POINT PINOLE REGIONAL SHORELINE
RESTORATION OF COASTAL PRAIRIE USING PRESCRIBED BURNING

2010 and 2011: Second and third year report to the East Bay Regional Park District

Principal Investigator: Professor James W. Bartolome
Co-Investigators: Peter Hopkinson, Michele Hammond, Naomi Schowalter
Department of Environmental Science, Policy, and Management
University of California, Berkeley

February 2012

EXECUTIVE SUMMARY

Limited information is available on fire management for native and exotic species in California's coastal prairie. Using a scientifically robust experimental design, this project aims to generate management information that will add to existing literature on using fire to restore native grasslands. The main goals of this research project are to assess the effects of prescribed burning on the encroaching shrub coyote brush (*Baccharis pilularis*) and on native and non-native plant species in Point Pinole Regional Shoreline's coastal prairie grassland.

In many areas of California's central coast, shrub encroachment is converting grasslands, such as coastal prairie, into shrub-dominated areas. Fire does not generally prevent shrub encroachment because many shrubs, including coyote brush, are able to resprout following a fire and quickly re-establish pre-burn cover. However, there is some evidence that fire in two consecutive years kills coyote brush; high coyote brush mortality would likely inhibit rapid re-establishment of shrub cover. Fire may also affect desired native species, such as bunchgrasses, and non-native weeds. These effects can be site- and species-specific so these data may help inform coastal prairie restoration strategies at Point Pinole and possibly elsewhere along the coast.

In 2009, ten coyote brush stands (SHRUB plots) were identified and the burn treatment randomly assigned to 5 of them. The remaining 5 stands serve as unburned controls and were protected from fire by mowlines and blacklines. In addition, 10 native bunchgrass-dominated plots (GRASS plots) adjacent to coyote brush stands were located, 5 burned and 5 unburned. Cover data were recorded along permanent, 10-meter line-point transects for each of the 20 plots in 2009, 2010, and 2011. In addition, we tagged 250 coyote brush individuals within the 10 SHRUB plots and recorded their mortality status. Prescribed burns occurred in fall 2009 and late summer 2010, following data collection. The first burn took place under less than ideal fuel conditions and was consequently not as effective as hoped. The second burn was more intense and appeared effective.

Cover of coyote brush was significantly reduced by the two consecutive prescribed fire treatments. In pre-burn 2009, there was no statistical difference in coyote brush cover between those plots selected for the burning treatment (28% coyote brush cover) and those plots selected as unburned controls (37% coyote brush cover). In 2010, following the 1st burn, average coyote brush cover on burned plots decreased to 10%, and the average coyote brush cover on unburned control plots increased slightly to 40%. In 2011, following the 2nd prescribed burn, average % cover of coyote brush on burn treatment plots fell to 7%, while average % cover of coyote brush

on unburned control plots increased to 52%. Although the further reduction in coyote brush cover on burned plots following the second burn was fairly small (10% in 2010 to 7% in 2011), mortality of coyote brush more than doubled following the second burn, suggesting that the reduction in cover may last longer with a second fire than with only one burn.

Average coyote brush mortality following the first prescribed burn was 22% in the burned plots and 3% in the unburned control plots. Average coyote brush mortality following the second burn (mortality in 2010 and 2011 combined) was 50% in the burned plots and 7% in the unburned plots. The mortality rate following the 2nd burn was not as great as that observed in an earlier study, which may be due partly to poor burn conditions in 2009.

Mortality in the burned plots after the first burn varied from 0-52%, suggesting that environmental differences (slope, soil moisture) probably have an appreciable impact on the effectiveness of burns at fairly small scales.

Coyote brush resprouting was ubiquitous. In 2011, almost all of the individuals still alive in the burned plots had lost their above-ground biomass in the fire but were resprouting. The remaining two years of the study will show whether the 50% mortality following the second fire is sufficient to suppress coyote brush cover enough to justify the expense and risk of a second prescribed burn.

The native bunchgrass purple needlegrass (*Nassella pulchra*) was the dominant species in the GRASS plots. Its response to the burns appears to involve a complex treatment, year, and site interaction. Following the trend in purple needlegrass cover for another two years may show whether fire has any clear multiyear effect on this species. Currently, however, fire does not appear to have a significantly deleterious effect on purple needlegrass cover. There was little evidence of any effect of burning on California oatgrass (*Danthonia californica*). Creeping wildrye (*Leymus triticoides*) was barely present on unburned plots but showed an increasing trend on burned plots.

Although purple needlegrass was the overall dominant in the GRASS plots, much of the remaining cover comprised common non-native, annual grass species, most of which showed no clear fire effect. A possible exception was purple false-brome (*Brachypodium distachyon*), a potentially spreading grass weed and one of the most abundant weeds in the GRASS plots. In 2011, it decreased by 70% on the burned plots. Whether this decline reflects a lasting fire effect is unclear (no such decline was observed in the SHRUB plots) but is intriguing, as effective control methods for this weed are currently unknown.

Forbs, mostly non-native, generally occurred only at very low levels and did not exhibit any strong fire effect. The burns did not appear to encourage two invasive species that occur on the plots, fennel (*Foeniculum vulgare*) and black mustard (*Brassica nigra*); both species remained at very low cover.

