*Assessment of Impacts of Feral Horses (***Equus caballus***) in the Australian Alps*

An experimental monitoring program in the Cobberas-Tingaringy Unit of the Alpine National Park: Progress 1999 to 2005.

A report to Parks Victoria

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Introduction

In 1999, a two-part study was undertaken for the Australian Alps Liaison Committee on the impacts of feral horses in the Australian Alps. Part 1 provided a survey of literature on feral horses and their impacts in Australia, and proposed a monitoring program for determining impacts within the Alpine National Park. After discussion and consultation with the Australian Alps Liaison Committee, Friends of the Cobberas, Parks Victoria and the Department of Sustainability and Environment, an experimental monitoring program was established to assess feral horse impacts at two sites in the Cobberas-Tingaringy Unit of the Alpine National Park.

This report summarizes the aims and methods of the feral horse monitoring program and presents results from 2005 floristic and streambank monitoring at the experimental plots. The reader is directed to the initial reports (Thiele & Prober 1999a,b) for more detailed background information.

The Experimental Monitoring Program

The aims of the monitoring program are to monitor the effects of exclosure from feral horses on floristic composition and structure of favoured grazing areas (grasslands), and on bank condition and disturbance of streams draining these areas.

Methods

Replicated exclosure trials were established at two sites, Cowombat Flat and Native Cat Flat. These sites were selected by the AALC and Friends of the Cobberas as areas that support permanent populations of feral horses but are not currently grazed by cattle (although both have been grazed by cattle in the past). Both sites are naturally treeless grasslands or herbfields within a broad landscape of forested mountains.

At each site, eight 10m x 10m plots were established in pair-wise fashion (4 replicate pairs) either side of a small stream line (see Fig. 1). Plots were sited so that each was relatively uniform, both plots of the pair (either side of the creek) were visually similar, and both were dominated by grazed grassland (shrubby or heathy vegetation and areas under tree canopies were not included). Plots were established adjacent to the streamline but beyond the zone of direct riparian influence, and permanently marked using steel star posts.

Plots in each pair were randomly assigned to one of two treatments: fenced to exclude horses but not other grazers (rabbits, wombats, macropods), and unfenced so that grazing by all animals is unrestricted. Fences were erected by Parks Victoria and Friends of the Cobberas during winter 1999. The fence for each fenced plot was constructed so as to extend over the creekline to the far edge of the riparian zone. A 1m buffer was allowed around the experimental plot to reduce edge effects and to allow space for any future destructive sampling such as biomass or soil samples.

In addition to the plots, four replicate pairs of stream transects were marked using steel star posts, one post either side of the stream on the edge of the bank. Transects were sited so that one of each pair was within and one outside each exclosure.

Breaches of exclosures and other grazers

Unfortunately, star posts were removed and fences destroyed at Native Cat Flat by vandals in late 2000 or early 2001. Corner posts remained in place, so it was possible to replace fences in an identical location, and this was undertaken by Friends of Cobberas in October 2001. However, markers for unfenced plots and all streambank transects were lost; these were re-established as near as practicable to their original locations at the time of monitoring in 2005. In addition, all plot corners were marked with steel pipes driven to ground level alongside the marker pegs. Hence, if the pegs or star posts are removed again it will be possible to relocate the corners using a metal detector.

Given that the locations of some plots and of the stream transects were not identical from 1999 to 2005, initial data from Native Cat Flat can only be considered as providing an approximate indication of vegetation composition for the comparisons across time.

Several other minor breaches of fences by horses also occurred over the 1999-2005 period, particularly at Native Cat Flat (see Appendix 1 for details).

In keeping with the design of exclosures to allow entry of other grazers such as wombats and rabbits, evidence (manure) of other grazers, e.g. wombats, was present on both fenced and unfenced plots. However, droppings were too infrequent to assess potential differences between exclosed and unexclosed sites.

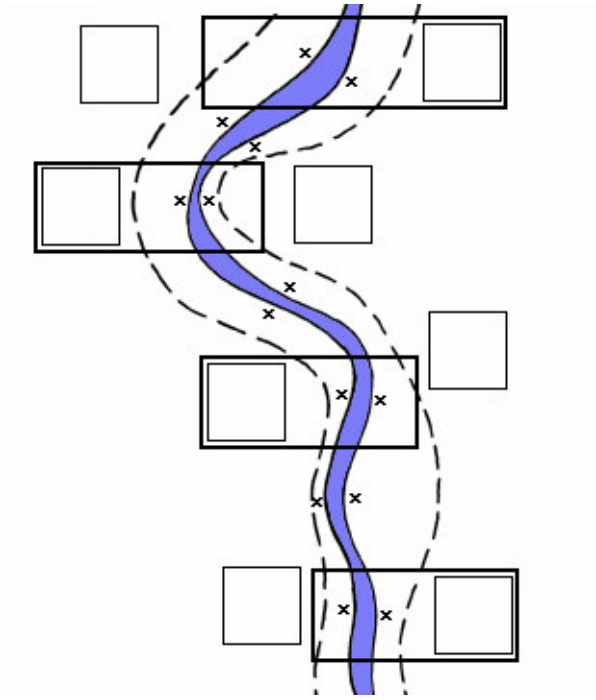

Fig. 1. Generalised layout of experimental plots at Native Cat Flat and Cowombat Flat. Squares are monitoring plots, bold lines are fences, the dashed line is the limit of direct riparian (streamside) influence. Crosses represent points on the streambanks permanently marked with star posts for the stream transects.

As well, the whole of two plots (one fenced and one unfenced) and about one-third of two others (one fenced and one unfenced) were lightly burnt at Cowombat flat during the 2003 bushfires (see Appendix 1). The burnt areas, mapped by Friends of Cobberas shortly after the fires, were no longer visually detectable by 2005.

Monitoring

Vegetation plots.

Detailed vegetation monitoring was undertaken in April 1999 and in March-April 2005. All plant species present within each plot were recorded, and their abundance estimated by recording presence/absence of each species at 100 non-permanent points (5 mm diameter pin) located in an approximated grid system of ten rows of ten across each plot. This led to a relative abundance estimate with a maximum possible value of 100 for each species. Species not intercepting a point were allocated a nominal abundance of 0.5.

Plot-scale (total species per plot) and point-scale richness (average number of species per point) for a range of species groups (total, native, exotic, herb, shrub, grass, sedge) were calculated from the raw data. Abundance values for these groups could not be reliably estimated using the common technique of summing the point scores across species within a group. The latter measures the cumulative abundance of species within a group, and when divided by the number of points, equates to the point-scale richness for that group. Where total abundance of any group is low (approximately one or fewer species from the relevant group per point), cumulative abundance provides a good indication of the total abundance of the relevant group. However, where cover of any group is high, with significant overlap between species at a point and differing point richness between plots, cumulative abundance provides a poor estimate of total relative abundance, due to confounding with point richness. At Cowombat and Native Cat Flats, total vegetation cover and species richness per point was often high, and thus cumulative abundance was not a good indicator of the total abundance of some species groups. Conversely, estimates of point-scale richness provided a related and valuable indication of emerging treatment effects that were not yet evident at the plot scale.

In addition to detailed floristic monitoring, a number of structural vegetation variables were estimated for each plot (average height of the groundlayer, tree seedling and shrub density and cover). Permanent photopoints were established at one corner of each plot, and images were taken annually by Friends of the Cobberas (details for these measurements are provided in Thiele and Prober 1999b).

Streambank plots

The design of the floristic monitoring plots created a paired series of fenced and unfenced stream transects, marked using steel posts (see Fig. 1). An initial subjective monitoring of streambank condition, disturbance and erosion along these transects was undertaken in 1999. The same monitoring techniques were applied in 2005, although the location of transects was not always identical to 1999 (see above).

