Testing techniques for weed control at the Shipley Reserve (Western Riverside County Multispecies Reserve)

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Edith B. Allen
Department of Botany and Plant Sciences
University of California, Riverside, 92521

Introduction

Invasions by exotic plant species have become a major problem for land managers of nature reserves in many areas, including the Shipley Reserve. Exotic plants may replace native species over large landscapes, where they reduce the available space for natives and may cause increased scarcity and endangered status of rare species (D'Antonio and Vitousek 1992, Pavlik et al. 1993, Pysek et al. 1995, Carlsen et al. 2000). One of the most invasible vegetation types in southern California is the coastal sage scrub (CSS), which is a dominant vegetation at the Shipley Reserve. CSS has been subject to fragmentation, heavy grazing, frequent fire, and air pollution, all of which promote weed invasion (Allen et al. 2000, Allen 2004, Minnich and Dezzani 1998). The dominant invasive species include species of the grass genera *Avena, Hordeum, Bromus*, and *Schismus*, and the forbs *Brassica* and *Erodium* (Rejmanek et al. 1991).

In some vegetation types annual weeds decline after cessation of disturbance during the process of succession. However, longterm observations of many CSS sites show that, once established, the weeds persist and are not replaced by native species (Minnich and Dezzani 1998, Allen et al. 2000, Allen 2004, Stylinski and Allen 1999, Zink et al. 1995). Experimental studies show them to be highly competitive with various native species, and weed control is necessary before natives will reestablish (Gordon and Rice 1993, Nelson and Allen 1993, Eliason and Allen 1997, Cione et al. 2002). Weed control over large landscapes is costly, and weeds may reinvade. A project was initiated in 1999 to test cost effective methods of weed control. This project has turned into a long-term project to understand the rate at which weeds invade following treatment. Such data are critical to designing weed control programs. From an ecological standpoint, long-term data will help determine the stability of the vegetation type to future weed invasions.

Several weed control methods were implemented at the Shipley Reserve, funded from 1999-2001 by the Western Riverside County Multispecies Reserve. During the 2001-2002, and 2002-2005 growing seasons funding was obtained from the CNAS

Shipley Skinner fund, as the WRCMR Management Committee was not able to continue funding the project. This report updates the 2002-2005 growing season funded by CNAS, but, to set the context, the data from all years of the project will be shown. The timing of the Shipley-Skinner call for proposals has shifted from a January to a July date for initiation of annual funding, thus this project covers spring of both 2003 and 2004. Since we have not finished collecting the data for 2004, we show completed data for spring 2003, as proposed in our spring 2003 proposal.

The objectives were to test several weed control techniques that are especially suited for the Shipley Reserve, including areas of CSS and annual forb lands. These were timed grazing, grass-specific herbicide, and dethatching. Fire was not used because the Reserve Management Committee does not feel that fire should be used as a tool at this time because much of the vegetation recently burned in the wildfire of 1993. The vegetation response was measured yearly following weed control to determine how often treatments must be reapplied, and to determine whether the desired native species reestablish or must be reseeded because the seedbank has been depleted.

Methods

A research plan for weed control was designed by the Scientific Advisory Committee of the WRCMR (including UCR researchers, Reserve managers, and others) in 1998. Two sites were chosen for treatment, exotic annual grassland in Crown Valley and weedy coastal sage scrub in Lopez Canyon, both sites in the Shipley Reserve. The treatments agreed upon were timed grazing by sheep, application of the grass-specific herbicide Fusilade, and dethatching plus Fusilade. However, grazing was not done at Crown Valley, because the objective of vegetation management was to establish a native forbland at this site, and sheep consume both forbs and grasses. Sheep grazing was used at Lopez Canyon, where there is an overstory of CSS shrubs with an understory of exotic grasses and forbs.

The experimental design was a randomized block design with three replicates of 1-ha plots of each of the following treatments: 1) Untreated controls, 2) grass-specific herbicide, 3) grass-specific herbicide plus dethatching, applied at both Crown Valley and Lopez Canyon, and 4) sheep grazing, applied at Lopez Canyon only. The dethatching treatment was applied to remove a build-up of thatch that might have reduced the effectivity of herbicide, e.g., to improve the contact of the herbicide with living vegetation.

The treatments were applied as follows:

Herbicide—February/March in 1999 and 2000, using hand-held applicators at the lowest level of the manufacturer's recommended dose.