In summary, two consecutive burns reduced coyote brush cover dramatically and also resulted in much greater shrub mortality than that observed after the first burn alone, suggesting that the reduction in cover may last longer with a second fire than with only one burn. Other species did not show unequivocal responses to the treatment; there are some potentially interesting trends in several species' responses to fire that will bear watching over the next two years.

INTRODUCTION

The main goals of this research project are to assess the effects of prescribed burning on encroaching shrubs, specifically coyote brush, and on native and non-native plant species in Point Pinole Regional Shoreline's coastal prairie grassland. Coastal prairie management involves several primary problems, two of which are: 1) encroachment of native and non-native shrubs and trees into grassland areas, and 2) invasion by non-native perennial grasses and other weeds. Both problems are likely to affect native herbaceous species negatively. Prescribed burning may help address these management problems and also increase native herbaceous species richness and cover; however, this is only a hypothesis based on limited research and observation. Experimental evidence generated by this project will help to determine whether this management strategy effectively achieves the District's coastal prairie restoration objectives at Point Pinole.

Shrub encroachment

Several stands of the native shrub coyote brush (*Baccharis pilularis*[1]) occupy the coastal prairie at Point Pinole (Figure 1). Whether these stands are expanding is unknown, but elsewhere along California's central coast, there is clear documentation that coyote brush is increasing in grassland areas (Ford and Hayes 2007, Russell and McBride 2003; Havlik 1984). A recent review of coastal prairie research noted that fire does not appear to prevent shrub encroachment because many shrubs, including coyote brush, are able to resprout following a fire and quickly re-establish pre-burn cover (Ford and Hayes 2007). Data from this project's first burn in 2009 support the contention that coyote brush indeed resprouts vigorously following a single fire.

However, there is some evidence that fire in two consecutive years kills coyote brush (Havlik 1984); high coyote brush mortality would likely inhibit rapid re-establishment of shrub cover. Havlik (1984) reported the results of fires in two East Bay Regional Park District properties: a single fire on Brooks Island and two fires in consecutive years in Anthony Chabot Regional Park. Following the Brooks Island fire, there was only 15% coyote brush mortality, and within three years, cover of woody vegetation was close to pre-burn conditions. Following the first fire at Anthony Chabot, coyote brush mortality was also low: 20%; however, after the second fire, coyote brush mortality was 83% (cover at Chabot was not reported; Havlik 1984).

Havlik's (1984) observations need to be confirmed and expanded upon. Results of this study should accomplish that goal and should likely be of general interest to California land managers.

Enhancement of native plant species

Two native, coastal prairie bunchgrasses are fairly abundant at Point Pinole: purple needlegrass (*Nassella pulchra*) and California oatgrass (*Danthonia californica*). The rhizomatous, native perennial grass creeping wildrye (*Leymus triticoides*) is also present. Both

[1] All plant scientific names follow the first edition of *The Jepson Manual* (Hickman 1993), although as of the date of this report, the second edition of the *Manual* is available.

bunchgrasses, but especially purple needlegrass, show inconsistent responses to fire (D'Antonio et al. 2002). Some of this inconsistency may relate to site-specific factors so studying burning effects on these bunchgrasses at Point Pinole may prove important to successful grassland restoration and management at this site. In addition, little research has been conducted on the effects of fire on coastal prairie forbs; the study may produce valuable information regarding this often overlooked, but important component of the coastal prairie.

Control of non-native species

The study should also provide data about the effect of burning on naturalized, non-native species such as wild oats (*Avena* spp.) and filaree (*Erodium* spp.), as well as potentially invasive species such as purple false-brome (*Brachypodium distachyon*), all of which dominate some areas of Point Pinole's coastal prairie to the probable detriment of native herbaceous species.

METHODOLOGY

In 2009, the first year of this study, ten coyote brush stands were identified as large enough to be included in the experiment. The burn treatment was randomly assigned to 5 of the coyote brush stands (Table 1 and Figure 1). The remaining 5 stands serve as unburned controls and are protected from fire by mowlines and blacklines (Table 1 and Figure 1).

In addition, ten native bunchgrass-dominated areas adjacent to coyote brush stands were selected (plot PP7 was the exception: the coyote brush stand and the bunchgrass-dominated area are not adjacent). The burn treatment category of a coyote brush stand was assigned to its adjacent bunchgrass area to simplify prescribed burn logistics (Table 1 and Figure 1).

Table 1: Plot treatment category for Point Pinole plots

Plot	Treatment category	Plot	Treatment category
PP3	burn	PP1	no burn
PP4	burn	PP2	no burn
PP5	burn	PP6	no burn
PP7	burn	PP9	no burn
PP8	burn	PP10	no burn

First year, pre-treatment baseline data were collected in June and July 2009. The first year burn took place on October 29, 2009. Second year data were collected in late June 2010. The second year burn took place on August 31 and September 21, 2010. Burn treatments have now ceased for the duration of the project (through field season 2013). Third year data were collected in late June 2011.

