POINT PINOLE REGIONAL SHORELINE
RESTORATION OF COASTAL PRAIRIE USING PRESCRIBED BURNING

2012: Final (fourth year) report to the East Bay Regional Park District

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EXECUTIVE SUMMARY

- Coyote brush cover was significantly reduced by two consecutive prescribed fire treatments. Despite resprouting and a poor first burn, two years after the 2^{nd} fire, coyote brush cover on the burned plots was still only about 40% of the cover on the unburned plots.
- Mortality of coyote brush more than doubled following the second burn, likely maintaining a reduction in cover for longer than a single burn would have.
- Purple needlegrass does not appear to be adversely affected by fire at Point Pinole.
- Creeping wildrye may benefit from fire; at a minimum, creeping wildrye is not adversely affected by prescribed burning at Point Pinole.
- Although data were few for California oatgrass, this study found no evidence of a deleterious burning effect, possibly even a hint of a positive fire effect.
- The two burns did not result in increases in fennel, black mustard, or prickly ox-tongue.
- Other non-native, annual grasses and forbs showed no lasting, if any, fire effects.
- Purple false-brome increased over the course of the study on all plots; it showed no clear fire effect.

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 has generated management information that will add to existing literature on using fire to restore native grasslands. The main goals of this research project were 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, a previous study provided 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, as well as non-native weeds. These effects can be site- and species-specific so this

study's 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 served 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 assigned to the burned treatment and 5 remaining unburned. Cover data were recorded along permanent, 10-meter line-point transects for each of the 20 plots from 2009-2012. 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. 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 in the SHRUB plots 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, one year after the 1st burn, average coyote brush cover on burned plots decreased to 10%, while average coyote brush cover on unburned control plots increased slightly to 40%. In 2011, one year after 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 once again increased to 52%. In 2012, two years after the 2nd prescribed burn, average % cover of coyote brush on burn treatment plots increased rapidly to 22%; average % cover of coyote brush on unburned control plots increased slightly to 54%. 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, likely maintaining a reduction in cover for 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 final (2012) coyote brush mortality following the second burn was 51% in the burned plots and 10% 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 and 2012, almost all of the individuals still alive in the burned plots had lost their above-ground biomass in the 2nd fire but were resprouting. Despite the resprouting, two years after the 2nd fire, coyote brush cover on the burned plots was still only about 40% of cover on the unburned plots.

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, but it does not appear to be adversely affected by fire at Point Pinole. Creeping wildrye (*Leymus triticoides*) was barely present on unburned plots but showed an increasing trend on burned plots. Creeping wildrye may benefit from fire; at a minimum, creeping wildrye is not adversely affected by prescribed burning at Point Pinole. By 2012, California oatgrass

(*Danthonia californica*) had increased on a burned plot and decreased on an unburned plot, but evidence was too limited to ascribe these trends to fire.

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. Purple false-brome (*Brachypodium distachyon*), a potentially spreading grass weed, was one of the most abundant species in the GRASS plots. Over the four years of the study, on both treatment types in the SHRUB and GRASS plots, purple false-brome increased between 50-130%; this was unlikely to have resulted from the prescribed burns.

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 over the course of the study, as did the noxious weed, prickly ox-tongue (*Picris echioides*).

In summary, two consecutive burns reduced coyote brush cover dramatically and also resulted in much greater coyote brush 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 generally did not show lasting responses to the two burns, although a desirable native grass may have increased with fire.

INTRODUCTION

The main goals of this research project were 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 and annual grasses and other weeds. Both problems are likely to affect native herbaceous species negatively. Prescribed burning may help ameliorate 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 has helped to determine whether this management strategy effectively achieves the District's coastal prairie restoration objectives at Point Pinole.

Shrub encroachment

Stands of the native shrub coyote brush (*Baccharis pilularis*[1]) occupy the coastal prairie at Point Pinole (Figure 1). This study has documented that unmanaged coyote brush stands are increasing their cover at Point Pinole. Elsewhere along California's central coast, coyote brush is also clearly expanding within 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.

This study was initiated because there is some evidence that, in contrast to a single burn, fire in <u>two consecutive years</u> does kill 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).

This experimental study has generally confirmed Havlik's (1984) observations and so may be of general interest to coastal California land managers.

