The Effect of Fire on Wild Horses in the Australian Alps National Parks

by

Michelle Walter

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SUMMARY

Wild horse management is a contentious issue in the Australian Alps national parks because they are viewed as both a vertebrate pest impacting on the environment and a cultural icon. In 2001, there was an estimated 5 200 (± 1 643 SE) wild horses in the Australian Alps national parks (Walter unpublished data). In 2002 - 2003 fires affected vast areas of the Australian Alps national parks with unknown consequences for wildlife. One of the primary concern with respect to wild horses is that they survived the fires (because they are highly mobile animals) while much of their habitat was burnt.

A post-fire survey was conducted in April 2003 to assess the size of the wild horse population and determine whether animals were concentrated in unburnt habitat. It was estimated that the population halved and is now 2369 ± (800 SE) horses. Horses were not concentrated on unburnt or burnt areas, 69.5% of groups being sighted in burnt habitat, which is remarkably similar to the proportion of total horse habitat burnt (71.3%). Horse group size observed from the air was smaller post-fire than pre-fire, which was not anticipated. Smaller groups were observed in burnt habitat so it is likely that fire had the effect of reducing group size.

The implications of the fire for managers varies depending on the region. Much of the horse habitat in north Kosciuszko was not burnt, so it is unlikely that fire had a major effect on this population. Furthermore, prior to the fire, the population appeared to be expanding its distribution and increasing in size (Walter 2002). It is recommended that this population is managed to prevent further increase in population size or range. In north Victoria and south Kosciuszko the majority of horse habitat was burnt, and it appears that the numbers were reduced by the fire. Such a large reduction was not feasible through available control methods pre-fire. One view is that the fire has been very effective at controlling horse numbers, and no more management is needed at this stage. Alternatively, the current low numbers could be viewed as an opportunity to be exploited and populations can be further reduced.

INTRODUCTION

Wild horse management is a contentious issue in the Australian Alps national parks (AAnp) because horses are viewed as both a vertebrate pest impacting on the environment (Dobbie *et al.* 1993) and a cultural icon (e.g. appearing on the Australian ten-dollar note). The Australian Alps national parks have shown a strategic approach to wild horse research (Walter 2002) and management in recent years (e.g. NSW National Parks and Wildlife Service 2003a). The 2002-2003 bushfires were a major environmental event for the Australian Alps, with dramatic effects expected for wild animals, including horses.

Wild horses first became established in the Australian Alps over 150 years ago. The populations have fluctuated in size and distribution since then, primarily as a result of human intervention, but also in response to environmental influences such as food and snow (Walter 2002). In the past few decades there has been very little human intervention in parts of the AAnp resulting in wild horse populations becoming food limited with a rate of increase of zero (e.g. Cowombat Flat on the border of NSW and Victoria)(Walter 2002). In other areas the populations were increasing but not at the maximum intrinsic rate (e.g. Currango, north Kosciuszko) or limited below their carrying capacity by brumby-running (in Victoria) (Walter 2002). A survey of wild horses in the AAnp was conducted pre-fire and the estimated population size was 5 200 (± 1 643 SE) horses (Walter unpublished data).

The wildfires in 2002-03 burnt large parts of the Australian Alps national parks (Figure 1) with likely dramatic implications for the survival of the fauna in the area. The effect of the fire will depend on the animals themselves including their response to the fire-front and their habitat requirements in the post-fire environment. The ability to escape the initial fire-front varies among fauna, depending on their mobility and their ability to find refuge in places like pockets of unburnt vegetation (e.g. wet gullies), underground, in rock crevices or in tree hollows (Christensen 1980, Recher 1981, Gill and Bradstock 1995, Williams & Gill 1995). After the fire, the different habitat requirements of species will also lead to differential affects on different species (Williams & Gill 1995).