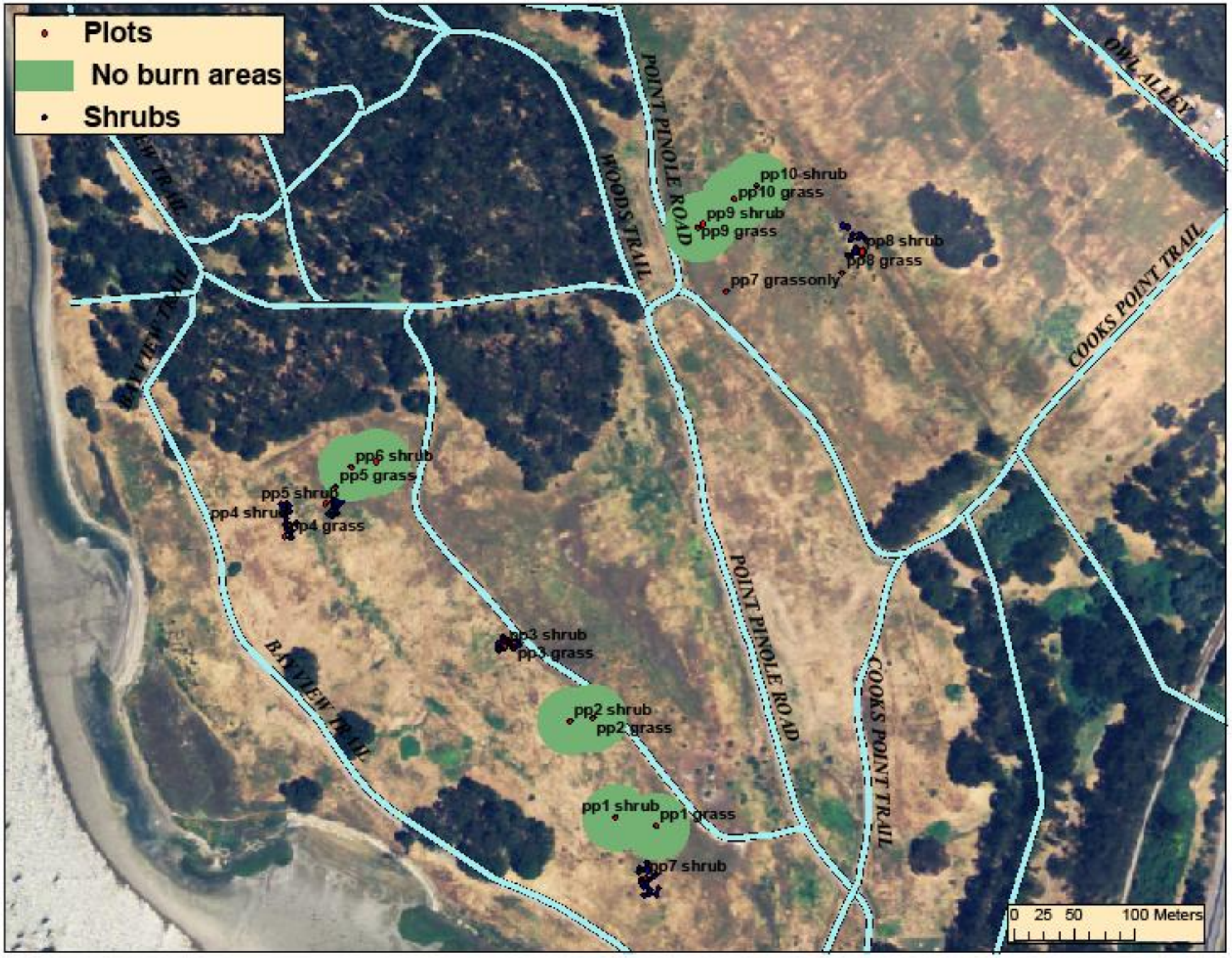

Figure 1: Location of SHRUB and GRASS plots in Point Pinole; plots within green circles are unburned controls

Cover data with line-point transects

In each field season, we determined shrub and herbaceous cover with permanent, 10-meter line-point transects, one transect randomly located (in 2009) in each of the 10 coyote brush stands (SHRUB plots) and one randomly located (in 2009) in each of 10 adjacent native bunchgrass-dominated areas (GRASS plots). A total of 50 points were recorded per transect (see 2009 report for detailed methodology). Because surveys were completed after seed-fall, wild oats (*Avena* spp.) were generally not identifiable to species; most other species were readily identifiable. We took two photographs in each direction for every transect and noted effects of any herbicide spraying (see below).

Mortality data with tagged shrubs

A goal of the project is to determine the effect of burning on mortality of coyote brush. In 2010 and 2011, we relocated the 25 randomly-selected, coyote brush individuals, alive and tagged in 2009, in each of the 10 SHRUB plot stands (total of 250 individual shrubs). For each tagged shrub, we recorded:
1) whether it was alive or dead (defined as the absence of visible above-ground live tissue, including resprouts),
2) whether, if dead, it appeared to have been killed by fire (e.g., black scorch marks on dead stems; absence of above-ground biomass),
3) whether, if alive, the tag was on a live or dead branch,
4) whether, if alive, the shrub had resprouted
5) notes, such as presence of herbicide-treated fennel (*Foeniculum vulgare*) or teasel (*Dipsacus* sp.); in some plots (PP3, PP8, PP9) the herbicide appeared also to have affected adjacent coyote brush shrubs.

