THE BALD HILLS PRAIRIES OF REDWOOD NATIONAL PARK

M.M. Hektner, R.W. Martin, D.R. Davenport[1]

1983

ABSTRACT

Approximately 2,000 ac of prairie occur along the ridgetop and southwest facing slopes of the Bald Hills in Redwood National park. Since the arrival of white settlers in the 1850s, livestock grazing, fire suppression, cultivation and introduction of exotic plants resulted in the reduction of many of the once dominant native species. Research has been initiated to define present grassland dynamics and to investigate methods of re-establishing a more nearly native grassland system. Permanent plots were established in 1980 and resampled in 1982 to describe species composition and to monitor the effects of grazing and prescribed burning. Analysis indicates a shift towards a more native perennial cover over the 2 yrs, regardless of treatment. Annuals decreased from an average of 53% to 35% relative cover. Species richness dropped from an average of 50 species/sample area to 33/area. Discriminant analysis indicates that only some of the most dominant species changed as a direct result of treatments.

INTRODUCTION

Alterations in California grasslands as a result of European settlement have been great, and alien plant species of Mediterranean origin now dominate much of the grassland flora. One of several problems facing a manager who wishes to enhance the native component and reduce the exotics in these grasslands is to define what exists today. This paper describes the vegetation composition of two areas of prairie acquired in the 1978 park expansion and changes which have occurred between 1980 and 1982. The effects of grazing and prescribed burning are also examined.

STUDY AREA

Geography and Physiography

The Bald Hills prairies of Redwood National Park occur as discontinuous grasslands alternating with forest along the ridge crest of the Bald Hills above Redwood Creek. Finger-like extensions follow the subbasin divides into southwest facing valleys below (see Fig. 1). Beginning 11 km (7 mi) from the Pacific Ocean, the prairies extend inland in a southeastern direction 11 km to the park boundary and discontinuously, another 50 km (31 mi) along the southern ridgecrest dividing the Redwood Creek and Klamath River drainages. Most of the grasslands occur between 229 m (750 ft) and 762 m (2500 ft) elevation.

Geology and Soils

The geological substrate of the area is partly residuum from highly sheared Franciscan siltstone, sandy siltstone and graywacke sandstone and partly colluvium from these same materials (Gordon 1980). Soils derived from these substrates exhibit thick, dark A horizons, which are morphologically similar to those in other prairies elsewhere. However, they have umbric rather than mollic epipedons, with low base saturation, probably due to leaching from the high rainfall. Individual profiles have been classified Umbrepts, Humults, and Xeralfs, depending on their B horizon characteristics. In general Umbrepts and Humults are stable, well-drained soils, while Xeralf soils are moderately-well to somewhat poorly-drained and prone to mass movement.

Redwood National Park, P.O. Box SS, Arcata, CA 95521
California Department of Fish and Game, P.O. Box 47, Yountville, CA 94559

