RESTORATION OF A GRAZED RIPARIAN AREA

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Abstract

Clearing of woody vegetation in California's oak woodlands has resulted in the degradation of riparian communities, causing erosion, sedimentation and a reduction in critical wildlife habitat. We evaluated several approaches for restoring woody plants along a grazed stream and found that restoration is possible, but only if steps are taken to protect plants from cattle browsing and other damaging factors. The most effective protective measures depended upon the species planted. For three species of oaks, treeshelters promoted the greatest survival and growth. For two species of willows, on the other hand, fencing out cattle resulted in the largest and most vigorous plants after four years. With neither fencing nor protection of individual plants, growth and survival of oaks was negligible and was significantly reduced for the willow cuttings. These findings indicate that a combination of planting and protection methods may yield the greatest restoration success.

Keywords

California oaks, regeneration, treeshelters, livestock, willows

Introduction

The University of California Sierra Foothill Research and Extension Center (SFREC) is located in the low-elevation Sierra foothills northeast of Marysville, CA. In the late 1960's, an area of oak woodland at the Center comprising close to 400 hectares was completely cleared of woody vegetation as part of a range conversion program. This conversion was undertaken to improve forage production for a research cattle herd and to provide a set of relatively uniform pastures for fertilization trials. Looking back, we realize that while such clearing may have facilitated livestock management and provided some new research opportunities, it also had its down side in terms of wildlife habitat deterioration, a greater potential for erosion and the creation of a visually barren landscape. It also reduced the total acreage of oaks at the Center, raising concerns about the sustainability of oak woodlands in the area.

In 1994, we initiated a project at the SFREC to restore woody vegetation along a 600-m section of a perennial stream within the cleared area. We wanted to evaluate what techniques would be effective in restoring woody plants in a pasture area that is seasonally grazed by cattle.

Methods

The experimental design consisted of five treatments, replicated in four blocks. Each plot was 30 m long and 30 m wide, and was centered along the stream. The five treatments were:

1 - Planting with treeshelters

2 - Planting with fencing

3 - Planting without protection

4 - No planting with fencing

5 - No planting without fencing

Treeshelters are rigid, translucent, double-walled plastic cylinders that are placed over individual plants. They were developed in England and have been used there for more than a decade (Potter 1988). They are reported to protect seedlings from a variety of animals and stimulate aboveground growth. We have used them quite successfully in several oak regeneration projects at the SFREC and elsewhere (McCreary and Tecklin, 1993; McCreary and Tecklin, 1997). We used 1.2-meter shelters in this project. They were installed over the tops of the seedlings and cuttings within 2 days of planting. Fenced plots were enclosed with 4 strands of barbed wire to a height of approximately one-meter.

The first three treatments were designed to evaluate different intensities of protection of planted seedlings and cuttings. The fourth and fifth treatments were included to determine if fencing out livestock would result in the natural recruitment of woody plants, and what would happen with no remediation. After four years there has been little evidence of seedling recruitment in the fenced plots, though existing oak seedlings and saplings have suffered less cattle browsing. In this paper, only the first three treatments are compared and evaluated.

Treatment locations within blocks were randomly assigned. In each of the plots from the first three treatments we planted 30 willow cuttings and 30 four-month old oak seedlings in March 1994. The individual species and number planted per plot were:

Arroyo willow (*Salix lasiolepis*)	20
Narrow-leaved willow (*Salix exigua*)	10
Blue oak (*Quercus douglasii*)	10
Interior live oak (*Quercus wislizenii*)	10
Valley oak (*Quercus lobata*)	10

All willow cuttings were collected at the Center in the winter, 1994. We harvested cuttings that were 60 cm long and at least one cm in diameter. After harvest, cuttings were placed in heated and aerated water baths for several weeks to promote the development of active root buds.

All oaks for the project were from acorns gathered locally, within one km of the planting area. They were collected in fall, 1993, germinated in early December, and planted in 5.7 x 5.7 x 20-cm plant bands. The following March the 4-month old seedlings were planted in holes excavated with clamshell type post-hole diggers. Each oak was irrigated with approximately four liters of water from the stream within four days of planting. No additional supplemental water was provided. Soon after planting, the weeds in a 1.0-m radius circle around each seedling were killed by spot spraying with glyphosate. Herbicide was also applied around surviving oak seedlings in spring of 1995, 1996 and 1997. However, no herbicide was sprayed around the willows, or after 1997.

The willows were planted at the same time in 40-cm deep holes created using a 2 1/2-cm diameter metal dibble. All cuttings were planted close to the edge of the creek, but not in standing water. The oaks were planted further up-slope. The valley oaks were planted closest to the creek, while the blue oaks were planted furthest up-slope, with the interior live oaks in between. We tried to distribute the plants throughout the length of each plot on each side of the stream, and to select planting sites that appeared favorable for establishment.