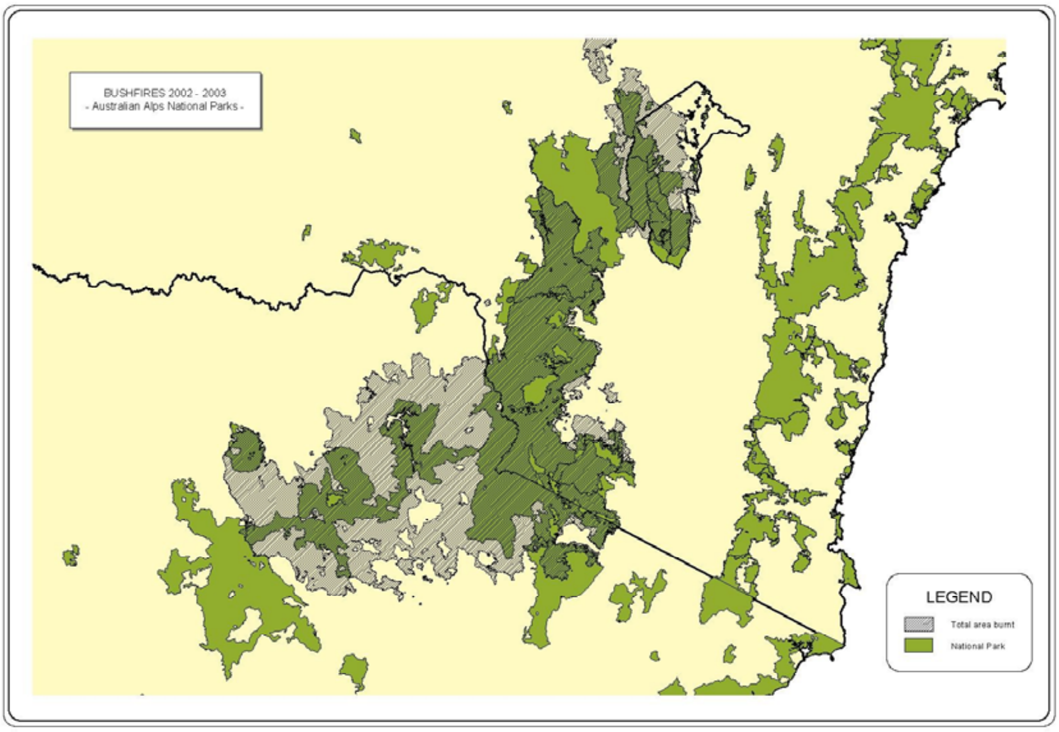

Figure 1: Areas of the Australian Alps affected by fire (hatched) in the Australian Capital Territory, New South Wales and Victoria in 2002-2003. The Australian Alps are the dark area (green) running through the centre of the image (Image produced by NSW National Parks and Wildlife Service).

Wild horse habitat (Walter 2002) was burnt to varying degrees with unknown effects on the wild horse population. The major concern regarding wild horses post-fire is that since they are highly mobile animals, they may have survived the fire-front while much of their habitat was burnt.

On the 6th and 7th February 2003, two aerial survey were conducted in north Kosciuszko by NSW National Parks and Wildlife Service to establish where wild horses were located after the fires and to estimate the minimum density of wild horses in north Kosciuszko (NSW National Parks and Wildlife Service 2003b). No horses were observed in the burnt or unburnt ranges, but they were observed on plains, some of which were burnt. The estimated minimum densities were 0.34 horseskm^{-2} and 0.33 horseskm^{-2} respectively. The methods used in this survey differed considerably from the Australian Alps survey conducted in 2001 (Walter 2002).

Aims

The aims of this research were to:

1. Estimate the post-fire abundance of wild horses in the Australian Alps national parks, and compare it to pre-fire abundance,
2. Estimate the proportion of wild horse habitat effected by fire,
3. Determine whether wild horse populations are concentrated in burnt or unburnt habitat,
4. Assess the likely relative impact of horses post-fire relative to pre-fire and in burnt and unburnt areas, and
5. Discuss management implications of the findings.

METHODS

Survey Area

The survey was carried out on 12th and 22 - 27th April 2003 within the Australian Alps national parks and was a repeat of a pre-fire survey conducted in 2001 (Walter 2002 and Walter unpublished data. Note: the aerial survey section of Walter 2002 was accepted by the Wildlife Society Bulletin for publication with revision. The revisions resulted in a minor modification to the final population estimate for the 2001 survey. The revised paper was not in press at the time this report was written and therefore has not been cited). The regions surveyed were the same as the regions surveyed in 2001, with the exception of three transects in northern Kosciuszko. The regions were north Kosciuszko, Snowy Plain, south Kosciuszko (Pilot Wilderness), north Victoria (Cobberas, Davies Plain, Buenba, Buchan River), and the Bogong High Plains. Regions where horses occur but not surveyed include west of Tantangara Dam and Byadbo. These areas were not surveyed in 2001 primarily to keep costs down. The terrain is particularly rugged making the survey methods less reliable, and the density of horses was thought to be very low. The areas were not surveyed in 2003 for the same reasons and because the aim was to make a comparison pre- and post-fire. Transects flown in the 2003 survey and reasons for excluding the three northern Kosciuszko transects are included in Appendix 1.

Survey Design

The survey was done in a Bell Jet Ranger helicopter with the doors off to improve visibility. Parallel east west transects were flown two kilometres apart at approximately 100km/h and 100m above ground level. Transect co-ordinates were entered into a Global Positioning System (GPS) prior to surveys and the pilot flew these transects with the aid of the GPS and a light bar. One observer was positioned on the left-hand-side front seat and the second in the rear on the left-hand-side. The same two observers were used in 2001 and 2003. Observations were recorded independently and without collusion. A strip 200m wide was surveyed giving approximately a 10% sampling intensity. The strip was broken down into 4 intervals (described below) so the data could be analysed using line transect methods.

The area counted was delineated with a bar attached to the underside of the helicopter and stabilized with struts with marks delineating 50, 100, 150 and 200m intervals when at survey height. The survey took 30 hours and was carried out between 0900 and 1700 hours when weather permitted, with breaks for refueling, lunch and to avoid fatigue. The weather during the survey was generally cool, (about 6°C) and winds were calm. Studies of horses suggest that horse behaviour does not alter noticeably with time of day (Dyring 1990, Black 2000, Walter unpublished data).

