

Peterswald Map Sheet Terrestrial Vertebrate Fauna Survey – Great Victoria Desert Western Australia



26 August - 9 September 2014

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Abstract

Systematic sampling was undertaken over two weeks in August and September 2014 at 15 sites across differing habitats within the Peterswald map sheet area of the Great Victoria Desert. Sampling methods included pitfall and Elliott trapping as well as active searching and opportunistic observations. Prior to this survey no vertebrate data existed in state or Commonwealth data repositories for this area, thus all species recorded are new records. However, most of these are widespread species within the arid interior of the state and would reasonably have been expected to occur within the survey area and from the types of habitats sampled.

We recorded 48 species of reptiles from eight families: 8 Agamidae, 1 Carphodactylidae, 5 Diplodactylidae, 4 Elapidae, 3 Gekkonidae, 3 Pygopodidae, 20 Scincidae and, 4 Varanidae. We recorded 18 species of mammal with 12 of these native and six introduced. The native species consisted of 3 Muridae, 5 Dasyuridae, 2 Macropodidae, *Notoryctes caurinus* (northern marsupial mole) and *Canis familiaris* (dingo). Introduced species were *Equus asinus* (donkey), *Bos taurus* (cattle), *Camelus dromedarius* (one-humped camel), *Mus musculus* (house mouse), *Felis catus* (cat) and *Vulpes vulpes* (red fox).

Only one of the species recorded is considered of conservation significance, *Notoryctes caurinus*, however nine species were either at the extent of their known distributions or were actual range extensions. We recorded 45 bird species across the 15 sampling sites and 57 species in total across the Peterswald map sheet.

A total of 385 individuals of mammals and reptiles were recorded through all sampling methods and 293 DNA samples were collected and catalogued. The number of voucher specimens collected and lodged with the Western Australian Museum (WAM) was 63 individuals comprising 46 species.

Introduction

Information on species occurrence is sparse for most of the desert regions of Western Australia and data that does exist has largely been collected opportunistically rather than as part of any coordinated survey. The Commonwealth have identified a number of 1:100,000 map sheets in Western Australia that are particularly data depauperate and provided funding to implement survey for the specific purpose of collecting species occurrence data, particularly for flora and vertebrates. This report completes the vertebrate survey component for the Peterswald Map Sheet.

The survey area was defined by the boundary of the Peterswald (3644) 1:100,000 topographic map sheet which is situated in the north west of the Central subregion of the Great Victoria Desert Bioregion (Thackway and Cresswell 1995). The centre of the survey area is approximately 100km northeast of Lake Wells Station and 250km northeast of the town of Laverton.

The geology for the area is identified in the Roberts 1:250,000 geological series map sheet and the associated explanatory notes (Jackson 1978). A detailed description of the area surveyed is given by Gibson *et al.* (2016) but broadly, it is dominated by sand plain and dune complexes with vegetation comprising mulga or marble gum and mallee over spinifex. There are extensive rocky areas including the breakaway systems of the Ernest Giles Range, along with mesas such as that of Peterswald Hill

and surrounds. On and around these, the vegetation is classified as mulga scrub (Beard 1974).

Access within the project area is restricted to two main tracks. The primary track runs from the edge of Lake Wells from the Blaxland Range-Lake Wells Road up through to the southwest corner of the project area and continues in a north easterly direction through the centre of the map sheet and beyond. Peterswald Hill is situated approximately central in the project area in close proximity to the main access track. At this point there is a junction with a second track heading southeast towards and through the Ernest Giles Range (Figure 1). These two tracks provide surprisingly good landscape coverage and habitat diversity for such a remote part of the state.

The survey was undertaken between the 25th August and 9th September 2014.

Methods

Site selection

Fifteen trapping sites were chosen to capture as much of the major landform and vegetation diversity as possible. Soils were generally either sand, sandy loams or shallow loams with varying degrees of calcrete, sandstone, sandstone gravel or quartzite exposed at the surface. Vegetation of the sandy sites was typically mulga, mallee or *Eucalyptus gongylocarpa* over hummock grasslands, while the shallower loams and exposed rock surfaces generally comprised of open acacia shrublands over *Eremophila* spp., *Senna* spp., and *Scaevola spinescens* with scattered grass and/or herbs. General descriptions of the vegetation (Gibson *et al.* 2016) at each trapping site, along with site photos are provided in Appendix 3 and 4. Sites were also selected to maximise geographical coverage (within the logistical constraints of ethical considerations for animal trapping). Coordinates for each of the trapping sites, along with site descriptions, are given in Table 1, and relative positions are shown in Figure 1.

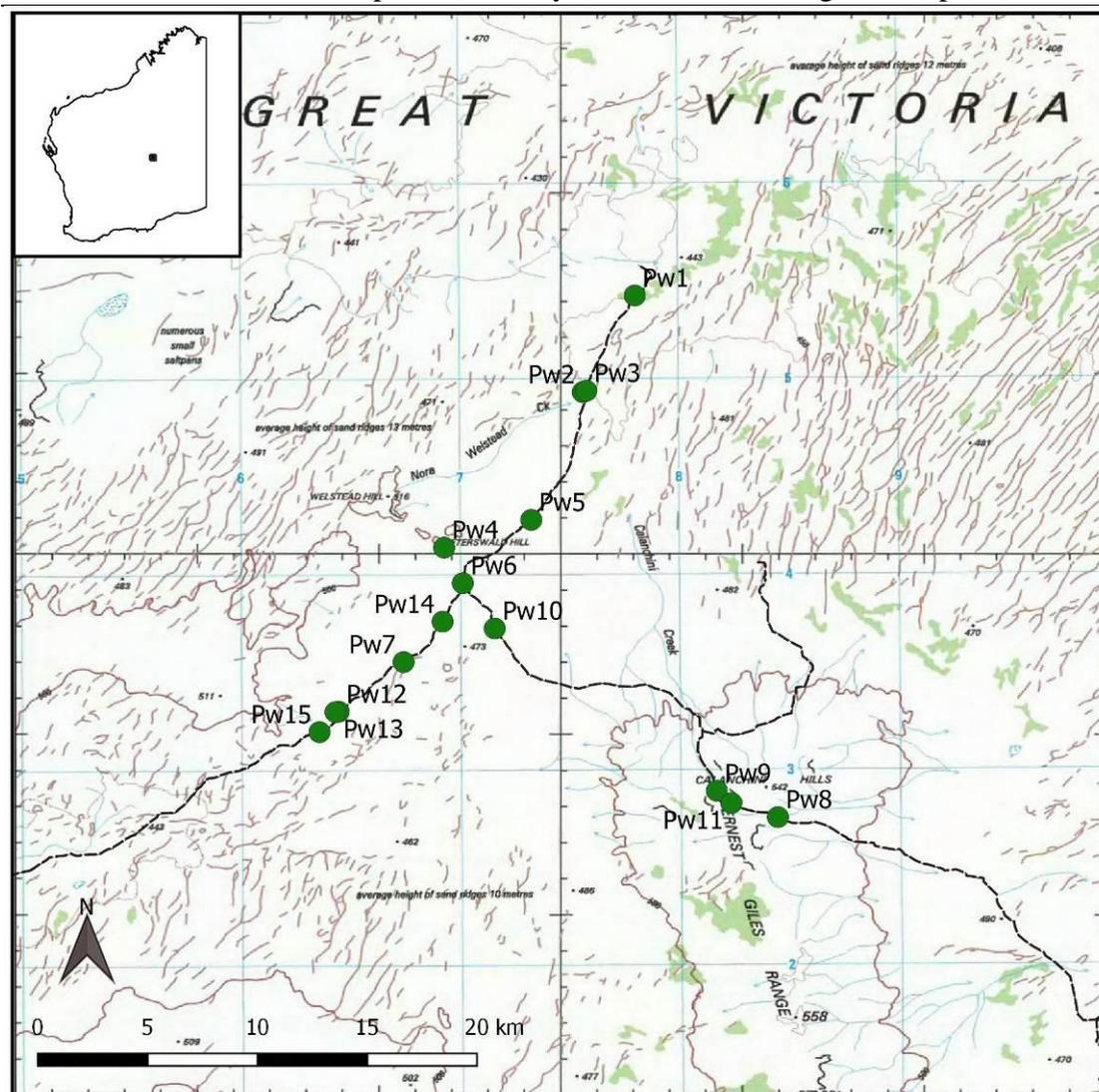


Figure 1: Topographic map (1:250000) of the survey area showing trapping locations (green dots) and vehicle tracks (dashed lines).

