodland #1	Neg.	Present	Low weeds

Note: 'Present' indicates a drainage line occurring within the site, while 'Floodplain' indicates that the site was in the flood zone; however, a drainage line did not occur within the site itself. * Disturbance information was not available during site selection, but has been added to this table following on-site assessment.

6.2 Sampling Methods

Survey sites were sampled using a combination of active foraging, litter / soil sifting and pitfall trapping methods. Over all sites, 130 pitfall traps were deployed, 112 individual litter sifts were undertaken, and approximately 56 person hours were spent actively searching for SRE invertebrates. Further details on each sampling method are presented below.

Wet Pitfall Trapping

Quantity: 5 per site (130 total)

Unbaited, wet pitfall traps (Figure 6a, b) were installed at approximately 20 m intervals (5 traps per site) along an 80 m transect line. The traps consisted of a 1.2 L plastic bucket with a 10 cm rim diameter, dug into the ground so the rim was flush with ground level. The surrounding leaf litter was replaced so as to provide a consistent habitat right up to the rim of the trap. Plastic lids (15 cm diameter) were installed above the traps, supported by wire pegs, leaving an approximate 2-3 cm gap between the ground surface and the lid. These lids were designed to prevent flooding during rainfall, to minimise potential disturbance from vertebrate animals, and to minimise accidental by-catch. The traps were one-third filled with a preservative solution of 100 % ethylene glycol. Surface active invertebrates randomly fell into the traps and were preserved in the solution. The traps were left open for a 2 week period (26 March – 10 April 2011), during which humid conditions and rainfall (approx. 4 mm) provided optimum conditions for SRE activity.

Active Foraging

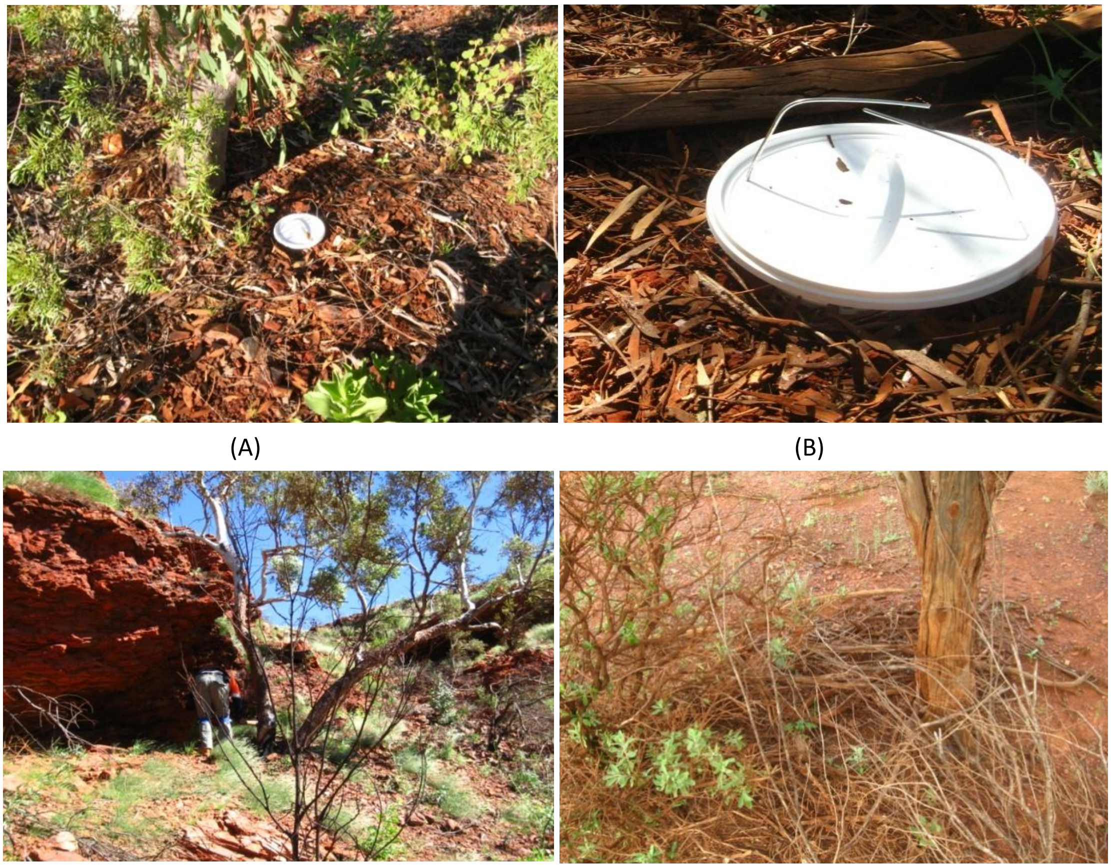
Duration: 1 person hour per site (56 person hours total)

Active foraging targeted micro-habitats such as leaf litter, the bases of trees, the undersides of stones, wood piles and woody debris, rocky outcrops, cracks and crevices, the undersides of bark, and accumulated debris from sheet flows (Figure 6c). Specimens were collected using forceps and preserved in vials containing 100 % ethanol (except for snails, which were stored in calico bags). Two personnel conducted active foraging for 30 minutes each, ranging up to approximately 50 m from the pitfall trapping transect at each site. Samples were combined and those preserved in ethanol were chilled on ice. Observed micro-habitats were noted, including the presence of invertebrate burrows.

Litter / Soil Sifting

Quantity: 4 collections per site (112 total)

Leaf litter, including topsoil and debris, was collected from the bases of trees and shrubs or from piles deposited by sheet water flows (Figure 6d). A representative sample from each of the dominant tree species at each site was collected into a stout plastic bag, and transported to a suitable location for sifting. Leaf litter and top soil was then sifted through graded sieves (mesh sizes 1.5 cm, 0.7 cm and 0.3 cm) in order to systematically extract target invertebrate taxa. Invertebrates were collected using forceps, and placed into a sample vial containing 100 % ethanol. Snails were stored in dry calico bags.



(A) (B) (C) (D)

Figure 6. SRE invertebrate sampling; (A) pitfall trapping site, (B) pitfall trap installed with lid, (C) active foraging around a BIF outcrop, and (D) a leaf litter / wood litter collection site.

6.3 Species Identifications

Sorting of samples occurred in the laboratory using dissecting microscopes. Each taxon was identified to morpho-species level using a parataxonomic approach (refer Glossary). External specialists involved with species-level identifications are listed in Table 4. High resolution images were taken with a Leica® M205C Stereo Dissection Microscope; Leica® DFC420 Camera and LAS image capturing software. Voucher specimens of target taxa (arachnids, myriapods and snails) were photographed and lodged at the WAM (refer Appendix 6 for WAM lodgement numbers). DNA analysis of the mitochondrial gene cytochrome-oxidase subunit-I (COI) was used in particular cases to confirm species identifications and investigate distributions outside of the Survey area (refer WAM 2012, Appendix 7 for full methods of analyses).

Table 4. External specialist taxonomists who undertook identifications of target SRE taxa

Personnel	Institution	Taxonomic expertise
Dr Mark Harvey, Dr Mieke Burger, Julianne Waldock, Dr Cathy Carr, Mark Castalanelli	WAM	Spiders, pseudoscorpions, myriapods, DNA analysis
Corey Whisson, Shirley Slack-Smith	WAM	Molluscs
Dr Volker Framenau	Phoenix	Mygalomorph spiders
Dr Erich Volschenk	Private consultant	Scorpions
Dr Simon Judd	Private consultant	Isopods

6.4 Assessment of Survey Adequacy

The adequacy of the survey effort was evaluated by comparing the observed number of target SRE species recorded with the predicted species richness, for four widely-used species diversity estimators (mean values of ACE, Chao1, Jackknife1, and Bootstrap). Species accumulation curves and diversity estimations were made with EstimateS® (v 8.2) (Colwell 2006) using the default settings, with the following exceptions:

- Accumulation curves were smoothed using 1,000 repetitions;
- Diversity estimators: Bias Corrected Formulas for Chao 1 and Chao 2 were chosen, and;
- Upper abundance limit set to 5, so as to more reliably treat ‘rare’ taxa.

Species richness estimation was performed on combined collections from all methods at each site, in order to take into account the complementarities of the sampling methods (Colwell and Coddington 1994, Moir *et al.* 2005). Species identified on the basis of DNA alone were excluded, as DNA analyses were limited to a few taxa only. Non-target taxa were excluded, and diversity estimations were conducted on abundance data of the target SRE taxa for developing the species accumulation curves.

6.5 Constraints and Limitations

Specific constraints or limitations of the Survey and the techniques used to overcome them are listed below:

Potential constraints / limitations:

- Site accessibility – habitats within Fortescue Marsh, including the immediately adjacent Samphire Flats were inaccessible during the survey, due to localised flooding and poor road conditions. Two accessible sites (sites 36 and 37) in the south of the Survey area were sampled during the second field trip; however, these sites were not located in Samphire habitat or within the Marsh itself.
- Site planning – the vegetation information used at the time of survey planning (Biota 2005a) was superseded later by additional studies (ENV 2010), as shown within this report. The differences in scale and classification between the two sources may have had a limited influence on the apparent coverage of some vegetation types. However, in terms of vegetation structure (which may have a greater influence on habitat value for SRE) there was little if any difference between the two information sources.
- No information regarding the location of disturbances (such as fires, or clearing for exploratory drilling) was available prior to field survey. However, during the initial field survey, sites were relocated as far as practicable to avoid major disturbances, while staying within the same vegetation / habitat type. Some broad disturbances such as weeds (grassy and herbaceous species that may have resulted from pastoral activity) were unavoidable.
- Information available regarding potential impacts - at the time of assessment, only the pit boundaries for the LOM footprint were available. The extent of vegetation clearing, proposed infrastructure, stockpiles and other Project elements which may have the potential to impact terrestrial SREs were not available for assessment. Given the above, the

overall potential for impacts was assessed by investigating the degree to which target species and habitats were known to occur beyond the Survey area.

Not a constraint / limitation:

- Rarity of the target taxa and cryptic habitats – overcome by use of a comprehensive sampling regime at each site;
- Limited prior sampling in Survey area itself – overcome by use of desktop assessments and survey reports from relevant nearby areas (*e.g.* Ecologia 2010, 2011) to inform survey design and methods;
- Inadequate sampling effort - species accumulation curves verified the adequacy of the sampling effort undertaken, and numbers of samples for each method met or exceeded the requirements of the EPA Guidance (2009);
- Duration of pitfall trapping (2 weeks) – some pitfall trapping surveys use up to 6 weeks, although the results of the Survey (verified by species accumulation curves) suggested that the detection rates and sampling effort were adequate;
- Unsuitable weather conditions - the season and weather conditions prior to and during the Survey were optimal for sampling most SRE species (*i.e.* wet, warm, and humid) according to EPA Guidance (2009); and
- Uncertainty of SRE status due to incomplete taxonomic knowledge – overcome by use of DNA analyses in relevant cases.

7 RESULTS

7.1 SRE Habitat Assessment

Prospective SRE habitats were placed into five broad categories. These include drainage lines, floodplains, alluvial / colluvial plains, isolated vegetation groves (mostly Mulga), rocky hills / gullies, and gorges. A brief description of each of these habitats is presented below.

Drainage lines

Undulating creek lines, dominated by open *Eucalyptus* or *Acacia* woodland over Spinifex tussock grassland. Most creek lines were dry at the time of sampling, although there was some evidence of recent flooding (Figure 7). Generally low amounts of leaf litter were present under trees and shrubs, although in some places, litter and debris had been washed into large piles. The majority of soils were sandy / loamy, with patches of alluvial gravels (Table 5). Invertebrate burrows of several shapes and sizes were observed, including the characteristic elliptical burrows of *Urodacus* scorpions. Target SRE micro-habitats in drainage lines included leaf litter at the base of trees and under shrubs, leaf litter and debris piles, underneath the bark of trees, and around logs and woody debris. Previous surveys from the local area suggested that drainage lines would be highly prospective for SRE fauna (Ecologia 2010a, 2011).

Table 5. Site characteristics of drainage lines in the Survey area**.**

Site	Slope, Direction	Soil Type	Vegetation Unit (ENV 2010)	Leaf litter depth	Disturbance
XC01	Low, East	Loam	Creeks/drainage – Low woodland #2	1-5cm	Mod. weeds, mod. grazing
XC07	Low, NW	Sand	Creeks/drainage – Low woodland #2	< 1cm	Mod fire, low weeds, mod. grazing
XC25	Low, SW	Sandy loam	Creeks/drainage – Low woodland #2	< 1cm	Low weeds, mod. grazing
XC37	Negligible	Gravelly clay	Creeks/drainage – Open woodland #1	1-5cm	Low weeds

(A)

(B)

Figure 7. Drainage lines in the Christmas Creek Survey area: A) dry creek bed at site XC25, B) drainage line near site XC10.

Floodplains

Broad, flat or undulating alluvial floodplains, within the flood zone of nearby drainage lines, but not intersecting any part of them. Floodplains differed in size and land surface characteristics relative to the size of the nearby drainage line and whether they had recently been flooded. Floodplains were dominated by open *Eucalyptus* or *Acacia* woodland over Spinifex tussock grassland, and most had a high density of grassy or herbaceous weeds, probably due to the recent rainfall (Table 6, Figure 8). Floodplains typically had sandy / loamy soils with some areas of clay, and alluvial gravel beds. Some sites had invertebrate burrows present. Leaf litter was generally scarce or present only in small patches under trees and shrubs. Target SRE micro-habitats included leaf litter at the base of trees and under shrubs, underneath the bark of trees, stone piles (under rocks and stones) and around logs and woody debris. Due to persistent moisture and pockets of tall vegetation, floodplains would be expected to be a moderately prospective habitat for SRE fauna.

Table 6. Site characteristics of floodplains in the Survey area**.**

Site	Slope and Direction	Soil Type	Vegetation Unit (ENV 2010)	Leaf litter depth	Disturbance
XC05	Negligible	Sand	Creeks/drainage – Low woodland #2	< 1cm	High weeds, low grazing
XC06	Negligible	Clay - Loam	Creeks/drainage – Open woodland #1	< 1cm	High weeds, mod. grazing
XC08	Negligible	Sand-loam	Creeks/drainage – Low woodland #2	< 1cm	Young fire, high weeds, mod. grazing
XC15	Low, East	Clay - Loam	Creeks/drainage – Low woodland #2	< 1cm	Mod. fire, high weeds, mod. grazing

(A) (B)

Figure 8. Floodplains in the Christmas Creek Survey area: A) site XC06, B) site XC15.

Alluvial / Colluvial Plains

Broad, flat or undulating plains, outside of the flood zone of streams and creeks. The vegetation was dominated by dense Spinifex tussock grassland, or patchy, open *Acacia* woodland, with sparse understorey. Some sites were located in native vegetation adjacent to cleared drill lines, and large piles of woody debris were present, as a result of the nearby clearing. Some sites showed evidence of fire, and nearly all showed some level of grassy / herbaceous weed coverage (Figure 9). Alluvial / colluvial plains had clay - loam soils, often with significant gravels, including areas of exposed stone piles (Table 7). Leaf litter was present in low to moderate depth, almost always occurring at the base of trees and shrubs. Some sites showed evidence of sheet water flows. Micro-habitats that were targeted included leaf litter at the base of trees and shrubs, stone piles and the underside of rocks, and wood piles / debris. The alluvial / colluvial plains represent broad, continuous habitats that occur widely throughout the Survey area and beyond. This habitat type would not be expected to be as prospective for SRE fauna as some of the other habitat types in the Survey area.

Table 7. Site characteristics of alluvial / colluvial plains in the Survey area.

Site	Slope and Direction	Soil Type	Vegetation Unit (ENV 2010)	Leaf litter depth	Disturbance
XC02	Low, SE	Gravelly loam	Creeks/drainage – Low woodland #2	1-5cm	Negligible
XC09	Negligible	Clay - Loam	Creeks/drainage – Low woodland #2	< 1cm	High weeds
XC10	Negligible	Clay - Loam	Creeks/drainage – Low woodland #2	< 1cm	Mod. fire, low weeds
XC11	Negligible	Gravelly loam	Creeks/drainage – Low woodland #2	1-5cm	Mod. weeds, nearby clearing
XC12	Negligible	Clay- Loam	Flats/plains - Low open woodland #4	< 1cm	Low weeds, nearby clearing
XC18	Negligible	Sandy loam	Flats/plains – Low woodland #3	1-5cm	Mod. fire, low weeds, mod. grazing
XC19	Negligible	Sandy loam	Creeks/drainage – Closed scrub #8	< 1cm	Mod. fire, mod. weeds
XC27	Negligible	Gravelly clay	Flats/plains – Low open woodland #4	5-10cm	Low weeds, low grazing
XC28	Negligible	Loam	Creeks/drainage – Low woodland #2	1-5cm	High weeds, mod. grazing

(A) (B)

Figure 9. Alluvial / Colluvial plains in the Christmas Creek Survey area: A) site XC09, B) site XC18.

Vegetation Groves

Shady / dense bands or groves of woodland that were isolated by bare ground or distinct from the surrounding tussock grassland of the alluvial / colluvial plains. Dominant shrub and tree species included Mulga (*Acacia aneura*), over low native herbs or a sparse understorey, with frequent woody debris. Weed density was variable, ranging from low to high (Table 8), while very little evidence of fire or grazing was present. Vegetation groves showed rich loam or clay soils, and frequent patches of moderately deep, moist leaf litter. Although mostly flat, all groves showed evidence of sheet water flows, including piles of deep leaf litter accumulated around woody debris (Figure 10). Potential SRE micro-habitats included leaf litter piles, the underside of bark, woody debris and logs. Many different types of invertebrate burrows (including scorpion and mygalomorph burrows) were observed. Due to the dense, shady vegetation and clay soils this habitat type would be expected to be highly prospective for SRE fauna.

Table 8. Site characteristics of vegetation groves in the Survey area.

Site	Slope and Direction	Soil Type	Vegetation Unit (ENV 2010)	Leaf litter depth	Disturbance
XC13	Negligible	Clay	Flats/plains – Low woodland #3	1-5cm	Low weeds, low grazing
XC14	Negligible	Loam	Creeks/drainage – Low woodland #2	< 1cm	High weeds, low grazing
XC17	Negligible	Clay	Flats/plains – Low woodland #3	5-10cm	High weeds, mod. grazing
XC24	Negligible	Sandy loam	Creeks/drainage – Low woodland #2	< 1cm	Low weeds, mod. grazing
XC36	Low, SW	Gravelly clay	Creeks/drainage – Low woodland #2	1-5cm	Low weeds, mod. grazing

(A) (B)

Figure 10. Vegetation (Mulga) groves in the Christmas Creek Survey area: A) site XC14, B) site XC13

Rocky Hills and Gullies

Rocky, undulating foothills of the Chichester Ranges, including minor gullies. The vegetation was dominated by low Spinifex tussock grassland, with small patches of low, dense *Acacia* shrubs and tall Snappy Gum trees (*Eucalyptus leucophloia)* in gullies. Leaf litter was very sparse and patchy, weeds and grazing were negligible, and some sites had recently been affected by fires, with considerable regrowth observed in the gullies at the time of the Survey (Figure 11). These habitats had gravelly loam / scree soils and areas of outcropping BIF (Table 9). There was some evidence of recent runoff, particularly in gullies, where leaf litter had been washed into small clumps and piles. Target SRE micro-habitats included rock outcrops and caves, cracks and crevices, the underside of stones, and leaf litter at the base of shrubs and trees. Broad, continuous areas of rocky hills would not be expected to be highly prospective for SRE fauna, although gullies and outcrops may provide suitable sheltered microhabitats.

Table 9. Site characteristics of rocky hills and gullies in the Survey area.

Site	Slope and Direction	Soil Type	Vegetation Unit (ENV)	Leaf litter depth	Disturbance
XC30	Moderate, South	Gravelly scree	Hills/slopes – Hummock grassland #16	< 1cm	Young fire
XC31	Moderate, South	Gravelly loam, scree	Hills/slopes – Hummock grassland #16	< 1cm	Negligible
XC32	Steep, SE	Gravelly scree	Hills/slopes – Hummock grassland #16	< 1cm	Nearby clearing
XC34	Moderate, North	Gravelly loam, scree	Burnt	< 1cm	Recent fire

(A) (B)

Figure 11. Rocky hills and Gullies in the Christmas Creek Survey area: A) view south from site XC30, B) regrowth after fire in a gully at site XC34

Gorges

Deeply-incised gorges comprising eroded BIF outcrop, cliffs, caves and overhangs, leading down to scree slopes and rocky debris in the valley below (Figure 12). Vegetation was tall and moderately – high density on the scree slopes, including mixed *Eucalyptus leucophloia* and *Acacia* shrubs over thick Spinifex tussock grassland and herbaceous species. These areas had gravelly scree / loam soils with moderate amounts of leaf litter, with deeper patches accumulated down slope (Table 10). There was little evidence of grazing or weed infestation. Target SRE micro-habitats included rock crevices, entrances to overhangs and caves, underneath rocks and within scree, leaf litter, woody debris, and bark. Based on regional results, gorges would be expected to be highly prospective SRE habitats (Ecologia 2010a, 2011).

Table 10. Site characteristics of gorges in the Survey area

Site	Slope and Direction	Soil Type	Vegetation Unit (ENV)	Leaf litter depth	Disturbance
XC33	Steep, East	Gravelly scree	Hills/slopes – Hummock grassland #16	1-5 cm	Low weeds
XC35	Steep, South	Gravelly scree	Burnt	1-5 cm	Recent fire nearby

(A) (B)

Figure 12. Gorges in the Christmas Creek Survey area: A) cliff face at site XC33, B) fire affected gorge at site XC35

7.2 Invertebrate Fauna Collected

A total collection of approximately 11,456 invertebrate specimens were collected during the survey, representing 36 families and 6 orders. After parataxonomic sorting, 154 specimens representing 26 species, from 6 taxonomic groups (spiders, pseudoscorpions, scorpions, myriapods, isopods and snails) were identified as target SRE taxa (refer glossary or Section 3.5).

DNA sequencing of target SRE taxa (WAM 2012) revealed the occurrence of two potential SREs, *Antichiropus* sp. 'christmas' (Paradoxosomatidae), and *Karaops* sp. 'christmas' (Selenopidae).

The remaining target SRE taxa were considered not SRE (Table 11, Appendices 1-5). Refer Figure 13 and Appendix 9 for locations of species of potential conservation significance. The fauna is discussed in detail below.

Polydesmida: Paradoxosomatidae (*Antichiropus* sp.)

The paradoxosomatid millipedes collected during the Survey were all juvenile and unidentifiable by morphology alone. DNA sequencing undertaken by the WAM (WAM 2012, Appendix 7) revealed the existence of two distinct groups of *Antichiropus* at Christmas Creek;

1. FMG group 1 – herein referred to as *Antichiropus* sp. 'christmas' and
2. FMG group 2 – herein referred to as *Antichiropus* sp. 'anketell'.

There is some precedent for different species of *Antichiropus* to occur in the same location, as was found at Orebody 35 near Newman (WAM 2012, Appendix 7). Despite a lack of identifiable male specimens to confirm morphological differences, these groups are thought to correspond to two different species (WAM 2012, Appendix 6).

Antichiropus sp. 'christmas' (FMG group 1) was collected in many sites throughout the Survey area including XC11, XC24, XC25, XC27 XC33, XC34 and XC35 (Figure 13). This species belonged to a broader clade of other *Antichiropus* sequences from Abydos, Marble bar, Nullagine, Wodgina, and Anketell / Millstream (Figure 14). The COI sequences within FMG group 1 were between 1.7% - 3.7% divergent, whereas the divergence between FMG group 1 specimens and the other specimens in the clade was 5 - 10% (WAM 2012, Appendix 7). Based on this analysis, *Antichiropus* sp. 'christmas' is only known from the Survey area and is considered a likely (suspected) SRE species (WAM 2012, Appendix 7).

Antichiropus sp. 'anketell' (FMG group 2), was recognised from a single sequence at Christmas Creek, collected at site XC24. The DNA of this specimen matched pre-existing sequences collected at Anketell Point and Millstream-Chichester National Park (COI <0.2% divergence), indicating a single species distributed over approximately 300-350 km (Figure 14). Such a wide distribution for a species of *Antichiropus* is unusual but not unprecedented; there are other widespread species in the south-west and wheatbelt regions of WA (M. Harvey WAM pers. comm. 2012). Based on this genetic data FMG group 2, *Antichiropus* sp. 'anketell' is not considered a SRE.

There were additional indeterminate *Antichiropus* specimens from sites XC1, XC7, XC12, XC25, and XC30 that did not yield a DNA sequence (Table 11, Figure 13). In the absence of any reliable morphological or genetic characters, these specimens cannot be allocated to one species or another, therefore their identifications remain unresolved.

Araneae: Selenopidae (*Karaops* sp. 'christmas')

The genus *Karaops* (flat rock spiders) are often known from restricted ranges, and are considered to have high SRE potential due to their specialisation for rocky outcrops, cracks and crevices (Crews and Harvey 2011, V. Framenau, Phoenix pers. comm. 2011, Appendix 1). A single juvenile *Karaops* specimen was detected during the Survey (site XC25). DNA analysis revealed a strong match (0.4% divergence, COI) with a juvenile specimen collected at Bonney Downs station, approx. 18 km to the north west, beyond the boundary of the Survey area. These two juvenile specimens almost certainly represent a new, undescribed species herein referred to as *Karaops* sp. 'christmas'. Due to the low number of specimens collected within a relatively limited area, *Karaops* sp. 'christmas' is considered to be a potential SRE species (M. Harvey WAM, pers. comm. 2012).

Pseudoscopiones: Olpiidae (*Beierolpium* sp.)

Beierolpium is a poorly studied, highly diverse genus of minute pseudoscorpions. Current morphological knowledge of WA's *Beierolpium* fauna is insufficient to satisfactorily identify the specimens from Christmas Creek (M. Burger, WAM pers. comm. 2011, Appendix 3). DNA analyses showed the occurrence of two highly divergent species, herein referred to as *Beierolpium* sp. XC32 and *B*. sp. XC14 (COI 25% divergence), which did not match any other known sequences (WAM 2012). Another specimen of *Beierolpium*, detected at site XC28, failed to amplify. At the current time, there is insufficient knowledge of the *Beierolpium* pseudoscorpions from Christmas Creek to assess their SRE status.

