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Survival and recolonisation following wildfire at Moyston West, Western Victoria. 1. Mammals

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Abstract

Wildfire is a common occurrence in south-eastern Australia affecting fauna populations in various ways. Data were collected at a site near Moyston in western Victoria on three occasions before and five occasions after wildfire. Seventeen mammal species were recorded pre-wildfire whilst 23 species were recorded post-wildfire. The diversity of insectivorous bats was not affected by the wildfire, maybe because a number of mature River Red Gums *Eucalyptus camaldulensis* with numerous suitable roosting hollows survived the wildfire. Populations of Sugar Glider *Petaurus breviceps*, Common Brushtail Possum *Trichosurus vulpecula* and Common Ringtail Possum *Pseudocheirus peregrinus* also survived the fire in an area of mature River Red Gums. A small population of Swamp Rat *Rattus lutreolus* survived the fire and successfully recolonised regenerating habitat. Yellow-footed Antechinus *Antechinus flavipes* and Eastern Pygmy Possum *Cercartetus nanus* were recorded in regenerating Heathy Woodland after wildfire severely burnt this vegetation. The population of Black Wallaby *Wallabia bicolor* increased three years after wildfire as regenerating vegetation produced dense cover. Few studies provide pre-wildfire and post-wildfire data, especially on mammals at inland woodland sites. (*The Victorian Naturalist* 129 (6) 2012, 192-202).

Keywords: Wildfire, inland woodlands, insectivorous bats, marsupials, rodents

Introduction

Numerous wildfires have burnt large parts of south-eastern Australia since European settlement 200 years ago. The intensity of fire and condition of local environments produces a range of effects on landscapes and mammal populations (Wilson and Friend 1999). Several studies have been conducted into recolonisation by mammals following wildfire in south-eastern Australia, especially in coastal heathland (Newsome *et al.* 1975; Fox *et al.* 1985; Wilson and Moloney 1985; Catling 1986; Lunney *et al.* 1987; Lunney and O'Connell 1988; Catling *et al.* 2001; Recher *et al.* 2009). There are, however, few studies that provide both pre-fire and post-fire data, especially on the effects of wildfire on populations of mammals at inland woodland sites (Friend 1993; Sutherland and Dickman 1999).

In December 2005 and January 2006 a severe wildfire burnt 46% of the Grampians National Park and adjoining areas in western Victoria, especially around the Moyston district. Wuurak is a 150 ha property situated seven km west of Moyston in western Victoria (Lat 37° 18'S, Long 142° 41'E) approximately 210 km west of the Melbourne CBD. The owners operate a native plant nursery on-site that provides

indigenous plants for revegetation projects in surrounding districts. Small scale sheep grazing is also conducted at the property. Wuurak is located on the plains east of Mt William, the highest point in the neighbouring Grampians National Park (Fig. 1). The terrain is mostly flat grazing country; however, an ancient sand-dune system covers a large proportion of the western and central parts of the property. Reservoir Creek, an ephemeral tributary of Mt William Creek, flows in a northerly direction along the eastern boundary.

Four Ecological Vegetation Classes (EVCs) are represented (DSE 2004). Heathy Woodland and Sand Forest (partly degraded) exist on the ancient sand-dune system; Damp Sands Herb-rich Woodland exists along Reservoir Creek; and Plains Grassy Woodland is present across the northern section of the property. Grazing was conducted along Reservoir Creek by previous owners and some introduced weed species exist in this part of the property. The current owners joined the Victorian Government's Land for Wildlife voluntary conservation scheme in 2002 and have since carried out several conservation initiatives including fencing off large areas along Reservoir Creek and revegetation



Fig 1. Wuurak Land for Wildlife property, with Mt William in background. Photo by Peter Homan.

of degraded areas. The Heathy Woodland section of Wuurak adjoins the eastern extremity of the Grampians National Park and, apart from this area of crown land, much of the indigenous vegetation in other neighbouring properties is degraded or fragmented to some extent. A study of the presence and relative abundance of vertebrate fauna commenced at Wuurak in October 2004 and the property was severely affected by wildfire in January 2006.

