Department of Sustainability and Environment

Assessment of the status of threatened herpetofauna following fire in sub alpine habitat at Lake Mountain and Mount Bullfight, near Marysville, north-east Victoria

Black Saturday Victoria 2009 – Natural values fire recovery program

Katie Howard, Nick Clemann, Joanne Antrobus

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Assessment of the status of threatened herpetofauna following fire in sub alpine habitat at Lake Mountain and Mount Bullfight, near Marysville, north-east Victoria

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Front cover photo: Lake Mountain bog system (© Gavin Currie).

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Acknowledgements

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Summary

The 'Black Saturday' "Murrindindi" fire intensely burnt sub-alpine habitats at Lake Mountain on 7th February 2009. Most of Mount Bullfight Nature Conservation Reserve (NCR) was also burnt, although at a lower intensity than at Lake Mountain.

Several species of herpetofauna that are listed as threatened at state and federal levels are known historically from Lake Mountain. Conversely, the herpetofauna of Mount Bullfight NCR is poorly known. Surveys were conducted in the summer of 2009/2010 to determine the status of the Alpine Tree Frog *Litoria verreauxii alpina* and the Alpine Bog Skink *Pseudemoia cryodroma* in these areas. A previously unknown population of Alpine Tree Frogs was detected at Mount Bullfight NCR. The Alpine Bog Skink was recorded at Lake Mountain, although numbers were low. This report documents a second season of surveys for threatened herpetofauna in these areas over the summer of 2010/2011. Survey results from 2010/2011 are compared with 2009/2010 findings.

Diurnal and nocturnal frog surveys were conducted during November and December 2010 at Lake Mountain and Mount Bullfight NCR. Surveys in 2010/2011 were expanded to include bogs at Mount Bullfight NCR that were further upslope than the bog system surveyed in 2009/2010. At the lower bog at Mount Bullfight NCR a large population of Alpine Tree Frogs was detected. Alpine Tree Frogs and Victorian Smooth Froglets *Geocrinia victoriana* were detected at the upslope bogs. Common Froglets *Crinia signifera* were detected at the lower bog, and were recorded in large numbers on the upper bog. In addition to the Common Froglets detected at Lake Mountain (the only frog species detected on this plateau in 2009/2010), three *Litoria ewingii*-complex frogs were detected at Lake Mountain in 2010/2011. It is unknown whether these individuals migrated into the area, were introduced to the area via human activities, or were present during previous surveys but not detected.

Reptile surveys were conducted at Mount Bullfight NCR in November 2010 and March/April 2011, and at Lake Mountain in February/March 2011. Alpine Bog Skinks were captured at Lake Mountain in higher numbers than the previous year. No Alpine Bog Skinks were detected at Mount Bullfight NCR, although one *Pseudemoia* species of intermediate colour pattern was collected and will be identified through molecular analysis at a later date. The Southern Grass Skink *Pseudemoia entrecasteauxii* was the most common species captured at Mount Bullfight NCR. The Mountain Skink *Liopholis montana* was not detected during the present surveys. The Mountain Skink has specific habitat requirements and high site fidelity; consequently, it is easily missed in surveys. Therefore, it is possible the Mountain Skink may occur in the area, but went undetected.

At Lake Mountain, seven of nine sites returned positive tests for the Amphibian Chytrid Fungus. The Amphibian Chytrid Fungus was not detected on frogs swabbed at Mount Bullfight NCR. Although it is possible that this site was free of the fungus at the time of sampling, the fungus may have been persisting at a low prevalence and not been detected.

The disease chytridiomycosis, caused by the Amphibian Chytrid Fungus, represents the greatest threat to populations of the Alpine Tree Frog at Mount Bullfight NCR. We recommend that all people working in this area adhere to strict hygiene protocols in order to minimise the risk of introducing the Amphibian Chytrid Fungus to Mount Bullfight NCR, and suggest that unnecessary entry to the bog systems in this area be avoided.

We also recommend that additional site management activities be minimised, including road works, as this may introduce the fungus or infected frogs to the area. We suggest that limited weed, deer and predator control could be beneficial if it does not increase the risk of introducing the fungus, and is not carried out in the immediate vicinity of the bog systems. Impacts on habitat at Lake Mountain related to recreational activities or ski resort activities, that cause physical or chemical disturbance to water or native vegetation, should be avoided. Further recommendations are provided including bi-yearly surveying of Alpine Tree Frogs and the Amphibian Chytrid Fungus at Mount Bullfight NCR.

1 Introduction

1.1 The Black Saturday Fires

Extensive and multiple bushfires ignited in Victoria on February 7th 2009. This date is routinely referred to as 'Black Saturday'. These fires followed a long period of exceptional weather, with many records set for maximum temperature, heatwave duration and low rainfall (BOM 2009). Both Lake Mountain and Mount Bullfight Nature Conservation Reserve (NCR) were burnt by the 'Murrindindi' bushfire during the afternoon and evening of Black Saturday. The entire Lake Mountain plateau, including all woodlands, heathlands and mossbeds, was burnt (Figure 1). At Mount Bullfight NCR, 98% of the reserve was burnt; however, the fire was of a lower intensity than that at Lake Mountain (Tolsma and Shannon 2009).

1.2 Study areas

Lake Mountain lies within the Yarra Ranges National Park in the Victorian Central Highlands, and Mount Bullfight NCR is situated approximately seven kilometres north-east of Lake Mountain. Parks Victoria co-manages the Lake Mountain plateau, with the skiing infrastructure managed by the Lake Mountain Alpine Resort under a Heads of Agreement. Parks Victoria is responsible for the management of Mount Bullfight NCR (Parks Victoria 2002).

1.3 Project background

In 2009, Parks Victoria received funding from the Australian Government's *Caring for Our Country* fund to investigate the impact of the Black Saturday 'Murrindindi' fire on a range of threatened species. The results of the herpetofauna components of this work were reported by Howard *et al.* (2010) and Clemann and Antrobus (2010). Second year surveys were also funded by the Victorian and Commonwealth governments 'Rebuilding Together' – Statewide Bushfire Recovery Plan, announced in October 2009 This report documents the second season's surveys for threatened herpetofauna at Lake Mountain and Mount Bullfight NCR.

1.4 Distribution and conservation status of the Alpine Tree Frog, Alpine Bog Skink and the Mountain Skink

1.4.1 The Alpine Tree Frog

The Alpine Tree Frog *Litoria verreauxii* alpina is listed as a threatened taxon under the *Victorian Flora and Fauna Guarantee Act 1988*. It is also listed as Critically Endangered by DSE (2007), and as Vulnerable nationally under the *Environment Protection and Biodiversity Conservation Act 1999*. A draft Victorian Action Statement (Clemann in prep.) and a draft National Recovery Plan (Clemann and Gillespie 2007) have been prepared for this

Historically, the Alpine Tree Frog was distributed across most of the high country of the south-eastern Australian mainland (Osborne *et al.* 1999) (Figure 2). Within this broader range, the frog has a small and fragmented geographic distribution due to its restriction to isolated mountain peaks and plateaux. Within Victoria, records of the Alpine Tree Frog extend from the vicinity of Tom Groggin in the north-east of the state, across the higher altitudes of the Great Dividing Range, to Mt Baw Baw in the south-west of the taxon's range (Figure 2).

The Alpine Tree Frog occurs in high montane, subalpine and alpine environments. It is a habitat generalist, recorded in a range of terrestrial habitats including woodland, heath, grassland and herb fields, and human modified habitats. Although the Alpine Tree Frog was once common and abundant throughout its range, there have been severe declines in recent decades (Clemann and Gillespie 2007), including local extinctions e.g. Mount Baw Baw and the Bogong High Plains. Alpine Tree Frogs were common at Lake Mountain during the 1960's, with the last voucher specimen collected in 1970. Only one Alpine Tree Frog has been recorded at Lake Mountain since then, in 1993 (Victorian Fauna Database). Unfortunately this individual was only heard and not observed. Therefore this record should be treated cautiously given known declines, uncertainty in taxonomy, and the similarities between the call of the Alpine Tree Frog and related species. The Alpine Tree Frog was first recorded at Mount Bullfight NCR in December 2009, during the first year of this study (Howard *et al.* 2010).

The draft National Recovery Plan for Alpine Tree Frogs lists disease (chytridiomycosis, caused by the Amphibian Chytrid Fungus) and climate change as major threats (Clemann and Gillespie 2007). The Amphibian Chytrid Fungus has been strongly implicated in the declines of amphibians worldwide (Berger *et al.* 1999). The disease has been detected in Alpine Tree Frog populations in the Snowy Mountains, the Dargo High Plains and around Mount Hotham (Hunter *et al.* 2008, Clemann *et al.* 2009). Another potential threat is the likely increase in the frequency, extent and severity of wildfire due to climate change or extended periods of drought.

1.4.2 The Alpine Bog Skink

The Alpine Bog Skink *Pseudemoia cryodroma* is only known from Victoria, where it is listed as threatened under the Flora & Fauna Guarantee Act 1988. It is also listed as Endangered in Victoria by DSE (2007). Alpine Bog Skinks are restricted to the north-eastern highlands in Victoria (Figure 3). Although Alpine Bog Skinks have not been recorded in New South Wales, the presence of populations close to the border (at Davies Plain), and the difficulties in capturing and identifying the species (Clemann 2002a), suggest that it may yet be detected in alpine areas of southern New South Wales.

Alpine Bog Skinks occur in alpine and subalpine habitats above 1000 m elevation. They commonly occur in bogs, boggy creeks, alpine grasslands and wet heath, and less commonly in dry heath and Snow Gum woodland (Hutchinson and Donnellan 1992, N. Clemann unpublished data). Although sympatric with the Tussock Skink *P. pagenstecheri* and Southern Grass Skink *P. entrecasteauxii*, the Alpine Bog Skink tends to occur in wetter microhabitats than the Tussock Skink, and more open areas than the Southern Grass Skink (Hutchinson and Donnellan 1992). The similarities between the *Pseudemoia* species often makes it difficult to confidently identify individuals. Maggie Haines (Melbourne University) is completing a PhD studying the genetics of the *Pseudemoia* genus. It is hoped that this study will remove the ambiguity associated with identifying members of this genus of skinks.

A draft Action Statement (Clemann in prep.) prepared for Alpine Bog Skinks identifies several threats to the species, including:

- climate change;
- loss and degradation of habitat due to development of roads, tracks, ski resort infrastructure, weed invasion, inappropriate fire regimes, grazing and trampling by exotic herbivores (cattle, horses, deer);
- direct mortality due to fire;
- direct mortality due to elevated levels of predation by exotic predators (Feral Cats *Felis catus* and Red Foxes *Vulpes vulpes*); and
- extreme vulnerability of populations to stochastic events such as disease.