<i>site</i>	<i>Latitude</i>	<i>Longitude</i>	<i>Datum</i>	<i>Description</i>
Pw1	-26.6305	123.7840	WGS84	Flat plain, shallow red loam
Pw2	-26.6752	123.7602	WGS84	Dune, deep red sand
Pw3	-26.6745	123.7618	WGS84	Sandplain below dune, deep red sand
Pw4	-26.7471	123.6966	WGS84	Upper scree slope, shallow pink-grey sandy loam
Pw5	-26.7342	123.7366	WGS84	Flat plain, deep red sand, previously burnt
Pw6	-26.7635	123.7052	WGS84	Flat stony plain, shallow pale orange sandy loam with sandstone and calcrete on surface
Pw7	-26.8000	123.6781	WGS84	Dune crest, deep red sand
Pw8	-26.8716	123.8497	WGS84	Flat on creek, shallow pale orange loam, quartzite on surface
Pw9	-26.8594	123.8217	WGS84	Flat plain, shallow pale orange loam with calcrete at depth
Pw10	-26.7844	123.7198	WGS84	Flat plain, shallow loam

<i>site</i>	<i>Latitude</i>	<i>Longitude</i>	<i>Datum</i>	<i>Description</i>
Pw11	-26.8652	123.8284	WGS84	Scree slope below breakaway, skeletal pale brown sandy loam with sandstone gravel and cobbles
Pw12	-26.8229	123.6483	WGS84	Dune crest, deep red sand
Pw13	-26.8231	123.6468	WGS84	Sand plain between dunes, deep red sand
Pw14	-26.7813	123.6959	WGS84	Flat partially burnt plain, red sandy loam with scattered pisoliths
Pw15	-26.8323	123.6395	WGS84	Flat plain, shallow red sandy loam

Table 1: Trapping site coordinates and site description (descriptions from Gibson *et al.* 2016)

Sampling methods

Sampling sites were split into two groups due to the amount of time required to travel between sites and to check traps, with sites Pw1 to Pw8 run in the first week of the survey and sites Pw9 to Pw15 run in the second week.

Trapping methods consisted of six equidistant 20L buckets buried flush to the ground below a 30 cm high and 60 m long flywire drift fence at each site except Pw11 (Image 1). The topographic position and rock substrate at site Pw11 made installation of pits impractical so trapping at Pw11 comprised of six pairs of funnel traps evenly spaced along a 60 m fence. At all other sites, three pairs of funnel traps were positioned along the flywire fence equidistant between pit traps. A schematic of the standard trap layout is provided in Figure 2. Each site was surveyed for six days/nights. At least two Reconyx HC600 infrared camera traps were placed at each of the trapping locations. Fifteen aluminium box traps (Elliott traps) baited with universal bait (peanut butter and oats) and spaced at 10-15 m intervals were also used at each of the 15 trapping sites. These were set in a line at least 50 m away from pitfalls.



Image 1. Bucket below flywire drift fence

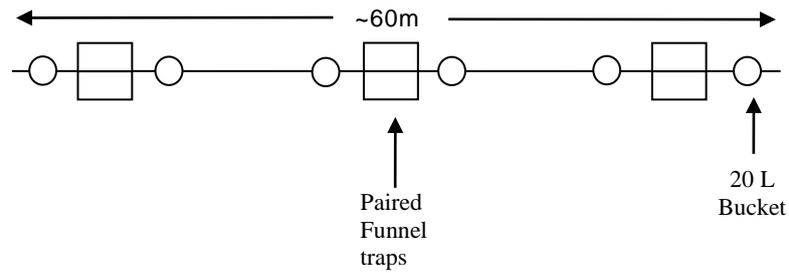


Figure 2: Schematic of trap configuration.

Pit traps contained a layer of soil and cover for captured animals in the form of a polystyrene tray. Funnel traps were covered with vegetation to minimise exposure to heat (Image 2). Elliott traps were positioned to make use of natural shade either under shrubs and bushes or positioned within hummock grasses. All traps were checked and cleared within three hours of sunrise as per the conditions set by the Department's Animal Ethics Committee.



Image 2. Funnel traps.

Opportunistic sampling was undertaken by observation and searches at all sites, as well as at a number of other locations throughout the study area. Tracks were driven early in the evening on several occasions in an attempt to detect nocturnal species such as geckoes and owls.

The most reliable way of detecting the presence of *Notoryctes* spp. (either Northern or Southern marsupial moles) is through the construction of 'mole trenches' (Benshemesh 2005 and 2014). This requires a narrow trench excavated in sand, usually on dunes, with a north facing wall. As the sand dries on the wall the old backfilled burrows created by *Notoryctes* spp. become apparent as can be seen in Image 3.

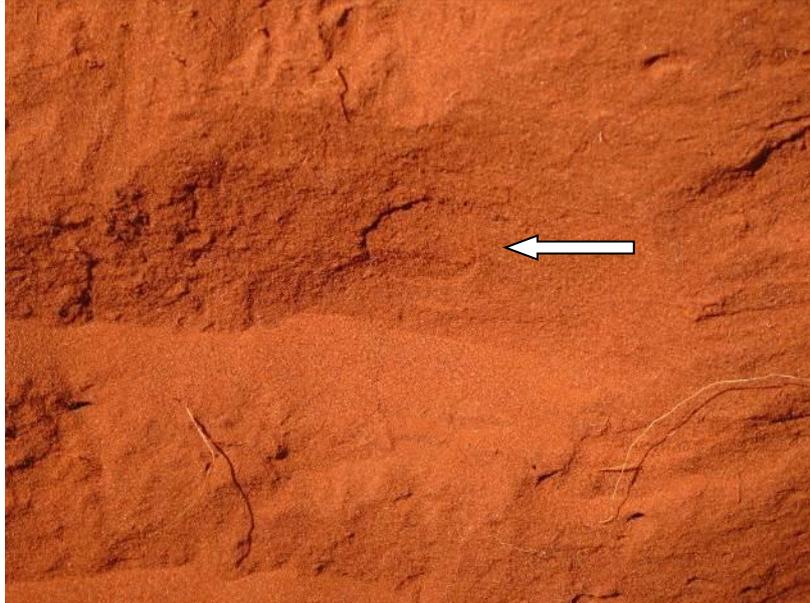


Image 3. Arrow highlighting backfilled *Notoryctes spp.* burrow visible in the wall of a ‘mole trench’.

Evidence of the presence of a number of species, particularly the larger introduced mammals was often through secondary sign such as scats or tracks. Observations were also made of the remains of *Leporillus spp.* (stick-nest rat) nests in several breakaways and at Peterswald Hill (Image 4.) Both species, *L. conditor* and *L. apicalis*, are now considered extinct on the Australian mainland but had relatively recent distributions covering the survey area. It is not possible to reliably distinguish the nests between these species (Copley 1999).



Figure 4. Remains of *Leporillus spp.* (stick-nest rat) in shallow cave at Peterswald Hill.

It was recognised that the level of effort at any individual site would not provide comprehensive species data; rather the purpose of this program was to undertake a rapid assessment of species’ at a landscape scale in an area identified for its lack of data. As a result, collection methods focused around as much geographic coverage

and habitat variation as possible within the constraints and limitations to both access and time.

The presence of bird species was recorded within unbounded quadrats of approximately four hectares centred on the trap lines at each of the 15 sampling sites. Each site was visited on at least three different days, at different times of day, with each site receiving an early morning visit (<2 hours from sunrise, most within <1 hour of sunrise). Opportunistic observations were made at other sites and whilst travelling. Birds were detected aurally and visually, with most aural detections confirmed by sight. Where appropriate, digital field guides (Morcombe 2011; Pizzey and Knight 2014) were consulted to check identifications in the field.