Permanent photopoints were established at each transect and images were taken annually by Friends of Cobberas. See Thiele and Prober (1999) for more detailed methodology.

Data analysis

Derived floristic variables, structural variables and streambank data for 2005 were analysed using Analysis of Variance (ANOVA), using *Genstat* (2003). ANOVA was performed on data pooled across sites, and tested for treatment and site x treatment interaction effects. The blocking term of the design acknowledged that replicate pairs were nested within sites. To adjust for initial variation, 1999 data were included as covariates in preliminary analyses. Where the covariate was significant, means adjusted for covariates are presented; otherwise unadjusted means and significance values are shown. Data were transformed where necessary to homogenize variance.

Due to very different vegetation composition at the two sites (Native Cat Flat and Cowombat Flat), ordinations were performed separately on floristic datasets (including both 1999 and 2005 data) for each site. The exploratory technique global non-metric multi-dimensional scaling (nMDS) was used to assess floristic patterns, using the program DECODA (Minchin 1989). This technique arranges sites in two or more dimensions according to their floristic similarity, creating "scatter plots" in which sites that are close together are similar while plots that are further apart are more different. While not allowing precise statements about specific variables, as with analysis of variance, ordination is a powerful tool for exploring trends in floristic composition.

Analyses were performed on two floristic datasets: all plots from Native Cat Flat, and all plots from Cowombat Flat. For each analysis, all species were standardised to equal maxima and the Bray-Curtis coefficient of dissimilarity was used to produce a distance matrix (see e.g. Faith et al. 1987 for a detailed description of the analysis method). Analyses were initially performed in one to four dimensions; the three dimensional analyses were chosen for presentation because stress values (a measure of "poorness of fit") were only minimally improved using further dimensions. Correlation of environmental and derived floristic parameters with the ordinations were visually assessed by plotting variables directly onto ordinations, and by calculating vectors of maximum correlation (R_{max}) using the VECFIT procedure in DECODA (Minchin 1989). Monte-Carlo tests, using 1000 random permutations of the data, were used to estimate the significance of vector correlations. The ANOSIM procedure of DECODA (Minchin 1989) was also used to test for significant effects of exclosure.

1999 Initial Results

Initial data were analysed to test for chance initial differences between treatments. In general, there were few initial biases in floristic composition, derived floristic variables or stream variables related to treatment allocation. The 1999 analyses are presented in greater detail in Thiele & Prober (1999b).

2005 Results

Structural and richness attributes

Exclosure resulted in a significant increase in the average height of the vegetation (Table 1). There were no significant effects of exclosure on shrub numbers or on shrub or litter cover, and no eucalypt seedlings were observed on any plot.

Effects of exclosure on plot species richness were not significant ($p>0.05$) for any species group. However, fenced plots had a significantly ($P=0.018$) lower total richness at the point-scale. This suggests that exclosure from grazing is beginning to reduce the local richness of the vegetation. This was also reflected in a decline ($P=0.065$) in herb richness at the point-scale. Point richness effects were not significant for other species groups; in particular, there was no indication of an increase in weed richness/abundance due to exclosure (Table 1).

Table 1. Effects of exclosure on vegetation height and plot and point-scale richness of floristic components. There were no significant interactions between site and exclosure for any of the variables shown. Variables in bold text showed significant (or marignially significant) responses.

Variables	Unfenced	Fenced	*P*
Structural variables			
Vegetation Height (cm)	**19.4**	**42.2**	**0.006**
Litter (points)	54.2	65.5	ns
Number of shrubs	10.6	5.8	ns
Shrub diameter* (Cowombat only)	316	478	ns
Shrub%cover NC	2.1	2.0	ns
Plot richness variables			
All species*	32.7	31.7	ns
Natives*	28.0	26.3	ns
Weeds	4.8	5.3	ns
Grasses	7.8	6.9	ns
Herbs*	17.4	18.0	ns
Sedges	6.1	5.5	ns
Shrubs	1.4	2.5	ns
*Point richness** variables*			
All species	**3.3**	**2.9**	**0.018**
Natives	2.8	2.5	ns
Weeds	0.6	0.4	ns
Grasses	0.8	0.8	ns
Herbs	**1.9**	**1.4**	**0.065**
Sedges	0.7	0.7	ns
Shrubs	0.03	0.02	ns

*adjusted for covariate
**equivalent to cumulative abundance/100, see Methods

Stream variables

Exclosure from grazing caused a significant reduction in stream depth at both sites, by an average of 4.5 cm. There was also a small, marginally significant reduction in streambank slumping, and at Native Cat Flat, pugging declined from high to low-moderate (Table 2). Effects on bare ground and stream width were not significant.

Table 2. Effects of exclosure on stream condition. Variables other than depth and width were measured on a subjective scale from 1 (low) to 3 (high). There were no significant interactions between site and exclosure except for stream pugging (main effect *P*=0.001, interaction *P*=0.017, means for individual sites shown). Variables in bold text showed significant or marginally significant responses.

Variable	Unfenced	Fenced	*P*
Streambank bare ground	1.1	1.0	Ns
Stream Depth (cm)	**10.0**	**5.5**	**0.006**
Stream Pugging (Native Cat)	**3.0**	**1.3**	**0.017**
Stream Pugging (Cowombat)	1.5	1.0	Ns
Streambank Slumping	**1.4**	**1.0**	**0.097**
Stream Width	162	145	Ns

Floristic composition

Correlation of environmental variables with floristic ordinations (Table 3) indicated three main influences on the floristic composition of experimental plots: exclosure, year of sampling and creekbank (i.e. whether a plot was on the north or south bank). These trends occurred at both sites.

Table 3. Correlation (R_{max}) of environmental and floristic variables with the ordination of 1999-2005 floristic data for Native Cat Flat and Cowombat Flat. *P* indicates significance of correlations. Variables in bold text showed significant correlations.

	Native Cat Flat		Cowombat Flat	
Variable	R_{max}	*P*	R_{max}	*P*
Environmental variables				
Year	**0.75**	**0.021**	**0.84**	**0.000**
Block	0.48	0.360	0.57	0.176
N or S creekbank	**0.90**	**0.000**	**0.81**	**0.008**
Exclosure*	**0.84**	**0.001**	**0.71**	**0.024**
Bareground %	0.36	0.771	0.61	0.105
Rock %	0.51	0.377	-	-

*Variable "Exclosure" scored as fenced only for 2005 fenced plots as all plots were unfenced in 1999

At Cowombat Flat, the correlation of exclosure (2005 fenced plots vs unfenced or pre-fenced plots) with the ordination was significant (p=0.024), while ANOSIM indicated that distinction between fenced plots and other plots was not significant (*P*=0.13). Thus trends due to exclosure described below must be viewed as preliminary. The weakness of exclosure effects may be partly due to the apparently lower levels of grazing by feral horses on all Cowombat plots since the 2003 fires: while fenced plots fell furthest to the left on the ordination (Fig. 2), all plots shifted to the left compared with 1999 (Fig. 3). Potential changes involved in the trend due to exclosure include a decline in *Cotula alpina, Juncus falcatus* and *Euchiton* sp. (all native species of low stature) in the fenced plots, and an increase in the exotic annual *Trifolium dubium* in the fenced plots (Appendix 2a). Given the relationship between trends for exclosure and for year, these species were similarly associated with the effect of sampling year. As well, *Asperula conferta* and *Ranunculus graniticolus* were more abundant in 2005 than 1999 (Appendix 2b).