We were unable to relocate tags for some of the coyote brush individuals. Using a sub-meter accuracy GPS unit (Trimble GeoXH), we searched the area around the individual shrub's GPS coordinates. If we could find no living coyote brush within a 1 meter radius of the coordinates, we assumed for the purposes of analysis that individuals in burned plots were dead and had been consumed and killed by fire. For plot PP7 in particular, we made this assumption frequently; in 2011, we had 12 individuals confirmed dead (tag relocated, individual dead) and 8 individuals presumed dead (tag not relocated but no living coyote brush within 1 meter of the individual shrub's GPS coordinates).

First prescribed burn, October 2009

The project's first prescribed burn took place on October 29, 2009. Although burning prescriptions were met, fuel conditions from a project perspective were not ideal. Frustratingly, two weeks prior to the burn, the region experienced a major germinating rain: e.g., 4 inches fell in Oakland in a single day, 20% of the annual average, making it the biggest October storm since 1962 (*San Francisco Chronicle*, October 14, 2009). As a result, significant plant germination and initial growth had occurred by October 29, in addition to decomposition of the residual dry matter. Fire intensity was consequently fairly low and burn coverage patchy, despite the best efforts of the EBRPD fire department. Fire intensity was described as "mostly creeping fire through the dead thatch under the green grass with flame lengths under 1 foot tall" (Brad Gallup, EBRPD Fuels Management Captain, pers. comm., March 2010).

Second prescribed burn, August-September 2010

The second year burn occurred on August 31 and September 21, 2010. Burn conditions were much better than the previous year, as there was ample, dry fuel. Flame lengths were ~4 meters high at times (pers. obs., August 31, 2010). During the August burn, one unburned GRASS plot was accidentally burned: approximately 2/3 of the PP1 GRASS transect (from north to south) was blackened; at the September burn, we decided to burn the rest of PP1 GRASS so that its treatment was uniform in 2010, even though it was not the assigned treatment.

In February 2011, goats grazed some of the plots for at least several days. Which plots and how intensely they were grazed is unknown.

RESULTS

Cover in SHRUB plots

Cover of coyote brush was significantly reduced by the two consecutive prescribed fire treatments. In pre-burn 2009, there was no statistical difference in coyote brush cover[2] between those plots selected for the burning treatment (28%) and those plots selected as unburned controls (37%; two-tailed t-test, p-value = 0.37; Table 2).

Table 2: Coyote brush (*Baccharis pilularis*) cover by treatment, 2009-2011

Plot	Treatment status	2009 cover (abs %)	2010 cover (abs %)	2011 cover (abs %)
PP3	burned	30	40	18
PP4	burned	44	2	12
PP5	burned	20	2	4
PP7	burned	22	6	0
PP8	burned	24	0	2
	Burned average:	**28**	**10**	**7.2**
PP1	unburned	64	72	96
PP2	unburned	36	40	58
PP6	unburned	42	58	60
PP9	unburned	22	12	20
PP10	unburned	20	18	26
	Unburned average:	**36.8**	**40**	**52**

[2] All percent cover in this report is absolute cover (that is, non-live plant hits such as litter, bare ground, or rock are included in total cover).

In 2010, following the 1st burn treatment, average coyote brush cover on burned treatment plots decreased to 10%, and the average coyote brush cover on unburned control plots increased slightly to 40% (Table 2). However, the difference in coyote brush cover between burned treatment plots and unburned control plots in 2010 was still statistically insignificant (two-tailed t-test, p-value = 0.07), possibly due to variable effects of 2009's relatively poor burn.

In 2011, following the 2nd prescribed burn, average % cover of coyote brush on burn treatment plots fell to 7%, while average % cover of coyote brush on unburned control plots increased to 52% (Table 2). This result was statistically significant (two-tailed t-test, p-value = 0.03). Although the further reduction in coyote brush cover on burned plots following the second burn was fairly small (10% in 2010 to 7% in 2011), <u>mortality</u> of coyote brush more than doubled following the second burn, suggesting that the reduction in cover may last longer with a second fire than with only one burn (see below for detailed mortality results).

Other than coyote brush, common non-native annual grasses and a native bunchgrass made up most of the rest of the SHRUB plots' cover in 2010 and 2011 (see Table 3). Wild oats (*Avena* spp.), Italian ryegrass (*Lolium multiflorum*), and purple false-brome (*Brachypodium distachyon*), a non-native annual grass with invasive potential, were the most common species in all SHRUB plots and years, along with the native bunchgrass, purple needlegrass (*Nassella pulchra*). Burn effects on these species varied. Wild oats appeared to be the big winner in the burned plots, especially in 2011, when it made up over 1/3 of the total cover (Table 3). On unburned plots, wild oats declined to <5% cover. Purple false-brome and Italian ryegrass exhibited similar although less dramatic trajectories: increasing slightly on burned plots and decreasing slightly on unburned plots.