Both observers had stopwatches, which were synchronized at the start of each transect. When a group of horses were observed, the number of animals in the group, time, distance interval and vegetation cover was recorded. The time was later used to assess whether one or both of the observers saw the group. The groups were considered to be the same if times were within 10 seconds of one another. Vegetation cover was broken into three classes: open, woodland/forest and edge (of woodland/forest and open). The edge class was included because horses were often seen on the woodland/clearing edge during ground-based surveys. An extra category relating to whether the horses were in an area affected by fire was added in the 2003 survey. The categories were unburnt (no evidence of fire in the vicinity), burnt (the entire area burnt including pasture) or patchily burnt (a mosaic burn pattern with patches of pasture (>10m^2) remaining unburnt).

Analysis

Mean group size and standard error were calculated independently for both observer 1 and observer 2. These were compared to observations from 2001 from the air and from the ground (Walter 2002). The ground estimates in 2001 are assumed to be correct because they are taken from a comprehensive study based on recognition of individuals (Walter 2002).

In the post-fire survey, observed mean group size was lower. This result was not predicted before the survey. Unfortunately there were no ground surveys done in 2003 to accompany the aerial survey, so actual group size is not known. To account for this, expected group size was adjusted by assuming that the same proportion of individuals in groups were missed in the pre- (2001) and post- (2003) fire surveys.

In the 2001 pre-fire survey, several analysis techniques were assessed to see which one gave the most accurate and precise result (Walter 2002). All of these techniques were used again in the post-fire survey, however only the line transect technique for both observers combined is presented here because it is the preferred technique. In cases where group size counts for the same group differed between observers, it was assumed that the higher estimate was correct because it is likely that one of the observers failed to see all of the animals.

Line transect data were analysed using program DISTANCE 4.0 (Thomas *et al.* 2002) to estimate horse densities and standard errors. Data on horse groups in each transect were combined for both observers and analysed as interval data in four intervals. When observers recorded a group over two interval classes, they were entered into the interval class with the most horses. The estimator adjusted for the presence of observers on only one side of the aircraft. Four detection functions were fitted to the data: half-normal, hazard rate, uniform and negative exponential. The best function was selected as that with the lowest value of the Akaike's Information Criterion corrected for small sample size (AICc) (Buckland *et al.* 1993, Burnham & Anderson 2002). An estimate of horse group density was then calculated by model averaging (Burnham & Anderson 2002) using the corrected Akaike weights for the four detection functions.

It is standard practice to use Program DISTANCE to compute expected group size by regressing log(s(i)) on g(x(i)) where s(i) is group size of the ith observation and x(i) is distance to the ith observation (Buckland *et al.* 1993: p. 80). However in the current analysis this lead to a regression line with a negative slope, and thus the computed expected group size was lower than the observed group size. Using these results is likely to lead to increased inaccuracy. In the 2001 survey group size was under-estimated from the air (Walter 2002); the same pattern is highly likely in the 2003 survey. The analysis was therefore set so that models used the mean observed group size from the air. Additional analysis was done using the adjusted group size (as discussed above). The variance of the estimate of horse abundance was the exact variance of a product (group density x mean group size) (Leatherwood et al. 1978).

Proportions of horse habitat burnt were estimated by overlaying transects on fire maps (maps prepared by Greg Mifsud, NSW National Parks and Wildlife Service). The proportion of survey area burnt was calculated by dividing the length of transects in burnt areas by the total transect length. This is a line intercept method (Krebs 1999).

RESULTS

Group size

Both observers saw 28 groups, with 20 groups in common but both observers saw 8 groups not seen by the other observer. The average group size seen by observer 1 and observer 2 were very similar at 3.11 $\pm$ 0.59SE and 3.10 $\pm$ 0.58SE respectively. These are lower than the mean group size observed in the 2001 aerial and ground surveys, and the difference between observers in 2001 is not apparent (Figure 2). Observer 1's estimates in the post-fire survey were significantly lower than her 2001 group size estimate (t_{62} = -2.61, P = 0.01), but observer 2's were not significantly different (t_{70} = -1.11, P = 0.27). The post-fire expected group size adjusted for failing to see all animals in the group was 4.59 ± 0.38SE horses/group.