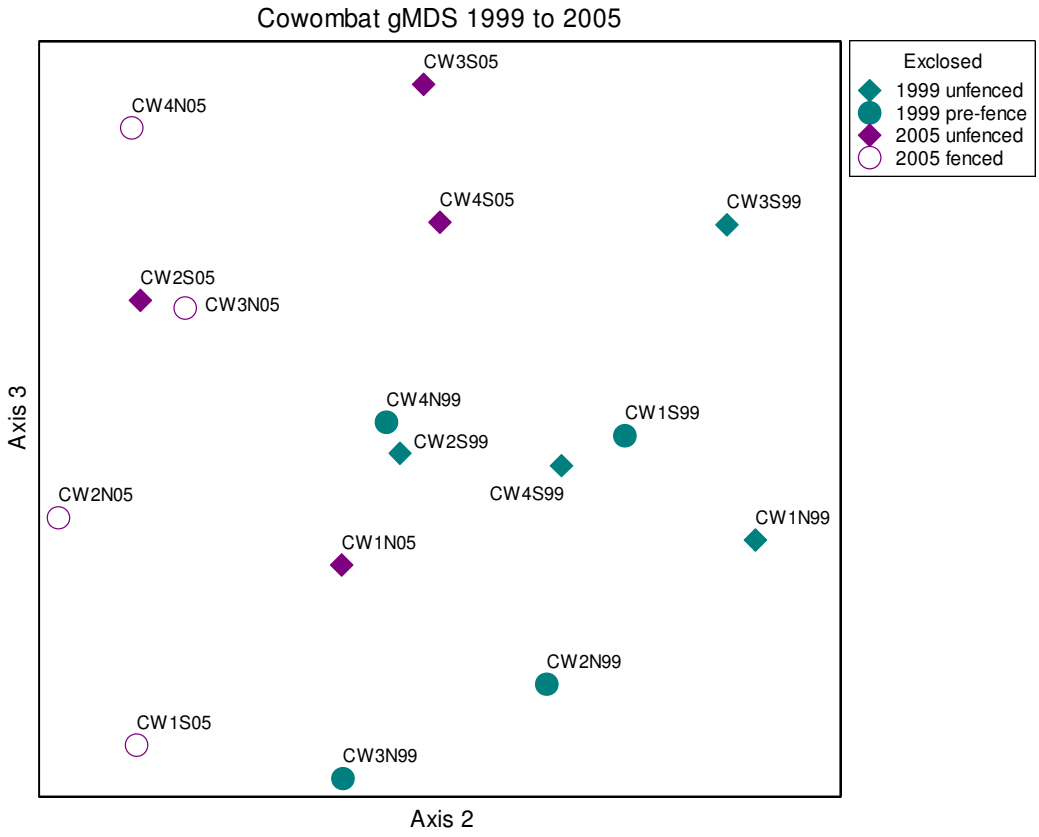

Figure 2. nMDS ordination of floristic data for Cowombat Flat, indicating effects of exclosure. Plots codes identify individual plots (CW = Cowombat Flat, 1-4 = block or pair number, 99/05 = year).

At Native Cat Flat, the effects of exclosure were stronger than at Cowombat Flat (R_{max} =0.84, *P* =0.001; ANOSIM *P*<0.001), with all fenced plots grouping together at the top left of the ordination (Fig. 4). The relationship between the effect of exclosure and of sampling year was less pronounced than at Cowombat Flat, probably because feral horse grazing levels at Native Cat Flat had been higher than at Cowombat Flat since the fires. Nevertheless, *Stellaria angustifolia* (a scrambling herb) and *Isolepis aucklandica* (a sedge of low stature) declined, and the tall herb *Veronica* aff. *gracilis* increased, in association with both exclosure and year. Other changes related to exclosure included a decline in *Lilaeopsis polyantha* and *Hydrocotyle algida* on fenced plots (herbs of low stature, Appendix 3a). Other effects included a decline in the herbs *Hypoxis hygrometrica, Euchiton involucratum* and *Gonocarpus micranthus* from 1999 to 2005 and an increase in the exotic grass *Holcus lanatus* over the same period (Appendix 3b).

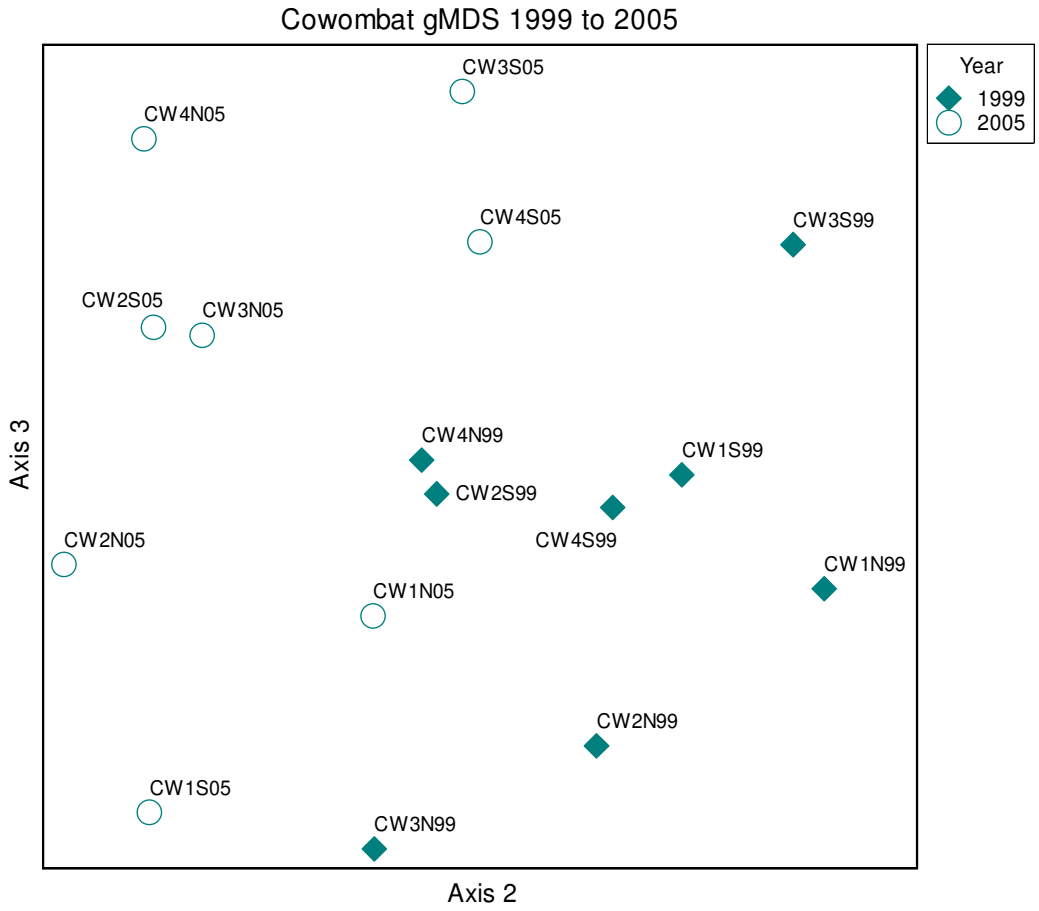

Figure 3. nMDS ordination of floristic data for Cowombat Flat, indicating changes with sampling year. Plots codes identify individual plots (CW = Cowombat Flat, 1-4 = block or pair number, 99/05 = year).

