Department of Parks and Wildlife

Malaga Wetland Offset Project

Fauna Surveys 2011-2015






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Department of Parks and Wildlife, 2015

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Introduction

In 2009 a conservation category wetland (CCW) on Beringarra Avenue, Malaga, Western Australia, owned by Sandbourne Holdings Pty Ltd, was designated for clearing and development. A wetland in Gnangara pines north of Perth metro area, known as Melaleuca Park wetland was chosen as the offset site for the planned clearing of the CCW category wetland. The offset strategy, Wetland Offset Implementation Strategy (WOIS) (King 2010), outlined that removal of the threats and modifications of the wetland, including the revegetation of the degraded areas, would be carried out to increase management category of the wetland to CCW. Revegetation and restoration of the wetland was through weed control, fencing, pest control, pine reduction, revegetation over three years including two years of maintenance works. Monitoring of the revegetation works with completion criteria was planned to occur on a regular basis. Many contributing offsets were part of this project including an inventory of wetlands within the Gnangara pine plantation (Sommer *et al.* 2013), monitoring of the revegetation work (Tranen Pty Ltd 2014), a fauna survey (this report) and providing the funds for a research project in restoration completed by a university. The fauna survey in particular was to be undertaken in accordance with the Environmental Protection Authority's Guidance statement No. 56 Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (Level 2 Fauna Survey). This involves inspecting and mapping fauna habitat and surveying fauna presence, including *Isoodon obesulus* and potential pest species. This report is the result of the fauna surveys from 2011-2015.

Methods

The wetland offset site

The wetland is made up of the "Resource Enhancement" wetland (21.4 ha), wetland buffer (16.2 ha) and dryland linkage (19.8 ha) (Figure 1). It is surrounded by Gnangara pine plantations and Melaleuca Conservation Park, a conservation estate containing predominantly banksia woodland in the north of Perth. All areas are managed by the Department of Parks and Wildlife. Restoration commenced in 2011 with the end –point aimed at resembling the banksia woodlands and associated melaleuca damplands found in Melaleuca Park (King 2010). Most pines were removed during the restoration of the wetland, however some were ringbarked and left to die in an attempt to reduce degradation of the remaining native vegetation around and beneath them which would have otherwise been crushed if they were felled.and are still standing at the time of this report.

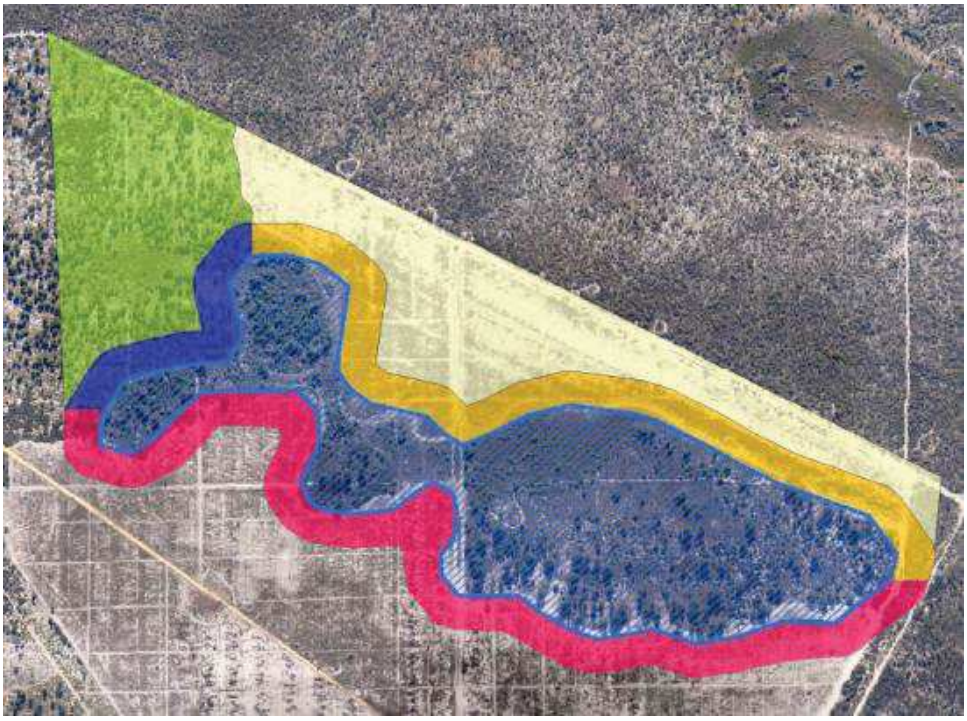

Figure 1: Image of the wetlands and the three wetland areas- wetland (blue lines), wetland buffer (blue, yellow and red surrounding the wetland and linkage dryland area (green and yellow north of the wetland).

Faunal surveys

Surveys for all vertebrate faunal species were conducted within the 57ha offset site in the locality of Melaleuca. A faunal survey was conducted in December 2011, March 2012, October 2014 and March 2015 to determine whether the revegetation and improvement of the wetland was providing improved habitat for wildlife. All survey methods were conducted in accordance with the Department of Parks and Wildlife's Animal Ethics Committee (DPAW AEC 3013/31).

Birds

Bird surveys were conducted on the 18th of October 2011 and 2014. Three 2ha area surveys were used to ensure all habitat types were captured (Figure 2). Area searches occur over a 20 minute timeframe listening and sighting birds within a 2ha area, excluding bird that fly over and don't use the 2 ha area (Craig and Roberts 2001; Kavanagh and Recher 1983). These surveys were completed in the three areas (wetland, wetland buffer and linkage dryland) in 2011 and 2014, except for the wetland buffer where a second survey in 2014 was not completed.

Figure 2: Centre point locations of the bird surveys at the Malaga offset site.

Amphibians

Frog surveys were conducted in spring 2011 and 2014. Vocal surveys were performed in the centre of the offset site listening for 20 minutes for frog calls.