Identification of collections

Captured animals were identified in the field, or at camp for more difficult species, and then released at point of capture (unless required as representative voucher specimens for lodgement with the WAM).

A number of field guides were used for identification of animals (Cogger 2014; Menkhorst and Knight 2004; Storr *et al.* 1983; Storr *et al.* 1990; Storr *et al.* 1999; Storr *et al.* 2002; Van Dyck *et al.* 2008; Wilson and Swan 2008). Due to continual taxonomic revision and the description of new taxa, we also referred to a number of additional publications including Doughty and Hutchinson (2008), Doughty *et al.* (2012), Hutchinson *et al.* (2009) and Mecke *et al.* (2013).

The collections database of the WAM, the Atlas of Living Australia and NatureMap were accessed to identify the extent of previous collections in the area and the number of voucher and tissue samples within collections.

We collected basic morphological information for all captures including sex, mass, snout-vent length, and tail length along with pes and cranium lengths for mammals.

Tissue samples were taken from most captured animals. These consisted of a small portion of liver for vouchered animals and either an ear punch for live mammals or a tail tip for live reptiles. These samples were labelled and preserved in individual vials containing 100% ethanol in preparation for storage and future molecular analysis.

Voucher specimens were humanely euthanized under Department of Parks and Wildlife (DPaW) Animal Ethics Approval (no 2013/11) and processed according to normal preservation protocols for museum specimens. All specimens had a unique six-digit field number label attached via linen thread. Specimens were re-examined in Perth to confirm field identifications.

Results and Discussion

Temperatures during the survey period were cool nights and warm days (Figure 3). While the survey timing and prevailing conditions were generally adequate to promote activity in diurnal species, nocturnal and crepuscular activity remained low. As a result, the geckos in particular may have been under sampled.

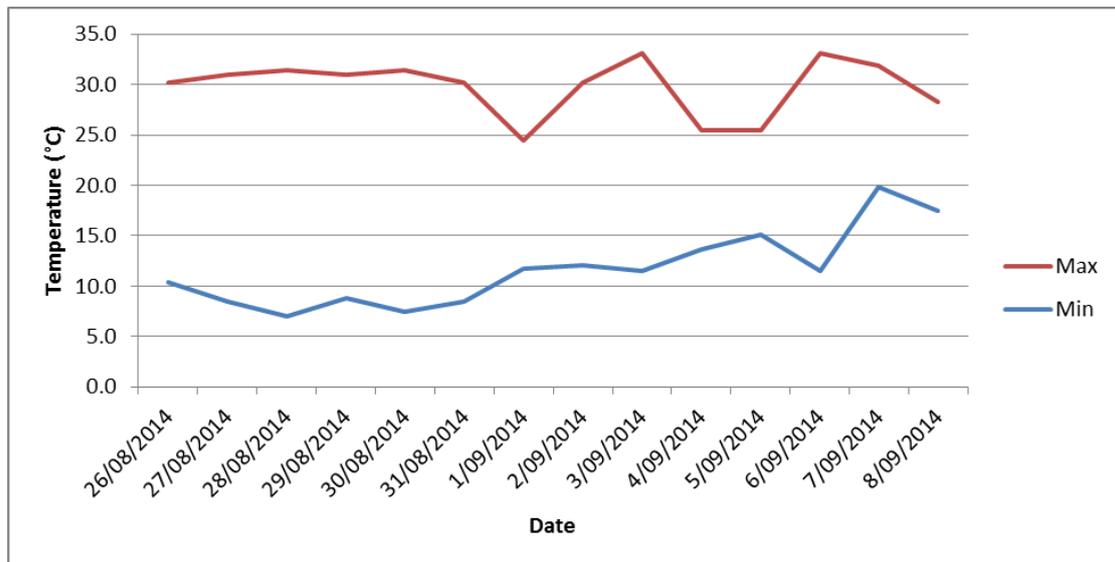


Figure 3. Daily minimum and maximum temperatures throughout the survey period.

Reptiles and mammals

Daily capture rates for species and individuals are shown in Figure 4.

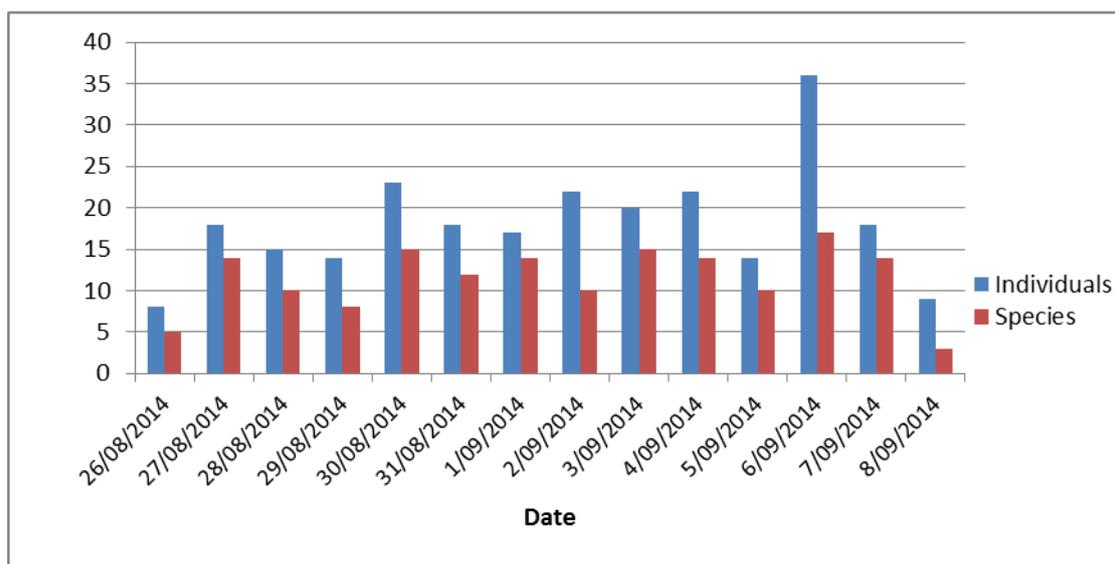


Figure 4. Daily capture rates of species (red) and individuals (blue) from all traps and trapping sites.

Prior to this survey there were no documented records of any terrestrial vertebrate fauna within the actual project area. There were however records of 32 species of reptile and five species of mammal from within 50km radius of the boundary of the project area (Western Australian Museum 2014), all of which could reasonably be expected to be present within the project area. Appendix 1A provides a list of previously known species from the surrounding area along with those identified during this survey. Appendix 2A provides a list of species recorded at each site during this survey. Of the 32 species previously known from museum records there were 14 that we did not detect during this survey although we added another 30 reptile species and seven native mammal species to this list.

Species accumulation analysis of the trapping data, which accounted for 43 of the vertebrates we recorded, indicates that we would have continued to detect new species with additional effort (Figure 5). The Jackknife1 estimator, considered a relatively robust species accumulation measure (Magurán 2005), predicted at least 49 species. We can infer that our trapping could have resulted in as much 87% of trappable species being detected. However, 49 species would still appear low when compared against more detailed survey work using similar methods in other Western Australian arid environments (e.g. Cowan and How 2004, Cowan *et al.* 2017, Thompson *et al.* 2003) and taking into consideration species known from the surrounding area. This likely underestimation of species richness probably occurs as a result of using single season data under climatically mild conditions to construct species accumulation curves and predictors. Warmer months invariably result in increased activity and concomitant detection for reptiles in particular and this would have a direct influence on the shape of species accumulation curves and species richness predictors derived from this data.