The effect of plot location relative to the creek (N or S bank) was more prominent than the effect of exclosure at both sites (Cowombat Flat R_{max}=0.81, Native Cat Flat R_{max}=0.90). The creekbank effect was already evident in the initial 1999 data set at Cowombat Flat (Thiele & Prober 1999b). Consistent with the initial analysis, plots on the south bank were lower in native species richness and abundance (mainly contributed by native grass and forb species). Species that were more frequent or abundant on the north bank at Cowombat Flat include the native grasses *Elymus scaber, Austrodanthonia penicillata* and *Deyeuxia quadriseta,* the native forbs *Solenogyne gunnii, Prasophyllum* sp., *Euchiton* sp., *Oreomyrrhis eriopoda, Viola betonicifolia, Scleranthus brockiei, Plantago antarctica* (broad form) and *Linum marginale,* and the exotics *Hypochaeris radicata* and *Trifolium dubium. Juncus falcatus* was more common on the south bank (Appendix 2c). Note that these trends were largely due to species of low abundance (mostly <5%). The dominant species (*Plantago antarctica* narrow form, *Poa* spp., *Schoenus apogon*) were similar on each bank, thus the differences between banks were not readily visually apparent.

Creekbank effects were not significant in the initial dataset at Native Cat Flat (Thiele & Prober 1999b), but were strong in 2005. The reason for this difference between years is unclear, but could reflect differing placement of plots in 2005 than 1999, changed moisture regimes or horse grazing preferences. Species contributing to

creekbank trends in 2005 differed from those at Cowombat Flat. *Plantago antarctica* (narrow form) was very abundant and *Hakea microcarpa,* and *Juncus australis* were more frequent on the south bank, while *Austrofestuca hookeriana, Chionogentias cunninghamii* and *Empodisma minus* were more common or frequent on the north bank (Appendix 3c).

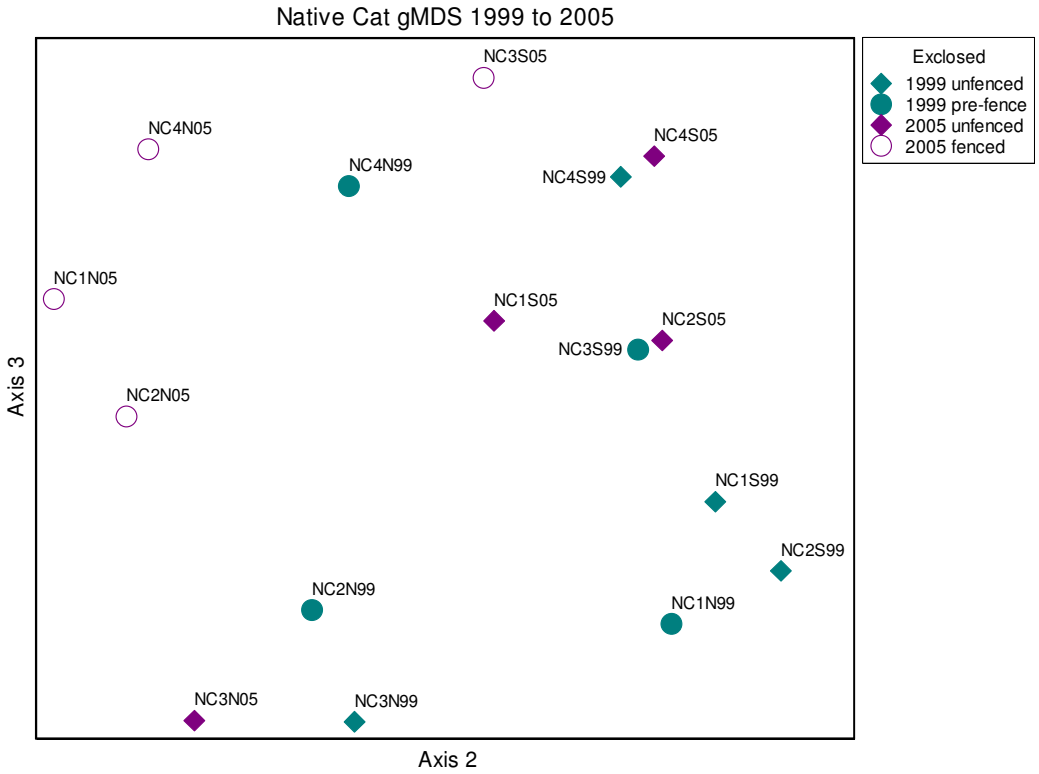

Figure 4. nMDS ordination of floristic data for Native Cat Flat, indicating effects of exclosure. Plots codes identify individual plots (NC = Native Cat Flat, 1-4 = block or pair number, 99/05 = year).

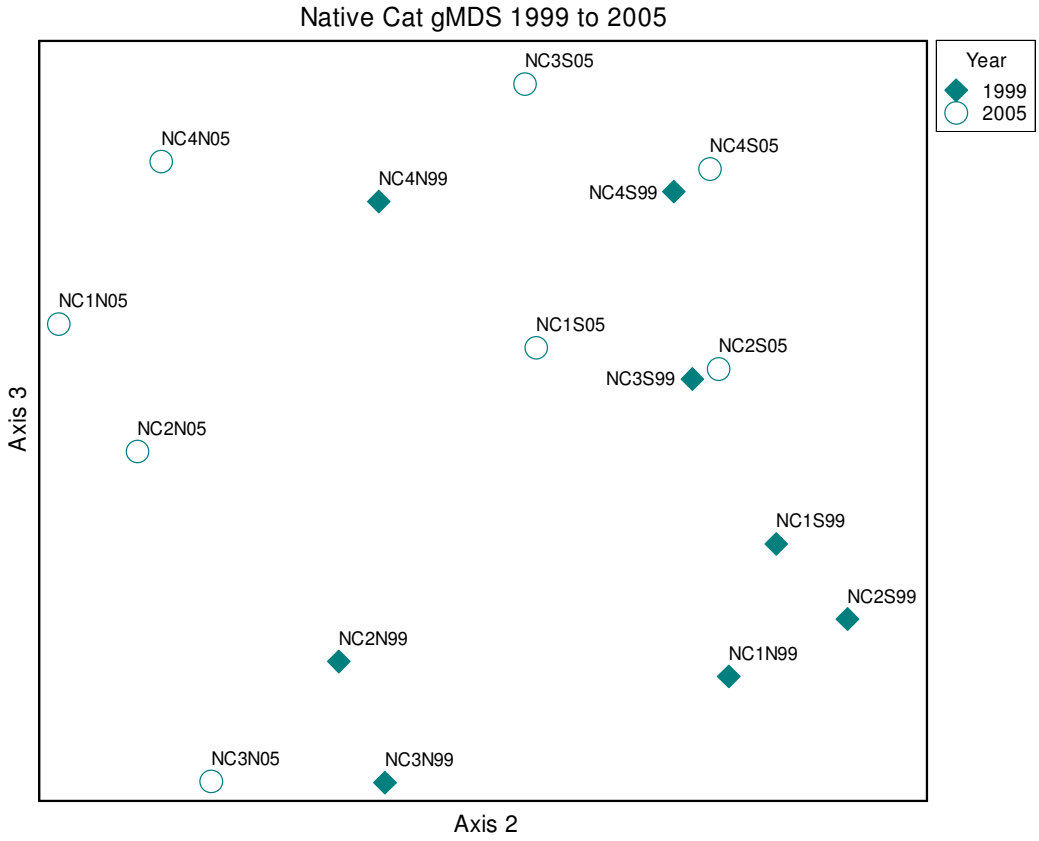

Figure 5. nMDS ordination of floristic data for Native Cat Flat, indicating changes with sampling year. Plots codes identify individual plots (NC = Native Cat Flat, 1-4 = block or pair number, 99/05 = year).