Isopoda: Armadillidae (*Buddelundia* sp. n. 54)

Buddelundia is the most diverse genus of native terrestrial isopods in the Pilbara, and includes both widespread species and SRE species (S. Judd pers. comm. 2011). Although only 24 species have been described to date, the taxonomy of the group is currently under revision, and many new species are recognised (S. Judd pers. comm. 2012, Appendix 5).

Buddelundia sp. n. 54 is a new undescribed species, detected at two locations in the Survey area, sites XC33 and XC34 (S. Judd pers. comm. 2012, Appendix 5). The male specimens from the Survey area match with a male specimen recently collected from Rocklea Homestead, while the female specimens from the Survey match with others collected in the Hamersley Ranges. Based on this morphological analysis, *Buddelundia* sp. n. 54 occurs outside of the Survey area and is unlikely to be an SRE species (S. Judd pers. comm. 2012, Appendix 5).

Further details regarding the identification and SRE status of the remaining taxa, as reported by relevant specialists, are presented in Appendices 1-5. Table 11 (below) shows numbers of specimens from each taxon detected, at each site in the Survey area. Figure 13 and Appendix 9 show the recorded location of the potential SRE species.

Table 11. Prospective SRE taxa detected at each site within the Survey area.

Higher Taxon / Species ID	Drainage line				Floodplain				Alluvial/ Colluvial Plains								Vegetation Groves					Rocky hills/ Gullies				Gorges		SRE status	Outside survey area?
	XC 01	XC 07	XC 25	XC 37	XC 05	XC 06	XC 08	XC 15	XC 02	XC 09	XC 10	XC 11	XC 12	XC 18	XC 27	XC 28	XC 13	XC 14	XC 17	XC 24	XC 36	XC 30	XC 31	XC 32	XC 34	XC 33	XC 35		
ARANEAE																													
Mygalomorphae: Barychelidae																													
Synothele sp. 'MYG127'		1											1						1									No	Yes
Synothele sp. indet. (juv)															1													No	Unknown
Araneomorphae: Selenopidae																													
Karaops sp. 'christmas'			1																									Potential	Yes
SCORPIONES																													
Buthidae																													
Lychas sp. *'harveyi'*													1					2										No	Yes
Urodacidae																													
Urodacus sp. *'butleri'*														2				1	1									No	Yes
Urodacus sp. *'pilbara 8'*					2		2	1		1	1								1	1								No	Yes
PSEUDOSCORPIONES																													
Atemnidae																													
Oratemnus sp. indet. XC								1														3						No	Yes
Chthoniidae																													
Austrochthonius sp. indet. XC		1																										No	Likely
Garypidae																													
Synsphyronus sp. nov. 'PSE006'																			2									No	No*
Olpiidae																													
Beierolpium sp. XC14																		1										Unknown	No*
Beierolpium sp. XC32																								1				Unknown	No*
Beierolpium sp. indet.																2												Unknown	Unknown
Indolpium sp. indet. XC	1									6	3				1			2				1		3	4		1	No	Likely

Numbers of specimens occur within table, total numbers of taxa per site are recorded below table. Site XC19 is excluded as no target SRE taxa were detected. SRE status and distribution relative to the Survey area are shown at right. "Unknown" refers to the inability to determine distribution for juvenile and indeterminate specimens. "Likely" indicates that while no specimens have yet been detected outside the Survey area, current knowledge suggests that the species would be likely to occur widely outside the Survey area. Asterisk (*) indicates that there are no records outside of the Survey area, only because the taxon is newly discovered. For genetically determined species (*i.e. Beierolpium* spp. and *Antichiropus* spp.), the occurrence / abundance recorded herein is a function of the success rate of sequencing. Specimens that did not yield a sequence cannot be allocated, and remain "sp. indet."

Table 11. Continued.

Higher Taxon / Species ID	Drainage line				Floodplain				Alluvial/ Colluvial Plains								Vegetation Groves					Rocky hills/ Gullies				Gorges		SRE status	Outside survey area?
	XC 01	XC 07	XC 25	XC 37	XC 05	XC 06	XC 08	XC 15	XC 02	XC 09	XC 10	XC 11	XC 12	XC 18	XC 27	XC 28	XC 13	XC 14	XC 17	XC 24	XC 36	XC 30	XC 31	XC 32	XC 34	XC 33	XC 35		
MYRIAPODA: POLYDESMIDA																													
Paradoxosomatidae																													
Antichiropus sp. 'christmas'			1									1	1		1					1					1	1	1	Likely	No
Antichiropus sp. 'anketell'																				1								No	Yes
Antichiropus sp. indet.		2	3									3	3							1		3						Unknown	Unknown
ISOPODA																													
Armadillidae																													
Buddelundia sp. 10											1								2			8	40					No	Yes
Buddelundia sp. 13		1	1	17		11	8					8			1				1		4							No	Yes
Buddelundia sp. 14		2				6	2		14		4				2			1	2			8				3	9	No	Yes
Buddelundia sp. n. 54																									1	2		No	Yes
Gen. n. sp. n.	3		2		7	1		1		1		2	1	2		2	1	2		1		1						No	Yes
Philosciidae																													
Laevophiloscia sp.	1							3	13		2											1					3	No	Yes
GASTROPODA																													
Pupillidae																													
Pupoides beltianus								1				9		5														No	Yes
Pupoides cf. *pacificus*											1																	No	Yes
Pupoides pacificus				1	1			1				7																No	Yes
Gastrocopta larapinta				3																								No	Yes
Gastrocopta mussoni			1	1	1						1																	No	Yes
Planorbidae																													
Gyraulus sp. indet								2																				No	Likely
Subulinidae																													
Eremopeas interioris								3				1														1		No	Yes
Total species per site	**3**	**5**	**6**	**4**	**4**	**3**	**3**	**8**	**2**	**3**	**7**	**7**	**5**	**3**	**5**	**2**	**1**	**6**	**7**	**5**	**1**	**7**	**1**	**2**	**3**	**4**	**4**		
Total per habitat	**12**				**11**				**18**								**13**					**9**				**6**			
Mean per habitat (± S.dev)	**4.5 ± 0.6**				**4.5 ± 2.4**				**4 ± 1.9**								**2.6 ± 2.8**					**3.3 ± 2.6**				**4**			

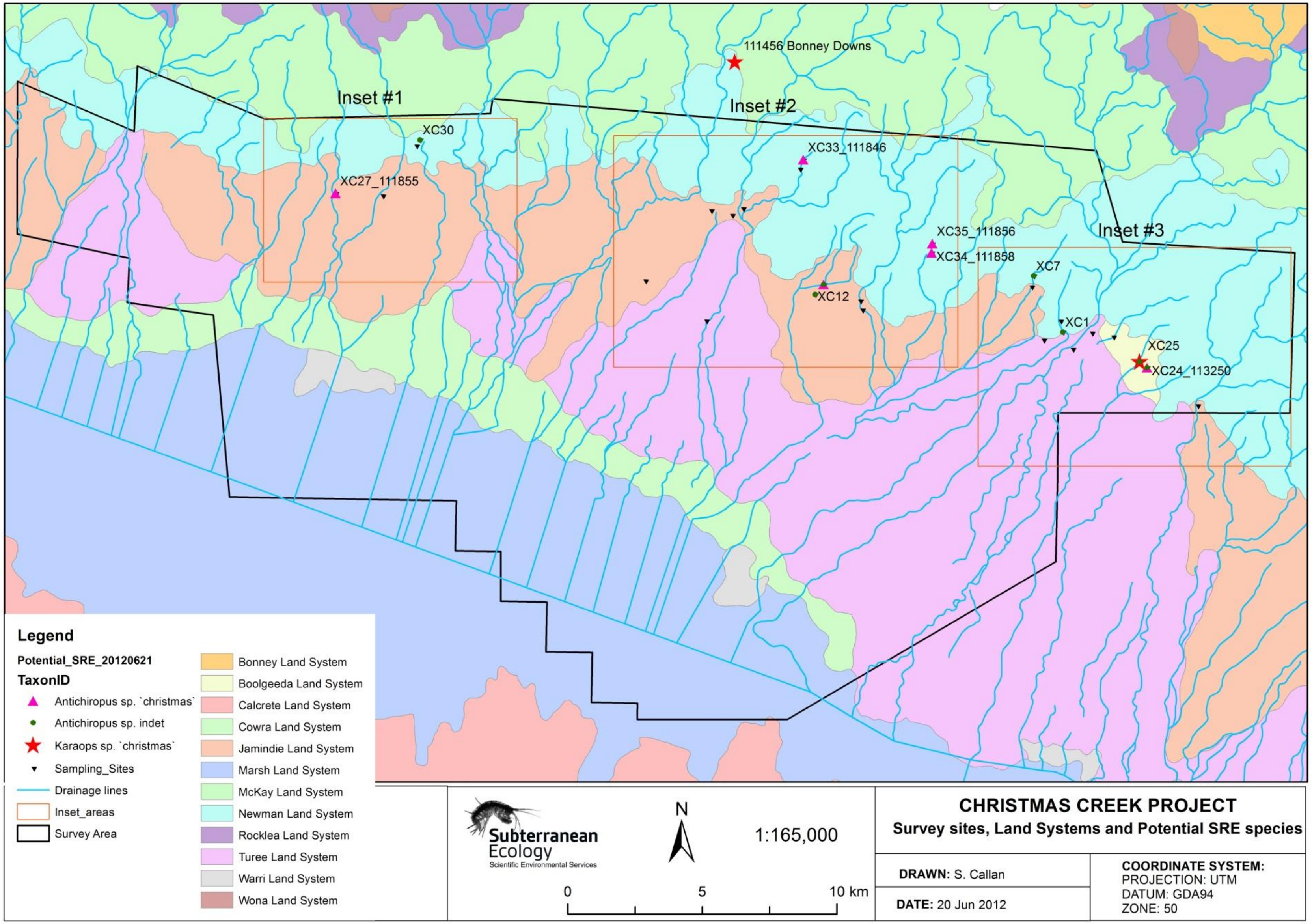


Figure 13. Likely SRE and potential SRE species detected during the Survey. Refer Appendix 9 for closer insets showing vegetation associations.

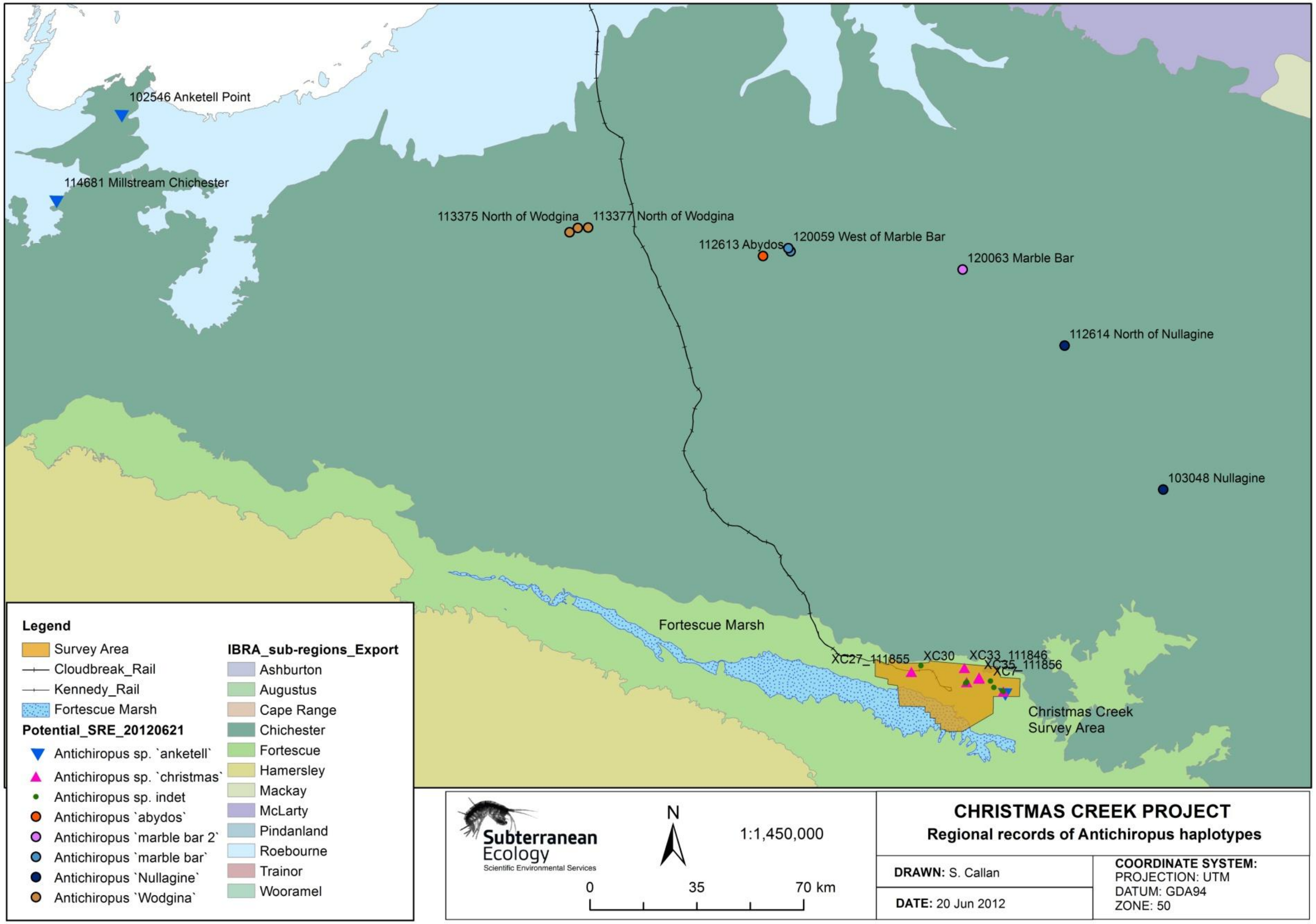
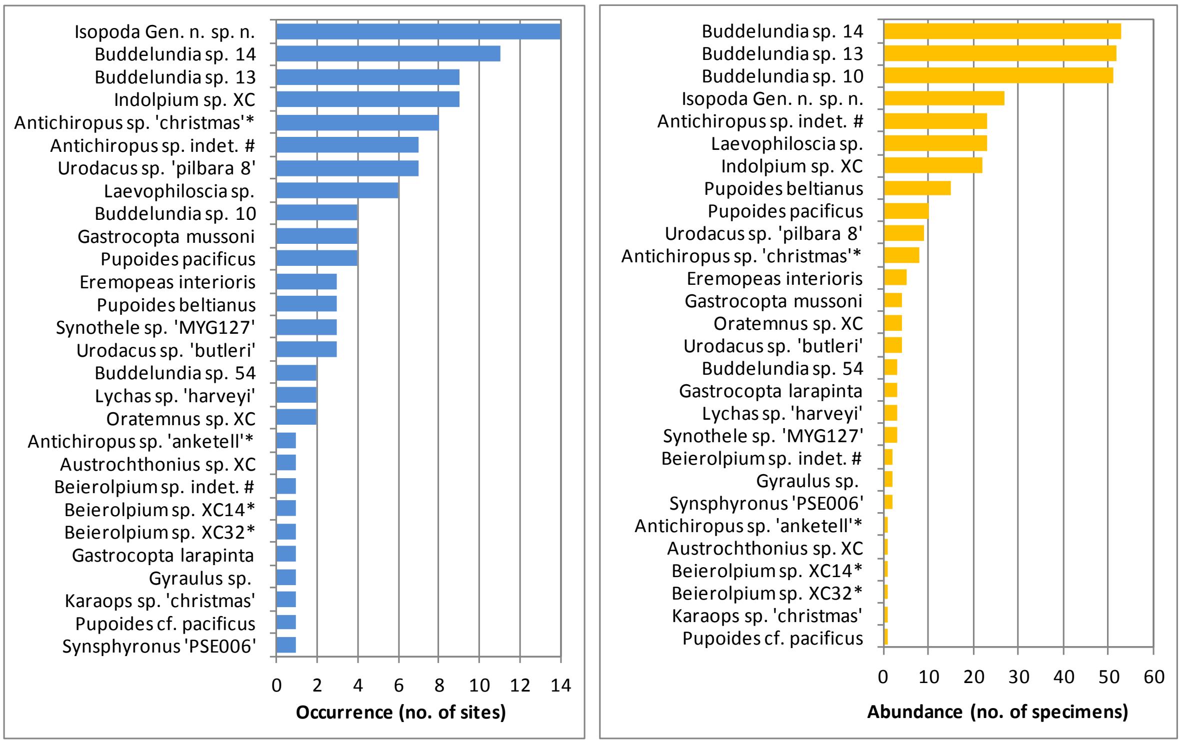


Figure 14. Regional records of *Antichiropus* haplotypes of relevance to the species detected at Christmas Creek.

7.3 Abundance and Frequency of Occurrence

Figure 15 shows that the majority of target SRE taxa detected during the survey occurred in few sites (< 4 sites), and were detected in low abundance (< 10 specimens). The most commonly occurring taxa comprised isopods (*Buddelundia* spp.) and millipedes (*Antichiropus* species), although a species of pseudoscorpion (*Indolpium* sp. indet. XC) and a scorpion (*Urodacus* sp. 'pilbara 8') were also commonly detected (Figure 15, Appendices 2 and 3). In general, the same groups (isopods, *Antichiropus*, and *Indolpium* pseudoscorpions) were among the most numerous taxa collected. The least abundant and most infrequently collected taxa included three snail species (*Gastrocopta larapinta*, *Gyraulus* sp. and *Pupoides* cf. *pacificus*) (refer Appendix 4), two pseudoscorpions (*Austrochthonius* sp. indet. XC and *Synsphyronus* 'PSE006'), and the potential SRE spider *Karaops* sp. 'christmas'.



(A) **(B)**

Figure 15. A) Occurrence (as no. of sites), and B) abundance (as no. of specimens) of target SRE taxa detected in the Survey. Asterisk (*) indicates genetically determined species (*i.e.* recorded occurrence / abundance is a function of success rate of sequencing). Hash (#) indicates taxa that were not able to be sequenced, and therefore cannot be allocated. The unidentifiable juvenile *Synothele* specimen (site XC27) was excluded.

7.4 Species Distributions and Habitat Associations

Overall, most of the target taxa detected during the Survey are known to occur widely beyond the Survey area. There were a few exceptions, including the potential SRE species *Karaops sp.* 'christmas' and *Antichiropus* sp. 'christmas', the genetically determined *Beierolpium* species (*B*. sp. XC14 and *B*. sp. XC32), and the pseudoscorpions *Austrochthonius* sp. indet. XC, and *Synsphyronus* sp. PSE006 which probably represent new species that have not yet been recorded elsewhere (M.

Harvey pers. comm. 2011, Appendix 3). The latter two taxa are not considered SRE species, and are likely to be found more widely over time.

Table 12 shows the sites where the taxa of potential conservation concern were recorded, and the range of habitats in which they are known to occur. *Karaops sp. '*christmas' has been recorded outside of the Survey area (at Bonney Downs, to the immediate north), while *Antichiropus* sp. 'christmas', to date, has not. However, *Antichiropus* sp. 'christmas' was detected in a wide range of different habitat types and it appears to be locally widespread.

Table 12. Sites and range of habitats where taxa of interest were recorded, at the time of Survey.

Taxon	Sites recorded	Range of habitats	SRE Status	Outside Survey area
Selenopidae (flat rock spiders)				
Karaops sp. 'christmas'	XC25	Drainage line	Potential	Bonney downs (18 km NW)
Pseudoscorpiones (pseudoscorpions)				
Beierolpium sp. indet. XC14	XC14, XC28	Veg Groves	Unknown	Unknown
Beierolpium sp. indet. XC32	XC32	Rocky hills and gullies	Unknown	Unknown
Polydesmida (Polydesmid millipedes)				
Antichiropus sp. 'christmas'	XC11, XC12, XC24, XC25, XC27, XC33, XC34, XC35	Drainage lines, Veg groves, Alluvial/ colluvial plains, Rocky Hills and gullies, Gorges	Likely	No

Table 11 and 12 show that millipedes and isopods were generally widespread across all habitat types, except for *Buddelundia* sp. 54, which appears to have an association with rocky hills, gullies and gorges. This species is known to occur outside the Survey area in the Hamersley Ranges and at Rocklea Homestead (S. Judd pers. comm. 2012, Appendix 5). The snail fauna was generally associated with drainage lines and floodplains, possibly due to the persistence of moisture in these habitats. The majority of arachnids were detected across a variety of habitat types; however, mygalomorph spiders and *Urodacus* scorpions were absent from rocky hills, gullies, and gorges, possibly due to the lack of suitable soils for burrowing.

The most species-rich habitat type was the alluvial / colluvial plains, with 18 target taxa in total, followed by drainage lines and vegetation groves (12 target species each). However, on average, drainage lines and floodplains recorded the highest numbers of target species per site (4.5 species each, Table 11).

Vegetation type #2 ("Creeks / Drainage Low Woodland to Low Open Forest of *Acacia aneura* var. *aneura*...") (ENV Australia 2010) occurred at the majority of sites sampled, including the single location where *Karaops sp. '*christmas' was detected. On-site habitat assessment revealed a number of prospective SRE habitats within this broader vegetation type (*e.g.* alluvial / colluvial plains, drainage lines, floodplains, and vegetation groves). Sites affected by recent fires (XC34 and XC35) did not show a significantly reduced diversity of target SRE taxa (respectively 3 to 4 species recorded), and both sites recorded the potential SRE species *Antichiropus* sp. 'christmas' (Table 11). Sites heavily affected by grassy weeds (*e.g.* XC05, XC06, XC08, XC09, XC14, and XC17) also did not appear to have a significantly reduced richness of target SRE taxa (species richness between 2-7 species).

The observed patterns of species distribution did not appear to be associated with land systems, although mygalomorph spiders, scorpions and snails were virtually absent from the Newman land system (comprising rocky hills and slopes). Most of the sampling occurred within the Jamindie and Newman land systems, which are relatively broad and continuous throughout the Survey area and the wider region (Figure 4). The Boolgeeda land system was relatively restricted within the Survey area despite occurring widely throughout the region (Table 1, Figure 4). Both of the potential SRE species detected in the Boolgeeda land system (*Karaops sp.* 'christmas' and *Antichiropus* sp. 'christmas') were also recorded in other land systems nearby (Figure 13, Appendix 9).

7.5 Species Accumulation Curves

The species accumulation curve of target SRE taxa collected during the Survey (Figure 16) gave a smooth curve which approached a plateau towards the end of the survey effort (82 samples).

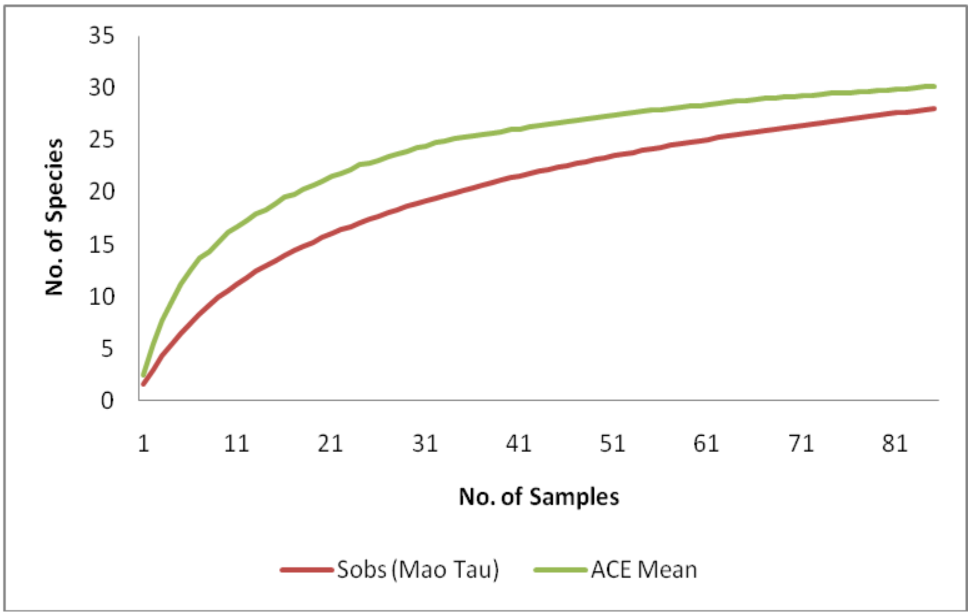


Figure 16. Species accumulation of target SRE fauna abundance data using the observed number of species (Sobs Mao Tau) and the Abundance Coverage Estimator (ACE Mean). This analysis does not include genetically determined species or haplotypes.

Four species estimator models in EstimateS® (Colwell 2006) were used to predict the total number of target SRE taxa that should occur, based on the observed detection rate (Figure 17). The four species estimator models found that the Survey has detected between 76% and 93% of the predicted total target SRE taxa. The findings of these analyses meet and exceed the recommendations of EPA (2009) Guidance 20 for terrestrial SRE fauna. The results confirm the adequacy of the survey effort, indicating that the Survey has detected a high proportion (76% - 93%) of the target SRE taxa predicted to occur. The results also suggest that a small number of rare or difficult to detect species may remain undetected at the current time.