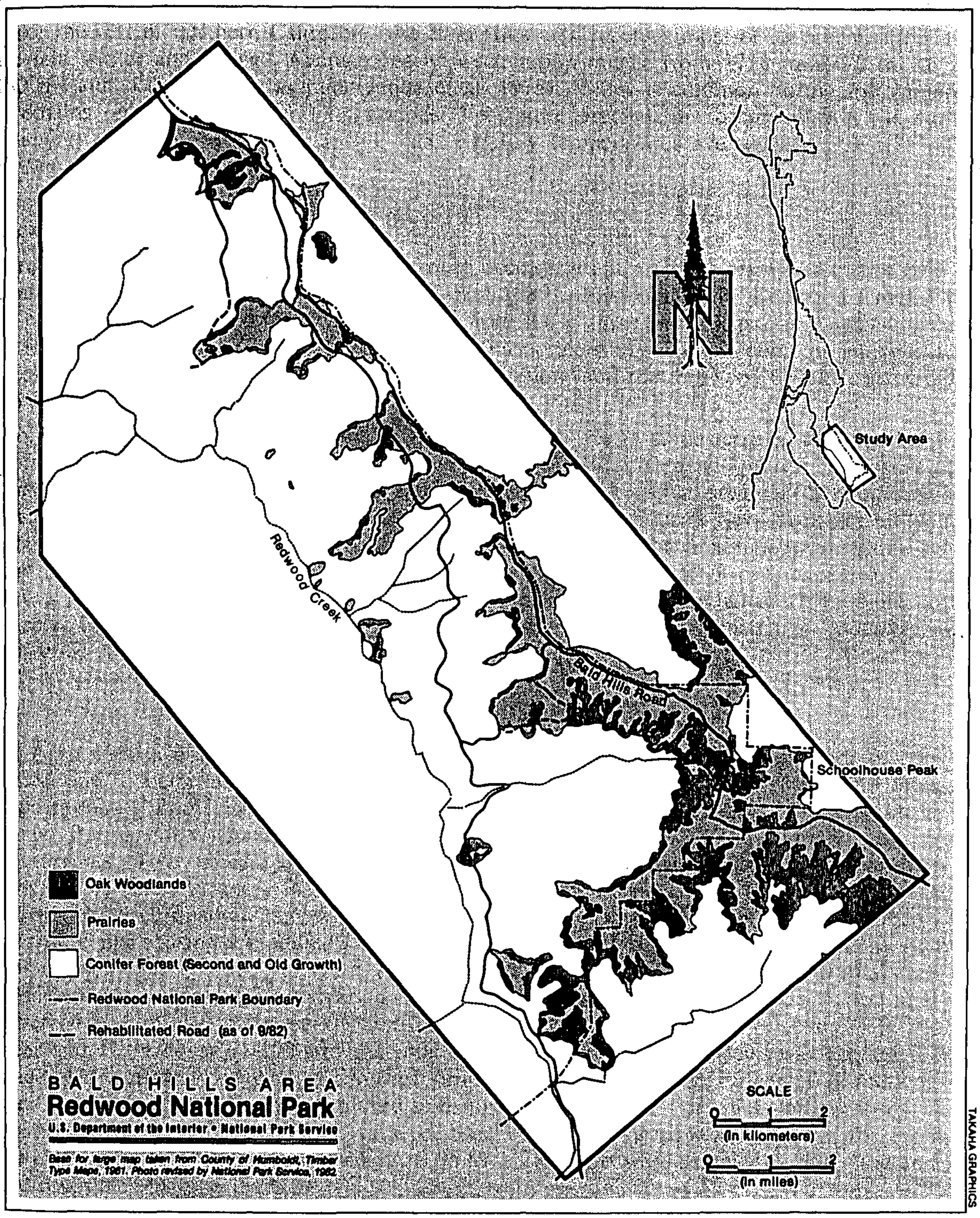

Figure 1

Bald Hills Prairies, Redwood National Park

Climate

Like the rest of northern California, the Bald Hills area receives most of its precipitation during the late fall, winter and spring. Average yearly precipitation ranges from 1778 mm (70 in) to 2,032 mm (80 in) and occurs mostly as rain (Janda et al. 1975). Snow is common during the winter, but rarely remains on the ground for long periods. Very little precipitation occurs during the summer. Mean January temperature is about 1.7° C (35° F), July temperatures average 24-27° C (75°-80° F) (Range Mgt. Class 170, 1974).

Historical Use

Archaeological evidence indicates people were occupying and utilizing resources in the Bald Hills prairie areas at least 2,000 yrs ago (King and Bickel 1980). Historically the Redwood Creek Chilula Indians occupied the Redwood Creek basin and utilized the prairies and oak/prairie margins, gathering grasses for ornamental fabrics, acorns, grass seeds and edible bulbs. It was common practice among many California Indians to use fire to manipulate vegetation, and the Redwood Creek Indians did this in the Bald Hills (Heizer 1972).

Homesteads became established in the area after 1850. Early homesteaders raised cattle, horses and mules, then shifted to sheep between 1875 and the 1940s (Greene 1980). Increasing coyote populations eventually made sheep ranching infeasible. Except for a small area near Schoolhouse Peak, which last held sheep in 1962-1963, none of the prairies now in the park have been grazed by sheep since about 1949. During the 1950s, cattle grazing again became the predominate ranching activity. With the inclusion of the prairies into Redwood National Park via the 1978 park expansion, livestock grazing was phased out; the last special use permit for grazing ended in the fall of 1981. Since portions of the park boundary are unfenced, trespass has occurred. However, fencing is underway and is expected to be completed in 1983.