Methods

Several methods were used pre-wildfire and post-wildfire to detect the presence of mammals. These were cage trapping (Wiretainers Pty Ltd, Preston Victoria), Elliott trapping, type A (Elliott Scientific Equipment, Upwey, Victoria), harp trapping (Faunatech, Bairnsdale Victoria and Ecological Consulting Services, Newport, Victoria), pitfall trapping, remote surveillance cameras (Scoutguard, Models: SG550V and KG680V, China), spotlighting on foot and general observation. One pitfall line consisting of ten 20 L plastic buckets was established on a sand-dune in the area of Heathy Woodland. Buckets were 5 m apart and

a 30 cm high aluminium flywire drift fence stretched for 60 m. Cage and Elliott traps were set in lines of 10 with 20 m between traps. Cage trapping was conducted pre-wildfire only; remote surveillance cameras were introduced as a replacement for cage traps post-wildfire. The number of cameras varied between four and six and were set approximately 25 m apart in small natural clearings where minimal disturbance to vegetation was necessary. Cameras were set facing in a southerly direction to avoid sun-glare. Harp trapping was restricted mainly to Damp Sands Herb-rich Woodland and Sand Forest due to a lack of suitable trapping sites in the other EVCs. Baits for traps and camera stations consisted of a mixture of smooth peanut butter, quick oats, golden syrup, sardines and vanilla essence. Common and scientific names and taxonomy follow Menkhorst (1995), except for House Cat *Felis catus* and European Hare *Lepus europeaus*, which follow Menkhorst and Knight (2011).

The study sites were visited on three occasions before wildfire (October 2004, November 2004 and March 2005) and on five occasions after wildfire (December 2008, April 2010, Decem-

Table 1. Survey methods and effort (trap-nights, camera-nights, spotlight hours) completed pre-wildfire and post-wildfire for each Ecological Vegetation Class (EVC). DSHRW = Damp Sands Herb-rich Woodland; PG Woodland = Plains Grassy Woodland; RSC = remote surveillance camera; S/H = spotlight hours.

EVC		Survey Method					S/H
		Elliott	Cage	Pitfall	Harp	RSC	
Heathy Woodland	Pre-fire	300		60			2
	Post-fire	340		80		10	2
DSHRW	Pre-fire	60	156		10		8
	Post-fire	150			15	22	14
PG Woodland	Pre-fire				2		
	Post-fire						
Sand Forest	Pre-fire						2
	Post-fire				8		1

ber 2010, March 2011 and April 2012). Overall, 1213 trap-nights were completed; 588 pre-wildfire and 625 post-wildfire (Table 1).

Results

Pre-wildfire

Seventeen species were recorded before wildfire: one monotreme, seven marsupial and nine eutherian (Table 2). Fourteen species were native and three were introduced. One Short-beaked Echidna *Tachyglossus aculeatus* was seen in Damp Sands Herb-rich Woodland. Diggings typical of those made by this species were also found in this EVC and Heathy Woodland. Yellow-footed Antechinus *Antechinus flavipes* was captured in Elliott traps overnight and during the day in Heathy Woodland and Damp Sands Herb-rich Woodland (Fig. 2). The species was also seen on two occasions during the day feeding high in the canopy of flowering Shining Peppermint *Eucalyptus willisii* in the Heathy Woodland area.

Sugar Glider *Petaurus breviceps* was seen during spotlighting in Heathy Woodland and in Sand Forest. Common Brushtail Possum *Trichosurus vulpecula* and Common Ringtail Possum *Pseudocheirus peregrinus* were seen during spotlighting in Damp Sands Herb-rich Woodland. Common Brushtail Possum was also recorded in Sand Forest. Small numbers of Black Wallaby *Wallabia bicolor* were recorded in Damp Sands Herb-rich Woodland and Heathy Woodland. Significant numbers of Red-necked Wallaby *Macropus rufogriseus* were recorded in Heathy Woodland, Plains Grassy Woodland and Sand Forest. Large numbers of Eastern Grey Kangaroos *Macropus giganteus* were seen in open grassy areas of the property. White-

striped Freetail Bat *Tadarida australis* was heard in Damp Sands Herb-rich Woodland. Little Forest Bat *Vespadelus vulturinus*, Southern Forest Bat *Vespadelus regulus*, Large Forest Bat *Vespadelus darlingtoni* and Lesser Long-eared Bat *Nyctophilus geoffroyi* were recorded in Damp Sands Herb-rich Woodland. Swamp Rat *Rattus lutreolus* (front cover) was captured in Elliott and cage traps in Damp Sands Herb-rich Woodland. Burrows and runways of this species were found throughout this EVC. Two House Cats *Felis catus* were seen during spotlighting in Damp Sands Herb-rich Woodland.