Three native grasses, purple needlegrass, creeping wild rye (*Leymus triticoides*), and California oatgrass (*Danthonia californica*), were present on the SHRUB plot transects from 2009-2011, the last occurring at negligible cover. Creeping wildrye was also barely present on the unburned plots, but showed an increasing trend on the burned plots (1.6% in 2009 to 6.8% in 2011). Purple needlegrass maintained about 10% cover on unburned plots. On burned plots, cover rose slightly after the first burn (8.8% to 10%) but then declined to 7.2% after the second burn.

Happily, the two burns did not appear to encourage two invasive species that occur on the plots, fennel (*Foeniculum vulgare*) and black mustard (*Brassica nigra*); both species remained at very low cover (Table 3). Prickly ox-tongue (*Picris echioides*) also showed no fire effect. Fennel is being treated with herbicide at Point Pinole, including on our plots. In general, SHRUB plot forbs, all of which were non-native, remained at low levels (<3%), with the exception of spring vetch (*Vicia sativa*), which reached 6.4% cover in 2010 on burned plots but was not found on transect the following year (Table 3).

Table 3: SHRUB plots species cover (% absolute) by treatment for 2009-2011 (burned plots n=5; unburned plots n=5)

Treatment status	Species in 2009	Absolute cover in 2009 (%)	Species in 2010	Absolute cover in 2010 (%)	Species in 2011	Absolute cover in 2011 (%)
burned	***Baccharis pilularis***	28	*Avena* sp.	19.6	*Avena* sp.	35.2
	Avena sp.	20.4	*Brachypodium distachyon*	19.6	*Brachypodium distachyon*	18.4
	Brachypodium distachyon	14.4	litter	11.2	*Lolium multiflorum*	9.6
	Nassella pulchra	8.8	***Baccharis pilularis***	10	***Baccharis pilularis***	7.2
	Lolium multiflorum	6.4	*Nassella pulchra*	10	*Nassella pulchra*	7.2
	litter	4.8	*Vicia sativa*	6.4	*Leymus triticoides*	6.8
	Bromus hordeaceus	3.6	*Lolium multiflorum*	6	*Vulpia bromoides*	4
	Rumex acetosella	2.8	*Leymus triticoides*	3.6	litter	2.4
	Plantago lanceolata	2	*Plantago lanceolata*	2.8	*Rumex acetosella*	2.4
	Leymus triticoides	1.6	*Bromus hordeaceus*	2.4	*Bromus hordeaceus*	1.2
	Bromus diandrus	1.2	soil	2.4	*Vulpia myuros*	1.2
	Vicia sativa	1.2	*Bromus diandrus*	1.6	*Erodium botrys*	0.8
	Brassica nigra	0.8	*Danthonia californica*	1.6	*Gastridium ventricosum*	0.8
	Foeniculum vulgare	0.8	*Foeniculum vulgare*	0.8	*Plantago lanceolata*	0.8
	soil	0.8	*Picris echioides*	0.8	soil	0.8
	Vulpia bromoides	0.8	*Rumex acetosella*	0.8	*Bromus diandrus*	0.4
	Convolvulus arvensis	0.4	*Vulpia bromoides*	0.4	*Foeniculum vulgare*	0.4
	Erodium botrys	0.4			*Picris echioides*	0.4
	Picris echioides	0.4				
	rock	0.4				

Table 3 (continued): SHRUB plots species cover (% absolute) by treatment for 2009-2011 (burned plots n=5; unburned plots n=5)

Treatment status	**Species in 2009**	**Absolute cover in 2009 (%)**	**Species in 2010**	**Absolute cover in 2010 (%)**	**Species in 2011**	**Absolute cover in 2011 (%)**
unburned	***Baccharis pilularis***	36.8	***Baccharis pilularis***	40	***Baccharis pilularis***	52
	Nassella pulchra	10.8	*Brachypodium distachyon*	13.6	*Nassella pulchra*	11.2
	Avena sp.	10	*Avena* sp.	12.4	*Brachypodium distachyon*	8.4
	Brachypodium distachyon	9.6	*Nassella pulchra*	8.8	*Lolium multiflorum*	6.4
	Lolium multiflorum	8.4	*Lolium multiflorum*	5.2	*Avena* sp.	4.4
	Vulpia bromoides	7.2	*Vulpia bromoides*	3.6	*Bromus hordeaceus*	3.6
	Bromus hordeaceus	4.4	*Bromus hordeaceus*	3.2	litter	3.6
	litter	4	litter	3.2	*Vulpia bromoides*	3.6
	Plantago lanceolata	2.4	*Rumex acetosella*	2.8	*Bromus diandrus*	2
	Rumex acetosella	2	*Bromus diandrus*	2.4	*Rumex acetosella*	2
	Bromus diandrus	2	*Plantago lanceolata*	2.4	*Anagallis arvensis*	0.4
	Leymus triticoides	0.8	*Foeniculum vulgare*	0.8	*Briza minor*	0.4
	Picris echioides	0.4	*Anagallis arvensis*	0.4	*Cirsium vulgare*	0.4
	Foeniculum vulgare	0.4	*Cirsium vulgare*	0.4	*Foeniculum vulgare*	0.4
	Anagallis arvensis	0.4	*Erodium botrys*	0.4	*Picris echioides*	0.4
	Erodium botrys	0.4	*Leymus triticoides*	0.4	unknown grass	0.4
					Vicia sativa	0.4

