Gnangara Sustainability Strategy

An across-government initiative

Groundwater – Biodiversity – Land use

POST FIRE RECOLONISATION OF FAUNA ON THE GNANGARA GROUNDWATER SYSTEM

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Post fire recolonisation of fauna on the Gnangara groundwater system

Report for the Department Parks and Wildlife for the Gnangara Sustainability Strategy

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This document has been produced as part of the Gnangara Sustainability Strategy (GSS). The GSS is a State Government initiative which aims to provide a framework for a whole of government approach to address land use and water planning issues associated with the Gnangara groundwater system. For more information go to www.gnangara.water.wa.gov.au

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Introduction

An integral part of the world's and Australia's environment for millions of years has been fire (Bowman *et al.* 2009). Fire events are a natural disturbance mechanism in many ecosystems that play a key role in modifying landscapes and habitats, promoting ecosystem change (Whelan 1995). Ecosystem change, such as germination and recruitment, influences environmental and biological heterogeneity, vegetation and faunal assemblages (Masters 1993; Brawn *et al.* 2001; Kelly *et al.* 2011).

Human-mediated fire has been an important disturbance that has influenced the Australian environmental landscapes for at least the last 5000 years (Bowman *et al.* 2009). Fire is employed as a land management tool for a variety of reasons, as well as occurring naturally in the ecosystem. There is often a gap between the knowledge of fire behaviour, ecology and its influence on the natural environment (Burrows 2008; Kelly *et al.* 2012).

Abundances of most species of fauna are related to fire events and the resultant changes in the habitat (Fox 1982; Friend 1993; Whelan 1995; Kelly *et al.* 2010; Steen *et al.* 2013). Wildlife have ecological and behavioural traits that enable them to survive fire (Friend 1993), and are often adapted to specific fire regimes, in terms of intensity, frequency, season and scale. For example, in the Simpson desert, *Pseudomys desertor* (desert mouse) prefers long unburnt habitat for the vegetation density (Letnic and Dickman 2005) and the dragon, *Gemmatophora gilberti* in the Victoria River District of the Northern Territory prefers recently burnt habitat for foraging and older fire aged habitat for the denser shelter (Woinarski *et al.* 1999). Both these examples demonstrate that fauna are linked to not only the habitat and the fire induced habitat changes.

Post-fire succession of wildlife and their response to the changes in vegetation is described by the 'habitat accommodation' model (Fox 1982; Letnic et al. 2004; Letnic and Dickman 2005; Driscoll and Henderson 2008; Lindenmayer et al. 2008a; Lindenmayer et al. 2008b). The theory outlines that a species' abundance is highest when their requirements are met by a revegetating post-fire habitat but declines in abundance occur when the resources are suboptimal. Burrowing reptile and mammals that forage in the open, with an opportunistic diet are commonly found immediately post-fire. Following on from early succession fauna, mid-succession fauna generally consists of semi-arboreal reptiles that use perches and low vegetation and seasonal breeding mammals requiring dense vegetation. Many years since a fire (late succession) litter dwelling reptiles and mammals with a specialised diet, seasonal and synchronized breeding (mammals only), requiring very dense and flammable shelter are common (Friend 1993). Frogs are often burrowers therefore resilient to fire and prefer older and denser vegetation (Friend 1993). In Australia, this model is generally supported by the results of studies in southern heathlands, healthy woodlands and arid grasslands (Masters 1993; Newsome *et al.* 1975; Recher *et al.* 1974; Wilson 1996; Wilson *et al.* 2001). However, Lindenmayer (2008b) suggests that overall there are mixed results to support this theory and more research is required.

In banksia woodlands on the Swan Coastal Plain, north of Perth, Western Australia very few pre- and post- fire fauna surveys have been undertaken due to a lack of pre-fire data. Fauna studies to assess patterns of terrestrial vertebrate biodiversity, habitat associations and time since last fire were conducted at 40 sites in 2007-08 as part of the Gnangara Sustainability Strategy (GSS) (Government of Western Australia 2009; Valentine *et al.* 2009; Wilson *et al.* 2010). As part of the GSS Biodiversity project 40 sites were surveyed to assess terrestrial fauna distribution and biodiversity (Valentine *et al.* 2009). The study focussed on faunal diversity in sites with varying time since last fire (3 – 36 years) of banksia woodlands and melaleuca damplands.

On January 16th 2009 a wildfire, Yanchep fire, burnt through 7640 hectares of Yanchep National Park, private property, state forest and Yanchep and Pinjar Pine Plantations. Of the 40 GSS faunal sites surveyed in 2008, 14 were burnt by the Yanchep fire. This provided an opportunity to compare pre- (2008) and post- (2009) fire fauna data.

Several questions could be answered using the pre- and post- fire faunal survey data about the relationships with fire, fauna and habitat (vegetation), including:

1) What are the differences in terrestrial fauna before and after wildfire in banksia and melaleuca vegetation?,

2) What effect does a wildfire have on the habitat in banksia and melaleuca vegetation? and,

3) How does the thermal environment change between burnt and unburnt habitat in banksia and melaleuca vegetation after wildlife?

Methods

Study area

The Gnangara Groundwater System (GGS) which is located in south-west Western Australian on the Swan Coastal Plain covers approximately 220 000 ha and provides the city of Perth with ~ 60% of its drinking water. The groundwater system consists of an unconfined, superficial aquifer known as the Gnangara Mound (Government of Western Australia 2009). Although, the region has undergone extensive habitat modification it contains some of the largest remnant vegetation patches on the Swan Coastal Plain, and has been noted for high biodiversity values, particularly of the ground-dwelling vertebrates and wetlands (Kitchener *et al.* 1978; Storr *et al.* 1978).

In the past 30 years, a drying climate has been a significant feature of the Gnangara Groundwater System. Groundwater levels which have decreased by up to 4 m in some areas, due to decreased rainfall and increased aquifer abstraction (Vogwill *et al.* 2008). Climate modelling by CSIRO and the Indian Ocean Climate Initiative (IOCI) has predicted the possibility of an even greater decline in rainfall in future years, than the last 10 year average (11% drier than the 1997-2006 period). Aquifer modelling Perth Regional Aquifer Modelling System (PRAMS) predicts the possibility of even greater declines in groundwater levels, up to 11m on the crest of the superficial aquifer. The Gnangara Sustainability Strategy (GSS) was developed to consider issues confronting this complex system (Government of Western Australia 2009). To deal with the impending water crisis, a number of land management actions were recommended, including an increase in fire frequency of the banksia woodlands on the northern Swan Coastal Plain in order to increase recharge into the aquifer (Government of Western Australia 2009). There was thus a need to assess and understand the biodiversity consequences and impacts of any inappropriate fire regimes (Wilson *et al.* 2010).

Upon the Gnangara mound there are essentially two native vegetation types in between the introduced plantation of pine forest. *Banksia*s are found all over the south-west of Western Australia and range from trees up to 10m to rhizomatous creepers (Groom et al. 2001; Lamont et al. 2007). After a fire banksias rely on seedling germination for regeneration (Lamont *et al.* 2007). Banksia habitat in this study consists over a 10m open woodland canopy of banksia trees with variable understorey vegetation from low to high, including *Acacia* spp. *Melaleuca* vegetation is typified as dampland areas that undergo periodic flooding. It has a canopy of melaleuca trees with a dense understorey (Semeniuk et al. 1990; Groom et al. 2001).

Within the banksia and melaleuca habitat on the Gnangara mound there is known to be an array of vertebrate diversity. A total of 573 vertebrates are found in the GSS area including 13 species of frogs, 64 species of reptiles and 33 native species of mammals (Bleby *et al.* 2009). Many of these species are endemic to the area (Mittermeier *et al.* 2004), including *Pletholax gracilis gracilis* and *Ctenophorus adelaidensis* (Bleby *et al.* 2009). Mammals across Australia and upon the Gnangara mound are known to be declining (Cardillo and Bromham 2001; Abott 2008). These declines are not exclusive to mammals, reptile abundance has undergone a decline due to the urbanisation of the Northern Swan Coastal Plain and GSS area (Storr *et al.* 1978; Bleby *et al.* 2009). Although no amphibian species are threatened many are endemic to the area and depend on the vegetation of the Northern Swan Coastal Plain to persist (Bleby *et al.* 2009).

Fire event

The Yanchep Fire started at 0930hrs on Friday 16 January 2009 south of Breakwater Drive, east of Two Rocks. The fire was later found to have started on private property south of Breakwater Drive. The fire rapidly spread south under a northerly wind travelling in excess of 5000 meters per hour through grasslands and low coastal remnant vegetation before a wind change from the west pushed to fire towards Yanchep National Park. After travelling through the park, private property, state forest and large sections of Yanchep and Pinjar Pine Plantations the Yanchep Fire was contained on Saturday 17th of January at 0400hrs; the final fire area was 7640 hectares.

Site selection: Pre- and post- fire trapping survey

Of the 40 faunal trapping sites from the GSS Biodiversity project surveyed in 2007-2008 (only 2008 data was used in this study), 14 were burnt during the Yanchep Fire, six of which were re-established (pit-fall traps re-installed) and surveyed for ground-dwelling vertebrate in spring 2009. Ten unburnt sites were selected from the original 40 GSS fauna trapping sites that had not experienced the wildfire. This resulted in this study surveying a total of 16 sites using pitfall trap arrays placed in the original location, pre-fire (using GPS coordinates), including seven melaleuca sites and nine banksia sites (Figure 1; Table 1).

Table 1: Details of sites, their habitat and burn status. Burnt sites are those that underwent the 2009 wildfire event. All sites were surveyed in 2008 and 2009.

Site	Site description	Unburnt/burnt (control/impact)
4A	melaleuca	burnt
4B	melaleuca	burnt
7A	banksia	unburnt
7B	banksia	unburnt
8A	banksia	unburnt
8B	melaleuca	unburnt
9A	banksia	unburnt
9B	banksia	unburnt
10A	melaleuca	unburnt
10B	melaleuca	unburnt
12A	banksia	burnt
12B	banksia	burnt
13A	banksia	burnt
13B	banksia	burnt
15A	melaleuca	unburnt
15B	melaleuca	unburnt

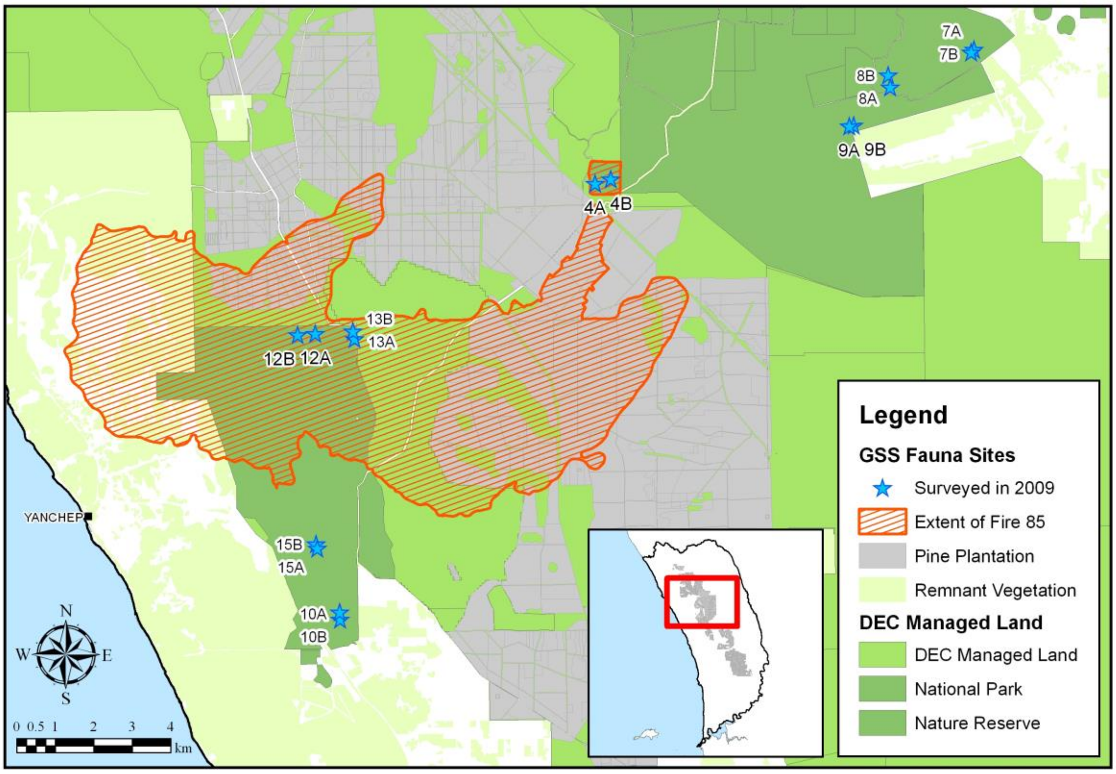

Figure 1: Location of the 16 sites surveyed pre- (2008) and post- (2009) wildfire event on the Gnangara mound.