Post-wildfire

Twenty-three species were recorded post-wildfire: one monotreme, eight marsupial and 14 eutherian (Table 2). Eighteen species were native and five were introduced. One Short-beaked Echidna was seen in Damp Sands Herb-rich Woodland during the first visit to the property post-wildfire in December 2008. Yellow-footed Antechinus was recorded in the Heathy Woodland area five years after wildfire and in Damp Sands Herb-rich Woodland and in Sand Forest six and a half years after wildfire. Common Brushtail Possum was recorded in Damp Sands Herb-rich Woodland three years after fire and in Heathy Woodland six and a half years after fire. Eastern Pygmy Possum *Cercartetus nanus* was captured in a pitfall trap four and a half years after wildfire (Fig. 3) and in an Elliott trap six and a half years after wildfire in Heathy Woodland. Sugar Glider was recorded in Damp Sands Herb-rich Woodland five years after wildfire and in Heathy Woodland and Sand Forest six and a half years post-wildfire. Common Ringtail Possum was seen

Table 2. List of mammals and numbers recorded pre-wildfire and post-wildfire for each Ecological Vegetation Class (EVC). DSHRW = Damp Sands Herb-rich Woodland; HW = Heathy Woodland; SF = Sand Forest; PGW = Plains Grassy Woodland; E = estimated number; * = introduced species; i = indirect evidence (digging, scats etc).

Species	Pre-wildfire					Post-wildfire				
	10/04	11/04	3/05	12/08	4/10	12/10	3/11	4/12	4/12	4/12
Short-beaked Echidna <i>Tachyglossus aculeatus</i>		DSHRW HW	1	1	1					1
Yellow-footed Antechinus <i>Antechinus flavipes</i>		DSHRW HW	4 10	i		1				1
Common Brushtail Possum <i>Trichosurus vulpecula</i>	1	DSHRW HW	14 10	10	7	6	6	5	1	1
Eastern Pygmy Possum <i>Cercartetus nanus</i>		HW	2		1					1
Sugar Glider <i>Petaurus breviceps</i>		DSHRW HW		1					1	1
Common Ringtail Possum <i>Pseudocheirus peregrinus</i>		SF	1							1
Eastern Grey Kangaroo <i>Macropus giganteus</i>	20E	DSHRW	1	100E	50E	100E	150E	200E		2
Red-necked Wallaby <i>Macropus rufogriseus</i>	5	HW	15	10	5	2	1	4		5
Black Wallaby <i>Wallabia bicolor</i>		PGW	10	5	3	2	5	5		5
White-striped Freetail Bat <i>Tadarida australis</i>		DSHRW	5		20E	7	3	2		2
Gould's Wattled Bat <i>Chalinolobus gouldii</i>		HW	2	1		1	3	1		1
Chocolate Wattled Bat <i>Chalinolobus morio</i>		DSHRW	1	1	2	2	1	2		1
Large Forest Bat <i>Vespadelus darlingtoni</i>		DSHRW	1			1	2	1		2
Southern Forest Bat <i>Vespadelus regulus</i>		SF								1
Little Forest Bat <i>Vespadelus vulturinus</i>		DSHRW	2	3	1	1	1	1		1
Lesser Long-eared Bat <i>Nyctophilus geoffroyi</i>		SF	7	1	4		1	1		1
Gould's Long-eared Bat <i>Nyctophilus gouldi</i>		SF								1
House Mouse <i>Mus musculus</i> *		DSHRW		4		1	3	2		2
Swamp Rat <i>Rattus lutreolus</i>		DSHRW				41	2	3		3
Black Rat <i>Rattus rattus</i> *		HW	1	1	i	1	1	1		1
Red Fox <i>Vulpes vulpes</i> *		DSHRW	1	2		1	1	1		1
House Cat <i>Felis catus</i> *		PGW			2	1	1	1		1
European Rabbit <i>Oryctolagus cuniculus</i> *		DSHRW	2							1
European Hare <i>Lepus europeaus</i> *		PGW	1		1	1	5	7		1



Fig 2. Yellow-footed Antechinus *Antechinus flavipes*. Photo by Peter Homan.

during spotlighting in Damp Sands Herb-rich Woodland six and a half years post-wildfire.