Tagged coyote brush mortality in burned and unburned plots

Coyote brush resprouts readily after fire (Ford and Hayes 2007), a fact borne out at Point Pinole: of the coyote brush individuals that were still alive after the first fire, 73% were "top-killed" (i.e., had their above-ground biomass consumed in the fire) but had resprouted by the following field season (the remaining 27% were not even "top-killed"). With such high rates of resprouting after a single fire, coyote brush cover is likely to rebound rapidly. This study was initiated to find out whether a second burn, in the year following the first burn, would kill the resprouting individuals and result in a much higher mortality rate, with long-lasting reductions in coyote brush cover.

Average coyote brush mortality following the first prescribed burn was 22% in the burned plots and 3% in the unburned plots (Table 4); 22% mortality is a little higher than the 15% mortality observed by Havlik (1984) at his once-burned site but about the same as at his twice-burned site. Average coyote brush mortality following the second burn (mortality in 2010 and 2011 combined) was 50% in the burned plots and 7% in the unburned plots (Table 5). Fifty percent mortality after two burns is considerably less than the 83% mortality observed by Havlik (1984) in his twice-burned site. The lower mortality may be partly due to the poor burn conditions in 2009 (described above).

Table 4: 2010 mortality and resprouting percentages of 250 tagged coyote brush plants in burned and unburned SHRUB plots

Plot	Treatment category	Dead (%)	Killed by fire (%)	Resprouting (%)
PP3	burned	0	0	44
PP4	burned	16	16	80
PP5	burned	32	32	64
PP7	burned	52	52	48
PP8	burned	8	8	28
Burned average (%):		**22**	**22**	**53**
PP1	unburned	0	0	0
PP2	unburned	0	0	4
PP6	unburned	4	0	0
PP9	unburned	9	0	0
PP10	unburned	4	0	0
Unburned average (%):		**3.4**	**0**	**0.8**

Mortality in the burned plots after the first burn varied from 0-52% (Table 4), suggesting that environmental differences (slope, soil moisture) probably have an appreciable impact on the effectiveness of burns at fairly small scales. Coyote brush in plots PP3 and PP8 suffered little mortality; both plots are fairly flat (Figure 1). Plot PP4 is both fairly flat and in a swale that may collect water; coyote brush mortality was also low in this plot. Plots PP5 and PP7, which had higher mortality levels, are on steeper slopes. It is interesting to note that one unburned plot, PP9, had fairly high “background” mortality in both 2010 and 2011 (Tables 4 and 5).

Table 5: 2011 (total of 2010 and 2011) mortality and resprouting percentages of 250 tagged coyote brush plants in burned and unburned SHRUB plots

Plot	Treatment category	Dead (%)	Killed by fire (%)	Resprouting (%)
PP3	burned	28	28	72
PP4	burned	32	32	68
PP5	burned	70	70	26
PP7	burned	80	80	20
PP8	burned	42	42	54
Burned average (%):		**50.4**	**50.4**	**48**
PP1	unburned	0	0	4
PP2	unburned	0	0	0
PP6	unburned	8	0	0
PP9	unburned	24	0	0
PP10	unburned	5	0	0
Unburned average (%):		**7.4**	**0**	**0.8**

Resprouting was ubiquitous. In 2011, almost all of the individuals still alive in the burned plots had lost their above-ground biomass in the fire and were resprouting. This was not the case following the first burn; in plots PP3 and PP8, many individuals did not even lose their above-ground biomass, attesting the poor burn conditions.

The remaining two years of the study will show whether the 50% mortality following the second fire is sufficient to suppress coyote brush cover enough to justify the expense and risk of a second prescribed burn.

<u>Cover in GRASS plots</u>

Purple needlegrass was the most abundant species overall on the GRASS plots, both burned and unburned, in all three years, ranging from 24-37% cover (Table 6). The native bunchgrass’ response to the burns appears to involve a complex treatment, year, and site interaction. In pre-burn 2009, there was no statistical difference in purple needlegrass cover between those plots selected for the burning treatment and those plots selected as unburned controls (two-tailed t-test, p-value = 0.9; Table 6). In 2010, following the first burn, all the unburned plots increased in purple needlegrass cover, while all but one of the burned plots decreased in cover; nonetheless, the difference in cover between the two treatment types remained statistically not significant (two-tailed t-test, p-value = 0.2). In 2011, after 2 fires, 3 of 5 unburned plots fell in purple needlegrass cover, whereas all but one of the burned plots increased in cover; once again, the difference between treatments was not significant (two-tailed t-test, p-value = 0.7). Following the trend in purple needlegrass cover for another two years may show us whether fire has any clear multiyear effect on this species. Currently, however, fire does not appear to have a significantly deleterious effect on purple needlegrass cover.