Other terrestrial fauna: mammals, reptiles and amphibians

Trapping occurred from the 29th of November to the 14th of December 2011, 12th- 16th of March 2012, 12th to the 22nd of October 2014 and 16th-20th of March 2015. An array of traps were used including pitfall (30 20L buckets), funnel (18 traps), Elliot (13 traps) and cage traps (13 traps). The bucket and funnel traps were arranged into three Y grid formations with a single central bucket and three arms each consisting of three pitfall traps with two funnel traps at each end (Figure 3). A Y-grid was installed in each of the areas within the offset site, wetland, wetland buffer and dryland linkage to survey all areas or habitat types. All pitfall traps were provided with styrofoam trays as shelter for the captured animals and dampened to avoid desiccation of any animals. The cage and Elliot traps were arranged in a single transect through the centre of the offset site (Figure 4). In 2014 and 2015, no elliot traps were used, instead 26 cage traps were deployed. Cage trap locations in 2014 and 2015 were also in similar locality's to 2011 and 2012 (Figure 4), however, the ringbarking of pine trees within the wetland made it impossible to position the traps in exactly the same locations due access restrictions to those areas. Cage and Elliot traps were baited with universal bait (peanut butter, oats and sardines). The traps were placed under vegetation to provide added shelter to captured animals. All traps were checked in both the morning and afternoon in accordance with the Department of Parks and Wildlife's Animal Ethics Committee.

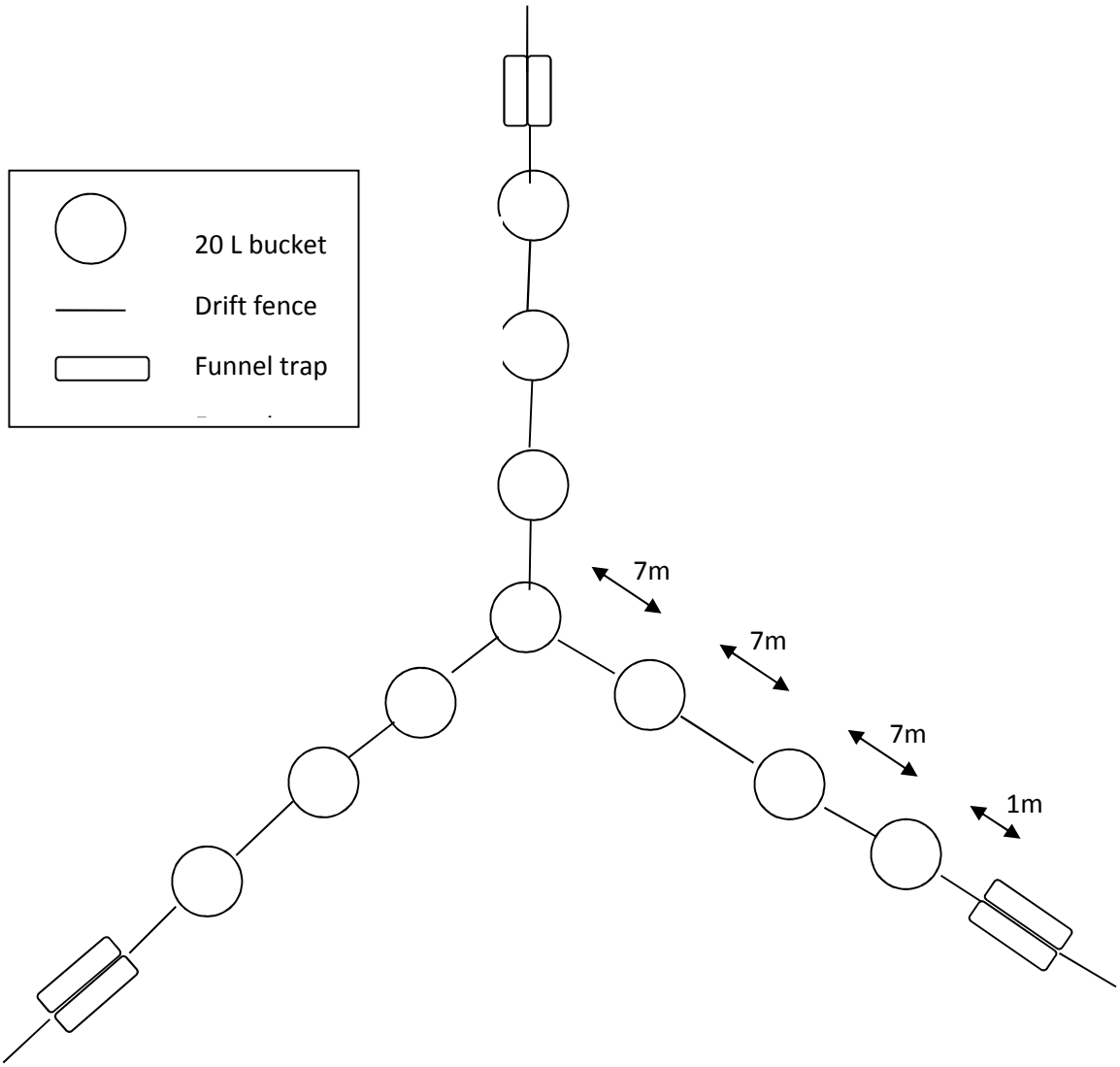

Figure 3: Trapping set up for targeting reptiles using the Y formation grid incorporating ten 20L buckets, 6 funnel traps and 66m of drift fence.