Eastern Grey Kangaroo and Black Wallaby were recorded in increased numbers post-wildfire, whilst Red-necked Wallaby was recorded in reduced numbers post-wildfire. White-striped Freetail Bat and Lesser Long-eared Bat were recorded three years post-wildfire in Damp Sands Herb-rich Woodland. Little Forest Bat, Large Forest Bat and Gould's Long-eared Bat *Nyctophilus gouldi* (Fig. 4) were recorded in Damp Sands Herb-rich Woodland four and a half years post-wildfire. Chocolate Wattled Bat *Chalinolobus morio* was recorded in Sand Forest five years post-wildfire. Southern Forest Bat and Gould's Wattled Bat *Chalinolobus gouldii* were recorded five and a half years post-wildfire in Damp Sands Herb-rich Woodland. Burrows and runways typical of those made by Swamp Rat were found three years post-wildfire in a small unburnt area of Damp Sands Herb-rich Woodland. Swamp Rat and Black Rat *Rattus rattus* were photographed by remote surveillance camera in Damp Sands Herb-rich Woodland four and a half years after wildfire. Significant numbers of House Mice were captured in Damp Sands Herb-rich Woodland four and a

half years post-wildfire and in Heathy Woodland five and a half years post-wildfire. Red Fox *Vulpes vulpes* was seen in Plains Grassy Woodland three years after fire. Numerous European Rabbits *Oryctolagus cuniculus* and smaller numbers of European Hares *Lepus europeus* were seen in Plains Grassy Woodland six and a half years post-wildfire.

Discussion

Insectivorous bats make up a significant proportion of native mammal populations in many parts of south-eastern Australia, especially in fragmented landscapes in agricultural districts (Lumsden and Bennett 2000). Lumsden *et al.* (1995) suggested that bats are more tolerant of habitat fragmentation than other vertebrates and that several factors, including the ability to fly, colonial roosting habits and overlapping foraging areas, enable insectivorous bats to live successfully in farmland environments.

All insectivorous bats recorded in the Grampians and surrounding agricultural areas, except Common Bent-wing Bat *Miniopterus schreibersii*, use tree hollows as roosting sites (Menkhorst 1995; Churchill 2008). Studies in Tasmania and south-east New South Wales



Fig 3. Eastern Pygmy Possum *Cercartetus nanus*. Photo by Adam Merrick.

found that several species of forest bats favour roost sites in large, old trees with a diameter-at-breast-height of over 80 cm (Lunney *et al.* 1988; Taylor and Savva 1988). Lumsden *et al.* (2002) found that preferred roost sites for Gould's Wattle Bat were in dead spouts of living, large, old River Red Gums *Eucalyptus camaldulensis*. At Wuurak and on surrounding properties these kinds of hollows were present in large River Red Gums that survived the wildfire. Lumsden *et al.* (2002) radio-tracked Gould's Wattle Bats and Lesser Long-eared Bats in northern Victoria and found that individual bats foraged in farmland up to 12 km from roosting sites in forested areas. Lunney *et al.* (1985) recorded Chocolate Wattle Bats foraging 5 km from roosting sites located in exceptionally large trees. Taylor and Savva (1988) recorded a female Lesser Long-eared Bat travelling 4.8 km from roost site to foraging area.

Several variables influence data obtained by bat trapping, especially in open woodland habitats, where a high number of possible flight paths may exist. It is therefore not unusual for a chosen trap site to fail to capture any bats, and hence traps may be moved to new locations that are considered possible capture sites. Six-

teen individual bats from four species were captured pre-wildfire (12 harp trap-nights), whilst 63 bats from seven species were captured post-wildfire (23 harp trap-nights). The increase in species and numbers may be due to a number of factors. More surveys were conducted post-wildfire and hence there was an increase in survey effort. Five years after wildfire at Wuurak, dense regrowth along the edges of previously wide tracks in Sand Forest formed new and improved sites for harp trapping. A new trap-site near Reservoir Creek in Damp Sands Herb-rich Woodland, used post-fire only, was particularly successful. The significant increase in vegetation post-wildfire especially along Reservoir Creek may have caused a greater abundance of insects, making the site more attractive as a foraging location for bats roosting throughout the local district.