Trapping design

At each of the 16 sites, ten pitfall traps were located in a 'Y' shape, with three pits placed along each arm radiating out from a central pit at approximately 7 metre intervals. The pitfall traps were connected with 30 cm high aluminium fly wire drift fence extended out one metre past the end of the last trap (Appendix 1).

Pre- fire data was collected in autumn 2008 and spring 2008 over 12-20 nights. Post- fire data was collected in late October and early November 2009 over nine nights.

During the pre- and post -fire trapping all traps were checked once per day in the early morning. Captured animals were identified, processed and released onsite. Measurements taken included: weight (g), snout-vent length (mm), total length (mm) for reptiles; weight (g), snout-vent length (mm), tibia length (mm) for amphibians; and, weight (g), head length (mm), short pes length (mm), gender, and presence of pouch young for mammals. Mammals were ear notched for recapture purposes, whilst reptiles were marked with a non-toxic permanent marker pen under the throat. Amphibians were not marked. Taxonomic nomenclature, including common names, followed the Western Australian Museum taxonomic checklist (Western Australian Museum 2009).

Habitat Assessment

Habitat assessments were conducted at all sites in 2008, and repeated at all sites post-wildfire event in 2009 to assess changes in the habitat after a wildfire. To examine microhabitat attributes randomised 1 m^2 quadrats were established on either side of each individual trap at all sites. Attributes assessed included vegetation structure and ground substrate composition. To provide an index of vegetation complexity within a 2 m height range, vegetation contact (both live and dead) was recorded (for height classes 0-20cm, 20-40cm, 40-60cm, 60-80cm, 80-100cm, 100-150cm, 150-200cm) using a graduated pole, placed at the point in the centre of the quadrat. Ground cover within the $1m^2$ quadrat was estimated as a percentage of vegetation (live and dead), soil (bare ground) and litter (including leaf and woody debris) to a total combined cover of 100%. Litter depth (cm) was measured using a ruler that was pressed through the litter (where relevant) until it touched a firm soil surface.

Thermal microhabitat data

Temperature data was collected using iButton thermologgers (Thermochron, Dallas Semiconductor/Maxim) located at various exposures to the sun within each burnt and unburnt site. Reptiles are ectothermic and use their environment to regulate their body temperature (Cogger 1996). Determining the differences in thermal habitat in burnt and unburnt sites will determine if wildfire has an impact on the thermal habitat of reptiles and their ability to body temperature regulation, as well as other fauna. In total 41 thermologgers located in 16 sites (melaleuca sites, two thermologgers per site = 14; banksia sites, three thermologgers per site = 27) collected temperature data over seven trapping days during late October and early November 2009. Thermologgers within gauze cloth were placed i) on top of the litter layer under a shrub (litter-shade) and ii) on top of the litter layer in full sun (litter-sun). Average daily temperatures (minimum, maximum, mean, range and co-efficient of variation) were then calculated for each iButton (an average of the two litter-sun iButtons was calculated for each site and used in analyses).

Statistical Analysis

Analysis of aim 1: examine differences in terrestrial fauna before and after wildfire in two main vegetation types in the GSS study area - banksia and melaleuca vegetation types.

To answer the first aim, examine differences in terrestrial fauna before and after wildfire in two main vegetation types in the GSS study area - banksia and melaleuca vegetation types, pre-fire data (2008) and post-fire (2009) were compared. Trap nights differed between 2008 and 2009, so data was standardised using 10 trap nights. The number of replicates within melaleuca sites were minimal (burnt = 2, unburnt = 4), whereas the number of replicates in banksia sites were robust (burnt = 4, unburnt = 6). For the purposes of this report, we have conducted separate analyses based on vegetation type.

Two way ANOVAs determined the relationships between the faunal measures and year (2008 and 2009) and burn status (unburnt and burnt) (IBM 2009). The dependant variables were reptile abundance, reptile species richness and the abundance of dominant individual species (*Ctenotus fallens*, *Hemiergis quadrilineata*, *Morethia obscura*, *Pogona minor* and *Aprasia repens Tarsipes rostratus*, *Mus musculus* and *Myobatrachus gouldii*). Few mammal and amphibian species were caught therefore mammal or amphibian abundance or species richness were not calculated or analysed.

Fauna community measures were compared at burnt and unburnt sites over the two time periods using a BACI (Before-After-Control-Impact) design using a repeated ANOVA. Burn status was the treatment (control- impact; unburnt and burnt) and year was the time factor (before - after; 2008 and 2009). A pair-wise comparison and post hoc tests (Tukey) determined the relationship between the four categories (before control =2008 unburnt, before impact = 2008 burnt, after control = 2009 unburnt sites and after impact = 2009 burnt sites) and the faunal measures (IBM 2009). The dependant variables were reptile abundance, reptile species richness and the abundance of dominant individual species (*Ctenotus fallens*, *Hemiergis quadrilineata*, *Morethia obscura*, *Pogona minor* and *Aprasia* *repens Tarsipes rostratus*, *Mus musculus* and *Myobatrachus gouldii*). Mammal and amphibian abundance were not calculated or analysed as captures were too low.

Community composition, defined as the average abundance (per 10 trap nights) of each species per site, was compared between burn status and year using a Multi-Response Permutation Procedure (MRPP, Mielke 1984) was used based on a rank-transformed Sorensen distance matrix in the statistical package, PC-ORD (McCune and Mefford 1999). MRPP is a type of nonparametric multivariate procedure for testing differences between groups and provides an A statistic, which is the chance-corrected within group agreement, and an associated p-value (McCune *et al.* 2002). All reptile species were included in community analyses of burnt/unburnt sites from 2008 and 2009. MRPP was performed on three groups based on the combination of burn status and year: unburnt, 2009; burnt 2009, unburnt sites 2008 and burnt sites 2008 (pre-wildfire), for both the banksia and melaleuca vegetation types independently.

Post-hoc pair-wise comparisons were used to examine differences in reptile assemblages among burn status and year combinations. Non-metric multidimensional scaling (NMDS, Kruskal 1964) was used to graphically depict the site assemblage relationships using PC-ORD (McCune and Mefford 1999). Dimensionality was determined using scree plots and Monte Carlo tests. Reptile species that were correlated with either NMS axes ($r^2 > 0.2$) are graphically depicted on the ordinations. In addition, Indicator Species Analyses on the reptile assemblage was conducted using the methods of Dufrene and Legende (1997) in PC-ORD (version 5.0).

Analysis of aim 2: to assess habitat changes following fire.

To analyse the habitat variables and the year (2008, 2009), burn status (burnt or unburnt) and year×burn status two-way ANOVAs were perfomed. Independent habitat variables were the percentage estimates of live vegetation cover, dead vegetation cover, soil cover and leaf litter cover, a measurement of litter depth and data collected on understorey structure, touch pole data. Counts for touch pole height classes 80-100cm, 100-150cm and 150-200cm were excluded from analyses due to limited data. Additionally habitat variables for each site were correlated with reptile species richness and abundance, and abundance data for dominant species from 2008 and 2009 using Pearson correlation coefficient (IBM 2009).

Analysis of aim 3: to compare temperatures in burnt and unburnt vegetation as an assessment of the thermal microhabitats available for fauna.

A two-way ANOVA (IBM 2009) of thermal microhabitat data tested the interactions between burn status (burnt and unburnt) and exposure to the sun (sun/shade) for five average daily temperature variables (minimum, maximum, mean, range, and coefficient of variation) was performed.

Results

Ground-dwelling fauna survey 2008 (pre-fire event)

In 2008 35 fauna species were trapped including, four mammal species, three frog species and 28 reptile species over an average of 2560 nights (range 1920-3200 trap nights) (Figure 2a and b; Appendix 2). The four mammal species were *Tarsipes rostratus* (Tarsipedidae), *Mus musculus* (Muridae), *Rattus fuscipes* (Muridae) and *Sminthopsis* sp. Five frog species (Limnodynastidae and Myobatrachidae families) were recorded. Reptiles captured included a range of families; Agamidae (2 genera, 2 species), Diplodactylidae (1 species), Gekkonidae (2 species), Pygopodidae (5 genera, 6 species), Scincidae (10 genera, 16 species), Elapidae (2 genera, 3 species) and Typhlopidae (1 species).

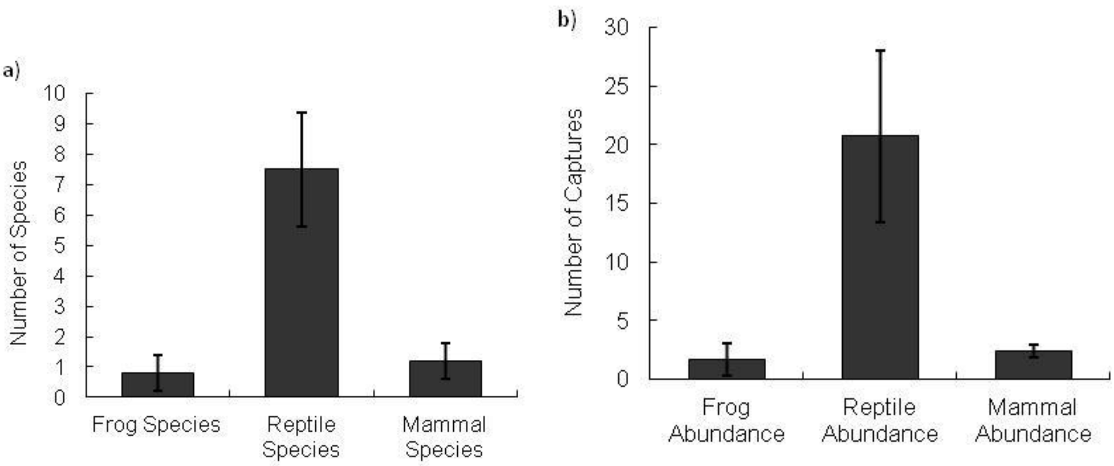

Figure 2: a) Species richness and b) total abundance of trapped fauna before the fire (2008) in *Banksia* and *Melaleuca* habitats.