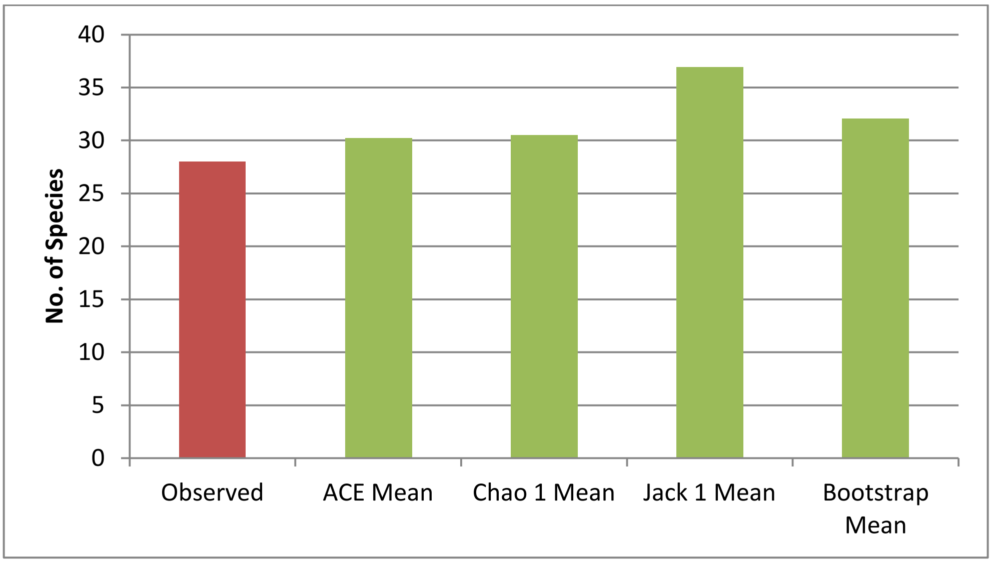


Figure 17. Chart of observed (Sobs Mao Tau) and predicted number of species using four species estimator models.

8 DISCUSSION

8.1 Survey Adequacy

The methods and survey design were in accordance with the requirements of the EPA (2009) Guidance Statement 20 for Terrestrial SRE Fauna. Within the practical limitations of site accessibility (*i.e.* excluding the Samphire flats surrounding Fortescue Marsh) the Survey has achieved good coverage of vegetation types, land systems, drainage and landforms over a wide range of habitat types throughout the Survey area. Species richness estimation and accumulation curves confirmed the adequacy of the survey effort, indicating that between 76% and 93% of the predicted target SRE taxa have been detected. This analysis shows a high level of confidence in the faunal results, with only a low proportion of target taxa that could potentially remain undetected. Representatives from all target taxonomic groups predicted to occur at Christmas Creek and Cloudbreak (Ecologia 2010a, 2011) were detected during the Survey.

8.2 Local and Regional Comparisons

The results of the Survey broadly aligned with previous results from the Pilbara region, specifically from nearby areas such as Cloudbreak and Roy Hill. At the taxonomic level, the SRE surveys at Christmas Creek and at Cloudbreak (Ecologia 2011) detected a highly similar fauna, with 71% of invertebrate families, 73% of genera, and 22% of species in common. A further 26% of species may possibly be shared pending direct taxonomic comparisons of the specimens collected, which has not yet been undertaken. The similarity of the fauna at Christmas Creek and Cloudbreak is consistent with the similarity of the habitats at these locations, which both occur in the foothills of the Chichester ranges and on the alluvial plains to the north of Fortescue Marsh. The results from Roy Hill had fewer species in common with Christmas Creek (potentially 17% of species, all unresolved identifications), and only 20% of families and genera in common (Ecologia 2006, 2008). This may be attributed to a variety of reasons such as potential habitat differences, differences in sampling intensity, seasonality or collection methods, or land use history (*e.g.* impact of intense grazing at Roy Hill) (Ecologia 2006, 2008).

The Cloudbreak and Roy Hill SRE surveys detected a number of confirmed SRE species, whereas no confirmed SRE species were found in the Survey at Christmas Creek. The WAM databases for the surrounding sub-regional area showed records of up to 25 other species that were considered SRE based on current distributions (Ecologia 2010). The types of habitats found within the Christmas Creek Survey area are known to be suitable for SRE species (*e.g.* drainage lines, gorges, rocky hills, vegetation groves), which is consistent with other local results (*e.g.* Cloudbreak survey, Ecologia 2011).

8.3 SRE Habitats

At the landscape-scale, the habitats of the Survey area are relatively broad and continuous such as Spinifex covered hills, Mulga woodland, Drainage line vegetation, and Samphire flats surrounding Fortescue Marsh (refer Figure 2, as described by Ecologia [2010a]). ENV Australia (2010) noted the importance of these vegetation communities in a floristic sense, and at Cloudbreak, Ecologia (2011) detected the highest richness and abundances of target SRE taxa from these types of communities. However, the differences between the habitat types were not considered statistically significant and various target SRE taxa were detected in each habitat type (Ecologia 2011). The results from Christmas Creek concur in regards to the occurrence of various target SRE taxa (including mygalomorph spiders, pseudoscorpions, scorpions, snails, and millipedes), within these broad habitat types. However, the current survey also identified finer-scale, prospective SRE habitats and micro-habitats within the broader habitat types, including gullies, gorges, and rocky outcrops within 'Spinifex covered hills', and isolated vegetation groves within 'Mulga woodland' and 'Drainage lines'.

On-site habitat assessment showed a degree of variability between characteristics of sites of the same broader habitat types; the drainage lines, floodplains, gorges, and vegetation groves were particularly variable in a number of ways. This habitat heterogeneity influences the suitability of micro-habitats for SRE taxa at a localised scale, and this can be assumed to have an effect on the presence of certain target taxa. However, none of the habitat types sampled during the Survey appeared particularly unique or restricted, and the majority of the fauna detected showed locally or regionally widespread distributions (those species whose distribution range could be assessed). Habitat mapping (Figures 3, 4 and 5, Appendices 7-9) has shown that the majority of the vegetation types, landforms, and land systems within the Survey area are well-represented outside of the Survey area.

8.4 Habitat Associations

The potential SRE spider *Karaops* sp. 'christmas' belongs to a genus that is generally considered to be specialist inhabitants of cracks and crevices in rocky outcrops, or under the bark of trees (V. Framenau pers. comm. 2011, Appendix 1). This species was collected from an isolated patch of the Boolgeeda land system within the Survey area; however, outside the Survey area (at Bonney Downs) it was recorded from the Newman land system (Figure 13). Its habitat probably comprises cracks and crevices in rocky outcrops, rock piles and potentially tree bark, that occur throughout the northern part of the Survey area and beyond into the Chichester ranges.

The potential SRE millipede *Antichiropus* sp. 'christmas' was collected widely throughout the Survey area in most SRE habitat types including drainage lines (XC25), alluvial/ colluvial plains (XC11, XC27), Mulga groves (XC24), rocky hills and gullies (XC34), and gorges (XC33, XC35). The majority of specimens were collected from leaf litter sifting, therefore it is assumed that this species inhabits moist leaf litter under Mulga and other Acacias, like many other *Antichiropus* species. *Antichiropus* can be very difficult to detect, as seasonality and moisture availability play a key role in their activity levels and lifecycle. The frequency at which *Antichiropus* sp. 'christmas' were detected during the Survey was unexpectedly high, probably as a result of suitable environmental conditions including high rainfall before and during the Survey.

The pseudoscorpions *Beierolpium* sp. indet. XC14 and B. sp. XC32 were detected in two very different habitat types (respectively, a dense grove of Mulga vegetation, and rocky hill slope with outcrop and caves), which may be reflected in their high level of genetic divergence (WAM 2012, Appendix 7). These species can be assumed to occur more widely than currently recognised, although additional specimen records would be required to test any hypothesis regarding their distribution range or habitat preferences. The isopod species *Buddelundia* sp. 54 is thought to specialise in sloping habitats such as rocky hills / gullies, and gorges (S. Judd. pers. comm. 2012, Appendix 5). The species is also known to occur outside of the Survey area at Rocklea Station and in the Hamersley Ranges.

The remaining target taxa occur relatively widely throughout the sub-region or region. A few taxa were detected only in one habitat type, or in several similar habitat types, although there was no overall relationship between the habitat types as defined by the assessment, and the occurrence of most of the target taxa. This was consistent with findings from Cloudbreak (Ecologia 2011), and combined with the relatively wide distribution of many of the taxa (*e.g. Indolpium* sp. indet. XC, *Urodacus* sp. 'pilbara 8', *Synothele* sp. 'MYG127', and all species of isopods except *Buddelundia* sp. 54). It is also consistent with the classification of most of the target taxa as non-SRE species.

8.5 Considerations for Environmental Impact Assessment

Environmental impact assessment in relation to the potential SRE fauna collected is contingent upon definition of the direct and indirect impact areas of the Project. The proposed mining pits would be the obvious direct impact, although other direct impact areas include any areas of vegetation clearing, stockpiles and infrastructure. Potential indirect impacts could include changes to surface and groundwater hydrology (*e.g.* flooding / ponding or drying that affects vegetation or the land surface), and environmental incidents such as fire, infestation of weeds, soil pathogens, invasive invertebrates, or contamination by spills and leakages. In most cases, these types of indirect impacts are managed or mitigated by standard mining practises (*e.g.* management of surface hydrology, control of fire, pathogens and weeds).

The key findings of relevance to environmental impact assessment are:

- The majority of species detected are not of conservation concern for the Project (*i.e.* widespread species, or those known beyond the Survey area);
- None of the key habitat types surveyed are unique or restricted to the Survey area; at a broad scale, the habitats are well-represented in the wider local area;
- Two (2) species were of potential significance to the Project:
    - *Karaops* sp. 'christmas' (selenopid spider); a potential SRE species, which is also known to occur at Bonney Downs Station, outside of the Survey area to the immediate north; and
    - *Antichiropus* sp. 'christmas' (millipede); a likely SRE species that was found frequently in most of the habitat types present throughout the Survey area. This species has not been recorded outside of the Survey area to date;
- *Antichiropus* sp. 'christmas' was found in alluvial/ colluvial plains, gorges, rocky hills and gullies, Mulga vegetation groves, and drainage lines. These types of habitats are not locally restricted, and are all well represented outside of the Survey area. It may be reasonable to assume that this species could occur in similar habitats in the wider local area beyond the boundaries of the Survey area, despite the fact that this is unconfirmed by sampling.

9 CONCLUSIONS

The following key points are concluded from the Survey:

- Twenty-seven (27) target taxa from 6 invertebrate orders (spiders, pseudoscorpions, scorpions, myriapods, isopods and snails) were collected;
- There is a high level of confidence in the faunal results, for the following reasons:
  - The Survey has met the recommendations of EPA (2009) Guidance Statement 20 for terrestrial SRE fauna;
  - The Survey achieved a high rate of detection, with 76% - 93% of the predicted species richness detected; and
  - The Survey achieved good coverage of vegetation types, land systems, drainage and landforms throughout the Survey area, excluding the Samphire flats surrounding Fortescue Marsh that were inaccessible due to flooding;
- The majority of taxa are widely distributed species (*i.e.* not SRE), that are known outside of the Survey area;
- No conservation listed species were found (under relevant legislation);
- Two (2) species were of potential significance to the Project:
  - *Karaops* sp. 'christmas' (selenopid spider); a potential SRE species, which is also known to occur at Bonney Downs Station, outside of the Survey area to the immediate north; and
  - *Antichiropus* sp. 'christmas' (millipede); a likely SRE species that was found frequently in most of the habitat types present throughout the Survey area. This species has not been recorded outside of the Survey area to date;
- *Antichiropus* sp. 'christmas' was found in alluvial/ colluvial plains, gorges, rocky hills and gullies, Mulga vegetation groves, and drainage lines. These types of habitats are not locally restricted, and are all well represented outside of the Survey area. Although unconfirmed by sampling data, there is no reason to suggest that this species would not occur in these types of habitats beyond the boundaries of the Survey area.

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APPENDICES

Appendix 1: Araneae Taxonomic Report

PHOENIX

ENVIRONMENTAL SCIENCES

Short-range endemic spiders (Araneae: Mygalomorphae, Araneomorphae) from Christmas Creek

Prepared for Subterranean Ecology

May 2011

Taxonomic Report

Short-range endemic spiders (Araneae: Mygalomorphae, Araneomorphae) from Christmas Creek

Prepared for Subterranean Ecology

Taxonomic report

Author/s: Volker W. Framenau, Peter Langlands

Reviewer/s: Erich Volschenk, Melanie White

Date: 23 May 2011

Submitted to: Shae Callan, Subterranean Ecology

Chain of authorship and review			
Name	**Task**	**Version**	**Date**
Volker W. Framenau	Interim for technical review		13 May 2011
Melanie White	Interim for editorial review		16 May 2011
Volker Framenau	Final submitted to client		23 May 2011

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Contents

List of Tables

EXECUTIVE SUMMARY

In May 2011, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Subterranean Ecology (the Client) to identify spiders collected at Christmas Creek (Pilbara region of Western Australia). In particular, a selection of 189 vials of spiders was to be screened for short-range endemic (SRE) target taxa and these to be identified to the lowest possible taxonomic level and their distribution assessed.

All other spiders were to be identified to family level to assist the Client in building a reference collection of spider families.

Of the 189 vials assessed, a total of five vials included three target SRE taxa:

- *Synothele* MYG127 (Mygalomorphae, Barychelidae – Brushfooted Trapdoor Spiders): genus with high incidence of short-range endemism in WA; however, *Synothele* MYG127 is widespread in the Pilbara region and not an SRE
- *Synothele* sp. (juv.) (Mygalomorphae, Barychelidae – Brushfooted Trapdoor Spiders): species-specific identification not possible; possibly conspecific with *Synothele* MYG127
- *Karaops* sp. (juv.) (Araneomorphae, Selenopidae - Flatties): genus with high incidence of short-range endemism in Pilbara region; putative SRE but mature female required for further assessment of distribution

In addition to the species of infraorder Mygalomorphae, the 189 samples yielded members of 19 araneomorph families: Araneidae, Clubionidae, Corinnidae, Desidae, Gnaphosidae, Hersiliidae, Lamponidae, Lycosidae, Miturgidae, Oonopidae, Oxyopidae, Pholcidae, Prodidomidae, Salticidae, Theridiidae, Thomisidae, Trochanteriidae, Zodariidae and Zoridae.

Many of these spiders could not be identified beyond family level as they are immature. Many were in very early developmental stages, and even the family designation remains doubtful in some cases.

1 SCOPE OF WORKS

In May 2011, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Subterranean Ecology (the Client) to identify spiders collected at Christmas Creek (Pilbara region of Western Australia). In particular, a selection of 189 vials of spiders was to be screened for short-range endemic (SRE) target taxa and these to be identified to the lowest possible taxonomic level and their distribution assessed.

All other spiders were to be identified to family level to assist the Client in building a reference collection of spider families.

2 METHODS

A number of taxonomic groups include a considerable proportion of species with naturally small ranges and are targeted in SRE surveys as part of environmental impact assessments (EPA 2009; Harvey 2002)

- Araneae (spiders, in particular Mygalomorphae - Trap-door Spiders - and selected Araneomorphae - Modern Spiders, e.g. Selenopidae)
- Pseudoscorpiones (pseudoscorpions)
- Scorpiones (scorpions)
- Schizomida (false whipscorpions)
- Diplopoda (millipedes)
- Chilopoda (centipedes)
- Gastropoda (land snails)
- Isopoda (slaters)
- Onychophora (velvet worms)
- Annelida (in particular terrestrial earthworms)

2.1 IDENTIFICATION AND PERSONNEL

All spiders were examined in 70% or 100% ethanol under Leica M205A and M80 stereomicroscopes.

The method of identification for each taxon, i.e. by taxonomic literature or comparison with type or other reference material, is indicated in the taxonomic part of this report. Personnel involved in the identification are listed (Table 2-1).

Table 2-1 Phoenix personnel involved in identification

Taxonomic group	Title	Qualification
Dr Volker Framenau	Principal Invertebrate Scientist	One of Australia's leading arachnologists with taxonomic expertise in major araneomorph and mygalomorph spiders; established the WAM mygalomorph reference collection
Dr Peter Langlands	Invertebrate Zoologist	Arachnologist with significant expertise in araneomorph and mygalomorph surveys and taxonomic expertise

2.2 TAXONOMY AND NOMENCLATURE

The taxonomic nomenclature of invertebrates treated here follows published references (Table 2-2).

Morphospecies designations of undescribed species are generally adopted from the systems of the scientist(s) working on the group. For mygalomorph spiders, the Western Australian Museum has established a morphological reference collection of males that aids in the identification of spiders. Morphospecies are numbered consecutively with the prefix "MYG", e.g. *Aname* MYG001 (Nemesiidae).

In addition, Phoenix maintains its own morphospecies database and species for which no other interim naming system exists are assigned a Phoenix morphospecies designation (PES+number), i.e. *Encoptarthria* PES324 (a gnaphosid spider).

Table 2-2 Taxonomic (nomenclature) references for SRE invertebrates

Taxonomic group	Taxonomic reference
Araneae (Mygalomorphae, Araneomorphae)	Platnick (2011)

2.3 SPECIMEN DEPOSITORY

As recommended by the EPA guidance statement No. 20 ('*Sampling of short-range invertebrate fauna for environmental impact assessment in Western Australia*') (EPA 2009) all specimens representing target SRE groups were lodged with the WAM to enhance the knowledge of the distribution of putatively rare species.

Phoenix registered these specimens on behalf of the WAM (registration numbers as indicated in Appendix 1). Some duplicate specimens have been returned to the Client.

3 RESULTS

Of the 189 spider samples assessed, five contained species in target SRE groups. Three males and a juvenile of *Synothele* MYG127 (Barychelidae) are not considered SREs and an immature *Karaops* (Selenopidae) could not be identified to species level to ascertain its distribution and conservation status.

The remaining samples represented 19 araneomorph families not considered to be SRE: Araneidae, Clubionidae, Corinnidae, Desidae, Gnaphosidae, Hersiliidae, Lamponidae, Lycosidae, Miturgidae, Oonopidae, Oxyopidae, Pholcidae, Prodidomidae, Salticidae, Theridiidae, Thomisidae, Trochanteriidae, Zodariidae and Zoridae.

3.1 MYGALOMORPHAE (TRAPDOOR SPIDERS)

Trapdoor spiders represent one of the focal groups in surveys of short-range endemic taxa (EPA 2009; Harvey 2002). A number of mygalomorph spiders, e.g. *Idiosoma nigrum* Main, 1952, *Kwonkan eboracum* Main, 1983, and *Moggridgea tingle* Main, 1991, are listed on Schedule 1 ("Fauna that is rare or likely to become extinct") of the Wildlife Conservation (Specially Protected Fauna) Notice 2010(2) of the Western Australian Government (Western Australian Government 2010).

The Western Australian mygalomorph fauna is vast and remains taxonomically poorly known for many families and genera (e.g. Barychelidae: *Idiommata*; Idiopidae: *Aganippe*; Nemesiidae: *Aname*, *Chenistonia*, *Kwonkan*).

3.1.1 Family Barychelidae (Brush-footed Trapdoor Spiders)

Barychelid spiders, commonly called Brush-footed Trapdoor Spiders, are small to fairly large in size with well-developed claw tufts and short terminal segment of the posterior lateral spinnerets (Raven 1994). In Western Australia, the genera *Aurecocrypta*, *Idiommata, Mandjelia* and *Synothele* are known to occur from the Southwest region into the Pilbara region and *Moruga* has been found in the Kimberleys (Raven 1994). Of all trapdoor spiders, few are as cryptic as the Barychelidae. Their burrows tend to be less than 60 cm deep and often lack the firm thick door of the Ctenizidae or the extensive webs of Dipluridae.

3.1.1.1 Genus *Synothele*

The genus *Synothele* can be identified by the low number of maxillary cuspules in combination with the lack of lyra (specialised clubbed setae) on the maxillae, and the often mottled abdomen (uniformly dark in the similar *Aurecocrypta*). The genus is widespread throughout Western (21 species) and South Australia (3 species) with most species known only from very limited ranges (Raven 1994).

***Synothele* MYG127**

Three males of *Synothele* MYG127 were recovered by the Client at Davidson Creek (Appendix 1). This species has been collected at numerous localities throughout the Pilbara region and is not an SRE.

***Synothele* sp. (juv.)**

This juvenile specimen (Appendix 1) could not be identified to species level, but it is very likely that it is conspecific with *Synothele* MYG127. It is therefore not considered to represent an SRE.

3.2 ARANEOMORPHAE (MODERN SPIDERS)

Araneomorph spiders are generally not targeted in SRE surveys although some putative relictual Gondwanan species have recently been shown to display extremely narrow distributions along the south coast of Western Australia (Framenau *et al.* 2008). Recent systematic studies on araneomorph spider family Micropholcommatidae has also shown significant levels of localized speciation on the Swan Coastal Plain (Rix & Harvey 2010).

The material supplied by the Client included representatives of 20 araneomorph spider families: Araneidae, Clubionidae, Corinnidae, Desidae, Gnaphosidae, Hersiliidae, Lamponidae, Lycosidae, Miturgidae, Oonopidae, Oxyopidae, Pholcidae, Prodidomidae, Salticidae, Selenopidae, Theridiidae, Thomisidae, Trochanteriidae, Zodariidae and Zoridae (Appendix 1). Of these, only the Selenopidae are considered to include SRE species.

3.2.1 Selenopidae (Flatties)

Selenopidae are small to medium-sized dorso-ventrally flattened spiders with laterigrade (i.e. crab-like) legs. They differ from the superficially similar Huntsmen Spiders (Sparassidae) and Flattened Ground Spiders (Trochanteriidae) by the arrangement of the eight eyes in two rows, six in the front row and two in the back. They are often mottled in colouration with distinct darker rings on the legs. In Australia, the Selenopidae are represented by only a single genus, *Karaops*, that currently includes 24 described species (Crews & Harvey 2011).

3.2.1.1 Genus *Karaops*

Members of the genus *Karaops* are generally found under the bark of trees or under the exfoliating rocks of rocky outcrops. Their preference for isolated rocky habitats predisposes these spiders to short-range endemism and more than half of the Australian *Karaops* are known from very restricted ranges only. For example, *K. burbidgei* Crews & Harvey 2011 is only known from Barrow Island. Very recent collections in the Pilbara region have revealed a number of females of species not treated in the revision of Crews and Harvey (2011), all from single localities only. Due to this distribution pattern, Selenopidae have emerged as the latest target group for SRE surveys. As females have distinctive genitalia and are generally more often collected than males they represent the more suitable sex for comparative species identification.

***Karaops* sp. (juv.)**

The single specimen of *Karaops* collected by the Client at Davidson Creek is juvenile (Appendix 1) and an accurate species identification is not possible. A mature female from the same locality should be obtained to assess the distribution and conservation status of this species. Based on the currently known distribution patterns within the genus *Karaops*, it is possible that the juvenile *Karaops* represents an SRE.

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IDENTIFICATION OF SPIDERS (ARANEAE) FROM CHRISTMAS CREEK

LN_number (WAM T-number)	Identification	Visit code	Trap	No.	Target SRE taxon	Remarks
11:0286 (WAM T111971)	Barychelidae: *Synothele* MYG127	FMG007_XCP12_FN11291	Pit Trap	1	Y	
11:0439 (WAM T111972)	Barychelidae: *Synothele* MYG127	FMG007_XCP27_FN11288	Pit Trap	1	Y	
11:0454	Barychelidae: *Synothele* MYG127	FMG007_XCP17_FN10929	Pit Trap	1	Y	
11:0391	Barychelidae: *Synothele* sp. (juv.)	FMG007_XCF07_FN11307	Forage	1	Y	Species identification not possible
11:0588	Selenopidae: *Karaops* sp. (juv.) (also Lycosidae, Hersiliidae, Zodariidae)	FMG007_XCF25_FN11499	Forage	7	Y	Mature female *Karaops* required for further morphological assessment
11:0181	Zodariidae	FMG007_XCL11_FN10974	litter	3		
11:0182	Gnaphosidae	FMG007_XCL11_FN10974	litter	6		
11:0211	Corinnidae, Zodariidae	FMG007_XCP33_FN10937	Pit Trap	8		
11:0214	Sparassidae	FMG007_XCP33_FN10937	Pit Trap	1		
11:0218	Araneidae	FMG007_XCP11_FN10927	Pit Trap	1		
11:0222	Lycosidae, Miturgidae	FMG007_XCP32_FN10936	Pit Trap	10		
11:0227	Lycosidae, Zoridae	FMG007_XCP10_FN10926	Pit Trap	8		
11:0228	Oxyopidae, Zodariidae	FMG007_XCP10_FN10926	Pit Trap	6		
11:0260	Gnaphosidae	FMG007_XCF37_FN10985	Forage	1		
11:0261	Zoridae	FMG007_XCF37_FN10985	Forage	1		
11:0262	Gnaphosidae	FMG007_XCF37_FN10985	Forage	1		
11:0263	Zodariidae	FMG007_XCF37_FN10985	Forage	1		
11:0264	Araneidae	FMG007_XCF37_FN10985	Forage	1		
11:0266	Zodariidae	FMG007_XCL37_FN10986	litter	1		

11:0267	Gnaphosidae	FMG007_XCL37_FN10986	litter	1		
11:0268	Gnaphosidae	FMG007_XCL37_FN10986	litter	1		
11:0276	Gnaphosidae	FMG007_XCL36_FN10984	litter	2		
11:0279	Lycosidae juv.	FMG007_XCP14_FN11292	Pit Trap	7		
11:0280	Oxyopidae	FMG007_XCP14_FN11292	Pit Trap	2		
11:0281	Miturgidae, Corinnidae, Salticidae	FMG007_XCP14_FN11292	Pit Trap	12		
11:0282	Araneidae	FMG007_XCP14_FN11292	Pit Trap	1		
11:0287	Lycosidae	FMG007_XCP12_FN11291	Pit Trap	2		
11:0288	Oxyopidae, Thomisidae	FMG007_XCP12_FN11291	Pit Trap	11		
11:0295	Lycosidae juv., Oxyopidae	FMG007_XCP31_FN10935	Pit Trap	7		
11:0296	Salticidae, Lycosidae juv.	FMG007_XCP31_FN10935	Pit Trap	2		
11:0332	Hersiliidae	FMG007_XCF36_FN10983	Forage	1		
11:0334	Theridiidae	FMG007_XCF36_FN10983	Forage	1		
11:0339	Salticidae	FMG007_XCF36_FN10983	Forage	1		
11:0341	Clubionidae	FMG007_XCF36_FN10983	Forage	1		
11:0345	Pholcidae + juvs	FMG007_XCF13_FN11312	Forage	5		
11:0359	Desidae	FMG007_XCF28_FN11495	Forage	1		
11:0361	Gnaphosidae, Corinnidae	FMG007_XCL28_FN11496	litter	1		
11:0369	Oonopidae	FMG007_XCL36_FN10984	litter	1		
11:0370	Gnaphosidae	FMG007_XCL36_FN10984	litter	2		
11:0375	Pholcidae	FMG007_XCF27_FN10981	Forage	1		
11:0376	Trochanteriidae	FMG007_XCF27_FN10981	Forage	1		
11:0377	Gnaphosidae	FMG007_XCF27_FN10981	Forage	1		
11:0378	Araneidae	FMG007_XCF27_FN10981	Forage	1		
11:0379	Zodariidae	FMG007_XCF27_FN10981	Forage	1		