Enhancement of native plant species

Two native, coastal prairie bunchgrasses are also 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. Unlike

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[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.

the shunned coyote brush, managers consider all three native grasses desirable elements in coastal prairie so evaluating fire effects on these species was an important component of the study. Both 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 a study such as this can prove important to elucidating burning effects on Point Pinole bunchgrasses, thereby informing successful grassland restoration and management in the park.

Little research has been conducted on the effects of fire on native forbs, an often overlooked, but important component of the coastal prairie. Unfortunately, native forb cover was almost non-existent on our study plots so we were unable to shed any light on this neglected topic.

Control of non-native species

An additional component of the study was to provide site-specific information 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. Very little is known about the control of purple false-brome in particular, despite anecdotal evidence that it has been spreading in parts of California for 10-15 years. Any suggestion that fire was an effective control method would be of interest to California land managers.

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 served as unburned controls and were 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 were 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

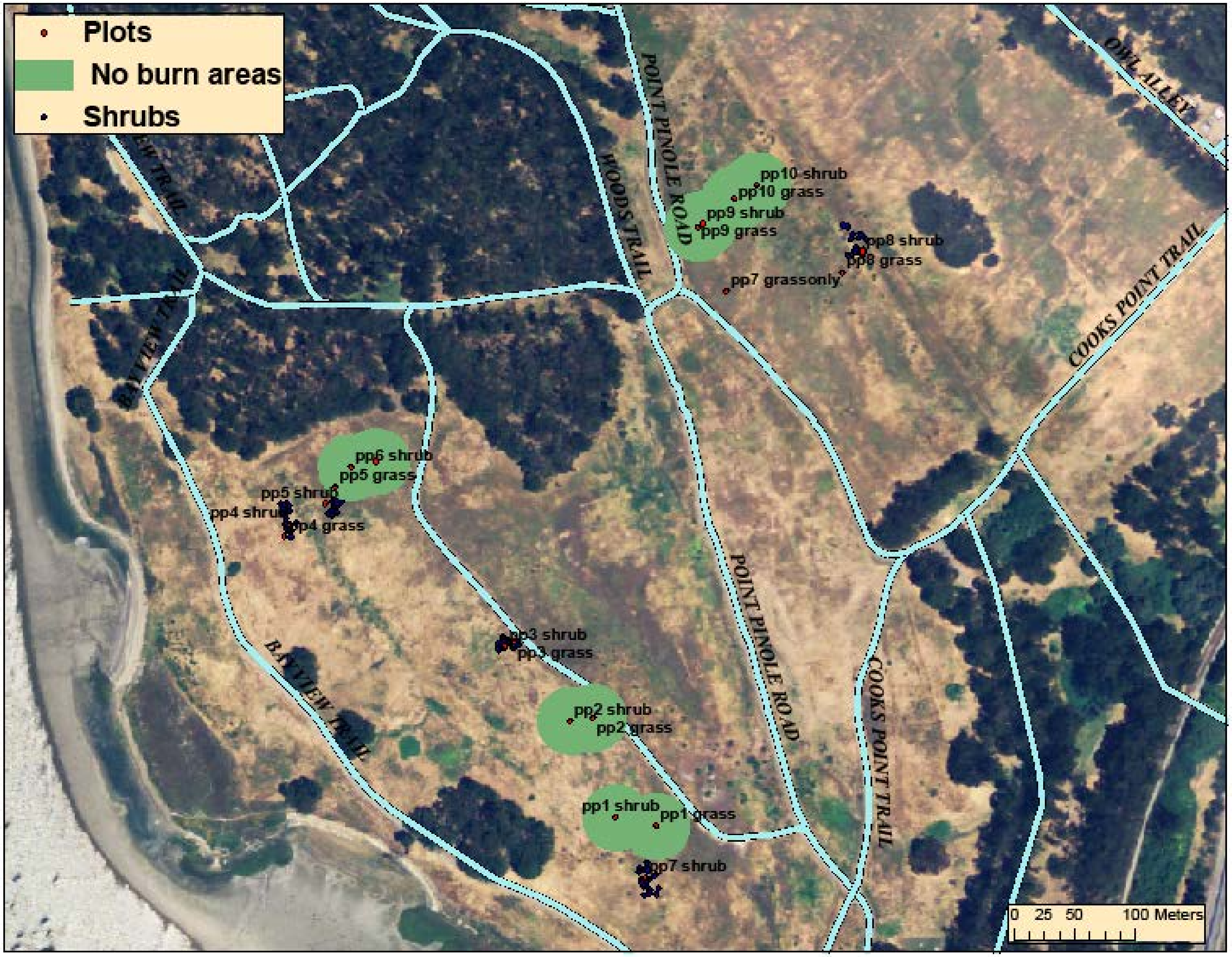

Figure 1: Location of SHRUB and GRASS plots in Point Pinole; plots within green circles are unburned controls