Ground-dwelling fauna survey 2009 (post-fire event)

In 2009 the survey yielded 33 fauna species, three mammal species, four frog species and 26 reptile species over 1440 pitfall trap nights (Appendix 2). The mammals included *T. rostratus* and *R. fuscipes* and *M. musculus*. Four frog species were recorded with *Heleioporus eyrei* from absent from the 2009 surveys. Reptile families captured included: Agamidae (2 genera, 2 species), Diplodactylidae (1 species), Gekkonidae (1 species), Pygopodidae (5 genera, 6 species), Scincidae (10 genera, 13 species), Elapidae (2 genera, 2 species) and Typhlopidae (1 species). Generally more species and higher abundances were captured in unburnt sites compared to burnt sites (Figure 3a, b) and numbers of species captured in 2009 are lower than 2008.

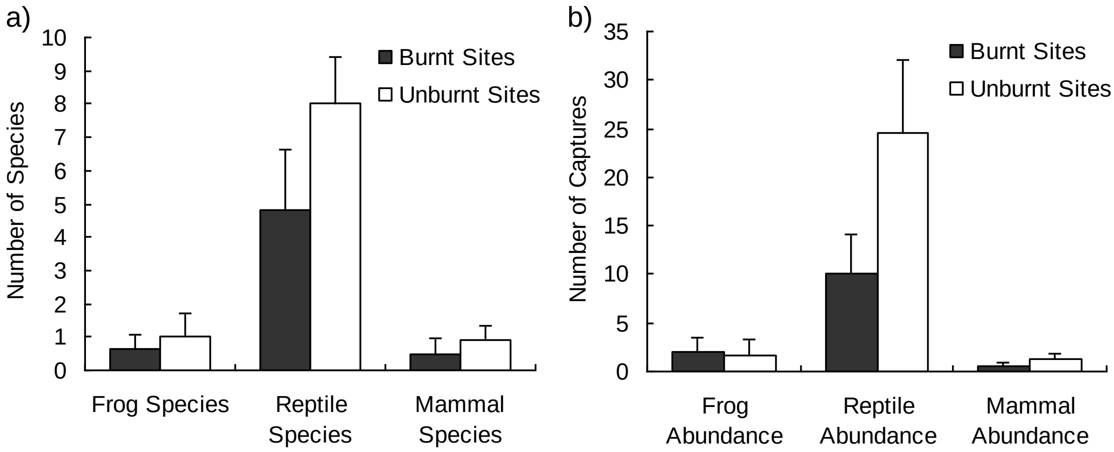

Figure 3: a) Species richness and b) total abundance of trapped fauna at burnt and unburnt sites (*Banksia* and *Melaleuca* habitats) in 2009.

Comparison of ground-dwelling fauna pre- and post- fire

Menetia greyii and *Ctenophorus adelaidensis* were the most abundant reptile species, followed by *Lerista elegans* and *Cryptoblepharus buchananii*, and were found at 75%, 63%, 56% and 75% of sites respectively. These species as well as *Ctentous fallens*, *Hemiergis quadrilineata*, *Morethia obscura*, *Pogona minor* and *Aprasia repens* were all examined independently.

Both mammal and amphibian capture rates were low. The abundance of two mammal species, *Tarsipes rostratus* (25% of sites-all unburnt) and *Mus musculus* (44% of sites-burnt and unburnt), and the frog *Myobatrachus gouldii* (50% of sites-burnt and unburnt) were examined independently. Only one individual of *Rattus fuscipes* was captured in an unburnt site. *Limnodynastes*, *Crinia* and *Pseudophyrne* frog species were captured only at unburnt sites in low numbers.

Almost 75% of the reptile species captured in the 2008 and 2009 surveys were caught in both years (23 out of 31 species) with all gecko and dragons species recorded in both surveys. Of the 23 species caught in both years, six species were caught in the 2008 impact sites, but not in the same sites in 2009 after they were burnt. These were:

- *Ctenotus fallens* (intermediate succession; above ground)
- *Hemiergis quadrilineata* (intermediate succession – but high early; prefer cool moist areas)
- *Lerista praepaedita* (Early succession; sand-swimmers)
- *Delma fraseri fraseri* (Semi-arboreal)
- *Lialis burtonis* (Late succession)
- *Pletholax gracilis gracilis*

Fauna at banksia sites

Significant interactions for reptile species richness and reptile abundance at the banksia sites were related to year, burn status and the interaction between the year and burn status (Table 2). *Ctenotus fallens*, *Lersita elegans* and *M. musculus* were related to the year alone. *Lerista elegans*, *Menetia greyii*, *Aprasia repens* and *Myobatrachus gouldii* were related to whether the sites were burnt or unburnt. Interaction between year and burn status was related to *Cryptoblepharus buchananii*, *C. fallens*, *M. greyii*, *Pogona minor*, *M. gouldii* and *Tarsipes rostratus*. *Hemiergis quadrilineata*, *Morethia obscura* and *C. adelaidensis* were unaffected by the year, burn status and year ×burn status of the sites (Table 2, Figures 4 and 5).

Table 2: Relationships in banksia sites between the species richness, reptile abundance, and individual species' abundances showing and year (2008 and 2009), burn status (burnt and unburnt) and year × burn status from two way ANOVA analyses (*F*-values and $P < 0.5$*, $P < 0.05$**, $P < 0.01$***).

Variable	**Year** df=1,14	**Burn Status** df=1,14	**Year×Burn Status** df=1,14
Species Richness	**7.248 ***	**4.804 ***	**4.804 ***
Reptile Abundance	**5.119 ***	**22.571 *****	**4.729 ***
Cryptoblepharus buchananii	1.652	0.110	**5.137 ***
Ctenotus fallens	**50.028 *****	0.946	**5.720 ***
Hemiergis quadrilineata	3.889 ^	3.889 ^	3.889 ^
Lersita elegans	**9.288 ****	**14.639 ****	1.037
Menetia greyii	2.629	**48.877 *****	**5.763 ***
Morethia obscura	1.476	4.400 ^	2.013
Pogona minor	0.386	0.068	**13.129 ****
Ctenophorus adelaidensis	0.001	1.592	0.953
Aprasia repens	0.584	**40.093 *****	0.584
Myobatrachus gouldii	1.228	**62.682 *****	**6.260 ***
Tarsipes rostratus	0.050	1.132	**7.605 ***
Mus musculus	**7.453 ***	1.826	1.407

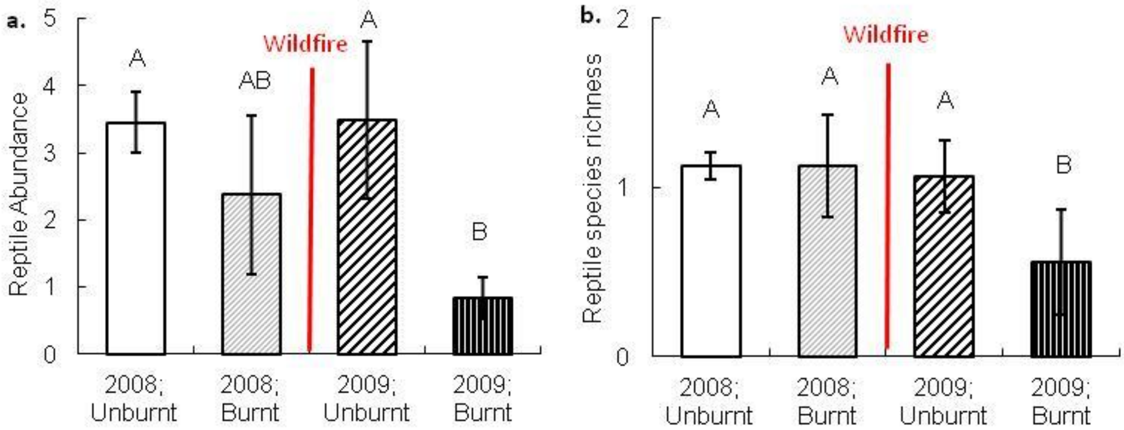

Figure 4: Differences in the mean (±95% CI) of a) reptile abundance and b) reptile species richness between burnt (impact) and unburnt (control) sites before and after the fire (2008 and 2009). Letters above error bars indicate significant differences of means between categories (Tukey HSD, $P < 0.05$).

Reptile abundance was significantly lower at the burnt sites in 2009 than unburnt sites in 2008 and 2009 and burnt sites in 2008. Reptile species richness was similar at sites before the fire and at unburnt sites post- wildfire. After the wildfire reptile species richness was lower at burnt sites, generating a significant difference between the burnt sites in 2009 and all other categories (Figure 4).

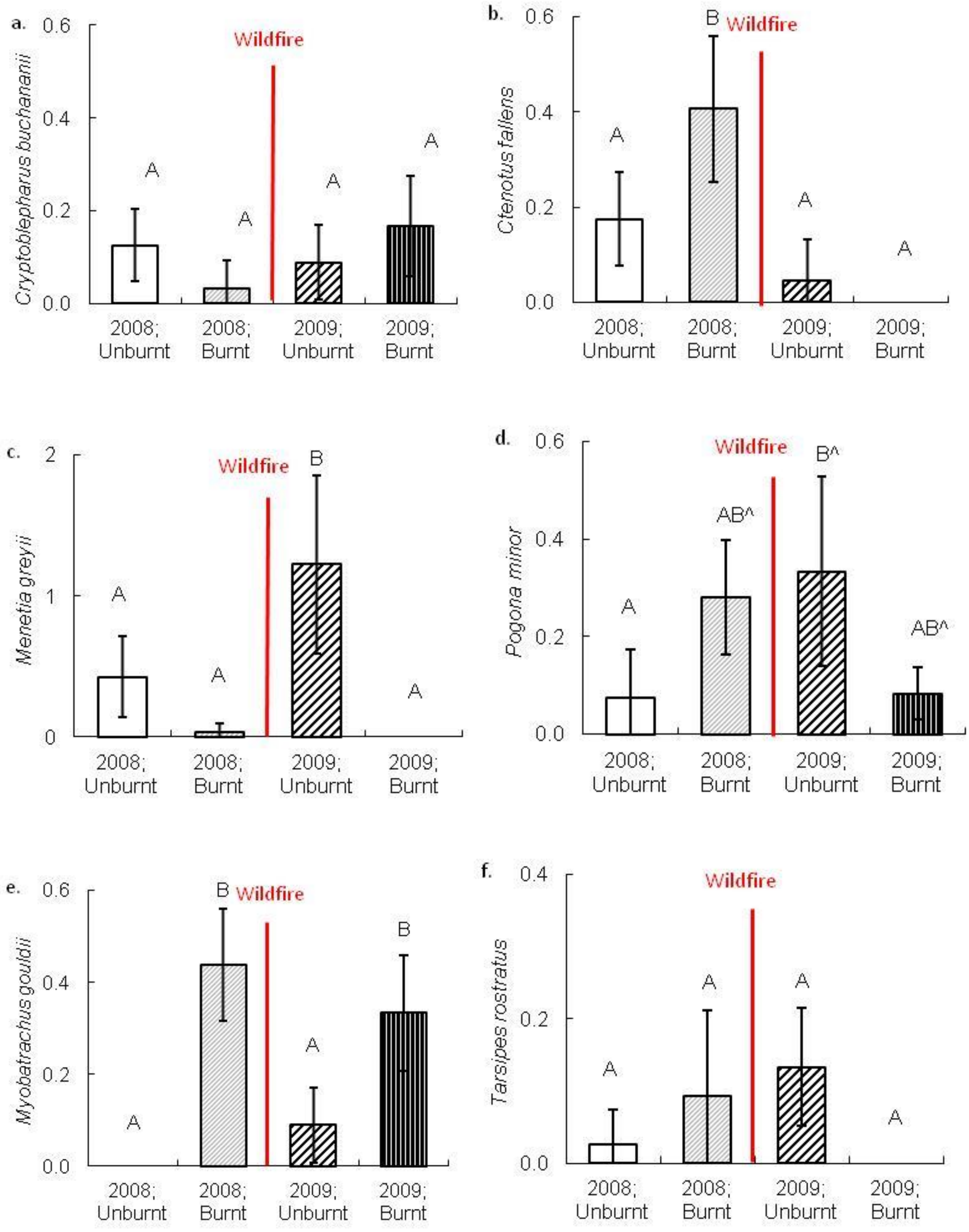

Figure 5: Differences in mean (±95% CI) of *Cryptoblepharus buchananii* (a), *Ctenotus fallens* (b), *Menetia greyii* (c), *Pogona minor* (d), *Myobatrachus gouldii* (e) and *Tarsipes rostratus* (f) between burnt and unburnt sites in 2008 and 2009 (pre- and post- fire). Letters above error bars indicate significant differences of means between categories (Tukey HSD, ▯ < 0.05; ^ $P < 0.07$).