11:0382	Gnaphosidae	FMG007_XCL27_FN10982	litter	4		
11:0383	Zodariidae	FMG007_XCL27_FN10982	litter	2		
11:0384	Desidae	FMG007_XCL27_FN10982	litter	2		
11:0385	Lamponidae	FMG007_XCL27_FN10982	litter	1		
11:0389	Prodidomidae	FMG007_XCF07_FN11307	Forage	1		
11:0390	Zoridae	FMG007_XCF07_FN11307	Forage	2		
11:0395	Zoridae	FMG007_XCF18_FN11300	Forage	2		
11:0396	Zoridae	FMG007_XCF18_FN11300	Forage	1		
11:0397	Zodariidae	FMG007_XCF18_FN11300	Forage	1		
11:0398	Gnaphosidae	FMG007_XCF18_FN11300	Forage	1		
11:0399	Araneidae	FMG007_XCF18_FN11300	Forage	1		
11:0400	Gnaphosidae	FMG007_XCL18_FN11301	litter	1		
11:0401	Gnaphosidae	FMG007_XCL18_FN11301	litter	1		
11:0402	Gnaphosidae	FMG007_XCL18_FN11301	litter	1		
11:0405	Salticidae	FMG007_XCF17_FN10977	Forage	2		
11:0406	Lycosidae	FMG007_XCF17_FN10977	Forage	1		
11:0407	Araneidae	FMG007_XCF17_FN10977	Forage	1		
11:0412	Zodariidae	FMG007_XCL17_FN10980	litter	4		
11:0413	Oonopidae	FMG007_XCL17_FN10980	litter	3		
11:0414	Gnaphosidae	FMG007_XCL17_FN10980	litter	2		
11:0415	Gnaphosidae	FMG007_XCL17_FN10980	litter	1		
11:0416	Clubionidae	FMG007_XCL17_FN10980	litter	1		
11:0417	Araneidae	FMG007_XCL17_FN10980	litter	1		
11:0422	Zodariidae	FMG007_XCL09_FN11508	litter	3		
11:0423	Gnaphosidae	FMG007_XCL09_FN11508	litter	2		

11:0424	Gnaphosidae	FMG007_XCL09_FN11508	litter	1		
11:0425	Zodariidae	FMG007_XCL09_FN11508	litter	1		
11:0426	Oxyopidae	FMG007_XCL09_FN11508	litter	1		
11:0427	Gnaphosidae	FMG007_XCL09_FN11508	litter	1		
11:0430	Zodariidae	FMG007_XCF06_FN11330	Forage	1		
11:0433	Gnaphosidae	FMG007_XCL06_FN11331	litter	1		
11:0434	Oonopidae	FMG007_XCL06_FN11331	litter	1		
11:0435	Gnaphosidae	FMG007_XCL06_FN11331	litter	1		
11:0440	Oxyopidae, Corinnidae	FMG007_XCP27_FN11288	Pit Trap	10		
11:0441	Araneidae	FMG007_XCP27_FN11288	Pit Trap	1		
11:0445	Zodariidae	FMG007_XCP06_FN10923	Pit Trap	1		
11:0453	Lycosidae juv., Miturgidae	FMG007_XCP17_FN10929	Pit Trap	7		
11:0455	Thomisidae	FMG007_XCP17_FN10929	Pit Trap	2		
11:0463	Gnaphosidae	FMG007_XCF31_FN11314	Forage	1		
11:0464	Zodariidae	FMG007_XCL31_FN11315	litter	2		
11:0465	Salticidae	FMG007_XCL31_FN11315	litter	1		
11:0466	Desidae	FMG007_XCL31_FN11315	litter	1		
11:0472	Zodariidae	FMG007_XCF01_FN11298	Forage	3		
11:0473	Zoridae	FMG007_XCF01_FN11298	Forage	2		
11:0474	Lycosidae	FMG007_XCF01_FN11298	Forage	1		
11:0475	Zodariidae	FMG007_XCF01_FN11298	Forage	1		
11:0476	Araneidae	FMG007_XCL01_FN11299	litter	1		
11:0477	Zodariidae	FMG007_XCL01_FN11299	litter	4		
11:0478	Gnaphosidae	FMG007_XCL01_FN11299	litter	2		
11:0479	Zodariidae	FMG007_XCL01_FN11299	litter	1		

11:0480	Araneidae	FMG007_XCL01_FN11299	litter	1		
11:0488	Lycosidae juv.	FMG007_XCF15_FN11511	Forage	1		
11:0489	Corinnidae	FMG007_XCF15_FN11511	Forage	1		
11:0490	Zodariidae	FMG007_XCF15_FN11511	Forage	1		
11:0491	Zoridae	FMG007_XCF15_FN11511	Forage	1		
11:0492	Zodariidae	FMG007_XCL15_FN11510	litter	1		
11:0493	Gnaphosidae	FMG007_XCL15_FN11510	litter	4		
11:0494	Zodariidae	FMG007_XCL15_FN11510	litter	2		
11:0495	Gnaphosidae	FMG007_XCL15_FN11510	litter	1		
11:0496	Lycosidae	FMG007_XCL15_FN11510	litter	1		
11:0502	Zodariidae	FMG007_XCF25_FN11499	Forage	1		
11:0503	Gnaphosidae	FMG007_XCF25_FN11499	Forage	3		
11:0504	Zoridae	FMG007_XCF25_FN11499	Forage	3		
11:0505	Zoridae	FMG007_XCF25_FN11499	Forage	3		
11:0506	Salticidae	FMG007_XCF25_FN11499	Forage	2		
11:0507	Oxyopidae	FMG007_XCF25_FN11499	Forage	1		
11:0508	Gnaphosidae	FMG007_XCF25_FN11499	Forage	1		
11:0512	Gnaphosidae	FMG007_XCL25_FN11497	litter	2		
11:0513	Gnaphosidae	FMG007_XCL25_FN11497	litter	2		
11:0514	Zodariidae	FMG007_XCL25_FN11497	litter	2		
11:0515	Gnaphosidae	FMG007_XCL25_FN11497	litter	1		
11:0516	Lycosidae juv.	FMG007_XCL25_FN11497	litter	1		
11:0517	Lamponidae	FMG007_XCL25_FN11497	litter	1		
11:0518	Oonopidae	FMG007_XCL25_FN11497	litter	1		
11:0530	Lycosidae, Oxyopidae	FMG007_XCP25_FN11289	Pit Trap	17		

11:0531	Zodariidae	FMG007_XCP25_FN11289	Pit Trap	6		
11:0532	Thomisidae	FMG007_XCP25_FN11289	Pit Trap	1		
11:0539	Oxyopidae, Lycosidae, Corinnidae	FMG007_XCP05_FN10922	Pit Trap	30		
11:0540	Zodariidae	FMG007_XCP05_FN10922	Pit Trap	5		
11:0541	Lycosidae juv.	FMG007_XCP05_FN10922	Pit Trap	3		
11:0542	Corinnidae	FMG007_XCP05_FN10922	Pit Trap	1		
11:0551	Lamponidae	FMG007_XCP24_FN10932	Pit Trap	1		
11:0552	Zodariidae	FMG007_XCP24_FN10932	Pit Trap	1		
11:0553	Gnaphosidae, Lamponidae, Araneidae	FMG007_XCL07_FN11308	litter	12		
11:0557	Zoridae, Gnaphosidae	FMG007_XCL08_FN11311	litter	10		
11:0565	Zodariidae	FMG007_XCL10_FN11306	litter	1		
11:0566	Zodariidae, Gnaphosidae	FMG007_XCL13_FN11313	litter	10		
11:0570	Zodariidae, Lycosidae juv.	FMG007_XCF19_FN11303	Forage	5		
11:0575	Salticidae, Gnaphosidae	FMG007_XCF08_FN11310	Forage	4		
11:0581	Zoridae, Gnaphosidae	FMG007_XCF10_FN11305	Forage	6		
11:0587	Gnaphosidae, Lamponidae	FMG007_XCF10_FN11305	Forage	5		
11:0595	Salticidae, Gnaphosidae	FMG007_XCL35_FN11326	litter	3		
11:0603	Lycosidae, Zoridae	FMG007_XCF05_FN11328	Forage	5		
11:0610	Zodariidae, Oonopidae	FMG007_XCL30_FN11317	litter	7		
11:0628	Zodariidae, Araneidae	FMG007_XCF11_FN10973	Forage	4		
11:0640	Zodariidae, Araneidae, Lamponidae	FMG007_XCL12_FN11333	litter	17		
11:0647	Zodariidae, Sparassidae	FMG007_XCF12_FN11332	Forage	6		
11:0649	Zodariidae	FMG007_XCF32_FN11318	Forage	1		
11:0651	Zodariidae, Salticidae	FMG007_XCL32_FN11319	litter	8		
11:0656	Zodariidae	FMG007_XCF32_FN11318	Forage	4		

11:0660	leg.	FMG007_XCF32_FN11318	Forage	1		
11:0664	Gnaphosidae, Lamponidae, Pholcidae	FMG007_XCL02_FN11297	litter	10		
11:0672	Gnaphosidae	FMG007_XCF02_FN11296	Forage	1		
11:0677	Zoridae	FMG007_XCF14_FN11294	Forage	2		
11:0679	Gnaphosidae	FMG007_XCL14_FN11295	litter	1		
11:0692	Zodariidae, Zoridae	FMG007_XCF24_FN11514	Forage	3		
11:0699	Desidae	FMG007_XCF30_FN11316	Forage	2		
11:0708	Zoridae	FMG007_XCF33_FN11322	Forage	1		
11:0739	Lycosidae juv.	FMG007_XCP09_FN10925	Pit Trap	3		
11:0745	Lycosidae	FMG007_XCP13_FN10928	Pit Trap	6		
11:0749	Lycosidae, Miturgidae	FMG007_XCP30_FN10934	Pit Trap	6		
11:0756	Lycosidae juv.	FMG007_XCP08_FN11293	Pit Trap	3		
11:0761	Lycosidae	FMG007_XCP15_FN11290	Pit Trap	1		
11:0762	Lycosidae, Oxyopidae	FMG007_XCP15_FN11290	Pit Trap	15		
11:0763	Zodariidae, Gnaphosidae	FMG007_XCP15_FN11290	Pit Trap	9		
11:0768	Lycosidae, others	FMG007_XCP28_FN10933	Pit Trap	7		
11:0773	Lycosidae, Zoridae, Oxyopidae	FMG007_XCP07_FN10924	Pit Trap	10		
11:0777	Oxyopidae, Lycosidae	FMG007_XCP34_FN10938	Pit Trap	9		
11:0785	Zoridae	FMG007_XCP18_FN10930	Pit Trap	1		
11:0786	Corinnidae	FMG007_XCP18_FN10930	Pit Trap	2		
11:0787	Zodariidae	FMG007_XCP18_FN10930	Pit Trap	2		
11:0788	Oxyopidae, Lycosidae Juv.	FMG007_XCP18_FN10930	Pit Trap	7		
11:0789	Lycosidae, Miturgidae	FMG007_XCP18_FN10930	Pit Trap	3		
11:0794	Salticidae, Lycosidae, Thomisidae	FMG007_XCP35_FN10939	Pit Trap	11		
11:0795	Oxyopidae	FMG007_XCP35_FN10939	Pit Trap	6		

11:0796	Prodidomidae, Pholcidae	FMG007_XCP35_FN10939	Pit Trap	10		
11:0805	Sparassidae	FMG007_XCP01_FN10920	Pit Trap	1		
11:0806	Zodariidae, Thomisidae	FMG007_XCP24_FN10932	Pit Trap	2		
11:0817	Trochanteriidae	FMG007_XCP19_FN10931	Pit Trap	1		
11:0818	Lycosidae juv., Oxyopidae	FMG007_XCP19_FN10931	Pit Trap	7		
11:0819	Corinnidae	FMG007_XCP19_FN10931	Pit Trap	1		
11:0852	Zodariidae, Corinnidae	FMG007_XCP01_FN10920	Pit Trap	4		
11:0853	Zodariidae, Lycosidae, Oxyopidae	FMG007_XCP01_FN10920	Pit Trap	20		
11:6082	Lycosidae female	FMG007_XCL24_FN11513	litter	1		No. 11:0682
11:6084	leg.	FMG007_XCL24_FN11513	litter	1		No. 11:0684
11:6085	Oonopidae, Salticidae, Araneidae	FMG007_XCL24_FN11513	litter	10		No. 11:0685
11:8011	Zodariidae, Prodidomidae	FMG007_XCP02_FN10921	Pit Trap	12		
11:8012	Zodariidae	FMG007_XCP02_FN10921	Pit Trap	4		
11:8013	Gnaphosidae	FMG007_XCP02_FN10921	Pit Trap	1		
11:0217a	Lycosidae, Miturgidae	FMG007_XCP11_FN10927	Pit Trap	3		
11:0217b	Corinnidae, Zodariidae, Lycosidae, Oxyopidae	FMG007_XCP11_FN10928	Pit Trap	5		
11:0404b	-	FMG007_XCF17_FN10977	Forage	1		
11:0444a	Lycosidae juv.	FMG007_XCP06_FN10923	Pit Trap	6		
11:0444b	Corinnidae + others	FMG007_XCP06_FN10924	Pit Trap	12		
11:0550a	Oxyopidae + others	FMG007_XCP24_FN10932	Pit Trap	14		
11:0550b	Lycosidae juv.	FMG007_XCP24_FN10933	Pit Trap	1		
11:0593a	-	FMG007_XCL34_FN11327	litter	2		
11:0597a	-	FMG007_XCL05_FN11329	litter	4		
11:0631a	-	FMG007_XCF17_FN10977	Forage	1		
11:0631b	-	FMG007_XCF17_FN10977	Forage	1		

Appendix 2: Scorpiones Taxonomic Report

Christmas Creek Scorpion Identification Report

Report no. SE-1105

Prepared for: Subterranean Ecology

by Erich S. Volschenk Tuesday, 17 May

2011

Summary

Subterranean Ecology is undertaking a short-range endemic survey at Christmas Creek, and has requested:

- Taxonomic identifications of scorpion from the survey;
- SRE assessment of the species represented in the collection, and;
- Lodgement of these specimens in the Western Australian Museum Arachnology Collection.

The scorpion collection is comprised of 12 samples obtained from wet pitfall trapping and foraging: ***Lychas* 'harveyi',** 2; ***Urodacus* 'butleri',** 3**;** ***Urodacus* 'pilbara 8',** 7.

Current data on these species indicates that none of these are short-range endemics.

Taxonomy, Conservation Status and Recommendations

FAMILY BUTHIDAE

The family Buthidae is the most diverse and wide spread of all scorpion families (Fet and Lowe 2000). In Australia, Buthidae is represented by the genera *Australobuthus* Locket; *Isomerus* Ehrenberg; *Isometroides* Karsch, *Lychas* C.L. Koch, and *Hemilychas* Hirst. In Western Australia, only the Isometrus, *Isometroides* and Lychas, have been recorded. The taxonomy of the constituent species of *Isometrus*, *Isometroides* and *Lychas* is very problematic and each genus contains numerous undescribed species, most notably in the genus *Lychas* (Volschenk unpublished data). Most Authors refer to LE Koch (1977) for keys and identification. That revision represents an important study of the Australian scorpions; however, several taxonomic decisions made by (Koch 1977) have been rejected by subsequent authors and the taxonomy in that publication is not up to date. Most Australian buthid species appear to have wide distributions; however, a few taxa have confirmed SRE distributions (Volschenk unpublished data).

Lychas 'harveyi'

Lychas 'harveyi' has been widely sampled from the Pilbara region of Western Australia.

Current data on this species indicate that it is NOT a short-range endemic.

NOTE: *Lychas* 'harveyi' is a morphospecies name and is NOT published. It is not a valid name under the International code of Zoological Nomenclature (International Commission on Zoological Nomenclature 1999).

FAMILY URODACIDAE

The family Urodacidae is endemic to Australia (Fet 2000; Prendini 2000; Prendini 2003) where it is represented by the genera *Urodacus* Peters, and Aops Volschenk and Prendini. *Urodacus* has been considered a member of the family Scorpionidae for many years, but in a revision of the superfamily Scorpionoidea Latreille, (Prendini 2000) placed *Urodacus* in its own family. Unlike the treatment of Buthide, LE Koch's (1977) treatment of *Urodacus* has been mostly supported by subsequent authors (Volschenk et al. 2000; Harvey and Volschenk 2002; Volschenk and Prendini 2006). The biggest issue confronting *Urodacus* taxonomy is the number of undescribed species being uncovered through current revisionary work (Volschenk unpublished data). Currently 22 species of *Urodacus* are described; however, this may represent only 15-20% of the real diversity of this genus in Australia. *Urodacus* is most diverse in Western Australia and few species are recorded east of the Great Dividing Range in eastern Australia.

Urodacus 'butleri'

This is an undescribed species, but one that has been collected from two widely disjunct locations, Barrow Island and nearby mainland WA, as well as Eastern Chichester Range

This species was however absent from the Pilbara Biodiversity survey, implying a patchy distribution.

Current data on this species indicates that it is not a short-range endemic.

NOTE: *Urodacus* 'butleri' is a morphospecies name and is NOT published. It is not a valid name under the International code of Zoological Nomenclature (International Commission on Zoological Nomenclature 1999).

Urodacus 'pilbara 8'

This is an undescribed species, but one that has been collected from several locations in the Pilbara to date. Several specimens were collected during the Pilbara Biological Survey undertaken by the Western Australian Museum and The Department of Environment and Conservation). This is one of the most widespread species of *Urodacus* in the Pilbara.

Current data on this species indicate that it is NOT a short-range endemic.

NOTE: *Urodacus* 'pilbara 8' is a morphospecies name and is NOT published. It is not a valid name under the International code of Zoological Nomenclature (International Commission on Zoological Nomenclature 1999).

Identification Table

Species	Client Reg. Num.	WAM Reg. Num.	Males	Females
Lychas 'harveyi'	SE11:0285	105540	1	
Lychas 'harveyi'	SE11:0278	105527	1	1
Urodacus 'butleri'	SE11:0451	105547	1	
Urodacus 'butleri'	SE11:0277	105541	1	
Urodacus 'butleri'	SE11:0783	105574	2	
Urodacus 'pilbara 8'	SE11:0452	105542	1	
Urodacus 'pilbara 8'	SE11:0225	105534	1	
Urodacus 'pilbara 8'	SE11:0738	105524	1	
Urodacus 'pilbara 8'	SE11:0549	105532	1	
Urodacus 'pilbara 8'	SE11:0760	105538	1	
Urodacus 'pilbara 8'	SE11:0755	105535	2	
Urodacus 'pilbara 8'	SE11:0537	105573	2	

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Appendix 3: Arachnida & Myriapoda Taxonomic Report

Arachnida & Myriapoda
from
Christmas Creek
(Subterranean Ecology project FMG007)

Report to Subterranean Ecology

17 May 2011

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Summary

The samples from Christmas Creek were submitted to the Western Australian Museum on the 3rd May 2011 (accession no. A7038). Included the batch of specimens were pseudoscorpions from four families (Atemnidae: Oratemnus; Chthoniidae: Austrochthonius; Garypidae: Synsphyronus; and Olpiidae: Beierolpium and Indolpium). Most of the pseudoscorpions examined do not represent short-range endemics. Due to a lack of research knowledge in some groups, in particular for the genus Beierolpium, one cannot be certain of their distribution.

Also included in the samples were millipedes from three families (Paradoxosomatidae, Polyxenidae, and Synxenidae); and centipedes from three families (Cryptopidae, Mecistocephalidae, and Oryidae). The majority of the myriapod samples do not belong to target groups for short-range endemic surveys and identification beyond family level was not possible due to the lack of taxonomic information on for the other families. However, many species of Paradoxosomatidae are short-range endemic species in the Pilbara. Unfortunately these specimens could also not be identified to beyond family level as they were immature. The identifications of the myriapods are listed in Appendix 1 for completion, but these invertebrates are not discussed in detail here.

Short-Range Endemism

The terrestrial invertebrate fauna of inland Australia contains a plethora of species, and just the arthropods were recently estimated to consist of more than 250,000 species (Yeates, Harvey et al. 2004; Chapman 2009). The vast majority of these are found within the Insecta and Arachnida, although significant numbers of millipedes are to be expected. For many years, the prospect of including invertebrates in assessments of biological systems subject to alteration proved daunting and were largely ignored as being too diverse and too difficult to comprehend to satisfy the rapid turn-around needed for environmental surveys.

In a recent publication, the issue of Short-Range Endemism in the Australian invertebrate fauna was examined (Harvey 2002), and series of major groups were nominated as having a very high proportion of individual species that satisfied a certain set of criteria. The main criterion nominated for inclusion as a Short-Range Endemic (SRE) was that the species had a naturally small range of less than 10,000 km^2. Harvey (2002) found that those species possessed a series of ecological and life-history traits, including:

- poor powers of dispersal;
- confinement to discontinuous habitats;
- usually highly seasonal, only active during cooler, wetter periods; and
- low levels of fecundity.

The Western Australian fauna contains a number of SRE taxa, including millipedes, land snails, trap-door spiders, some pseudoscorpions, slaters, and onychophorans and these represent focal groups in Environmental Impact Assessment studies in the state (EPA 2009). The south coast region is relatively well known compared with other regions of the state (Framenau, Moir et al. 2008), but there are many poorly known species and gaps in our understanding of the distributions of many species.

Methods

Arachnids and myriapods were collected by Subterranean Ecology at Christmas Creek (Western Australia) and were submitted to the Western Australian Museum on 5th May 2011 (accession no. A7038). The specimens were examined using Leica dissecting microscopes (MZ 6 & MZ16).

ARACHNIDA

Order Pseudoscorpiones

The Western Australian pseudoscorpion fauna is fairly diverse with representatives of 17 different families. They are found in a variety of biotopes, but can be most commonly collected from the bark of trees, from the underside of rocks, or from leaf litter habitats.

Family Atemnidae

Oratemnus

Two specimens of Oratemnus were collected at Christmas Creek (Appendix 1). Atemnids are frequently found under bark of trees in Western Australia, but the systematics of the group, particularly of the genus Oratemnus, is uncertain and the taxonomy of individual species unclear. However, based upon current evidence, it seems that most species will eventually be found to be widely distributed. For this reason, we do not believe that the specimens from Christmas Creek represent a short-range endemic species.

Family Chthoniidae

Austrochthonius sp. nov.

A single specimen of a new species of Austrochthonius was collected at Christmas Creek (Appendix 1). Species of Austrochthonius occur in leaf litter and soil environments throughout much of Western Australia, as well as subterranean ecosystems in Cape Range and near Busselton (Harvey 1991; Harvey and Mould 2006). The taxonomy of the Western Australian representatives is not resolved but there are clearly several species represented in the collections of the Western Australian Museum. Most species appear to be widespread and the specimen from Christmas Creek is not believed to represent a short-range endemic species.

Family Garypidae

Synsphyronus sp. nov. PSE006

Two specimens of a new species of Synsphyronus were collected from Christmas Creek. Many species of Synsphyronus may represent short-range endemic species (Harvey 1987), but these species are generally found in ground habitats such as under rocks. While there have been no previous records of this species, the tree-dwelling species tend to be much more widely distributed, and are not short-range endemics.

Family Olpiidae

Beierolpium sp.

Three specimens of Beierolpium were collected from Christmas Creek (Appendix 1). The systematic status of members of this genus has not been fully assessed. At present it is not possible to firmly establish the identity of these species until a complete systematic revision of the Western Australian members of Beierolpium is undertaken. It is possible that these specimens represent short-range endemic species, but a full taxonomic revision of the genus Beierolpium in Western Australia is necessary to confirm their status.

Indolpium sp.

Twelve specimens of Indolpium were collected at Christmas Creek (Appendix 1). Extremely similar specimens have been collected from other regions of Western Australia, suggesting that only a single species is involved. Based on our current levels of knowledge, it is unlikely that this species is a short-range endemic species.

MYRIAPODA

Order Polydesmida

Family Paradoxosomatidae

The polydesmid millipede samples submitted from Christmas Creek were all juveniles which did not facilitate identification beyond family level. In this area, the most abundant and diverse genus is Antichiropus. With the exception of Antichiropus variabilis, which inhabits the jarrah forests of south-western WA, and Antichiropus ‘PM1’ from the northern Wheatbelt and the Geraldton sandplain, all species of the genus are known to be short-range endemics, and many are known from only a few hundred square kilometres (Harvey, Sampey et al. 2000; Harvey 2002).