Of the species that were recorded, all were typical of the Great Victoria Desert and the types of habitats we sampled. The sites with sandy substrates were the most speciose and had the highest captures of individuals, and this is also typical for Australian arid environments (Pianka 1984). The heavier soil and rocky sites contributed few species that were not recorded on sandy sites and these were the reptiles *Varanus giganteus*, *Gehyra variegata*, *Diplodactylus granariensis*, *Ctenopus uber*, *Ctenophorus caudicinctus*, *Ctenophorus scutulatus* and *Ctenophorus reticulatus* and the mammals *Sminthopsis macroura*, *Pseudantechinus woolleyae* and *Mus musculus*. There were 34 species however that were only detected in habitats with a sandy substrate (Appendix 2A).

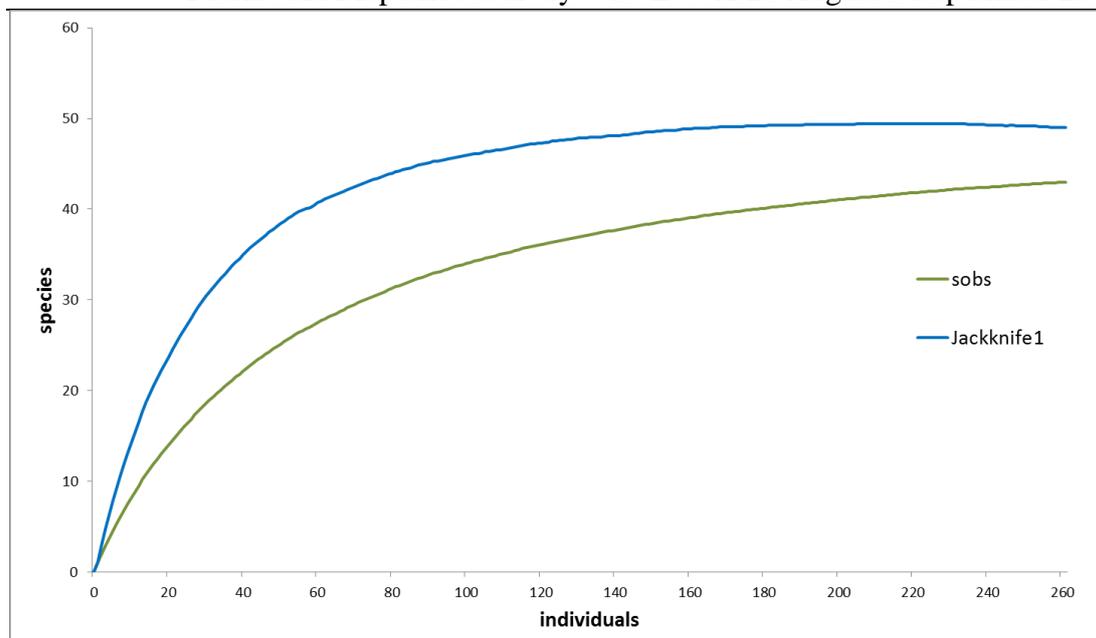


Figure 5. Accumulation data for trapping data from across all 15 survey sites. Species observed (sobs) was 43 while the Jackknife 1 estimator was 49.

Birds

Appendix 1B provides a list of the 91 previously known species from the surrounding area along with the 57 species identified across the Peterswald map sheet during the present survey. Of the species that were recorded, all were typical of the Great Victoria Desert and the types of habitats we sampled.

We recorded 45 bird species across the 15 sampling sites, with a mean of 9.3 species (± 3.8 SD) and a range of 3-14 per sample site (Appendix 2B). Sites with the most species (Pw1, Pw3, Pw6 and Pw10) were woodland sites (open woodlands of mallees or *Acacia*, or mixed mallee and *Acacia*), mostly on loamy soils. Understorey layers of these sites included shrubs and/or *Triodia* hummock grasslands (Appendix 3). This is broadly consistent with findings elsewhere in Australian desert areas (e.g. Burbidge et al. 2010; Bell et al. 2015).

Although there has been some bird survey in the Great Victoria Desert for environmental impact assessments, there are few published studies with which we can compare our site data. Pianka and Pianka (1970), working at five sites about 100 km south of our study area, found species richness to vary from 15-36, but their sites were considerably larger than ours (unspecified, but apparently of the order of 2 km²) and sampled over multiple years and seasons. Burbidge and Fuller (2007) found species richness values in the Gibson Desert varying from <10 to about 35, but their sites were also much larger than ours (1 km²). In a somewhat similar survey in the Katjarra area north of Wiluna in the Gascoyne/Little Sandy Desert bioregions, but with more effort and a greater variety of habitats, Burbidge and Blythman (2015) reported an average species richness of 12.0 \pm 5.7 SD, with a range of 1-24, from 20 sampling sites. In the Gascoyne-Murchison regions, average species richness is about 19, but this includes riparian woodland sites (absent from the Peterswald area), which are likely to have an average species richness of about 25 (Bell et al. 2015).

With more sampling, we may have recorded some of the 34 species recorded in the surrounding area but not on the Peterswald map sheet. However, a substantial portion of those species are waterbirds, and there is little, if any, suitable habitat for those

species in our study area. In addition, our study area did not include eucalypt woodlands on drainage lines, which may have attracted species such as southern boobook, striated pardalote and white-plumed honeyeater. On the other hand, we recorded 10 species not known from the surrounding area. Given that these included some rare or difficult to detect species (grey honeyeater, rufous-crowned emu-wren), and we missed few widespread species that might be expected to occur at the time, our sampling is likely to have produced a reasonable listing of the bird fauna of the map sheet.

New records of taxa

As no vertebrate survey had occurred in the project area and there were no vertebrate records within the WAM database, Nature Map or Australia's Living Atlas, all species recorded are new records for the area. However as previously identified earlier in the report most of the recorded species have geographical distributions that span across the project area and could have reasonably been expected to occur. The exceptions to this are the species listed in Table 3 below for which their occurrence is either a range extension or considered to be at the edge of their known ranges.

Taxon	Comment
<i>Ctenophorus scutulatus</i>	North eastern extent
<i>Diporiphora amphiboluroides</i>	North eastern extent
<i>Diporiphora paraconvergens</i>	Close to south western extent
<i>Pseudantechinus woolleyae</i>	Eastern extent
<i>Diplodactylus granariensis</i>	Extended from known north east range
<i>Demansia psammophis</i>	Northern Edge of eastern distribution
<i>Ctenopus uber</i>	Eastern extent
<i>Morethia butleri</i>	North eastern extent
<i>Varanus gilleni</i>	South western extent

Table 3. List of species that represent range extensions or occurrence at the edge of their known ranges.

Photographs for each of these species and a map of point records from the Western Australian Museum database is presented in Appendix 5.

In addition, two bird species have been only rarely recorded, if at all, in this region. The rufous-crowned emu-wren, *Stipiturus ruficeps*, has not previously been recorded within 160 km of our sighting, and it has not previously been recorded in the far western end of the Great Victoria Desert. The grey honeyeater, *Lacustroica whitei*, is near its southern limit, and there are no other confirmed records in the western end of the Great Victoria Desert.

Introduced species

The presence of at least six introduced and one naturalised (the dingo) species was recorded through direct observation, tracks, scats or remote cameras (Table 4). Of these, *Camelus dromedarius* (camel), *Canis familiaris* (dingo), *Felis catus* (cat) and *Mus musculus* (mouse) are ubiquitous within semiarid and arid environments of

Western Australia. The remaining species tend to be associated with particular habitat elements or prevailing environmental conditions such as granite hills and lake systems for *Equus asinus* (donkey), or during summer months in the presence of readily available free-standing water for *Vulpes vulpes* (red fox) and *Bos taurus* (cattle). The presence of these species is likely to have some level of detrimental effect on a variety of native fauna, especially larger mammal species, either through direct predation or habitat degradation.

Pest species	Location sighted	Indication of abundance
<i>Equus asinus</i>	Sign of presence through tracks and dropping observed at numerous locations	Common
<i>Mus musculus</i>	Only recorded at site 9	Low
<i>Camelus dromedarius</i>	Observed at numerous locations	Common
<i>Canis familiaris</i>	Tracks frequently seen on sandy substrates	Low but widespread
<i>Vulpes vulpes</i>	Caught on three separate cameras	Low but widespread
<i>Felis catus</i>	Tracks at most sandy sites	Common
<i>Bos taurus</i>	Sign through scats and tracks	Relatively common

Table 4. Introduced species recorded over the duration of the survey.