Crytopheblarus buchananii had the highest abundances in the 2008 unburnt sites and 2009 burnt sites. Unburnt 2009 sites and 2008 burnt sites had the lowest abundance of *C. buchananii* (Figure 5a). Despite this species having a significant interaction between burnt status and year (Table 2) there was not a significant difference in the repeated ANOVA and post-hoc test analysis (Figure 5a).

Ctenotus fallens abundance was highest at burnt sites pre-wildfire event and was significantly different to all other categories (Figure 5b). Post-fire abundances of the skinks declined in both burnt and unburnt sites and the species was no present at burnt sites post-fire (Figure 5b).

Menetia greyii abundance was low in both unburnt and burnt sites prior to the wildfire. The skink's high abundance at unburnt sites in 2009 was significantly different to all other categories (Figure 5c). There were no captures of this skink in the 2009 burnt sites (Figure 5c).

Pogona minor abundance was significantly higher at unburnt sites in 2009. At the burnt sites captures of *P. minor* declined significantly from 2008 to 2009 (Figure 5d). Abundances of *P. minor* were significantly different in the burnt sites (before and after the fire event) to the unburnt sites (Figure 5d).

Myobachtrachus gouldii abundance was highest at burnt sites in 2008 and 2009, with no captures at unburnt sites until 2009. Captures of this species in the burnt sites were significantly different to the unburnt sites (Figure 5e).

The repeated ANOVA and post-hoc test analysis showed no difference in *T. rostratus* between the years and unburnt and burnt sites. After the fire event no captures were recorded at the burnt sites (Figure 5f).

Changes in fauna at melaleuca sites

In the melaleuca sites few relationships were seen between faunal measures and year, burn status and year×burn status. A significant interaction was detected for abundance of reptiles, and the skink *M. greyii* and burn status and year×burn. *Ctenophorous adelaidensis* was related to the burn status only (Table 3).

Table 3: Relationships in the melaleuca sites between for reptile abundance, species richness, and individual species' abundances showing responses to year (2008 and 2009), burn status (burnt and unburnt) and year × burn status from ANOVAs (*F*-values and $P < 0.5$*, $P < 0.05$**, $P < 0.01$***)

Variable	**Year** $_{df=1,10}$	**Burn Status** $_{df=1,10}$	**Year×Burn Status** $_{df=1,10}$
Species Richness	0.690	1.108	0.874
Reptile Abundance	2.518	**6.304 ***	**9.360 ***
Cryptoblepharus buchananii	1.027	3.220	1.429
Ctenotus fallens	0.424	0.271	0.661
Hemiergis quadrilineata	3.164	0.230	1.259
Lersita elegans	1.664	0.245	0.100
Menetia greyii	1.152	**4.979 ***	**8.854 ***
Morethia obscura	1.064	3.371 ^	2.504
Pogona minor	2.084	0.160	0.160
Ctenophorus adelaidensis	0.003	**5.064 ***	0.242
Aprasia repens	0.952	0.952	0.952
Myobatrachus gouldii	0.572	0.572	2.796
Tarsipes rostratus	0.908	0.908	0.908
Mus musculus	1.105	0.757	2.983

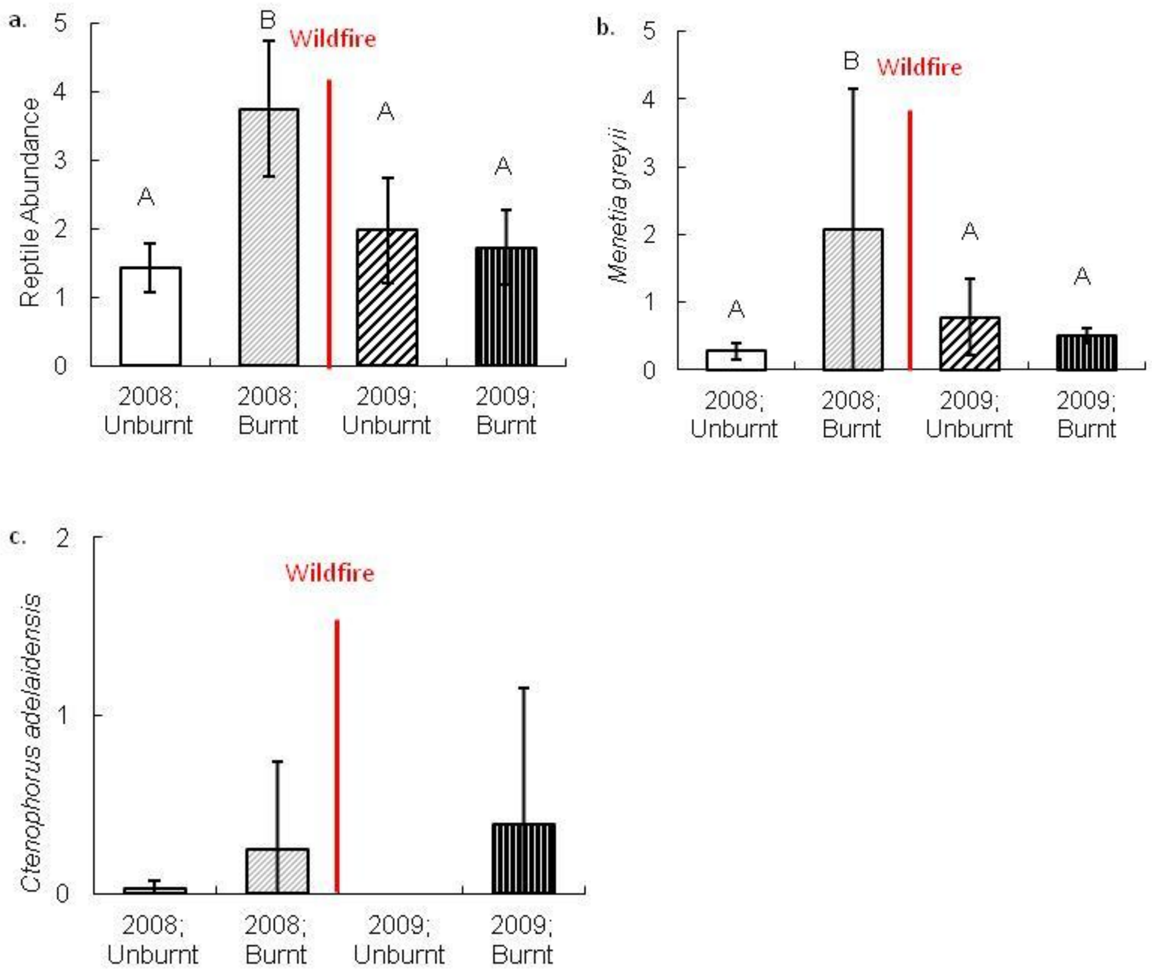

Figure 6: Differences in the mean (±95% CI) of reptile abundance (a), *Menetia greyii* (b) and *Ctenophorus adelaidensis* (c)between burnt and unburnt sites in 2008 and 2009 (pre- and post-wildfire). Letters above error bars indicate significant differences of means between categories (Tukey HSD, $P < 0.05$).

Reptile abundance at the pre-wildfire, burnt sites was significantly different to all other sites (Figure 6a).

Menetia greyii captures significantly declined at burnt sites after the wildfire event. *Menetii greyii* abundance at the 2008 burnt sites was significantly different to all other categories (Figure 6b).

Ctenophorus adelaidensis abundance was higher in burnt sites before and after the wildfire compared to the unburnt sites (Figure 6c). Abundance of *C. adelaidensis* was significantly difference at burnt and unburnt sites (Table 3), however, when a repeated ANOVA and a post-hoc test was performed these relationships were not significant. The relationships were only based on a few captures in the treatment sites and no captures in the control sites (Figure 6c).

Community composition of reptiles, year and burn status

There were differences in community structure between the four groups (unburnt and burnt in 2008 and 2009; MRPP: A = 0.218, $P = 0.036$) for the melaleuca sites and the banksia sites (MRPP: A = 0.533, $P < 0.001$). Pair-wise comparisons indicated that the banksia sites within each of the four categories differed (all $P < 0.01$).

NMDS ordination found a stable 2-dimensional solution representing 78% variance and a final stress value of 0.15. Burn status clearly separated along Axis 1, with differences in year evident along Axis 2. Pygopod, *A. repens* and the skink, *M. greyii* were both associated with 2009 unburnt sites, whilst the burnt sites had a lack of species (Figure 7).

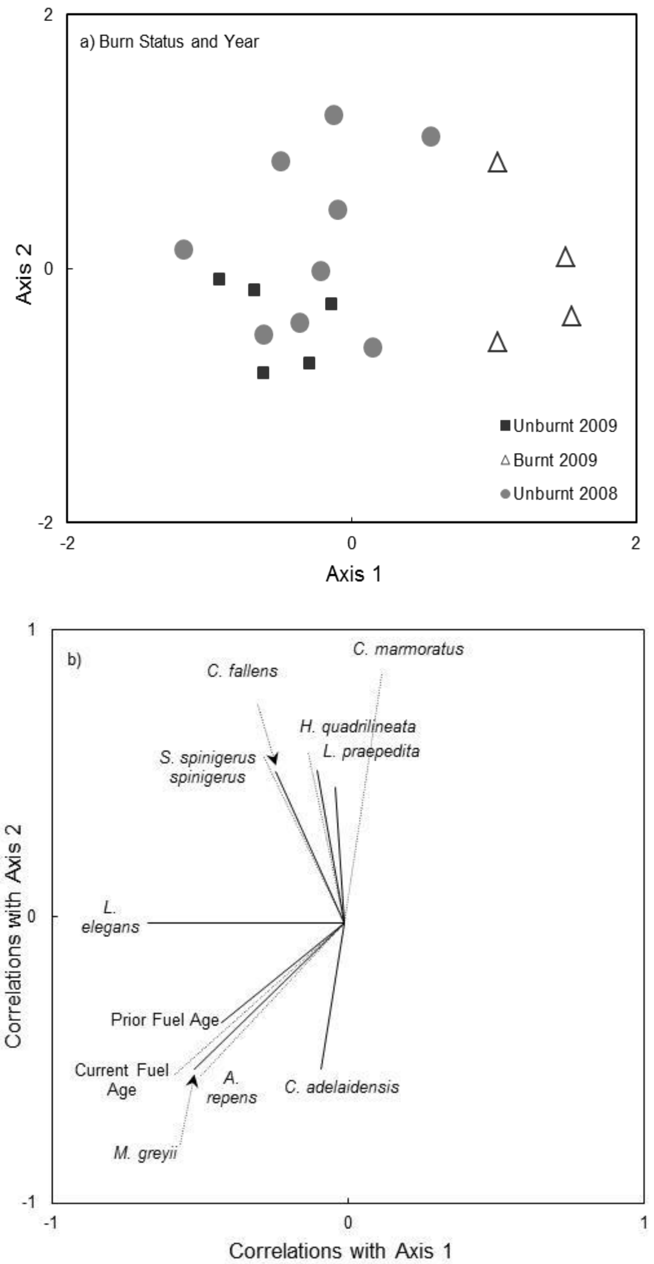

Figure 7: NMDS ordination (Sorensen distance measure) on the assemblage of reptiles (n = 30 species) at 9 sites from different years (2008, 2009) and burn status (pre- and post-fire). The ordination is in two dimensions (stress + x), with axis 1 and 2 cumulatively representing 78% variance (r squared = 50% and 29% respectively) (a). Correlations of species and fuel age ($r^2 > 0.25$) with NMDS ordination (b).