METHODS

In April 1980 a program was begun to quantitatively describe present species composition and distribution and to determine the effects of livestock grazing and the possible restoration of fire via prescribed burning. Two 1 ha cattle exclosures were installed at the Maneze Road and Stagecoach Stop study sites. Permanent vegetation sample plots were established both within and immediately adjacent to the exclosures. To establish plots, 1/8 m^2 circular sample quadrats were placed randomly within a 10 m distance along parallel transects themselves placed randomly within a 10 m band, giving one sample per 100 m^2. For each quadrat, percent bare ground and cover of each species were recorded. Cover estimates were made using a modified Domin Index, after Evans and Dahl (1955). In this study the scale was defined as: 3 = cover less than 1% of the total area; 4 = cover 1-4% of the total area; 5 = cover 5-10% of the total area; 6 = cover 11-20% of the total area; 7 = cover 21-33% of the total area; 8 = cover 34-50% of the total area; 9 = cover 51-75% of the total area; 10 = cover 76-90% of the total area; and 11 = cover 91-100% of the total area. Total cover for a species was estimated as the percentage of the quadrat occupied by a vertical projection onto the ground surface of all individuals of that species. The Domin Index was also used to estimate bare ground. For tabulation purposes, Domin indices were converted to the midpoint value of their corresponding percentage range; for example a Domin value of 11 = 91-100% is equivalent to 95.5%. The plots were sampled during June and July, 1980 and resampled in June 1982.

Cattle grazed in the park throughout the study period under a special use permit. Due to the relative scarcity of internal fences, cattle were more or less free to graze all 2,000 ac at will, therefore it is not possible to give exact grazing usage in the study areas. The special use grazing permits varied each year, averaging 80-150 AUMs, five months a year, January through May.

In September 1980, one-half of each exclosure and one-half of the adjacent sampled area was prescribed burned using a combination of head and backing fire. Rate of spread for the backing fire averaged 3 to 6 ft/min. Rate of spread for the headfire averaged 6-24 (to 120) ft/min. Relative humidity at the time of the burn averaged 59%, dry bulb temperature averaged 59° F and wind was from the SW at 3 to 6 mph. The experimental design provided two sites with four areas each that were either ungrazed and unburned, ungrazed and burned, grazed and burned or grazed and unburned.

... relatively homogeneous, species richness varied between si even before treatment, reflecting natural, small scale patchiness of species distribution. In 1980, befc treatment, the total number of species in the 1/2 ha areas ranged from 39 to 60, average = 50 (Tat 1). Introduced species accounted for an average of 58% of all species and an average of 68% of t total relative cover. (Relative cover is defined as the summation of cover values of a specie normalized as percentage of all cover values for all species). Annual grasses averaged 38% of the tot relative cover; annual forbs, 15%, perennial grasses, 23%, and perennial forbs 10%. While there was great number of species in each area and a total of 78 species sampled, a very few species accounted f most of the cover. Dominance was generously interpreted as those species with a frequency of ≥ 5 and relative cover ≥ 5%. No site had more than seven dominants (Table 2), and in most cases th same species were dominant throughout in various combinations. *Cynosurus echinatus*, *Air caryophyllea* and *Danthonia californica* were dominants in all eight areas. *Plantago lanceolat* appeared as a dominant in seven of the eight areas, *Vulpia bromoides* in six, *Trifolium dubium* in five *Linum bienne* in four and *Trifolium subterraneum* in two. *Agrostis tenuis* and *Holcus lanatu* appeared as dominants in one area. Only one species, *Danthonia*, is a native. In each area the smal number of dominant species accounted for 56 to 78% of the total relative cover. Because of spac limitations, tables presenting quantitative lists of all species in each of the areas, by year, will be published elsewhere.

By 1982, on all areas, there was a significant shift towards the more perennial, native cover. There was also a significant drop in species richness, from an average of 50 species per 1/2 ha area in 1980 to an average of 33 species in 1982 (range = 31 to 45). The percent of total species that were introduced went up slightly from 58% in 1980 to 64% in 1982. Introduced species accounted for 58% of the total relative cover, a decrease from 68% in 1980. Annual grasses dropped from an average of 38% relative cover in 1980 to 28% in 1982; annual forbs dropped from 15% to 7%; perennial grasses increased from 28% to 36% and perennial forbs increased from 10% to 16%.