Table 6: Purple needlegrass (*Nassella pulchra*) cover on GRASS plots, 2009-2011; *during second burn, PP1 was burned

Plot	Treatment status	2009 cover (abs %)	2010 cover (abs %)	2011 cover (abs %)
PP3	burned	18	16	26
PP4	burned	10	6	12
PP5	burned	54	36	44
PP7	burned	26	20	28
PP8	burned	20	42	26
Burned average:		**25.6**	**24**	**27.2**
PP1	unburned*	10	24	8*
PP2	unburned	38	50	56
PP6	unburned	32	56	58
PP9	unburned	22	30	16
PP10	unburned	20	24	20
Unburned average:		**24.4**	**36.8**	**31.6**

Two GRASS plots, one burned and one unburned, contained California oatgrass (*Danthonia californica*) but at fairly low levels. The burned and unburned plots showed little evidence of a burning effect on California oatgrass (Table 7).

Table 7: California oatgrass (*Danthonia californica*) cover on the two GRASS plots in which it occurred, 2009-2011; *during second burn, PP1 was burned

Year	Plot	Treatment status	% absolute cover
2009	PP1	unburned	12
2009	PP3	burned	6
2010	PP1	unburned	10
2010	PP3	burned	10
2011	PP1	unburned*	6*
2011	PP3	burned	6

Although purple needlegrass was the overall dominant, much of the remaining cover comprised common non-native, annual grasses: Italian ryegrass, wild oats, brome fescue (*Vulpia bromoides*), and purple false-brome (Table 8). The first three showed no clear treatment effects. Purple false-brome was the second most abundant species in the unburned GRASS plots in all three years and in the 2010 burned plots (3rd most abundant species in 2009). Interestingly, in 2011, purple false-brome cover decreased by 70% on the burned plots (Table 8). If this proves to be a lasting difference, it may be of interest to managers. The California Invasive Plant Council's Invasive Plant Inventory (Cal-IPC 2006) assigns purple false-brome an invasive plant score of "moderate," that is: a species that has "substantial and apparent—but generally not severe—ecological impacts." Little is known about its ecological effects, but it may be spreading locally and regionally (Cal-IPC 2003; Bartolome et al. 2010), and little control information appears available (DiTomaso and Healy 2007; Gelbard 2004). Note that a large purple false-brome decline on burned plots did not occur in the SHRUB plots.

Forbs generally occurred at low levels on the GRASS plots (Table 8); most forb species were non-native. Although commonly considered to be favored by fire (Bartolome et al. 2007; D'Antonio et al. 2002), forbs did not exhibit a strong treatment response. Non-native perennial arrowleaf plantain (*Plantago lanceolata*) was modestly abundant but only on unburned plots. Filaree (*Erodium* spp.) often increases following fire (D'Antonio et al. 2002) but exhibited no such response on the GRASS (or SHRUB) plots (Table 8); it should be noted that by our June survey, filaree biomass may have begun to disappear. A possible exception to this trend is one of the two native forbs[3] found on the GRASS plots, hayfield tarweed *(Hemizonia congesta* ssp. *luzulifolia*). Hayfield tarweed occurred only on two burned plots (PP7 and PP8; Fig. 1), and although the species almost disappeared after the first burn, it had increased to >5% cover in 2011 (Table 8). Whether this is a lasting effect remains to be seen.

As in the SHRUB plots, the two burns did not appear to encourage invasive species on the GRASS plots. Fennel and prickly ox-tongue remained at very low cover (Table 8). It is also worth noting that coyote brush steadily increased on the unburned GRASS plots (6% cover in 2011) but was not found on transect on the burned GRASS plots (Table 8).

[3] The other native forb found on GRASS plots was blue-eyed-grass (*Sisyrinchium bellum*); it was present only at very low cover.

Table 8: GRASS plots species cover (% absolute) by treatment for 2009-2011 (burned plots n=5; unburned plots n=5)

Treatment status	Species in 2009	Absolute cover in 2009 (%)	Species in 2010	Absolute cover in 2010 (%)	Species in 2011	Absolute cover in 2011 (%)
burned	*Nassella pulchra*	25.6	*Nassella pulchra*	24	*Nassella pulchra*	27.2
	Lolium multiflorum	21.2	*Brachypodium distachyon*	22.4	*Vulpia bromoides*	15.6
	Brachypodium distachyon	14.4	*Lolium multiflorum*	21.2	*Lolium multiflorum*	14
	Vulpia bromoides	9.2	*Avena* sp.	11.2	*Avena* sp.	12.4
	Bromus hordeaceus	6.8	*Bromus hordeaceus*	5.6	*Brachypodium distachyon*	6.8
	Avena sp.	5.2	*Picris echioides*	2.8	*Gastridium ventricosum*	5.2
	Erodium botrys	4	*Danthonia californica*	2	*Hemizonia congesta* ssp. *luzulifolia*	5.2
	litter	3.6	*Foeniculum vulgare*	1.2	*Bromus hordeaceus*	4
	Hemizonia congesta ssp. *luzulifolia*	3.2	*Rumex acetosella*	1.2	soil	3.2
	Foeniculum vulgare	2.4	soil	1.2	*Rumex acetosella*	1.6
	soil	1.2	*Vulpia bromoides*	1.2	*Danthonia californica*	1.2
	Rumex acetosella	1.2	*Agrostis* sp.	0.8	*Picris echioides*	0.8
	Danthonia californica	1.2	litter	0.8	*Plantago lanceolata*	0.8
	Agrostis sp.	0.4	*Plantago lanceolata*	0.8	*Briza minor*	0.4
	Sisyrinchium bellum	0.4	*Sonchus asper*	0.8	*Erodium botrys*	0.4
			Aira caryophyllea	0.4	*Geranium dissectum*	0.4
			Bromus diandrus	0.4	litter	0.4
			Gastridium ventricosum	0.4	*Vicia sativa*	0.4
			Hemizonia congesta ssp. *luzulifolia*	0.4		
			Leymus triticoides	0.4		
			Sisyrinchium bellum	0.4		
			Vicia sativa	0.4		

