The Population Ecology of Feral Horses in the Australian Alps

Management Summary

Prepared for the Australian Alps Liaison Committee

April 2005

by Michelle Dawson

Contents

Introduction

From 1999-2002 I studied the population ecology of wild (feral) horses in the Australian Alps for my Doctorate through the Applied Ecology Research Group, University of Canberra (under my maiden name 'Walter'). The Australian Alps Liaison Committee (AALC) funded most of the field work and many parks staff from across the Alps were involved. In 2005, the AALC commissioned me to summarise my thesis into a version suitable for park managers and this is the result. It provides a synthesis of the work and its key findings. If people are after details of any component of the research, I refer them to the thesis and other references mentioned in the text. There have been numerous developments in wild horse management since 2002, as well as a very large fire. I have not dealt with them here.

This study was the first of its kind in the Australian Alps, and therefore has a broad focus. It stemmed from a need to improve our understanding of this controversial species and aims to provide interested parties with information to determine the best approach to management. It also contributes to broader knowledge on survey techniques for large mammals and horse population dynamics in general and examines brumby-running for the first time. The only previous study of wild horses in the Australian Alps was on their impact in sub-alpine and montane environments (Dyring 1990).

Horses were first introduced into Australia in 1788 (Dobbie *et al.* 1993). They adapted well to conditions and numbers rose rapidly. Between 1830 and 1850 they increased from an estimated 14 000 to 160 000 largely by natural increase and were first recognised as feral pests in Australia in the 1860's. Australia has the highest number of wild horses in the world (Dobbie *et al.* 1993). They occur mostly in remote, usually rugged, semi-arid areas. The largest populations are on unfenced pastoral country in the Northern Territory and Queensland. The major concentration of wild horses in New South Wales and Victoria are found in the Australian Alps (Dobbie *et al.* 1993).

Wild horses are an introduced species in the Australian Alps. They are a large and hard-hoofed animal occupying an environment that evolved without similar species. There is concern that they have a negative impact on the Alps environment. Wild horses were seen to be a problem during last century (Helms 1890 in Dyring 1990) and many scientists (Costin 1954, Walters & Hallam 1992, Dobbie *et al.* 1993, Green & Osborne 1994) have expressed concern about the threat of increasing numbers of wild horses to environmental values of the Alps. In the Australian Alps, Dyring (1990) identified track formation, soil compaction, change in vegetation structure and streambank disturbance as impacts of wild horses on sub-alpine and montane environments.

There is a considerable amount of folklore associated with wild horses in the Australian Alps and many people see them as having cultural value. They even feature on the Australian ten dollar note. These contradictory views of wild horses will always make them a sensitive management issue. The aim of this research is to provide people with information so that we can better understand wild horses and how they are interacting with the Alps environment with the hope of aiding more effective management.

Improving our understanding of wild horses in the Australian Alps national parks has been on the agenda for some time. In 1992, a review of wild horses in the Australian Alps national parks recommended that an action plan for feral horses be developed and implemented at the earliest opportunity (Walters & Hallam 1992). The action plan was to be preceded by two key studies: 1) a study of wild horse demography and their ecology, and 2) a study of wild horse impact on vegetation communities and the environment of the Australian Alps national parks. This study addressed the first point.

Distribution

Keeping track of the distribution of wild horses over time helps us to monitor the effect of control programs (or no control) and environmental events such as severe winters or fire. We can learn from past changes in distribution and its causes, and will assist future land managers by keeping records of changes in distribution especially in response to control programs. In this section I present a revised distribution map of wild horses in the Australian Alps national parks and discuss reasons for current and historical distribution.

Dyring (1990) produced a distribution map of wild horses in the Australian Alps. The main features of her maps were: 1) the absence of horses in the ACT, 2) small isolated populations in northern Kosciuszko at Peppercorn, Wild Horse and Nungar Plains, and in nearby Bago and Maragle State Forests, 3) a small population at Botherum Plain near Lake Jindabyne, 4) a large continuous population south of Thredbo River extending through southern Kosciuszko to the Victorian border, 5) a continuation of the same population in Victoria, in the Cobberas-Tingaringy National Park (now part of the Alpine National Park), and 6) a population on the Bogong High Plains near Omeo and smaller populations at Mount Willis (west of Lake Dartmouth) and on the Moroka and Caledonia Rivers.

I revised the wild horse distribution maps between 1999-2002 by searched NSW and Victorian wildlife atlases, holding discussions with local managers and park users to determine current boundaries and factors influencing past distribution, and visiting a lot of the range. Wild horses are found in Kosciuszko National Park, NSW (Figure 1) and the Alpine National Park, Victoria (Figure 2) and were present on the border of the Australian Capital Territory.