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Appendix 1. Identification of myriapods and pseudoscorpions from Christmas Creek

REGNO	FLDNO	FAMILY	GENUS	SPECIES	LATITUDE	LONGITUDE	M	F	JUV	TOTAL	AGE
113155	FMG007_XC10_FN11305	Olpiidae	Indolpium	\`sp.\`	22°23\`54.686S	119°47\`34.755E		1		1	A
111829	FMG007_XC01_FN11299	Olpiidae	Indolpium	\`sp.\`	22°24\`27.736S	119°51\`58.420E			1	1	J
111830	FMG007_XC07_FN11308	Chthoniidae	Austrochthonius	\`sp.\`	22°23\`20.488S	119°51\`19.180E		1		1	A
111831	FMG007_XC09_FN11508	Olpiidae	Indolpium	\`sp.\`	22°24\`05.377S	119°47\`37.779E			4	4	J
111832	FMG007_XC09_FN11508	Olpiidae	Indolpium	\`sp.\`	22°24\`05.377S	119°47\`37.779E			1	1	J
111833	FMG007_XC14_FN11295	Olpiidae	Indolpium	\`sp.\`	22°24\`32.344S	119°53\`04.192E	1			1	A
111834	FMG007_XC15_FN11510	Atemnidae	Oratemnus	\`sp.\`	22°25\`53.201S	119°54\`55.288E	1			1	A
111835	FMG007_XC27_FN10982	Olpiidae	Indolpium	\`sp.\`	22°21\`56.456S	119°36\`11.293E			1	1	J
111836	FMG007_XC28_FN11496	Olpiidae	Beierolpium	\`sp.\`	22°21\`58.401S	119°37\`12.782E			2	2	J
111837	FMG007_XC30_FN11317	Atemnidae	Oratemnus	\`sp.\`	22°20\`50.218S	119°37\`59.726E	2	1		3	A
111838	FMG007_XC32_FN11319	Olpiidae	Indolpium	\`sp.\`	22°21\`17.042S	119°46\`13.324E		2		2	A
111839	FMG007_XC34_FN11327	Olpiidae	Indolpium	\`sp.\`	22°22\`55.107S	119°49\` 6.196E			1	1	J
111840	FMG007_XC35_FN10939	Olpiidae	Indolpium	\`sp.\`	22°22\`44.091S	119°49\`06.772E	1			1	A
111841	FMG007_XC10_FN10926	Olpiidae	Indolpium	\`sp.\`	22°23\`54.686S	119°47\`34.755E	1	1		2	A
111842	FMG007_XC34_FN10938	Olpiidae	Indolpium	\`sp.\`	22°22\`55.107S	119°49\`06.196E	1	1		2	A
111843	FMG007_XC17_FN10977	Garypidae	Synsphyronus	\`sp. nov. PSE006\`	22°22\`09.024S	119°44\`19.203E	1	1		2	A
113156	FMG007_XC30_FN11317	Olpiidae	Indolpium	\`sp.\`	22°20\`50.218S	119°37\`59.726E			1	1	J
113157	FMG007_XC32_FN11319	Olpiidae	Beierolpium	\`sp.\`	22°21\`17.042S	119°46\`13.324E			1	1	J
113158	FMG007_XC14_FN11295	Olpiidae	Beierolpium	\`sp.\`	22°24\`32.344S	119°53\`04.192E	1			1	A
111859	FMG007_XC36_FN10983	Mecistocephalidae			22°23\`35.063S	119°42\`55.358E				2	A
111860	FMG007_XC08_FN11310	Oryidae			22°23\`33.951S	119°51\`16.624E				1	A
111862	FMG007_XC10_FN11305	Mecistocephalidae			22°23\`54.686S	119°47\`34.755E				1	A
111863	FMG007_XC13_FN11312	Mecistocephalidae			22°24\`37.599S	119°51\`33.616E				1	A
111864	FMG007_XC06_FN11331	Mecistocephalidae			22°24\`48.112S	119°52\`11.668E				1	J
111865	FMG007_XC25_FN11497	Mecistocephalidae			22°25\`01.468S	119°53\`38.716E				1	A
111867	FMG007_XC36_FN10984	Mecistocephalidae			22°23\`35.063S	119°42\`55.358E				1	A
111869	FMG007_XC14_FN11294	Mecistocephalidae			22°24\`32.344S	119°53\`04.192E				1	J
111870	FMG007_XC02_FN11296	Mecistocephalidae			22°24\`14.380S	119°51\`55.144E				1	J

REGNO	FLDNO	FAMILY	GENUS	SPECIES	LATITUDE	LONGITUDE	M	F	JUV	TOTAL	AGE
111871	FMG007_XC24_FN11513 (FN115152)	Mecistocephalidae			22°25`08.632S	119°53`48.580E				1	A
111455	FMG007_XC24_FN11514	Mecistocephalidae			22°25`08.632S	119°53`48.580E				1	A
111861	FMG007_XC10_FN11305	Cryptopidae			22°23`54.686S	119°47`34.755E				2	A
111866	FMG007_XC33_FN11323	Cryptopidae			22°21`05.702S	119°46`17.356E				2	A
111868	FMG007_XC24_FN11514	Cryptopidae			22°25`08.632S	119°53`48.580E				1	A
111872	FMG007_XC27_FN10981	Cryptopidae			22°21`56.456S	119°36`11.293E				5	A
111844	FMG007_XC11_FN10973	Paradoxosomatidae			22°23`35.785S	119°46`46.839E				1	J
111845	FMG007_XC30_FN11316	Paradoxosomatidae			22°20`50.218S	119°37`59.726E				1	J
111846	FMG007_XC33_FN11322	Paradoxosomatidae			22°21`05.702S	119°46`17.356E				1	J
111847	FMG007_XC01_FN11299	Paradoxosomatidae			22°24`27.736S	119°51`58.420E				1	J
111848	FMG007_XC07_FN11309	Paradoxosomatidae			22°23`20.488S	119°51`19.180E				2	J
111849	FMG007_XC11_FN10974	Paradoxosomatidae			22°23`35.785S	119°46`46.839E				3	J
111850	FMG007_XC12_FN11333	Paradoxosomatidae			22°23`47.953S	119°46`36.003E				1	J
111851	FMG007_XC12_FN11333	Paradoxosomatidae			22°23`47.953S	119°46`36.003E				1	J
111852	FMG007_XC24_FN11513	Paradoxosomatidae			22°25`08.632S	119°53`48.580E				3	J
111853	FMG007_XC25_FN11497	Paradoxosomatidae			22°25`01.468S	119°53`38.716E				1	J
111854	FMG007_XC25_FN11497	Paradoxosomatidae			22°25`1.468S	119°53`38.716E				2	J
111855	FMG007_XC27_FN10982	Paradoxosomatidae			22°21`56.456S	119°36`11.293E				1	J
111856	FMG007_XC35_FN10939	Paradoxosomatidae			22°22`44.091S	119°49`06.772E				1	J
111857	FMG007_XC30_FN11317	Paradoxosomatidae			22°20`50.218S	119°37`59.726E				2	J
111858	FMG007_XC34_FN11327	Paradoxosomatidae			22°22`55.107S	119°49`06.196E				1	J
111873	FMG007_XC36_FN10983	Polyxenidae			22°23`35.063S	119°42`55.358E				1	A
111874	FMG007_XC37_FN10985	Synxenidae			22°24`22.044S	119°44`15.278E				1	A
111875	FMG007_XC10_FN11305	Polyxenidae			22°23`54.686S	119°47`34.755E				2	A
111876	FMG007_XC27_FN10981	Synxenidae			22°21`56.456S	119°36`11.293E				2	A
111877	FMG007_XC37_FN10986	Synxenidae			22°24`22.044S	119°44`15.278E			1	1	J
111878	FMG007_XC01_FN11299	Synxenidae			22°24`27.736S	119°51`58.420E				1	A
111879	FMG007_XC02_FN11297	Synxenidae			22°24`14.380S	119°51`55.144E				1	A
111880	FMG007_XC08_FN11311	Synxenidae			22°23`33.951S	119°51`16.624E				2	A
111881	FMG007_XC09_FN11508	Polyxenidae			22°24`05.377S	119°47`37.779E				3	A

REGNO	FLDNO	FAMILY	GENUS	SPECIES	LATITUDE	LONGITUDE	M	F	JUV	TOTAL	AGE
111882	FMG007_XC10_FN11306	Polyxenidae			22°23`54.686S	119°47`34.755E				1	A
111883	FMG007_XC12_FN11333	Synxenida			22°23`47.953S	119°46`36.003E				1	A
111884	FMG007_XC14_FN11295	Synxenidae			22°24`32.344S	119°53`04.192E				1	A
111885	FMG007_XC17_FN10980	Synxenidae			22°22`09.024S	119°44`19.203E				1	A
111886	FMG007_XC24_FN11513	Synxenidae			22°25`08.632S	119°53`48.580E				1	A
111887	FMG007_XC25_FN11497	Synxenidae			22°25`01.468S	119°53`38.716E	1			1	A
111888	FMG007_XC27_FN10982	Synxenidae			22°21`56.456S	119°36`11.293E				5	A
111889	FMG007_XC28_FN11496	Synxenidae			22°21`58.401S	119°37`12.782E				1	A
111890	FMG007_XC31_FN11315	Polyxenidae			22°20`57.310S	119°37`55.370E				1	A
111891	FMG007_XC36_FN10984	Synxenida			22°23`35.063S	119°42`55.358E				3	A

Appendix 4: Mollusca Taxonomic Report

Report to *Subterranean Ecology*

Land Snails from the Christmas Creek area, Western Australia (Project FMG 007)

collected by *Subterranean Ecology* during April 2011

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WESTERN AUSTRALIAN museum

Background

Eleven lots of land snail specimens were collected by the environmental consultancy *Subterranean Ecology* in April 2011, during a faunal survey of the Christmas Creek area in the Pilbara region of Western Australia (Project FMG 007). These specimens were presented to the Mollusc Section of the Western Australian Museum on the 3rd May 2011 for identification and comment (Accession Form A6046).

Survey data (collecting dates and methods, plus the co-ordinates for all sites at which land snails were collected) were provided with the specimens electronically (see Appendix A).

However, no information was provided concerning the relationship of any sites to the tenement boundaries or the habitat details for any of the survey sites.

Procedures

The land snail specimens received from *Subterranean Ecology* were examined under a *Leica* MZ95 dissecting microscope. They were then compared with dry and preserved specimens in the Molluscan Collections of the Western Australian Museum, and with descriptions and figures in relevant publications.

As the Museum's collections contain only limited material from the Christmas Creek area, all of the survey specimens have been registered and deposited into its Mollusc Collection.

Results

The land snails collected during this survey belong to the terrestrial pulmonate families Pupillidae and Subulinidae and to the aquatic family Planorbidae (Table 1).

All species recorded during this survey are considered to form part of the indigenous Western Australian fauna.

Table 1. Identifications of the non-marine molluscs collected during *Subterranean Ecology's* survey of the Christmas Creek area during April 2011 (Project FMG 007).

Field No	Family	Genus	Species	Author	No Spec.	WamNo
FMG007_XC11_FN10974	Pupillidae	*Pupoides*	*beltianus*	(Tate, 1894)	7 dead-taken	WAM S65598
FMG007_XC37_FN10986	Pupillidae	*Pupoides*	*pacificus*	(Pfeiffer, 1846)	1 dead-taken	WAM S65599
FMG007_XC15_FN11510	Planorbidae	*Gyraulus*	sp.		1 dead-taken	WAM S65600
FMG007_XC11_FN10975	Pupillidae	*Pupoides*	*beltianus*	(Tate, 1894)	1 live-taken	WAM S65601
FMG007_XC18_FN11302	Pupillidae	*Pupoides*	*beltianus*	(Tate, 1894)	5 live-taken	WAM S65602
FMG007_XC25_FN11497	Pupillidae	*Gastrocopta*	*mussoni*	Pilsbry, 1917	1 dead-taken	WAM S65603
FMG007_XC10_FN11305	Pupillidae	*Gastrocopta*	*mussoni*	Pilsbry, 1917	1 dead-taken	WAM S65604
FMG007_XC05_FN11329	Pupillidae	*Gastrocopta*	*mussoni*	Pilsbry, 1917	1 dead-taken	WAM S65605
FMG007_XC11_FN10973	Pupillidae	*Pupoides*	*beltianus*	(Tate, 1894)	1 dead-taken	WAM S65606
FMG007_XC15_FN11512	Subulinidae	*Eremopeas*	*interioris*	(Tate, 1894)	3 dead-taken	WAM S65607
FMG007_XC33_FN11322	Subulinidae	*Eremopeas*	*interioris*	(Tate, 1894)	1 dead-taken	WAM S65608
FMG007_XC05_FN11329	Pupillidae	*Pupoides*	*pacificus*	(Pfeiffer, 1846)	1 dead-taken	WAM S65609
FMG007_XC10_FN11305	Pupillidae	*Pupoides*	cf. *pacificus*	(Pfeiffer, 1846)	1 dead-taken	WAM S65610
FMG007_XC37_FN10986	Pupillidae	*Gastrocopta*	*mussoni*	Pilsbry, 1917	1 dead-taken	WAM S65611
FMG007_XC37_FN10986	Pupillidae	*Gastrocopta*	*larapinta*	(Tate, 1896)	3 dead-taken	WAM S65612
FMG007_XC15_FN11512	Planorbidae	*Gyraulus*	sp.		1 dead-taken	WAM S65613
FMG007_XC15_FN11512	Pupillidae	*Pupoides*	*beltianus*	(Tate, 1894)	1 dead-taken	WAM S65614
FMG007_XC15_FN11512	Pupillidae	*Pupoides*	*pacificus*	(Pfeiffer, 1846)	1 dead-taken	WAM S65615
FMG007_XC11_FN10973	Subulinidae	*Eremopeas*	*interioris*	(Tate, 1894)	1 dead-taken	WAM S65616
FMG007_XC11_FN10974	Pupillidae	*Pupoides*	*pacificus*	(Pfeiffer, 1846)	1 dead-taken	WAM S65617

Family Pupillidae

Sub-family Pupillinae

Pupoides sp. cf. *P. beltianus* (Tate, 1894)

The specimens collected during this survey most closely resemble the central Australian species *Pupoides beltianus* (Tate, 1894).

The known distributional range of *P. beltianus* encompasses an area from the Reynolds and Jervois Ranges in the Northern Territory, south to the Musgrave and Mann Ranges in South Australia and then west to the Barrow Ranges in Western Australia. These areas are situated near the junction of the borders of Western Australia, South Australia and the Northern Territory (Solem 1988).

In his 1986 and 1988 publications, Dr Solem suggested that the distribution of the species *P. beltianus* in Western Australia may extend as far to the north-west as the Hamersley Range and as far west as the Shark Bay area. However, because of some differences in the shell morphology of specimens from the more western areas of WA when compared with those of central Australia, he listed those western specimens only as *Pupoides* aff. *beltianus* in his 1986 publication, indicating a doubt as to their conspecificity with the central Australian specimens.

Pupoides pacificus (Pfeiffer, 1846)

In his 1988 and 1991 publications, Solem discussed the distribution of *P. pacificus*, establishing its then-known distribution in Western Australia as extending from east of Kununurra westward and southward to Quondong Point, north of Broome, with a single isolated record from the Chichester Range in the Pilbara.

However, more recently-collected specimens housed in the Mollusc Collections of the Western Australian Museum indicate that this species is more widely spread throughout the Pilbara region.

Sub-family Gastrocoptinae

Gastrocopta mussoni Pilsbry, 1917

The shell characters of these specimens most closely resemble those of the species *G. mussoni* Pilsbry, 1917, discussed by Pokryszko in his 1996 publication on the pupillid subfamily Gastrocoptinae. In that publication, he states that there are two forms of this species, a cylindrical form and an ovate form.

G. mussoni is recorded (Pokryszko 1996) as having a geographical distribution in Central Australia (the southern part of Northern Territory), with specimens recorded from a few localities in the northern parts of Western Australia, the northern parts of the Northern Territory, the northern and north-eastern parts of Queensland and also from the mid-west coastal region of Western Australia. There are also a few records from South Australia. This geographical distribution is based on the recognition of *Gastrocopta deserti* Pilsbry, 1917 as a synonym of *G mussoni*.

Gastrocopta larapinta (Tate, 1896)

Gastrocopta larapinta is a minute dextrally-coiled species that has a large but apparently patchy distribution in central Australia (southern part of the Northern Territory), with a few records from the north-western and the eastern coasts of Queensland. There is a single published record of this species from the Oscar Ranges in the southern Kimberley region of Western Australia (Pokryszko 1996).

Family Subulinidae

Records of this family, widespread through tropical and temperate regions of the world, indicate that the Australian representatives consist of 2 species of the endemic genus *Eremopeas* and four introduced species, each belonging to one of four separate genera (Shea 2007).

Eremopeas interioris (Tate, 1894)

This species is native to the warmer areas of Australia, being recorded from the North West Cape area to the Kimberleys and through the Northern Territory to western Queensland. In the Pilbara Region it has been found in the areas of Roy Hill, Port Hedland, and the western Hamersley Range.

Family Planorbidae

Records of the occurrence of this or any other freshwater molluscan family in the Hamersley Range area - as in most of the inland Pilbara region - are sparse. The family Planorbidae is distributed practically world-wide and, in Australia, is diverse and generally abundant through a wide variety of habitats. Many groups have been shown to be well adapted to drought conditions.

Gyraulus sp.

Species of the genus *Gyraulus* are known from coastal and inland areas of all Australian states. Two species, *G. hesperus* (Iredale, 1943) and *G. essingtonensis* (Smith, 1883) have been recorded from the Pilbara region. Both species are widespread across northern Queensland, the Northern Territory and northern Western Australia (Brown 2001).

Being an inhabitant of streams and pools in the Pilbara area (e.g. the Fortescue, Harding and Maitland river systems), it seems unlikely that this species of *Gyraulus* should exhibit any significant degree of endemism - the wide dispersal of such aquatic species generally being accomplished by flooding during the rainy season and, perhaps, by transport by aquatic birds.

Remarks

All of the species collected during this survey have (or are likely to have) wide distributional ranges.

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Appendix A. Locality and habitat data from non-marine molluscs collected during *Subterranean Ecology's* survey of the Christmas Creek area during April 2011 (Project FMG 007)

Field No.	Locality	Coordinates		Collector	Collecting Method	Date Collected	Habitat
		Latitude	Longitude				
FMG007 XC37 FN10986	Christmas Creek	22°24`22.044"S	119°44`15.278"E	Danti, S. & Callan, S.	Litter sifting	8/04/2011	Leaf litter
FMG007 XC25 FN11497	Christmas Creek	22°25`01.468"S	119°53`38.716"E	Danti, S. & Callan, S.	Litter sifting	8/04/2011	Leaf litter
FMG007 XC15 FN11510	Christmas Creek	22°25`53.201"S	119°54`55.288"E	Danti, S. & Callan, S.	Litter sifting	8/04/2011	Leaf litter
FMG007 XC15 FN11512	Christmas Creek	22°25`53.201"S	119°54`55.288"E	Danti, S. & Callan, S.	Forage	8/04/2011	Leaf litter
FMG007 XC18 FN11302	Christmas Creek	22°22`14.281"S	119°44`46.563"E	Danti, S. & Callan, S.	Forage	9/04/2011	Leaf litter
FMG007 XC10 FN11305	Christmas Creek	22°23`54.686"S	119°47`34.755"E	Danti, S. & Callan, S.	Forage	9/04/2011	Leaf litter
FMG007 XC33 FN11322	Christmas Creek	22°21`05.702"S	119°46`17.356"E	Danti, S. & Callan, S.	Forage	10/04/2011	Leaf litter
FMG007 XC11 FN10974	Christmas Creek	22°23`35.785"S	119°46`46.839"E	Danti, S. & Callan, S.	Litter sifting	11/04/2011	Leaf litter
FMG007 XC11 FN10975	Christmas Creek	22°23`35.785"S	119°46`46.839"E	Danti, S. & Callan, S.	Forage	11/04/2011	Leaf litter
FMG007 XC11 FN10973	Christmas Creek	22°23`35.785"S	119°46`46.839"E	Danti, S. & Callan, S.	Forage	11/04/2011	Leaf litter
FMG007 XC11 FN10974	Christmas Creek	22°23`35.785"S	119°46`46.839"E	Danti, S. & Callan, S.	Litter sifting	11/04/2011	Leaf litter
FMG007 XC05 FN11329	Christmas Creek	22°24`28.096"S	119°52`36.220"E	Danti, S. & Callan, S.	Litter sifting	11/04/2011	Leaf litter

Appendix 5: Isopoda Taxonomic Reports 2011-2012

Subterranean
Ecology Suite 8,
37 Cedric St
Stirling, WA. 6021

2nd June 2011

Re: Terrestrial Isopod Identification for Christmas Creek.

I have examined the material for the above project. There were six species present. Most of these are common and have been collected from projects nearby. However, *Buddelundia* sp. 20 is a potential SRE species

Family Armadillidae

Buddelundia sp. 10

This is a large species and perhaps the most common arid zone form of *Buddelundia*. It is widespread but there are slight differences among specimens collected across the Pilbara. It has been collected elsewhere in the Pilbara and, although not as common and widespread as *Buddelundia* sp. 14, it is likely to be relatively common and widespread. This is not a short range endemic species but a part of my revision I anticipate a number of sub-species at least will be recognised.

Buddelundia sp. 14

This is very similar to *Buddelundia* sp.10 but has a different structure of the interlocking lobes (schisma) on the first pereonal epimera and is also one of the most common species in the Pilbara. It has been found at at least eight other locations in the Pilbara. It is probably common and widespread and is likely to be found outside the Pilbara as well. This is not a short range endemic species.

Buddelundia sp. 13

This is a smaller and highly convex species of *Buddelundia.* It is less common than sp. 10 or sp. 14

but I have seen it from five other project areas. It is so far confined to the Pilbara. There is little variation in the form of this species across its range. I don't think it has been collected outside the Pilbara and is most likely a Pilbara endemic. Probably not a short range endemic species.

Buddelundia sp. 20

This is perhaps the most interesting of the *Buddelundia* species. It was only found in two vials (3 specimens). The only other specimens I have are probably juveniles and were collected about 75 km to the north west of your project area. This is a small and highly convex species with a very distinctive structure of the interlocking lobes on the first pereonal epimera. I may have more of this species in the material I still have to go through but at this stage it should be considered a potential short range endemic species. It is almost certainly an undescribed species.

Buddelundia sp.

I have previously referred to this as both *Barrowdillo* and *Buddelundia* but it may rightly belong in a

new genus because it lacks the prominent schisma on the first pereonal epimera that is characteristic of *Buddelundia*. It is convenient to refer to it as *Buddelundia* for the present time. There is also variation in the nature of the raised bumps on the dorsal surface of this species and also among a number of other characters but this occurs as much within samples as between them. It is sometimes completely smooth (as with these specimens) and sometimes bumpy. I consider it to be one species at the present time. However, a considerable amount of work is needed to establish this and to refine the diagnoses of both *Buddelundia* and *Barrowdillo*. This is perhaps the most common species in the Pilbara and is found at almost all sites in one form or another.

***Laevophiloscia* sp. N.**

I consider these Philoscidae specimens to be *Laevophiloscia*. However, the diagnosis given by

Wahrberg (1922) is based solely on mouthparts and I have not examined these. To identify confidently any *Laevophiloscia* a redescription of type material is necessary. The potential for *Laevophiloscia* to be SRE species is largely unknown because the taxonomy has not been done. However, I am sure there are many species and that the drier areas are likely to be where any SRE species would be found.

End of report. Please feel free to contact me if you require further information.

Yours sincerely,

Dr Simon Judd.

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11th May 2012

FURTHER INVESTIGATION FOR TERRESTRIAL ISOPOD *BUDDELUNDIA* SP. NOV. 20 FROM CHRISTMAS CREEK.

Introduction

In June 2011 I examined some material from Christmas Creek. Among the species identified were three specimens from two localities determined as *Buddelundia* sp.nov .20. This taxon was considered a potential SRE species. Since then I have done considerably more work on *Buddelundia*, and I am in possession of more material. This report investigates further these specimens and aims to determine whether or not the species to which the specimens determined as *Buddelundia* sp. nov. 20 belong occur outside the Christmas Creek project area.

Methods & material examined

Reference numbers for all the specimens examined as part of this review are given in this section. These are preceded by the letters "SJ". The specimens will be given WAM "C" numbers when lodged with the Museum. The number of specimens present in each of the vials examined is shown followed by male (♂) female (♀) or Juvenile (J). Geographical coordinates of the specimens examined are also shown. There is significant sexual dimorphism in *Buddelundia* and male specimens are required for an accurate determination. Where both male and female specimens are collected at a locality it is sometimes possible to make determination from females from subsequent localities.

The two vials from Christmas Creek examined previously were re-examined (SJ1434, FMG007_XC33_FN11322, 22°21'5.702"S 119°46'17.356"E, 1♂ 1♀J) (Subterranean specimen FMG007_XC34-11:0606, 22°22'55.107"S 119°49'6.196"E, 1♀). A database search was made to identify all specimens that were potentially the same species as those collected at Christmas Creek. This resulted in the selection of eight vials from four other localities. These are as follows:

1. The voucher specimen for *Buddelundia* sp. nov. 20 from the Fortescue Marsh area (SJ159, 22°13'13.404"S 119°2'35.124"E, 1♂) and two other specimens from the same locality (SJ157, 22°17'37.824" 119°4'23.664", 1♂) (SJ158, 22°18'56.844" 119°14'26.412", 1♂). This locality is approximately 75 kilometres to the WNW of the Christmas Creek project area.

2. Two vials from north-west of Mount Webber (SJ1115, 21°28'41.5"S 119°4'2.7"E, 1♀) (SJ1116, 21°27'1.2"S 119°3'53.8"E 1♀2J). This locality is approximately 130 kilometres NW of the Christmas Creek project area.

3. Two vials from the Hamersley Range in the central Pilbara (SJ1182, 22°08'06"S 117°28'23"E, 1♀) (SJ1183, 22°15'14" S 117°29'42"E, 1♀1♀J.). This locality is approximately 250 kilometres to the west of the Christmas Creek project area.

4. A single vial from Rocklea Homestead (SJ1939, 22°48'53.51''S 117°29'59.88''E, 1♂). This locality is about 250 kilometres to the WSW of the Christmas Creek project area and about 60 kilometres S of the locality described in number three above.

The full range of morphological characters was examined for all the specimens listed above except juveniles. Mouthparts are of limited diagnostic use in the Armadillidae and were not examined. The vouchers specimen (types) for *Buddelundia* sp. nov. 20 and the specimens collected with it (syntypes) are all males. The specimens for locality 2 listed above were all females and so were those collected at locality 3. The single specimen collected at locality 4 was an adult male. An adult male and female specimen were collected from Christmas Creek.

Results

While of a very similar morphological type significant morphological differences in a number of characters were found between the male specimen from Christmas Creek (SJ1434) and the voucher (type) specimen (SJ159). This is unexpected because the voucher specimens were collected much closer to the project area than any of the other material examined. A new species number is therefore required for the Christmas Creek specimens and the material examined here will become the voucher specimens. This will done in due course and I can advise you of the new species number.

The material collected at locality 2 (SJ1115, SJ1116) well to the north of both the "type" locality and the Christmas Creek project area contained only females but these were a different species to both the voucher specimens of *Buddelundia* sp. nov. 20 and the Christmas Creek specimens. This probably represents another species but male specimens are needed before a species number and vouchers specimens can be allocated.