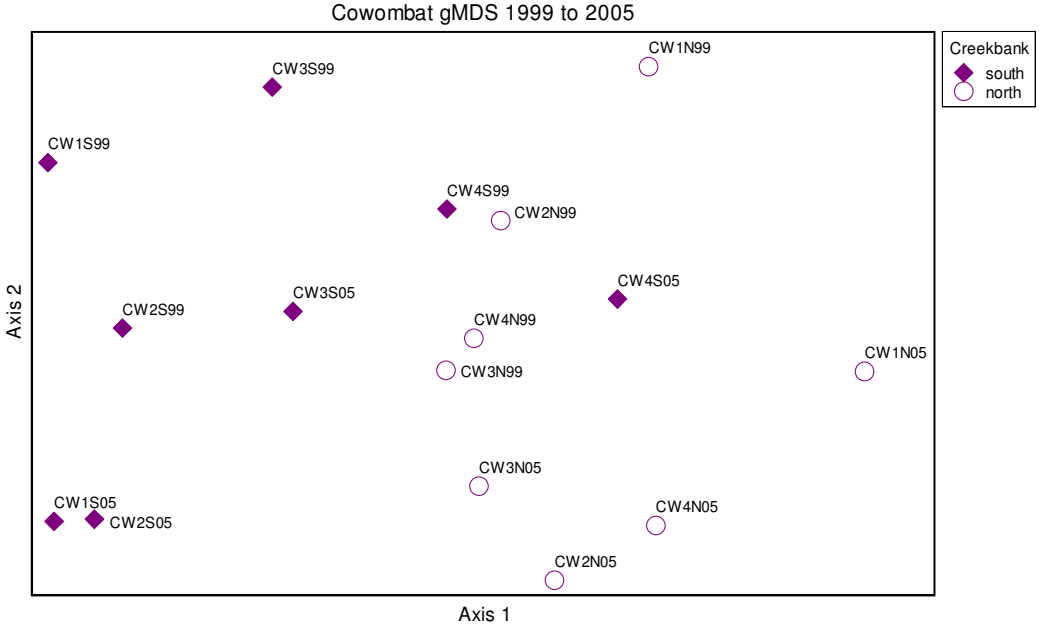

Figure 6. nMDS ordination of floristic data for Cowombat Flat, indicating effects of creekbank. Plots codes identify individual plots (CW = Cowombat Flat, 1-4 = block or pair number, 99/05 = year).

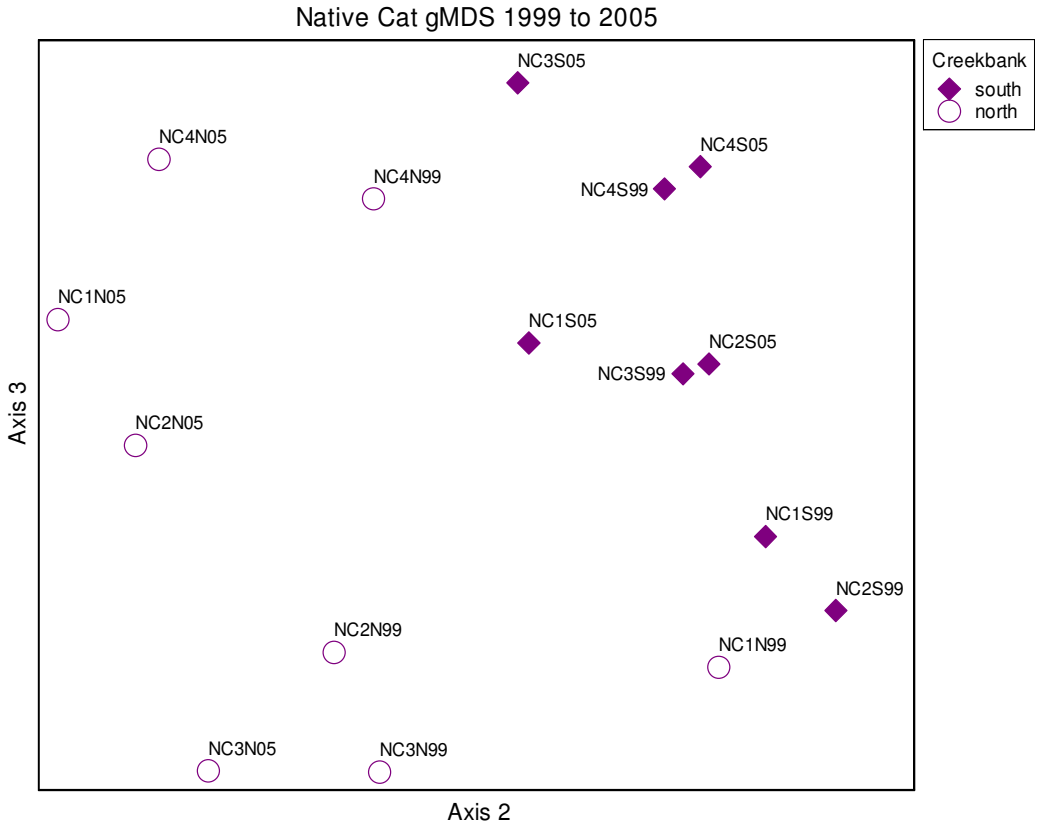

Figure 7. nMDS ordination of floristic data for Native Cat Flat, indicating effects of creekbank. Plots codes identify individual plots (NC = Native Cat Flat, 1-4 = block or pair number, 99/05 = year).

Discussion

Vegetation effects

Results to date show that exclosure from horse grazing has not had striking effects on vegetation composition at either site. While some minor effects were becoming apparent by 2005, they were still weaker than natural local variation at the site, e.g. as observed between the north and south creekbanks. The weak response from the vegetation may partly reflect low grazing levels at Cowombat Flat since the 2003 fires, and multiple breaching of exclosures at Native Cat Flat. No effects of the bushfires were obvious, however these could have contributed to reduced overall effects of exclosure at Cowombat Flat.

Nevertheless, there was some evidence that vegetation change is beginning to occur with exclosure from horse grazing. The most significant effect of exclosure at both sites was an increase in the height of the vegetation. Concomitant with this was a reduction in point-scale species richness reflecting a decline in abundance of some species, particularly native forbs. At Native Cat Flat, it was visually apparent that the vigorous native perennial sedge *Carex gaudichaudiana* had become dominant in some fenced plots. No single species stood out at Cowombat Flat, although several species of *Poa* were dominating in the same way in some plots. The increase of one or a few tall, dominant species may be expected to reduce point scale richness by excluding

light-dependent herbs of low stature, such as *Cotula alpina*, *Dichondra repens* and *Hydrocotyle* spp.

In time, such changes may lead to reduced richness at the plot scale as these species become excluded completely. This had not yet occurred in 2005, and may not occur if these low-growing species are able to persist (albeit at lower abundance) in suitable microhabitats amongst the *Carex* sward.

Note that this change, from a close-cropped, relatively species-rich sward to a taller, potentially less diverse one, cannot necessarily be seen as a negative trend, as the vegetation may be moving to a state similar to its pre-European, pre-disturbance condition. The lower-growing herbs may naturally have occurred on higher ground amongst more open vegetation and have 'invaded' the swampy flats as a result of feral horse grazing. However, no historical benchmarks are available against which the present vegetation can be compared.

It is notable that there was no significant change in weed richness/abundance as a result of exclosure. At both sites (though particularly at Native Cat Flat) there are relatively few introduced species, and these have been relatively unaffected by changes in grazing pressure to date. This is an important result, as it allays concerns for potential invasion by exotics such as *Holcus lanatus* should feral horse grazing be excluded from larger areas.

Stream structure and function

Changes to stream structure and function as a result of exclosure were more striking than changes to vegetation composition. The fenced stream segments were significantly shallower, with less streambank pugging and slumping than the unfenced segments. Visually, the unfenced (grazed) stream segments were more entrenched and had distinct, open water channels, while many of the fenced (ungrazed) segments had very indistinct channels, a more or less complete vegetation cover across the channel (of species such as *Carex gaudichaudiana, Ranunculus pimpinellifolius* and *Hydrocotyle* spp.) and no or little visible open water.