1.4.3 The Mountain Skink

The Mountain Skink *Liopholis montana* is a recently described species (Donnellan *et al.* 2002) that occupies montane, subalpine and alpine areas, typically in open forest, snow gum woodlands and heathland in the uplands of south-eastern Australia. The occurrence of Mountain Skinks is usually linked to granite boulders, slabs or rock screes. Mountain Skinks are a burrowing species that typically shelter in elaborate burrow systems excavated beneath rocks (Chapple 2003). Although not well known, it is likely that this species' distribution is disjunct. Within Victoria records exist from the upper Yarra Valley, along the higher elevations of the Great Dividing Range, to Davies Plain in the far north-east of the state. Mountain Skinks are listed as Data Deficient by DSE (2007).

1.5 Project objectives

The aim of this study was to determine if the Alpine Tree Frog, Alpine Bog Skink and the Mountain Skink occupy the Lake Mountain Plateau and Mount Bullfight NCR in the second year since fire, and to compare these results to the 2009/2010 surveys. Specifically, this project aimed to:

- reassess and determine post-fire persistence of Alpine Tree Frogs and the Alpine Bog Skink at Lake Mountain and Mount Bullfight NCR;
- attempt to detect any threatened herpetofaunal species, other than those recorded in 2009/2010 are present at Lake Mountain and Mount Bullfight NCR;
- provide management advice to Parks Victoria about practices required to maintain and enhance habitat for threatened species detected during the project.

Figure 1. Location of Lake Mountain and Mount Bullfight Nature Conservation Reserve, and the extent of the fire that affected the area, starting on 7th February 2009.

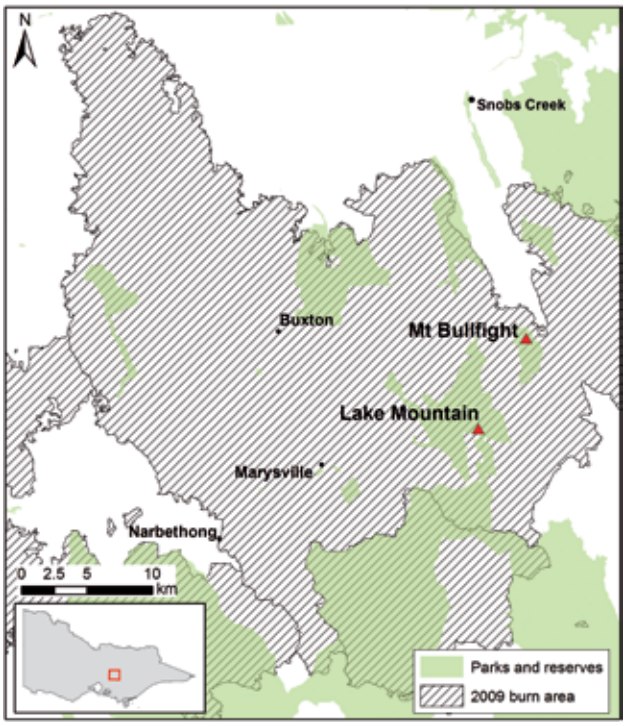


Figure 2. Historic records of the Alpine Tree Frog *Litoria verreauxii alpina* (sources: Victorian Fauna Database, Atlas of New South Wales Wildlife database, Museum Victoria, Australian Museum).

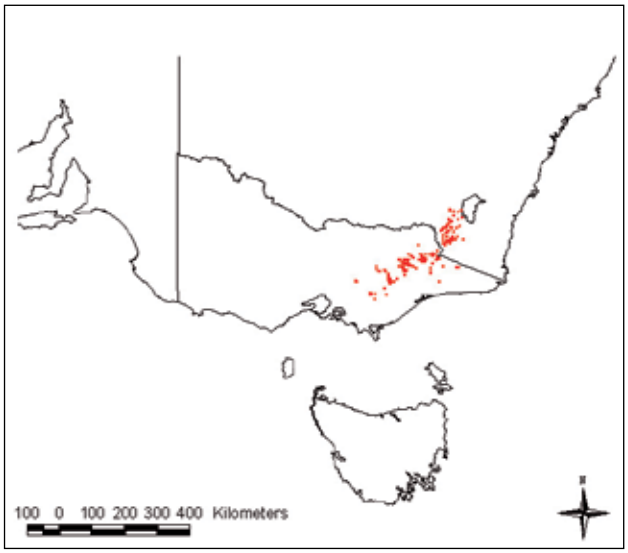
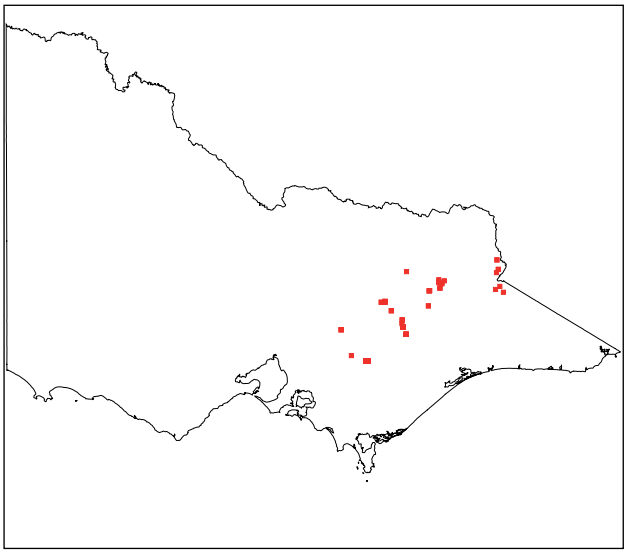


Figure 3. Distribution of the Alpine Bog Skink *Pseudemoia cryodroma* (source: Victorian Fauna Database). Note – this map represents records up to 2007. More recent records do not appear on this database.



2 Methods

2.1 Study areas

Lake Mountain is located at the western edge of the alpine/subalpine zone of mainland Australia (Parks Victoria 2002). The plateau rises to 1480 m in altitude, although much of it is at altitudes of 1250 to 1450 m (ARC and DCE 1990), and may be considered subalpine. Wetland vegetation communities at Lake Mountain cover around 2.5% of the area above 1300 m (Hargreaves 1977). Figures 4 and 5 display the location of Lake Mountain and the sites surveyed during this project.

Most of Mount Bullfight NCR is higher than 1300 m and is dominated by subalpine vegetation. The wetland areas are more restricted and cover only about 1% of the area above 1300 m (Tolsma and Shannon 2009). During 2009/2010 only the lower bog system at Mount Bullfight NCR was surveyed. In the 2010/2011 season, surveys were expanded to include the bog system located upslope. The upper bog system consisted of five separate bog areas up to 320 m apart (Figure 4 and 6).

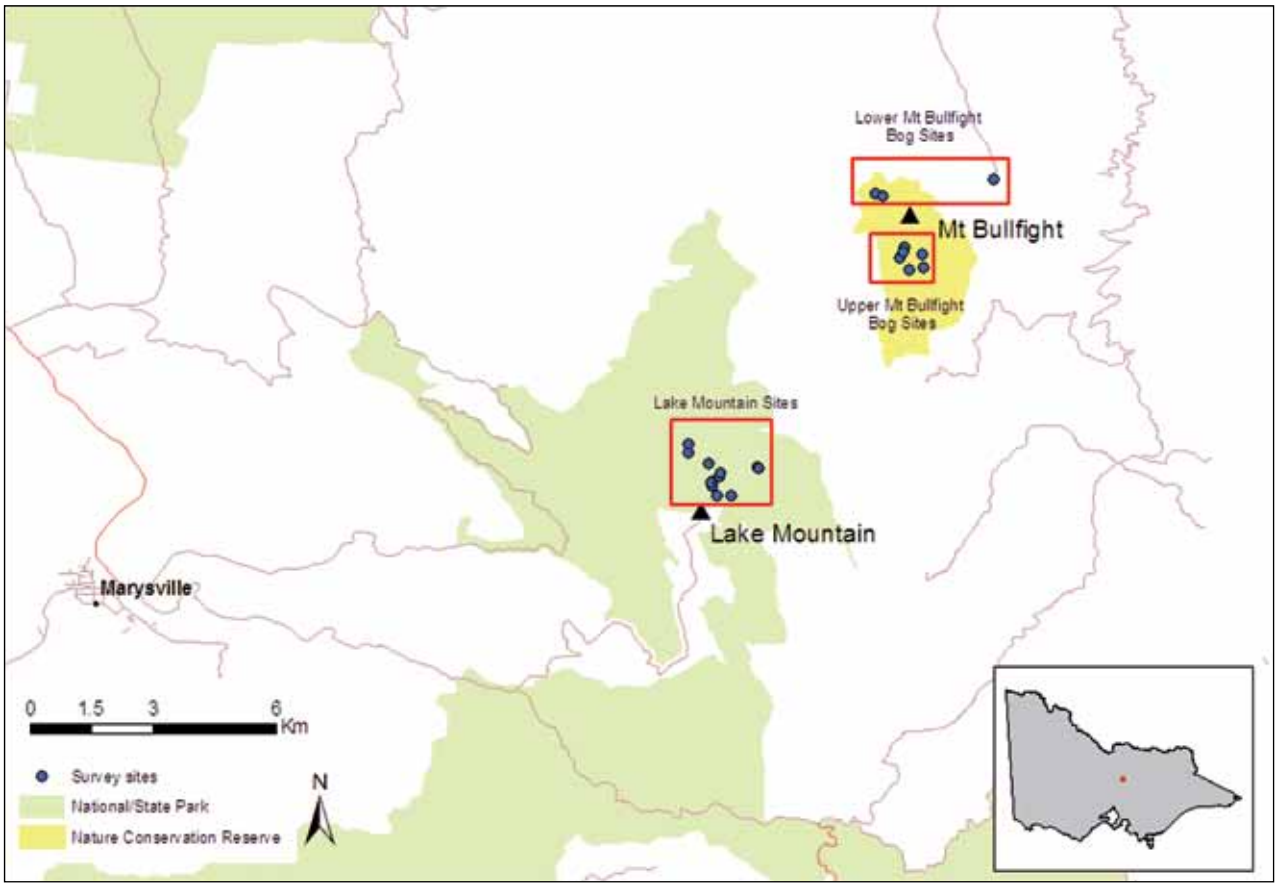
2.2 Frog surveys and testing for the Amphibian Chytrid Fungus

Frog surveys were conducted at Lake Mountain on the nights of 30 November and 22 December 2010. Day surveys were also conducted opportunistically on 1 December 2010 and 16 February 2011. The lower bog at Mt Bullfight NCR was surveyed on 18 and 24 November 2010. The upper bog could not be surveyed at night due the distance from the road and the dangerous terrain leading to the peak. It was surveyed during the day and late afternoon on 19 November 2010.