Table 8 (continued): GRASS plots species cover (% absolute) by treatment for 2009-2011 (burned plots n=5; unburned plots n=5)

Treatment status	Species in 2009	Absolute cover in 2009 (%)	Species in 2010	Absolute cover in 2010 (%)	Species in 2011	Absolute cover in 2011 (%)
unburned	*Nassella pulchra*	24.4	*Nassella pulchra*	36.8	*Nassella pulchra*	31.6
	Brachypodium distachyon	13.2	*Brachypodium distachyon*	18	*Brachypodium distachyon*	18
	Lolium multiflorum	13.2	*Avena* sp.	13.6	*Vulpia bromoides*	9.6
	Avena sp.	12.4	*Plantago lanceolata*	8.4	*Bromus hordeaceus*	8
	Vulpia bromoides	10.8	*Bromus hordeaceus*	6	*Baccharis pilularis*	6
	litter	6.4	*Lolium multiflorum*	4	*Lolium multiflorum*	5.6
	Bromus hordeaceus	6	*Picris echioides*	2.8	litter	4.4
	Plantago lanceolata	4.4	*Danthonia californica*	2	*Plantago lanceolata*	4
	Erodium botrys	2.4	*Bromus diandrus*	1.6	*Avena* sp.	3.2
	Danthonia californica	2.4	*Baccharis pilularis*	1.2	soil	2
	Picris echioides	1.2	*Convolvulus arvensis*	1.2	*Bromus diandrus*	1.6
	Baccharis pilularis	0.8	litter	1.2	*Erodium botrys*	1.6
	Bromus diandrus	0.8	unknown grass	1.2	*Danthonia californica*	1.2
	no data collected	0.4	*Vulpia bromoides*	0.8	*Vulpia myuros*	1.2
	Geranium dissectum	0.4	soil	0.4	*Picris echioides*	0.8
	soil	0.4	*Sonchus oleraceus*	0.4	*Anagallis arvensis*	0.4
	Foeniculum vulgare	0.4	*Vulpia myuros*	0.4	*Cirsium vulgare*	0.4
					Juncus occidentalis	0.4

REFERENCES

Bartolome, J.W., R.H. Barrett et al. 2010. **Annual report for the East Bay Regional Park District Grassland Monitoring Project 2009 Field Season (Year 8)**. Unpublished report submitted to District.

Cal-IPC (California Invasive Plant Council). 2003. **Plant assessment form [for *Brachypodium distachyon*]**. Available at: http://www.cal-ipc.org/ip/inventory/PAF/Brachypodium%20distachyon.pdf.

Cal-IPC (California Invasive Plant Council). 2006. **California invasive plant inventory**. Cal-IPC Publication 2006-02. Berkeley, CA: California Invasive Plant Council. Available at: http://www.cal-ipc.org.

D'Antonio, C., S. Bainbridge, C. Kennedy, J. Bartolome, and S. Reynolds. 2002. **Ecology and restoration of California grasslands with special emphasis on the influence of fire and grazing on native grassland species**. Unpublished report prepared for the David and Lucille Packard Foundation. Berkeley, CA: University of California.

DiTomaso, J.M. and E.A. Healy. 2007. **Weeds of California and other western states**. Oakland, CA: University of California Division of Agriculture and Natural Resources.

Ford, L.D. and G.F. Hayes. 2007. Northern coastal scrub and coastal prairie. Pages 180-207 in: M.G. Barbour, T. Keeler-Wolf, and A.A. Schoenherr (eds.), **Terrestrial vegetation of California**. Berkeley, CA: University of California Press.

Gelbard, J.L. 2004. **Site weed management plan for the UC Davis McLaughlin Reserve Napa and Lake counties, CA 2004-200X** (draft). Available on-line: http://www.conservationvalue.org/McLaughlin_weeds.pdf.

Havlik, N.A. 1984. **Effects of urban-industrial land use on vegetation and flora in the Potrero Hills, Richmond, California**. PhD dissertation, University of California, Berkeley.

Hickman, J.C., ed. 1993. **The Jepson manual**. Berkeley, CA: University of California Press.

Russell, W.H. and J.R. McBride. 2003. Landscape scale vegetation-type conversion and fire hazard in the San Francisco Bay Area open spaces. **Landscape and urban planning** 64: 201-208.