The extra vegetation in the fenced segments and lack of an open water channel suggests that water flow along the stream may be slower in the ungrazed segments. Scaled to a catchment level, this suggests that feral horse grazing may be impacting significantly on stream and catchment hydrology, and this may be greater than their impact on the vegetation further from the streambank. However, further data from larger-scale studies throughout the catchment would be required to confirm this.

Limitations on interpretation of results

The following limitations should be considered when interpreting the results of these trials:

1. Landscape scale effects that might occur if feral horses are excluded from the entire region, such as changes in broad-scale hydrology and changes to populations of other grazers, may not occur under the conditions of the

experiment. Conversely, localised effects observed in this study may not translate across the landscape.

2. Unusually high levels of grazing by other herbivores could occur on the exclosed plots, leading to a smaller effect than might be expected if horses were excluded over a larger area. However, such effects were not apparent in 2005.

3. The ecosystem has already been modified by past horse, sheep and cattle grazing. It remains possible that species sensitive to grazing have been lost from the system, and return of these species may be unlikely even after grazing is removed.

Recommendations and conclusions

The floristic plots at both sites are beginning to show differences between grazed and ungrazed treatments, and should be maintained. The most critical requirement is to maintain the fences and to quickly repair further breaches by horses or through vandalism, to minimise the chance of the fenced plots being grazed.

The design of fences should be reviewed to ensure that the original goals, to allow entry of grazers other than horses (Thiele and Prober 1999), are being met. Evidence of other grazers e.g. wombats, was present on both fenced and unfenced plots, however, droppings were too infrequent to assess differences between exclosed and unexclosed sites. It may be useful to remove wires from ground level to reduce any potential deterrent to entry by small mammals and marsupials.

The plot photographs taken annually by Friends of Cobberas comprise a valuable record of the overall vegetation of the plots. However, if capacity to continue with annual photography is limited, it is more important for effort to be directed into maintaining the fences and preventing breaches. The experimental design allows for minimal annual monitoring.

Plots should be remonitored in another 5 years. At this time, it may be possible to draw further conclusions about the trends observed (but not yet significant) in this study.

Potentially the most significant effect observed in 2005 is the nature of the stream channels along the fenced and unfenced segments. The changes observed (open-water incised channels in the grazed plots *versus* diffuse, vegetated channels in the fenced plots), when scaled to subcatchment or catchment scale, may imply that feral horse grazing is having a significant effect on hydrology and stream health.

Given these potentially significant effects of exclosure on stream channels, it would be useful to value-add to the existing experimental plots with further studies (on a small scale) of stream function and hydrology in the marked stream segments. In particular, a study of rates of water flow through the fenced and unfenced segments using appropriate methods may be valuable.

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Appendix 1: Summary of monitoring of Feral Horse exclusion plots by Friends of the Cobberas 1999-2005

DATE	Cowombat Flat Plots	Native Cat Flat Plots
July 1999	Fences installed by NRE crew from Nowa Nowa under direction from Scott Perkins	Fences installed by NRE crew from Nowa Nowa under direction from Scott Perkins
March 3, 2001	Friends conducted annual photo monitoring at Cowombat Flat. Some star pickets from unfenced plots were missing and needed replacement. Plots B2f, B3f and B4f had all been breeched by horse during January 2001. Plot B3f had apparently had a horse or horse inside the plots for some time as is evident from the presence of large quantities of dung within the plot. Fences re-strained to avoid this happening.	This site had been completely vandalised some time prior to the monitoring day. Al star pickets had been removed from the site and all fences cut with wire left lying on the ground. The 1997 plot was left untouched.
October 27 2001		Friends Working Bee to re-instate exclusion fences at Native Cat Flat. Corner assemblies strengthened, additional Pine posts added and new wires fitted with wooden droppers rather than star pickets. Marking of plots and stream segments within fences and marking of unmarked plots was not conducted. Need input from consultants.
July 2001	Friends received a Community Grant for $3000 to produce and install interpretive signs at Feral Horse exclosures.	Friends received a Community Grant for $3000 to produce and install interpretive signs at Feral Horse exclosures.
February 2002	Wording for signs finalised with input form Friends, MCAV and ABMA. Signs at graphic designer.	Wording for signs finalised with input form Friends, MCAV and ABMA. Signs at graphic designer.
April 14, 2002	Friends conducted annual photo monitoring at Cowombat Flat. All four fenced plots remain secure since last year's monitoring and were showing good growth of vegetation compared with heavily grazed unfenced areas. New interpretive signage installed at the plots and at both entry points to Cowombat Flat (McFarlanes Flat Track and Cowombat Flat Track)	Friends did not conduct photo monitoring at Native Cat this year. PV to install new sign here ASAP.
May 2002		PV staff discovered fences had again been vandalised (wires cut) in the preceding months leaving fenced plots open for grazing and trampling. Fences repaired by

		crew immediately. Interpretive signage installed to deter further vandalism .
January 2003	On approx January 30 the Alpine Fire burnt across both Cowombat Flat and Native Cat Flat.	On approx January 30 the Alpine Fire burnt across both Cowombat Flat and Native Cat Flat.
April 7 2003	Jenny Edwards visited Cowombat Flat Plots and made observations on the burn pattern and intensity at the site. All fences intact. Fences on old 1997 plots burnt. All three signs intact and in good condition	
April 29 2003	Jenny Edwards conducted annual photo monitoring at Cowombat Flat with PV staff. Noting: A large portion of Cowombat Flat was burnt possible by a medium intensity burn. There was no damage to fences on exclusion plots. Both plots at the eastern end (plots CW-B1 and CW-B2) were not burnt at all. CW-B3f had approx a third lightly burnt. CW-B3u was completely burnt. CW-B4f was completely burnt and CW-B4u had approx one third to one half burnt. (see map attached to monitoring sheet for exact details) All plots were covered by a wash of, ash, charcoal, silt and burnt vegetative matter. The build up of this is particularly evident in vegetation along streamline within plots.	
May 1 2003		Jenny Edwards conducted annual photo monitoring at Native Cat with PV staff. No official photos taken as there are still no markers indicating exact location of plots and photo points. 4 photos were taken from approx point of photo point within fenced plots only. No plots were burnt in recent bushfire, although surrounding area and sphagnum bog upstream has burnt fiercely. Fenced plot NC-B1f had had all wires cut some time ago. From evidence on fence it would seem that a horse may have forced it's way in and someone has cut the wires to release it. All other plot fences intact. Sign in good condition.
May/June 2003	Fences strained by PV crew.	Damaged fence at Native Cat repaired by PV crew. All other fences strained
March 13 2004	Margaret Schutte from the Friends accompanied PV rangers to conduct annual photo monitoring at Cowombat Flat. All fences intact.	

July 2 2004	Friends received a Community Grant for $4000 to have consultants complete full monitoring of Cowombat Flat Plots and re-instate control plots at Native Cat.	Friends received a Community Grant for $4000 to have consultants complete full monitoring of Cowombat Flat Plots and re-instate control plots at Native Cat.
January 2005		A visit to Native Cat Flat by PV staff showed the plot fences all intact and in good condition.
April 2005		Breaching of one fenced plot evident at Native Cat Flat.

Appendix 2

Two way tables indicating effects of (a) exclosure (U=unfenced, P=pre-fencing, F=fenced), (b) sampling year (99=1999, 05=2005) and (c) creekbank (N=north, S=south) on floristic composition at Cowombat Flat. All species occurring in greater than 2 plots are included.