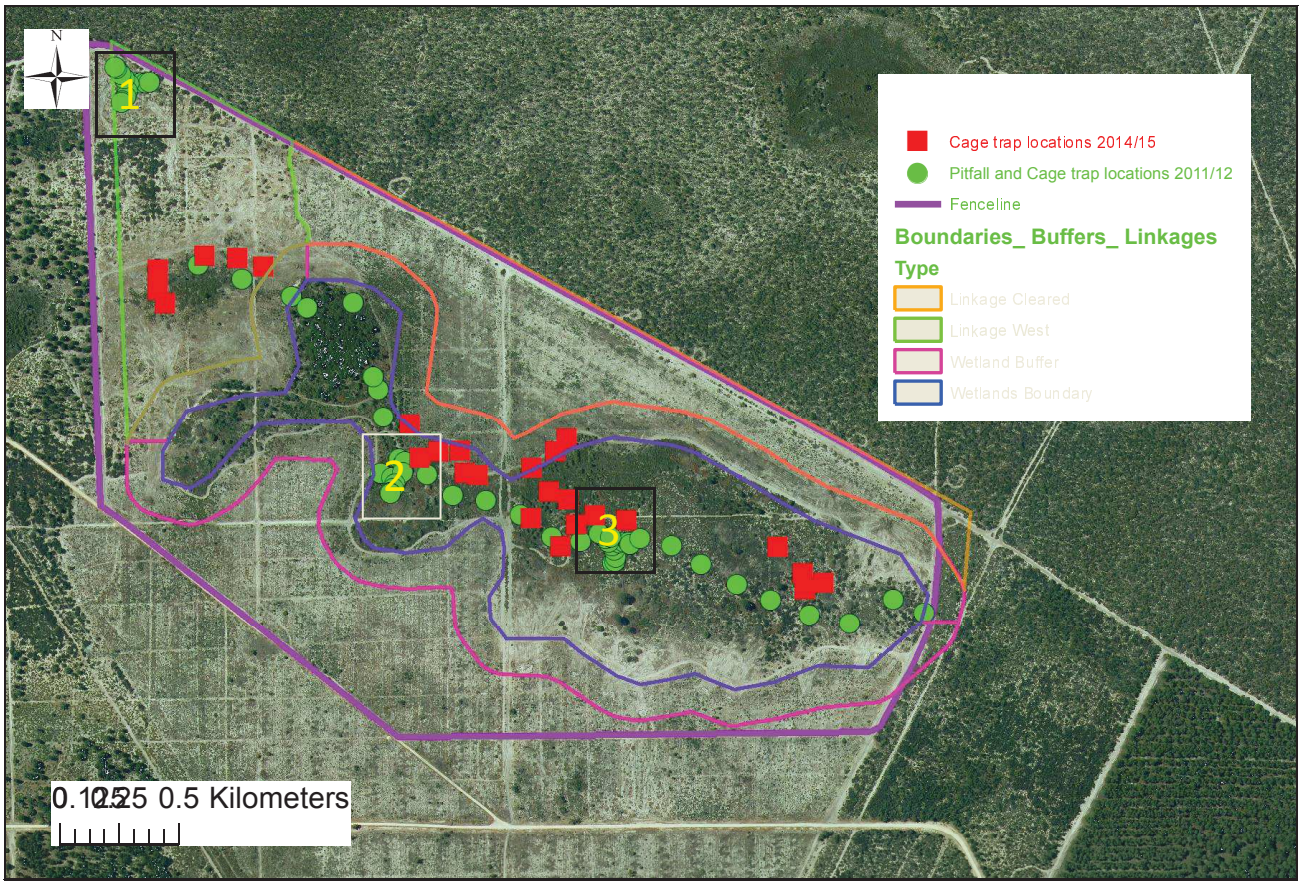

Figure 4: Trap locations within the Malaga offset site for 2011-2015. The green circles signify the Y grids, cage and Elliot trap locations for 2011 and 2012 surveys (the Y grids were in the same location for all years). The red squares signify the cage trap locations for 2014 and 2015. The three Y grids are numbered on the map Linkage (1), Buffer (2) and Wetland (3).

Pest Species

Whilst conducting the fauna surveys and during the pest removal conducted by the contractors, pest species were listed and noted

Opportunistic sightings

During all sites visits by contractors, consultants and Departmental staff sightings of native fauna were made.

Results

Revegetation

The Malaga offset site in Melaleuca Park was improved over three years (2011-2014) through the reduction of pine trees and other weeds, animal pest control for *Oryctolagus cuniculus*, planting of over 429 810 seedling and direct seeding and fencing of the entire wetland area to reduce herbivory (King 2010; Moore *et al.* 2014; Tranen Pty Ltd 2014). The revegetation had several completion criteria to meet in order to be classified as a successful revegetation project. However, only two of these targets were met, tree stem density (dryland) and weed stem density. The revegetation had to content with drought condition in the summer of 2013 and 2014 that resulted in widespread loss of individual plants and species (Tranen Pty Ltd 2014). Despite this the resulting restoration has improved the wetland and associated remnant vegetation considerably.

Birds

Many bird species were seen in the two bird surveys conducted over 2011 and 2014 (Table 1). Only one species was seen in all surveys, the grey fantail. Many species were only seen in one survey in one of the years; common bronzewing pigeon, red-capped parrot, western gerygone, yellow-rumped thornbill, rufous whistler, magpie-lark, black-eared cuckoo, pallid cuckoo and Australian magpie. Overall 23 bird species have been seen in the offset site.

Table 1: Bird species identified during the bird surveys in 2011 and 2014 at the Linkage, Wetland and Buffer areas. The black box indicates the bird was seen.

Area survey was conducted Year	Linkage 2011	Wetland 2011	Buffer 2011	Linkage 2014	Wetland 2014
Common Bronzewing pigeon (*Phaps chalcoptera*)				■	
Red-capped parrot (*Purpureicephalus spurius*)					■
Western rosella		■			
Australian ringneck (*Barnardius zonarius*)	■		■		
Splendid fairy wren (*Malurus cyaneus*)		■		■	■
White browed scrubwren (*Sericornis frontalis*)		■			
Western gerygone (*Gerygone fusca*)					■
Yellow-rumped thornbill (*Acanthiza chrysorrhoa*)	■				
Western wattlebird (*Anthochaera lunulata*)	■	■	■	■	
White naped honeyeater (*Melithreptus lunatus*)				■	■
Brown honeyeater (*Lichmera indistincta*)	■	■	■	■	
New holland honeyeater (*Phylidonyris novaehollandiae*)				■	■
White-cheeked honeyeater (*Phylidonyris niger*)	■	■		■	■
Brown-headed honeyeater (*Melithreptus brevirostris*)	■	■		■	■
Rufous whistler (*Pachycephala rufiventris*)		■			
Grey shrike-thrush (*Colluricincla harmonica*)	■		■		
Magpie-lark (*Grallina cyanoleuca*)			■		
Grey fantail (*Rhipidura albiscapa*)	■	■	■	■	■
Black-faced cuckoo shrike (*Coracina novaehollandiae*)		■	■	■	
Black-eared cuckoo (*Chrysococcyx osculans*)					■
Pallid cuckoo (*Cacomantis pallidus*)				■	
Australian magpie (*Cracticus tibicen*)					■
Silvereye (*Zosterops lateralis*)			■		■
Total	8	10	8	11	11

Amphibians

No amphibians were heard calling during the vocal surveys for amphibians. Amphibians were captured in the trapping surveys and will be reported on in the next section.