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 (1st year post-fire) were collected in late June 2010. The second year burn took place on August 31 and September 21, 2010. Burn treatments thereafter ceased for the duration of the project. Third year data were collected in June 2011, fourth and final year data in June 2012.

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 was to determine the effect of burning on mortality of coyote brush. In 2010-2012, 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; for example, 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: 4 inches fell in nearby 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 the time the fire took place, 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. Two years after the second burn, coyote brush cover on the burned plots was still only about 40% of cover on the unburned plots.

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).

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 =

[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).

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), 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 (see below for detailed mortality results).

In 2012, two years after the 2nd prescribed burn, average % cover of coyote brush on burn treatment plots increased to 22%, and average % cover of coyote brush on unburned control plots increased slightly to 54% (Table 2). Although average cover on burned plots tripled between 2011 and 2012, two years after the 2nd fire, coyote brush cover was still only about 40% of the average cover on the unburned plots. This difference was marginally statistically significant (two-tailed t-test, p-value = 0.055).

Table 2: Coyote brush (*Baccharis pilularis*) cover by treatment, SHRUB plots, 2009-2012

Plot	**Treatment status**	**Percent absolute cover**			
		2009	**2010**	**2011**	**2012**
PP3	burned	30	40	18	48
PP4	burned	44	2	12	32
PP5	burned	20	2	4	18
PP7	burned	22	6	0	6
PP8	burned	24	0	2	8
	Burned average:	**28**	**10**	**7.2**	**22.4**
PP1	unburned	64	72	96	80
PP2	unburned	36	40	58	64
PP6	unburned	42	58	60	72
PP9	unburned	22	12	20	24
PP10	unburned	20	18	26	30
	Unburned average:	**36.8**	**40**	**52**	**54**

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 2010-2012 (see Table 4). Wild oats (*Avena* spp.), Italian ryegrass (*Lolium multiflorum*), and purple false-brome (*Brachypodium distachyon*), a non-native annual grass with invasive potential, were generally the most common non-native herbaceous species in SHRUB plots, along with the native bunchgrass, purple needlegrass (*Nassella pulchra*). Burn effects on the non-native grasses varied. With the reduction of shrub cover, wild oats appeared to be a big winner in the burned plots, especially in 2011, when it contributed over 1/3 of the total cover, but it declined precipitously in cover on all study plots in 2012, probably due to the year's weather (Table 4). On unburned plots, wild oats also declined to <2% cover by 2012. Italian ryegrass increased on burned plots in 2011 and then declined on all plots in 2012, again probably reflecting an annual weather effect; like wild oats, annual ryegrass almost disappeared from unburned plots in 2012. Purple false-brome generally increased on both burned and unburned plots. In contrast to oats and ryegrass, it dipped slightly in 2011 but approximately doubled its cover in 2012 on both treatment types. On the 2012 burned plots, it made up almost 1/3 of the total cover; as with wild oats in 2011, this may represent an indirect effect of fire, namely, the reduction of shrub cover, allowing increases in the dominant herbaceous species.

Three native grasses, purple needlegrass, creeping wildrye (*Leymus triticoides*), and California oatgrass (*Danthonia californica*), were present on the SHRUB plot transects from 2009-2012 (Table 4). California oatgrass occurred at 2% cover on burned plots in 2010 and 2012 (Table 4), too infrequently to evaluate.

Creeping wildrye was present at very low cover on the unburned plots in 2009 and 2010 and disappeared from the unburned plots thereafter; in contrast, on the burned plots, the species showed an increasing trend (1.6% in 2009 to 6.8% in 2012; Table 3); this difference in cover between burned and unburned plots is statistically significant only for 2012 (two-tailed t-test, p-value = 0.02). Given the overall low cover values for creeping wildrye, the increasing trend may not represent a clear positive fire effect (perhaps, if real, caused by removal of the overstory coyote brush). At a minimum, however, it suggests that creeping wildrye is not adversely affected by prescribed burning.