During night surveys, time and air temperature were recorded at the start of each survey. A period of 10 minutes was spent listening for frogs, identifying and estimating the number of calling individuals. A visual search (aided by torchlight) was undertaken to capture frogs.

Captured frogs were swabbed to test for Amphibian Chytrid Fungus. Swabbing of frogs involved rubbing a sterile swab (Medical Wire and Equipment, MW-100) along the ventral

Figure 4. Location of the Lake Mountain and Mount Bullfight Nature Conservation Reserve survey sites.



and dorsal surfaces, in the groin area, and underneath the hand as the frog gripped the swab. Each swab was labelled with the site number, species and date. After swabbing, frogs were released at their points of capture. New disposable gloves were used to handle each frog in order to prevent transmission of the fungus between individuals. To prevent the spread of pathogens researcher's hands and footwear were sprayed with a solution of methylated spirits and water between sites. Swab samples were sent to EcoGene in New Zealand to test for the Amphibian Chytrid Fungus. EcoGene analysed the samples by Taqman real-time PCR assay, using the methods described by Hyatt *et al*. (2007).

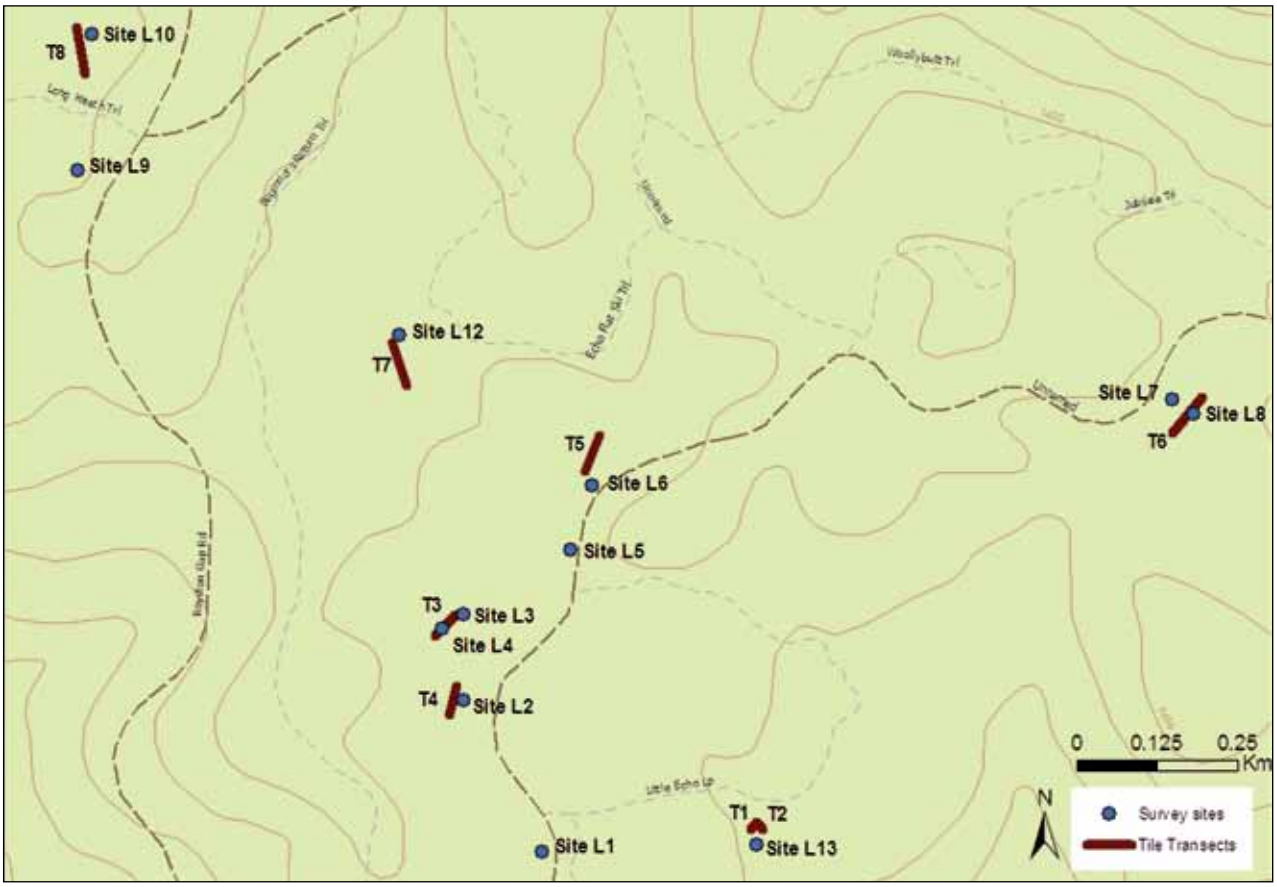
We inferred the most likely values and 95% confidence intervals for Amphibian Chytrid Fungus prevalence (proportion of individuals infected) by applying the binomial probability distribution to the diagnostic testing data from Mount Bullfight NCR and Lake Mountain. A binomial test was used to test the null hypothesis that the prevalence of fungal infection was equal in the two populations.

2.3 Lizard surveys

Transects of artificial cover-objects, consisting of 10 secondhand roof tiles, were deployed to survey for reptiles at Lake Mountain and at both the upper and lower bogs at Mount Bullfight NCR, whereas only visual searches were used in the first year of this study. Tiles have proven to be an effective method to survey for alpine reptiles (e.g. Clemann 2011). Each tile was lifted during surveys and reptiles sheltering underneath were captured by hand. For more detail on the survey method see Clemann (2011). All tiles deployed to Mount Bullfight NCR were thoroughly cleaned, disinfected and dried prior to deployment to minimise any potential spread of the Amphibian Chytrid Fungus.

Seven transects were randomly spread between the major bogs throughout the Lake Mountain plateau on 30 November and 22 December 2010 (Figure 5). At Mount Bullfight NCR, four transects were placed throughout the lower bog on 18 and 24 November 2010. Five transects

Figure 5. Location of transects and sites surveyed during the 2010/2011 season at Lake Mountain.



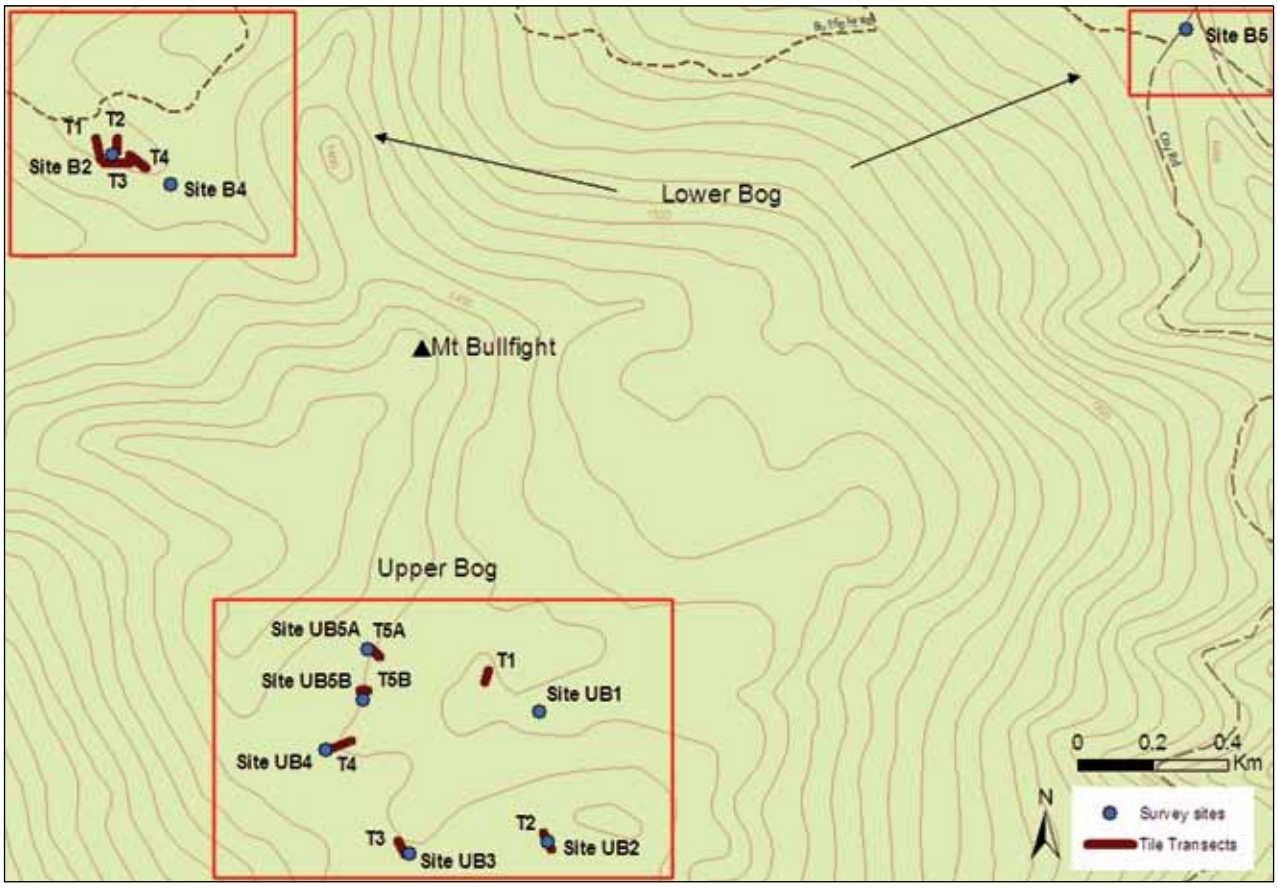
were placed at the five bogs that form the large upper bog system on 19 November 2010 (Figure 6).

The seven tile transects at Lake Mountain were surveyed three times - on 16 February and 3 and 29 March 2011. In addition to this, Transect 1 and 2 were surveyed on 1 December 2010, and Transect 2 again on 22 December 2010.

