Restoration of Native Grasses in California Old Fields II: Cheap Tills

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Introduction

Native perennial grasslands in California are among the most endangered ecosystems in the United States (Peters and Noss 1995). An area of approximately 7,000,000 ha (about 25% of the area of California) is now dominated by exotic species primarily of Mediterranean origin (Huenneke 1989). Typical annual grassland species include Bromus diandrus, B. mollis, B. rubens, Avena barbata, A. fatua, Erodium cicutarium, E. botrys and Vulpia myuros (Heady et al. 1988). Conversion to an exotic annual vegetation was so fast, extensive, and complete that the original extent and species composition of most native perennial grasslands is unknown (Burcham 1957, Barry 1972, Keeley 1989, Heady et al. 1992, Holland and Keil 1995). Cover of exotics is often over 80% in this annual vegetation type (Biswell 1956).

Old fields, land that was farmed and then abandoned, offer a variety of possibilities for re-establishment of native perennial grasses. They are level, often accessible to tractors, and are not susceptible to erosion as are steeper hillsides. Old fields in central California are often dominated by annual, non-native species cited above. Even if some native, perennial grasses are nearby, simply leaving the old fields alone does not promote the natural establishment of native, perennial grasses (Stromberg and Griffin 1996). Restoration ecologists in California have tried various methods to re-establish these natives. Some methods are more effective than others (Stromberg and Kephart 1996) and here we report on re-establishment trials based on one of the most cost-effective; that of tillage and subsequent fallowing before planting native grass seed. What would a re-established plot of native Nassella pulchra (purple needlegrass), Elymus glaucus (blue wild rye) and Hordeum brachyantherum (California meadow barley) look like after several years? These species still occur on Hastings in small patches. Because we don't fully understand the ecological amplitude of these species, we planted them across all micro-habitats in the restoration trial sites, just as Curtis and others pioneered trials in Midwest prairie restorations (Howell and Stearns 1993). Because the restoration was initiated on the Hastings Reserve, these plots will continue to be available for long-term observations and the abundance of each species in the various micro-habitats can be tracked over time.

This six-year study provides information on one of the least expensive methods of native grass restoration that deals with the problems of exotic weeds and gopher disturbance. We recognize that this project is not a true "restoration" as we know neither the original grassland composition nor are we dealing with all of the native flora that may have made up a functional perennial grassland (Young et al. 2001). However, the three co-dominant native perennial grasses we used still occur in patches on the reserve; these relicts serve as our guides.

Methods

In 1996, we selected three old fields on the Hastings Natural History Reservation, Carmel Valley, Monterey County, California, for restoration and control sites. Each has slopes of less than 4%. Both the Lower Barn and Well site are Gorgonio sandy loams and the Corral Field site is a Sheridan coarse sandy loam (Cook 1978). Each restoration site is 50 m x 20 m and shares a boundary with plots that have been monitored for species composition since 1971 (Stromberg & Griffin 1996). These fields had been in small grain production continuously from about 1865 to 1935. Since 1937, at the establishment of the Hastings Reservation, these fields had been left to natural processes and not grazed or disturbed.

Starting in November 1995, we disked three restoration sites (Barn, Well, and Corral) to a depth of about 18". A control site, contiguous to each restoration site, was left undisturbed. Students from Carmel High School (see photo) used a spring-toothed harrow and small tractor to cultivate successive crops of annual weeds. Each time the field was covered with seedlings, we harrowed to remove the annual plants before they could set seed. The harrow was adjusted to a depth of about 25 cm. Tillage started in November and continued through March each year. Each field was harrowed four times during the rainy season and when vehicle access was not possible (usually wet soils in April), glyphosphate was applied at label rates. We only sprayed the fields once a year to remove all sprouting vegetation. In December 1997, we harrowed the restoration sites, sowed seeds with a hand broadcaster, and covered the seeds by dragging a steel pipe behind the tractor. On each restoration plot we planted 3 kg (6.7 lb.) of Nassella pulchra, 4.5 kg (10 lb.) of Hordeum brachyantherum californicum , and 2.3 kg (5 lb.) of Elymus glaucus. The N. pulchra source was from ConservaSeed, Lot # SFSTPUNC01, the Hordeum californicum, also from ConservaSeed, Lot #SGHOA11 derived from populations at Hastings and southern Monterey County, and the Elymus glaucus was from Rana Creek Habitat Restoration, Lot RANAMB01, derived from populations in Carmel Valley (Upper Rancho San Carlos). We compacted the soil around the seed by driving the tractor back and forth across the plot until it was covered uniformly with tire tracks.