Habitat assessment

Patterns in banksia habitat variables

A number of significant interactions between year and burn status were observed in the analysis of the microhabitat and vegetation structure variables in banksia vegetation. The number of touches in the 0-20 and 20 – 40 cm height classes was related to year×burn status only. Litter depth soil cover, litter cover and canopy cover were related to burn status and year×burn status. Litter cover and canopy cover were additionally related to year (Table 4).

Table 4: Relationships between habitat variables and year (2008 and 2009), burn status (burnt and unburnt) and year × burn status from two-way ANOVA analyses (*F*-values and $P < 0.5$*, $P < 0.05$**, $P < 0.01$***).

Habitat Variable	Year	Burn Status	Year×Burn Status
0-20cm	0.394	0.082	**4.980 ***
20-40cm	3.154 ^	0.002	**10.944 ****
40-60cm	0.540	0.034	2.653
60-80cm	0.081	0.318	0.133
Litter Depth	0.641	**24.973 *****	**19.503 *****
Soil Cover	2.495	**17.725 *****	**45.820 *****
Litter Cover	**5.617 ***	**8.845 ****	**28.313 *****
Vegetation Cover	0.033	2.435	1.226
Canopy Cover	**5.647 ***	**12.120 ****	**4.716 ***

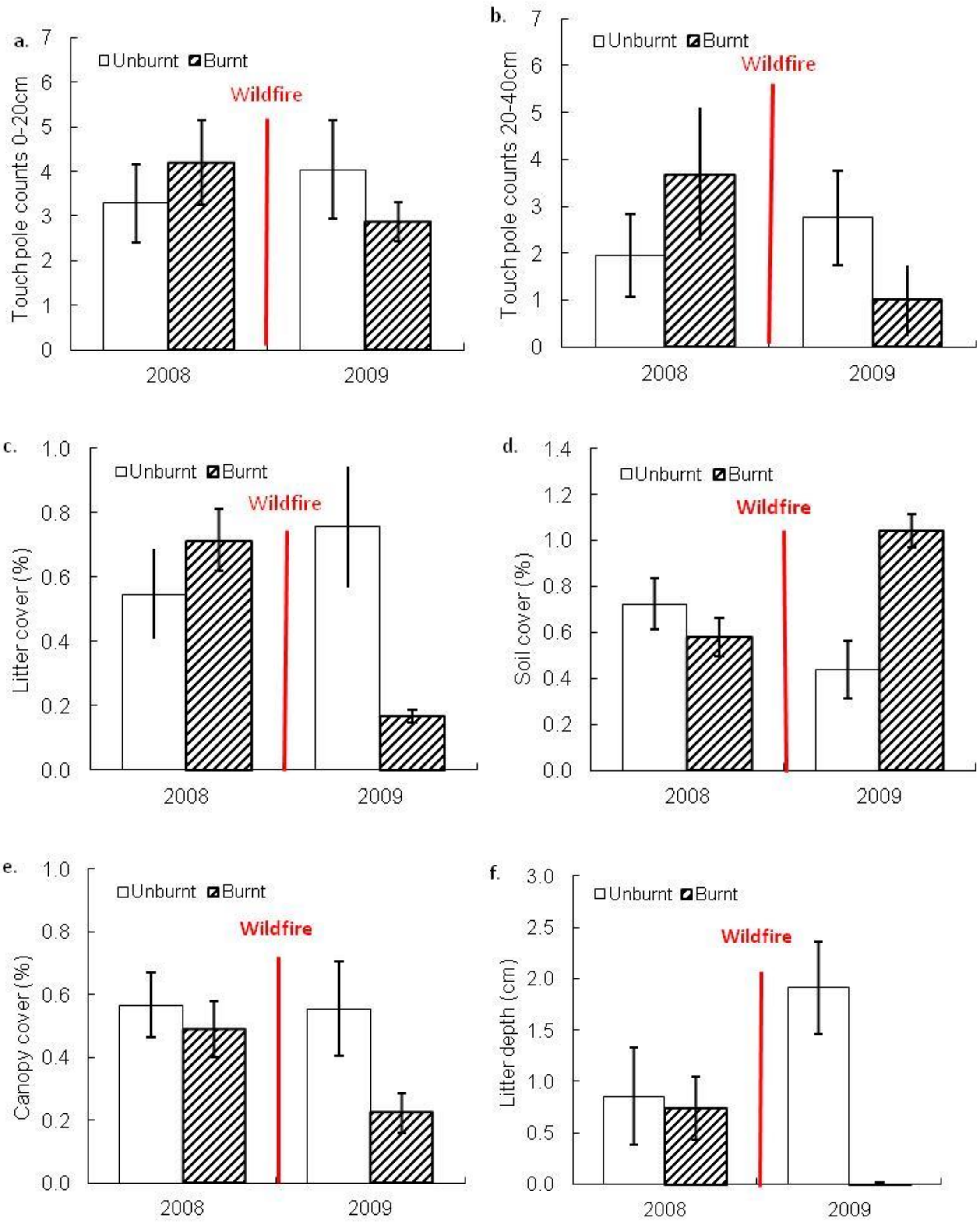

Figure 8: Interactions between year and burn status (mean ±95% CI) for touchpole counts at 0-20cm (a), b) touchpole counts at 20-40cm (b), litter cover (c), soil cover (d), canopy cover (e) and litter depth (f).

Touch poles counts from 0-20cm and 20-40cm and litter cover, canopy cover and litter depth were higher in burnt sites before the wildfire event in 2008 unburnt sites and in unburnt sites post-wildfire (2009) (Figure 8a, b, c, e and f). Litter depth was 0cm in 2009 after the wildfire (Figure 8f). Soil cover was the inverse and decreased at the unburnt sites from 2008 to 2009 and increased in the burnt sites (Figure 8d).

Fauna and banksia habitat measures

Several faunal measures were related to the banksia habitat. Both reptile abundance and species richness were positively correlated to litter cover and negatively to soil cover. Only reptile abundance was correlated positively with canopy cover and reptile species richness was positively related to touch pole counts 20-40cm (Table 5 and Figure 9a, b, c, and d).

Cryptoblepharus buchananii was negatively related to litter cover and positively to soil cover. *Lerista elegans* was positively correlated with canopy cover (Figure 9e) and *M. greyii* was positively associated with litter depth. *Aprasia repens* was negatively related to soil cover and positively to canopy cover and litter depth (Figure 9f). *Myobatrachus gouldii* was negatively correlated with canopy cover. The small mammal *T. rostratus* was negatively related to soil cover and positively to litter cover and litter depth. Several species had no relationships with the habitat such as, *C. fallens*, *H. quadrilineata*, *M. obscura*, *P. minor*, *C. adelaidensis* and *M. musculus* (Table 5).

Table 5: Pearson's correlations (r) of reptile abundance, species number and individual species' abundance from 2008 and 2009 trapping surveys with habitat variables.

	Litter cover	Soil cover	Canopy cover	Litter Depth	Touch Pole Counts	
					0 – 20 cm	20 – 40 cm
Reptile Abundance	**0.478***	**-0.512***	**0.502***	0.441^	0.259	0.188
Reptile Species Richness	**0.561***	**-0.539***	0.465^	0.375	0.375	**0.516***
Cryptoblepharus buchananii	**-0.492***	**0.508***	-0.450^	-0.329	0.119	-0.125
Ctenotus fallens	0.351	-0.253	0.282	-0.100	0.049	0.318
Hemiergis quadrilineata	0.247	-0.201	0.022	-0.032	0.215	0.416^
Lerista elegans	0.385	-0.270	**0.588***	0.341	0.008	-0.085
Menetia greyii	0.300	-0.450^	0.243	**0.504***	0.374	0.324
Morethia obscura	-0.044	0.030	0.219	-0.063	-0.088	-0.089
Pogona minor	0.439^	-0.450^	0.267	0.301	0.397	0.430^
Ctenophorus adelaidensis	-0.305	0.231	-0.0119	-0.221	-0.103	-0.083
Aprasia repens	0.361	**-0.519***	**0.500***	**0.648***	0.094	0.115
Mybatrachus gouldii	-0.253	0.283	**-0.511***	-0.438^	0.140	0.238
Tarsipes rostratus	**0.574***	**-0.585***	0.179	**0.489***	-0.089	0.144
Mus musculus	0.168	-0.032	0.145	-0.171	0.041	0.045

Significant values are in bold (* $P < 0.05$) and values approaching significance are identified (^ $0.1 > P \geq 0.05$*).