Dethatching—November 1999 using hand-held weed trimmers, followed by herbicide in February 2000

Grazing—March/April in 1999, 2000, and 2001, using 200 sheep per hectare plot for 48 hours.

Percent cover data were collected in permanent 0.5 X 1.0 m quadrats, 20 per 1-ha plot, in February/March and again in late April/early May of each year. Only the April/May data will be shown in this brief report. No additional treatments were applied in 2002, but percent cover data were collected to determine the longterm response to treatments, and whether the native plants had recovered from sheep grazing.

Results

Lopez Canyon

The exotic grass cover (mainly *Bromus madritensis* ssp. *rubens* and *B. diandrus*, with some *Avena fatua*, *Vulpia* spp., and *Schismus* spp.) decreased with the herbicide treatment in 1999 compared to control plots, and decreased even more in 2000, the second and final year of herbicide application (Fig. 1). The dethatching plus herbicide treatment was not significantly different from herbicide alone, indicating that the herbicide did have good contact with the grasses in spite of the dense thatch. No additional herbicide was applied in 2001, but exotic grass cover was still significantly lower than in control plots. By 2002 there were no significant differences among the treatments, but this was the driest year on record in this region since record-keeping began in the state, only about 10 cm in an area that averages 28 cm. In 2003 the thatched Fusilade treatment still had lower grass cover than the control, but the grazing and Fusilade treatments were not different. Overall the grass cover was still low in 2003 and 2004 compared to earlier years, likely the result of continued low precipitation.

The grazing treatment was not effective in controlling grasses until the third season, 2001 (Fig. 1). The grazing was done in March/April, before the percent cover data were collected in April/May, and showed that the sheep did not consume grasses until 2001. This was the only year that the grasses had not produced seed by the time the sheep were placed in the plots, and sheep will not graze the seeds because of sharp awns.

The exotic forbs consisted mainly of *Erodium cicutarium* and *E. brachycarpum* with less than 2% wild mustard (*Brassica geniculata*), but there were no significant differences among the treatments in any year except the very dry spring of 2002 when the grazed plots had slightly higher cover of exotic forbs than control plots (Fig. 1). In 2003 the exotic forbs were not significantly different in cover among the treatments, although the grazing treatment had higher exotic forb cover in 2004.

The native forb cover increased significantly in the 2000 and 2001 growing seasons in response to the herbicide treatment, but decreased with grazing (Fig. 1). In 2002 there was virtually no forb growth at all due to the drought. Finally, in 2003 we were able to show that grazing did increase the native forbs, which had higher cover than the control plots, as did the Fusilade and Fusilade-thatch treatment. This suggests that, even though the sheep consumed the native forbs in 2001, they had a persistent seed bank that lasted through the 2002 drought and were able to recover in 2003. By 2004 the sheep grazing treatment was significantly lower in cover than the herbicide treatments, and not significantly different from the controls.

Native forbs were the most diverse of any plant group sampled, with up to a mean value of 7 species per 0.5 m^2 sample quadrat, and a maximum of 75 species total found in all 240 quadrats during 2001 (Tables 1 and 2). The lowest number of native forbs occurred during the 2002 drought year. The herbicide and dethatch-herbicide treatments tended to have the highest per-quadrat and per-treatment number of species.

The native shrubs did not respond in cover to any of the treatments (Fig. 1). We examined the sample quadrats for germinating shrub seedlings, but did not observe a higher density of seedlings in response to any of the treatments. The dominant shrub by far is *Eriogonum fasciculatum*, with lesser coverage for *Artemisia californica* and *Ericameria palmeri.*

The wildfire that burned through Lopez Canyon in November 2003 burned approximately 2/3 of all the plots. The data were reanalyzed separately for burned and unburned plots, showing the cover of each of the treatments in April 2004 (Fig. 2). Exotic grass was overall higher for unburned than burned plots, but there were no significant differences among treatments. Conversely, exotic forbs were greater in burned than unburned plots, with significantly higher forb cover in the grazed, burned plots. Native forbs were not different in burned and unburned plots, and the grazed, burned treatment had the lowest native forb cover.