At Mount Bullfight NCR, the four transects in the lower bog were surveyed four times - on 25 November 2010, and 1 and 16 March, and 7 April 2011. Additionally, Transects B1 and B2 were surveyed on 24 November 2010. The five transects on the upper bog at Mount Bullfight NCR were surveyed three times on 2 and 17 March and 8 April 2011.

Each captured lizard was photographed for later confirmation of identification. Where time permitted, general surveying for herpetofauna was also conducted at each site. This involved rock-rolling and searches for basking lizards on vegetation, rocks and logs. Environmental variables including air temperature, rain, cloud cover, sunlight and wind were recorded at each transect at the time of survey.

Figure 6. Location of transects and sites surveyed during the 2010/2011 season at Mount Bullfight Nature Conservation Reserve.



3 Results

Ten months after the Black Saturday fires little regeneration of ground-level vegetation was evident in many of the areas surveyed (Figure 7). During the second season of this study, 21 months after the fires, there was marked increase in vegetation cover. Ground-level vegetation had recovered in most of the bog areas, sphagnum was growing on the bog margins and small heaths were establishing (Figure 8).

Additional sites were surveyed in 2010/2011 at Mount Bullfight NCR, with the inclusion of five upper bogs on the summit of Mount Bullfight. In this area, not all sites were extensively burnt compared to Lake Mountain. Site UB3 suffered minor burning and Sites UB1 and UB4 were burnt in patches. Sites UB2 and UB5 were completely burnt (Figure 9).

Figure 7. Bog at Lake Mountain 10 months after the Black Saturday fires.

Figure 8. Bog on Echo Flat, Lake Mountain showing vegetation regrowth 21 months after the Black Saturday fires.

Figure 9. Site UB3 (top), UB4 (middle) and UB5 (bottom) on the summit of Mount Bullfight showing differing degrees of burn severity during the 2009 fires.

3.1 Lake Mountain

3.1.1 Frog surveys at Lake Mountain

Twelve sites were surveyed for frogs at Lake Mountain. Common Froglets *Crinia signifera* were detected in high numbers and were present at all surveyed waterbodies (Table 1). Choruses of more than 50 Common Froglets were heard at four sites during the day and night surveys. Other sites recorded greater than 20 and 30 Common Froglets calling at night. High numbers of recently metamorphosed Common Froglets were observed, with 64 juvenile Common Froglets captured at one waterbody alone.

An additional frog species was detected this year at Lake Mountain. Three male *Litoria ewingii*-complex frogs were calling on Echo Flat between Sites L1 and L4 (Table 1, Figures 10 and 11). Due to difficulties in differentiating similar species from the *Litoria ewingii*-complex of frogs, these three frogs were not able to be definitively identified to species level. Based on morphological characteristics, including having an undivided dorsal patch between the eyes, relatively large toe pads and coloration on the concealed areas of the flanks and inner surfaces of the thighs, we believe these frogs are either Southern Brown Tree Frogs or Plains Tree Frogs *Litoria paraewingi* (Barker *et al*. 1995). Toe pads were sampled from two of these frogs and sent to Museum Victoria to confirm identification by molecular analysis. The call of one frog was recorded but background noise rendered the recording inconclusive for identification purposes.

Table 1. Results of frog surveys conducted at Lake Mountain on 30 November and 22 December 2010.

Location	Common Froglet			*Litoria ewingii*-complex frogs		
	Tadpole	Metamorph	Adult	Tadpole	Metamorph	Adult
Site L1 – Echo Flat	✓		✓			✓
Site L2 – Echo Flat			✓			✓
Site L3 – Echo Flat		✓	✓			
Site L4 – Echo Flat	✓	✓	✓			✓
Site L5 – Echo Flat		✓	✓			
Site L6 – Echo Flat			✓			
Site L7 – Jubilee Track	✓		✓			
Site L8 – Jubilee Track	✓		✓			
Site L9 – Royston			✓			
Site L10 – Royston			✓			
Site L12 – Echo Flat			✓			
Site L13 – Home Trail	✓		✓			

Figure 10. *Litoria ewingii*-complex frog from Lake Mountain, 30 November 2010.

Figure 11. *Litoria ewingii*-complex frogs from Lake Mountain, 22 December 2010 (Gavin Currie).

3.1.2 Lizard surveys at Lake Mountain

Seventy-two skinks were captured during surveys at Lake Mountain in 2010/2011. Of these, 57 were Alpine Bog Skinks (Figure 12). Most Alpine Bog Skinks were located beneath tiles, although a few were located and captured basking close to tiles or on vegetation. Alpine Bog Skinks were recorded at every tile transect on Lake Mountain. Female, male and juvenile Alpine Bog Skinks were amongst those captured. Male Alpine Bog Skinks displayed varying degrees of breeding colouration on their throats, sides and underbellies (Figure 13). Three Southern Water Skinks *Eulamprus tympanum tympanum* and two Southern Grass Skinks *Pseudemoia entrecasteauxii* were also captured. Another 10 lizards were recorded that were identified only to genus level (*Pseudemoia* sp.) as they could not be definitively identified to species level. No Mountain Skinks were recorded at Lake Mountain.

Figure 12. Alpine Bog Skinks captured at Lake Mountain, 3 March 2011.

Figure 13. Variation in male breeding colours in Alpine Bog Skinks captured at Lake Mountain.

3.2 Mount Bullfight Nature Conservation Reserve

3.2.1 Frog surveys at Mount Bullfight Nature Conservation Reserve

Both the Alpine Tree Frog and Common Froglet were recorded at the upper and lower bogs at Mount Bullfight NCR (Table 2). The Victorian Smooth Froglet *Geocrinia victoriana* and an unidentified frog, most likely a Plains Brown Tree Frog *Litoria paraewingi*, were detected at the upper bog. At the lower bog Common Froglets (over 20 individuals) were heard throughout the day, with occasional Alpine Tree Frogs calling. In the evenings, large choruses of Alpine Tree Frogs were calling, with occasional Common Froglets heard. On both nights, more than 20 Alpine Tree Frogs were calling at the main lower bog. Adult frogs were calling amongst sphagnum regrowth and in dead branches of Candle Heath *Richea continentis* (Figure 14). Juvenile Alpine Tree Frogs were observed moving throughout the bog during the day (Figure 15). Tadpoles collected from the lower bog at Mount Bullfight NCR in November 2009 were subsequently identified as Alpine Tree Frogs by Katie Smith (Museum Victoria) using molecular methods (Smith *et al.* 2011).

Site B5, a drain on the roadside leading to the main lower bog, had recently been excavated. No Alpine Tree Frogs or their tadpoles were detected at this site. Common Froglet tadpoles were recorded at this site.

Surveys of the upper bog at Mount Bullfight NCR were conducted during the day so it was not possible to rely on calling adults only to determine presence at a site, and tadpoles were also used for identifying species' presence. A juvenile Alpine Tree Frog was captured at site UB5 in the upper bog system, confirming the subspecies' presence in this area (Figure 16). An unidentified *Litoria ewingii*-complex frog was also captured at Site UB5 (Figure 17). *Litoria ewingii*-complex tadpoles were detected at two sites, and adults were heard calling at three sites (Table 2). Species/subspecies within the *Litoria ewingii*-complex of frogs are similar both in advertisement call structure and morphology. As field workers were uncertain about the precise identification of some *Litoria ewingii*-complex frogs recorded at the upper bog, all tadpoles and calling males were listed as *Litoria ewingii*-complex frogs, although it is possible, and perhaps likely, that some or all of these tadpoles may be Alpine Tree Frog larva

Tadpoles of the Common Froglet were detected at all five sites, and a large chorus of adults was heard at Site UB1.

Figure 14. Adult Alpine Tree Frog in the lower bog at Mount Bullfight Nature Conservation Reserve.

Figure 15. Juvenile Alpine Tree Frogs observed moving throughout the lower bog at Mount Bullfight Nature Conservation Reserve during the day.

Figure 16. Juvenile Alpine Tree Frog site UB5 at the upper bog at Mount Bullfight Nature Conservation Reserve.

Figure 17. Alpine Tree Frog, site UB5 at the upper bog at Mount Bullfight Nature Conservation Reserve.

Table 2. Results of frog surveys conducted at Mount Bullfight Nature Conservation Reserve on 18, 19 and 24 November 2010.

Location	Common Froglet			Alpine Tree Frog			Unknown *Litoria ewingii*-complex frog		Victorian Smooth Froglet
	Tadpole	Metamorph	Adult	Tadpole	Metamorph	Adult	Tadpole	Adult	Adult
Lower bog sites									
Site B2 - main bog	✓		✓	✓	✓	✓			
Site B4 - deer wallow	✓		✓						
Site B5 - drainage line	✓								
Upper bog sites									
Site UB1	✓		✓				✓	✓	
Site UB2	✓						✓	✓	
Site UB3	✓							✓	✓
Site UB4	✓								
Site UB5	✓				✓	✓		✓	

3.2.2 Lizard surveys at Mount Bullfight Nature Conservation Reserve

Forty skinks were captured at Mount Bullfight on the upper and lower bogs. All but five of these skinks were found under tiles. Whilst Alpine Bog Skinks were not confirmed at Mount Bullfight NCR, this species' occurrence at this site remains plausible (see below). The Southern Grass Skink was the most commonly recorded species, with 21 individuals captured (52% of all recorded lizards) (Figure 18). Eighteen Southern Water Skinks were also captured. One skink could not be confidently identified to species level, as it had pattern characteristics that were intermediate between Alpine Bog Skink and Southern Grass Skink. This individual was collected and will be analysed using molecular methods by Maggie Haines (Museum Victoria). No Mountain Skinks were recorded at Mount Bullfight NCR.

Figure 18. Southern Grass Skinks captured at both the lower and upper bogs at Mount Bullfight Nature Conservation Reserve (Maggie Haines and Ryan Chick).

3.3 Amphibian Chytrid Fungus

One hundred and fifty-seven swabs were collected from Lake Mountain, consisting of 156 swabs from Common Froglets and one swab from a *Litoria ewingii*-complex frog. Forty-seven swabs were collected from frogs at Mount Bullfight NCR; 17 of these were from Common Froglets, 30 from Alpine Tree Frogs.

Fungal prevalence at Lake Mountain was high, with seven of eight sites returning positive readings for the fungus (Table 3). Site L13, which returned an equivocal result, had only one swab tested. Equivocal results represent either one or two of the three test assays returning a positive result. This could be evidence of contamination of the sample or may represent a very low number of fungal spores in the sample (Hyatt *et al.* 2007). Equivocal swabs are considered neither negative nor positive for the fungus. The Southern Brown Tree Frog captured at site L1 tested negative for the fungus.