Other terrestrial fauna: mammals, reptiles and amphibians

Over a total of 1565 trap nights including 431 funnel trap nights, 312 cage trap nights, 719 pitfall trap nights and 104 elliot trap nights, 207 individual mammals, reptiles and amphibians were captured (a full list is in Appendix 1). Many families were caught including Agamidae (dragons; 2 genera, 2 species), Elapidae (front-fanged snakes; 3 genera, 3 species), Gekkonidae (geckos; 1 genera, 1 species), Leporidae (rabbits and hares; 1 genera, 1 species), Myobatrachidae (burrowing frogs; 3 genera, 3 species), Peramelidae (bandicoots; 1 genera, 1 species), Pygopodidae (legless lizards; 3 genera, 5 species), Rodentia (rodents; 2 genera, 2 species), Scinidae (skinks; 6 genera, 10 species), Tachyglossus (echidna, 1 genera, 1 species) and Typhlopidae (blind snakes, 1 genera, 2 species).

Over the four trapping events within the four trapping locations (three Y grids and transect line) at the offset site the number of captures of reptiles, mammals and amphibian varied (Figure 5a and b). Reptiles were mostly captured in the Spring sessions of trapping, with the highest captures in the Buffer grid; and also in the Linkage, Wetland grids, and transect line with decreasing success (Figure 5a and b). More reptiles were captured in pitfall and funnel traps (at the Linkage, Wetland and Buffer grids), only *Tiliqua rugosa* or *T. occipitalis* were caught in cage or Elliot traps. Amphibian captures were low overall but highest in Spring 2014, at the Buffer and Linkage grids only. Mammal captures (both native and feral) remained fairly constant over the trapping sessions and in the four grid locations.

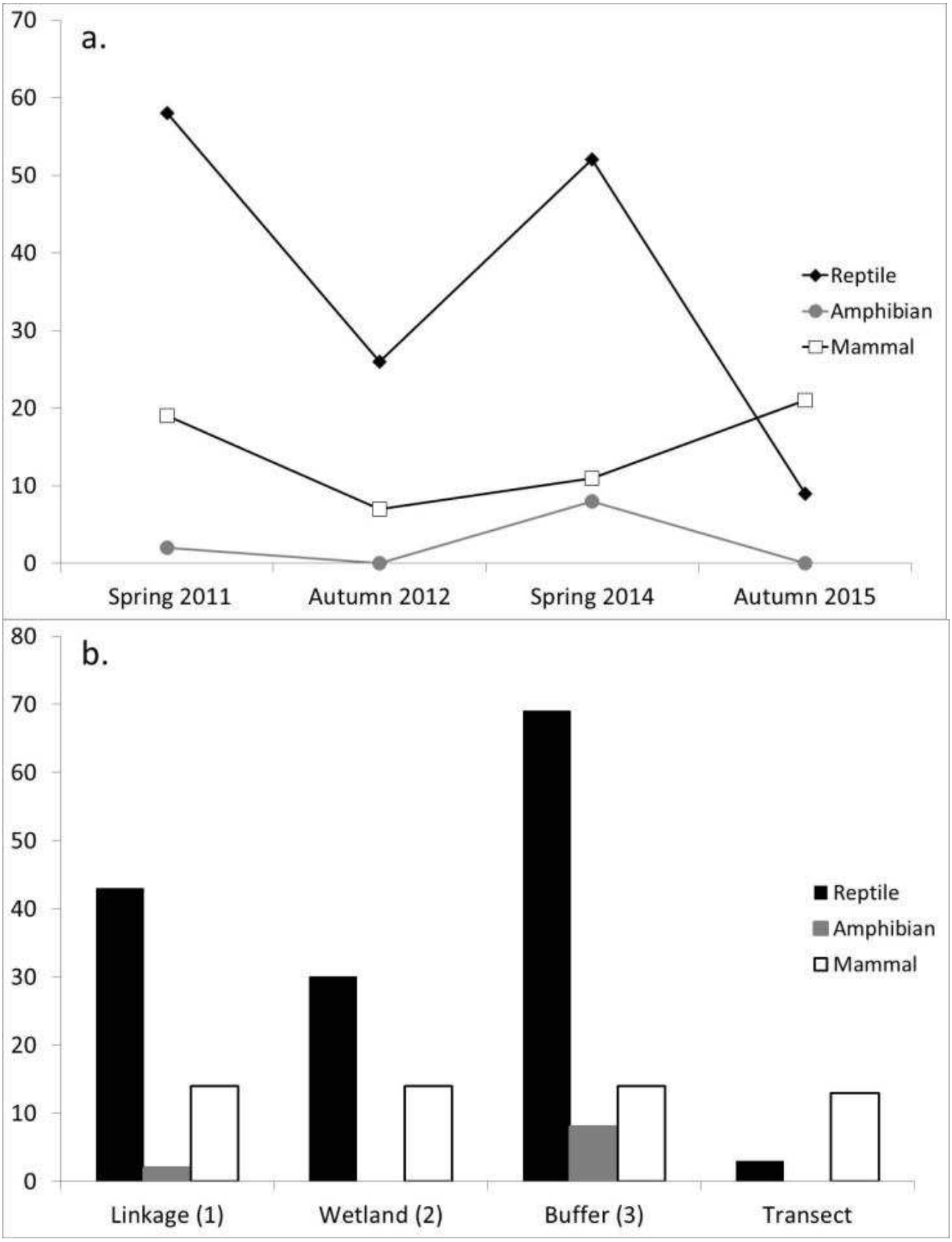

Figure 5: The number of reptile, amphibian and mammal captures over the four trapping events, Spring 2011, Autumn 2012, Spring 2014 and Autumn 2015 (a); and in the four trapping location, Linkage, Wetland, Buffer grids, and the transect line (b).