Threatened or priority species

No terrestrial vertebrates listed as threatened under State or Commonwealth legislation were encountered during this survey. Two species listed as priority 4 under State legislation were detected (Table 5).

For *Notoryctes* spp. (marsupial mole) it is not possible to define which species, *N. caurinus* (northern marsupial mole) or *N. typhlops* (southern marsupial mole) is present as both have potentially overlapping distributions within the project area and observations were only made through secondary evidence in the form of burrows. There have been no records of *Dasyercus cristicauda* (crest-tailed mulgara) in Western Australia for more than six decades (Woolley 2005) and none from close proximity to the project area. While there is work currently underway assessing the genetics of *Dasyercus* records in WA, at the current time only *D. blythi* (brush-tailed mulgara) is thought to be extant in Western Australia. Subsequently the single image we had from a remote camera that appears to be *Dasyercus* is identified here as *D. blythi*.

Species	Location sighted	Indication of abundance
<i>Notoryctes</i> spp.	Dune complexes	Sign relatively common
<i>Dasyercus blythi</i>	Sand plain	A single probable detection on a camera

Table 5. Near-threatened species encountered within the Peterswald map sheet area.

General Comment on Species Lists

The number of documented species for each reptile family compares quite favourably

in comparison with the average for nine surveys spanning arid areas of Australia (Thomson *et al.* 2003). The following was recorded from the Peterswald map sheet while the figure in brackets is the average from survey at Redsands (Great Victoria Desert), Uluru, Ewaninga, Simpson Desert, L area (Great Victoria Desert), Roxby Downs, Tanami Desert (two sites) and Lake Eyre: Agamids 8 (5.5), Varanids 4 (3.5), Skinks 19 (17), Geckos 9 (8.5), Pygopods 4 (3.3), Elapids 4 (3.7), Blind snakes 0 (1.5) and Pythons 0 (0). While we observed no pythons, at least two species are likely to occur in the area, *Antaresia stimsoni* and *Aspidites ramsayi*, but these frequently go undetected during surveys because they have relatively low densities and a cryptic nature. Similarly, we did not record any blind snakes of which there would almost certainly be two species, *Anolios endoterus* and *A. waitii*, but as these spend most of their time under ground and are only on the surface in certain conditions, they also can easily go undetected. The terrestrial mammal fauna identified here is probably relatively complete other than possibly several additional dasyurids such as *Antechinomys laniger* (kultar), *Sminthopsis crassicaudata* (fat-tailed dunnart) and *S. ooldea* (Ooldea dunnart) as each of these have distributions that are thought to overlap the project area.

Bird surveys of similar areas are few but McKenzie and Burbidge (1979), with roughly similar effort, detected 46 species in the Lake Disappointment area, 58 in the Gibson Desert Nature Reserve, 66 in the Carnarvon Range and 75 in the Lake Yeo area (where there was more effort); these figures are not too different from our results (57 species from the Peterswald map sheet area). Bird species occurrence at a given site in the deserts is influenced by seasonal conditions at the site, as well as conditions elsewhere in the desert (Burbidge and Fuller 2007; Gosper 2011) and other species, such as black-eared cuckoo or spotted harrier, might be expected to occur in this area in different seasons.

Conclusion

Despite the relatively short duration of this survey and the timing being just towards the beginning of peak activity for reptiles we documented a high proportion of species that are likely to occur in the area. The number of reptile species recorded was 48 and for mammals it was 18, and this came from a total of 385 individual captures. Our total of 57 bird species would also be a high proportion of the species from the area. Despite this it is clear from the species accumulation data, and from recorded species from the surrounding areas, that additional sampling at the same and other locations, along with different seasonal timing, will invariably result in an increase in species. This will particularly be the case for blind snakes, pythons and dasyurids but there are a number of likely additions to all the terrestrial vertebrate families.

Overall this survey continues to demonstrate that the Great Victoria Desert remains as one of the most speciose arid environments for small terrestrial vertebrates and particularly reptiles (Pianka 1984).

Species that we detected that require further work to ascertain unequivocal identifications are for *Dasyercus blythi* as this was only recorded from a relatively low resolution and for *Notoryctes* spp. as this was only detected through secondary sign.

Continuation of these types of survey remain paramount in efforts to document, record and conserve the diverse array of species within Western Australia as most of the semi-arid and arid regions of the state, along with the Kimberley, remain unsurveyed (How and Cowan 2006).

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Appendices

Appendix 1. List of vertebrate fauna known from surrounding area and recorded during survey.

A. Reptiles and mammals

Family	Scientific Name	Species known from within 50km of map boundaries	Species recorded from this survey
Agamidae	<i>Ctenophorus caudicinctus</i>		+
Agamidae	<i>Ctenophorus isolepis</i>		+
Agamidae	<i>Ctenophorus nuchalis</i>	+	+
Agamidae	<i>Ctenophorus reticulatus</i>	+	+
Agamidae	<i>Ctenophorus salinarum</i>	+	
Agamidae	<i>Ctenophorus scutulatus</i>	+	+
Agamidae	<i>Diporiphora amphiboluroides</i>		+
Agamidae	<i>Diporiphora paraconvergens</i>		+
Agamidae	<i>Moloch horridus</i>	+	
Agamidae	<i>Pogona minor</i>		+
Agamidae	<i>Tympanocryptis pseudopsephos</i>	+	
Carphodactylidae	<i>Nephrurus laevisissimus</i>		+
Carphodactylidae	<i>Underwoodisaurus milii</i>	+	
Diplodactylidae	<i>Diplodactylus conspicillatus</i>	+	+
Diplodactylidae	<i>Diplodactylus granariensis</i>		+
Diplodactylidae	<i>Lucasium stenodactylum</i>	+	
Diplodactylidae	<i>Rhynchoedura ornata</i>	+	+
Diplodactylidae	<i>Strophurus ciliaris</i>	+	
Diplodactylidae	<i>Strophurus elderi</i>		+
Diplodactylidae	<i>Strophurus strophurus</i>		+
Elapidae	<i>Brachyuropsis semifasciatus</i>	+	
Elapidae	<i>Demansia psammophis</i>		+
Elapidae	<i>Parasuta monachus</i>		+
Elapidae	<i>Pseudechis australis</i>		+
Elapidae	<i>Pseudonaja modesta</i>		+
Elapidae	<i>Simoselaps anomalus</i>	+	
Gekkonidae	<i>Gehyra purpurascens</i>	+	+
Gekkonidae	<i>Gehyra variegata</i>	+	+
Gekkonidae	<i>Heteronotia binoei</i>	+	+
Pygopodidae	<i>Delma butleri</i>		+
Pygopodidae	<i>Delma nasuta</i>		+
Pygopodidae	<i>Lialis burtonis</i>	+	+
Pygopodidae	<i>Pygopus nigriceps</i>		+
Scincidae	<i>Cryptoblepharus buchananii</i>	+	
Scincidae	<i>Ctenotus brooksi</i>		+
Scincidae	<i>Ctenotus calurus</i>		+
Scincidae	<i>Ctenotus dux</i>	+	+
Scincidae	<i>Ctenotus grandis</i>		+
Scincidae	<i>Ctenotus helenae</i>	+	+
Scincidae	<i>Ctenotus leonhardii</i>		+
Scincidae	<i>Ctenotus pantherinus</i>	+	+
Scincidae	<i>Ctenotus piankai</i>		+
Scincidae	<i>Ctenotus quattuordecimlineatus</i>	+	+
Scincidae	<i>Ctenotus schomburgkii</i>		+
Scincidae	<i>Ctenotus uber</i>		+
Scincidae	<i>Cyclodomorphus melanops</i>	+	+
Scincidae	<i>Eremiascincus pallidus</i>	+	
Scincidae	<i>Eremiascincus richardsonii</i>	+	
Scincidae	<i>Lerista bipes</i>	+	+
Scincidae	<i>Lerista desertorum</i>	+	+
Scincidae	<i>Lerista timida</i>	+	+
Scincidae	<i>Liopholis inornata</i>	+	+
Scincidae	<i>Liopholis striata</i>	+	
Scincidae	<i>Menetia greyii</i>		+
Scincidae	<i>Morethia butleri</i>		+
Scincidae	<i>Tiliqua multifasciata</i>		+