The maximum observed rate of spread of wild horses in the Australian Alps between Dyring's (1990) study and the maps presented here is remarkably low (< 4 km per year). The areas where they appear to have spread is in northern Kosciuszko National Park, and into alpine areas near Mount Kosciuszko. They now do not occupy the full extent of their potential range (for example they used to be present in Namadgi National Park, ACT). Horses are adaptable to a wide range of environments, and are present from the highest to lowest elevations in the Australian Alps so they have the potential to have a much greater distribution than at present.

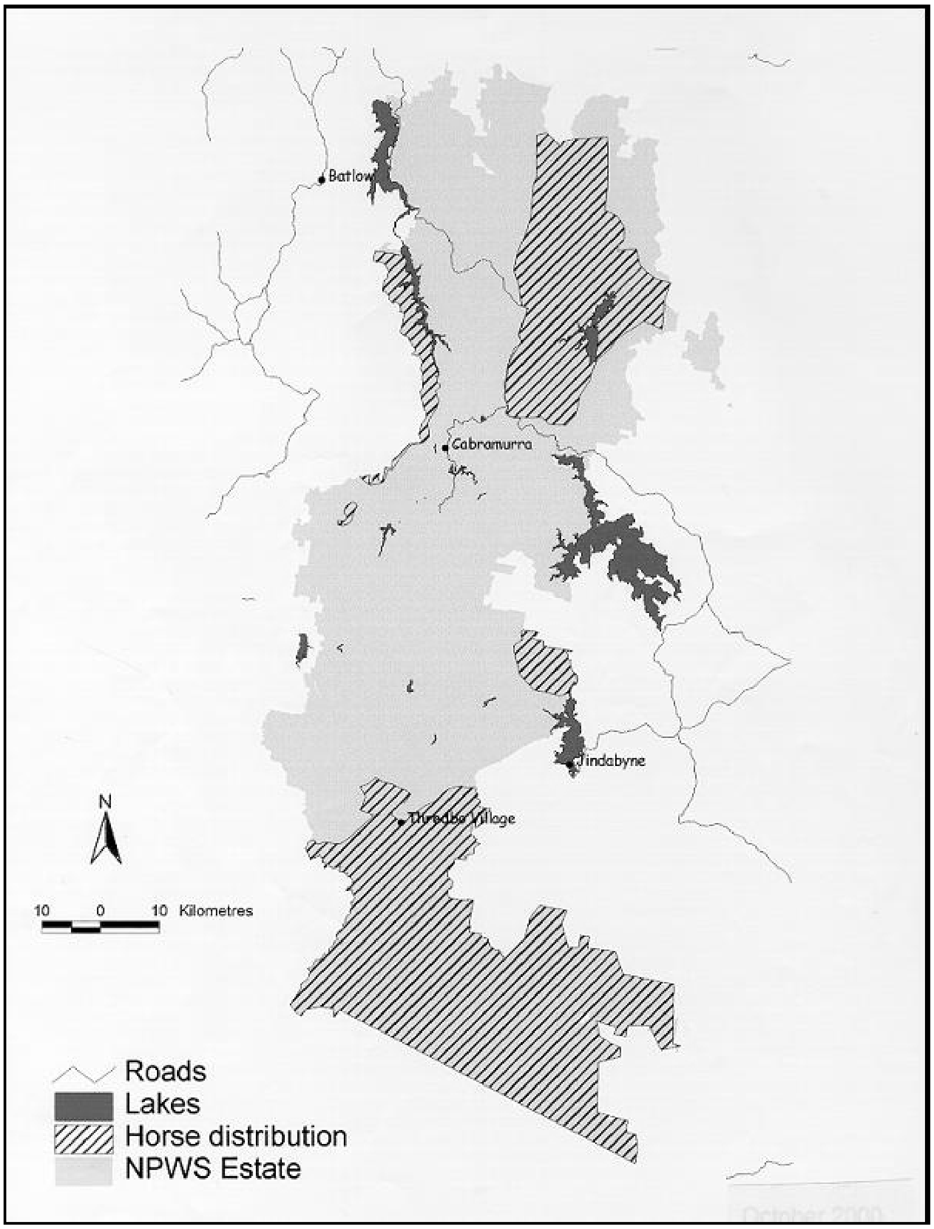

Figure 1: Distribution of wild horses in Kosciuszko National Park. Map produced courtesy of NSW NPWS.

Humans appear to be the most important factor influencing wild horse distribution. The presence of horses in an area can usually be traced back to an introduction event, and control efforts have removed them or reduced their range. Other factors that appear to influence wild horse distribution include geographical barriers, severe snow events, drought and possibly behaviour.