At Mount Bullfight NCR, 42 of the 45 swabs (93%) returned negative results for the fungus (Table 3). The remaining three swabs returned equivocal results.

Table 3. Results from tests for the Amphibian Chytrid Fungus at Lake Mountain and Mount Bullfight Nature Conservation Reserve.

Site	Location	Total swabs	Positive	Negative	Equivocal
Lake Mountain					
L1	Echo Flat	1	0	1	0
L4	Echo Flat	70	24	19	27
L5	Echo Flat	5	5	0	0
L6	Echo Flat	10	9	0	1
L7	Jubilee Track	27	25	1	1
L9	Royston	20	19	0	1
L10	Royston	19	15	0	4
L12	Echo Flat	4	4	0	0
L13	Home Trail	1	0	0	1
	Subtotal	**157**	**101**	**21**	**35**
Mount Bullfight NCR					
B2	Lower main bog	45	0	42	3
UB5	Upper Bullfight bog 5	2	0	2	0
	Subtotal	**47**	**0**	**44**	**3**

3.4 Comparison of 2010/2011 Amphibian Chytrid Fungus results to the 2009/2010 results

3.4.1 Lake Mountain Amphibian Chytrid Fungus results

Although swabs were taken from fewer sites at Lake Mountain this season, more frogs were swabbed in total, with an additional 120 animals tested (Table 4). The focus this year was on swabbing a larger number of frogs from fewer sites, instead of fewer frogs from a greater number of sites, to increase confidence in the results. In 2009/2010, 12 sites were tested for the fungus, and 11 sites had five or fewer swabs obtained. This year, nine sites were tested for the fungus and four sites had five swabs or less tested, with an average of 17 swabs tested.

A high prevalence of Amphibian Chytrid Fungus was detected this year at Lake Mountain, with seven of the nine sites returning positive results. Only three sites (L3, L8 and L13) have not returned positive readings for the fungus over the two seasons sampled. This is due to the low numbers of swabs obtained at these sites. Due to the prevalence of the fungus throughout the plateau, it is unlikely that these sites are fungus-free.

Table 4. Comparison of Amphibian Chytrid Fungus results from the 2009/2010 and 2010/2011 survey seasons at Lake Mountain.

Site	Location	2009/2010			2010/2011		
		Total swabs	No. of positives	Chytrid detected	Total swabs	No. of positives	Chytrid detected
L1	Echo Flat	4	3	Detected	1	0	Not detected
L2	Echo Flat	7	6	Detected	NA	NA	Not tested
L3	Echo Flat	4	0	Not detected	NA	NA	Not tested
L4	Echo Flat	5	5	Detected	70	24	Detected
L5	Echo Flat	1	1	Detected	5	5	Detected
L6	Echo Flat	NA	NA	Not tested	10	9	Detected
L7	Jubilee Trk	2	0	Not detected	28	26	Detected
L8	Jubilee Trk	1	0	Not detected	NA	NA	Not tested
L9	Royston	3	0	Not detected	20	19	Detected
L10	Royston	2	0	Not detected	19	15	Detected
L11	Echo Flat	2	1	Detected	NA	NA	Not tested
L12	Echo Flat	5	2	Detected	4	4	Detected
L13	Home Trail	2	0	Not detected	1	0	Not detected
	Total	**38**	**18**		**158**	**102**	

3.3.2 Mount Bullfight NCR Amphibian Chytrid Fungus results

At Mount Bullfight NCR, the collection of swabs for diagnostic testing focused on the main lower bog (site B2) in order to increase certainty of the status of the fungus at this location. A total of 45 swabs were collected this season, an increase of 32 from the 2009/2010 season (Table 5). Similar to the previous year, all swabs from 2010/2011 returned a negative or equivocal result, suggesting that the site is likely to still be free of the fungus.

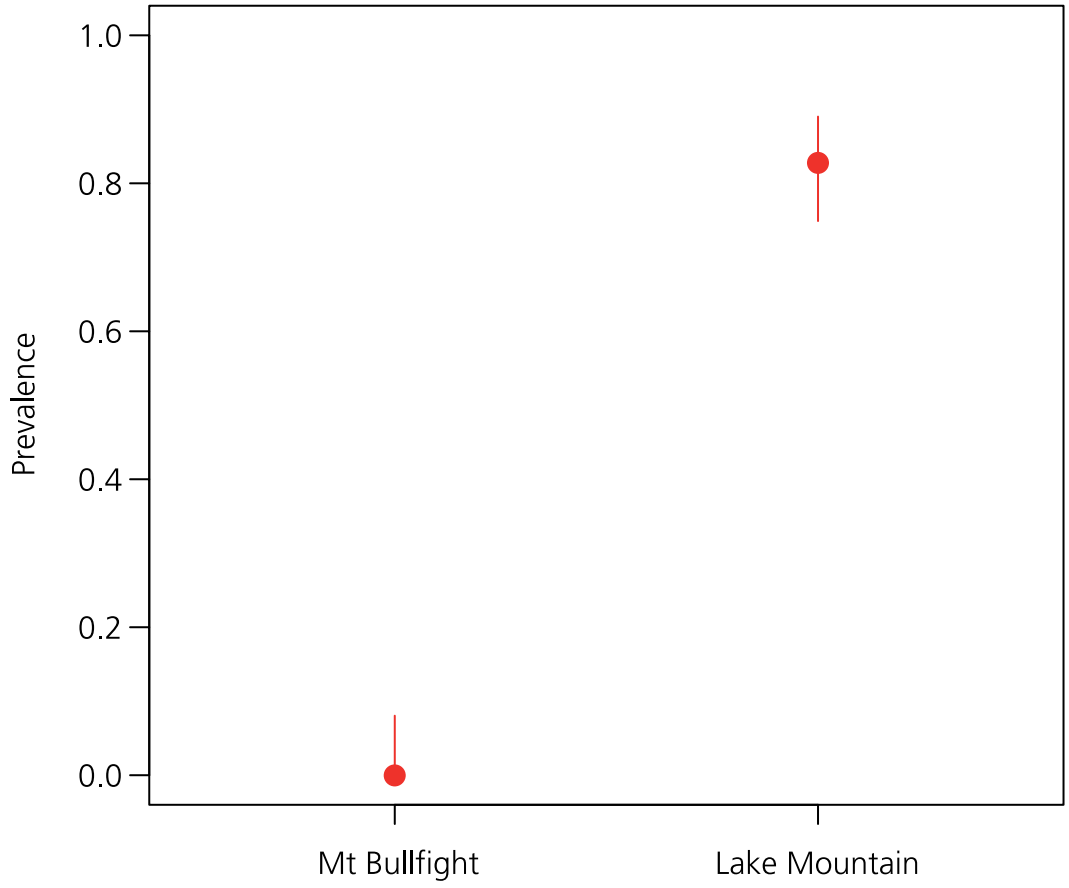
Table 5. Comparison of the Amphibian Chytrid Fungus results from the 2009/2010 and 2010/2011 survey seasons at Mount Bullfight NCR.

Site	Location	2009/2010			2010/2011		
		Total swabs	No. of positives	Chytrid detected	Total swabs	No. of positives	Chytrid detected
B1	Small pool near main lower bog	1	0	Not detected	0	0	Not tested
B2	Main lower bog	13	0	Not detected	45	0	Not detected
B5	Road side drain	5	0	Not detected	0	0	Not tested
UB5	Upper bog 5	0	0	Not tested	2	0	Not detected
	Total	19	0		47	0	

3.3.3 Analysis of the likely prevalence of the Amphibian Chytrid Fungus at Mount Bullfight NCR and Lake Mountain

Based on the diagnostic tests conducted on swabs collected during the 2010/2011 field season, the most likely disease prevalence at Mt Bullfight NCR is 0, with 95% confidence interval (0, 0.084). At Lake Mountain, the most likely disease prevalence is 0.829, with 95% confidence interval (0.751, 0.891) (Figure 19). A binomial test led to rejection of the null hypothesis of equal chytrid prevalence between the two populations ($p < 0.0001$).

Figure 19. Likely prevalence of Amphibian Chytrid Fungus at Mount Bullfight Nature Conservation Reserve and Lake Mountain, based on diagnostic testing of swabs collected during 2010/2011.



4 Discussion

4.1 Frog surveys

The Common Froglet was the only amphibian detected at Lake Mountain during the 2009/2010 surveys. Common Froglets were present at all 13 surveyed water bodies, with tadpoles, metamorphs and adults detected (Howard *et al.* 2010). Higher numbers were recorded in 2010/2011, with larger choruses of calling adults as well as hundreds of metamorphs observed. As there is no pre-fire baseline data, it is impossible to state how abundant the froglets were before the fires. The increase in numbers post fire may be a result of the increased vegetation cover, more favourable conditions in the 2010/2011 season, or simply a return to pre-fire abundance after last summer's breeding season.

Alpine Tree Frogs were not detected at Lake Mountain in both survey years, and it is unlikely that they still occur on this plateau. The species has not been recorded at Lake Mountain for nearly 20 years (Clemann 2002), and it is unlikely that they were present during the 2009 fires. *Litoria ewingii*-complex frogs were not detected during the first season's frog surveys for this project at Lake Mountain. Either this species has persisted in the area in low numbers and was not previously detected, has recently moved back into the area, or has recently been re-introduced. Construction work is being undertaken on the summit of Lake Mountain, and the arrival of construction materials is a plausible introduction vector for frogs.

During the first season of this project, a large population of Alpine Tree Frogs was found at the lower bog at Mount Bullfight NCR. The ability for Alpine Tree Frogs to persist after fire in severely and recently burnt areas has been recently observed in the Dargo – White Timber Spur fire zone (Clemann *et al.* 2010). Breeding populations of Alpine Tree Frogs have been observed in that area during surveys in 2009/2010 and 2010/2011 (Clemann *et al.* 2010, Howard *et al.* in prep.). It is likely that the persistence of Alpine Tree Frogs at Mount Bullfight NCR was facilitated by the tracts of unburnt vegetation in and around the bog system (Howard *et al*. 2010).

Surveying the summit of Mount Bullfight at night was not possible, therefore we did not obtain a measure of the relative abundance of Alpine Tree Frogs in that area. Camping or deploying timed call recorders on the summit, that record calling frogs during the evenings, would permit a measure of calling intensity in this area.