A large portion of the captures were reptiles (141 individuals) and mammals (56 individuals), and to a lesser extent amphibians (10 individuals). The number of reptile, mammal and amphibian captures in the four trapping sessions varied seasonally at the Linkage, Buffer, Wetland and transect line (Figure 6). Reptile captures were highest in Spring 2011 and 2014 and to a lesser extent Autumn 2012 and 2015 at the Buffer and Linkage grids (Figure 8a). Reptile captures in the Wetland grid decreased steadily over the trapping sessions and the transect line consistently caught no reptiles except for Spring 2014 (Figure 6a). Mammal captures were highest in Spring 2011 and Autumn 2015 in the Linkage grid and transect line (Figure 6b). Mammal captures in the buffer grid increased over the four trapping sessions (Figure 6b). Within the wetland grid four mammals were captured in each survey, dropping down to two captures in Autumn 2015 (Figure 6b). The majority of amphibian captures were noted in Spring (Figure 6c). The Buffer grid caught two amphibians in Spring 2011 and six in Spring 2014 (Figure 6c). Two amphibian captures in Spring 2014 at the Linkage grid location was also recorded (Figure 6c). No amphibians were caught in any other sessions, grids or transect locations (Figure 6c). Mammal captures when divided by species shown another story, that the captures of the non-native rodents, *Mus musculus* captures were higher than any other mammal species, with 16 captures in Spring 2011, dropping down to seven captures in Autumn 2012 (Figure 8d). *Rattus rattus* captures were lowest in Spring 2011(1 capture) and increased during the Autumn 2015 survey (3 captures; Figure 6d). Captures of the native mammals, *Tachyglossus aculeatus* and *Isoodon obesulus* were in low by comparison; a single *T aculeatus* capture in Spring 2014; and a single capture of *I. obesulus* in Spring 2011 and two *I. obesulus* captures in Autumn 2015 (Figure 6d).

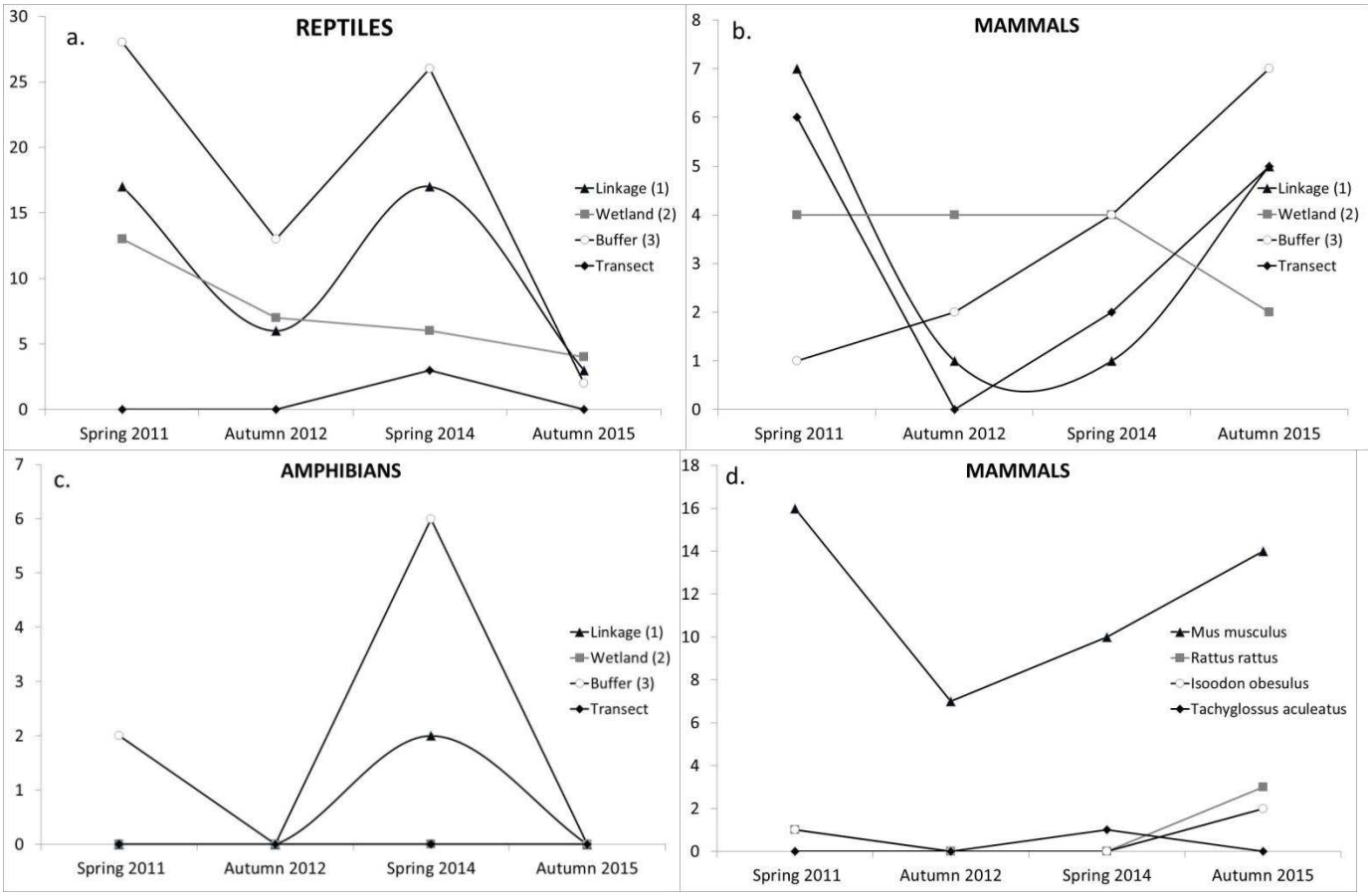

Figure 6: The number of reptile (a), mammal (b), and amphibian (c) captures over the four trapping events at Malaga offset site in the Linkage, Wetland and Buffer areas (Y grid) and the transect. Mammals have been further divided into *Mus musculus*, *Rattus rattus*, *Isoodon obesulus*, and a single capture of *Tachyglossus aculeatus* due to the small number of species captured (d).

Species richness of reptiles, mammals and amphibians captured in the Linkage, Buffer, Wetland areas and transect line was variable (Figure 7). In the Buffer and Linkage areas the peak number of reptile species captured was in Spring 2011 and 2014. Reptile species richness has steadily decreased since Spring 2011 in the Wetland grid. The only reptile species captured in the transect line was during the Autumn 2015 survey (*Tiliqua* spp., Figure 7a). Consistently, one species of mammal was captured in each grid or transect for each trapping events, with the exception of the transect line where two mammal species were captured in Spring 2014 and Autumn 2015 (Figure 7b). Amphibian species richness was highest in Spring 2011 at the Buffer grid and to a lesser extent Linkage and Buffer sites in Spring 2014. No amphibian species were captured in Spring 2011 and Autumn 2015 (Figure 7c).