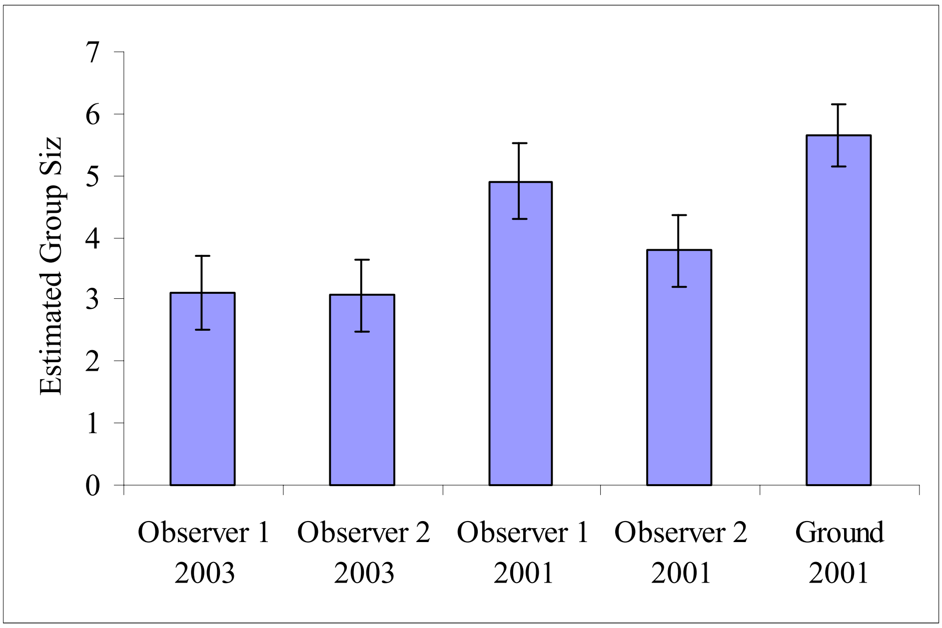

Figure 2: Mean estimated group size (with standard error bars) for both observers in the post-fire survey (2003) and the pre-fire survey (2001), and ground estimates, which were comprehensive and assumed to be accurate in 2001.

Group sizes tended to be smaller in burnt area than unburnt areas (Figure 3). Seventy-three percent of horses observed in burnt areas were comprised of 1-3 individuals. Numbers of horses in patchily burnt or unburnt areas were fairly evenly spread between groups containing 1-6 individuals. The largest group size observed during the post-fire survey was 6. Larger groups were seen during the survey but they were not sighted in the survey area so were not included in analyses.

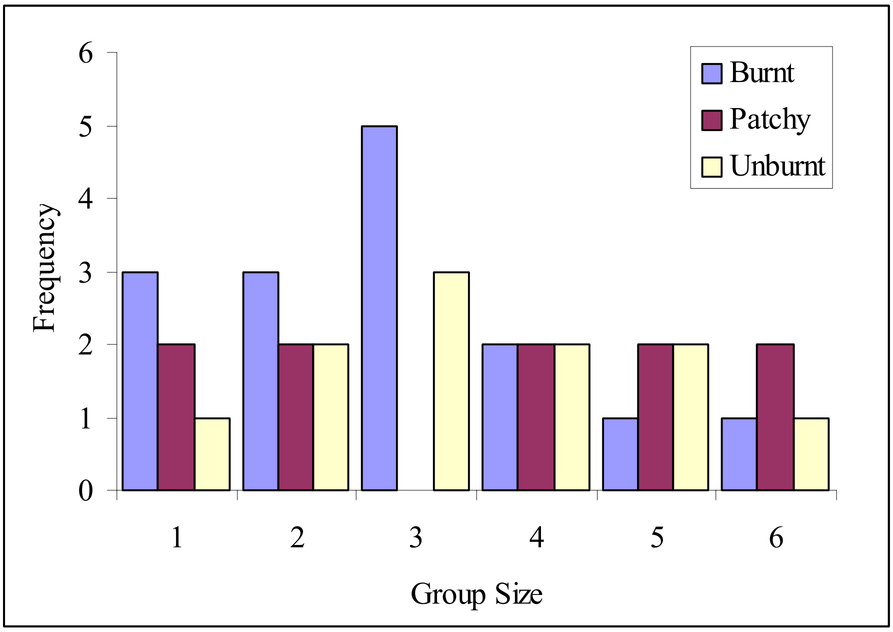

Figure 3: The number of groups of varying size for both observers combined in different burn categories.

Estimated number of horses

The estimated density of horses is 0.61 (± 0.21) SE km^{-2} using model averaging from line transect analysis (results for each model are shown in Table 1). The estimated number of horses in the survey area using the averaged model is 1657 (± 575 SE) however, this is probably an under estimate because it uses an estimate of group size that is probably biased low (see analysis section). A more accurate estimate uses the adjusted expected group size (4.59 ± 0.38 SE) to estimate total number of horses, giving a horse density of 0.872 (± 0.29 SE) horses km^{-2} or a total of (2244 ± 800 SE) horses.

Table 1: Density ($\hat{D}$ km^{-2}) of groups of wild horses derived from line transect analysis for both observers combined using data in 4 intervals. * The goodness of fit of each detection function (the probability of a greater chi square value)

Model	P*	$\hat{D}$ groups	CV (%)	$\hat{D}$ horses	CV (%)	AICc
Half Normal	0.81	0.18	29.48	0.57	30.61	98.69
Negative Exponential	0.79	0.21	35.24	0.68	36.19	98.70
Uniform	0.76	0.18	29.16	0.59	30.31	98.79
Hazard Rate	0.46	0.19	43.83	0.61	44.60	101.3

The detection function that provides the best fit to the data using AICc values is the half normal model (Figure 4), however it is only slightly better than the negative exponential and uniform models (Table 1). The data shows a pattern of reduced sightability with increasing distance from the line (Figure 4), however the slope of the function is far less than that in the pre-fire survey (Figure 5).