Table 3: Creeping wildrye (*Leymus triticoides*) cover by treatment, SHRUB plots, 2009-2012

Plot	Treatment status	Percent absolute cover			
		2009	**2010**	**2011**	**2012**
PP3	burned	2	4	12	8
PP4	burned	0	0	2	6
PP5	burned	6	6	4	10
PP7	burned	0	8	16	10
PP8	burned	0	0	0	0
Burned average:		**1.6**	**3.6**	**6.8**	**6.8**
PP1	unburned	2	0	0	0
PP2	unburned	2	2	0	0
PP6	unburned	0	0	0	0
PP9	unburned	0	0	0	0
PP10	unburned	0	0	0	0
Unburned average:		**0.8**	**0.4**	**0**	**0**

Purple needlegrass also did not appear to be adversely affected by fire. The bunchgrass fluctuated between 9-13% cover on unburned plots. On burned plots, cover rose slightly after the first burn (8.8% to 10%), then declined to 7.2% in 2011 after the second burn, but rose again to 11% in 2012 (Table 4; see GRASS plots results for further discussion of fire effects on purple needlegrass).

Happily, the two burns did not encourage two invasive species that occur on the SHRUB plots, fennel (*Foeniculum vulgare*) and black mustard (*Brassica nigra*); both species remained at very low cover over the course of the study (Table 4). The noxious weed, prickly ox-tongue

(*Picris echioides*), also showed no fire effect, never reaching 1% in either treatment type (Table 4). 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 (<4%), with the exception of spring vetch (*Vicia sativa*), which reached 6.4% cover in 2010 on burned plots but made only a minor appearance in 2011 and was absent in 2012 (Table 4).

Table 4: SHRUB plots species cover (% absolute) by treatment for 2009-2012 (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 (%)**	**Species in 2012**	**Absolute cover in 2012 (%)**
burned	***Baccharis pilularis***	28	*Avena* sp.	19.6	*Avena* sp.	35.2	*Brachypodium distachyon*	32.4
	Avena sp.	20.4	*Brachypodium distachyon*	19.6	*Brachypodium distachyon*	18.4	***Baccharis pilularis***	22.4
	Brachypodium distachyon	14.4	litter	11.2	*Lolium multiflorum*	9.6	*Nassella pulchra*	10.8
	Nassella pulchra	8.8	***Baccharis pilularis***	10	***Baccharis pilularis***	7.2	*Leymus triticoides*	6.8
	Lolium multiflorum	6.4	*Nassella pulchra*	10	*Nassella pulchra*	7.2	*Avena* sp.	6.4
	litter	4.8	*Vicia sativa*	6.4	*Leymus triticoides*	6.8	Litter	6
	Bromus hordeaceus	3.6	*Lolium multiflorum*	6	*Vulpia bromoides*	4	*Lolium multiflorum*	5.6
	Rumex acetosella	2.8	*Leymus triticoides*	3.6	litter	2.4	*Plantago lanceolata*	3.6
	Plantago lanceolata	2	*Plantago lanceolata*	2.8	*Rumex acetosella*	2.4	*Rumex acetosella*	2.4
	Leymus triticoides	1.6	*Bromus hordeaceus*	2.4	*Bromus hordeaceus*	1.2	*Danthonia californica*	2
	Bromus diandrus	1.2	soil	2.4	*Vulpia myuros*	1.2	*Bromus hordeaceus*	0.4
	Vicia sativa	1.2	*Bromus diandrus*	1.6	*Erodium botrys*	0.8	*Convolvulus arvensis*	0.4
	Brassica nigra	0.8	*Danthonia californica*	1.6	*Gastridium ventricosum*	0.8	*Foeniculum vulgare*	0.4
	Foeniculum vulgare	0.8	*Foeniculum vulgare*	0.8	*Plantago lanceolata*	0.8	Soil	0.4
	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 4 (continued): SHRUB plots species cover (% absolute) by treatment for 2009-2012 (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 (%)**	**Species in 2012**	**Absolute cover in 2012 (%)**
unburned	***Baccharis pilularis***	36.8	***Baccharis pilularis***	40	***Baccharis pilularis***	52	***Baccharis pilularis***	54
	Nassella pulchra	10.8	*Brachypodium distachyon*	13.6	*Nassella pulchra*	11.2	*Brachypodium distachyon*	19.6
	Avena sp.	10	*Avena* sp.	12.4	*Brachypodium distachyon*	8.4	*Nassella pulchra*	13.2
	Brachypodium distachyon	9.6	*Nassella pulchra*	8.8	*Lolium multiflorum*	6.4	litter	7.6
	Lolium multiflorum	8.4	*Lolium multiflorum*	5.2	*Avena* sp.	4.4	*Avena* sp.	1.6
	Vulpia bromoides	7.2	*Vulpia bromoides*	3.6	*Bromus hordeaceus*	3.6	*Plantago lanceolata*	1.6
	Bromus hordeaceus	4.4	*Bromus hordeaceus*	3.2	litter	3.6	*Bromus hordeaceus*	0.8
	litter	4	litter	3.2	*Vulpia bromoides*	3.6	*Lolium multiflorum*	0.4
	Plantago lanceolata	2.4	*Rumex acetosella*	2.8	*Bromus diandrus*	2	*Picris echioides*	0.4
	Rumex acetosella	2	*Bromus diandrus*	2.4	*Rumex acetosella*	2	soil	0.4
	Bromus diandrus	2	*Plantago lanceolata*	2.4	*Anagallis arvensis*	0.4	unknown grass	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 5); 22% mortality is a little higher than the 15% mortality observed by Havlik (1984) at his once-burned site but about the same as that following the first fire at his twice-burned site. Average final (2012) coyote brush mortality following the second burn was 51% in the burned plots and 10% in the unburned plots (Table 6). Fifty-one 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 5: 2010 (following the first prescribed burn) 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 5), suggesting that environmental differences (slope, soil moisture) probably have an appreciable impact at fairly small scales on the effectiveness of burns. 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 three unburned plots experienced some "background" mortality, including one plot, PP9, in which more than a quarter of the tagged shrubs died, for reasons unknown (Tables 5 and 6).