The *Litoria ewingii*-complex of frogs comprises, amongst others, Verreaux's Tree Frog, the Alpine Tree Frog, the Southern Brown Tree Frog and the Plains Brown Tree Frog (Barker *et al*. 1995). The identification of these taxa is often not certain due to similarities both morphologically and in their advertisement call structure. For example, the Plains Tree Frog and the Southern Brown Tree Frog are often indistinguishable morphologically, and molecular analysis is needed for species' identification (Barker *et al*. 1995). Similarly, the two subspecies of *Litoria verreauxii* are difficult to differentiate using morphological and colour pattern characteristics. Although it has been suggested that the Alpine Tree Frog may be larger and more colourful than Verreaux's Tree Frog (Barker *et al.* 1995), this is not a conclusive method for identification. Similarly, the advertisement calls are difficult to distinguish in the field. Taxa within the *Litoria ewingii*-complex of frogs can also hybridise where their distributions overlap, creating further uncertainty (Watson and Littlejohn 1978, Watson *et al.* 1985). Molecular tests and/or advertising call analysis may be necessary to accurately identify all taxa at both Lake Mountain and Mount Bullfight NCR.

The relative abundance (based on number of frogs and tadpoles observed, and size of calling choruses) of Common Froglets at the Mount Bullfight NCR lower bog was considerably less than at Lake Mountain. High abundances of Common Froglets in areas where Alpine Tree Frogs have disappeared are common (Hunter *et al.* 2008, Clemann *et al*. 2009). Conversely, in areas where Alpine Tree Frogs are present, the Common Froglet is often either absent, absent from specific waterbodies containing Alpine Tree Frogs, or occurs at lower densities than areas where Alpine Tree Frogs have been extirpated (D. Hunter pers. comm., N. Clemann pers. obs.). This relationship is evident when comparing Common Froglets at Mount Bullfight NCR and Lake Mountain. Populations of Common Froglets at Lake Mountain, where Alpine Tree Frogs are absent, occur in much higher abundances than those at Mount Bullfight NCR (based on estimation of the number of calling males). Due to its persistence in highly infected areas, the Common Froglet may be a vector of, or have a higher immunity to the fungus, and is known to be a reservoir host for the fungus (Hunter *et al.* 2008, Clemann *et al.* 2009).

The results of our sampling for Amphibian Chytrid Fungus again demonstrate that the fungus is widespread amongst Common Froglets at Lake Mountain, and probably absent from Mount Bullfight NCR. Chytrid infection at Lake Mountain is very high, whilst the prevalence of chytrid infection at Mt Bullfight NCR is likely to be less than 8 % (Figure 18). In addition to our failure to detect the fungus over two years, the greater diversity of frogs, and the co-occurrence of healthy populations of Alpine Tree Frogs and Common Froglets at Mount Bullfight NCR suggests that the site is most likely free of the fungus at the time of last sampling. However, there remains a small chance that the fungus was present but not detected at Mount Bullfight NCR.

In addition to the Alpine Tree Frog, there are historic records of the Victorian Smooth Froglet and Southern Toadlet (*Pseudophryne semimarmorata*) at Lake Mountain. Neither of these species were recorded during the last two season's surveys at Lake Mountain (not surprisingly in the case of the Southern Toadlets, as their breeding season extends from March to April). The Victorian Smooth Froglet has been recorded at Mount Bullfight NCR in both survey seasons (once at both the lower and upper bog). Failure to detect

both Alpine Tree Frogs and Victorian Smooth Froglets at Lake Mountain, where fungal infection rates are high, compared to the detection of good numbers of both taxa at Mount Bullfight NCR, where Amphibian Chytrid Fungus is yet to be detected, may explain this localised pattern of apparent decline at Lake Mountain.

4.2 Lizard surveys

Surveys conducted in February 2010 at Lake Mountain located only two Alpine Bog Skinks (Clemann and Antrobus 2010). In the second season of surveying we recorded 57 Alpine Bog Skinks. This dramatic difference is most likely attributed to the improved conditions and use of an additional survey technique (tiles). The recovering vegetation provided habitat allowing breeding, shelter from predators and expansion of range from the tiny amounts of suitable habitat that remained immediately after the fire (Clemann and Antrobus 2010). The use of tiles may have improved detection of this species. Alpine Bog Skinks were found at all tile transects at Lake Mountain, and the presence of gravid females and juveniles indicated that breeding was occurring.

The presence of Alpine Bog Skinks has not been confirmed at at Mount Bullfight NCR. One specimen of *Pseudemoia* was collected by Maggie Haines (Museum Victoria) during this project. This specimen displayed colouration and patterning that was intermediate between the Alpine Bog Skink and Southern Grass Skink, and will be identified through the use of molecular analysis. The Mountain Skink was not recorded during surveys in either season of this study at either Lake Mountain or Mount Bullfight NCR. Whilst this may indicate that this species does not occur in these locations, it is also plausible that surveys were not conducted within microhabitats occupied by this species. Several species closely related to the Mountain Skink are only found by locating their burrow systems (Chappel 2003).

4.3 Management implications

The introduction or spread of the Amphibian Chytrid Fungus remains the greatest threat to the Alpine Tree Frog at Mount Bullfight NCR. We recommend continued monitoring of the status of the fungus at this site. All staff accessing the site must adhere to strict hygiene protocols to minimise the risks of introducing the fungus to this site. Similarly, contractors completing work of any kind at Mount Bullfight NCR should adhere to strict fungus hygiene protocols, and any disturbance to existing conditions should be minimised wherever possible (Phillott *et al.* 2010).

Any site management activities increase the risk of introducing Amphibian Chytrid Fungus to Mount Bullfight NCR. Consequently, we recommend minimising such activities where possible, and the application of strict hygiene protocols when activities must occur. Weed control would be best managed by preventing weeds from entering the bog, rather than conducting weed control within the bog itself. If weed control is undertaken within or near these habitats, non-chemical control measures are strongly advised. Similarly, predator control increases the likelihood of introducing Amphibian Chytrid Fungus. The impact of feral predators on threatened upland herpetofauna has not been quantified, but is unlikely to represent a threat of the magnitude of chytridiomycosis. We recommend that any predator control operations are maintained, but that work immediately near the bog is avoided and all contractors adhere to the hygiene protocols.

Evidence of deer presence was found at both the upper and lower bogs at Mount Bullfight NCR, and two Sambar Deer *Cervus unicolour* were observed at Site L8 during night surveys at Lake Mountain. Feral deer creating wallows damages waterbodies and the habitat of both the Alpine Bog Skink and Alpine Tree Frog. Deer may be a vector for the Amphibian Chytrid Fungus. Lowering the number of deer at both study sites will be beneficial to frogs in these areas, but there is a risk of introducing the Amphibian Chytrid Fungus to Mount Bullfight NCR during control activities. If deer control is carried out, we recommend that all workers adhere to the hygiene protocols and that control activities do not take place within the bog.

Impacts on habitat due to recreational activities or ski resort management that cause physical or chemical disturbance to water or native vegetation should be avoided. This includes activities associated with the National Bicentennial horse trail at Mount Bullfight NCR. Horses and people should be encouraged to remain on the trail, with no overnight camping permitted near the bogs.

5 Future directions and recommendations

We recommend that any disturbance to the existing conditions at Mount Bullfight NCR is minimised. The introduction of new management activities such as road works, are likely to increase the risk of introducing Amphibian Chytrid Fungus into the area.

We recommend monitoring the Alpine Tree Frog population at Mount Bullfight every two years, with this monitoring to include further testing for the Amphibian Chytrid Fungus. All scientists and contractors who enter the bog are to adhere to strict hygiene protocols (Phillott *et al.* 2010). If the Amphibian Chytrid Fungus is detected, we recommend that an intense monitoring program be implemented to document the effect on the frog populations at this site.

If future frog surveying is conducted at the upper bogs at Mount Bullfight NCR, frog call recorders should be considered as a means to assess the calling size of the populations. We also recommend that genetic samples of *Litoria ewingii*-complex frogs (including Alpine Tree Frogs) be collected for molecular analyses in order to confirm the taxonomic status of these frogs.

The tiles deployed at Lake Mountain and Mount Bullfight NCR can be used for future monitoring. Once the taxonomic status of *Pseudemoia* species at both Lake Mountain and Mount Bullfight NCR is established, monitoring of significant species may be warranted. Future surveys for Alpine Bog Skinks at Mount Bullfight NCR are recommended.

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Appendix 1

Results of frog surveys conducted at Lake Mountain and Mount Bullfight Nature Conservation Reserve during November and December 2010, and February 2011. AM = adult male; Juv = juvenile; Tad. = tadpole; Met = metamorphling; C1 = 1 to 10; C2 = 11 to 100; unk. = unknown; H = heard; T = trapped (i.e., hand-held); O = observed.