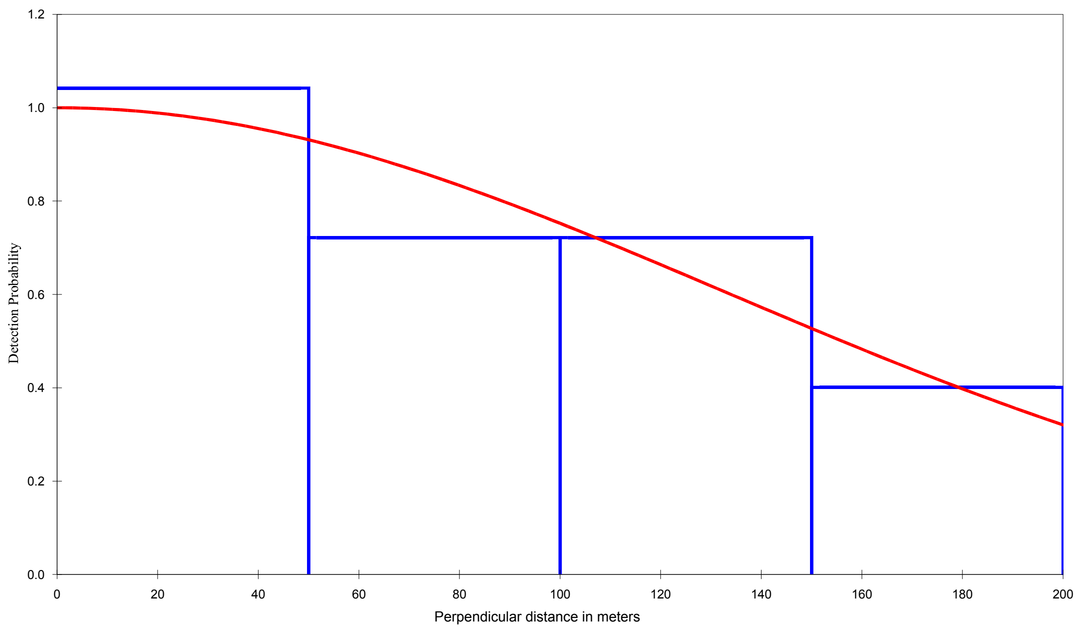

Figure 4: Half normal model fitted to line transect data of post-fire (2003) wild horses for both observers combined.

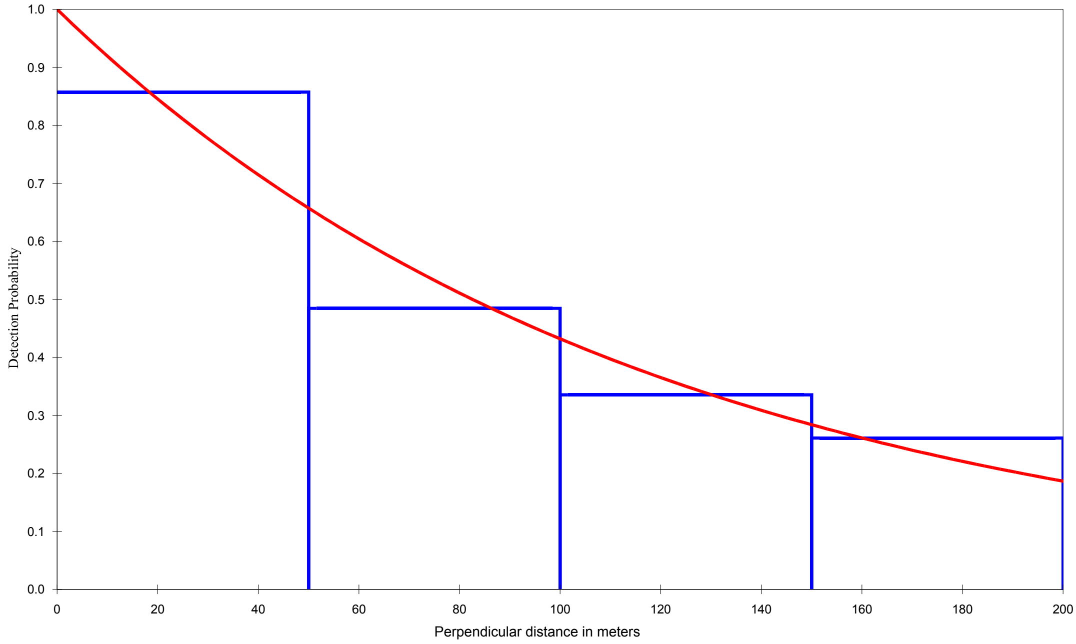

Figure 5: Negative exponential model fitted to line transect data of pre-fire (2001) wild horses for both observers combined.