Crown Valley

The responses of exotic annual grasses to herbicide and dethatching plus herbicide were similar in Crown Valley (Fig. 3) as for Lopez Canyon, with a greater effect of herbicide in 2000 than 1999, and a continual significant effect into 2002. Although vegetation at Crown Valley also suffered from the drought of 2002, it had a higher cover of vegetation than the slopes of Lopez Canyon, probably due to moisture in the valley bottom. Grass cover was in fact lower in 2003 than 2002, even though the precipitation was higher. This may be because of continually declining seedbank due to poor grass productivity. However, the beneficial effects of herbicide on reducing grass cover continued into 2003 and 2004.

The exotic forbs had increased cover following grass control with herbicide, possibly because the reduction in grass cover opened areas for germination of annual forbs (Fig. 3). This effect was consistent through 2004. Again, most of the exotic cover was *Erodium cicutarium* and *E. brachythecium* with a very small amount of *Brassica geniculata*. The response of the exotic annuals to grass removal persisted into the 2002 drought year and 2003. Cover of *Erodium* spp. was the highest during 2003 of all years, up to 70% where grass had been controlled.

Native forbs showed an increase in cover following exotic grass control by 2001, but the native cover was virtually 0% in the 2002 drought year (Fig. 3). However, the native forbs recovered from the seed bank with higher rainfall of 2003, and were still significantly higher in herbicide-treated than control plots. Thus the herbicide that had been last applied in 2002 had residual effects into 2003. But native forb cover was low in 2004, and no longer significantly different among treatments and control.

Discussion

Grass-specific herbicide gives a more rapid and reliable response both in terms of reduced grass cover, as grazing did not cause a reduction in grasses until the third growing season of application. By contrast, the herbicide reduction in grasses was immediate, and greater in the second than the first year of application. However, there are trade-offs of using herbicides and grazing. Grazing can only be applied during years of sufficient rainfall when there is early spring growth of grasses to provide forage.

Herbicide application also requires a standing crop of grass, but the window of application is longer, and the result is immediate.

The reduction of grass cover by the herbicide promoted an increase in both native and exotic forbs, but the exotic forb cover overall was higher than native forbs at both Crown Valley and Lopez Canyon. This was especially true in the 2002 drought year, when native forbs did not grow at all. The conservative response of native forbs to drought has also been observed in the Mojave Desert, where at least some exotic annuals germinated even in the driest years, but native plants emerged primarily during wetter years (Brooks 1999b, 2000).

The lack of response of exotic grasses to grazing during the first two years was not due to poor management of the sheep herd, but rather to timing of rains. The rains came late in 1999 and 2000, and by the time grasses had produced sufficient forage for sheep to graze (at least 5 cm of vegetation growth), they had also produced seeds. Timing of precipitation was more conducive to annual grass grazing in 2001, as rains came earlier, were more abundant, and grasses had sufficient forage for grazing prior to seed production. Grazing was used successfully to control exotic grasses in northern California (Weiss 1999), where the levels of precipitation are greater and the rainfall season is longer. Native forbs, including *Plantago erecta* that is the host plant for the endangered Bay checkerspot butterfly, were more abundant in areas that had cattle grazing, while dense grass cover in ungrazed areas was probably responsible for sparse forb cover and an absence of butterflies. An analogy exists in the adjacent Lake Skinner Reserve which has the endangered Quino checkerspot butterfly and its host plant *Plantago erecta*, that must also compete with exotic grasses (USFWS 2003).

In our study sheep consumed the native forbs preferentially in all three years when grazing was done, especially 2001. To determine whether the sheep had positive or negative long-term effects on the native forbs, the plots were observed in 2002, 2003, and 2004. Since 2002 was such a dry year, there was virtually no forb growth at all. However, it was apparent in 2003 that sheep grazing was just as beneficial to native forb growth as herbicide, even though sheep grazing had not been done since 2001. It is likely that the native forbs were able to maintain a viable seed bank during the years of grazing, as these are fire-adapted species. The CSS vegetation burns at 25-30 year intervals, and the "fire-following-annuals" must maintain their seedbank between these natural burn intervals (Keeley and Keeley 1984, Keeley 1991). Thus the native forbs are adapted to recovery from the sheep grazing, and this experiment has validated that this is an effective treatment to both control exotic grasses and increase native forb cover. However, by 2004 native forb cover was low and there was no longer a beneficial effect of any of the treatments.