Date	Time	Locality	Site	Species	Age/ sex	Count	Type of record	Comments
18/11/2010	1421	Mount Bullfight	B2	*Crinia signifera*	AM	C2	H	Large chorus of greater than 20
18/11/2010	1421	Mount Bullfight	B2	*Litoria verreauxii alpina*	AM	C1	H	Occasional frog heard
18/11/2010	1421	Mount Bullfight	B2	*Litoria verreauxii alpina*	Juv	1	T	
18/11/2010	1503	Mount Bullfight	B2	*Litoria verreauxii alpina*	AM	3	H	
18/11/2010	1503	Mount Bullfight	B2		Tad.		O	Present in most waterbodies
18/11/2010	1503	Mount Bullfight	B4	*Crinia signifera*	AM	C1	H	
18/11/2010	1503	Mount Bullfight	B4	*Crinia signifera*	Tad.		O	
18/11/2010	1530	Mount Bullfight	B5	*Crinia signifera*	Tad.		O	
18/11/2010	1530	Mount Bullfight	B5	*Litoria verreauxii alpina*				Nothing present at this site
18/11/2010	1600	Mount Bullfight	B2	*Litoria verreauxii alpina*	Juv	C1	0	
18/11/2010	2047	Mount Bullfight	B2	*Crinia signifera*	AM	C1	H	
18/11/2010	2047	Mount Bullfight	B2	*Litoria verreauxii alpina*	AM	C2	H	Calling from sphagnum and burnt shrubs
19/11/2010	1246	Mount Bullfight	UB5A	*Crinia signifera*	Tad.		O	
19/11/2010	1256	Mount Bullfight	UB5B	*Crinia signifera*	Tad.	C1	O	Very low water levels
19/11/2010	1258	Mount Bullfight	UB5B	*Litoria verreauxii alpina*	Adult	1	T	
19/11/2010	1300	Mount Bullfight	UB5B	*Litoria verreauxii alpina*	Juv	1	T	
19/11/2010	1345	Mount Bullfight	UB4	*Crinia signifera*	Tad.		O	
19/11/2010	1635	Mount Bullfight	UB3	*Crinia signifera*	Tad.	C1	O	
19/11/2010	1637	Mount Bullfight	UB3	*Litoria verreauxii alpina*	AM	1	H	Warm-up call
19/11/2010	1715	Mount Bullfight	UB2	*Litoria verreauxii alpina*	AM	2	H	
19/11/2010	1715	Mount Bullfight	UB2	*Litoria verreauxii alpina*	Tad.		O	Varying stages of development
19/11/2010	1715	Mount Bullfight	UB2	*Crinia signifera*	Tad.		O	
19/11/2010	1715	Mount Bullfight	UB2	*Litoria verreauxii alpina*	Tad.		O	Five collected
19/11/2010	1715	Mount Bullfight	UB2	*Litoria verreauxii alpina*	Tad.		O	
19/11/2010	1812	Mount Bullfight	UB1	*Crinia signifera*	AM	C2	H	Tens of *Crinia* calling
19/11/2010	1812	Mount Bullfight	UB1	*Litoria verreauxii alpina*	AM	2	H	
19/11/2010	1812	Mount Bullfight	UB1	*Litoria verreauxii alpina*	Tad.		O	
19/11/2010	1812	Mount Bullfight	UB1	*Crinia signifera*	Tad.		O	
24/11/2010	1500	Mount Bullfight	B2	*Crinia signifera*	AM	C2	H	
24/11/2010	1500	Mount Bullfight	B2	*Litoria verreauxii alpina*	Met	1	T	Swabbed
24/11/2010	1600	Mount Bullfight	B2	*Litoria verreauxii alpina*	AM	C1	H	

Date	Time	Locality	Site	Species	Age/ sex	Count	Type of record	Comments
24/11/2010	2046	Mount Bullfight	B2	*Litoria verreauxii alpina*	AM	C1	H	
24/11/2010	2046	Mount Bullfight	B2	*Crinia signifera*	AM	C1	H	
24/11/2010	2100	Mount Bullfight	B2	*Litoria verreauxii alpina*	AM	C2	H	More than 20 calling
24/11/2010	2100	Mount Bullfight	B2	*Crinia signifera*	AM	C1	H	
25/11/2010	1000	Mount Bullfight	B2	*Crinia signifera*	AM	10	H	
30/11/2010	1359	Lake Mountain	Site L13	*Crinia signifera*	AM	C2	H, T	More than 15 calling
30/11/2010	1359	Lake Mountain	Site L13	*Crinia signifera*	Tad.		O	
30/11/2010	1500	Lake Mountain	Site L4	*Crinia signifera*	AM	C2	O	Many pools with more than 20 calling
30/11/2010	1500	Lake Mountain	Site L4	*Crinia signifera*	Met	C2	T	Approximately 42 swabs collected
30/11/2010	1500	Lake Mountain	Site L4	*Spawn*			O	Spawn
30/11/2010	2055	Lake Mountain	Site L8	*Crinia signifera*	AM	C2	H	More than 30 calling
30/11/2010	2055	Lake Mountain	Site L8	*Crinia signifera*	Tad.		O	
30/11/2010	2055	Lake Mountain	Site L8				O	Two Sambar Deer observed
30/11/2010	2149	Lake Mountain	Site L8	*Crinia signifera*	AM	C2	H	More than 50 calling
30/11/2010	2150	Lake Mountain	Site L7	*Crinia signifera*	AM	C1	H	30 swabs collected
30/11/2010	2150	Lake Mountain	Site L7	*Crinia signifera*	Tad.		O	
30/11/2010	2216	Lake Mountain	Site L10	*Crinia signifera*	AM	C2	H	More than 50 calling, 20 swabs collected
30/11/2010	2251	Lake Mountain	Site L9	*Crinia signifera*	AM	C2	H	More than 40 calling, 20 swabs collected
30/11/2010	2315	Lake Mountain	Site L1	*Ewingi complex* frog	AM	1	T	
1/12/2010	1203	Lake Mountain	Site L1	*Crinia signifera*	AM	C2	H	More than 20 calling
1/12/2010	1203	Lake Mountain	Site L1	*Crinia signifera*	Tad.		O	
1/12/2010	1203	Lake Mountain	Site L1				O	Spawn
1/12/2010	1240	Lake Mountain	Site L13	*Crinia signifera*	AM	C2	H	More than 50 calling
1/12/2010	1317	Lake Mountain	Site L6	*Crinia signifera*	AM	C2	H	More than 50 calling, 10 swabs collected
1/12/2010	1317	Lake Mountain	Site L6	Eggs seen			O	No tadpoles observed
1/12/2010	1401	Lake Mountain	Site L5	*Crinia signifera*	AM	C1	H	

Date	Time	Locality	Site	Species	Age/ sex	Count	Type of record	Comments
1/12/2010	1401	Lake Mountain	Site L5	*Crinia signifera*	Met	C1	O	
1/12/2010	1401	Lake Mountain	Site L5	Eggs seen			O	No tadpoles observed
22/12/2010	2153	Lake Mountain	Site L2	*Ewingi complex* frog	AM	2	H	
22/12/2010	2153	Lake Mountain	Site L4	*Ewingi complex* frog	AM	1	H, T	
16/02/2011	1045	Lake Mountain	Site L2	*Crinia signifera*	AM	C1	H	
16/02/2011	1115	Lake Mountain	Site L3	*Crinia signifera*	Met	C2	O, T	Tens of metamorphs
16/02/2011	1115	Lake Mountain	Site L4	*Crinia signifera*	Met	C2	O, T	Tens of metamorphs
16/02/2011	1144	Lake Mountain	Site L6	*Crinia signifera*	AM	C1	H	
16/02/2011	1232	Lake Mountain	Site L12	*Crinia signifera*	AM	C1	H	
16/02/2011	1400	Lake Mountain	Site L7/L8	*Crinia signifera*	AM	C1	H	
3/02/2011	1151	Lake Mountain	Site L10	*Crinia signifera*	AM	C2	H	

Appendix 2

Results of lizard surveys conducted at Lake Mountain and Mount Bullfight Nature Conservation Reserve from November 2010 to April 2011. NR = not recorded.

Location	Date	Transect	Time	Tile number	Species	Air temp	Tile temp	Sex
Mount Bullfight lower bog	18/11/2010	B1	2100	Not found under tile	*Eulamprus tympanum*	NA	NA	Adult
Mount Bullfight lower bog	24/11/2010	B1	1407	7	*Pseudemoia entrecasteauxii*	19	28	Adult
Mount Bullfight lower bog	24/11/2010	B1	1407	10	*Eulamprus tympanum*	19	35.5	
Mount Bullfight lower bog	24/11/2010	B2	1620	4	*Pseudemoia entrecasteauxii*	NR	NR	Adult
Mount Bullfight lower bog	24/11/2010	B2	1543	6	*Pseudemoia entrecasteauxii*	NR	NR	Adult
Mount Bullfight lower bog	24/11/2010	B2	1555	Not found under tile	*Pseudemoia entrecasteauxii*	NA	NA	
Mount Bullfight lower bog	24/11/2010	B1	1640	5	*Pseudemoia entrecasteauxii*	NR	27.1	Male
Mount Bullfight lower bog	24/11/2010	B1	1653	7	*Pseudemoia entrecasteauxii*	NR	29.9	Adult
Mount Bullfight lower bog	25/11/2010	B1	950	3	*Pseudemoia entrecasteauxii*	12.6	12.8	Adult
Mount Bullfight lower bog	1/03/2011	B3	1630	5	*Pseudemoia entrecasteauxii*	23.8	7.8	Adult
Mount Bullfight lower bog	1/03/2011	B3	1630	2	*Eulamprus tympanum*	6.9	22.6	Juv
Mount Bullfight lower bog	1/03/2011	B3	1630	2	*Eulamprus tympanum*	6.9	22.6	Juv
Mount Bullfight lower bog	1/03/2011	B3	1630	2	*Eulamprus tympanum*	6.9	22.6	Juv
Mount Bullfight lower bog	1/03/2011	B3	1630	4	*Eulamprus tympanum*	6.9	22.6	Juv
Mount Bullfight lower bog	1/03/2011	B2	1645	3	*Pseudemoia entrecasteauxii*	6.5	16.4	Adult
Mount Bullfight lower bog	1/03/2011	B2	1645	4	*Pseudemoia entrecasteauxii*	6.5	15.7	Adult
Mount Bullfight lower bog	1/03/2011	B2	1645	9	*Eulamprus tympanum*	5.8	12.8	
Mount Bullfight lower bog	1/03/2011	B4	1700	5	*Eulamprus tympanum*	8	18.8	Juv
Mount Bullfight lower bog	1/03/2011	B4	1700	7	*Eulamprus tympanum*	8	17	Adult
Mount Bullfight upper bog	2/03/2011	UB1	945	4	*Pseudemoia* sp.	7.1	9.7	Adult
Mount Bullfight upper bog	2/03/2011	UB1	945	9	*Pseudemoia entrecasteauxii*	7.1	9.7	Adult
Mount Bullfight upper bog	2/03/2011	UB1	945	1	*Eulamprus tympanum*	7.1	9.7	Juv
Mount Bullfight upper bog	2/03/2011	UB1	945	2	*Eulamprus tympanum*	7.1	13.5	Juv
Mount Bullfight upper bog	2/03/2011	UB1	945	3	*Eulamprus tympanum*	7.1	13.2	Adult
Mount Bullfight upper bog	2/03/2011	UB2	1030	Not found under tile	*Pseudemoia entrecasteauxii*	25.3	NA	Adult
Mount Bullfight upper bog	2/03/2011	UB4	1200	Not found under tile	*Pseudemoia entrecasteauxii*	34.8	NA	Adult