There were no morphological differences found between the male specimen collected at Christmas Creek (SJ1434) and the male specimen from Rocklea Homestead (SJ1939). This is highly likely to be the same species even though the localities are quite distant. It is also likely that the female specimens from locality 3 (SJ1182, SJ1183) in the Hamersley Range are also this species. They also appear identical to the female FMG007_XC34-11:0606 but additional material is necessary to confirm this. The male specimen from Rocklea Homestead had not been collected at the time of writing the original report.

Conclusion

Buddelundia sp. nov. 20 and other species of this type are potential SRE species. However, due to additional investigation, more extensive knowledge of the morphological characters of the genus *Buddelundia* and more specimens becoming available, the specimens collected in Christmas Creek should no longer be determined as Buddelundia sp. nov. 20. The presence of what appears to be the same species at a considerable distance to the west of the study area suggest that this is not a SRE species. A new species will be established and described using the material from Christmas Creek. My current work on the Pilbara isopods will provide a both more precise distribution, an understanding of the biogeographical patterns within the Pilbara and hopefully more specimens of this new species. Results should be available later this year. At this stage, based on a morphological analysis, the species under investigation occurs outside of the Christmas Creek project area and is unlikely to be an SRE species.

Yours sincerely,

Dr Simon Judd.

Appendix 6: WAM Lodgement Numbers

Table of WA Museum Lodgement Numbers, specimens vouchered from Christmas Creek SRE Survey

WAM Reg. No.	Class	Order	Family	Genus	Species	Total
T111971	Arachnida	Araneae	Barychelidae	*Synothele*	*MYG127*	1
T111972	Arachnida	Araneae	Barychelidae	*Synothele*	*MYG127*	1
105540	Arachnida	Scorpiones	Buthidae	*Lychas*	*'harveyi'*	1
105527	Arachnida	Scorpiones	Buthidae	*Lychas*	*'harveyi'*	1
105547	Arachnida	Scorpiones	Urodacidae	*Urodacus*	*'butleri'*	1
105541	Arachnida	Scorpiones	Urodacidae	*Urodacus*	*'butleri'*	1
105574	Arachnida	Scorpiones	Urodacidae	*Urodacus*	*'butleri'*	2
105542	Arachnida	Scorpiones	Urodacidae	*Urodacus*	*'pilbara 8'*	1
105534	Arachnida	Scorpiones	Urodacidae	*Urodacus*	*'pilbara 8'*	1
105524	Arachnida	Scorpiones	Urodacidae	*Urodacus*	*'pilbara 8'*	1
105532	Arachnida	Scorpiones	Urodacidae	*Urodacus*	*'pilbara 8'*	1
105538	Arachnida	Scorpiones	Urodacidae	*Urodacus*	*'pilbara 8'*	1
105535	Arachnida	Scorpiones	Urodacidae	*Urodacus*	*'pilbara 8'*	2
105573	Arachnida	Scorpiones	Urodacidae	*Urodacus*	*'pilbara 8'*	2
113155	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*	*`sp.`*	1
111829	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*	*`sp.`*	1
111830	Arachnida	Pseudoscorpiones	Chthoniidae	*Austrochthonius*	*`sp.`*	1
111831	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*	*`sp.`*	4
111832	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*	*`sp.`*	1
111833	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*	*`sp.`*	1
111834	Arachnida	Pseudoscorpiones	Atemnidae	*Oratemnus*	*`sp.`*	1
111835	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*	*`sp.`*	1
111836	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	*`sp.`*	2
111837	Arachnida	Pseudoscorpiones	Atemnidae	*Oratemnus*	*`sp.`*	3
111838	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*	*`sp.`*	2
111839	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*	*`sp.`*	1
111840	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*	*`sp.`*	1
111841	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*	*`sp.`*	2
111842	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*	*`sp.`*	2
111843	Arachnida	Pseudoscorpiones	Garypidae	*Synsphyronus*	*`sp. nov. PSE006`*	2
113156	Arachnida	Pseudoscorpiones	Olpiidae	*Indolpium*	*`sp.`*	1
113157	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	*`sp.`*	1
113158	Arachnida	Pseudoscorpiones	Olpiidae	*Beierolpium*	*`sp.`*	1
111859	Chilopoda	Geophilomorpha	Mecistocephalidae			2
111860	Chilopoda	Geophilomorpha	Oryidae			1
111862	Chilopoda	Geophilomorpha	Mecistocephalidae			1
111863	Chilopoda	Geophilomorpha	Mecistocephalidae			1
111864	Chilopoda	Geophilomorpha	Mecistocephalidae			1
111865	Chilopoda	Geophilomorpha	Mecistocephalidae			1
111867	Chilopoda	Geophilomorpha	Mecistocephalidae			1
111869	Chilopoda	Geophilomorpha	Mecistocephalidae			1
111870	Chilopoda	Geophilomorpha	Mecistocephalidae			1
111871	Chilopoda	Geophilomorpha	Mecistocephalidae			1
111455	Chilopoda	Geophilomorpha	Mecistocephalidae			1

WAM Reg. No.	Class	Order	Family	Genus	Species	Total
111861	Chilopoda	Scolopendromorpha	Cryptopidae			2
111866	Chilopoda	Scolopendromorpha	Cryptopidae			2
111868	Chilopoda	Scolopendromorpha	Cryptopidae			1
111872	Chilopoda	Scolopendromorpha	Cryptopidae			5
111844	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		1
111845	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		1
111846	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		1
111847	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		1
111848	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		2
111849	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		3
111850	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		1
111851	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		1
111852	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		3
111853	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		1
111854	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		2
111855	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		1
111856	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		1
111857	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		2
111858	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		1
113249	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		1
113250	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		1
113251	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		1
113481	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*		2
124140	Diplopoda	Polydesmida	Paradoxosomatidae	(tissue only)		1
111873	Diplopoda	Polyxenida	Polyxenidae			1
111874	Diplopoda	Polyxenida	Synxenidae			1
111875	Diplopoda	Polyxenida	Polyxenidae			2
111876	Diplopoda	Polyxenida	Synxenidae			2
111877	Diplopoda	Polyxenida	Synxenidae			1
111878	Diplopoda	Polyxenida	Synxenidae			1
111879	Diplopoda	Polyxenida	Synxenidae			1
111880	Diplopoda	Polyxenida	Synxenidae			2
111881	Diplopoda	Polyxenida	Polyxenidae			3
111882	Diplopoda	Polyxenida	Polyxenidae			1
111883	Diplopoda	Polyxenida	Synxenida			1
111884	Diplopoda	Polyxenida	Synxenidae			1
111885	Diplopoda	Polyxenida	Synxenidae			1
111886	Diplopoda	Polyxenida	Synxenidae			1
111887	Diplopoda	Polyxenida	Synxenidae			1
111888	Diplopoda	Polyxenida	Synxenidae			5
111889	Diplopoda	Polyxenida	Synxenidae			1
111890	Diplopoda	Polyxenida	Polyxenidae			1
111891	Diplopoda	Polyxenida	Synxenida			3

WAM Reg. No.	Class	Order	Family	Genus	Species	Total
S65598	Gastropoda	Stylommatophora	Pupillidae	*Pupoides*	*beltianus*	7
S65599	Gastropoda	Stylommatophora	Pupillidae	*Pupoides*	*pacificus*	1
S65600	Gastropoda	Basomatophora	Planorbidae	*Gyraulus*	sp.	1
S65601	Gastropoda	Stylommatophora	Pupillidae	*Pupoides*	*beltianus*	1
S65602	Gastropoda	Stylommatophora	Pupillidae	*Pupoides*	*beltianus*	5
S65603	Gastropoda	Stylommatophora	Pupillidae	*Gastrocopta*	*mussoni*	1
S65604	Gastropoda	Stylommatophora	Pupillidae	*Gastrocopta*	*mussoni*	1
S65605	Gastropoda	Stylommatophora	Pupillidae	*Gastrocopta*	*mussoni*	1
S65606	Gastropoda	Stylommatophora	Pupillidae	*Pupoides*	*beltianus*	1
S65607	Gastropoda	Stylommatophora	Subulinidae	*Eremopeas*	*interioris*	3
S65608	Gastropoda	Stylommatophora	Subulinidae	*Eremopeas*	*interioris*	1
S65609	Gastropoda	Stylommatophora	Pupillidae	*Pupoides*	*pacificus*	1
S65610	Gastropoda	Stylommatophora	Pupillidae	*Pupoides*	cf. *pacificus*	1
S65611	Gastropoda	Stylommatophora	Pupillidae	*Gastrocopta*	*mussoni*	1
S65612	Gastropoda	Stylommatophora	Pupillidae	*Gastrocopta*	*larapinta*	3
S65613	Gastropoda	Basomatophora	Planorbidae	*Gyraulus*	sp.	1
S65614	Gastropoda	Stylommatophora	Pupillidae	*Pupoides*	*beltianus*	1
S65615	Gastropoda	Stylommatophora	Pupillidae	*Pupoides*	*pacificus*	1
S65616	Gastropoda	Stylommatophora	Subulinidae	*Eremopeas*	*interioris*	1
S65617	Gastropoda	Stylommatophora	Pupillidae	*Pupoides*	*pacificus*	1

Appendix 7: WAM DNA Report 2012

DNA bar-coding of *Karaops*, *Antichiropus*, and *Beierolpium* from Christmas Creek and surrounding areas

Report to *Subterranean Ecology*

21 June 2012

M. A. Castalanelli, C. A. Car, M. A. Burger & M. S. Harvey

Department of Terrestrial Zoology, Western Australian Museum,
Locked Bag 49, Welshpool DC, Western Australia 6986, Australia

Summary

Specimens that were successfully DNA bar-coded by the Western Australian Museum included:

- 19 *Karoaps* specimens from the family Selenopidae,
- 28 *Antichiropus* specimens from the family Paradoxosomatidae,
- 13 *Beierolpium* specimens from the family Olpiidae.

The unknown *Karaops* juvenile (WAM specimen number: T123838) that was collected by Subterranean Ecology was closely matched (99.6% similarity) to *Karaops* `BD2` (T111456) which was collected at Bonney Downs, 115 km NNW of Newman. These two specimens were geographically close and would be considered a putative short-ranged endemic.

The results from the Paradoxosomatidae bar-coding study revealed that the Subterranean Ecology specimens formed two groups, denoted as FMG group 1 and FMG group 2. The first group, FMG group 1, was restricted to a localised area and would be considered a SRE species. In comparison, FMG group 2 was widespread and was not considered as a SRE.

Two *Beierolpium* specimens were collected by Subterranean Ecology and compared to specimens collected nearby. Both specimens were genetically distinct and didn't match with any of the specimens nearby. At present it is not possible to firmly establish the identity of these species and also if these species represent a SRE.

Short-Range Endemism

The terrestrial invertebrate fauna of inland Australia contains a plethora of species, and just the arthropods were recently estimated to consist of more than 250,000 species (Chapman, 2009; Yeates et al., 2004). The vast majority of these are found within the Insecta and Arachnida, although significant numbers of millipedes are to be expected. For many years, the prospect of including invertebrates in assessments of biological systems subject to modification proved daunting because of the large numbers of unknown species. These animals were largely ignored, as they were too diverse and their taxonomy too little known for them to be considered in environmental surveys that require a rapid turn-around time.

In two publications, the issue of Short-Range Endemism in the Australian invertebrate fauna was examined (Harvey, 2002) (Harvey et al., 2011). Species that could be defined as Short-Range Endemics (SRE) were those that had a naturally small range of less than 10,000 km^2. Harvey (2002) found that those species possessed a series of distinct ecological and life-history traits that contributed to their limited distributions, including:

- poor powers of dispersal;
- confinement to discontinuous habitats;
- usually highly seasonal, only active during cooler, wetter periods; and
- low levels of fecundity.

A number of major invertebrate groups have a high proportion of individual species that show these traits and can be considered SRE's. The Western Australian fauna contains a number of SRE taxa, including millipedes, land snails, trap-door spiders, some pseudoscorpions, slaters, and onychophorans and these represent focal groups in Environmental Impact Assessment studies in the state (EPA, 2009). The south coast region is relatively well known compared with other regions of the state (Framenau et al., 2008), but there are many poorly known species and gaps in our understanding of the distributions of many species.

Methods

Specimens

The specimens submitted to the WA Museum by Subterranean Ecology were allocated unique registration numbers and included on the Museum's arachnology database.

Molecular Methods

Amplification of the bar-coding fragment was performed using primer outlined in Table 1.

Table 1. Primers used to generate the bar-coding fragments.

Primer	Sequence `5-3`	Reference
LCO1490	GGTCAACAAATCATAAAGATATTGG	(Folmer et al., 1994)
HCO2198	TAAACTTCAGGGTGACCAAAAAATCA	(Folmer et al., 1994)
C1-J-1718F-mygal	GGAGGATTTGGAAATTGATTAGTTCC	Modififed (Simon et al., 1994)
C1-N-2191	CCCGGTAAAATTAAAATATAAACTTC	(Folmer et al., 1994)

The sequences were edited using Geneious Pro 5.5.6 (Biomatters Ltd) and aligned with the reference dataset using Geneious' built in alignment algorithm.

Geneious Pro 5.5.6 was used to detect the presence of NuMTs by translating each *COI* sequence with the standard invertebrate and *Drosophila* codes, and calculate net divergences between mitochondrial sequences.

Phylogenetic trees were generated for each taxonomic group using Mr Bayes 3.1.2 (Ronquist & Huelsenbeck, 2003). *Cytochrome Oxidase I* was partitioned in three; each allowed to evolve independently under a general time reversal (GTR) model. The program was run for gen=5,000,000, sample freq=1,000, sump burnin=5,000, and sumt burnin=5,000.

Results and Discussion

ARANEAE

Karaops sp. juv. (T123838; Family Selenopidae)

Spiders from the family Selenopidae are dorsoventrally flattened spiders that are well camouflaged by their mottled colouring. Species of this family are found worldwide in tropical and subtropical regions (Crews & Harvey, 2011). Spiders of the genus *Karaops* are found throughout mainland Australia. Some species in this genus seem to have fairly widespread distributions. However, current literature suggests there is cryptic speciation in this genus due to the large range of some species, yet stable morphology in isolated populations (Crews & Harvey, 2011) and while species in this genus are not officially recognised as SRE's, evidence is pointing towards localised distributions of species, especially in semi-arid and arid land systems within Australia.

One morphologically unidentifiable juvenile specimen (T123838) was successfully amplified and genetically compared to other *Karaops* specimens collected from the nearby areas in the Pilbara bioregion of Western Australia. This specimen closely matched (99.6% pairwise similarity; Table 2) to *Karaops* `BD2` (T111456) which was collected at Bonney Downs, 115 km NNW of Newman. The next most similar *Karaops* specimen was T92503 (93.1% pairwise similarity; Table 2 and Fig. 1) collected 2 km S of Tom Price. At this level of similarity it is difficult to ascertain whether T123838 (Christmas Creek) and T92503 (Tom Price) are the same species.

In summary, *Karaops* `BD2` definitely contains T123838 (Christmas Creek) and T111456 (Bonney Downs). These two locations are 19.95 km apart, suggesting that this species is a potential SRE. Even if T92503 (Tom Price) is included in this species and the distribution is extended to ~2,200 km^2, the species would still be a potentially a SRE species.

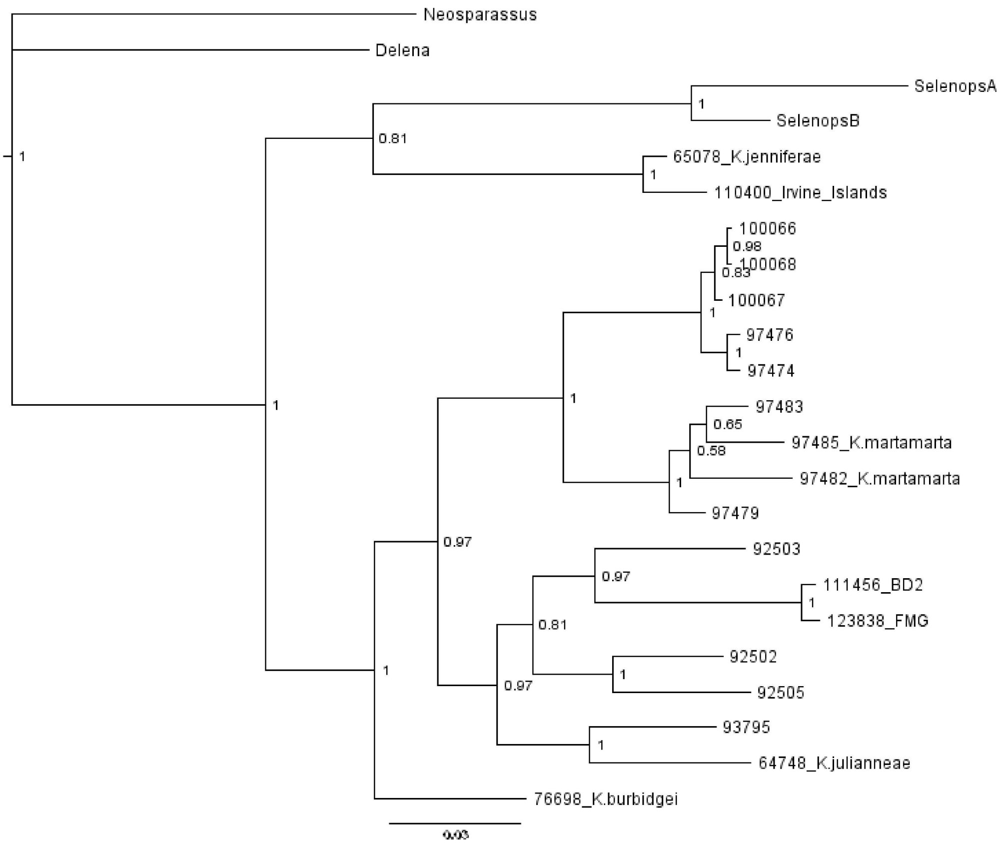

Fig 1. Bayesian phylogenetic tree based on the mitochondrial gene COI. The value at the end of each node represents the Bayesian posterior probably. Outgroups were *Neosparassus punctatus* (Araneae: Sparassidae; http://www.ncbi.nlm.nih.gov accession GQ338537) and *Delena gloriosa* (Araneae: Sparassidae; accession GQ338534), *Selenops A* (*Selenops micropalpus*; Araneae: Selenopidae; accession GU109936), and *Selenops B* (Araneae: Selenopidae; accession GU109924).

Table 2. Pairwise Similarity (percentage of nucleotide differences) Matrix for the *Karaops* specimens.

	Selenops A	Selenops B	65078 K. jenniferae	110400 Irvine Isd	100066	100068	92503	92502	97483	97476	100067	97474	97485 K. martamarta	92505	93795	76698 K. burbidgei	111456 `K. BD2`
SelenopsA	100	93.8	85	84.5	83.8	83.8	82.8	84	84.3	83.8	82.7	83.1	83.6	84.1	84.5	85.6	82.5
SelenopsB	93.8	100	86.7	86.4	85.5	85.5	84.4	86.5	85.2	85.9	84.9	85.3	84.9	85.1	86.5	86.5	85.1
65078 K. jenniferae	85	86.7	100	98.3	87.5	87.5	86.1	89	87.5	87.5	86.7	86.9	86.9	88.5	88	88.9	87.9
110400 Irvine Isd	84.5	86.4	98.3	100	87.2	87.2	86.4	88.4	86.7	87.4	86.7	86.9	86.2	87.8	87.8	88.3	86.4
100066	83.8	85.5	87.5	87.2	100	100	91.9	90	93.9	99	99.8	98.9	93.4	90.1	89.9	90.4	91
100068	83.8	85.5	87.5	87.2	100	100	91.9	90	93.9	99	99.8	98.9	93.4	90.1	89.9	90.4	91
92503	82.8	84.4	86.1	86.4	91.9	91.9	100	92	92.7	91.5	91.5	91.1	92.4	92.2	92	90.6	92.3
92502	84	86.5	89	88.4	90	90	92	100	91.2	90.2	89.7	89.9	91.5	94.7	92.4	91.8	91.2
97483	84.3	85.2	87.5	86.7	93.9	93.9	92.7	91.2	100	93.5	93.6	93.1	97.7	90.1	91	90.1	90.4
97476	83.8	85.9	87.5	87.4	99	99	91.5	90.2	93.5	100	99.1	99.6	92.7	89.9	90.1	90.4	90.8
100067	82.7	84.9	86.7	86.7	99.8	99.8	91.5	89.7	93.6	99.1	100	99.1	93.1	89.9	90.1	90.6	90.7
97474	83.1	85.3	86.9	86.9	98.9	98.9	91.1	89.9	93.1	99.6	99.1	100	92.2	90.1	90.2	90.6	90.7
97485 `K. martamarta`	83.6	84.9	86.9	86.2	93.4	93.4	92.4	91.5	97.7	92.7	93.1	92.2	100	90.1	90.8	90.6	90.2
92505	84.1	85.1	88.5	87.8	90.1	90.1	92.2	94.7	90.1	89.9	89.9	90.1	90.1	100	92	90.4	90.7
93795	84.5	86.5	88	87.8	89.9	89.9	92	92.4	91	90.1	90.1	90.2	90.8	92	100	91.8	91.4
76698 K. burbidgei	85.6	86.5	88.9	88.3	90.4	90.4	90.6	91.8	90.1	90.4	90.6	90.6	90.6	90.4	91.8	100	90.9
111456_BD2	82.5	85.1	87.9	86.4	91	91	92.3	91.2	90.4	90.8	90.7	90.7	90.2	90.7	91.4	90.9	100
97482 K. martamarta	83.4	84	88.4	86.9	92.6	92.6	91.2	90.2	96.7	92.2	92	91.8	95.9	89.1	89.8	89.3	91
123838 FMG	83	85.7	87.7	86.9	91.1	91.1	93.1	91.7	91.1	91.1	90.7	91	90.9	91.6	92.1	91	99.6
64748 K. julianneae	82.1	84.8	87.5	86.9	90.4	90.4	90.9	92.5	90.6	90.4	89.6	89.8	91.5	89.8	93.9	90.5	92.1
97479	84.8	84.6	87.7	86.4	93.3	93.3	91.9	90.8	97.9	92.9	92.7	92.5	97.1	89.1	90	91.2	91.4
Delena	81.6	81.9	83.9	82.5	82.7	82.7	82.7	82.9	81.1	82.9	82.9	82.9	81.5	81.7	83.8	83.6	81.4
Neosparassus	80.8	82.7	82.7	81.9	82.7	82.7	81.3	84.4	82.9	82.9	82.9	82.9	82.7	82.9	83	83	81.4

	97482 K. martamarta	123838 FMG	64748 K. julianneae	97479	Delena	Neosparassus
SelenopsA	83.4	83	82.1	84.8	81.6	80.8
SelenopsB	84	85.7	84.8	84.6	81.9	82.7
65078 K. jenniferae	88.4	87.7	87.5	87.7	83.9	82.7
110400 Irvine Isd	86.9	86.9	86.9	86.4	82.5	81.9
100066	92.6	91.1	90.4	93.3	82.7	82.7
100068	92.6	91.1	90.4	93.3	82.7	82.7
92503	91.2	93.1	90.9	91.9	82.7	81.3
92502	90.2	91.7	92.5	90.8	82.9	84.4
97483	96.7	91.1	90.6	97.9	81.1	82.9
97476	92.2	91.1	90.4	92.9	82.9	82.9
100067	92	90.7	89.6	92.7	82.9	82.9
97474	91.8	91	89.8	92.5	82.9	82.9
97485 `K. martamarta`	95.9	90.9	91.5	97.1	81.5	82.7
92505	89.1	91.6	89.8	89.1	81.7	82.9
93795	89.8	92.1	93.9	90	83.8	83
76698 K. burbidgei	89.3	91	90.5	91.2	83.6	83
111456_BD2	91	99.6	92.1	91.4	81.4	81.4
97482 K. martamarta	100	91.1	90.4	97.7	81	82.5
123838 FMG	91.1	100	91.7	91.4	81.9	81.9
64748 K. julianneae	90.4	91.7	100	90.6	82.4	82.9
97479	97.7	91.4	90.6	100	81.8	83.3
Delena	81	81.9	82.4	81.8	100	85
Neosparassus	82.5	81.9	82.9	83.3	85	100

POLYDESMIDA

***Antichiropus* (Family Paradoxosomatidae)**

Paradoxosomatid millipede species conform closely to the definition of short-range endemism (Harvey, 2002; Harvey et al., 2011). In addition, species may show complex distribution patterns: ranges may overlap in a pattern defined as mosaic parapatry (Mesibov, 2003) and there are many instances of sympatry in the fauna. For example, in the genus *Antichiropus,* to which most species belong in Western Australia, two species occur sympatrically in Geraldton, three at Mt Gibson, two at Rockingham, two at Marvel Loch and five at Boddington.

The results of *COI* bar-coding study has shown that two groups of *Antichiropus*, denoted as FMG group 1 and FMG group 2 (Fig. 2) were collected during this survey. FMG group 1 contained multiple specimens all collected by Subterranean Ecology. Individuals within this group were minimally diverse (ranging from 96.3 to 99.8% similarity) and formed a well supported clade (0.88 posterior probability). FMG group 2 was represented by three individuals that formed a well supported clade and ranged in diversity from 99.7 to 99.9% similarity. One specimen (T113251) was collected by Subterranean Ecology within the area of interest (Christmas Creek), while the other two samples were collected ~30 to 40 km east of Karratha. These two groups, FMG group 1 & 2, are genetically distinct (<93.1% pairwise similarity).

While it is common for more than one species to occur sympatrically, two morphologically identical male specimens (T120061 and T120063) were placed in two distinct lineages (within clade A; Fig 2). Genetically, specimen T120061 forms a sister clade to FMG group 1, with FMG group 1 forming a sister clade to specimen T120063 and FMG group 2. This suggests that either the specimens within clade A are one species or multiple species of which specimens T120061 and T120063 are cryptic. Without further investigation, whereby males are collected or more genes are used to examine the species boundaries, these two FMG groups need to be considered as separate species. The specimens within FMG group 2 are widespread and would not be considered a SRE, whereas the specimens within FMG group 1 are a suspected SRE.