(a)

Cowombat ordered on vector "exclosure"	UUPUP**U**UU**U**PPU**U** **FFUFF**
Cotula alpina	11-1---11-- -----
Haloragis heterophylla	1--1-----1- -----
Juncus falcatus	121--11---- --1--
Stylidium graminifolium	1---1-----1 -----
Euchiton sp.	2-112----12 -----
Plantago antarctica (broad)	6-142--3-14 1---3
Asperula gunnii	1--1---1--2 -----
Agrostis aff. *hiemalis*	111212-21-1 1---1
Epilobium pallidiflorum	12311111111 11111
Hydrocotyle algida	121113--111 11-1-
Hypericum japonicum	34444644335 3-313
Luzula sp.	11-111-1111 1--1-
Solenogyne gunnii	31-14--1124 2--11
Pentapogon quadrifidus	21-1-1-1211 1--2-
Carex inversa	41232334412 2332-
Velleia montana	11-131-31-2 1--11
**Festuca rubra*	48254936433 63554
Geranium antrorsum	22211222211 22221
**Hypochoeris radicata*	2-112-11124 2-111
Plantago antarctica (narrow)	69989999996 78999
Hakea microcarpa	12111111112 11111
Schoenus apogon	22543735347 52343
Dichelachne inaequiglumis	-1111121111 1-111
Brachychome scapigera	331333-3324 32134
**Aira* sp.	-------1-11 -----
Austrodanthonia laevis	11111112112 11-21
Poa spp.	62477345787 77779
**Trifolium repens*	114-1511213 23423
**Holcus lanatus*	42514451225 47813
Carex gaudichaudiana	2431134-211 47442
Veronica aff. *gracilis*	12-1-214213 42-31
Juncus australis	11121111311 12231
Senecio sp.CW4N	-------11-- ---1-
Elymus scaber	1--11--11-2 1--11
Scleranthus brockiei	11-11--1212 1--13
Ranunculus graniticolus	21-12313224 3-134
Austrodanthonia penicillata	1------2111 1--2-
**Cerastium vulgare*	-11-1111121 12-11
Asperula conferta	21122433322 51453
Oreomyrrhis eriopoda	4--23--3324 41146
Agrostis aemula	-----1----- 1-1--
Deyeuxia quadriseta	----1--1--- 1--1-
Viola betonicifolia	1--1----112 1-111
Dichondra repens	------2-1-- --41-
Linum marginale	1------121- 1--31
Prasophyllum sp.	-------1--1 1--11
**Trifolium dubium*	-------1--1 1--31

(b)

Cowombat ordered on vector for "creekbank"	SSSSSSS **NN**S**NNNNNN**
Juncus falcatus	12111-- ----1----
Dichondra repens	---42--1----1---
Agrostis aemula	--11--- -1-------
Epilobium pallidiflorum	3211111 111111111
Hydrocotyle algida	123--11 11-1111-1
Carex gaudichaudiana	3434471 24-124121
**Trifolium repens*	415413- 221112133
**Festuca rubra*	2895335 466445343
**Holcus lanatus*	5248571 241441235
Plantago antarctica (narrow)	9999988 979969996
Agrostis aff. *hiemalis*	112---2 11211--11
Hypericum japonicum	44634-4 334431335
Geranium antrorsum	2222221 222122111
Carex inversa	2133333 4242421-2
Cotula alpina	-1----1 1-1-1----
Dichelachne inaequiglumis	11112-1 1111-1111
Asperula conferta	1144312 353225232
Hakea microcarpa	1211111 111111112
Juncus australis	1112122 311113111
Schoenus apogon	5273324 355324437
**Cerastium vulgare*	111-12- 1111-1211
Luzula sp.	-11---1 1111111-1
Poa spp.	4237477 775767897
Brachychome scapigera	1331-23 333333244
Veronica aff. *gracilis*	-22-121 244-13113
Senecio sp. CW4N	------- 1-1--1---
Pentapogon quadrifidus	-11---1 211-221-1
Haloragis heterophylla	------1 ----1-1--
Velleia montana	-11---1 113311-12
Deyeuxia quadriseta	------- -111-1---
Linum marginale	------- 211-1311-
Austrodanthonia laevis	111-111 112112112
Ranunculus graniticolus	-1311-1 233223244
Austrodanthonia penicillata	------- 112-121-1
**Trifolium dubium*	------- -11--3-11
Plantago antarctica (broad)	1-----4 -1326-134
Scleranthus brockiei	-1----1 211111132
Viola betonicifolia	---1--1 11--11112
Oreomyrrhis eriopoda	---1-12 343344264
Euchiton sp.	1-----1 ---22-1-2
Prasophyllum sp.	------- -11--1-11
Solenogyne gunnii	-1----1 121431214
**Hypochoeris radicata*	1--11-1 121221214
Stylidium graminifolium	------- ---11---1
Aira sp.	------- --1---1-1
Elymus scaber	------1 111111-12
Asperula gunnii	------1 --1-1---2

(c)

Cowombat ordered on vector for year	UFUFUFUF FUUUUFFF
	99999999 55555555
Haloragis heterophylla	1---11-- --------
Stylidium graminifolium	1--1---- -1------
Euchiton sp.	21-211-- -2------
Cotula alpina	1-1-1--1 --1-----
Juncus falcatus	112---1- ---11---
Plantago antarctica (broad)	61-241-- -43--13-
Solenogyne gunnii	3-1412-1 -41--211
Asperula gunnii	1---1--- -21-----
Epilobium pallidiflorum	13211111 11111111
Hydrocotyle algida	112111-1 11-3-1-1
Agrostis aff. *hiemalis*	11112--1 -122-11-
Hypericum japonicum	34444343 -5463331
**Hypochoeris radicata*	21-21211 -41-1211
Carex inversa	42123134 324332-2
Luzula sp.	1-1111-1 -111-1-1
Pentapogon quadrifidus	2-1-11-2 -111-1-2
Velleia montana	1-131--1 -231-111
Geranium antrorsum	22211122 21222212
Plantago antarctica (narrow)	69998999 86999799
Hakea microcarpa	11211111 12111111
**Aira* sp.	-----1-- -11-----
**Holcus lanatus*	45241252 75148431
Dichelachne inaequiglumis	-1111121 -1111111
**Festuca rubra*	42845334 33695645
Carex gaudichaudiana	23411142 71-34424
Poa spp.	64277847 77537797
Brachychome scapigera	313332-3 24331343
Schoenus apogon	25234433 27573534
**Cerastium vulgare*	-111-211 2111-111
**Trifolium repens*	1411-112 33154232
Juncus australis	11112113 21112113
Scleranthus brockiei	1-1111-2 -21--131
Elymus scaber	1--11--1 -21--111
Austrodanthonia laevis	11111111 1221-112
Oreomyrrhis eriopoda	4--322-3 143-1464
Ranunculus graniticolus	2-121212 -4331343
Veronica aff. *gracilis*	1-2-1112 2342-413
Viola betonicifolia	1---11-1 -2--1111
Asperula conferta	21122233 12344535
Dichondra repens	------21 ----4--1
Senecio sp.CW4N	-------1 --1----1
Austrodanthonia penicillata	1----1-1 -12--1-2
Agrostis aemula	-------- ---111--
Prasophyllum sp.	-------- -11--111
Deyeuxia quadriseta	---1---- --1--1-1
Linum marginale	1----1-2 --1--113
**Trifolium dubium*	-------- -11--113

Appendix 3

Two way tables indicating effects of (a) exclosure (U=unfenced, P=pre-fencing, F=fenced), (b) sampling year (99=1999, 05=2005) and (c) creekbank (N=north, S=south) on floristic composition at Native Cat Flat. All species occurring in greater than 2 plots are included.