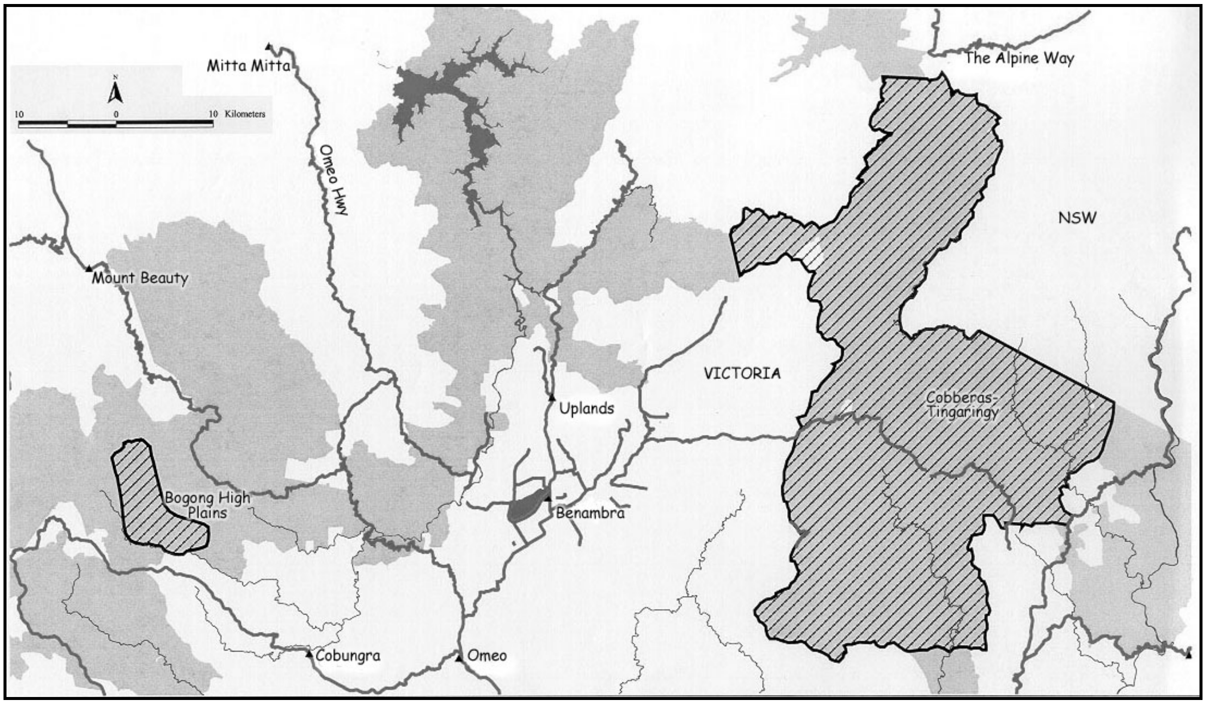

Figure 2: Distribution of wild horses in the Alpine National Park, Victoria. Map produced courtesy of the Department of Natural Resources and Environment. Refer to Figure 1 for legend.

Graziers controlled the distribution of wild horses in much of the Australian Alps from the mid-1800s to as late as the 1960s. Different graziers had different approaches to wild horses; some eradicated them locally and others were responsible for their release into new areas. With the area subsequently reserved as national parks humans continue to influence wild horse distribution. For example wild horses were successfully eradicated from Namadgi National Park in the 1980s (Higgins 1994). However no management action appears to contribute to the spread of horses, as do the occasional illegal reintroduction. (small populations (less than 10 animals) are less likely to establish after introduction than larger ones).

Barriers of dense vegetation and steep slopes appear to prevent horses from colonising new areas in the short term. The question in these cases is whether horses will eventually overcome these barriers. The effectiveness of a barrier will depend on the form of the barrier and the pressure on it from the wild horse population.

Heavy snow events can cause mortality of wild horses. These events appear to be rare and only affect populations at higher elevations. For example, wild horses in the ACT suffered a large reduction in numbers in the early 1960s due to heavy snowfalls (Higgins

1994). In the longer-term, heavy snow events may become less frequent if global warming raises mean temperatures in the Australian Alps (Whetton 1998). Such changes may facilitate the expansion of the distribution of wild horses.

Drought influences the distribution of wild horses in the rainshadow area on the eastern side of the Australian Alps south of Jindabyne. There is very little water available in this environment in contrast to the rest of the Alps where water is freely available. In 1982-83 drought killed off most of the horses in the area and kangaroo, wallaby and rabbit populations also suffered massive losses.