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Family	Scientific Name	Species known from within 50km of map boundaries	Species recorded from this survey
Typhlopidae	<i>Anilius endoterus</i>	+	
Typhlopidae	<i>Anilius margaretae</i>	+	
Varanidae	<i>Varanus eremius</i>		+
Varanidae	<i>Varanus giganteus</i>		+
Varanidae	<i>Varanus gilleni</i>		+
Varanidae	<i>Varanus tristis</i>		+
Bovidae	<i>Bos taurus</i>		+
Camelidae	<i>Camelus dromedarius</i>		+
Canidae	<i>Canis familiaris</i>		+
Canidae	<i>Vulpes vulpes</i>	+	+
Felidae	<i>Felis catus</i>		+
Dasyuridae	<i>Dasyercus blythi</i>		+*
Dasyuridae	<i>Ningai ridei</i>		+
Dasyuridae	<i>Pseudantechinus woolleyae</i>		+
Dasyuridae	<i>Sminthopsis hirtipes</i>		+
Dasyuridae	<i>Sminthopsis macroura</i>		+
Equidae	<i>Equus asinus</i>		+
Macropodidae	<i>Macropus robustus</i>	+	+
Macropodidae	<i>Macropus rufus</i>	+	+
Muridae	<i>Mus musculus</i>		+
Muridae	<i>Notomys alexis</i>	+	+
Muridae	<i>Pseudomys desertor</i>		+
Muridae	<i>Pseudomys hermannsburgensis</i>	+	+
Notoryctidae	<i>Notoryctes caurinus</i>		+*
# of mammals	18(6)	5 (1)	18(6)
# of reptiles	62	32	48

* Occurrence probable but inferred from secondary means such as camera traps and mole trenches
() refer to numbers of introduced species

B. Birds

Family	Scientific Name	Common name	Species known from within 50km of map boundaries	Species recorded from this survey
Dromaiidae	<i>Dromaius novaehollandiae</i>	Emu	+	+
Anatidae	<i>Cygnus atratus</i>	Black Swan	+	
Anatidae	<i>Tadorna tadornoides</i>	Australian Shelduck	+	
Anatidae	<i>Malacorhynchus membranaceus</i>	Pink-eared Duck	+	
Anatidae	<i>Chenonetta jubata</i>	Australian Wood Duck	+	
Anatidae	<i>Anas rhynchotis</i>	Australasian Shoveler	+	
Anatidae	<i>Anas gracilis</i>	Grey Teal	+	
Anatidae	<i>Aythya australis</i>	Hardhead	+	
Megapodiidae	<i>Leipoa ocellata</i>	Malleefowl	+	
Podicipedidae	<i>Tachybaptus novaehollandiae</i>	Australasian Grebe	+	
Podicipedidae	<i>Poliocephalus poliocephalus</i>	Hoary-headed Grebe	+	
Ardeidae	<i>Ardea pacifica</i>	White-necked Heron	+	
Ardeidae	<i>Ardea novaehollandiae</i>	White-faced Heron	+	
Accipitridae	<i>Elanus caeruleus</i>	Black-shouldered Kite	+	
Accipitridae	<i>Aquila audax</i>	Wedge-tailed Eagle	+	+
Accipitridae	<i>Accipiter fasciatus</i>	Brown Goshawk	+	
Accipitridae	<i>Circus assimilis</i>	Spotted Harrier	+	
Otididae	<i>Ardeotis australis</i>	Australian Bustard	+	+
Rallidae	<i>Tribonyx ventralis</i>	Black-tailed Native-hen	+	
Turnicidae	<i>Turnix velox</i>	Little Button-quail	+	+
Recurvirostridae	<i>Himantopus himantopus</i>	Black-winged Stilt	+	
Recurvirostridae	<i>Cladorhynchus leucocephalus</i>	Banded Stilt	+	
Recurvirostridae	<i>Recurvirostra novaehollandiae</i>	Red-necked Avocet	+	
Charadriidae	<i>Vanellus tricolor</i>	Banded Lapwing	+	

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Charadriidae	<i>Elseyornis melanops</i>	Black-fronted Dotterel	+	
Laridae	<i>Sterna nilotica</i>	Gull-billed Tern	+	
Laridae	<i>Sterna hybrida</i>	Whiskered Tern	+	
Columbidae	<i>Ocyphaps lophotes</i>	Crested Pigeon	+	+
Cuculidae	<i>Chrysococcyx basalix</i>	Horsfield's Bronze Cuckoo		+
Cuculidae	<i>Chrysococcyx osculans</i>	Black-eared Cuckoo	+	
Cuculidae	<i>Cacomantis pallidus</i>	Pallid Cuckoo	+	
Strigidae	<i>Ninox boobook boobook</i>	Southern Boobook	+	
Podargidae	<i>Podargus strigoides</i>	Tawny Frogmouth		+
Caprimulgidae	<i>Eurostopodus argus</i>	Spotted Nightjar		+
Alcedinidae	<i>Todiramphus pyrrhopygius</i>	Red-backed Kingfisher		+
Falconidae	<i>Falco cenchroides</i>	Nankeen Kestrel	+	+
Falconidae	<i>Falco longipennis</i>	Australian Hobby	+	
Falconidae	<i>Falco berigora</i>	Brown Falcon	+	+
Cacatuidae	<i>Cacatua roseicapilla</i>	Galah	+	+
Cacatuidae	<i>Nymphicus hollandicus</i>	Cockatiel	+	+
Psittacidae	<i>Platycercus zonarius</i>	Australian Ringneck	+	+
Psittacidae	<i>Platycercus varius</i>	Mulga Parrot	+	+
Psittacidae	<i>Neophema bourkii</i>	Bourke's Parrot	+	+
Psittacidae	<i>Melopsittacus undulatus</i>	Budgerigar	+	+
Ptilonorhynchidae	<i>Ptilonorhynchus maculatus</i>	Western Bowerbird		+
Maluridae	<i>Malurus lamberti</i>	Variagated Fairy-wren	+	+
Maluridae	<i>Malurus splendens</i>	Splendid Fairy-wren		+
Maluridae	<i>Malurus leucopterus</i>	White-winged Fairy-wren	+	+
Maluridae	<i>Stipiturus ruficeps</i>	Rufous-crowned Emu-wren		+
Meliphagidae	<i>Sugomel niger</i>	Black Honeyeater	+	+
Meliphagidae	<i>Certhionyx variegatus</i>	Pied Honeyeater	+	
Meliphagidae	<i>Epthianura tricolor</i>	Crimson Chat	+	+
Meliphagidae	<i>Lacustroica whitei</i>	Grey Honeyeater		+
Meliphagidae	<i>Acanthagenys rufogularis</i>	Spiny-cheeked Honeyeater	+	+
Meliphagidae	<i>Anthochaera carunculata</i>	Red Wattlebird	+	
Meliphagidae	<i>Manorina flavigula</i>	Yellow-throated Miner	+	+
Meliphagidae	<i>Pumella albifrons</i>	White-fronted Honeyeater	+	+
Meliphagidae	<i>Gavicalis virescens</i>	Singing Honeyeater	+	+
Meliphagidae	<i>Ptilotula plumula</i>	Grey-fronted Honeyeater	+	+
Meliphagidae	<i>Ptilotula penicillata</i>	White-plumed Honeyeater	+	
Pardalotidae	<i>Pardalotus rubricatus</i>	Red-browed Pardalote	+	
Pardalotidae	<i>Pardalotus striatus</i>	Striated Pardalote	+	
Acanthizidae	<i>Pyrrholaemus brunneus</i>	Redthroat	+	+
Acanthizidae	<i>Smicromis brevirostris</i>	Weebill	+	+
Acanthizidae	<i>Gerygone fusca</i>	Western Gerygone	+	+
Acanthizidae	<i>Acanthiza apicalis</i>	Inland Thornbill	+	+
Acanthizidae	<i>Acanthiza uropygialis</i>	Chestnut-rumped Thornbill	+	+
Acanthizidae	<i>Acanthiza robustirostris</i>	Slaty-backed Thornbill	+	+
Acanthizidae	<i>Aphelocephala leucopsis</i>	Southern Whiteface	+	
Acanthizidae	<i>Aphelocephala nigricincta</i>	Banded Whiteface		+
Pomatostomidae	<i>Pomatostomus superciliosus</i>	White-browed Babbler	+	+
Psophodidae	<i>Psophodes occidentalis</i>	Chiming Wedgebill	+	
Psophodidae	<i>Cinclosoma marginatum</i>	Western Quail-thrush	+	+
Artamidae	<i>Artamus personatus</i>	Masked Woodswallow	+	
Artamidae	<i>Artamus cinereus</i>	Black-faced Woodswallow	+	+
Artamidae	<i>Artamus minor</i>	Little Woodswallow		+
Cracticidae	<i>Cracticus torquatus</i>	Grey Butcherbird	+	+
Cracticidae	<i>Cracticus nigrogularis</i>	Pied Butcherbird	+	+
Cracticidae	<i>Cracticus tibicen</i>	Australian Magpie	+	
Campephagidae	<i>Coracina maxima</i>	Ground Cuckoo-shrike	+	+
Campephagidae	<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike	+	+
Campephagidae	<i>Lalage tricolor</i>	White-winged Triller	+	+
Neosittidae	<i>Daphoenositta chrysoptera</i>	Varied Sittella	+	+
Oreoicidae	<i>Oreoica gutturalis</i>	Crested Bellbird	+	+
Pachycephalidae	<i>Pachycephala rufiventris</i>	Rufous Whistler	+	+
Pachycephalidae	<i>Colluricincla harmonica</i>	Grey Shrike-thrush	+	+
Rhipiduridae	<i>Rhipidura leucophrys</i>	Willie Wagtail	+	+
Monarchidae	<i>Grallina cyanoleuca</i>	Magpie-lark	+	
Corvidae	<i>Corvus orru</i>	Torresian Crow	+	
Corvidae	<i>Corvus bennetti</i>	Little Crow	+	+
Petroicidae	<i>Melanodryas cucullata</i>	Hooded Robin	+	+
Petroicidae	<i>Microeca fascians</i>	Jacky Winter	+	
Petroicidae	<i>Petroica goodenovii</i>	Red-capped Robin	+	+
Hirundinidae	<i>Cheramoeca leucosterna</i>	White-backed Swallow	+	
Hirundinidae	<i>Hirundo neoxena</i>	Welcome Swallow	+	
Hirundinidae	<i>Petrochelidon ariel</i>	Fairy Martin		+
Locustellidae	<i>Megalurus mathewsi</i>	Rufous Songlark	+	
Locustellidae	<i>Megalurus cruralis</i>	Brown Songlark	+	
Dicaeidae	<i>Dicaeum hirundinaceum</i>	Mistletoebird	+	
Estrildidae	<i>Taeniopygia guttata</i>	Zebra Finch	+	+
Motacillidae	<i>Anthus australis</i>	Australian Pipit	+	+