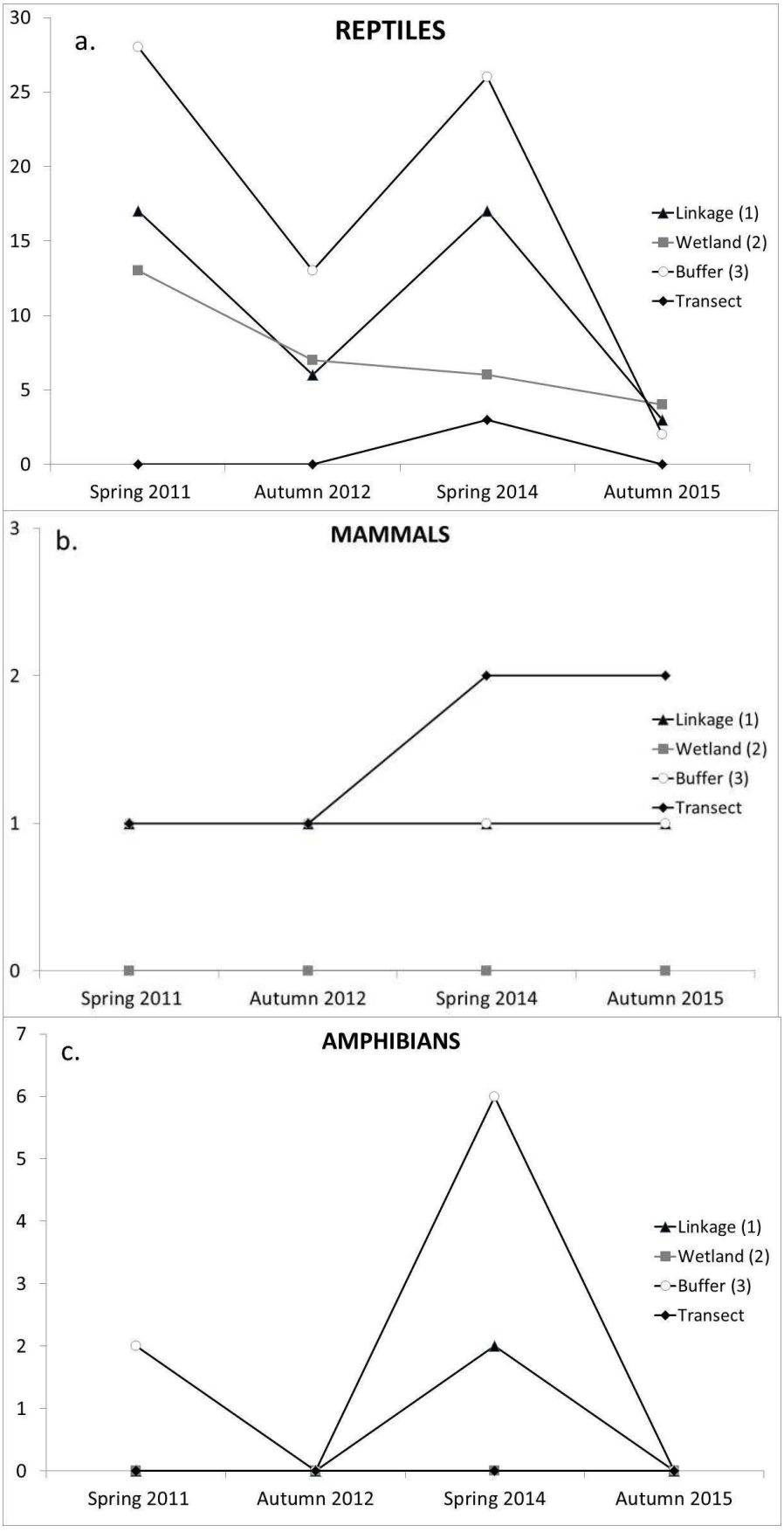

Figure 7: The number of reptile (a), mammal (b), and amphibian (c) species captured in the four trapping events at Malaga offset site in the Linkage, Wetland and Buffer areas (Y grid) and the transect.

Opportunistic sightings

During a site visit of July 2014 *I. obesulus* diggings were noted near and around the wetland area of the offset site. All West pest contractors and Departmental staff have noted many nests, dens and tracks left by *Oryctolagus cuniculus* and *Vulpes vulpes*.

Discussion

Birds

All 23 bird species recorded in the Malaga offset site are common birds located on the Swan Coastal Plain. Previous surveys of birds in the past have found between 13 and 28 different species in a single reserve (Davis *et al.* 2014; Moore 2012a). The variability in the bird species seen between surveys can most likely be put down to the limited number of bird surveys completed (two surveys per offset area). However, the aim was to determine the species present at the wetland and these surveys have provided a detailed bird species list for the wetland, not unlike other reserves on the Swan Coastal Plain.

Amphibians

Previous literature and species lists for the Swan Coastal Plain predict seven species of amphibians to be captured (Bamford 1992; Cogger 1996; Moore and Barrett 2013; Storr *et al.* 1978). During this faunal survey only three amphibians were captured including *Heleioporus eyrei, Limnodynastes dorsalis* and *Myobatrachus gouldii*. Bamford (1992) noted that the three amphibian species, *H. eyrei*, *L. dorsalis* and *M. gouldii*, made up to 95% of the captures in his survey work. Given the young age of this restoration project this number of amphibian species is acceptable and future surveys will hopefully record the additional missing species.

Isoodon obseulus

The presence of *I. obesulus* was noted through tracks, diggings and actual captures. One *I. obesulus* (unknown sex, adult) was captured during the trapping of 2011 indicating a potential population was present at the commencement of the revegetation works. In 2015, after a few years of restoration and maintenance works had been carried out two individual *I. obesulus* were captured, an adult female with pouch young and an adult male. The presence of female *I. obesulus* with two pouch young indicates a potentially increasing population in the revegetation area. Adjacent to the offset site is Melaleuca Conservation Park, where in 2011 many *I. obesulus* were also captured and PIT tagged, indicating there is a possibility of *I. obesulus* moving from nearby wetlands into the offset site and vice versa (Moore 2011). Overall, there are *I. obesulus* present in the wetland, with a potentially increasing population and the connectivity to adjacent habitat for outside *I. obesulus* to move in and use the revegetated wetland.