The potential of behaviour to limit the distribution of wild horses is difficult to assess. They are highly social animals and there is a general belief that they are strongly tied to their home range. Behaviour, environmental events (e.g. drought, snow, fire) and other species (eg wild dogs) may have acted in conjunction with humans to restrict the expansion in range of wild horses by keeping them below a threshold density. If wild horses are similar to wood bison in that they are pulse dispersers, they must reach a threshold density before they disperse and colonise a new area.

It will be interesting to see the patterns of wild horse distribution in the Australian Alps in the future. It is likely to depend heavily on the approach to management. If they are not actively managed they may disperse into new areas. Alternatively, management may result in a range reduction. The low rate of spread of wild horses in the Australian Alps should make them relatively easy to manage compared to other introduced species such as the European rabbit which spread at 64km per year (Caughley 1977).

Abundance

The goals of managing wild animal populations are usually expressed in terms of population size. For endangered species, managers try to increase population size, for pest species they try to reduce population size and for harvested populations they try to maintain a population size to optimise harvest. Population estimates are particularly useful if they are repeated through time. Population trend data is useful for assessing the success of management actions or response of the population to natural events. I used aerial survey to estimate the size of the wild horse population in the Australian Alps national parks in 2001. I repeated this survey in 2003 after the fires (refer to Walter 2003 for details).

Despite the obvious advantages of using aerial survey to estimate abundance and density of animals, it has many shortcomings. One of the challenges is to improve accuracy, which is a measure of how close a population estimate is to true population size. Undercounting is the rule in aerial surveys, so results usually are negatively biased. Some of the main factors contributing to bias are vegetation cover, species being surveyed, survey specifications (e.g. height above ground, speed, strip width), weather conditions and observer experience. There are several analysis techniques frequently used for aerial survey including strip surveys (used extensively in kangaroo surveys), mark-recapture models (used on emus and mule deer), and line transect models (a newer technique which is proving to be very useful). In this study I used all three methods simultaneously and assessed the best method. For full details, refer to Walter and Hone (2003).

The area surveyed follows the distribution maps presented in Figures 1 and 2 and are summarised in Table 1. It excluded the area adjacent to Talbingo Reservoir and east of the Snowy River in Byadbo as these areas were considered to be too rugged and population densities too low to provide accurate estimates.

Table 1: Regions surveyed in the Australian Alps national parks during the wild horse aerial survey in 2001.

Region	Area (km2)	No. of transects	Total transect length (km)
North Kosciuszko	795	25	412
Snowy Plain	77	6	42
South Kosciuszko	758	22	379
North Victoria	1069	30	587
Bogong High Plains	90	8	54
TOTAL	2789	91	1474

The average size of groups observed from the air was 4.91 (± 0.61 SE, n = 34) and 3.79 (± 0.57 SE, n = 4) for observer 1 and 2 respectively. This is in contrast to the group size observed from ground surveys done as part of the population dynamics study (below) of 5.65 (± 0.51 SE, n = 34). The smaller group sizes observed from the air is probably a result of not seeing all individuals in a group from the air. Two observers were used in the aircraft to improve the accuracy of estimates. Interestingly, observer 2 saw more singletons and pairs than observer 1.

We found that the number of horses sighted dropped rapidly with increasing distance from the aircraft. This meant that strip and mark-recapture estimates resulted in an underestimate of abundance. We cannot know what the most accurate survey method is because true population size was not known. However the line transect analysis for both observers combined appears to account for bias the most effectively. It also gave a higher level of precision.

Population estimates using the line transect method equated to 1.86 horses per km^2 and a population estimate of 5200 horses (coefficient of variation = 31%) (Walter and Hone 2003). The average density of wild horses across the entire Australian Alps national parks would be lower than the survey estimates because areas where there were no horses present and of lower horse abundance were not included in the surveys. Density was not uniform across the areas surveyed (if they were the coefficient of variation would be zero). No horses were seen in the southern section of north Victoria (lower Buchan River), but horses were seen frequently on the high plateau country on the NSW/Victoria border, and in the open plains in north Kosciuszko.

Dyring (1990) estimated the number of horses in the Australian Alps based on anecdotal evidence. She suggested that there were 1500-1700 horses in the area covered in her survey in Victoria, which is slightly lower than the estimates obtained in the current study for Victorian Alps parks, and for NSW she suggested there were several hundred horses in south Kosciuszko and approximately 100 in northern Kosciuszko. We have no way of knowing how accurate these estimates are, but they are much lower than the current study and suggest a 3 fold increase in the population in Kosciuszko National park over 10 years.