The shrub cover at Lopez Canyon has also not increased in response to reduction of exotic grasses, but this may be expected if exotic forbs are increasing. The relative competitive ability of exotic grasses and forbs are different, and has been shown in two other studies at Crown Valley (Gillespie 2003, Cox and Allen, unpubl.). Exotic grasses are highly competitive, and *Erodium* spp. are likely less competitive with native forbs.

Our recommendations for weed control at the Shipley Reserve are that both grass-specific herbicide and sheep grazing may be used to control exotic grasses and increase native forbs. While the increase in exotic *Erodium* spp. Following grass control may not be considered desirable because it simply replaces one weed for another, it does have some benefits. First, *Erodium* does not maintain a highly flammable litter cover during the summer as do the exotic grasses. *Erodium* litter degrades to fine fragments that can be observed as a sparse layer on the soil surface during the summer/fall fire season, while dry grass remains intact as standing litter that may carry fire from shrub to shrub (Brooks 1999b). A second benefit is that the Federally-listed Stephen's kangaroo rat, while considered a grassland species, in fact has higher populations in short-statured grasslands or forblands (M. Price, UCR, pers. comm.). The Stephen's kangaroo rat thrives very well in forblands that are dominated by the exotic *Erodium* rather than native forbs. The grass control treatments may be a benefit to those small mammals that do not thrive in tall stands of exotic grasses.

The third reason that replacing exotic grasses with *Erodium* still constitutes a beneficial response overall is that *Erodium* may not be as competitive with the native forbs as with exotic grasses, as was shown in a study at the Santa Rosa Plateau (Gillespie and Allen in press). A related study at Crown Valley has included seeding native forb and shrub species into stands dominated by exotic grass and *Erodium*. The preliminary results suggest that *Erodium* is not as competitive in enabling native forb establishment (Cox and Allen unpubl.). The most disappointing aspect of this study is that the treatments have had not impact on growth of mature shrubs or promoted establishment of shrubs from the soil seed bank. This suggests that additional studies on planting or seeding of shrubs must be done in the future, to improve this shrub of the vegetation.

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Table 1. Number of native forb species per 0.5 m^2 quadrat in three treatments and control during each of six years. Values in bold are significantly higher than other values in row.

Year	Control	Herbicide	Dethatch-Herb	Grazing
		#native forb species/quadrat		
1999	0.95	1.49	0.07	1.00
2000	2.77	**4.30**	**4.67**	1.53
2001	5.53	**6.77**	**6.95**	5.70
2002	0.00	0.00	0.08	0.00
2003	5.18	5.13	**5.80**	**5.70**
2004	1.25	**2.18**	**2.03**	0.78

Table 2. Number of native forb species in sample quadrats in each treatment and total in all treatments. Values in bold are the highest value in each row.

Year	Control	Herbicide	Dethatch-Herb	Grazing	Total
		#native forb species/60 quadrats			# /240 quadrats
1999	22	26	26	17	38
2000	35	**52**	47	25	71
2001	47	52	**58**	41	75
2002	0	0	4	0	4
2003	41	49	**53**	48	69
2004	23	34	**38**	15	48

Fig. 1 Responses of exotic grass, exotic forbs, native forbs, and native shrubs to three seed control treatments. A wildfire occurred after the 2003 assessment. Native forb responses to treatments were still significant through 2004.