Cattle have grazed the pasture where the plots were located during each of the four years since planting. Generally 30-60 head were placed in the 30-hectare pasture for a 3-6 week period.

All seedlings were evaluated for survival in June of 1994 and in October of

1994 - 1998. On the last four evaluation dates, the height of all surviving plants was also measured. Oaks were measured to the tip of the tallest shoot when it was held straight. The willows, however, were measured to the top of the tallest branch as it naturally drooped. It was necessary to measure the willows this way because by the end of 1995, some had become so tall that it would have required a ladder to hold their shoots straight.

Survival and height data were averaged over species within treatments within blocks and analyzed using analysis of variance for a randomized split-plot design with species nested within treatments. The data for the three species of oaks and the two species of willows were analyzed separately. Unfortunately, almost all oaks in the unfenced plots soon died, creating a large number of missing values for height analysis, requiring a simpler model. We therefore utilized a one way analysis of variance to evaluate height differences among both species and treatments. Differences reported as significant were at the $p < 0.05$ level. When we observed significant differences in survival among the protection treatments, we performed a Least Significant Difference (LSD) Test to determine which treatments were significantly different from one another.

Results

Initially, both species of willows had extremely high survival. During the first evaluation in June, 1994, more than 95% were alive, with visible green leaves or green tissue under the bark (Table 1). During this initial assessment, survival of the three species of oaks was considerably lower and ranged from 59% for blue oak to 70% for interior live oak.

By October 1994, survival of both the willows and the oaks went down substantially. Grasshopper herbivory appeared to be the most significant factor, though drought, gopher and vole damage and browsing by cattle and deer appeared to also contribute. As a result, overall survival of the willows dropped from just over 96% in June, to 67% in October. The survival of the oaks also dropped dramatically - from 65% to 32%. A large proportion of this drop was in the unfenced treatment. In June 1994, average oak survival in the unfenced treatment was nearly 50%. By October it had fallen to only 15% (Table 2).

By the end of 1995, survival in all treatments and species continued to decline, but not quite as rapidly as it did between June and October the first year. For the oaks, average survival for all species combined was just under 25%. It was still highest for the treeshelter treatment (63%), followed by the fenced (11%), and the unfenced (1%). Average survival of the willows declined to 45%. There were also smaller differences among the treatments, although the same general rankings remained. Over the next three years, survival stayed nearly constant — falling by less than 4% for oaks and 3% for the willows.

The first height measurements were recorded in October, 1995. At that time, there were no significant differences among the three oak species, whose averages ranged from 48.5 cm (blue oaks) to 66.9 cm (valley oaks). During the next three years, there were still no significant differences in height among the three species, although in 1998, the average height of the interior live oaks was almost 50 cm more than either other species. The differences in year-end height between the two willow species were more consistent. In all four years, the arroyo willows were significantly taller than the narrow-

Table 1. Average survival (%) by species for oaks and willows (combined over 3 treatments).[1]

	EVALUATION DATE					
SPECIES	JUNE 94	OCT. 94	OCT. 95	OCT. 96	OCT. 97	OCT. 98
OAKS						
Blue	59.2	33.3	26.7	24.2	24.2	24.2
Interior Live	70.0	25.8	24.2	22.5	20.8	18.3
Valley	64.4	36.2	23.3	21.7	20.8	20.8
Average	64.5	31.8	24.7	22.8	21.9	21.1
WILLOWS						
Narrow Leaved	95.8	65.8	30.0 a	29.2 a	29.2 a	24.2
Arroyo	96.5	68.3	59.6 b	59.6	59.2 b	59.2
Average	96.2	67.0	44.8	44.4	44.2	41.7

Table 2. Average survival (%) by treatment for oaks (combined over 3 species) and willows (combined over 2 species).[1]

	EVALUATION DATE					
SPECIES	JUNE 94	OCT. 94	OCT. 95	OCT. 96	OCT. 97	OCT. 98
OAKS						
Treeshelters	88.1 a	64.7 a	62.5 a	60.0 a	59.2 a	57.5 a
Fenced	55.8 b	16.0 b	10.8 b	8.3 b	5.8 b	5.0 b
Unfenced	49.7 b	14.7 b	0.8 c	0.0 c	0.8 b	0.8 b
Average	64.5	31.8	24.7	22.8	21.9	21.1
WILLOWS						
Treeshelters	96.9	79.4 a	57.5 a	58.8 a	56.3 a	50.6 a
Fenced	97.5	71.3 ab	47.5 a	45.6 ab	46.3 ab	46.3 a
Unfenced	94.1	50.5 b	29.4 b	28.8 b	30.0 b	28.1 b
Average	96.2	67.0	44.8	44.4	44.2	41.7

[1] For both tables 1 and 2, within genera and evaluation dates, averages with different letters are significantly different ($p<0.05$) by a Fisher's Protected Least Significant Difference (LSD) Test.

leaved willows (Table 3).