As in 1980, cover dominance was localized in a few species at each area. Again, no area had more than seven dominants but in 1982, several more species obtained relative covers and frequencies ≥ 5%, and the combinations were more varied. Of the total of 60 species sampled, 15 were dominant in at least one area. Only *Danthonia* remained dominant in all eight areas. *Aira* and *Cynosurus* which had been dominants in all areas in 1980 dropped to being dominant in only one and two areas, respectively. *Vulpia bromoides* remained dominant in six of the eight areas. *Bromus mollis* and *Plantago lanceolata* were dominant in four areas and *Agrostis alba*, *Trifolium dubium*, *Hypochoeris radicata*, *Avena barbata*, *Geranium molle*, *Lolium perenne*, *Trifolium subterraneum*, *Carex tumulicola* and *Holcus lanatus* dominated one or two areas. In each area the dominant species accounted for 68 to 80% of the total relative cover.

Many significant changes in mean cover by species occurred between 1980 and 1982 (Table 2), including changes in non-dominants not tabulated in this paper. Here, mean cover is defined as the average cover of a species in the plots in which it occurred. To determine if any of these changes were due to the various treatment combinations, discriminant analysis (Tatsuoka 1970) was first performed to determine which species were significant for differentiating among treated areas in 1982. Those species which are highly correlated to the discriminant function are those which most effectively discriminate among treatment areas. Assuming that there were no differences in cover of each of those species among the sites prior to treatment, the differences observed in 1982 can be interpreted as being the result of the treatments. Variables entered into the analysis were the mean cover percentages for the entire site, of those species which occurred with at least 3% frequency in 1980 and 1982. Note that these are not the same mean cover values as given in Table 2. For the discriminant analysis, species cover was averaged over the entire site and the lack of a species in a plot was included as a zero.

For the Maneze site, 81% of the variance within the data set was explained by the first two canonical functions. The functions correctly classified 78% of the plots as to the treatment received. Eighty-two percent of the variance within the Stagecoach Stop data was explained by the first two functions. The functions correctly classified 79% of the plots as to treatment received.

Table 1

Relative Cover (%) of all Species, Cross Tabulated by Site, Year, Treatment and Life Form. (n = number of species of a given life form with the number which are introduced given in parenthesis. + n? = species which have been only identified to genus with longevity unknown. Since complete identification has not been determined, their status as to native or introduced is also unknown.)

	MANEZE ROAD				STAGECOACH STOP				
[illegible]	Ungrazed Unburned	Ungrazed Burned	Grazed Unburned	Grazed Burned	Ungrazed Unburned	Ungrazed Burned	Grazed Unburned	Grazed Burned	Average
…al Grasses	37.24 n=8 (8)	38.70 n=12 (12)	38.54 n=8 (8)	47.26 n=12 (12)	36.99 n=8 (8)	29.17 n=10 (10)	44.73 n=9 (9)	34.03 n=8 (8)	38.33
…l Forbs	25.16 n=22 (10)	27.90 n=24 (10)	10.02 n=22 (10)	7.53 n=17 (9)	11.28 n=15 (7)	8.48 n=18 (8)	12.22 n=19 (10)	13.70 n=13 (5)	14.54
…nial Grasses	13.35 n=7 (5)	15.50 n=8 (5)	25.92 n=10 (6)	17.47 n=6 (4)	28.82 n=6 (5)	41.69 n=7 (6)	13.88 n=8 (5)	26.97 n=6 (4)	22.95
…nial Forbs	9.49 n=7 (4)	9.87 n=7 (5)	11.95 n=11 (6)	9.76 n=7 (4)	8.10 n=8 (4)	6.70 n=9 (5)	12.19 n=6 (4)	11.31 n=6 (4)	9.92
[illegible]	13.27 n=6 (2+1?)	7.42 n=6 (1+1?)	12.40 n=9 (1+4?)	15.80 n=8 (1+4?)	11.60 n=5 (1+1?)	10.71 n=6 (1+2?)	9.51 n=6 (1+2?)	8.56 n=6 (1+2?)	11.16
…Ground	1.49	0.61	1.17	2.18	3.21	3.25	7.47	5.42	3.10
…No. Species (n) …mber Introduced)	50 (29+1?)	57 (33+1?)	60 (31+4?)	50 (30+4?)	42 (25+1?)	50 (30+2?)	48 (29+2?)	39 (22+2?)	50
[illegible]									
…al Grasses	40.11 n=7 (7)	35.97 n=7 (7)	18.30 n=7 (7)	24.39 n=8 (8)	12.91 n=9 (9)	25.72 n=9 (9)	40.68 n=7 (7)	24.26 n=8 (8)	27.79
…l Forbs	2.69 n=8 (4)	2.36 n=10 (6)	4.38 n=8 (5)	20.68 n=13 (6)	0.52 n=4 (3)	2.13 n=11 (6)	6.04 n=16 (6)	17.04 n=12 (5)	6.89
…nial Grasses	36.40 n=5 (4)	43.58 n=8 (6)	52.57 n=8 (7)	0.44 n=5 (4)	70.29 n=6 (5)	48.73 n=6 (5)	19.38 n=18 (6)	18.82 n=7 (5)	36.28
…nial Forbs	5.86 n=6 (3)	15.31 n=7 (5)	5.23 n=8 (5)	23.58 n=6 (3)	7.40 n=9 (6)	15.86 n=7 (4)	23.72 n=7 (5)	32.00 n=8 (5)	16.12
[illegible]	12.25 n=4 (2+1?)	0.85 n=4 (2+1?)	16.78 n=10 (2+4?)	26.46 n=8 (2+2?)	4.58 n=4 (2)	4.12 n=5 (1+2?)	4.35 n=7 (2+3?)	3.52 n=9 (2+4?)	9.11
…Ground	2.69	1.93	2.74	4.45	4.30	3.44	5.83	4.36	3.72
…No. Species (n) …mber Introduced)	30 (20+1?)	36 (26+1?)	41 (26+4?)	40 (23+2?)	32 (25)	38 (25+2?)	45 (26+3?)	44 (25+4?)	38