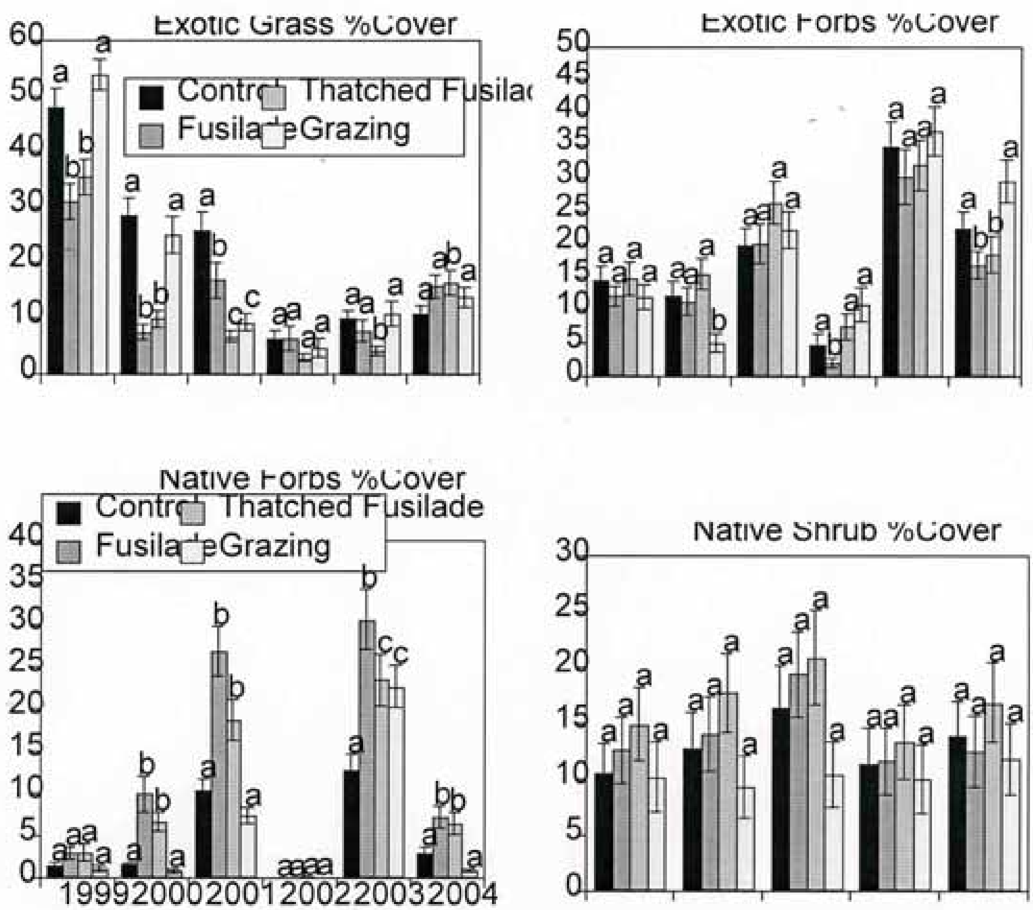
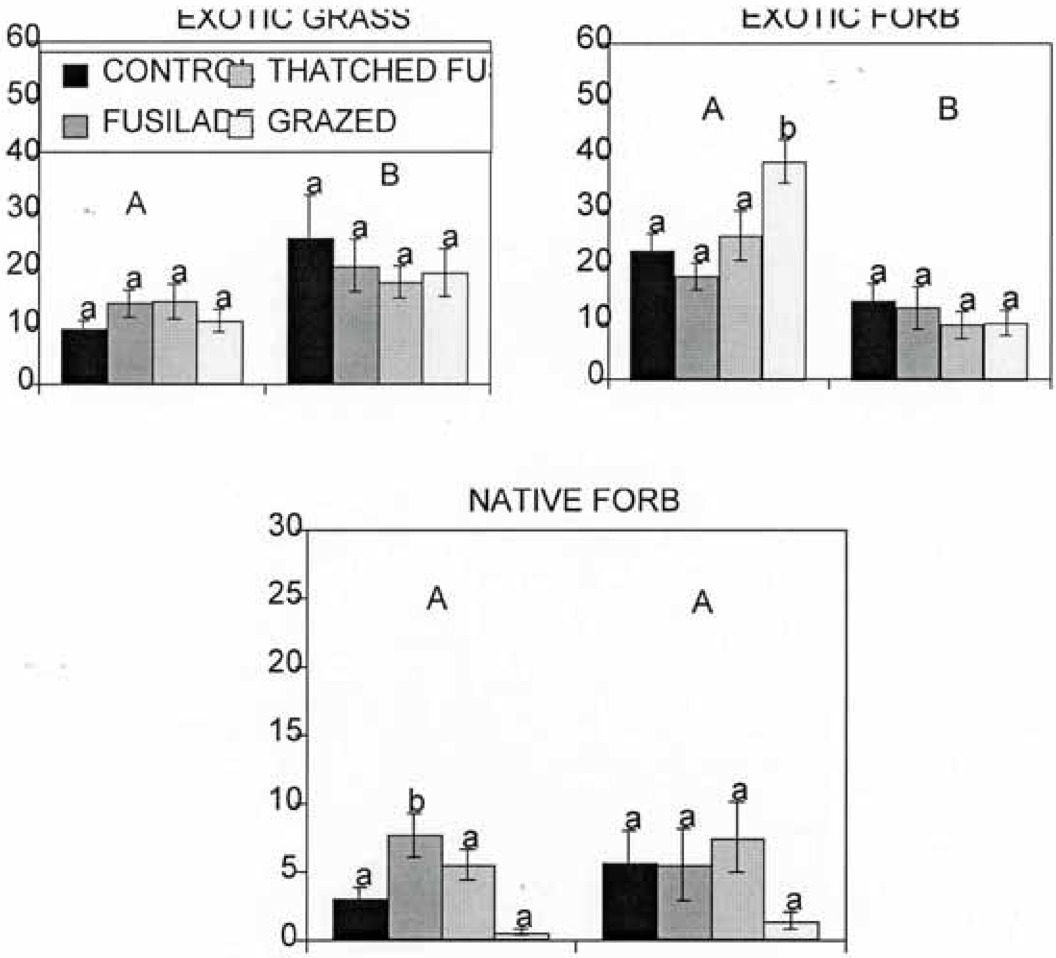