The Yellow-footed Antechinus has a wide distribution across central Victoria where it occupies mostly heathy woodland and dry sclerophyll forest on the inland side of the Great Dividing Range (Kelly 2006; Menkhorst 1995). The species can be locally common at sites with large areas of high quality habitat (Menkhorst 1995; Myers and Dashper 1999; Homan 2005).



Fig 4. Gould's Long-eared Bat *Nyctophilus gouldi*. Photo by Maryrose Morgan.

The Yellow-footed Antechinus has also been recorded in degraded and fragmented areas and in remnant, linear habitats along roadsides (Loyn *et al.* 2002; van der Ree 2003; Marchesan and Carthew 2004; Carthew *et al.* 2009; NMIT unpubl. data). Studies in fragmented landscapes near Euroa, Victoria and near Penola, South Australia showed that the species was able to move long distances through suitable habitat, but also across open, cleared farmland (van der Ree 2003; Carthew *et al.* 2009). The Yellow-footed Antechinus usually nests in tree hollows or hollow, fallen logs (Menkhorst 1995; Kelly 2006); however, the species will use other nest sites when these are not available (Menkhorst and Knight 2011).

Large scale wildfires often leave some areas only lightly burnt or completely unburnt. The wildfire at Wuurak severely burnt the Heathy Woodland area and surrounding areas, especially similar habitat in the adjacent Grampians National Park. The area of Damp Sands Herb-rich Woodland where Yellow-footed Antechinus was recorded pre-wildfire and all of the Sand Forest were also severely impacted by the

wildfire. In particular, large numbers of old-growth eucalypts with many hollows and fallen logs with hollows were destroyed by the fire. Yellow-footed Antechinus (one juvenile male) was recorded at Wuurak in Heathy Woodland in December 2010, five years after wildfire. This individual most likely entered the property from areas of nearby habitat that escaped the fire or that were only lightly burnt. Yellow-footed Antechinus was subsequently recorded in Damp Sands Herb-rich Woodland and Sand Forest six and a half years post-fire. The species could recolonise Wuurak only by moving through adjacent regenerating vegetation or across adjacent fragmented habitats and open grazing land.

The Eastern Pygmy Possum inhabits a wide range of vegetation communities within Victoria including Heathy Woodland (Menkhorst 1995). The species is a generalist omnivore, but feeds extensively on nectar and pollen especially from the inflorescences of several species of *Banksia* spp. (Turner 1984; Ward 1990). Huang *et al.* (1987) analysed the faeces of Eastern Pygmy Possums at a site near Nar Nar Goon, Vic-

toria, and found that pollen was a predominant item during the flowering of *Banksia spinulosa*. At Wuurak the species was not recorded pre-wildfire, but was recorded on two occasions post-wildfire in Heathy Woodland. Prior to the wildfire only a small number of mature specimens of Silver Banksia *Banksia marginata* were present; however, following wildfire large numbers of this plant germinated. The first record of Eastern Pygmy Possum, a juvenile female, occurred in April 2010, four and a half years post-wildfire, which coincided with a major flowering event for Silver Banksia. A second individual, an adult female, was captured in April 2012, which also coincided with prolific *Banksia* flowering.

The recording of Eastern Pygmy Possum post-wildfire at Wuurak was unexpected, especially considering the severe impact by wildfire on the Heathy Woodland and surrounding areas. It is unclear whether the species was present before fire, and was simply not detected despite a significant amount of survey effort, or whether it recolonised from the neighbouring section of the Grampians National Park. The species usually nests in hollows, which were mostly destroyed by the wildfire; however, Ward (1990) noted that the Eastern Pygmy Possum is very mobile and is able to use a wide range of nest sites.

Studies at other sites have recorded Eastern Pygmy Possum following wildfire. In the neighbouring Grampians National Park, Stevens (2008) conducted an extensive post-fire mammal trapping survey two and a half years after wildfire. Eastern Pygmy Possum (one individual only) was recorded from an isolated site that was severely impacted by wildfire. This site was 3 km from the nearest area of unburnt vegetation. In the eastern Otway Ranges in Victoria, one Eastern Pygmy Possum was recorded one year after a severe wildfire (Wilson and Moloney 1985). Wilson and Moloney (1985) concluded that animals can survive wildfire if sufficient refuges, such as unburnt pockets of vegetation, are available. At Ku-ring-gai Chase National Park in New South Wales, Eastern Pygmy Possum was recorded 13 months after wildfire, but no specimens were captured in nearby unburnt vegetation (Sutherland *et al.* 2004). At Nadgee Nature Reserve in south-east New South Wales

the species was recorded 2 to 3 months after a major wildfire, but was not recorded from this site during three years of survey effort immediately prior to the fire (Sutherland *et al.* 2004). Sutherland *et al.* (2004) suggested that the Eastern Pygmy Possum is a mid-storey species and, with the loss of this part of the habitat after fire, the species is forced to move across the ground. The studies in these two reserves demonstrated that the failure to trap Eastern Pygmy Possum on the ground in unburnt forest does not necessarily indicate its absence (Sutherland *et al.* 2004).