Appendix 2 List of vertebrate fauna recorded at each sampling site

A. Reptiles and mammals

Family	Scientific Name	Sites															recorded only off trapping sites	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Agamidae	<i>Ctenophorus caudicinctus</i>																	+
Agamidae	<i>Ctenophorus isolepis</i>			+				+					+	+			+	
Agamidae	<i>Ctenophorus nuchalis</i>					+				+								
Agamidae	<i>Ctenophorus reticulatus</i>																	+
Agamidae	<i>Ctenophorus scutulatus</i>						+											
Agamidae	<i>Diporiphora amphiboluroides</i>																	+
Agamidae	<i>Diporiphora paraconvergens</i>								+									
Agamidae	<i>Pogona minor</i>		+			+		+	+									
Carphodactylidae	<i>Nephrurus laevisimus</i>								+				+					
Diplodactylidae	<i>Diplodactylus conspicillatus</i>									+								
Diplodactylidae	<i>Diplodactylus granariensis</i>				+													
Diplodactylidae	<i>Rhynchoedura ornata</i>														+			
Diplodactylidae	<i>Strophurus elderi</i>												+	+	+	+		
Diplodactylidae	<i>Strophurus strophurus</i>																	+
Elapidae	<i>Demansia psammophis</i>	+		+											+			
Elapidae	<i>Parasuta monachus</i>	+									+							
Elapidae	<i>Pseudechis australis</i>									+								
Elapidae	<i>Pseudonaja modesta</i>					+	+						+				+	
Gekkonidae	<i>Gehyra purpurascens</i>								+						+			
Gekkonidae	<i>Gehyra variegata</i>				+					+		+						
Gekkonidae	<i>Heteronotia binoei</i>										+					+		
Pygopodidae	<i>Delma haroldi</i>			+													+	
Pygopodidae	<i>Delma nasuta</i>			+	+			+							+	+		
Pygopodidae	<i>Pygopus nigriceps</i>	+									+							
Scincidae	<i>Ctenotus brooksi</i>		+						+				+					
Scincidae	<i>Ctenotus calurus</i>			+									+	+	+			
Scincidae	<i>Ctenotus dux</i>		+										+					
Scincidae	<i>Ctenotus grandis</i>			+												+		
Scincidae	<i>Ctenotus helenae</i>					+	+		+					+	+	+		
Scincidae	<i>Ctenotus leonhardii</i>	+				+	+		+		+			+	+			
Scincidae	<i>Ctenotus pantherinus</i>	+		+							+		+	+	+	+		
Scincidae	<i>Ctenotus piankai</i>		+	+									+					
Scincidae	<i>Ctenotus quattuordecimlineatus</i>		+	+					+				+					
Scincidae	<i>Ctenotus schomburgkii</i>	+						+			+							
Scincidae	<i>Ctenotus uber</i>				+					+	+							
Scincidae	<i>Cyclodomorphus melanops</i>																+	
Scincidae	<i>Lerista bipes</i>		+						+				+	+			+	
Scincidae	<i>Lerista desertorum</i>													+				
Scincidae	<i>Lerista muelleri</i>														+			
Scincidae	<i>Lialis burtonis</i>								+						+	+		
Scincidae	<i>Liopholis inornata</i>																	+
Scincidae	<i>Menetia greyii</i>		+	+		+		+					+	+				
Scincidae	<i>Morethia butleri</i>							+										
Scincidae	<i>Tiliqua multifasciata</i>																	+
Varanidae	<i>Varanus eremius</i>												+					
Varanidae	<i>Varanus giganteus</i>				+													

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Family	Scientific Name	Sites															recorded only off trapping
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Varanidae	<i>Varanus gilleni</i>																+
Varanidae	<i>Varanus tristis</i>																+
Bovidae	<i>Bos taurus</i>																+
Camelidae	<i>Camelus dromedarius</i>																+
Canidae	<i>Canis lupus dingo</i>																+
Canidae	<i>Vulpes vulpes</i>																+
Felidae	<i>Felis catus</i>																+
Equidae	<i>Equus asinus</i>																+
Dasyuridae	<i>Dasyercus blythi</i>																+
Dasyuridae	<i>Ningauai ridei</i>		+	+					+					+	+	+	+
Dasyuridae	<i>Pseudantechinus woolleyae</i>																+
Dasyuridae	<i>Sminthopsis hirtipes</i>												+				+
Dasyuridae	<i>Sminthopsis macroura</i>						+					+					+
Macropodidae	<i>Macropus robustus</i>																+
Macropodidae	<i>Macropus rufus</i>																+
Muridae	<i>Mus musculus</i>																+
Muridae	<i>Notomys alexis</i>																+
Muridae	<i>Pseudomys desertor</i>																+
Muridae	<i>Pseudomys hermannsburgensis</i>							+	+	+					+	+	+
Notoryctidae	<i>Notoryctes caurinus</i>																+