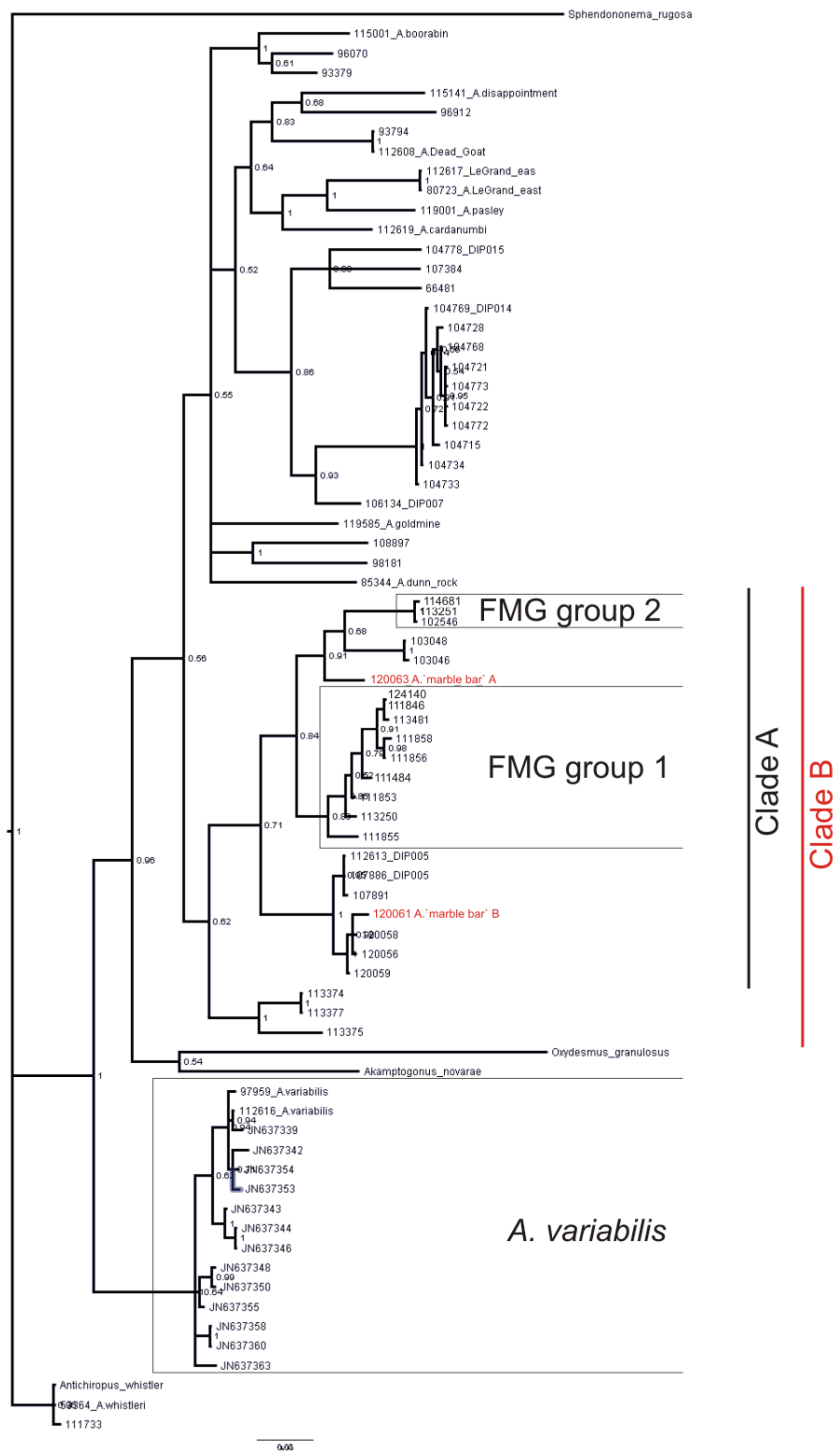

Fig 2. Bayesian phylogenetic tree based on the mitochondrial gene COI. The value at the end of each node represents the Bayesian posterior probably. Outgroups were *Sphendononema rugosa* (Scutigeromorpha: Scutigeridae; http://www.ncbi.nlm.nih.gov accession HQ591450), *Oxydesmus granulosus* (Polydesmida: Oxydesmidae; accession EF206736), and *Akamptogonus novarae* (Polydesmida: Paradoxosomatidae; accession JN637369).

Table 3. Pairwise Similarity (percentage of nucleotide differences) Matrix for the *Antichiropus* specimens within clade B (Fig 2).

											FMG Group 2		
		113374 A .`wodgina`	112613 A.`abydos`	120063 A. `marblebar` A	120061 A. `marblebar` B	*O. granulosus*	113377	113375	113374	103048	113251	114681	102546 Anketell Pt.
	113374 A .`wodgina`	100	90.7	91.7	89.7	79.9	100	94.7	100	90.9	90.8	90.9	91
	112613 A.`abydos`	90.7	100	91.3	97.9	81.3	90.7	89.3	90.7	91.5	91.9	92	91.8
	120063 A. `Marblebar` A	91.7	91.3	100	90.4	82.2	91.7	89.3	91.7	94.7	94.3	94.4	94.5
	120061 A. `Marblebar` B	89.7	97.9	90.4	100	81.3	89.7	89.1	89.7	90.7	90.4	90.5	90.4
	O. granulosus	79.9	81.3	82.2	81.3	100	79.9	80	79.9	81	81.3	81.3	81.3
	113377	100	90.7	91.7	89.7	79.9	100	94.7	100	90.9	90.8	90.9	91
	113375	94.7	89.3	89.3	89.1	80	94.7	100	94.7	88.7	88.1	88.1	88.1
	113374	100	90.7	91.7	89.7	79.9	100	94.7	100	90.9	90.8	90.9	91
	103048	90.9	91.5	94.7	90.7	81	90.9	88.7	90.9	100	93.4	93.5	93.7
FMG Group 2	113251	90.8	91.9	94.3	90.4	81.3	90.8	88.1	90.8	93.4	100	99.9	99.7
	114681	90.9	92	94.4	90.5	81.3	90.9	88.1	90.9	93.5	99.9	100	99.8
	102546 Anketell Pt.	91	91.8	94.5	90.4	81.3	91	88.1	91	93.7	99.7	99.8	100
FMG Group 1	111858	90.3	92	95	91.3	82.8	90.3	88.7	90.3	93.8	92.9	93.1	93.2
	111855	90.3	92.6	94.5	92.1	81.3	90.3	89.6	90.3	93.8	92	92.1	92.3
	111856	90.3	92.3	94.7	91.6	83.1	90.3	88.9	90.3	93.8	92.6	92.7	92.9
	111843	90.4	92.7	94.7	92.1	82.2	90.4	88.7	90.4	93.7	92.6	92.7	92.9
	111846	90.3	92	94.7	91.3	83.1	90.3	88.9	90.3	93.7	92.6	92.7	92.9
	113481	90.4	92.1	94.5	91.5	82.8	90.4	88.7	90.4	93.5	92.5	92.6	92.7
	124140	90.4	92.1	94.5	91.5	82.8	90.4	88.7	90.4	93.5	92.5	92.6	92.7
	111853	90	93.1	94.4	93.3	81.6	90	89.8	90	93.7	92.2	92.2	92.2
	113250	90	92.5	93.8	92.7	81.7	90	90.2	90	92.9	91.7	91.7	91.7

		FMG Group 1								
		111858	111855	111856	111844	111846	113481	124140	111853	113250
	113374 A .`wodgina`	90.3	90.3	90.3	90.4	90.3	90.4	90.4	90	90
	112613 A.`abydos`	92	92.6	92.3	92.7	92	92.1	92.1	93.1	92.5
	120063 A. `Marblebar` A	95	94.5	94.7	94.7	94.7	94.5	94.5	94.4	93.8
	120061 A. `Marblebar` B	91.3	92.1	91.6	92.1	91.3	91.5	91.5	93.3	92.7
	O. granulosus	82.8	81.3	83.1	82.2	83.1	82.8	82.8	81.6	81.7
	113377	90.3	90.3	90.3	90.4	90.3	90.4	90.4	90	90
	113375	88.7	89.6	88.9	88.7	88.9	88.7	88.7	89.8	90.2
	113374	90.3	90.3	90.3	90.4	90.3	90.4	90.4	90	90
	103048	93.8	93.8	93.8	93.7	93.7	93.5	93.5	93.7	92.9
FMG Group 1	113251	92.9	92	92.6	92.6	92.6	92.5	92.5	92.2	91.7
	114681	93.1	92.1	92.7	92.7	92.7	92.6	92.6	92.2	91.7
	102546 Anketell Pt.	93.2	92.3	92.9	92.9	92.9	92.7	92.7	92.2	91.7
FMG Group 2	111858	100	96.8	99.7	98.3	99.1	98.9	98.9	98	97.4
	111855	96.8	100	96.8	96.9	96.5	96.3	96.3	98	97.6
	111856	99.7	96.8	100	98.6	99.4	99.2	99.2	98.3	97.6
	111844	98.3	96.9	98.6	100	98.6	98.8	98.8	99.3	98.3
	111846	99.1	96.5	99.4	98.6	100	99.8	99.8	98.3	97.6
	113481	98.9	96.3	99.2	98.8	99.8	100	100	98	97.4
	124140	98.9	96.3	99.2	98.8	99.8	100	100	98	97.4
	111853	98	98	98.3	99.3	98.3	98	98	100	99.3
	113250	97.4	97.6	97.6	98.3	97.6	97.4	97.4	99.3	100

PSEUDOSCORPIONES

Beierolpium sp. juv. (Family Olpiidae)

The Western Australian pseudoscorpion fauna is fairly diverse with representatives of 17 different families. They are found in a variety of biotopes, but can be most commonly collected from the bark of trees, from the underside of rocks, or from leaf litter habitats. Molecular analysis of the two FMG specimens morphologically identified as *Beierolpium* (T113157 and T113158) revealed that they occupy different regions of the Bayesian tree (Fig. 3). The most similar specimen to T113157 was T113332 (75.2%), and for T113158 the most similar was T106675 (83.8%). There was, however, minimal similarity to any other specimen analysed in this study (Table 4). The high levels of divergence suggests long periods of isolation and the presence of multiple species.

The systematic status of members of this genus has not been fully assessed. At present it is not possible to firmly establish the identity of these species, and also whether T113157 and or T113158 represent a SRE species. This can only be achieved through a thorough and wide-ranging systematic study of the genus *Beierolpium*, across the various different bioregions of Western Australia.

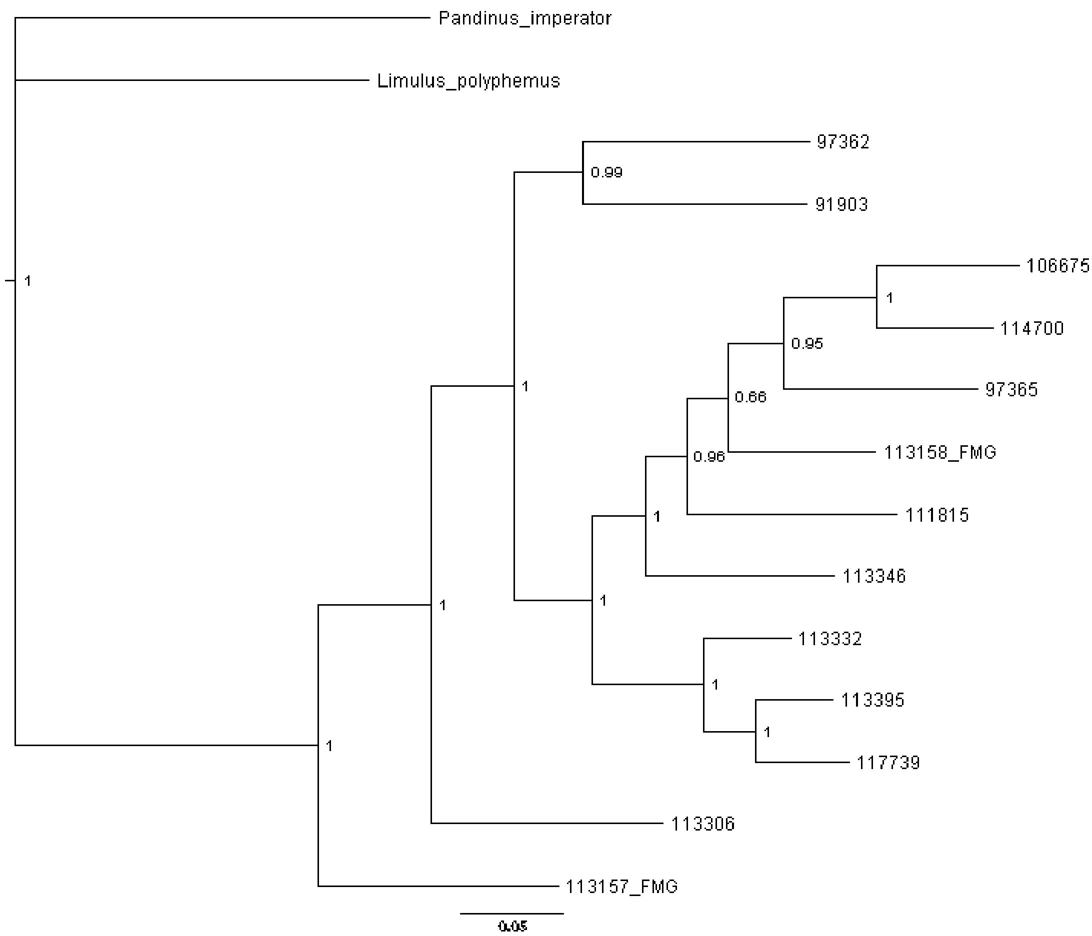

Fig 3. Bayesian phylogenetic tree based on the mitochondrial gene COI. The value at the end of each node represents the Bayesian posterior probably. Outgroups were *Limulus polyphemus* (Xiphosura: Limulidae; http://www.ncbi.nlm.nih.gov accession HQ588751) and *Pandinus imperator* (Scorpionoidea: Scorpionidae; accession JQ514251).

Table 4. Pairwise Similarity (percentage of nucleotide differences) Matrix for the *Beierolpium* specimens

	97362	106675	111815	113157 FMG007	113158 FMG007	113306	113332	113346	113395	114700	117739	91903	97365	*Limulus polyphemus*	*Pandinus imperator*
97362	100	76.5	78.4	77.1	80.7	76.7	77.9	79.2	78.8	77.9	77.7	81	78.8	68.1	67.9
106675	76.5	100	82.3	72.5	83.8	77.2	80.9	82.8	81.1	88.2	79.7	76.8	82.2	66.3	65.6
111815	78.4	82.3	100	74.4	83.7	79	80.9	83.4	81.5	83.7	79	77.6	81.6	65.5	65.1
113157 FMG007	77.1	72.5	74.4	100	75	77.6	75.2	73.4	76.3	72.9	74.9	75.9	74.6	67.5	68.2
113158 FMG007	80.7	83.8	83.7	75	100	76.1	81.7	83.7	81.7	84.6	80.3	78.5	82.9	68.1	66.2
113306	76.7	77.2	79	77.6	76.1	100	79.3	78.5	77.5	76.7	78.8	77	78.9	66.3	68.1
113332	77.9	80.9	80.9	75.2	81.7	79.3	100	82.8	89.7	80.2	90.2	80.6	81.4	66.3	68.1
113346	79.2	82.8	83.4	73.4	83.7	78.5	82.8	100	82.6	82	80.9	78.1	83.4	65.8	67.3
113395	78.8	81.1	81.5	76.3	81.7	77.5	89.7	82.6	100	81.5	92	81.4	80.3	68.1	70.6
114700	77.9	88.2	83.7	72.9	84.6	76.7	80.2	82	81.5	100	79	75.5	83.2	68.1	63.7
117739	77.7	79.7	79	74.9	80.3	78.8	90.2	80.9	92	79	100	79.5	80.2	66.4	67.4
91903	81	76.8	77.6	75.9	78.5	77	80.6	78.1	81.4	75.5	79.5	100	77.5	67.3	69.4
97365	78.8	82.2	81.6	74.6	82.9	78.9	81.4	83.4	80.3	83.2	80.2	77.5	99.9	68	66.1
Limulus polyphemus	68.1	66.3	65.5	67.5	68.1	66.3	66.3	65.8	68.1	68.1	66.4	67.3	68	100	70.6
Pandinus imperator	67.9	65.6	65.1	68.2	66.2	68.1	68.1	67.3	70.6	63.7	67.4	69.4	66.1	70.6	100

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Appendix I

Table 5. Details of the Specimens that were DNA bar-coded in this Study.

REGNO	FLDNO	ACCDT	ORDER	FAMILY	GENUS	SPECIES	AUTHORITY	SITE	LAT	LONG
64748		8/07/2005	Araneae	Selenopidae	Karaops	julianneae	Crews & Harvey, 2011	Lorna Glen Station, quadrat 19	26°00`05"S	121°33`48"E
65078		10/08/2005	Araneae	Selenopidae	Karaops	jenniferae	Crews & Harvey, 2011	Oscar Range	17°38`16"S	125°10`08"E
76698		9/08/2006	Araneae	Selenopidae	Karaops	burbidgei	Crews & Harvey, 2011	Barrow Island, site 45	20°47`18"S	115°28`31"E
92502		8/10/2008	Araneae	Selenopidae	Karaops	`sp. (juv.)`		Mt Herbert, 80.5 km SE. of Karratha, A20080811.CH01-02	21°20`48"S	117°16`06"E
92503		8/10/2008	Araneae	Selenopidae	Karaops	`sp. (juv.)`		Tom Price, 2 km S. of Tom Price, A20080815.CH23-01	22°42`46"S	117°46`33"E
92505		8/10/2008	Araneae	Selenopidae	Karaops	`sp. (juv.)`		Wickham, 54.2 km E. of Karatha, A20080813CH09-01	20°53`21"S	117°20`31"E
93795	EE08:0444	26/11/2008	Araneae	Selenopidae	Karaops	`sp. (juv.)`		Jack Hills area, Dead Goat Hill, (Ecologia project 987)	26°10`42.79"S	116°58`32.35"E
97474	SCC09_025	9/06/2009	Araneae	Selenopidae	Karaops	`sp. (juv.)`		Red Hill Station, c. 10 km NE. of homestead, Cochrane and Jewell bore site RNRC083	21°55`55.25"S	116°07`42.49"E
97476	SCC09_027	9/06/2009	Araneae	Selenopidae	Karaops	`sp. (juv.)`		Red Hill Station, c. 20 km SE. of homestead,Kens Bore site KBRC081	22°03`26.83"S	116° 11`46.82"E
97479	SCC09_030	9/06/2009	Araneae	Selenopidae	Karaops	`sp. (juv.)`		Red Hill Station, c. 24 km SE. of Cardo Outstation, Trinity Bore site TBRC031	22°20`2 6.89"S	116°20`20.28"E
97482	SCC09_033	9/06/2009	Araneae	Selenopidae	Karaops	martamarta	Crews & Harvey, 2011	c. 25 km SE. of Cardo Outstation, Trinity Bore South site TBRC078	22°23`54.89"S	116°19`32.43"E
97483	SCC09_034	9/06/2009	Araneae	Selenopidae	Karaops	`sp. (juv.)`		c. 23 km SE. of Cardo Outstation, Trinity Bore South site TBRC062	22°23`02.35"S	116°1 8`12.65"E
97485	SCC09_036	9/06/2009	Araneae	Selenopidae	Karaops	martamarta	Crews & Harvey, 2011	Red Hill Station, c. 10 km NE. of Cardo Outstation, Cardo Bore East site CBRC300	22°11`57.67"S	116°12` 00.69"E
100066	S20090825.MSG06MG-04	8/02/2010	Araneae	Selenopidae	Karaops	`sp. (juv.)`		Mesa G-Warramboo, 22.6 km WSW. of Pannawonica	21°44`25"S	116°08`05"E
100067	S20090826.MSG03EMG-01	8/02/2010	Araneae	Selenopidae	Karaops	`sp. (juv.)`		Mesa G-Warramboo, 22.4 km WSW. of Pannawonica	21°44`15"S	116°07`49"E
100068	S20090825.MSG06MG-05	8/02/2010	Araneae	Selenopidae	Karaops	`sp. (juv.)`		Mesa G-Warramboo, 22.6 km WSW. of Pannawonica	21°44`25"S	116°08`05"E
110400	O20100718.MARGISL-01	15/03/2011	Araneae	Selenopidae	Karaops	`sp. nov. Irvine Islands`		Buccaneer Archipelago, Margaret Island, 127 km N. of Derby	16°09`12"S	123°34`42"E
111456	PE11:2181	11/05/2011	Araneae	Selenopidae	Karaops	`sp. BD2`		Bonney Downs, 115 km NNW of Newman	22°19`04.32"S	119°44`51.27"E
123838		31/05/2012	Araneae	Selenopidae	Karaops	`sp. juv.`		100 km N of Newman	22°25`1.468"S	119°53`38.71"E
93794	EE08:0440	26/11/2008	Polydesmida	Paradoxosomatidae	Antichiropus	`Dead Goat`		Dead Goat Hill, ca. 120 km NE. Meekatharra, project 987	26°09`50.28"S	117°00`38.70"E
111844	FMG007_XC11_FN10973	10/05/2011	Polydesmida	Paradoxosomatidae				Christmas Creek, 110 km N. Newman	22°23`35.79"S	119°46`46.84"E
111846	FMG007_XC33_FN11322	10/05/2011	Polydesmida	Paradoxosomatidae				Christmas Creek, 110 km N. Newman	22°21`05.70"S	119°46`17.36"E
111853	FMG007_XC25_FN11497	10/05/2011	Polydesmida	Paradoxosomatidae				Christmas Creek, 110 km N. Newman	22°25`01.47"S	119°53`38.72"E
111855	FMG007_XC27_FN10982	10/05/2011	Polydesmida	Paradoxosomatidae				Christmas Creek, 110 km N. Newman	22°21`56.46"S	119°36`11.29"E
111856	FMG007_XC35_FN10939	10/05/2011	Polydesmida	Paradoxosomatidae				Christmas Creek, 110 km N. Newman	22°22`44.09"S	119°49`06.77"E
111858	FMG007_XC34_FN11327	10/05/2011	Polydesmida	Paradoxosomatidae				Christmas Creek, 110 km N. Newman	22°22`55.11"S	119°49` 6.20"E
112613	A2-SRE-MU-Z	11/11/2010	Polydesmida	Paradoxosomatidae	Antichiropus	`DIP005`		Abydos, ca. 64 km W. Marble Bar	21°08`32.00"S	119°06`54.01"E
112617		11/05/2011	Polydesmida	Paradoxosomatidae	Antichiropus	`LeGrand east`		Le Grand National Park, Mississippi Hill, site 5	33°59`39"S	122°15`16"E
113250	FMG007_XC24_FN11513	10/05/2011	Polydesmida	Paradoxosomatidae				Christmas Creek, 110 km N. Newman	22°25`08.63"S	119°53`48.58"E

113251	FMG007_XC24_FN11513	10/05/2011	Polydesmida	Paradoxosomatidae			Christmas Creek, 110 km N. Newman	22°25`08.63"S	119°53`48.58"E
113374	229	14/06/2011	Polydesmida	Paradoxosomatidae			c. 25 km N of Wodgina; site PS05	21°04`41.7"S	118°30`16.5"E
113375	269	14/06/2011	Polydesmida	Paradoxosomatidae			c. 25 km N of Wodgina; site PS03	21°03`53.4"S	118°31`49.1"E
113377	425	14/06/2011	Polydesmida	Paradoxosomatidae			c. 25 km N of Wodgina; site WE23	21°03`48.5"S	118°33`45.4"E
113481	FMG007_XC11_FN10974	10/05/2011	Polydesmida	Paradoxosomatidae			Christmas Creek, 110 km N. Newman	22°23`35.79"S	119°46`46.84"E
114681		23/08/2011	Polydesmida	Paradoxosomatidae	Antichiropus	`sp. indet. (juv.)`	Karratha to Millstream-Chichester National Park	20°59`07.08"S	116°52`51.97"E
115001		7/11/2011	Polydesmida	Paradoxosomatidae	Antichiropus	`boorabin`	Boondi Rock, Goldfields Woodlands National Park, Great Eastern Highway	31°10`48. 8"S	120°22`58.7"E
115141		7/11/2011	Polydesmida	Paradoxosomatidae	Antichiropus	`disappointment`	Disappointment Rock, Hyden-Norseman Rd	32°07`49.7"S	120°55`40.6"E
119001		30/08/2011	Polydesmida	Paradoxosomatidae	Antichiropus	`pasley`	Cape Arid National Park, Thomas River	33°49`21"S	122°58`51"E
119585	Site 10-377	11/01/2012	Polydesmida	Paradoxosomatidae	Antichiropus	`goldmine`	c. 15km NW of Boddington Town	32°45`22.8"S	116°27`2.3"E
120055	Site 1-32	7/03/2012	Polydesmida	Paradoxosomatidae	Antichiropus	`sp. indet (juv.)`	c. 150km W of Marble Bar	21°8`17.24"S	119°11`48.87"E
120056	Site 1-33	7/03/2012	Polydesmida	Paradoxosomatidae	Antichiropus	`sp. indet (juv.)`	c. 150km W of Marble Bar	21°8`17.24"S	119°11`48.87"E
120058	Site 4-60	7/03/2012	Polydesmida	Paradoxosomatidae	Antichiropus	`sp. indet (juv.)`	c. 150km W of Marble Bar	21°7`3.15"S	119°11`40.95"E
120059	Site 4-61	7/03/2012	Polydesmida	Paradoxosomatidae	Antichiropus	`sp. indet. (juv.)`	c. 150km W of Marble Bar	21°7`3.15"S	119°11`40.95"E
120060	Site 2-134	7/03/2012	Polydesmida	Paradoxosomatidae	Antichiropus	`sp. indet. (female)`	c. 150km W of Marble Bar	21°5`53.19"S	119°11`10.93"E
120061	MB-39	7/03/2012	Polydesmida	Paradoxosomatidae	Antichiropus	`marble bar`	Iron Clad Hotel Marble Bar	21°10`21.41"S	119°44`43.07"E
120063	MB-59	7/03/2012	Polydesmida	Paradoxosomatidae	Antichiropus	`marble bar`	Iron Clad Hotel Marble Bar	21°10`21.41"S	119°44`43.07"E
124140	FMG007_XC12-11:0633b	8/06/2012	Polydesmida	Paradoxosomatidae			100 km N. of Newman	22°23`47.95"S	119°46`36.00"E
91903		1/08/2008	Pseudoscorpiones	Olpiidae	Beierolpium	`sp. 8/4`	10 km NE. of Newman, Ore-body 24, site 03-3C	23°17`40.7"S	119°45`21.4"E
97362	HD4-opp.3-3ps	17/06/2009	Pseudoscorpiones	Olpiidae	Beierolpium	`sp. 8/4 (small)`	Hamersley Range, 60 km WNW Newman, Hope Downs 4	23°05`16.9"S	119° 09`39.7"E
97365	HD4-opp.2-1ps	17/06/2009	Pseudoscorpiones	Olpiidae	Beierolpium	`sp. 8/4 lge`	Hamersley Range, 60 km WNW Newman, Hope Downs 4	23°05`27.1"S	119°11`5 9.3"E
106675	PS20100626.WAGSRE15-01	17/09/2010	Pseudoscorpiones	Olpiidae	Beierolpium	`sp. 8/3`	West Angelas, 116 km SE. of Tom Price	23°22`27"S	118°39`27"E
111815	PS20110314.JMF58-01	24/03/2011	Pseudoscorpiones	Olpiidae	Beierolpium	`sp. 8/3`	74.3 km NW. of Newman	22°46`44"S	119°21`41"E
113157	FMG007_XC32_FN11319	10/05/2011	Pseudoscorpiones	Olpiidae	Beierolpium	`sp.`	Christmas Creek, 110 km N. Newman	22°21`17.04"S	119°46`13.32"E
113158	FMG007_XC14_FN11295	10/05/2011	Pseudoscorpiones	Olpiidae	Beierolpium	`sp.`	Christmas Creek, 110 km N. Newman	22°24`32.34"S	119°53`04.19"E
113306	214	14/06/2011	Pseudoscorpiones	Olpiidae	Beierolpium	`sp. (juv. 7/3, 6/2x3) lge`	c. 25 km N of Wodgina; site PS05	21°04`41.7"S	118°30`16.5"E
113332	311	14/06/2011	Pseudoscorpiones	Olpiidae	Beierolpium	`sp. 8/4 lge`	Mt Dove; site PS06	20°56`08.2"S	118°27`50.0"E
113346	365	14/06/2011	Pseudoscorpiones	Olpiidae	Beierolpium	`sp. 8/2`	c. 10 km W of Wodgina; site WE10	21°15`23.0"S	118°36`50.2"E
113395	200	16/06/2011	Pseudoscorpiones	Olpiidae	Beierolpium	`sp. 8/4 lge`	c. 3.8km NW of Wodgina Mine Site; site H3	21°09`07.9"S	118°39`25.4"E
114700	1.429861111	23/08/2011	Pseudoscorpiones	Olpiidae	Beierolpium	`sp. 8/4 lge`	Angelo River, 103 km W. Newman	23°20`10.032"	118°43`31.26"E
117739	1374; EE11:0635	25/10/2011	Pseudoscorpiones	Olpiidae	Beierolpium	`sp. 8/4 lge`	~150 km SE. Port Hedland, Glacier Valley	21°11`21.72"S	119°02`33.18"E