In February of 1998, heavy rainfall associated with an El Niño year caused a washout on part of the Barn site. We replanted the eroded section in late February 1998.

In July 2001, we sampled the canopy cover of plants on the site, recording Daubenmire cover classes (Daubenmire 1959) for each species. For data analysis, cover class values were converted to mid-point values, and we used Statview® for analysis of variance to compare restoration and controls. We used the current Jepson nomenclature for species (Hickman 1993). For each treatment (restoration) and control site, we used 20 quadrats (20 cm x 50 cm) at 2.5 m intervals along the long axis of the plots. We made periodic non-quantitative observations on the cover of plants and gopher activity before and after planting.

Results

During the pre-planting tillage, the number of gopher tailings on the restoration sites dropped to near zero and cover of gopher tailings was virtually absent. By the second year, the cover of annuals was minimal (5-10%) between tillage.

For the first year after planting, bare soil cover exceeded 90%. Gophers were absent on restored sites until 2001, but continued to be abundant on the adjacent controls. Virtually the only plants on the restored plots were the native, perennial grass seedlings. Native bunchgrass survival was good, with densities of seedlings persisting at 12-19/ m^2. After the second year, this density did not change perceivably. Basal diameter of the grasses varies from 3-10 cm.

In 2001, all three native grasses were present and doing well, (Table 1), although the cover of the native grasses was relatively low. Native grasses occur only on the restoration plots with a mean cover value of from 1 to 6%. However, the only other plant species on the restored plots with more cover are the introduced Filago gallica (Long-leafed filago) and Vulpia myuros (Foxtail fescue). The latter first occurred in the spring of 2001 and then on just one restoration plot (Corral). Cover of Vulpia there was 53% in the restoration plot, and 7% on adjacent control.

In the control plots, dominant vegetation was similar to that reported previously for old fields on Hastings (Stromberg & Griffin 1996). Bromus hordaceous was the dominant annual grass (Table 1) at 24%, with Erodium spp. (filaree or storksbill) cover at 26%.

Natives appear to be doing well on the restoration plots. Only 2 of 7 non-native grasses (Aira, and Vulpia) were more abundant on restoration sites. Only 1 of 8 non-native forbs (Filago) is more abundant on the restoration sites. Cover of most of the native forbs (7 of 11) was no lower on the restoration site, and for three species, native cover was significantly higher on the restoration plots (Table 1). Only one native (Plagiobothrys, popcorn flower) was less abundant on restoration sites.

Species diversity was not significantly different between the control and restoration plots, and the number of natives and non-natives have not differed yet.

One of the clearest patterns is the difference in the cover of gopher tailings and bare soil (Table 1). Even after 6 years, the cover of bare ground remains significantly higher (over 3x) on the sites that were tilled. Further, the cover of gopher tailings continues to be very low on the restoration sites (0.1%) compared to control sites (8.5%). Litter, or accumulated dry material in above-ground thatch, is much higher (2x) on the control sites.

Discussion

In general, observations showed that the pattern of successful grass establishment and growth, persistence of bare ground, and low gopher abundance was consistent in all three sites. This treatment created an environment conducive to the survivorship and growth of the native grasses. Weed management is a consistent problem for establishment of native grasses in California (Anderson 1993, Anderson and Anderson 1996). Tillage previous to the planting resulted in virtually no weeds during the first two years of growth of the native grass seedlings. Pre-planting tillage also reduced the impact of gophers on the grass seedlings and this effect seems to be persistent. After broadcasting the seed, no maintenance or other work has been required. This method is a low-cost alternative for establishing native, perennial grasses in California’s old fields.

Some cautions: this method is probably limited in application to level areas where soil erosion is not a probability in the winter. If erosion is likely, a variety of erosion control techniques should be put in place before the tillage is started. And, as have others, we observed that planting seeds in February is too late in the year for good success. In the parts of the Barn plots that were eroded in the 1998 El Niño, the grasses re-planted in February did not grow.