Height differences among the three protection treatments were even more dramatic (Table 4). In all four years, oak seedlings in treeshelters were significantly taller than those in fenced plots — averaging between two and three times as tall. There were also significant differences among protection treatments for the willows, although the rankings tended to change somewhat over time. In 1995, average height of the two willow species was significantly less in the unfenced plots (103.6 cm) than in either the fenced plots (179.9 cm) or the treeshelter plots (184.2 cm). During the next three years, however, willows in the fenced plots were significantly taller than those in treeshelters, which were also significantly taller than those in unfenced plots. By 1998, fenced willows were more than a meter taller than those in shelters and more than two meters taller than those in unfenced plots.

Discussion

The initial results from this study suggest that the best strategy to use for restoring woody plants in a moderately grazed riparian area may depend on the species being planted. Findings to date indicate that willows can be successfully established using cuttings, as long as cattle are fenced out of planted areas. They can also be established in grazed areas if cuttings are protected with treeshelters. The shelters, secured to heavy metal posts, were generally effective in preventing damage to individual plants. While the cattle occasionally rubbed against a few of the shelters, and in extreme cases, bent or even knocked over a shelter here and there, this was quite rare. Oaks fared poorly in fenced areas, and have only survived and grown well when individual seedlings were protected by treeshelters. The difference in response by oaks and willows to the fenced treatment appeared, in part, due to their relative growth rates. The willows grew far faster and, as a result, more rapidly got to a height where they were less susceptible to animal pressures, including insect herbivory and cattle, deer and rabbit browsing. Unprotected oaks, on the other hand, remained quite stunted, and as the pressures from various animals mounted during the latter part of the first year, they succumbed. Consequently, survival of oaks after two years in both the fenced and unfenced areas was very low. Inside the treeshelter protection, however, the oaks grew quite well. Even after the oaks grew up and out of the treeshelters, there was little browse damage from cattle - in contrasts to willows in shelters which were regularly browsed after they grew out the top. While average survival for the three oak species in treeshelters is somewhat lower than we would like (58% after 4 years), those that have survived are generally very robust and healthy plants. By the end of their second growing season, about 20% were above the tops of the 1.2-m tall treeshelters. By the end of 1996, this percent increased to over 70%, and by the end of 1998, it was 95%.

The main decrease in survival as a whole occurred between the June and October assessments the first year. Average survival for the oaks and wil-

Table 3. Average height (cm) by species for oaks and willows (combined over 3 treatments).[1]

	EVALUATION DATE			
SPECIES	1995	1996	1997	1998
OAKS[2]				
Blue	48.5	124.6	144.8	159.2
Interior Live	53.0	95.0	148.3	226.3
Valley	66.9	111.8	152.1	178.4
Average	57.2	108.7	148.6	184.8
WILLOWS				
Narrow Leaved	135.4 a	168.7 a	204.3 a	247.4 b
Arroyo	176.3 b	237.2 b	324.6 b	381.6 b
Average	155.9	203.0	264.5	314.5

Table 4. Average height (cm) by treatment for oaks (combined over 3 species) and willows (combined over 2 species).[1]

	EVALUATION DATE			
SPECIES	1995	1996	1997	1998
OAKS				
Treeshelters	78.9 a	138.2 a	179.1 a	209.1 a
Fenced	24.7 b	61.2 b	57.3 b	87.7 b
Unfenced	——[2]	——[2]	——[2]	——[2]
Average	57.2	108.7	148.6	184.8
WILLOWS				
Treeshelters	184.2 a	212.1 b	266.5 b	306.3 b
Fenced	179.9 a	271.4 a	349.5 a	428.2 a
Unfenced	103.6 b	126.2 c	177.5 c	208.9 c
Average	155.9	203.0	264.5	314.5

[1] For both tables 3 and 4, within genera and evaluation dates, averages with different letters are significantly different ($p<0.05$) by a Fisher's Protected Least Significant Difference (LSD) Test or One Way ANOVA.

[2] In the unfenced plots, fewer than 1% of oaks survived in any given year, so this data was removed from the analysis, and a One Way ANOVA was performed.

lows combined dropped by over 30% during this first interval, but only by about 13% during the next full year, and by only about 3% during the last three years, and is now relatively stable.

Conclusions

Results from this study indicate that woody species can be restored along a grazed perennial stream in foothill woodlands, but only if steps are taken to protect seedlings and cuttings from cattle browsing and other damage. The type of protective treatment most effective in protecting plants depends upon the species planted. For three species of oaks, treeshelters promoted the greatest survival and growth. For two species of willows, on the other hand, fencing out cattle resulted in the largest and most robust plants after 4 years. With neither fencing nor protection of individual seedlings, growth and survival of oaks was negligible and was significantly reduced for the willows.

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