Population dynamics

The options available to managers of any wildlife species are either to make the population increase, to make it decrease, harvest it for a continual yield or leave it alone. All of these options are greatly assisted by an understanding of the underlying dynamics of the population. Population dynamics are the variations in the sizes and densities of populations reflecting a change in demographic parameters including birth and death rates. Estimation and modelling of demographic parameters provides information on the state of the population, such as whether it is likely to be stable, increasing or declining, and possible causes. The aim of this section of the study was to examine the population dynamics of three populations of wild horses across the Alps, determine what factors are likely to be limiting the populations if any, and assess the sensitivity of population growth rate to change in key demographic parameters (which can be used to help make decisions on what component of the population to target if undertaking control).

Studies on other wild horses around the world give us a good basic understanding of typical population dynamics and social organisation of wild horses. Linklater (2000) reviewed feral horse populations in North America, South America, Europe and Australasia and found that comparison across different populations showed that horses had remarkably similar social and spatial organisation and that group sizes (range 1 – 28) and home range size (range 0.8 – 303km^2) varied as much between as within populations (Linklater 2000). The density of populations ranged from 0.1 to 35.4 horses per km^2, and adult sex ratios varied from 0.03 to 1.85 males per female. Variation in densities and sex ratios were often the result of management practices such as removal of animals. The maximum rate of increase observed for any wild horse population to date is 30% per year (Duncan 1992), however values of 21% per year are more common (Garrott *et al.* 1991). Horses have an annual breeding season with generally 80-90% of adult females (over 2 years) producing one foal each year (Garrott *et al.* 1991). Survivorship is high in adults with little annual variation and generally lower and more variable earlier in life (Garrott & Taylor 1990).

Variability in wild horse population dynamics occurs at different locations due to the fact that different limiting factors are operating on the various age and sex classes of the population. For example, mountain lion predation can drastically reduce juvenile survival, and food limitation reduces juvenile survival, delays age at first reproduction and reduces fecundity. Management practices can potentially limit populations by reducing fecundity (birth rate) using fertility control or reducing survival rates of adults and/or juveniles by culling.

The population dynamics of wild horses were studied in detail at three sites each spring and autumn between spring 1999 and autumn 2002. The sites were Big Boggy near Mount Kosciuszko in central Kosciuszko National Park, Cowombat on the border of

Kosciuszko National Park and the Alpine National Park near The Pilot, and Currango in northern Kosciuszko National Park southwest of Mount Bimberi (Table 2). These sites were chosen to sample a range of habitats, because they were areas of interest for park managers, wild horses could readily be found at all of the sites, and they are independent of each other (too far apart for horses to move between). There was no management of these populations for the duration of the study.

Population estimates through time at each site showed different patterns. The Big Boggy population showed seasonal patterns with higher numbers in autumn than in spring, and the spring estimates were more precise than the autumn estimates (range 57 ± 1 SE to 86 ± 6 SE horses). This trend is probably related to snow in the area over winter. Cowombat population estimates also showed seasonal trends but not as clearly as the Big Boggy, and were generally less precise than Big Boggy estimates (range from 64 ± 6 SE to 101 ± 10 SE horses). There was no clear seasonal trend in population estimates for Currango, and precision varied between occasions (range from 69 ± 4 SE to 109 ± 6 SE horses). The variability in estimates of the Currango population was probably due to immigration and emigration. The highest average density of horses was observed at Cowombat, while the Big Boggy and Currango populations had similar lower densities (Table 3).

Table 2: Population dynamics study area descriptions

Site	Area (km^2)	Elevation (m)	Vegetation
Big Boggy	35.5	1500-2228	Alpine, sub alpine woodland, cold air drainage shrub and herbfield
Cowombat	12.7	1000-1540	Montane and mixed open forest, subalpine woodland, tall gum and alpine ash forest
Currango	41.4	1220-1370	Cold air drainage shrub and herbfield, montane mixed open forest, subalpine woodland, tall gum and alpine ash forest

The demographics of the populations were similar to those of other wild horse populations with high adult survival rates, lower survival in the first 3 years of life and fecundity rates of about 0.25 (number of females born per female per year) (Table 3). All sites had a positive rate of increase but the only site where the rate of increase was significantly different to a stable population was Currango. Cowombat had the lowest rate of increase.

Table 3: Summary of key demographic variables for the three study sites 1999-2001. Fecundity is half juveniles per adult female per year, survival rates are annual, and rate of increase (λ) is the annual finite growth rate (with coefficient of variation in the estimate).

Site	Average density (horseskm^{-2})	Fecundity	Survival 0-3 years	Adult survival	Rate of increase (CV %)
Big Boggy	2.01	0.24	0.75	0.91	1.07 (3.5)
Cowombat	6.40	0.21	0.63	0.91	1.03 (3.4)
Currango	2.13	0.31	0.67	0.91	1.09 (4.2)

Horses at Cowombat had the poorest average body condition of the three sites, and horses at Currango had the highest body condition score. This trend of body condition was reflected in the trend in food available (Table 4). The body condition of females was poorer than males, overall however, the body condition of females at Currango was not significantly different to that of males.