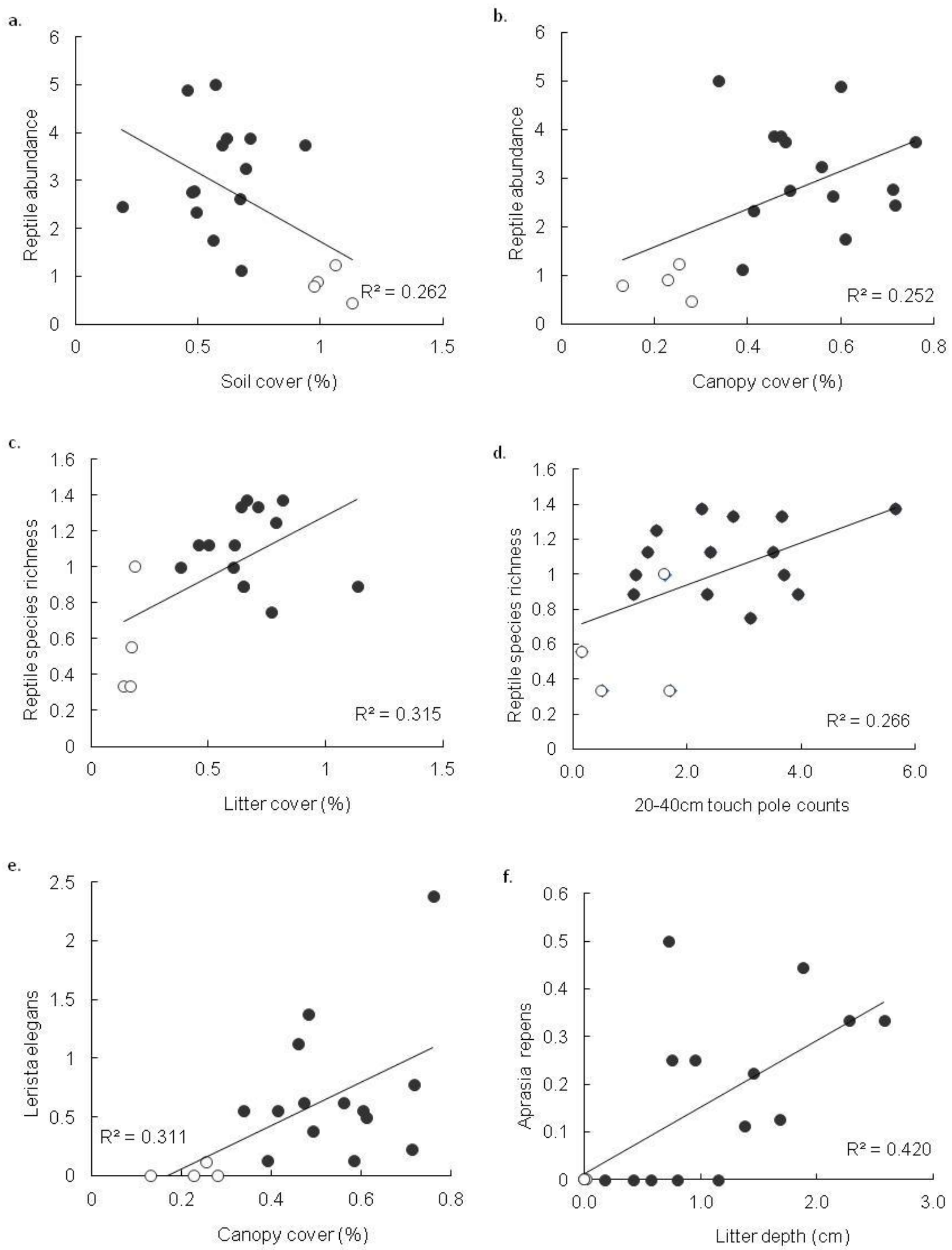

Figure 9: Relationships between reptile abundance and soil cover (a) and canopy cover (b), reptile species richness and litter cover (c) and 20-40cm touch pole counts (d) and *Lerista elegans* and canopy cover (e) and *Aprasia repens* and litter depth (f) from 2008 and 2009 trapping surveys in banksia habitat. Note that the relationship between reptile abundance and litter cover is similar to that of reptile species richness so only one figure is shown.

Patterns in melaleuca habitat variables

Few correlations between the melaleuca habitat and year, burn status and year×burn status were found. Year was related to litter cover, vegetation cover and canopy cover. Litter depth, litter cover and canopy cover were related year×burn status (Table 6).

Table 6: Relationships between the habitat variables and year (2008 and 2009), burn status (burnt and unburnt) and year × burn status from a two-way ANOVA analysis (*F*-values and $P < 0.5$*, $P < 0.05$**, $P < 0.01$***).

Habitat Variable	Year	Burn Status	Year×Burn Status
0-20cm	0.023	0.284	0.288
20-40cm	0.467	4.335 ^	0.013
40-60cm	1.402	1.943	0.317
60-80cm	1.490	1.815	0.746
Litter Depth	0.077	0.232	**6.591 ***
Soil Cover	0.331	0.645	2.953
Litter Cover	**10.543 ****	0.602	**33.210 *****
Vegetation Cover	**8.555 ***	0.580	1.031
Canopy Cover	**6.192 ***	1.349	**6.607 ***

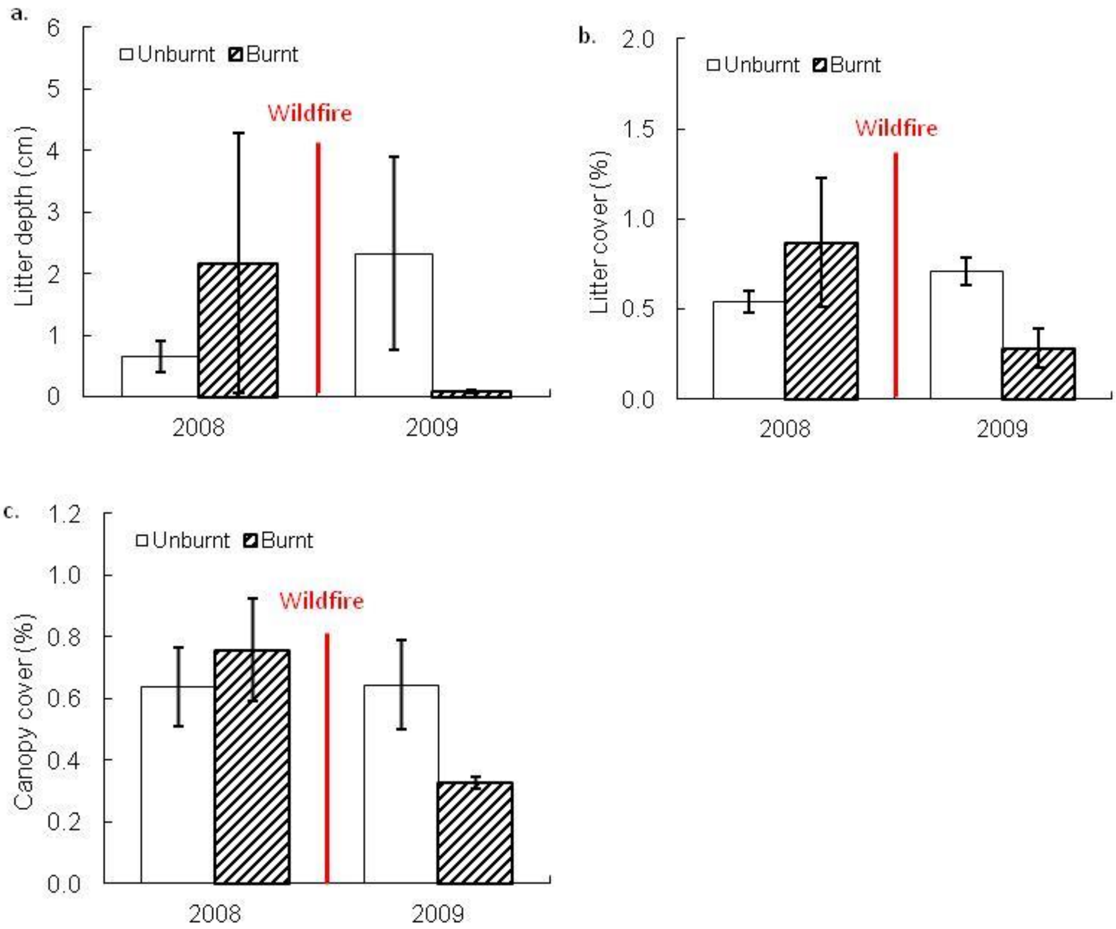

Figure 10: Significant interactions between year and burn status (mean ±95% CI) for litter depth (a), litter cover (b) and canopy cover (c).

Litter depth, litter cover and canopy cover significantly decreased in the burnt sites and increased in the unburnt sites from 2008 to 2009 (after the wildfire event; Figure 10a, b and c).

Fauna and melaleuca habitat measures

Reptile abundance was positively related to litter cover and depth (Figure 11a and b). *Ctenotus fallens* was related positively to canopy cover, litter depth and touch pole counts 0-20cm and negatively related to soil cover (Figure 11c, d and e). Positive correlations were seen between litter cover (Figure 11f), litter depth and *M. greyii*. *Morethia obscura* was negatively related to touch pole counts between 20-40cm. Lastly, *C. adelaidensis* was positively correlated with soil cover. Reptile species richness, *H. quadrilineata*, *L. elegans*, *P. minor*, *A. repens*, *M. gouldii*, *T. rostratus* and *M. musculus* had no relationships with the melaleuca habitat.

Table 7: Pearson's correlations (r) of reptile abundance, species number and individual species from 2008 and 2009 with habitat variables.

	Litter cover	Soil cover	Canopy cover	Litter Depth	Touch Pole Counts	
					0 – 20 cm	20 – 40 cm
Reptile Abundance	**0.619***	-0.253	0.473^	**0.556***	0.465^	-0.198
Reptile Species Richness	0.332	-0.312	0.427	0.097	0.352	0.156
Cryptoblepharus buchananii	-0.369	0.031	-0.387	-0.181	-0.102	-0.441
Ctenotus fallens	0.447	**-0.546***	**0.699****	**0.781****	**0.763****	0.368
Hemiergis quadrilineata	0.142	0.337	0.010	-0.225	-0.375	-0.100
Lerista elegans	0.052	0.160	0.229	-0.119	0.130	-0.136
Menetia greyii	**0.683****	-0.311	0.442	**0.600***	0.370	-0.220
Morethia obscura	0.166	0.034	0.320	0.076	-0.145	**-0.540***
Pogona minor	-0.253	0.172	-0.480^	-0.281	-0.318	-0.053
Ctenophorus adelaidensis	-0.298	**0.582***	-0.287	-0.270	-0.070	-0.168
Aprasia repens	0.089	-0.213	-0.283	-0.058	-0.362	-0.227
Mybatrachus gouldii	0.222	-0.022	0.011	0.024	-0.154	-0.339
Tarsipes rostratus	0.010	-0.256	0.092	-0.145	0.374	0.437
Mus musculus	-0.283	0.389	-0.138	-0.463^	-0.203	0.297

Significant values are in bold (* $P < 0.5$, ** $P < 0.01$) and values approaching significance are identified (^ $0.1 > P \geq 0.05$*).