Table 6: 2012 (total of 2010-2012) 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	36	36	64
PP5	burned	70	70	26
PP7	burned	80	80	20
PP8	burned	40	40	54
Burned average (%):		**50.8**	**50.8**	**47**
PP1	unburned	0	0	4
PP2	unburned	0	0	0
PP6	unburned	12	0	0
PP9	unburned	27	0	0
PP10	unburned	9	0	0
Unburned average (%):		**9.6**	**0**	**0.8**

Resprouting was ubiquitous. In 2011 and 2012, following the second fire, almost all of the individuals still alive in the burned plots had lost their above-ground biomass in the fire but were resprouting. This was not always 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.

<u>Cover in GRASS plots</u>

Purple needlegrass was the most abundant species overall on the GRASS plots, both burned and unburned, in all four years, ranging from 24-44% cover (Table 7). As noted in the SHRUB plot section, purple needlegrass does not appear to be adversely affected by fire at Point Pinole: average cover on burned and unburned GRASS plots was essentially the same in 2012 and had increased by 75% since 2009 (Table 7).

The native bunchgrass' response to the two 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 7). 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 insignificant (two-tailed t-test, p-value = 0.2). In 2011, after 2 fires, 3 of 5 unburned plots fell in purple needlegrass cover (including one accidental burn of an unburned plot), 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). In 2012, all but one burned plot and all but one unburned plot increased substantially in cover, with average burned and unburned cover values about the same (two-tailed t-test, p-value = 0.9). If fire does affect purple needlegrass at Point Pinole, positively or negatively, its impact is limited and transient, and some larger-scale factor, likely annual weather patterns, seems to have an over-riding effect.

Table 7: Purple needlegrass (*Nassella pulchra*) cover on GRASS plots, 2009-2012; *during second burn, PP1 was burned

Plot	**Treatment status**	**Percent absolute cover**			
		2009	**2010**	**2011**	**2012**
PP3	burned	18	16	26	26
PP4	burned	10	6	12	28
PP5	burned	54	36	44	58
PP7	burned	26	20	28	54
PP8	burned	20	42	26	54
Burned average:		**25.6**	**24**	**27.2**	**44**
PP1	unburned*	10	24	8*	16
PP2	unburned	38	50	56	72
PP6	unburned	32	56	58	68
PP9	unburned	22	30	16	36
PP10	unburned	20	24	20	18
Unburned average:		**24.4**	**36.8**	**31.6**	**42**

Two GRASS plots, one burned and one unburned, contained California oatgrass (*Danthonia californica*) but at fairly low levels until 2012, when the burned plot burgeoned to ~20% cover. This study found no evidence of a deleterious burning effect on California oatgrass, possibly even a hint of a positive fire effect (Table 8).