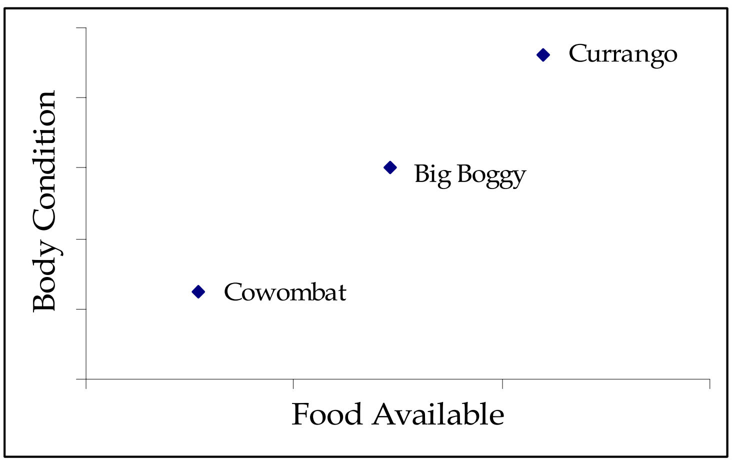

Figure 3: Average body condition scores and food availability scores for the three study sites between 1999 and 2001.

The trend in body condition and food availability (Figure 3) and rate of increase (Table 3) across the three sites suggests that the population at Cowombat is food limited and relatively stable while the population at Currango is not limited by food and increasing. The Big Boggy is in between the two. The implications of this for management is that the Currango population is likely to continue to increase if no control actions are taken, although the relative impact of the horses at Currango on vegetation is lower. At the other end of the scale, the population at Cowombat appears to be stable and in equilibrium with its environment and unlikely to increase in size in the absence of management, although the impact of the wild horses in the area on the vegetation is higher. The Cowombat site was burnt by intense wildfire in 2003 and it would be beneficial to revisit the sites to reassess the populations.

Managers that target adults (survival or removal) in any control measure will yield the most significant result, followed by fertility control then targeting 0-3 year olds. This is because the rate of increase of the wild horse populations were most sensitive to changes in adult survival. The next most influential parameter is fecundity, which has half the weighting of adult survival. Survival in the first 3 years of life has less influence receiving only $1/5^{th}$ the weighting of adult survival, and age of first reproduction had a negligible effect on population growth rate.

Brumby-running

Management of wild horses in the Australian Alps is not based purely in the context of an introduced species but also as one with cultural value. Brumby-running is an activity that began soon after the arrival of horses in the Australian Alps and is closely tied to the culture of wild horses. At the time of the study, the only active management of wild horses in the Australian Alps national park was brumby-running in the Victorian Alps. Brumby-running is a form of harvesting where horse-riders rope wild horses and remove them from the population; it is thought to have a limiting effect on the wild horse population in Victoria, but it has never been examined empirically. The purpose of this section of the study was to gain an understanding of the influence of brumby-running on the wild horse population in Victoria. In particular to describe the demography of wild horses removed by brumby-runners, assess the behaviour of brumby-runners relevant to the type and quantity of wild horses caught, and predict the likely effect of brumby-running on the wild horse population.

Demographic data on wild horses caught and removed from the Alpine National Park, Victoria was supplied by the Alpine Brumby Management Association (ABMA) and Parks Victoria from 1998 to 2002. Brumby-runners recorded the general location, number and type (stallion, colt, mare, filly) of all horses caught each financial year. The quality of information supplied improved over time. The data for 2000-2001 and 2001-2002 are the most detailed including the month of capture and estimated age. I gave body condition scores to 176 horses caught between autumn 1999 and spring 2001 inclusive based on photographic records kept by one brumby-runner (BR1). Body condition and demography of horses caught were compared to the wild horses studied in the population dynamics component of the study to see if the brumby-runners were selectively harvesting. I also used records kept by BR1 on trips made between January 2000 and January 2001 on number of brumby-runners, length of trip and capture rate to get an insight into the effectiveness of brumby-running. Finally, I used logistic growth models to assess whether the number of horses removed by brumby-runners is likely to be limiting the population.

About 200 horses were caught each year between 1998 and 2002 (Table 4). The majority of horses caught were young (colts and fillies). More females (mares and fillies) than males (stallions and colts) were caught in all years (ratio 0.67:1). The difference is due mostly to the fact that so few stallions were caught. Most horses were caught in autumn and least in summer with similar amounts being caught in winter and spring.