Appendix II – COI *Sequences*

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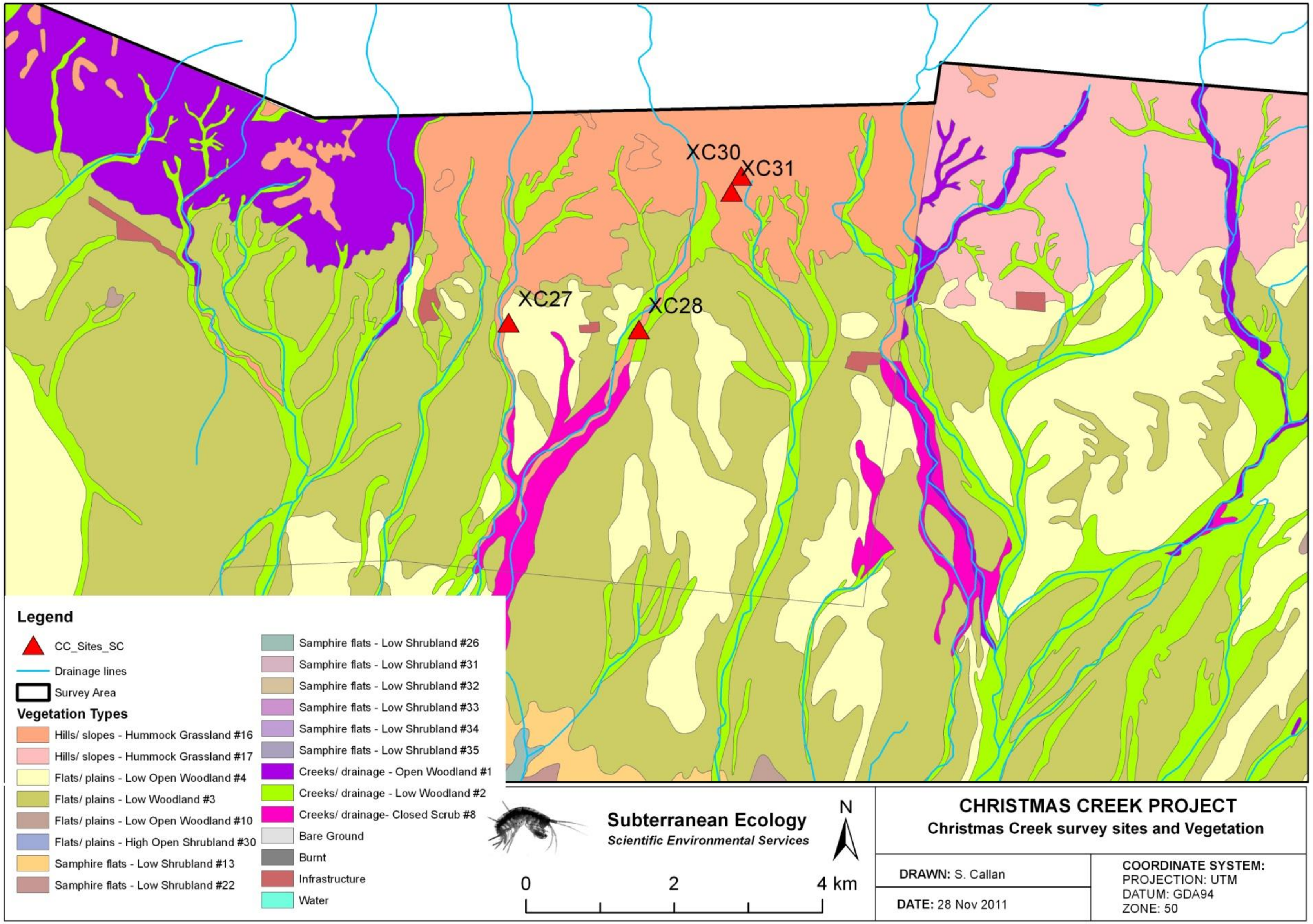
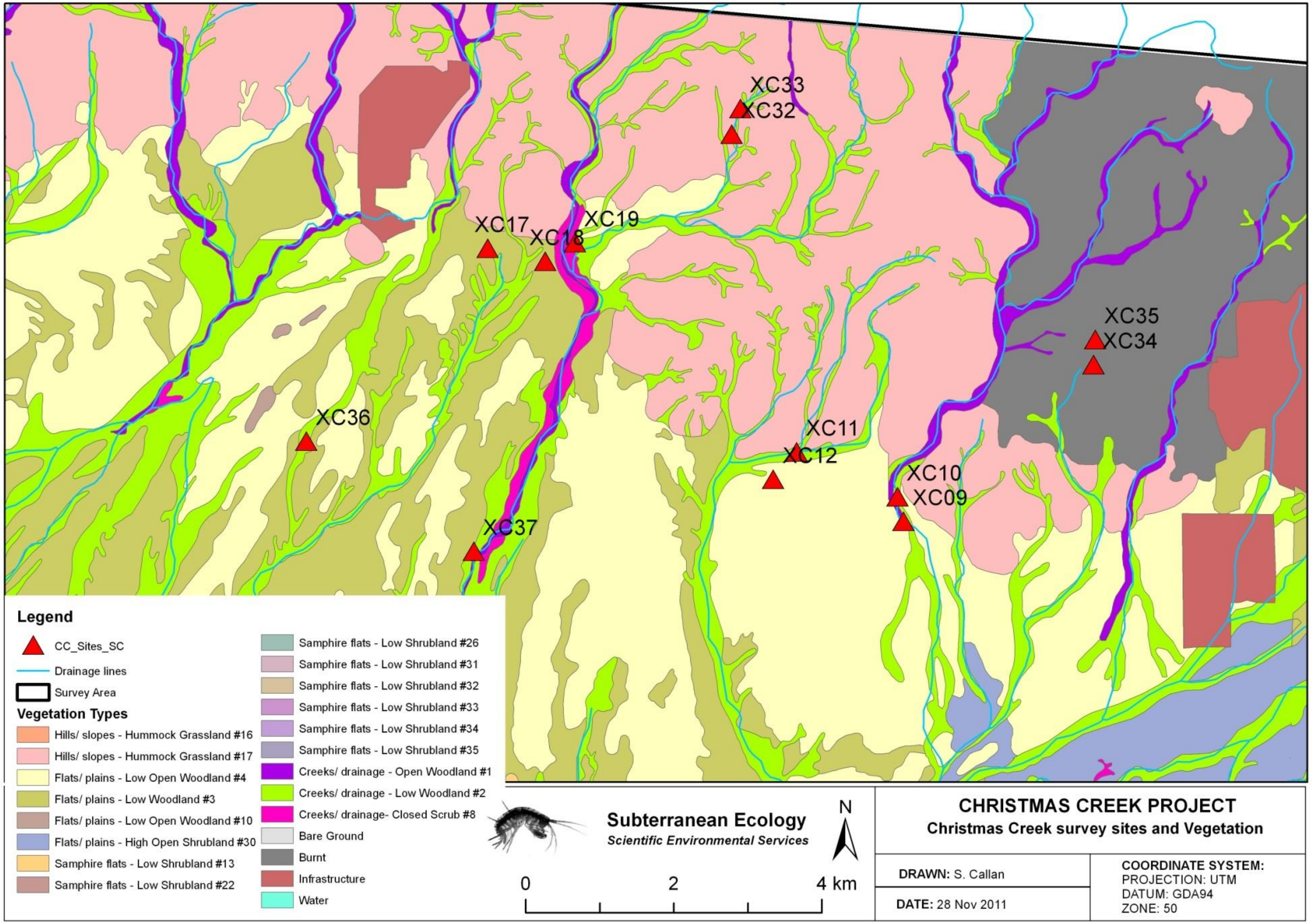
Appendix 8: Vegetation Map (insets)



Vegetation (ENV 2010) inset #1



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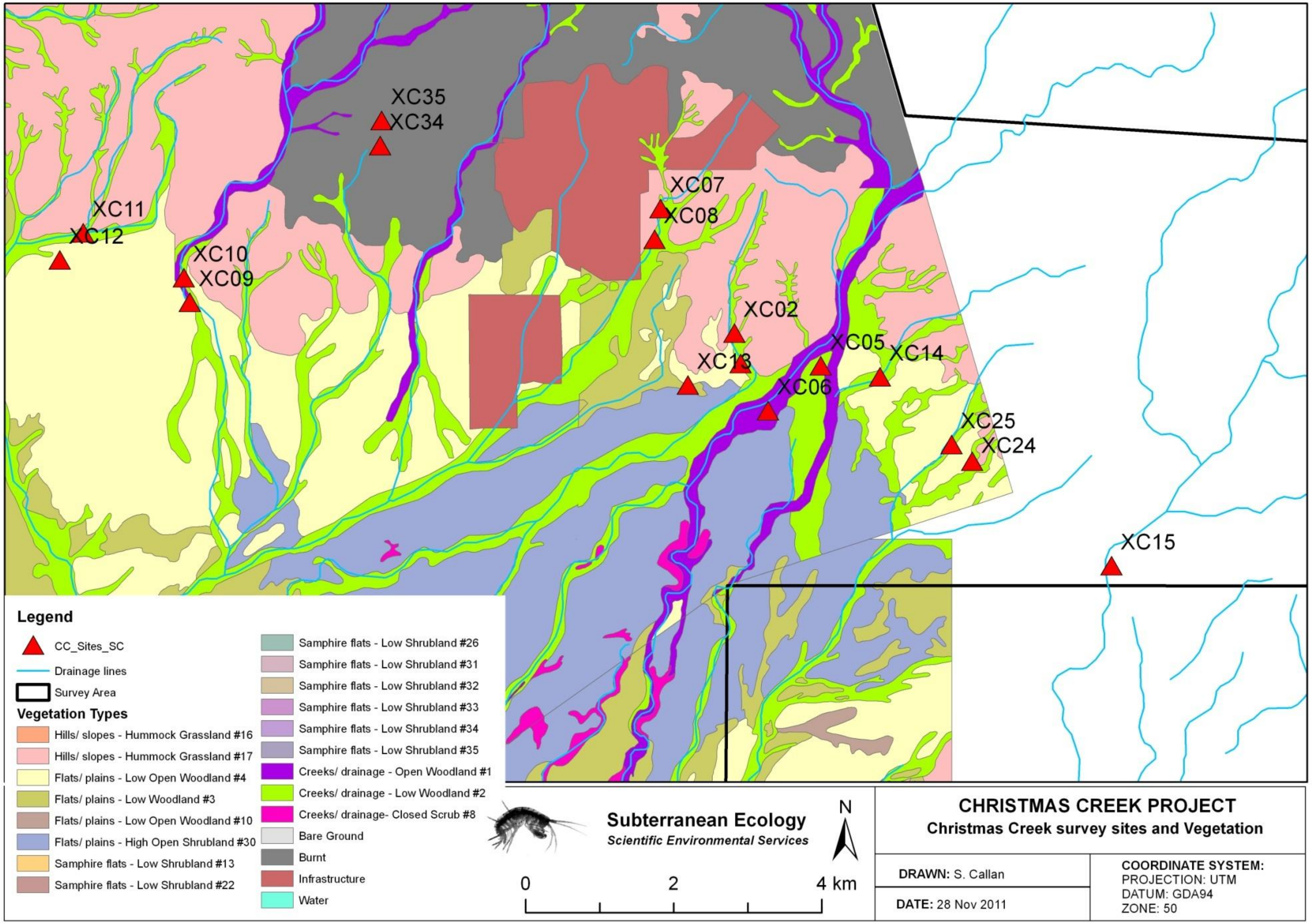
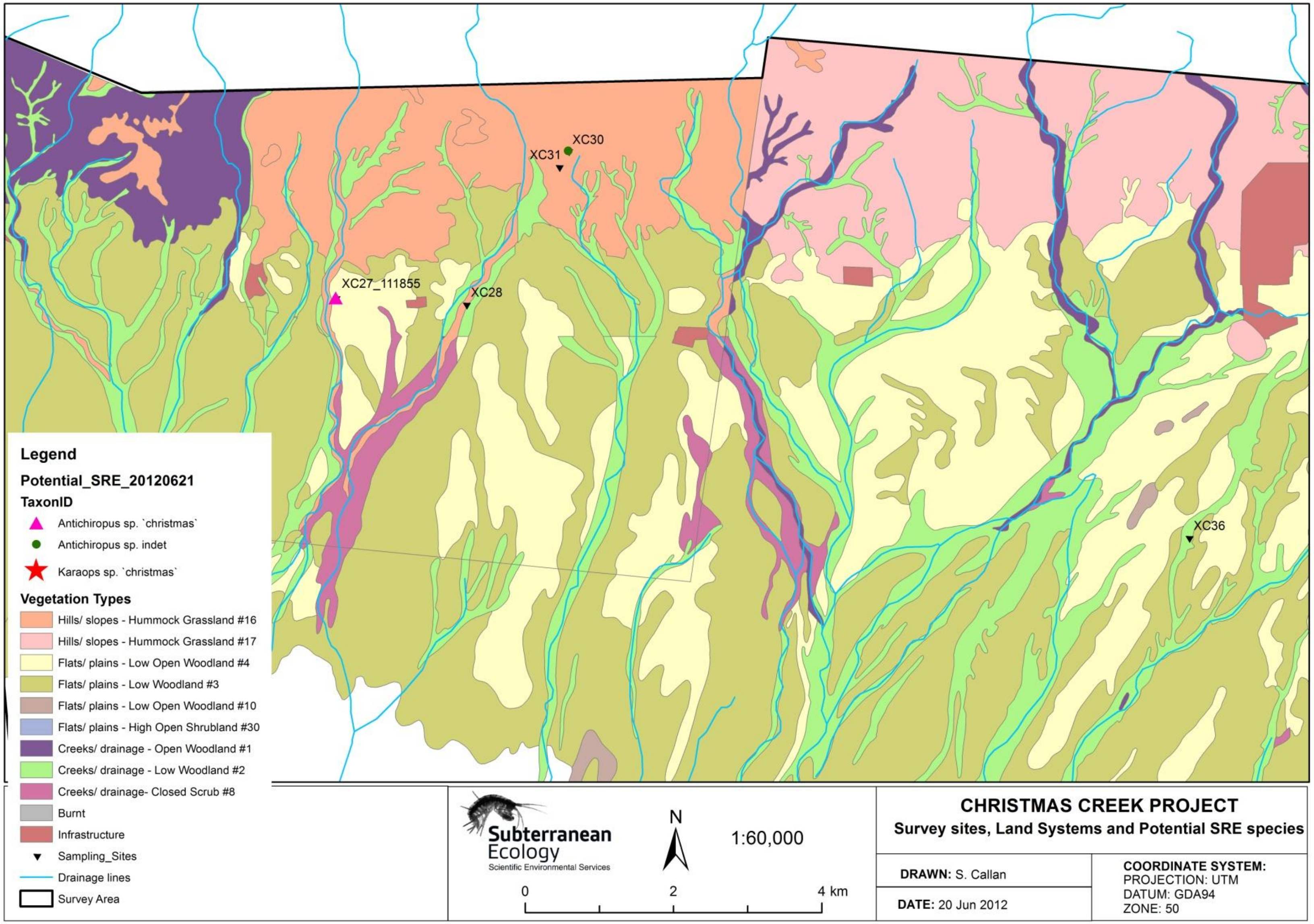
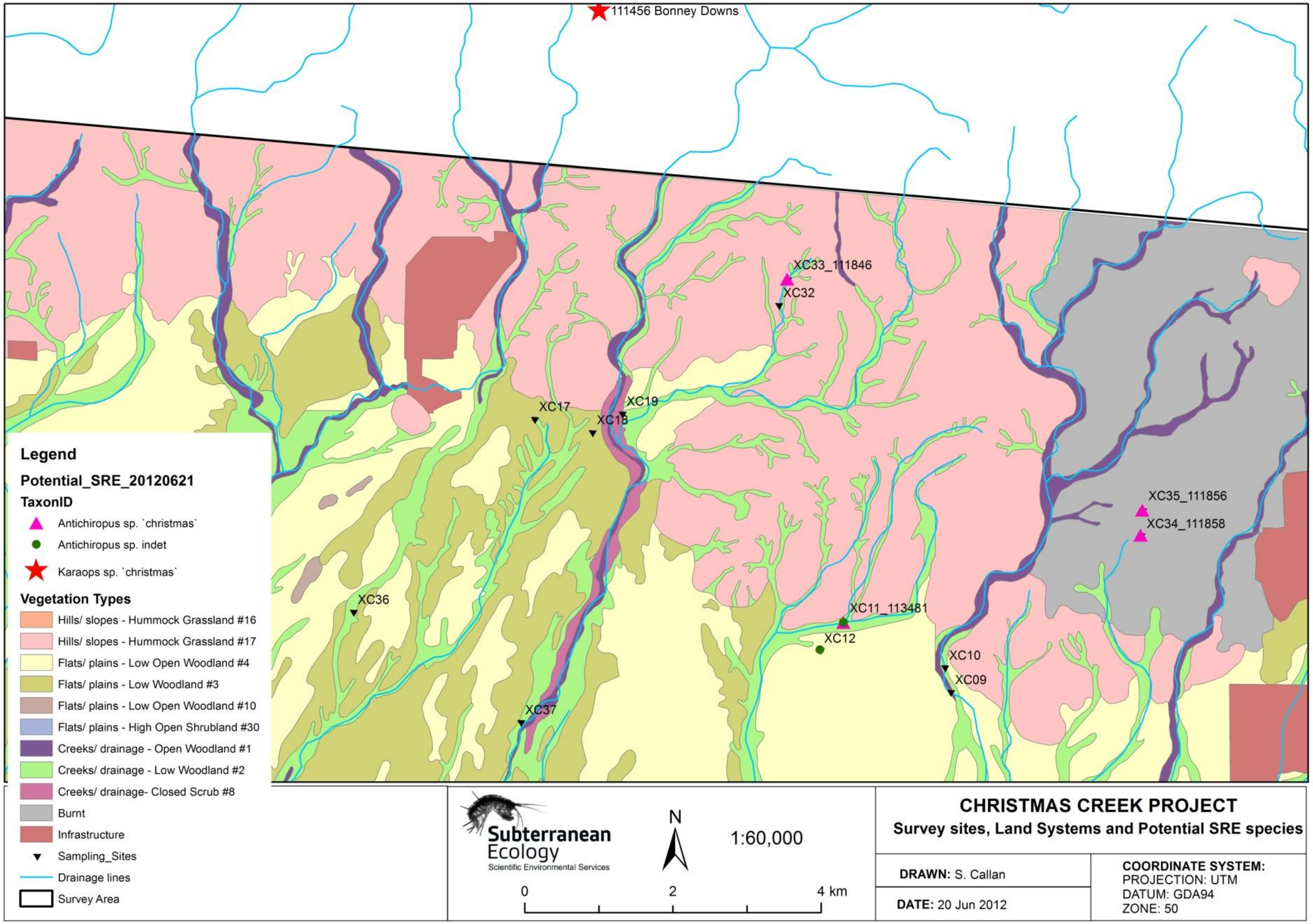


Vegetation (ENV 2010) inset #3

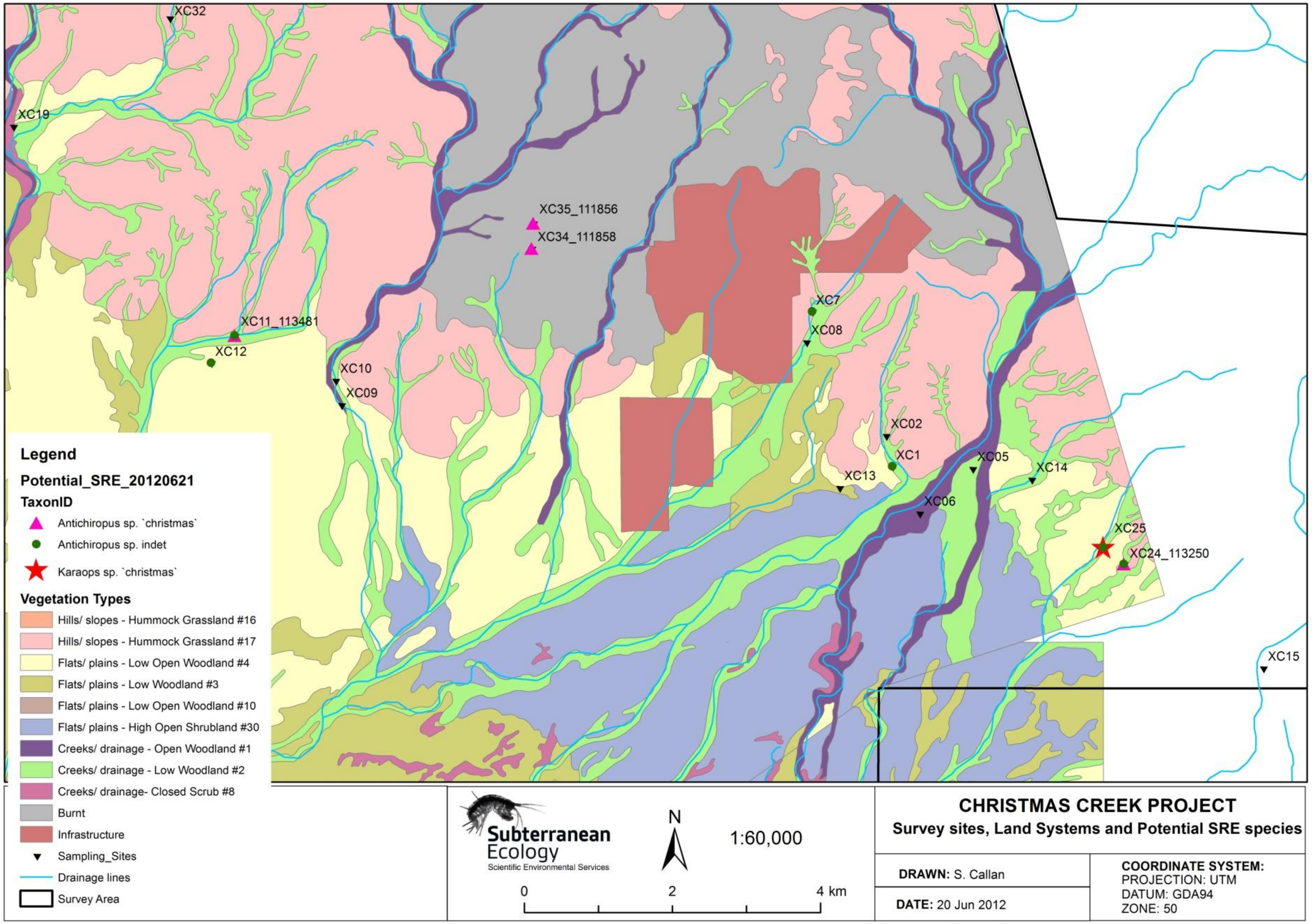
Appendix 9: Likely SRE and potential SRE species map (insets)



Likely and potential SRE species map inset #1



Likely and potential SRE species map inset #2



Likely and potential SRE species map inset #3

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