Three arboreal marsupials, Common Brush-tail Possum, Common Ringtail Possum and Sugar Glider, were recorded pre-wildfire and post-wildfire. All three species are nocturnal and use hollows in trees for shelter during the day (Menkhorst 1995). Studies at several inland sites have demonstrated that these species are able to survive in small patches and fragmented landscapes (Lunt 1988; Downes *et al.* 1997; van der Ree *et al.* 2003; Homan 2009). The severe wildfire at Wuurak destroyed virtually all old-growth eucalypts in the Heathy Woodland, Sand Forest and Damp Sands Herb-rich Woodland. Despite the severe impact of the fire an area of old-growth River Red Gums with many hollows survived the fire with their canopy intact in a section of Damp Sands Herb-rich Woodland and adjacent Plains Grassy Woodland, along the northern section of Reservoir Creek. With surrounding areas severely impacted by wildfire, this section of River Red Gums became an isolated patch. All three arboreal marsupial species were recorded for the first time post-wildfire in this patch. In the Grampians National Park, Stevens (2008) also recorded Common Brushtail Possum from small and large isolated patches that survived wildfire. Newsome *et al.* (1975) found that Common Brushtail Possum and Common Ringtail Possum survived wildfire in Nadgee Nature Reserve in wet areas where the tree canopy had not been destroyed.

The Swamp Rat is found over a wide area of southern Victoria, where it inhabits dense vegetation in wet heath, damp woodland and sedgefields (Menkhorst 1995). The species constructs extensive runways and burrow systems especially through areas of sedges and damp grasses (Menkhorst 1995). At Wuurak, Swamp

Rats were found before wildfire in dense sedge vegetation in Damp Sands Herb-rich Woodland along Reservoir Creek. As this vegetation regenerated at Wuurak, Swamp Rat successfully recolonised, within five and a half years, all areas where the species had been recorded pre-wildfire. When the property was visited three years after wildfire the only evidence of Swamp Rat was found in a small section of Damp Sands Herb-rich Woodland covering approximately 0.5 ha that had survived the fire. Despite considerable searching at this time no other evidence of the species could be found along other sections of Reservoir Creek. One and a half years later, runways and burrows were found along another section of Reservoir Creek approximately 200 m further downstream, and one Swamp Rat was photographed by remote surveillance camera at this location. Five and a half years after wildfire, fresh burrows and runways were found along all sections of Reservoir Creek.

Other studies have recorded Swamp Rat successfully recolonising regenerating vegetation following wildfire. At Nadgee Nature Reserve, Swamp Rat was the first native mammal species to recolonise regenerating heathland six years after wildfire (Catling 1986). During another study at this location Swamp Rat was recorded two years after intense wildfire as grassy ground vegetation developed and one year after another wildfire partially burnt the study site (Recher *et al.* 2009). However, Stevens (2008) did not record Swamp Rat from any survey sites in the Grampians that were impacted severely or mildly by wildfire.

Two introduced rodents, House Mouse and Black Rat, colonised parts of Wuurak following wildfire, especially areas of Damp Sands Herb-rich Woodland along Reservoir Creek. The House Mouse is seen as an early coloniser of disturbed sites (Menkhorst 1995). The species has been recorded in large numbers at numerous locations following wildfire (Newsome *et al.* 1975; Wilson and Moloney 1985; Catling 1986). Recher *et al.* (2009) found that House Mouse colonised burnt areas within two years of wildfire and persisted for three to four years before disappearing. Lunney *et al.* (1987) found that the species reached plague proportions two years after fire in an area that was intensely