Table 2

Dominant Species of Maneze Road and Stagecoach Stop Sites. (Dominants have a frequency of ≥5% and relative cover ≥5% in at last one year's sampling. Mean cover is the average cover of a species in the plots in which it occurred.)

INTRODUCED SPECIES N=NATIVE A=ANNUAL B=BIENNIAL P=PERENNIAL G=GRASS F=FORB S=SEDGE

*P=0.05 **P=0.01 ***P=0.005 N.S.=not significant

Site/Treatment/ # Plots	Taxon	Life History Pattern	Frequency (%) 1980	Frequency (%) 1982	Relative Cover (%) 1980	Relative Cover (%) 1982	Absolute Cover (%) 1980	Absolute Cover (%) 1982	Mean Cover (%) 1980	Mean Cover (%) 1982
Maneze Road Ungrazed, Unburned N=33	*Cynosurus echinatus*	IAG	100	76	14.72	9.11	2,337.5	225.0	70.1	6.8***
	Linum bienne	IBF	91	21	10.49	0.20	1,665.0	5.0	49.6	0.2***
	Trifolium dubium	IAF	82	15	9.29	0.16	1,474.5	4.0	44.7	0.1***
	Aira caryophyllea	IAG	85	27	9.27	1.13	1,472.0	28.0	44.6	0.8***
	Danthonia californica	NPG	67	70	9.14	20.79	1,451.5	513.5	46.5	15.6***
	Plantago lanceolata	IPF	82	33	7.29	2.02	1,157.5	50.0	35.1	1.5***
	Bromus mollis	IAG	58	97	2.02	16.86	320.5	416.5	9.7	12.6 N.S.
	Lolium perenne	IPG	46	73	1.71	11.66	272.0	288.0	8.2	8.7 N.S.
	Geranium molle	IBF	27	42	0.72	8.95	115.0	221.0	3.5	6.7 N.S.
	Avena barbata	IAG	42	24	4.26	6.82	676.5	168.5	20.5	5.1*
	Vulpia bromoides	IAG	49	46	4.95	5.99	785.5	148.0	23.8	4.5***
Maneze Road Ungrazed, Burned N=47	*Trifolium dubium*	IAF	98	36	14.50	0.59	2,800.0	27.0	59.6	0.6***
	Danthonia californica	NPG	79	81	13.17	31.67	2,542.5	1,446.5	54.1	30.8***
	Cynosurus echinatus	IAG	100	77	12.08	4.70	2,333.0	214.5	49.6	4.6***
	Vulpia bromoides	IAG	89	92	9.74	23.49	1,882.0	1,073.0	39.5	22.8**
	Aira caryophyllea	IAG	79	38	8.78	2.01	1,695.0	92.0	36.1	2.0***
	Plantago lanceolata	IPF	77	89	7.02	11.36	1,355.0	519.0	28.8	11.0***
	Trifolium subterraneum	IAF	40	21	5.79	0.18	1,117.5	8.0	23.8	0.2***
	Agrostis alba	IPG	6	9	0.65	5.88	125.5	268.5	2.7	5.7 N.S.
Maneze Road Grazed, Unburned N=48	*Danthonia californica*	NPG	90	98	20.17	49.35	3,406.5	2,841.5	72.3	59.1*
	Cynosurus echinatus	IAG	96	96	16.35	4.77	2,761.5	274.5	57.5	5.7***
	Vulpia bromoides	IAG	94	79	9.89	7.10	1,670.0	409.0	34.8	8.5***
	Aira caryophyllea	IAG	79	27	9.08	0.55	1,532.5	31.5	31.9	0.7***
	Plantago lanceolata	IPF	85	63	7.67	2.03	1,296.0	117.0	27.0	2.4***
	Trifolium dubium	IAF	81	58	6.62	1.33	1,118.0	76.5	23.6	1.6***
	Carex tumulicola	NPS	29	40	1.74	6.05	293.0	348.5	6.1	0.3*
	Bromus mollis	IAG	77	92	1.92	5.50	324.5	316.5	6.8	6.6 N.S.