Location	Date	Transect	Time	Tile number	Species	Air temp	Tile temp	Sex
Mount Bullfight upper bog	2/03/2011	UB4	1200	Not found under tile	*Pseudemoia entrecasteauxii*	34.8	NA	Adult
Mount Bullfight lower bog	16/03/2011	B1	1715	10	*Eulamprus tympanum*	13.1	22.8	Adult
Mount Bullfight lower bog	16/03/2011	B2	1730	3	*Pseudemoia entrecasteauxii*	12.7	14.7	Juv
Mount Bullfight lower bog	16/03/2011	B3	1800	4	*Eulamprus tympanum*	9.3	19.6	Adult
Mount Bullfight upper bog	17/03/2011	UB1	1108	1	*Eulamprus tympanum*	11.1	23.1	Juv
Mount Bullfight lower bog	7/04/2011	B1	935	6	*Eulamprus tympanum*	8.5	7.5	Juv
Mount Bullfight lower bog	7/04/2011	B1	935	6	*Eulamprus tympanum*	8.5	7.5	Juv
Mount Bullfight lower bog	7/04/2011	B2	1019	8	*Pseudemoia entrecasteauxii*	NR	7.4	Juv
Mount Bullfight lower bog	7/04/2011	B2	1019	3	*Pseudemoia entrecasteauxii*	NA	NA	
Mount Bullfight upper bog	8/04/2011	UB1	1110	1	*Eulamprus tympanum*	14.1	19.4	Juv
Mount Bullfight upper bog	8/04/2011	UB3	1215	10	*Pseudemoia entrecasteauxii*	16.1	36	Juv
Mount Bullfight upper bog	8/04/2011	UB4	1325	1	*Pseudemoia entrecasteauxii*	13.2	NR	Male
Mount Bullfight upper bog	8/04/2011	UB5	1420	A3	*Pseudemoia entrecasteauxii*	16.2	33	Male
Mount Bullfight upper bog	8/04/2011	UB5	1420	2	*Pseudemoia entrecasteauxii*	NA	NA	
Lake Mountain	30/11/2010	T1-2	1359	5	*Eulamprus tympanum*	20	NR	Juv
Lake Mountain	1/12/2010	T3	1840	NR	*Pseudemoia cryodroma*	NR	NR	Adult
Lake Mountain	1/12/2010	T3	1900	NR	*Pseudemoia cryodroma*	NR	NR	Adult
Lake Mountain	22/12/2010	T3	1807	1	*Pseudemoia cryodroma*	14.1	30.2	Juv
Lake Mountain	22/12/2010	T3	1807	4	*Pseudemoia cryodroma*	14.1	30.2	Adult
Lake Mountain	22/12/2010	T3	1807	5	*Pseudemoia cryodroma*	14.1	30.2	Juv
Lake Mountain	22/12/2010	T3	1807	7	*Pseudemoia cryodroma*	14.1	30.2	Adult
Lake Mountain	22/12/2010	T3	1807	8	*Pseudemoia cryodroma*	14.1	30.2	Adult
Lake Mountain	22/12/2010	T3	1807	9	*Pseudemoia cryodroma*	14.1	30.2	Adult
Lake Mountain	16/02/2011	T4	1045	1	*Pseudemoia cryodroma*	15.9	23.0	AF
Lake Mountain	16/02/2011	T4	1045	5	*Pseudemoia cryodroma*	15.9	23.0	Adult
Lake Mountain	16/02/2011	T4	1045	10	*Pseudemoia cryodroma*	15.9	23.0	AM
Lake Mountain	16/02/2011	T3	1115	4	*Pseudemoia cryodroma*	19.1	29.9	Adult
Lake Mountain	16/02/2011	T5	1144	1	*Pseudemoia cryodroma*	16.3	19.1	Adult
Lake Mountain	16/02/2011	T5	1144	1	*Pseudemoia cryodroma*	16.3	19.1	AM
Lake Mountain	16/02/2011	T5	1144	5	*Pseudemoia cryodroma*	16.3	19.1	AM
Lake Mountain	16/02/2011	T5	1144	5	*Pseudemoia cryodroma*	16.3	19.1	Adult
Lake Mountain	16/02/2011	T5	1144	7	*Pseudemoia cryodroma*	16.3	19.1	Adult

Location	Date	Transect	Time	Tile number	Species	Air temp	Tile temp	Sex
Lake Mountain	16/02/2011	T7	1232	2	*Pseudemoia cryodroma*	15.7	29.0	Adult
Lake Mountain	16/02/2011	T7	1232	5	*Pseudemoia cryodroma*	15.7	29.0	Adult
Lake Mountain	16/02/2011	T8	1313	2	*Pseudemoia cryodroma*	16.9	25.2	AM
Lake Mountain	16/02/2011	T8	1313	2	*Pseudemoia cryodroma*	16.9	25.2	Adult
Lake Mountain	16/02/2011	T8	1313	4	*Pseudemoia cryodroma*	16.9	25.2	
Lake Mountain	16/02/2011	T8	1313	7	*Pseudemoia cryodroma*	16.9	25.2	Adult
Lake Mountain	16/02/2011	T6	1400	2	*Pseudemoia cryodroma*	17.1	24.8	Adult
Lake Mountain	16/02/2011	T1-2	1700	5	*Pseudemoia cryodroma*	16.9	NR	Adult
Lake Mountain	3/03/2011	T7	1132	8	*Pseudemoia cryodroma*	7.0	11.8	Adult
Lake Mountain	3/03/2011	T8	1151	1	*Pseudemoia cryodroma*	6.5	10.9	Adult
Lake Mountain	3/03/2011	T8	1151	4	*Pseudemoia cryodroma*	6.5	10.9	Adult
Lake Mountain	3/03/2011	T8	1151	6	*Pseudemoia cryodroma*	6.5	10.9	Adult
Lake Mountain	3/03/2011	T8	1151	9	*Pseudemoia cryodroma*	6.5	10.9	Adult
Lake Mountain	3/03/2011	T6	1210	10	*Pseudemoia cryodroma*	6.7	8.4	Adult
Lake Mountain	3/03/2011	T5	1248	1	*Pseudemoia cryodroma*	6.9	9.9	Adult
Lake Mountain	3/03/2011	T5	1248	3	*Pseudemoia cryodroma*	6.9	9.9	AM
Lake Mountain	3/03/2011	T5	1248	4	*Pseudemoia cryodroma*	6.9	9.9	Adult
Lake Mountain	3/03/2011	T5	1248	6	*Pseudemoia cryodroma*	6.9	9.9	Adult
Lake Mountain	3/03/2011	T3	1313	1	*Pseudemoia cryodroma*	7.2	15.7	Adult
Lake Mountain	3/03/2011	T4	1320	4	*Pseudemoia cryodroma*	6.4	13.5	Adult
Lake Mountain	3/03/2011	T4	1320	4	*Pseudemoia cryodroma*	6.4	13.5	AM
Lake Mountain	3/03/2011	T4	1320	5	*Pseudemoia cryodroma*	6.4	13.5	Adult
Lake Mountain	3/03/2011	T1-2	1340	3	*Pseudemoia cryodroma*	7.9	15.0	AM
Lake Mountain	3/03/2011	T1-2	1340	4	*Pseudemoia cryodroma*	7.9	15.0	Adult
Lake Mountain	3/03/2011	T1-2	1340	4	*Pseudemoia cryodroma*	7.9	15.0	Adult
Lake Mountain	3/03/2011	T1-2	1340	5	*Pseudemoia cryodroma*	7.9	15.0	Adult
Lake Mountain	3/03/2011	T1-2	1340	6	*Pseudemoia cryodroma*	7.9	15.0	
Lake Mountain	3/03/2011	T1-2	1340	6	*Pseudemoia cryodroma*	7.9	15.0	
Lake Mountain	3/03/2011	T1-2	1340	7	*Pseudemoia cryodroma*	7.9	15.0	AM
Lake Mountain	3/03/2011	T1-2	1340	9	*Pseudemoia cryodroma*	7.9	15.0	Adult
Lake Mountain	3/03/2011	T1-2	1340	10	*Eulamprus tympanum*	7.9	15.0	Juvenile
Lake Mountain	29/03/2011	T4	1136	1	*Pseudemoia* sp.	14.5	27.9	
Lake Mountain	29/03/2011	T4	1136	4	*Pseudemoia entrecasteauxii*	14.5	27.9	AM
Lake Mountain	29/03/2011	T4	1136	8	*Pseudemoia cryodroma*	14.5	27.9	Juv
Lake Mountain	29/03/2011	T4	1136	9	*Pseudemoia cryodroma*	14.5	27.9	AF
Lake Mountain	29/03/2011	T3	1216	10	*Pseudemoia entrecasteauxii*	14.5	31.7	AF

Location	Date	Transect	Time	Tile number	Species	Air temp	Tile temp	Sex
Lake Mountain	29/03/2011	T3	1216	7	*Pseudemoia* sp.	14.5	31.7	
Lake Mountain	29/03/2011	T3	1216	4	*Pseudemoia cryodroma*	14.5	31.7	AF
Lake Mountain	29/03/2011	T7	1318	3	*Pseudemoia cryodroma*	15.3	34.5	Juv
Lake Mountain	29/03/2011	T8	1348	2	*Pseudemoia* sp.	15.8	24.8	
Lake Mountain	29/03/2011	T8	1348	2	*Pseudemoia* sp.	15.8	24.8	AF
Lake Mountain	29/03/2011	T8	1348	3	*Pseudemoia* sp.	15.8	24.8	
Lake Mountain	29/03/2011	T8	1348	7	*Pseudemoia* sp.	15.8	24.8	AF
Lake Mountain	29/03/2011	T6	1427	3	*Pseudemoia cryodroma*	17.7	33.4	A
Lake Mountain	29/03/2011	T6	1427	3	*Pseudemoia cryodroma*	17.7	33.4	A
Lake Mountain	29/03/2011	T6	1427	4	*Pseudemoia* sp.	17.7	33.4	
Lake Mountain	29/03/2011	T6	1427	5	*Pseudemoia cryodroma*	17.7	33.4	AF
Lake Mountain	29/03/2011	T1-2	1557	3	*Pseudemoia* sp.	15.8	30	
Lake Mountain	29/03/2011	T1-2	1557	4	*Pseudemoia* sp.	15.8	30	
Lake Mountain	29/03/2011	T1-2	1557	4	*Pseudemoia* sp.	15.8	30	
Lake Mountain	29/03/2011	T1-2	1557	6	*Pseudemoia cryodroma*	15.8	30	AF
Lake Mountain	29/03/2011	T1-2	1557	7	*Pseudemoia cryodroma*	15.8	30	A
Lake Mountain	29/03/2011	T1-2	1557	9	*Pseudemoia cryodroma*	15.8	30	AF
Lake Mountain	29/03/2011	T1-2	1557	10	*Eulamprus tympanum*	15.8	30	Juv

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