Table 4: Summary of horses caught by brumby-runners in the Alpine National Park, Victoria. *Not all horses caught were recorded in 1999-2000.

Year	Total caught	Stallions (%)	Colts (%)	Mares (%)	Fillies (%)
1998-1999	224	9.4	29.9	43.8	17
1999-2000	78*	7.7	37.2	41	14.1
2000-2001	174	9.8	25.9	36.2	28.2
2001-2002	207	7.7	36.2	33.3	22.7

The assignment of wild horses caught into categories of stallion, mares, colts and fillies can be misleading for interpreting age of horses, particularly males because males (3-6 years old) can be called colts while the classification of 3-year-old females and older as fillies is less common. I would recommend that any data collection should include an estimation of age in the future to address this. This was done between 2000 and 2002 and the data was used in comparisons with the Cowombat, Big Boggy and Currango wild populations.

Brumby-runners did not select for males or females when all age classes were combined for the analysis, however they did select for adult females over adult males. They also showed a preference for younger animals (<3 years old) than were present in the wild. 49% of all horses caught between July 2000 and June 2002 were younger than three while the average proportion of horses under the age of three at Cowombat, Currango and Big Boggy were 28%. Brumby-runners did not select horses in poorer condition. These findings suggest that the brumby-runners are not targeting the 'doomed surplus' (the old, young or weak).

The average trip length for BR1 was 2.93 days, and the majority of trips were 2 days in duration (weekends). He was accompanied by other brumby runners on most trips with a total effort of all brumby-runners n this sample being 172 days. The mean catch per unit effort for BR1 was 1.16 horses/day. All other riders combined had a mean catch per unit effort of 0.55 horses per day. So there is an effect of skill on catch per unit effort. Catch per unit effort did not vary across seasons. Mean catch per unit effort was highest when brumby-runners were in a group of three.

Predictive modelling for the wild horse population assuming logistic growth shows that brumby-running is likely to have a limiting effect on the population. The predicted effect of different levels of brumby-running on the population into the future are shown in Figure 4. The model assumes that the population size is 2000 (based on aerial survey results) and 200 horses have been removed annually prior to the present. The model assumes a stable environment. Note that the 2003 wildfires reduced the population size significantly (Walter 2003) so harvesting at a rate of 200 horses per year post-fire would drive the population to extinction.

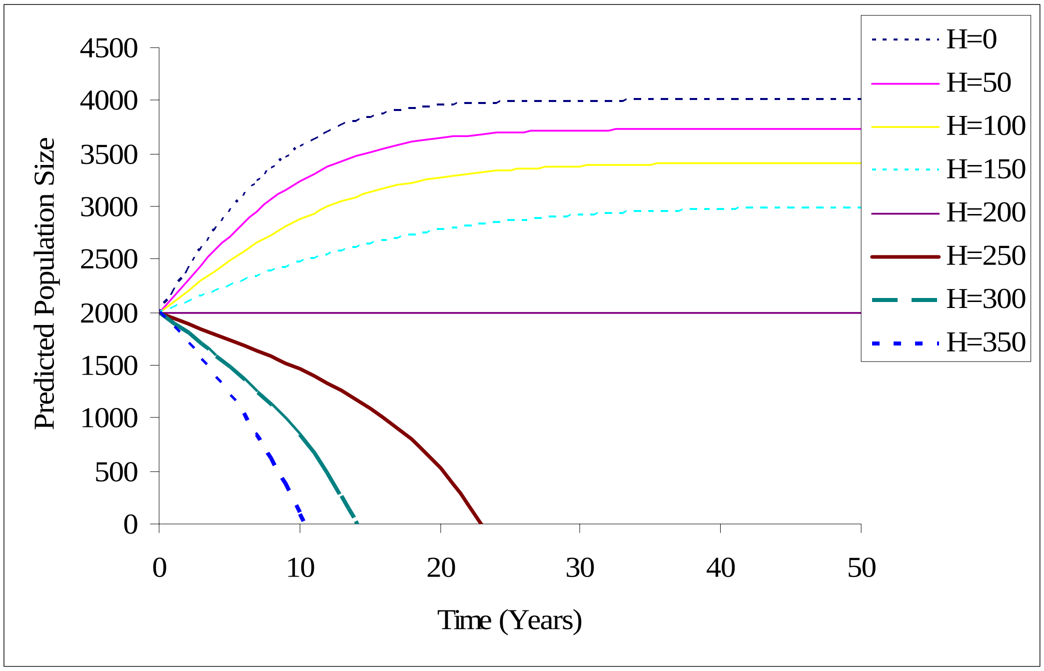

Figure 4: Predicted size of the Alpine National Park wild horse population at different levels of harvest (H) per year. The model assumes logistic growth with intrinsic rate of increase = 0.2, initial population size = 2000 and carrying capacity = 4000.