Distribution of horses with respect to regions and fire

The proportion of habitat burnt varied between regions (Table 2). The area affected most by fire was northern Victoria where 100% of horse habitat was burnt and north Kosciuszko was least fire affected with 16% of the area burnt. Horses were sighted in all regions with the highest sighting rate of horse groups occurring at Snowy Plain and then at north Kosciuszko. The lowest sighting rate was in south Kosciuszko, but it was very similar to north Victoria and the Bogong High Plains (Table 2). These results should be used as a general guide on relative densities in different areas because sample sizes were small and statistical power is very low.

Table 2: Proportion of regions affected by fire and the proportion of total number of horse groups sighted in each region.

Region	Area (km^2)	Fire affected (%)	Groups sighted (%)
North Kosciuszko	723	16.0	36.1
Snowy Plain	77	92.7	11.1
South Kosciuszko	758	79.7	19.4
North Victoria	1069	100.0	30.6
Bogong High Plains	90	84.6	2.8
TOTAL	**2717**	**71.3**	

Horses were not concentrated on unburnt areas in the post-fire environment. 69.5% of horse groups were sighted in burnt habitat, which is remarkably similar to the total proportion of horse habitat burnt (71.3% Table 2). In the unburnt habitat groups were spread fairly evenly between open, edge and woodland habitat (Figure 4). In burnt areas, horses were sighted most often in woodland. In areas, which had a patchy burn, horses tended to be in the open.

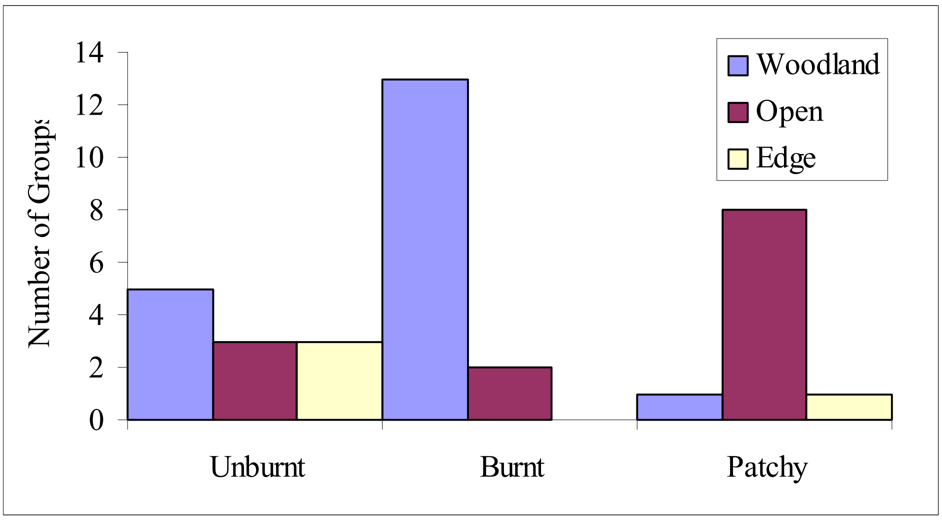

Figure 4: Location of groups sighted relative to habitat and fire. For explanation of terms refer to methods.

DISCUSSION

Group Size

The reduction in group size from the air post-fire compared to pre-fire was not expected, but is quite feasible considering the general impact of the fire event. This has lead to a level of uncertainty into the estimates of population size. Unfortunately the standard methods for adjusting expected group size to account for animals missed could not be applied here. In the pre-fire 2001 survey, ground counts provided a means to adjust observed group size (Walter 2002). An alternative method is to adjust group size in program DISTANCE. However in this case the estimated group size in the program was clearly inaccurate as it was lower than observed group size. The group sizes observed in the 2001 ground counts were typical for wild horse populations around the world (Walter 2002). A reduction in group size post-fire is feasible considering the reduction in the population size and the fact that smaller groups were generally observed in burnt areas (Figure 3). I asked brumby-runners whether they also observed a reduction in group size post-fire and the response was mixed. One said that group sizes were reduced while another observed small groups in one area and larger groups in another (M. Flanagan and C. Edwards pers. comm.).

The preferred method of estimating expected group size in the current study was to adjust the group size up in the same proportion that it was adjusted in the 2001 survey based on ground counts. Survey methods were the same and observers were the same, so hopefully error margins were also the same. This theory has been applied in the use of correction factors for observers in other aerial surveys (e.g. Bayliss & Yeoman 1989)

Population Size Pre- and Post-Fire

This is the first study of the effect of wild fire on wild horse populations in the world. The estimated population size of wild horses is considerably lower post-fire (2 369 $\pm$ 800 SE) than pre-fire (5 200 $\pm$ 1643 SE). Therefore the hypothesis that 'since horses are highly mobile, the population would not suffer as a result of fire' has been rejected. Reductions in horse populations are usually the result of human intervention, though predators can also suppress populations (Walter 2002 and references therein). The effect of wild fire has been observed in other species including the northern spotted-owl where large wild fire resulted in a population decline of 14%, similar to reported adult mortality rates (Bond *et al.* 2002). Other species that have been studied in the Australian Alps post-fire include the eastern grey kangaroo (*Macropus giganteus*), which had a 47% reduction (D. Fletcher unpublished data), the spotted-tailed quoll (*Dasyurus maculatus*), which had a 40% reduction (J. Dawson pers. comm.) and small mammals, which had a 75% reduction (K. Green pers. comm.). Prior to the 2002-03 wildfire, information on the effect of fire on fauna in the Australian Alps was scarce (Walter 1997).