Table 8: California oatgrass (*Danthonia californica*) cover on the two GRASS plots in which it occurred, 2009-2012; *during second burn, PP1 was burned

Plot	**Treatment status**	**Percent absolute cover**			
		2009	**2010**	**2011**	**2012**
PP3	burned	6	10	6	18
PP1	unburned*	12	10	6*	2

Although purple needlegrass was the overall dominant in the GRASS plots, much of the remaining cover comprised common non-native, annual grasses: Italian ryegrass, wild oats, brome fescue (*Vulpia bromoides*), and purple false-brome (Table 9). The first three showed no clear treatment effects; as in the SHRUB plots, ryegrass and oat cover declined in 2012 in both treatment types.

Purple false-brome was the second most abundant species in the unburned GRASS plots in all four years and in the 2010 and 2012 burned plots (3rd most abundant species in 2009). Interestingly, in 2011, purple false-brome cover decreased by 70% on the burned plots but not on the unburned plots, suggesting a possible impact after two consecutive fires (Table 9), although there was not a concomitant purple false-brome decrease in the SHRUB plots. Had this proved to be a lasting difference, it would have been of interest to managers because there is evidence that this weedy annual grass is increasing in some areas of California. Regrettably, in 2012, purple false-brome in the burned plots bounced back to a cover value close to that of the unburned plots, about 20% (Table 9); any fire effect was transient. In fact, over the four years of the study, on both treatment types in the SHRUB and GRASS plots, purple false-brome increased between 50-130%.

As noted above, purple false-brome may be spreading regionally and locally in California (Cal-IPC 2003), including on EBRPD properties (Bartolome et al. 2012). The ecological impacts of purple false-brome are unknown, although the Cal-IPC's Plant Assessment Form (Cal-IPC 2003) for this species notes that purple false-brome can "form dense stands in some locations," which could "reduce diversity and prevent native species from establishing." In addition, DiTomaso and Healy (2007) note that purple false-brome makes poor forage because it has fibrous stems, sparse foliage, and long awns, which can also injure animals. Unfortunately, almost no information about control of this grass is available (DiTomaso and Healy 2007; Gelbard 2004). Gelbard (2004) briefly notes that asulox may provide some control. The Conservation Biology Institute (CBI) in collaboration with San Diego State University is currently conducting purple false-brome control trials with herbicide (Fusillade II) and mowing in San Diego. Preliminary results after the first year indicate some measure of control with both the herbicide and the mowing; effects on neighboring species have not yet been evaluated as of spring 2012 (pers. comm., Patricia Gordon-Reedy, CBI, March 2012).

Forbs generally occurred at low levels on the GRASS plots (Table 9); 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, primarily 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 9), though it should be noted that by our June surveys, filaree biomass may have begun to disappear. A possible exception to this trend was one of the two native forbs[3] found on the GRASS plots, hayfield tarweed (*Hemizonia congesta* ssp. *luzulifolia*).

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[3] The other native forb found on GRASS plots was blue-eyed-grass (*Sisyrinchium bellum*), present only at very low cover (Table 9).

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). We did not observe it on transect in 2012, making any strong fire effect seem unlikely.

As in the SHRUB plots, the two prescribed burns did not appear to encourage invasive species on the GRASS plots: fennel and prickly ox-tongue remained at very low cover (Table 9). It must be noted that coyote brush increased on the unburned GRASS plots (6% cover in 2012), whereas it was not found on transect on the burned GRASS plots (Table 9).