Other native mammals

In addition to *I. obesulus*, the other native mammal captured was *Tachyglossus aculeatus* in the spring of 2014. This is a good sign of the ability of the restored wetland to provide for native mammals. *Tachyglossus aculeatus* are common throughout Australia (Short and Smith 1994) and in banksia woodlands of the Swan Coastal Plain (Kitchener *et al.* 1978; Moore 2011). Apart from *I. obesulus* and *T. aculeatus*, there are few other mammals on the Swan Coastal Plain in banksia woodlands or wetlands; *Tarsipes rostratus*, *Hydromys chryogaster*, *Rattus fuscipes* and *Phascogale tapoatafa* (Wilson et al. 2012). *Tarsipes rostratus* is commonly captured, however, it requires a healthy canopy with flowering plants (Dundas *et al.* 2013). Older restoration sites and woodlands are more likely to provide a flowering

canopy (Moore and Barrett 2013), the offset site is too young in terms of restoration to provide for *T. rostratus*. *Hydromys chryogaster* reside in riverine systems (Wilson *et al.* 2012), and *P. tapoatafa* are an arboreal, hollow dwelling species, that is rarely captured in traps (nest boxes are commonly used to monitor this species). The restored wetland in this report contains neither a riverine system nor hollow bearing trees (Rhind 2003; Rhind and Bradley 2002), accounting for the absence of *H. chryogaster* and *P. tapoatafa*. The only mammal species conspicuous in its absence was *R. fuscipes*. However, surveys across the Swan Coastal Plain note its variable and patchy distribution (Moore 2011; Valentine *et al.* 2009). *Tachyglossus aculeatus* was the only other likely other mammal species to be captured in the area, apart from *I. obesulus*. *Tachyglossus aculeatus*' presence is not all that surprising as the species are often only present in older restoration due to their requirement of dead and dying logs for termite food resources (Eldridge and Mensinga 2007), which could be commonly found in the surrounding pine plantations.

Reptiles

Potentially 177 different reptile species are present on the Swan Coastal Plain, with a high number of these endemic to the south-west of Western Australia (Cogger 1996; Mittermeier *et al.* 2004). Generally, it is noted that reptiles take the longest to return to restored jarrah forest (Nichols and Grant 2007). Other studies south of Perth have predicted in banksia woodland restoration sites < 5 years old, only 10 reptile species should be recorded (Moore and Barrett 2013). The most closely located study to the offset site is the Gnangara Sustainability Strategy (GSS), in which 38 reptile species were captured over 5600 pitfall trap nights (Valentine *et al.* 2009). A total of 23 reptiles species were seasonally captured in this faunal survey over 1565 trap nights. Considering the GSS surveys completed almost four times as many trap nights, the total number of species captured in this survey was outstanding for a newly revegetated wetland. The close proximity to existing banksia woodlands and the presence of native vegetation prior to restoration would most likely have increased the number of species captured above other studies and predictions, due to the connectivity to other suitable habitat patches. Young restoration sites, such as this restored wetland also provide increased solar radiation, which is often preferred by reptile species (Barton *et al.* 2011). This restored wetland can potentially be home to many more reptilian species as the restoration ages.

Seasonality in reptile captures is common in many studies across the Swan coastal Plain. Spring is seen as a better time to capture reptiles and this is represented again in these surveys in the offset site (Moore *et al.* 2013; Valentine *et al.* 2009).

Pest Species

Felius catus, M. musculus, *O. cuniculus, Rattus rattus* and *V. vulpes* were all likely to be caught in the wetland (Moore and Barrett 2013; Valentine *et al.* 2009). *Mus musculus*, *O. cuniculus, R. rattus* were all captured during the faunal surveys. Signs of *V. vulpes* were present around the wetland through tracks and dens. *Felius catus* was not noted in this survey but has been recorded in nearby pine plantations and nature reserves (Moore 2012b). On-going control for *O. cuniculus* was carried from 2011 to 2014, which would hopefully lead to secondary poisoning of *V. vulpes*. Due to adjacent pine plantations and native vegetation unbaited for any pest species it would be unlikely to remove all pest species within the wetland.

Conclusion

Overall, the wetland offset site has an abundant and species rich faunal presence. For a young restoration site, the number and species of mammals, reptiles, amphibians and birds is a great beginning. A large reason for this diversity would be the presence of some native vegetation prior to the restoration works and the adjacent native vegetation in nature reserves. Future restoration works could consider restoration sites with native vegetation already present or adjacent for better faunal results. Future surveys should be conducted in the wetland offset site to determine if the faunal species are still present or hopefully increasing as the restoration ages.

References

Bamford M. J. (1992) The impact of fire and increasing time after fire upon *Heleioporus eyrei*, *Limnodynastes dorsalis* and *Myobatrachus gouldi*i (Anura : Leptodactylidae) in banksia woodland near Perth, Western Australia. *Wildlife Research* **19**, 169-78.

Barton P. S., Manning A. D., Gibb H., Wood J. T., Lindenmayer D. B. & Cunningham R. B. (2011) Experimental reduction of native vertebrate grazing and additional logs benefit beetle diversity at multiple scales. *Journal of Applied Ecology* **48**, 943-51.

Cogger H. G. (1996) *Reptiles and amphibians of Australia*. Reed, Port Melbourne.

Craig M. & Roberts J. D. (2001) Evaluation of the impact of day, weather, vegetation density and bird movements on outcomes of area searches for birds ineucalypt forests of south-western Australia. *Wildlife Research* **28**, 33-9.

Davis R. A., Valentine L. E., Craig M. D., Wilson B. A., Bancroft W. J. & Mallie M. (2014) Impact of *Phytophthora*-dieback on birds in Banksia woodlands in south-west Western Australia. *Biological Conservation* **171**, 136-44.

Dundas S. J., Fleming P. A. & Hardy G. E. S. J. (2013) Flower visitation by honey possums (*Tarsipes rostratus*) in a coastal banksia heathland infested with the plant pathogen *Phythphthora cinnamomi*. *Australian Mammalogy* **35**, 166-74.

Eldridge D. J. & Mensinga A. (2007) Foraging pits of the short-beaked echidna (*Tachyglossus aculeatus*) as small-scale patches in a semi-arid Australian box woodland. *Soil Biology and Biochemistry* **39**, 1055-65.

Kavanagh R. & Recher H. F. (1983) Effects of observer variability on the census of birds. *Corella* **7**, 93-9.