This model assumes a non-selective harvest. Harvesting that targets younger animals means that more animals have to be removed to achieve the same population reduction, while selectively harvesting adult females will lead to a sex bias in the population and less animals would have to be removed to achieve the same target.

Modelling shows that although brumby-running is a form of recreational harvesting, it can suppress populations below carrying capacity and can be used as a management tool. Its effectiveness as a management tool will depend on the management objectives in each circumstance. I recommend that if it is used as a management tool in the future it should be accompanied by population and/or impact monitoring, as should any form of management.

Key management messages

- The maximum observed rate of spread of wild horses in the Australian Alps between Dyring's (1990) study and the maps presented here is remarkably low (< 4 km per year).
- Wild horses do not occupy the full extent of their potential range.
- Humans appear to be the most important factor influencing wild horse distribution. The presence of horses in an area can usually be traced back to an introduction event, and control efforts have removed them or reduced their range.

- Population estimates in the survey area using the line transect method equated to 1.86 horses per km^2 and a population estimate of 5200.
- There is some evidence to suggest that the wild horse population in Kosciuszko increased 3-fold in Kosciuszko National park over 10 years.
- Management practices can potentially limit populations by targeting reducing fecundity (birth rate) using fertility control or reducing survival rates (by removal or culling) of adults and/or juveniles. Managers that target adults will yield the most significant results, followed by fertility control then targeting 0-3 year olds.
- Across the three populations studied (Currango, Big Boggy and Cowombat) trends in population rate of increase, body condition and food availability suggest that the population at Cowombat is food limited and relatively stable while the population at Currango is not limited by food and increasing. The Big Boggy is in between the two.
- Brumby-runners in the Alpine National park, Victoria caught approximately 200 horses annually between 1998 and 2002. The majority of horses caught were young and more females than males were caught. The discrepancy between the sexes is because so few adult males (stallions) were caught.
- Modelling shows that brumby-running can suppress wild horse populations below carrying capacity and can be used as a management tool.

References

Caughley, G. (1977). Analysis of Vertebrate Populations. John Wiley & Sons, London.

Costin, A.B. (1954). A Study of the Ecosystems of the Monaro Region of New South Wales. Soil Conservation Service of NSW, Sydney.

Dobbie, W.R., Berman, D.McK. & Braysher, M.L. (1993). Managing Vertebrate Pests: Feral Horses. Australian Government Publishing Service, Canberra.

Duncan, P. (1992). Horses and Grasses. The Nutritional Ecology of Equids and Their Impacts on the Camargue. Volume 87, Ecological Studies. Springer-Verlag, New York.

Dyring, J. (1990). The Impact of Feral Horses (*Equus caballus*) on Sub-alpine and Montane Environments. Masters Thesis, University of Canberra, Canberra.

Garrott, R.A., Siniff, D.B. & Eberhardt, L.L. (1991). Growth rates of feral horse populations. *Journal of Wildlife Management* **55**: 641-648.

Garrott, R.A. & Taylor, L. (1990). Dynamics of a feral horse population in Montana. *Journal of Wildlife Management* **54**: 603-612.

Green, K. & Osborne, W. (1994). Wildlife of the Australian Snow-Country. Reed Books, Sydney.

Helms, R. (1890). Report on the grazing leases of the Mount Kosciusko Plateau. *NSW Agricultural Gazette* **4:** 530-531.

Higgins, M. (1994). On the trail of the Namadgi brumby runners. *Canberra Historical Society* **33:**16-22.

Linklater, W.L. (2000). Adaptive explanation in socio-ecology: lessons from the Equidae. *Biological Reviews* **75**: 1-20.

Walter M. J. (2002). The population ecology of wild horses in the Australian Alps. Ph.D. Thesis, University of Canberra, Canberra.
Walter, M. J. (2003). The Effect of Fire on Wild Horses in the Australian Alps National Parks. Unpublished report.
Walter M. J. & Hone J. (2003) A comparison of three aerial survey techniques to estimate wild horse abundance in the Australian Alps. *Wildlife Society Bulletin* **31**, 1138-49.
Walters, B. & Hallam, M. (Eds.). (1992). Feral Horses in the Alps, Report of a workshop. Australian Alps Liaison Committee, Canberra.
Whetton, P. 1998. Climate change impacts on the spatial extent of snow cover in the Australian Alps. In K. Green Ed. Snow A Natural History: An Uncertain Future. Australian Alps Liaison Committee, Canberra. Pp. 195-206.