Fig. 2 Responses of exotic grass, exotic forb, and native forb to a wildfire in November 2003. Data are from Apr./May 2004. B = burned, NB = not burned. Upper case letters indicate significant differences between burned and non-burned plots, lower case letters indicate significant differences among treatments within burned or non-burned treatments. Y-axis shows percent cover.



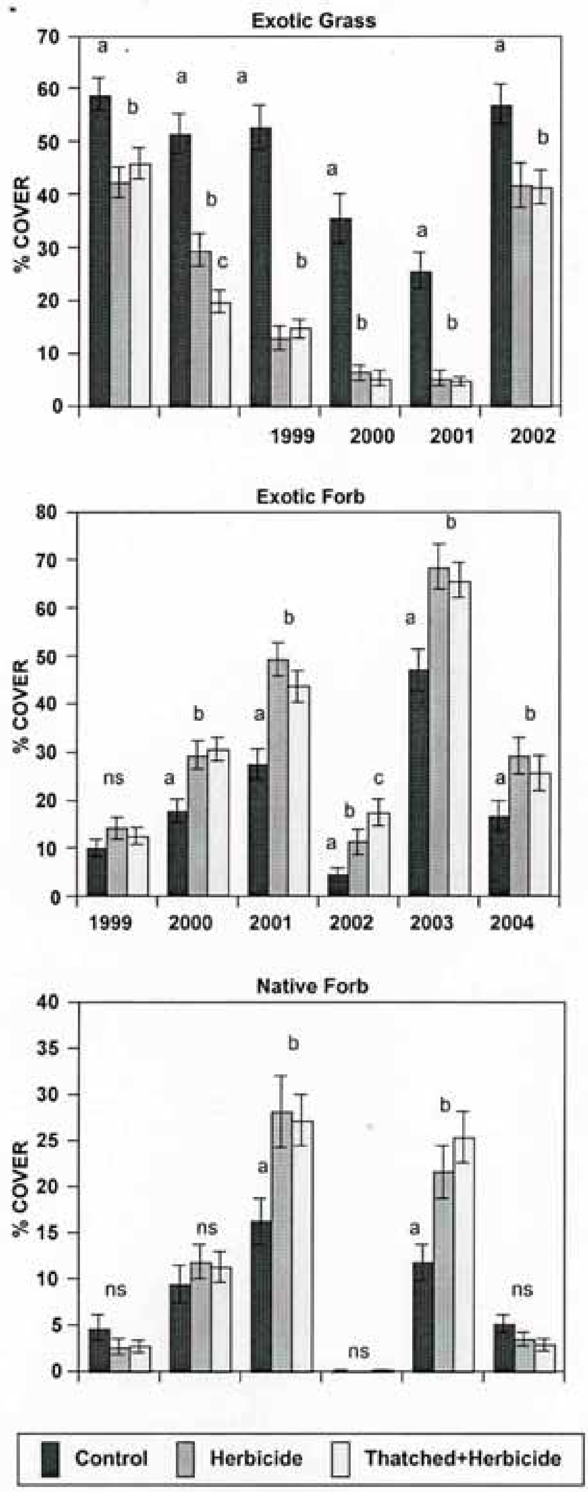


Fig. 2 Fig. 2. Responses of exotic grasses, exotic forbs, and native forbs to grass-specific herbicide and dethatching plus herbicide treatments during six years. Herbicide was applied in Mar. 1999 and Feb. 2000, and dethatching was done in November, 1999.