Maneze Road Grazed, Burned N=36	*Cynosurus echinatus*	IAG	94	89	17.07	0.61	1,849.5	29.0	51.4	0.8***
	Danthonia californica	NPG	75	78	15.65	21.38	1,695.5	1,008.5	47.1	28.0*
	Vulpia bromoides	IAG	92	97	14.36	15.57	1,556.0	734.5	43.2	20.4***
	Linum bienne	IBF	100	78	11.82	0.33	1,281.0	15.5	35.5	0.4***
	Aira caryophyllea	IAG	75	86	10.80	6.14	1,170.0	289.5	32.5	0.8***
	Plantago lanceolata	IPF	83	95	8.06	19.79	873.5	933.5	24.3	25.9 N.S.
	Trifolium dubium	IAF	28	92	1.70	11.75	184.5	549.5	5.1	15.3*
	Trifolium subterraneum	IAF	19	31	2.27	5.54	246.5	261.5	6.8	7.3 N.S.
Stagecoach Stop Ungrazed, Unburned N=32	*Danthonia californica*	NPG	91	78	20.81	63.87	1,780.5	1,463.0	55.6	49.5 N.S.
	Cynosurus echinatus	IAG	100	50	16.27	4.91	1,392.0	112.5	43.5	3.5***
	Aira caryophyllea	IAG	94	9	13.94	0.07	1,192.5	1.5	37.3	0.0***
	Linum bienne	IBF	84	9	8.71	0.07	745.5	1.5	23.3	0.0***
	Bromus mollis	IAG	72	84	0.61	5.41	52.0	124.0	1.6	3.9 N.S.
Stagecoach Stop Ungrazed, Burned N=48	*Danthonia californica*	NPG	88	93	24.61	27.01	2,782.0	875.0	58.0	18.2***
	Cynosurus echinatus	IAG	96	53	15.61	2.28	1,764.5	74.0	36.8	1.5***
	Agrostis tenuis	IPG	33	33	9.58	10.54	1,083.5	341.5	22.6	7.1*
	Aira caryophyllea	IAG	58	53	7.71	2.41	872.0	78.0	18.2	1.6***
	Holcus lanatus	IPG	90	73	6.02	8.75	681.0	283.5	14.2	5.9***
	Vulpia bromoides	IAG	69	91	1.76	13.69	199.0	443.5	4.1	9.2 N.S.
	Plantago lanceolata	IPF	60	71	2.08	7.66	235.5	248.0	4.9	5.2 N.S.
	Bromus mollis	IAG	69	96	0.79	7.16	89.5	232.0	1.9	4.8*
Stagecoach Stop Grazed, Unburned N=44	*Cynosurus echinatus*	IAG	100	91	23.14	6.02	2,344.5	249.0	53.3	5.7***
	Danthonia californica	NPG	55	55	12.55	16.19	1,271.5	669.5	28.9	15.2*
	Aira caryophyllea	IAG	66	55	8.00	2.72	810.5	112.5	18.4	2.6***
	Plantago lanceolata	IPF	64	75	6.89	13.75	698.0	568.5	15.9	12.9 N.S.
	Linum bienne	IBF	75	64	6.59	0.48	668.0	20.0	15.2	0.5***
	Vulpia bromoides	IAG	96	100	4.61	17.72	467.5	733.0	10.6	16.7 N.S.
	Bromus mollis	IAG	93	98	1.86	11.13	188.5	460.5	4.3	10.5***
	Hypochoeris radicata	IPF	36	55	2.23	6.95	225.5	287.5	5.1	6.5 N.S.
Stagecoach Stop Grazed, Burned N=36	*Danthonia californica*	NPG	89	84	23.19	14.72	2,058.0	597.0	57.2	16.1***
	Cynosurus echinatus	IAG	97	92	17.20	2.77	1,527.0	112.5	42.4	3.0***
	Aira caryophyllea	IAG	75	83	7.89	3.21	700.0	130.0	19.4	3.5***
	Plantago lanceolata	IPF	92	97	7.66	23.31	680.0	945.5	18.9	25.6 N.S.
	Vulpia bromoides	IAG	92	97	3.63	14.97	322.5	607.0	9.0	16.4*
	Trifolium dubium	IAF	56	86	3.52	12.45	312.5	505.0	8.7	13.6 N.S.
	Hypochoeris radicata	IPF	69	78	2.86	6.55	253.5	265.5	7.0	7.2 N.S.