King C. (2010) Wetland offset Implementation Stragety- Lots 300-303 and 9001 Beringarra Avenue, Malaga. (ed B. Pederson). Cardno (WA) Pty Ltd, Subiaco, Western Australia.

Kitchener D. J., Chapman A. R. & Barron G. (1978) Mammals of the northern Swan Coastal Plain. In: *Faunal Studies of the Northern Swan Coastal Plain - a consideration of past and future changes* pp. 54-92. Western Australian Museum, Department of Conservation and Environment, Perth, Western Australia.

Mittermeier R. A., Robles-Gil P., Hoffmann M., Pilgram J. D., Brooks T. M., Mittermeier C. G., Lamoreux J. L. & Fonseca G. (2004) *Hotspots revisited: Earth's Biologically Richest and Most Endangered Ecoregions*, Cemex, Mexico City.

Moore T. L. (2011) Mammals of the northern Swan Coastal Plain. Department of Parks and Wildlife, Perth, Western Australia.

Moore T. L. (2012a) Bird surveys in ten priority reserves on the Swan Coastal Plain. Department of Parks and Wildlife, Perth, Western Australia.

Moore T. L. (2012b) Yeal Nature Reserve Sand Pads 2012. Department of Parks and Wildlife, Perth, Western Australia.

Moore T. L. & Barrett G. (2013) Banksia woodland restoration project- Fauna monitoring and milestones. Department of Parks and Wildlife, Perth, Western Australia.

Moore T. L., Sonneman T., Reaveley A., Bettink K. & Wilson B. A. (2013) The fauna of Boonanarring Nature Reserve (Draft). Department of Parks and Wildlife, Perth, Western Australia.

Moore T. L., Sonneman T. & Wilson B. A. (2014) Malaga Wetland Offset- Reporting on Project Management. Department of Parks and Wildlife, Perth, Western Australia.

Nichols O. G. & Grant C. D. (2007) Vertebrate fauna recolonization of restored bauxite mines- key findings from almost 30 years of monitoring and research *Restoration ecology* **15**, S116-S26.

Rhind S. G. (2003) Communal nesting in the usually solitary marsupial, *Phascogale tapoatafa*. *The Zoological Society of London* **261**, 345–51.

Rhind S. G. & Bradley J. S. (2002) The effect of drought on body size, growth and abundance of wild brush-tailed phascogales (*Phascogale tafoatafa*) in south-western Australia. *Wildlife Research* **29**, 235-45.

Short J. & Smith A. (1994) Mammal decline and recovery in Australia. *Journal of Mammalogy* **75**, 288-97.

Sommer B., Froend R., McGuinness. & Wilson J. (2013) Identifying wetlands of significance within the Gnangara pine plantations - Final report (G1000885- SUB/38105). In: *Report No. CEM2013-07*. Edith Cowan University, Perth, Western Australia.

Storr G. M., Harold G. & Barron G. (1978) The Amphibians and Reptiles of the Northern Swan Coastal Plain. In: *Faunal Studies of the Northern Swan Coastal Plain - a Consideration of Past and Future Changes* pp. 172-203. Western Australian Museum, Perth, Western Australia.

Tranen Pty Ltd. (2014) P437 Malaga Wetlands Offset Project Summary, Prepared for the Department of Parks and Wildlife. Tranen Pty Ltd,, Perth, Western Australia.

Valentine L. E., Wilson B. A., Reaveley A., Huang N., Johnson B. & Brown P. (2009) Patterns of ground-dwelling vertebrate biodiversity in the Gnangara Sustainability Strategy study area. Department of Environment and Conservation, Perth, Western Australia.

Wilson B. A., Valentine L. E., Reaveley A., Issac J. & Wolfe K. (2012) Terrestrial mammals of the Gnangara Groundwater System, Western Australia: history, status, and the possible impacts of a drying climate. *Australian Mammalogy* **34**, 202-16.

Appendix

Appendix 1: A list of all terrestrial vertebrates captured during the trapping surveys in 2011, 2012, 2014, 2015.

	Species		2011	2012	2014	2015	Opportunistic sightings
Amphibians	Myobatrachidae						
	Heleioporus eyrei	Moaning frog	1				
	Lymnodynastes dorsalis	Western banjo frog			8		
	Myobatrachus gouldii	Turtle frog	1				
Mammals	Leporidae						
	Oryctolagus cuniculus	European rabbit	1				
	Peramelidae						
	Isoodon obesulus	Southern Brown Bandicoot	1			2	
	Rodentia						
	Mus musculus	house mouse	16	7	10	14	
	Rattus rattus	black rat	1			3	
	Tachyglossus						
	Tachyglossus aculeatus	Short-beaked Echidna			1		
Reptiles	Pygopodidae						
	Aprasia repens	Southwestern sandplain worm lizard	1		1		
	Delma concinna concinna	West coast javelin lizard	1				
	Delma fraseri	Fraser's delma	1	1			
	Delma grayii	Side-barred delma		1	1		
	Pletholax gracilis gracilis	Keeled legless lizard	1				
	Agamidae						
	Pogona minor	Western bearded dragon	1	2	2		
	Ctenophorus adelaidensis	Western heath dragon	6	3	2		1
	Scincidae						
	Cryptoblepharus buchananii	Fence skink			7		
	Ctenotus australis	Western limestone Ctenotus			3	1	
	Ctenotus fallens	West-coast laterite Ctenotus	14	6	3	1	
	Lerista distinguenda	Southwestern four-toed Lerista				2	
	Lerista elegans	West-coast four-toed Lerista	12	9	8	3	
	Lerista praepedita	West coast worm Lerista	2		1		
	Menetia greyii	Common dwarf skink	2	2	5	2	
	Morethia obscura	Shrubland pale-flecked Morethia	7	1	8		
	Tiliqua occipitalis	Western bluetongue			2		
	Tiliqua rugosa	Shingleback (bobtail)			2		
	Elapidae						
	Neelaps calonotus	Black-striped burrowing snake	1				
	Parasuta gouldii	Gould's hooded snake	1	1			
	Simoselaps bertholdi	Jan's banded snake	4				1
	Typhlopidae						
	Ramphotyphlops australis	Southern blind snake	1		2		
	Ramphotyphlops pinguis	Fat blind snake			3		
	Gekkonidae						
	Strophurus spinigerus spinigerus	Spiny tailed gecko	2				
	Total		78	33	69	28	2