The population of wild horses may decline further if the fire is followed by a severe winter. Simulation models for ungulate populations post-fire in Yellowstone National Park found that winter severity plays a dominant role in ungulate survival (Turner *et al.* 1994). Mild winters may have no effect on winter survival, however, when winters were average or severe, the effects of fire on ungulate survival become important. The model was based on the forage available and the depth and density of the snow.

In several years time, the horse populations in fire affected areas are likely to increase in size faster than pre-fire as a result of increased forage availability and reduced population pressure. In areas where the fire was severe and populations were dramatically reduced, the remaining population will not recover as fast as its food supply. Therefore, they are likely to increase at the maximum intrinsic rate for horses (approximately 20%) (Eberhardt 1987). Ungulates in Yellowstone National Park were found to utilize burnt areas more often than unburnt areas in mid to late winter at three to four years after fire (Pearson *et al.* 1995). This may be a result of increased palatability of forage after fire. Catling (1991) predicted that horses would be advantaged by frequent low intensity fires due to a simplification in forest structure. Following from this, a few years after a wild fire, the simplified forest structure could be advantageous to horses.

Distribution Post-fire

Horses were observed in burnt and unburnt habitat in the current study. In a survey one month after fires in north Kosciuszko a similar pattern was observed (NSW National Parks and Wildlife Service 2003b). This is likely to be the result of home range attachment. It is common for mammals to remain in their home range even when most of the physical characteristics of their home range are destroyed by fire (Christensen 1980).

Managers of different regions (Table 2) are interested in how the fire affected horses in their units. Due to the low density of horses and their clumped distribution (groups), it is not possible to draw strong inference from the results of this survey for small areas. Such information would require replication of aerial surveys at great expense so is unlikely to occur. An alternative method of studying horse populations is from the ground (Walter 2002). This requires a commitment of time and labour. A general conclusion that can be drawn from the current survey is that horse population size dropped most dramatically in areas that were severely fire affected. For example, the north Victorian population (100% fire affected) have suffered greater losses than north Kosciuszko (16% fire affected).

Management Implications

The survey suggests that the size of the wild horse population across the Australian Alps national parks has decreased dramatically as a result of the fire. The horses are not concentrated in unburnt patches, so there has not been a relative increase in these areas, which are potentially important refugia for native animals.

The population of wild horses in north Kosciuszko was affected least by fire. This is an area where the population was increasing and distribution spreading prior to the fire (Walter 2002). Neither of these is desirable for the environment and it is recommended that populations should not be allowed to increase or expand further.

There are two main options for management of horse populations that were heavily affected by fire:

1) Take advantage of the low population size and reduce the population further. Horse populations will take longer to recover if more horses are removed now.
2) Take no further action at this stage. The fires have already reduced the population below half. Such a reduction would have been almost impossible to achieve without the fire.

For both options I recommend that targets of acceptable wild horse population size and/or impacts are established and that horse numbers continue to be monitored.

ACKNOWLEDGEMENTS

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APPENDIX 1: POST-FIRE TRANSECTS FLOWN IN 2003

North Kosciuszko

TRANSECT	EASTINGS	NORTHINGS		EASTINGS	NORTHINGS
Start 1	647000	6027000	End 1	637000	6027000
Start 2	635000	6029000	End 2	647000	6029000
Start 3	648000	6031000	End 3	634000	6031000
Start 4	634000	6033000	End 4	649000	6033000
Start 5	650000	6035000	End 5	634000	6035000
Start 6	635000	6037000	End 6	650000	6037000
Start 7	653000	6039000	End 7	635000	6039000
Start 8	638000	6041000	End 8	655000	6041000
Start 9	662000	6043000	End 9	638000	6043000
Start 10	638000	6045000	End 10	662000	6045000
Start 11	662000	6047000	End 11	637000	6047000
Start 12	637000	6049000	End 12	662000	6049000
Start 13	662000	6051000	End 13	637000	6051000
Start 14	637000	6053000	End 14	659000	6053000
Start 15	658000	6055000	End 15	638000	6055000
Start 16	638000	6057000	End 16	655000	6057000
Start 17	655000	6059000	End 17	639000	6059000
Start 18	639000	6061000	End 18	654000	6061000
Start 19	653000	6063000	End 19	639000	6063000
Start 20	640000	6065000	End 20	652000	6065000
Start 21	652000	6067000	End 21	640000	6067000
Start 22	640000	6069000	End 22	652000	6069000

NB 3 extra transects were flown in 2001 (pre-fire) to the north of transect 22. These were not resurveyed in the post-fire survey because we reached them late in the day and there was insufficient time to finish them. They were not revisited the next day to keep costs of the survey down. It would have taken an hour flying time each way to revisit the area. Furthermore, the terrain was heavily dissected and the vegetation was tall forest. Sighting horses was highly unlikely.