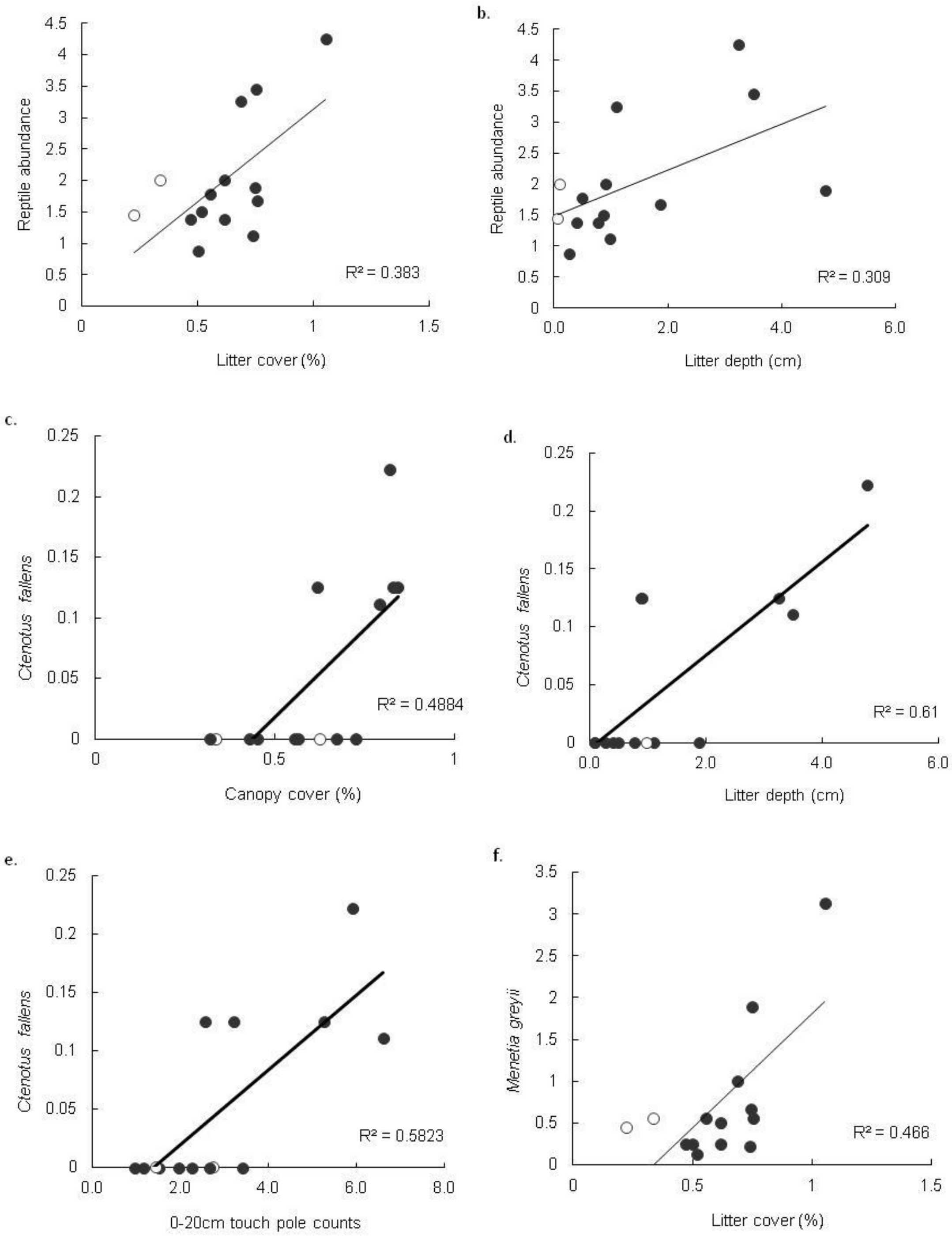

Figure 11: Relationships between reptile abundance and litter cover (a) and litter depth (b), *Ctenotus fallens* and canopy cover (c), litter depth (d) and touch pole counts from 0-20m (e), and *Menetia greyii* and litter cover (f) from the 2008 and 2009 trapping surveys in melaleuca habitat.

Thermal microhabitat data

Burn status significantly affected the minimum, mean temperatures and the coefficient of variation within the banksia sites only (Table 8a and Figure 12). Burnt banksia sites had a higher minimum and mean temperature than unburnt sites (Figure 12). Burnt banksia sites had lower variation in the temperature values (i.e. a lower coefficient of variation) than unburnt sites (Figure 12). Exposure significantly affected all variables within both vegetation groups with the exception of minimum temperature in melaleuca sites (Table 8b). Burn status×exposure had no effect on the temperature variables in either habitat type, with the exception of minimum temperatures and burn status×exposure in banksia and melaleuca sites which had a close to significant relationship with a p-value ≤ 0.1 (Table 8a and b).

Table 8: Burn status , exposure and burn status×exposure for daily average temperature variables, minimum, maximum, mean, range and coefficient of variation for a) banksia sites and b) melaleuca sites from a two-way ANOVA (F values in bold are $p \leq 0.1$^ and $p \leq 0.01$**).

a. Banksia sites

	Burn status	Exposure	Burn status×Exposure
Minimum temperature	**25.512****	**47.113****	4.266 ^
Maximum temperature	0.004	**342.106****	0.169
Mean temperature	**13.894****	**97.014****	0.005
Temperature range	2.815	**432.123****	1.154
Coefficient of variation	**19.133****	**443.855****	0.833

b. Melaleuca sites

	Burn status	Exposure	Burn status×Exposure
Minimum temperature	0.526	3.46	0.035 ^
Maximum temperature	0.784	**43.784****	0.729
Mean temperature	2.148	**25.11****	0.24
Temperature range	1.016	**40.829****	0.473
Coefficient of variation	2.228	**32.652****	0.032

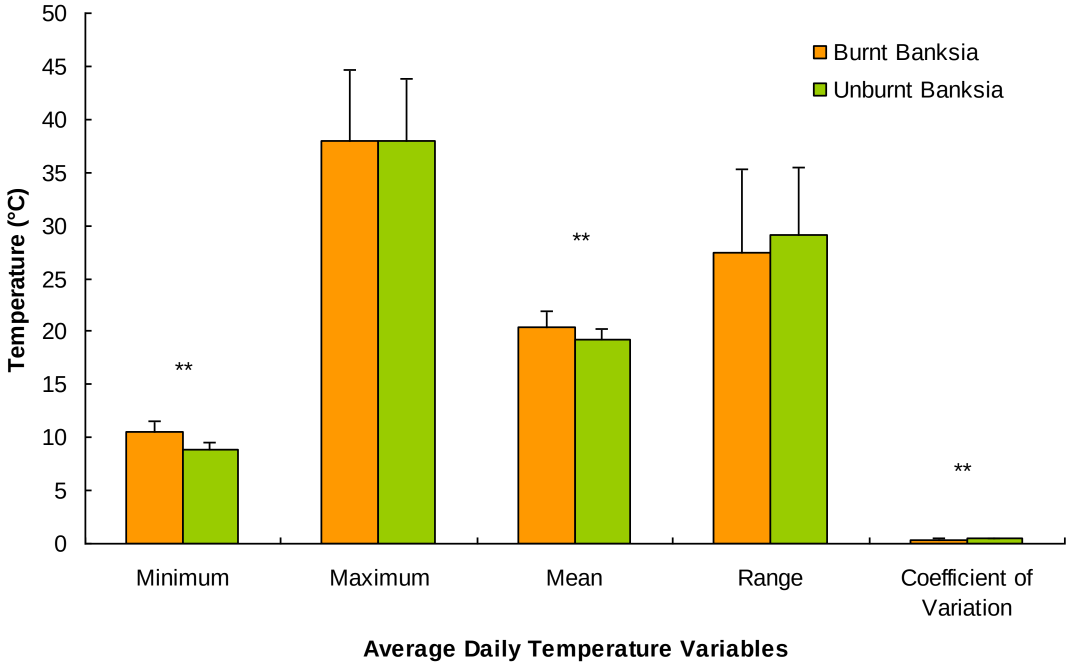

Figure 12: Average daily minimum temperature, maximum temperature, mean temperature, temperature range and coefficient of variation for burnt and unburnt banksia sites. Error bars are 95% confidence intervals; asterisks indicate a *p* value ≤ 0.01.

Mean temperatures of banksia and melaleuca, burnt and unburnt sites in the sun and shade over a 24hour period appear similar, with banksia habitat having slightly higher values (Figure 13). Unburnt sites in both banksia and melaleuca sites did differ in temperature over a 24 hour period from the burnt sites (Figure 13). Burnt melaleuca sites in the shade had the greatest variation most likely due to the small sample size (n= four iButtons).

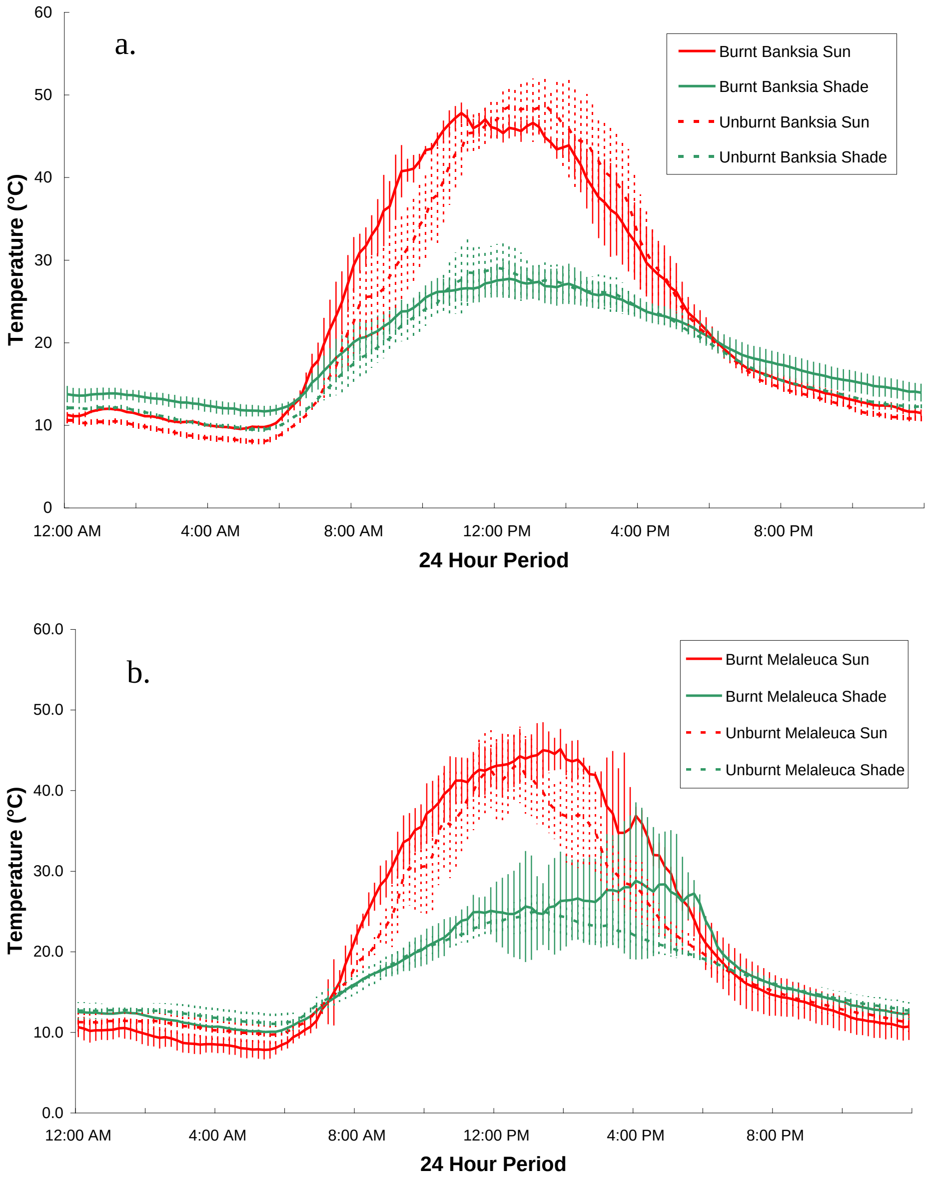

Figure 13: Temperature means over a 24 hour period in banksia (a) and melaleuca (b) burnt and unburnt sites in the shade and sun.

Discussion

Faunal measures and fire

Fire is a mechanism of change that alters the habitat available for fauna, thus potentially altering the faunal assemblages (Letnic et al. 2004; Letnic and Dickman 2005; Lindenmayer et al. 2008a). There are many studies investigating the succession of habitat and fauna post-fire (Fox 1982; Bamford 1992; Friend 1993; Masters 1993, 1996; Driscoll and Henderson 2008; Kelly et al. 2010). Generally, it can be said that faunal assemblages vary significantly between burnt and unburnt habitat with more faunal species in unburnt sites than burnt sites (Friend 1993; Masters 1996; Nimmo *et al.* 2012b). This study did not differ from these generalisations with more captures and higher species richness in the unburnt sites. Some species were not captured at all within the burnt sites in the post-wildfire surveys; *Ctenotus fallens*, *H. quadrilineata*, *L. praepaedita*, *D. f. fraseri*, *L. burtonis* and *P. gracilis*.

Banksia sites

Reptile abundance and species richness within banksia sites did not differ from the previous generalisations. In sites that remained unburnt, the increased habitat complexity most likely resulted in more captures and species (Nimmo *et al.* 2012b). Habitat changes after the wildfire including a reduction in leaf litter, canopy cover and understorey vegetation and increased soil cover, witnessed in this study and others (Lindenmayer *et al.* 2008a; Lindenmayer *et al.* 2008b), led to alterations in the reptiles present at burnt sites. As the habitat transforms post-fire so will the reptile assemblage (Fox 1982; Bamford 1992; Friend 1993; Masters 1993, 1996; Driscoll and Henderson 2008; Kelly et al. 2010).