Although the species with the highest correlations in each of the first two functions showed a statistically significant change in mean cover over an area from 1980 to 1982, we believe that some of the differences attributed to one or more treatments actually existed prior to treatment. Analysis of pre-treatment data revealed that for some species there was already in 1980 a significant difference in cover between the areas. Therefore, these differences in cover cannot be attributed to treatment. Other differences in cover shown to be statistically significant by the analysis were actually not detectable within the cover classes utilized and were differences which cannot be measured in the field. For example, the analysis found a change from 0.5 to 0.02 to be significant; however, both fall into the <1% cover class and would not be detectable in this sampling. Therefore, we also eliminated those species from consideration. Following this process only eight species remained which we feel showed a measurable response to treatment in one or both sites (Table 3). Only two species responded in both sites, *Plantago lanceolata* and *Trifolium dubium*. *Plantago* mean cover went down in both ungrazed, unburned areas, and at the Maneze Road Site. *Plantago* also went down in the ungrazed burned and grazed, unburned areas. *Trifolium dubium* decreased in all four ungrazed areas, decreased in the grazed, unburned Maneze area and increased in the most heavily disturbed, grazed burned Maneze area. *Trifolium subterraneum* and *Lupinus bicolor* went down in the Maneze burned areas with no change in the unburned areas. Grazing or lack of grazing had no effect. *Hypochoeris radicata* cover decreased in the ungrazed Stagecoach Stop areas with no change in the grazed areas. *Vulpia bromoides* decreased in the least disturbed (ungrazed, unburned) Stagecoach Stop area and increased in the most disturbed, grazed, burned area. *Lolium perenne* went down in the Maneze grazed, unburned area; elsewhere it showed no significant change. Mean cover of *Danthonia californica,* the only native of the eight species, went down under all treatments at the Stagecoach Stop site except in the least disturbed (ungrazed, unburned) area.

Table 3

Species Which Showed a Significant Response to Treatment. (+ indicates a significant increase in mean cover, - indicates a significant decrease in cover.)

Site	Species	Treatment Ungrazed Unburned	Ungrazed Burned	Grazed Unburned	Grazed Burned
Maneze Road	*Trifolium dubium*	-	-	-	+
	Plantago lanceolata	-	-	-	
	Lolium perenne			-	
	Trifolium subterraneum		-		-
	Lupinus bicolor		-		-
Stage-coach Stop	*Vulpia bromoides*	-			+
	Plantago lanceolata	-			
	Trifolium dubium	-	-		
	Hypochoeris radicata	-	-		
	Danthonia californica		-	-	

DISCUSSION AND CONCLUSIONS

There has been significant change in species composition over the 2 yrs since the study began, and only a small number of the changes can be directly attributed to the treatments. It is possible that unmeasured variables (weather ?) might be the cause of the changes. It may be that the intensity of the treatments was insufficient to cause a dramatic shift, or perhaps it is simply too early to detect changes which are incremental and long-term. It may be that other species did respond to the treatments but that the relatively conservative interpretation of the discriminant analysis missed those changes. Rare species of low cover may have responded but were considered chance changes due to their low frequency.