Snowy Plain

TRANSECT	EASTINGS	NORTHINGS		EASTINGS	NORTHINGS
Start 1	646000	5981000	End 1	641000	5981000
Start 2	638000	5983000	End 2	647000	5983000
Start 3	646000	5985000	End 3	637000	5985000
Start 4	635000	5987000	End 4	646000	5987000
Start 5	641000	5989000	End 5	635000	5989000
Start 6	637000	5991000	End 6	639000	5991000

South Kosciuszko

TRANSECT	EASTINGS	NORTHINGS		EASTINGS	NORTHINGS
Start 1	630000	5965000	End 1	611000	5965000
Start 2	610000	5963000	End 2	630000	5963000
Start 3	631000	5961000	End 3	610000	5961000
Start 4	609000	5959000	End 4	631000	5959000
Start 5	629000	5957000	End 5	607000	5957000
Start 6	609000	5955000	End 6	629000	5955000
Start 7	626000	5953000	End 7	610000	5953000
Start 8	611000	5951000	End 8	616000	5951000
Start 9	617000	5949000	End 9	611000	5949000
Start 10	611000	5947000	End 10	617000	5947000
Start 11	621000	5945000	End 11	611000	5945000
Start 12	611000	5943000	End 12	624000	5943000
Start 13	621000	5941000	End 13	610000	5941000
Start 14	609000	5939000	End 14	622000	5939000
Start 15	622000	5937000	End 15	606000	5937000
Start 16	605000	5935000	End 16	623000	5935000
Start 17	624000	5933000	End 17	601000	5933000
Start 18	600000	5931000	End 18	628000	5931000
Start 19	627000	5929000	End 19	599000	5929000
Start 20	599000	5927000	End 20	626000	5927000
Start 21	626000	5925000	End 21	610000	5925000
Start 22	614000	5923000	End 22	620000	5923000
Start 23	622000	5921000	End 23	617000	5921000

North Victoria

TRANSECT	EASTINGS	NORTHINGS		EASTINGS	NORTHINGS
Start 1	610000	5925000	End 1	592000	5925000
Start 2	591000	5923000	End 2	614000	5923000
Start 3	618000	5921000	End 3	590000	5921000
Start 4	589000	5919000	End 4	621000	5919000
Start 5	621000	5917000	End 5	588000	5917000
Start 6	588000	5915000	End 6	608000	5915000
Start 7	610000	5913000	End 7	587000	5913000
Start 8	586000	5911000	End 8	613000	5911000
Start 9	613000	5909000	End 9	586000	5909000
Start 10	587000	5907000	End 10	614000	5907000
Start 11	607000	5905000	End 11	588000	5905000
Start 12	587000	5903000	End 12	607000	5903000
Start 13	607000	5901000	End 13	587000	5901000
Start 14	584000	5899000	End 14	607000	5899000
Start 15	607000	5897000	End 15	584000	5897000
Start 16	585000	5895000	End 16	607000	5895000
Start 17	592000	5893000	End 17	590000	5893000

Davies and Buenba

TRANSECT	EASTINGS	NORTHINGS		EASTINGS	NORTHINGS
Start 1	599000	5951000	End 1	606000	5951000
Start 2	607000	5949000	End 2	598000	5949000
Start 3	597000	5947000	End 3	607000	5947000
Start 4	607000	5945000	End 4	595000	5945000
Start 5	594000	5943000	End 5	604000	5943000
Start 6	604000	5941000	End 6	591000	5941000
Start 7	582000	5939000	End 7	602000	5939000
Start 8	602000	5937000	End 8	576000	5937000
Start 9	575000	5935000	End 9	602000	5935000
Start 10	601000	5933000	End 10	575000	5933000
Start 11	575000	5931000	End 11	600000	5931000
Start 12	599000	5929000	End 12	589000	5929000
Start 13	590000	5927000	End 13	597000	5927000

Note: Davies and Buenba were included in north Victoria for analysis

Bogong High Plains

TRANSECT	EASTINGS	NORTHINGS		EASTINGS	NORTHINGS
Start 1	520000	5917000	End 1	518000	5917000
Start 2	517000	5915000	End 2	521000	5915000
Start 3	522000	5913000	End 3	517000	5913000
Start 4	516000	5911000	End 4	523000	5911000
Start 5	527000	5909000	End 5	517000	5909000
Start 6	518000	5907000	End 6	532000	5907000
Start 7	532000	5905000	End 7	524000	5905000
Start 8	527000	5903000	End 8	531000	5903000