Table 9: GRASS plots species cover (% absolute) by treatment for 2009-2012 (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 (%)	Species in 2012	Absolute cover in 2012 (%)
burned	*Nassella pulchra*	25.6	*Nassella pulchra*	24	*Nassella pulchra*	27.2	*Nassella pulchra*	44
	Lolium multiflorum	21.2	*Brachypodium distachyon*	22.4	*Vulpia bromoides*	15.6	*Brachypodium distachyon*	21.2
	Brachypodium distachyon	14.4	*Lolium multiflorum*	21.2	*Lolium multiflorum*	14	litter	9.6
	Vulpia bromoides	9.2	*Avena* sp.	11.2	*Avena* sp.	12.4	*Avena* sp.	8.8
	Bromus hordeaceus	6.8	*Bromus hordeaceus*	5.6	*Brachypodium distachyon*	6.8	*Lolium multiflorum*	4
	Avena sp.	5.2	*Picris echioides*	2.8	*Gastridium ventricosum*	5.2	*Danthonia californica*	3.6
	Erodium botrys	4	*Danthonia californica*	2	*Hemizonia congesta* ssp. *luzulifolia*	5.2	*Agrostis* sp.	2.8
	litter	3.6	*Foeniculum vulgare*	1.2	*Bromus hordeaceus*	4	*Erodium botrys*	1.2
	Hemizonia congesta ssp. *luzulifolia*	3.2	*Rumex acetosella*	1.2	soil	3.2	*Plantago lanceolata*	1.2
	Foeniculum vulgare	2.4	soil	1.2	*Rumex acetosella*	1.6	*Rumex acetosella*	1.2
	soil	1.2	*Vulpia bromoides*	1.2	*Danthonia californica*	1.2	*Bromus hordeaceus*	0.8
	Rumex acetosella	1.2	*Agrostis* sp.	0.8	*Picris echioides*	0.8	*Picris echioides*	0.8
	Danthonia californica	1.2	litter	0.8	*Plantago lanceolata*	0.8	*Vulpia bromoides*	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 9 (continued): GRASS plots species cover (% absolute) by treatment for 2009-2012 (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 (%)	Species in 2012	Absolute cover in 2012 (%)
unburned	*Nassella pulchra*	24.4	*Nassella pulchra*	36.8	*Nassella pulchra*	31.6	*Nassella pulchra*	42
	Brachypodium distachyon	13.2	*Brachypodium distachyon*	18	*Brachypodium distachyon*	18	*Brachypodium distachyon*	22.4
	Lolium multiflorum	13.2	*Avena* sp.	13.6	*Vulpia bromoides*	9.6	litter	10.8
	Avena sp.	12.4	*Plantago lanceolata*	8.4	*Bromus hordeaceus*	8	*Baccharis pilularis*	6.4
	Vulpia bromoides	10.8	*Bromus hordeaceus*	6	*Baccharis pilularis*	6	*Plantago lanceolata*	4
	litter	6.4	*Lolium multiflorum*	4	*Lolium multiflorum*	5.6	*Avena* sp.	2.8
	Bromus hordeaceus	6	*Picris echioides*	2.8	litter	4.4	*Bromus hordeaceus*	2.8
	Plantago lanceolata	4.4	*Danthonia californica*	2	*Plantago lanceolata*	4	*Lolium multiflorum*	2
	Erodium botrys	2.4	*Bromus diandrus*	1.6	*Avena* sp.	3.2	*Vulpia bromoides*	2
	Danthonia californica	2.4	*Baccharis pilularis*	1.2	soil	2	*Convolvulus arvensis*	1.2
	Picris echioides	1.2	*Convolvulus arvensis*	1.2	*Bromus diandrus*	1.6	unknown grass	1.2
	Baccharis pilularis	0.8	litter	1.2	*Erodium botrys*	1.6	soil	0.8
	Bromus diandrus	0.8	unknown grass	1.2	*Danthonia californica*	1.2	*Danthonia californica*	0.4
	no data collected	0.4	*Vulpia bromoides*	0.8	*Vulpia myuros*	1.2	*Erodium botrys*	0.4
	Geranium dissectum	0.4	soil	0.4	*Picris echioides*	0.8	*Picris echioides*	0.4
	soil	0.4	*Sonchus oleraceus*	0.4	*Anagallis arvensis*	0.4	*Sonchus asper*	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. 2012. **Management and monitoring options for the East Bay Regional Park District: Brushy Peak, Lake Chabot-Fairmont Ridge, Morgan Territory, Pleasanton Ridge, Sunol-Ohlone, Sycamore Valley, and Vasco Caves**. 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.

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.