Individual species had relationships with the burn status and year based on their habitat requirements. *Pogona minor* and *C. fallens* and prefer intermediate fuel age sites (Valenine et al 2009) for a mix of soil, leaf litter and understorey vegetation cover. Other studies on *P. minor* indicate perching sites and open foraging areas are used by the species (Bamford 1986; Friend 1993; Driscoll and Henderson 2008). A lack these habitat features in recently burnt habitat, aligns with a lack of captures post-wildfire at burnt sites. There were no captures of *C. fallens* in the burnt sites and fewer in the unburnt sites from 2008 to 2009, indicating that other factors may be affecting its abundance as well as the burn status of the sites.

Late successional habitat is often occupied by leaf litter dwelling reptiles that decline immediately after a fire event, recovering twenty to thirty years later as the leaf litter and understorey vegetation complexity increases (Friend 1993; Driscoll and Henderson 2008; Valentine et al. 2009). *Lerista elegans, A. repens* and *M. greyii* prefer late successional habitat after fire (Bamford 1986; Friend 1993; Valentine et al. 2009; Driscoll et al. 2012) and captures of this species were highest pre-fire event and lowest post-fire. All three species were related to the burn status of the site and *L. elegans* was also related to the year and *M. greyii* to the interaction between the year and burn status. Canopy cover was positively related to *L. elegans* and *A. repens* and *M. greyii* and, additionally *A. repens* was positively related to leaf litter depth and negatively related to soil cover. However, *M. greyii* abundance was lower in burnt sites before and after the fire event, indicating that other influences may be acting on their capture rate. Despite this, most of these reptile species and habitat relationships indicate preferences for a more complex habitat found many years since a fire event (Lindenmayer *et al.* 2008a; Lindenmayer *et al.* 2008b).

Not all reptiles followed the pattern of the habitat accommodation model (Fox 1982; Letnic et al. 2004; Letnic and Dickman 2005; Driscoll and Henderson 2008; Lindenmayer et al. 2008a; Lindenmayer et al. 2008b). *Crytopheblarus buchananii*, another late successional species had no change over year and burn alone but was related to the interaction between the year and burn status, similar to Bamford's (1986) study. This species was related negatively to litter cover, inverse of other reptile relationships and positively to soil over, indicating a preference for more open habitats. Open habitat found directly after a wildfire event was therefore of benefit to this reptile species.

Other species were unaffected by the fire event, differing again from the habitat accommodation model (Fox 1982; Letnic et al. 2004; Lindenmayer et al. 2008b). *Hemiergis quadrilineata* and *M. obscura* had no relationships with the year or burn status. *Hemiergis quadrilineata* is known to prefer intermediate fire age habitat (Valentine *et al.* 2009). In other studies the late successional species, *M. obscura* was influenced by fire events (Driscoll and Henderson 2008) and their numbers increased many years post-fire

(Driscoll *et al.* 2012), preferring dense understorey and deep leaf litter (Valentine *et al.* 2009). This study was conducted one year post-wildfire event, lacking the intermediate and late successional habitat required by these species, most likely resulting in their lower captures and lack of relationships with the year or burn status.

Some species, *C. adelaidensis* prefer more than one post-fire successional age, early successional habitat post-fire and often late successional habitat (Valentine *et al.* 2009). *Ctenophorus adelaidensis* requires above ground perches and areas of soil cover with low vegetation for foraging and shelter, generally located in sites that have been recently burnt or have an older fire history (Bamford 1986; Friend 1993). Captures of the species in this study were higher pre-fire and dropped immediately post-fire. However, *C. adelaidensis* had no relationships with the year or burn status. Perhaps, as noted previously the 2009 survey was too soon post-wildfire to pick up all habitat and reptile relationships. Surveys many years post-wildlife are likely to demonstrate different reptile and habitat correlations.

Myobatrachus gouldii abundances were most likely related to other environmental factors than the burn status of the sites. Abundances of the amphibian were higher in burnt sites pre- and post- fire, absent from unburnt sites before the fire event and related to burn status and year×burn status. Amphibians are only indirectly influenced by fire (Bamford 1992; Friend 1993), due to their burrowing ability to avoid fire events (Cogger 1996). Additionally, weather conditions may have altered the captures of this species instead of the fire event, creating a false relationship with burn status. Rainfall occurred before (29.4mm) and during the 2008 survey (3.2mm) and during the 2009 survey no rain was observed before the survey and only 2mm during survey (Pearce RAAF weather station, 009503; Bureau of Meterology 2009). Less canopy cover was also related to higher abundances of *M. gouldii*, perhaps indicating a requirement of more open areas for burrowing (Cogger 1996) as avoidance from the wildfire.

Tarsipes rostratus are known to prefer sites with an older fire history (Bamford 1986; Friend 1993). This species was not captured in the burnt sites after the wildfire event. Captures of *T. rostratus* were related to year×burn status, most likely a result of its habitat requirements being met in sites that were long since unburnt. Longer times since fire provides a build-up of litter depth and cover and reduced soil cover, required by the small mammal (Garavanta *et al.* 2000; Lindenmayer *et al.* 2008a). It is important to note that the variability in the captures of *T. rostratus* may have resulted in a lack of significant relationships between the burnt and unburnt and 2008 and 2009 sites.

Abundance of *M. musculus* changed from year to year but was not related to the fire event or any habitat variables. Other studies have noted that *M. musculus* abundance increases directly after a fire event, as the introduced species favours early successional habitat and are rarely captured in vegetation over 5 years since last fire event (Kelly *et al.* 2010; Kelly *et al.* 2011; Kelly *et al.* 2012). *Mus musculus* are evidently responding to habitat or environmental variables not measured in this study, such as the increased viability of *M. musculus* to potential predators in an recently burnt open habitat (Bos and Carthew 2003).

Melaleuca sites

Generally, there were fewer captures in melaleuca sites than banksia sites, resulting in fewer relationships between the year of survey, burn status and the faunal assemblage. Despite this there are several notable relationships.

Overall reptile and *M. greyii* abundance decreased in burnt sites after a fire, whereas *C. adelaidensis* abundance increased post-fire event. More and deeper leaf litter was found in sites that have not been burnt recently and were related to higher reptile abundances and the late successional species *M. greyii*, most likely for shelter and foraging resources (Bamford 1986; Friend 1993; Valentine et al. 2009; Driscoll et al. 2012). More soil cover is found in burnt sites and was related to higher abundances of *C. adelaidensis*. *Ctenophorus adelaidensis* intermediate successional species uses the open areas in recently burnt habitat (as well as long time since last fire habitat) for basking sites and prey capture opportunities (Bamford 1986; Friend 1993). Demonstrating the reptile species in melaleuca habitat are following the same succession and use of habitat post-fire (as per the habitat accommodation model) as those reptiles in banksia habitat.

Some reptile species were related to the habitat alone in melaleuca sites. *Ctenotus fallens* was related to a more complex habitat overall, including more canopy cover, leaf litter and vegetation and less soil cover, as found in other studies on the Swan Coastal Plain (Valentine *et al.* 2009). The leaf litter dweller *M. obscura* was negatively related to 20-40cm touch pole counts, which could be a result of their preference for lower vegetation and leaf litter, which would be obstructed by the growth of higher vegetation (Valentine *et al.* 2009; Moore *et al.* 2013). Species – habitat relationships in the melaleuca vegetation type generally indicate more captures in denser vegetation.

Habitat and fire

Banksia sites

Directly after a fire event, the literature indicates that there is decreased complexity habitat (i.e. less leaf litter, canopy cover and understorey vegetation and more soil cover) (Lindenmayer *et al.* 2008b) and this study did not deviate from the literature. In the control sites that underwent no wildfire event, complexity of the habitat was increasing over time (i.e. understorey vegetation complexity, litter cover and depth increased and soil cover decreased) compared to the burnt sites, where vegetation complexity was reduced directly after the wildfire event.

Melaleuca sites

In melaleuca sites burn status had fewer relationships with the habitat than in the banksia vegetation. However, relationships present were similar to those found in banksia vegetation. Litter, vegetation and canopy cover were lower after the fire event in the burnt sites and increased in those that did not undergo a fire event (with the exception of canopy cover).

Thermal habitat and fire

Fire events alter the habitat (Lindenmayer *et al.* 2008a; Lindenmayer *et al.* 2008b; Kelly *et al.* 2012; Nimmo *et al.* 2012a; Nimmo *et al.* 2012b) and therefore the environmental conditions reptiles are exposed to. As we know reptiles are ectothermic and rely heavily on the outside environment for maintenance of their body temperature (Shine 2005). Changes to their thermal habitat could significantly alter their behaviour and use of habitat (Shine 2005; Nimmo *et al.* 2012a). As banksia and melaleuca sites are structurally different, their thermal properties were likely to be as well. After a fire in banksia sites, the minimum and mean temperatures were higher with less variation than unburnt banksia sites. Melaleuca sites' thermal properties were unchanged by the wildfire event. However, when looking at the average temperatures over a 24 hour period banksia habitat appears be very similar to melaleuca habitat. A smaller sample size was used in melaleuca habitat, than the banksia habitat that could have influenced the result in this study. A stronger influence on the thermal properties of both habitat types was exposure to the sunlight (sun versus shade). Demonstrating that a fire event as well as exposure is likely to influence the thermal properties of the habitat and potentially alter the fauna assemblage.

Conclusion

Different faunal species have different resource requirements (food and shelter), and are therefore related to different habitat features before and after a fire, generally following the habitat accommodation model. Although, there were differences between the faunal groups, habitat and thermal properties of banksia and melaleuca vegetation, requirements by each faunal species remained the same across the vegetation types. Requirements by many faunal species were significantly influenced by the burn status and may not be met in all fire ages of habitat. To ensure that each species has its requirements met, a mosaic of fire ages is preferential across landscapes (Woinarski *et al.* 1999; Lindenmayer *et al.* 2008b; Nimmo *et al.* 2012a; Nimmo *et al.* 2012b). Surveys post- 2009 will better inform managers of the reptilian-habitat relationships over time.

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Appendix 1: Species captured during fauna surveys in 2008 and 2009.

Class	Family	Species
Amphibia	Limnodynastidae	*Limnodynastes dorsalis*
	Myobatrachidae	*Crinia insignifera*
		Myobatrachus gouldii
		Pseudophryne guentheri
Reptilia	Agamidae	*Pogona minor minor*
		Ctenophorus adelaidensis
	Diplodactylidae	*Strophurus spinigerus spinigerus*
	Gekkonidae	*Christinus marmoratus*
	Pygopodidae	*Aprasia repens*
		Delma concina concina
		Delma fraseri
		Lialis burtonis
		Pletholax gracilis gracilis
		Pygopus lepidopodus
	Scincidae	*Acritoscincus trilineatum*
		Cryptoblepharus buchananii
		Ctenotus fallens
		Ctenotus impar
		Cyclodomorphus celatus
		Egernia napoleonis
		Hemiergis quadrilineata
		Lerista elegans
		Lerista praepedita
		Menetia greyii
		Morethia lineoocellata
		Morethia obscura
		Tiliqua rugosa rugosa
	Typhlopidae	*Ramphotyphlops australis*
	Elapidae	*Demansia psammophis reticulata*
		Parasuta gouldii
Mammalia	Muridae	*Mus musculus*
		Rattus fuscipes
	Tarsipedidae	*Tarsipes rostratus*