burnt. In the Grampians, Stevens (2008) recorded a rapid resurgence of House Mouse two years after wildfire, especially at isolated sites many kilometres from unburnt vegetation. At Wuurak House Mouse was recorded in low numbers pre-wildfire, but numbers increased dramatically post-wildfire. In an area of Damp Sands Herb-rich Woodland the capture rate for House Mouse was 33.3% four and a half years after wildfire severely impacted this site. Two years later the capture rate at this location had dropped to 1%. In Heathy Woodland House Mouse capture rate was 11% five and a half years post-fire, but decreased to 0.8% six and a half years post-fire. Low capture rates for House Mouse in April 2012, corresponded to recolonisation by Yellow-footed Antechinus of all parts of Wuurak. Menkhorst (1995) suggested that in the presence of Yellow-footed Antechinus, House Mouse may be largely restricted to areas less favourable to Antechinus.

The Black Rat is found in many parts of western Victoria, especially near human habitation and around farm buildings (Menkhorst 1995). The species becomes established in areas where disturbance such as fire has displaced native rats (Menkhorst 1995). The Black Rat was not recorded from indigenous vegetation at Wuurak pre-wildfire; however, the owners of the property reported encountering the species occasionally around sheds and other human-made structures. The species was detected by remote surveillance camera on two occasions in Damp Sands Herb-rich Woodland along Reservoir Creek four and a half years and six and a half years post-wildfire.

In recent years remote surveillance cameras have become a common survey method to determine the presence of terrestrial mammals (Nelson *et al.* 2009; De Bondi *et al.* 2010; Johnston *et al.* 2012). In many instances, where there is no need to handle animals, cameras have replaced cage traps. Setting large numbers of cage traps, especially in thick vegetation, is very labour-intensive. Prior to wildfire at Wuurak the vegetation in Damp Sands Herb-rich Woodland was quite open, providing fairly easy access. Following wildfire, however, prolific regrowth of Swamp Gum *Eucalyptus ovata* combined with numerous fallen trees produced almost impenetrable thickets over much of this

EVC. This change in conditions made it almost impossible to replicate survey methods used and effort completed pre-wildfire. Due to the change in habitat structure, and with the ability of cameras to detect the presence of all terrestrial mammals recorded pre-wildfire and any possible additional species, remote surveillance cameras were chosen as an efficient and less labour-intensive alternative to cage trapping post-wildfire.

The three large macropod species recorded pre-wildfire were all recorded three years post-wildfire and during subsequent visits to the property. The Black Wallaby (also known as Swamp Wallaby) is widely distributed across much of Victoria (Menkhorst 1995). In recent decades the range of the species has expanded into many parts of western Victoria where it was previously unknown (Bird 1992). The Black Wallaby is a generalist browser and is often most numerous in dense understorey, especially in riparian vegetation (Menkhorst 1995). At Wuurak, dense vegetation developed following wildfire in Damp Sands Herb-rich Woodland along Reservoir Creek. When this habitat was visited three years post-wildfire, the population of Black Wallaby was noticeably higher than pre-wildfire. Numerous Black Wallabies were seen and fresh scats typical of those produced by the species were common. In Mumbulla State Forest in New South Wales, Lunney and O'Connell (1988) found that the population of Black Wallaby increased within two years of wildfire as shrub cover increased. Other studies in revegetation sites and plantations showed high usage by Black Wallabies of dense vegetation aged from two to four years (Floyd 1980; Hill and Phinn 1993).

The Red-necked Wallaby and Eastern Grey Kangaroo are both grazers (Menkhorst 1995). Both species rest during the day amongst vegetation in woodlands and forests and emerge at dusk or after dark to graze on adjacent grasslands (Hill 1981; Johnson 1987). Several years post-wildfire significant rainfall occurred in the Moyston district producing prolific growth of grasses and ideal grazing conditions for large macropods. Six and a half years post-wildfire the population of Eastern Grey Kangaroo had increased significantly and was noticeably higher than pre-wildfire. However, the Red-

necked Wallaby population had not returned to pre-wildfire levels. This may be due in part to competition with Eastern Grey Kangaroos or to predation on juvenile wallabies by the Red Fox. Juvenile Red-necked Wallabies that have recently vacated the pouch are left in dense vegetation whilst adults graze in nearby areas (Johnson 1987). Menkhorst (1995) stated that predation by Red Foxes at this stage may be high. The Red Fox was common at Wuurak post-wildfire and predation by this species on juvenile wallabies may have adversely affected recolonisation by the Red-necked Wallaby.

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