In our previous work (Stromberg & Kephart 1996) we observed that disturbance by gophers was a significant cause of seedling failure of native, perennial grasses. Further, we observed that establishment techniques using traditional tillage resulted in significantly lower gopher tailing cover (5-15% . vs. 30-50%). Our current study supports these observations. Either a single pass or repeated tillage over several years results in a dramatic reduction in gopher abundance. That tillage alone can reduce gopher abundance may also be supported by observations on ongoing tillage experiments (Kerry Steenwerth, pers. Com.) at the Well and Corral sites which used the tractor turn-around areas at the ends of each restoration plot (20 m x 10m). These areas were subsequently roto-tilled several times each winter, and at least twice each summer from 1995-2001. These areas have had no gopher activity since 1995.

There may be a number of reasons for this reduction in gophers. Certainly, the tilled soil lacks food resources (roots, stems) for gophers. But, this effect seems to persist on restored plots where new plants (primarily natives) are growing. Tillage may affect the soil structure and make it less likely to be used by gophers. We observed abundant gopher entrance holes (10-20/ m^2) and gopher tailing immediately adjacent to the restored plots. Gophers select the abundant, non-native annual grasses as diet items (Hunt 1992), and as these are almost absent from the restoration plots, it may deter the gophers from entering. Further, the amount of bare soil continues to be far higher on the restored plots, perhaps making any dispersing gophers far more obvious to predators. During the years the restored plots were tilled and left fallow, on occasion a new gopher pile would show up. We (MRS) observed bobcats (Felis rufus) selecting these new gopher tailings as resting sites until the gopher was killed by the bobcat on several occasions.

The abundance of the exotic grass Vulpia myuros at the Corral site was unique. In the winter of 2000-2001, a detailed research program was set up to monitor soil microbial activity on the Corral restoration site. This required many visits to the site each week for sampling soil, particularly during wet weather. This is the only site and year where we observed abundant Vulpia myuros. Does the slight disturbance of winter foot traffic encourage Vulpia? Vulpia is a dominant species in many grazed pastures in central, coastal California (Stromberg & Griffin 1996). Future studies might investigate the suggestion that the abundance of Vulpia may be dramatically increased as a result of grazing animals being present during the winter months.

Table 1. Cover (Mean , N = 60) of plant species on restoration and control plots, Hastings Reserve, Carmel Valley. Native plants are in bold. When a significant difference was observed, the higher mean value is indicated in bold. Significant differences were indicated by Bonferroni-Dunn post-hoc tests.

	Control	Restoration	
Grasses			
Aira caryophyllea	0.5	1.2	N. S.
Avena fatua	**8.9**	0.8	<.001
Bromus arenarius	0	0.1	N. S.
Bromus hordaceous	**24.5**	9.3	<.001
Bromus madritensis	< .5 %	< 0.5 %	N. S.
Bromus diandrus	**4.8**	1.4	<.001
Elymus glaucus	0	**5.7**	<.001
Hordeum brachyantherum	0	**1.3**	<.05
Nassella pulchra	0	**3.4**	<.001
Vulpia myuros	2.4	**17.8**	<.001
Broadleaf Plants			
Amsinckia menziesii	< .5 %	0	N.S.
Clarkia purpurea	< .5 %	0	N.S.
Centaurea melitensis	< .5 %	0	N.S.
Eremocarpus setigerus	0.04%	**0.5**	<.01
Eriogonum gracile	0.2	**1.05**	<.01
Erodium botrys	**17**	3.3	<.001
Erodium cicutarium	**9.4**	2.7	<.01
Eschscholzia californica	0.17	2.1	N. S.
Filago gallica	2.9	**13.3**	<.001
Galium parisiense	< .5 %	0	N. S.
Geranium dissectum	< .5 %	0	N. S.
Hypochaeris glabra	3.6	2.2	N. S.
Lagophylla ramosissima	0.1	0.9	N. S.
Lotus purshianus	0.08	0.3	N. S.
Lupinus spp.	1.2	2.1	N. S.
Plagiobothrys canescens	**1.6**	0	<.01
Silene gallica	0.2	0.8	N. S.
Stellaria nitens	0.4	**1.5**	<.01
Trifolium gracilentum	< .5 %	0	N. S.
No. Spp.	25	22	
No. Native Spp.	11	10	
Bare Soil	4.3	**14.2**	<.01
Gopher Tailings	**8.5**	0.1	<.001
Litter	**56.8**	25.3	<.001

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