With only eight of over 60 to 70 total species responding directly to the experimental treatments, there are too many other species responses which are yet unknown to be able to predict what changes would occur over the entire site with continued treatments. Some generalizations can be made about a few of the eight species, however. *Plantago lanceolata* and *Hypochoeris radicata* mean cover decreased where there was neither grazing nor burning, with no significant change in the most disturbed areas, the grazed and burned. The response to the intermediate amounts of disturbance (ungrazed, burned, or grazed, unburned) varied between sites but it appears that both species require a certain amount of disturbance to be maintained. Elsewhere, others have observed that *Plantago* and *Hypochoeris* actually increased with disturbance. As early as the turn of the century Davy (1902) observed that *Plantago* and *Hypochoeris* had become abundant on overgrazed ranges. *Trifolium dubium* also appears to benefit from disturbance, particularly grazing. Cover of this species decreased with the discontinuance of grazing, a trend which has been observed in other areas where livestock has been removed (G. Markegard, pers. comm.). *Trifolium subterraneum* and *Lupinus bicolor* decreased in the burned areas while grazing or lack of grazing had no effect. These are the only species which have thus far shown a detectable response to burning. It is too early to make any predictions about overall effects of burning on the entire grassland.

It should be noted that for all sites there was a generally significant drop in total absolute cover, defined as the sum of the actual cover values in each plot (Table 2). Percent bare ground did not increase but the degree of canopy overlap went down. Thus, while many species decreased in absolute cover, some species did not decrease as much as others, and actually increased in relative cover. If this trend persists and low cover, rare species continue to drop out, other species may actually increase in importance, regardless of treatments.

Early descriptions of the northwestern California grasslands do not adequately document the pristine species composition but it is generally felt that they were dominated by perennial bunchgrasses (Heady et al. 1977, Burcham 1957). Davy (1902) concluded that in 1853 the predominant "primitive" species were bunchgrasses *Danthonia californica* being the most dominant, along with *Stipas, Melicas, Poas* and perennial *Festucas* annual and perennial clovers *Trifolium* spp. wild pea vines *Lathyrus* spp. and wild sunflowers *Wyethia* sp. We have not observed any *Stipas* in the Bald Hills prairies and the *Melicas* and perennial fescues are only found in the adjacent oak woodland/grasslands. To what degree they were present under pristine conditions is unknown.

Today's grasslands include well adapted, naturalized "exotic" species which may never be eliminated although they can be reduced in cover. In other Northern California grasslands it was found that following the removal of grazing, perennial species increased in dominance (Huffaker and Kennett 1959, Elliott and Wehausen 1974, Hektner and Foin 1977) and over the 2 yrs of this study there has been a similar change. We expect, however, that the species composition will continue to adjust for several years. At a coastal prairie in northern Sonoma County, the species composition is still changing significantly, 10 to 15 yrs after grazing was discontinued (Foin, unpublished data). In that grassland and in our study areas it is the annuals that exhibit the most change. Variable and unpredictable climatic conditions cause much variation in productivity and floristic composition from year to year, particularly among annuals (Wester 1982).

It may be that simply by removing livestock grazing, the park will reach its goal of restoring the prairies to a more native species composition but it is at present too early to tell. The role of fire in a system which is no longer pristine needs to be further investigated, and other methods of restoration such as seeding and transplanting should be considered.

MANAGEMENT RECOMMENDATIONS

1) Refine management objectives. In light of the lack of detailed descriptions of the pristine prairies, define what composition is most desirable and, most importantly, feasible to manage for.

2) Continue monitoring of permanent sample plots to determine species composition changes now that cattle grazing has been discontinued on park lands. Attempt to determine whether a management program of no manipulation could achieve park goals of prairie restoration.

3) Determine the historical fire frequency in the prairies. Should prescribed burning be used to mimic those fires? Continue to monitor results of small experimental burns. Do they achieve their objectives?

4) Explore other methods of prairie restoration such as seeding and transplanting of natives.

ACKNOWLEDGEMENTS

We thank Michael Minden for his invaluable field assistance. Doug Lane and Gary Markegard provided much historical information and suggestions for the study. We are especially indebted to Ted Foin, Pat Hall and Jim Lenihan for providing computer programs, data analysis, and aid in the interpretation of the results.