(a)

Native Cat ordered on vector for "Exclosed"	PUUPPU**U**U**U**P**UU** **FFFF**
Stellaria angustifolia	32121--1-1-- ----
Hypoxis hygrometrica	111-11------ ----
Lilaeopsis polyantha	21----2-1--- ----
Dichondra repens	111--------- ---1
Dichelachne inaequiglumis	111-1---1--1 -1--
Isolepis aucklandica	9614745335-3 2423
Hakea microcarpa	--2-1--1--1- -1--
Euchiton involucratum	11143461-211 ----
Gonocarpus micranthus	433646412413 3-22
Schoenus apogon	454442386423 123-
Austrodanthonia laevis	111111111111 111-
Hydrocotyle algida	995879677846 5462
**Hypochoeris radicata*	111-11----2- 1---
Senecio lautus	--1-1-----1- ----
Epilobium pallidiflorum	454351442242 3314
Cotula alpina	433447455524 2331
Hypericum japonicum	556556555456 4442
Ranunculus pimpinellifolius	471444643614 4341
Juncus australis	111-1-111-2- ----
Brachychome scapigera	-14143224-23 13--
Acaena novae-zelandiae	--1--1---111 ----
**Trifolium repens*	445254443244 3452
Plantago antarctica (narrow)	248153378171 1713
Hydrocotyle tripartita	---1--1----- 1---
Agrostis aff. *Hiemalis*	111--111---1 --11
Oreomyrrhis ciliata	24444534644- 3-6-
Ranunculus graniticolus	---1-1-----1 1---
Elaeocharis gracilis	66341-8668-3 4185
**Cerastium vulgare*	--111111-121 1--1
Luzula sp.	--1121111121 1--1
Carex inversa	-2121-----31 --12
**Taraxacum sp.*	-111-1-----1 1--1
Juncus falcatus	111153244412 2242
Austrofestuca hookeriana	421415211--4 4-34
Agrostis aemula	11111-211111 1111
Stylidium graminifolium	-----1-----1 1---
Scleranthus brockiei	--1-------2- -1--
Chionogentias cunninghamii	---1-1---1-2 1-1-
Carex gaudichaudiana	754454433146 8719
Epacris celata	--1211-11112 1-2-
Epacris gunnii	---1-1----12 1-1-
Poa spp.	1-5356322185 5736
**Holcus lanatus*	113122313165 5424
Asperula gunnii	112211111142 4132
Unidentified daisy	----------2 111-
Empodisma minus	1--1-1---1-- 2-31
Deyeuxia gunniana	-----1-----1 --2-
Oreomyrrhis eriopoda	----------4 -7-1
Veronica aff. *gracilis*	---111211114 4245

(b)

Native Cat ordered on vector for "Creekbank"	SSSSSSS	NSNNNNNNN
Scleranthus brockiei	21-1---	---------
Senecio lautus	11---1-	---------
Hakea microcarpa	12-111-	---------
Juncus australis	211-111	11-------
Plantago antarctica (narrow)	7887754	231133111
**Hypochoeris radicata*	21---11	1----11--
Dichelachne inaequiglumis	-111-11	1-------1
**Cerastium vulgare*	21--11-	-11-11111
Brachychome scapigera	2443241	-2---3113
Oreomyrrhis eriopoda	---7---	----1---4
Schoenus apogon	2462845	4343-2143
Dichondra repens	-1----1	1---1----
Hypoxis hygrometrica	-1---11	1----1---
Epilobium pallidiflorum	4423455	442141332
Carex inversa	31---12	---12--21
Luzula sp.	211-12-	-11-11111
Lilaeopsis polyantha	--1---1	22-------
**Trifolium repens*	4534454	442524324
Agrostis aemula	1111111	12111-111
Austrodanthonia laevis	1111111	1111-1111
Juncus falcatus	1142451	124423212
Oreomyrrhis ciliata	446-444	2346-534-
Poa spp.	852725-	131366535
Hypericum japonicum	5654555	554426456
Isolepis aucklandica	-134376	955234243
**Holcus lanatus*	6334121	131242515
Hydrocotyle algida	4574779	968629586
Cotula alpine	2353543	445317244
Elaeocharis gracilis	-361616	68885-443
Stellaria angustifolia	-1--112	3-1----2-
Acaena novae-zelandiae	11-----	--1--1--1
Ranunculus pimpinellifolius	1133447	466414444
Carex gaudichaudiana	4437355	741194846
Agrostis aff. *hiemalis*	-1--1-1	11-111--1
Asperula gunnii	4211111	111321422
Euchiton involucratum	11--131	162--4-41
Gonocarpus micranthus	132-143	444226363
Epacris gunnii	1------	---1-1112
**Taraxacum* sp.	-1----1	----11111
Veronica aff. *gracilis*	1-1211-	-21451414
Epacris celata	111-11-	--12-1122
Hydrocotyle tripartita	-------	-1----11-
Empodisma minus	-------	1-131121-
Austrofestuca hookeriana	-11-112	42-345444
Deyeuxia gunniana	-------	---2-1--1
Unidentified daisy	---1---	---1--1-2
Stylidium graminifolium	-------	-----11-1
Chionogentias cunninghamii	-------	--11-1112
Ranunculus graniticolus	-------	-----1111

(a)

Native Cat ordered on vector for year	999959999 5555555
Stellaria angustifolia	3221--111 -------
Lilaeopsis polyantha	21--2---- 1------
Hypoxis hygrometrica	11-1-11-- -------
Dichondra repens	11-1----- ------1
Isolepis aucklandica	964154753 33-2243
Euchiton involucratum	114164321 -11----
Gonocarpus micranthus	436346441 23123-2
Dichelachne inaequiglumis	11-1--1-- 11---1-
Hydrocotyle algida	998569787 7646542
Schoenus apogon	454432448 632312-
Hydrocotyle tripartita	--1-1---- ----1--
Cotula alpina	434347455 5423231
Ranunculus pimpinellifolius	474164464 3414431
Austrodanthonia laevis	111111111 111111-
Hypericum japonicum	555656545 5654442
Epilobium pallidiflorum	453441524 2241334
Acaena novae-zelandiae	---1-1-1- -11----
Elaeocharis gracilis	66438-186 63-8415
Hakea microcarpa	---2--1-1 --1--1-
Agrostis aff. *hiemalis*	11-111--1 -1-1--1
**Trifolium repens*	442544524 3445342
Ranunculus graniticolus	--1--1--- -1--1--
Oreomyrrhis ciliata	244435444 6-463--
Brachychome scapigera	-114234-2 432-13-
**Hypochoeris radicata*	11-1-11-- --2-1--
Juncus falcatus	111123544 4214222
Austrofestuca hookeriana	4241251-1 14-34-4
Chionogentias cunninghamii	--1--1-1- -2-11--
**Taraxacum* sp.	-111-1--- -1--1-1
Plantago antarctica (narrow)	241833517 8171173
Juncus australis	11-11-1-1 1-2----
Stylidium graminifolium	-----1--- -1--1--
Luzula sp.	--1111211 112-1-1
Senecio lautus	---1--1-- --1----
Agrostis aemula	11112-111 1111111
**Cerastium vulgare*	--1111111 -12-1-1
Epacris celata	--21-1111 12121--
Carex inversa	-221--1-- -131--2
Carex gaudichaudiana	754444513 3641879
Epacris gunnii	--1--1--- -2111--
Poa spp.	1-3536512 2583576
Asperula gunnii	112211111 1243412
Unidentified daisy	--------- -2-111-
Empodisma minus	1-1--1-1- ---32-1
Deyeuxia gunniana	-----1--- -1-2---
**Holcus lanatus*	111332211 3562544
Scleranthus brockiei	---1----- --2--1-
Veronica aff. *gracilis*	--1-21111 1414425
Oreomyrrhis eriopoda	--------- -4---71