* Occurrence probable but inferred from secondary means such as camera traps and mole trenches

B. Birds

Common name	Site															Opportunistic
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Emu		+	+													
Wedge-tailed Eagle																
Australian Bustard	+		+										+			
Little Button-quail					+											
Crested Pigeon	+	+														
Horsfield's Bronze Cuckoo						+										
Tawny Frogmouth																+
Spotted Nightjar										+						
Red-backed Kingfisher								+								
Nankeen Kestrel				+												
Brown Falcon		+	+					+	+							
Galah							+									+
Cockatiel														+		
Australian Ringneck								+								
Mulga Parrot	+				+		+									
Bourke's Parrot						+		+		+						
Budgerigar	+										+			+	+	
Western Bowerbird																+
Variegated Fairy-wren		+						+		+				+		
Splendid Fairy-wren	+		+			+										
White-winged Fairy-wren																+

Appendix 3. Site vegetation descriptions (from Gibson et al. 2016)

site	vegetation description
Pw01	Mulga - <i>Eucalyptus youngiana</i> mallee shrubland over <i>Eremophila latrobei</i> subsp. <i>filifolia</i> shrubland over <i>Triodia basedowii</i> open hummock grassland
Pw02	<i>Grevillea stenobotrya</i> , <i>Eremophila gibsonii</i> , <i>Acacia</i> sp. open shrubland over <i>Senna</i> sp., <i>Ptilotus obovatus</i> open shrubland (to 1m height) over <i>Triodia schinzii</i> sparse hummock grassland
Pw03	<i>Eucalyptus youngiana</i> , <i>E. lucasii</i> open mallee woodland over <i>Triodia basedowii</i> hummock grassland
Pw04	<i>Acacia mulganeura</i> open shrubland over <i>Senna</i> sp., <i>Acacia tetragonophylla</i> open shrubland (to 1m tall) over <i>Sclerolaena</i> sparse shrubland (<0.25m tall)
Pw05	Mulga shrubland over herb land over <i>Triodia basedowii</i> open hummock grassland
Pw06	<i>Acacia aptaneura</i> , <i>A. incurvaneura</i> x <i>mulganeura</i> , <i>A. caesaneura</i> open shrubland over <i>Eremophila latrobei</i> , <i>Scaevola spinescens</i> , <i>Senna</i> sp. Meekatharra (E. Bailey 1-26) shrubland over <i>Triodia basedowii</i> sparse hummock grassland
Pw07	<i>Eucalyptus gongylocarpa</i> open woodland over <i>Dicrastylis</i> sp., <i>Grevillea stenobotrya</i> , <i>Eremophila latrobei</i> subsp. <i>filifolia</i> shrubland over <i>Triodia schinzii</i> open hummock grassland
Pw08	<i>Acacia mulganeura</i> open shrubland over <i>Senna</i> spp., over <i>Eragrostis</i> sp. sparse grassland
Pw09	<i>Acacia pteraneura</i> open shrubland over <i>Atriplex</i> sp., <i>Acacia tetragonophylla</i> , <i>Senna</i> spp., over <i>Aristida contorta</i> open grassland
Pw10	<i>Acacia aptaneura</i> , <i>A. incurvaneura</i> open shrubland over <i>Eremophila forrestii</i> open shrubland over <i>Triodia melvillei</i> hummock grassland with <i>Eragrostis xerophylla</i> and <i>Eriachne helmsii</i>
Pw11	<i>Acacia aptaneura</i> open shrubland over <i>Eremophila scoparia</i> , <i>Scaevola spinescens</i> shrubland over
Pw12	<i>Grevillea stenobotrya</i> , <i>Eremophila platythamnos</i> subsp. <i>exotrachys</i> , <i>Acacia ligulata</i> , <i>Acacia helmsiana</i> , <i>Eremophila forrestii</i> shrubland over <i>Triodia schinzii</i> open hummock grassland
Pw13	<i>Eucalyptus gongylocarpa</i> open woodland over <i>Eucalyptus youngiana</i> , <i>Senna</i> sp., <i>Eremophila latrobei</i> , <i>E. forrestii</i> over <i>Triodia schinzii</i> open hummock grassland
Pw14	<i>Acacia caesaneura</i> open shrubland over isolated <i>Eremophila latrobei</i> subsp. <i>filifolia</i> over <i>Triodia basedowii</i> hummock grassland
Pw15	Mulga shrubland over herb land over <i>Triodia schinzii</i> , <i>T. basedowii</i> open hummock grassland

Appendix 4. Site photographs



Pw 1



Pw 4



Pw 2



Pw 5



Pw 3



Pw 6



Pw 7



Pw 11



Pw 8



Pw 12



Pw 9



Pw 13



Pw 10



Pw 14

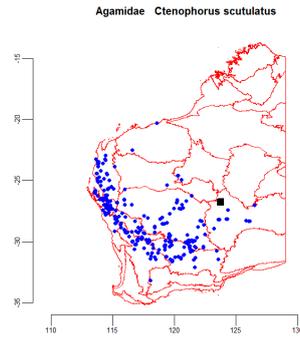


Pw 15

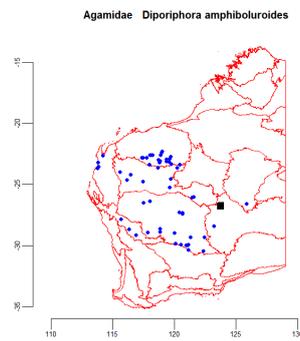
Appendix 5. Species at the limit of their known range or range extensions.



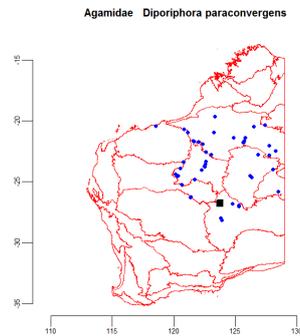
Ctenophorus scutulatus



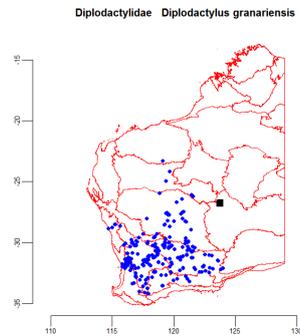
Diporiphora amphiboluroides



Diporiphora paraconvergens

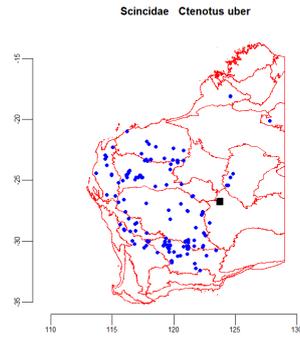


Diplodactylus granariensis

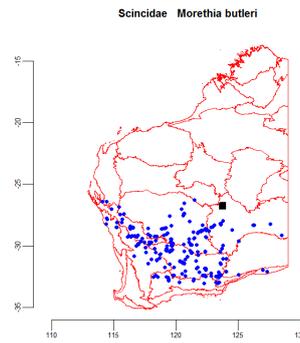




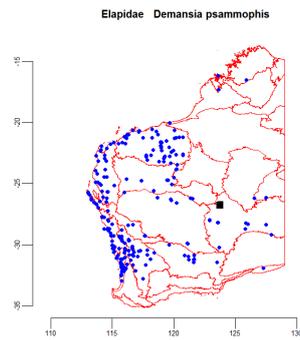
Ctenotus uber



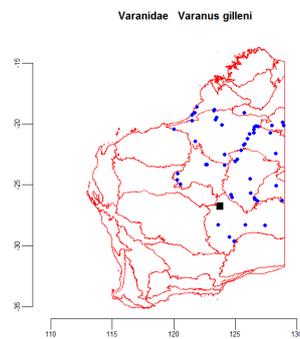
Morethia butleri



Demansia psammophis



Varanus gilleni





Pseudantechinus woolleyae

