Session E: Forestry, Range and Wildlands
Santa Ynez Room
Moderator: Nelroy Jackson, Monsanto

Survival And Growth Of Three Conifer Species Following Three Types Of Site Preparation And Three Levels of Subsequent Shrub Control: 21 Years After Planting

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Disturbance such as fire or logging, often lead to a forest site being occupied by commercially undesirable vegetation. On the west side of the Sierra Nevada mountains, weedy trees such as black oak (*Quercus Kelloggii*), and shrubs, such as manzanita's (*Arctostaphylos sp*.) and Ceanothus *spp*., are common invaders after disturbance, particularly on harsh (hot, dry) sites. Efforts to re-establish conifers on harsh sites have often led to failure. In order to determine the best type of site preparation for conifer planting on harsh sites, an experiment was established in the fall of 1978. The objectives of the experiment were to compare the survival and growth of transplanted white fir, sugar pine, and ponderosa pine following site preparation by the use of fire, a rotary masticator (Hydro ax), and a brush rake. We also examined three levels of subsequent weed control, a single herbicide treatment at one year after planting, two herbicide treatments at one and two years after planting, and no subsequent treatment after planting.

Methods: A seven-acre area on Humbug ridge road in Tahoe National Forest (Foresthill Ranger District) was used for the study. The area chosen for the study had been occupied by shrubs and weedy trees for at least 18 years since the Volcano fire, and possibly much longer. A split plot design was used with three replications. Main plots were site preparation method (150 ft. X 200 ft.), and sub-plots were number of herbicide release treatments (150 ft. X 66 ft.). Site preparation was done in September 1978. A rotary masticator cut shrubs off close to ground level, with no disturbance to the soil. A brush rake pushed all the shrubs and trees into a pile in the center of each plot, also removing large roots in the process and causing disturbance in the top 12- to 18- inches of soil. Brush piles were later burned, but no effort was made to redistribute the ashes prior to planting. The brush rake also drove over the fire plots (no blade) to crush the shrubs to aid in shrub drying and allow a hotter fire. Several weeks later, the fire plots were burned, with only a few random, charred-branches still standing after the burn. Soil disturbance on the fire plot was limited to heating of the top layer and the addition of ash to the surface.

In early May 1979, 1-0 ponderosa pine, sugar pine, and white fir seedlings, were transplanted into every plot. A forest service crew used a power auger to prepare each planting hole. Trees were planted in a 6 ft. X 6 ft. grid, with 11 trees per row and 24 rows in each subplot. Each 11-tree row consisted of a single species, with 8 rows of each species being randomly arranged in each sub-plot. The untreated subplot did not receive any further management. The single release plots received a directed herbicide treatment in the spring of 1980, and the two-release plot received a directed herbicide treatment in the spring of 1980 and 1981. In September 2000, 21 years after conifer planting, conifer survival, diameter at breast height, and height were measured on each surviving tree.

Results: Ponderosa pine survival was affected by the site preparation method and the level of subsequent weed control following site preparation (Table 1). Survival was best where shrubs were brush raked and least on the hydroax plots. This was similar to what was observed in 1982, however, the difference among treatments was much greater in 2000. Ponderosa pine survival declined about 17% on the brush rake plots between the 1982 and the 2000 evaluations, while survival declined by 25% on the fire and hydroax plots. Survival of ponderosa pine was also greater with herbicide release treatments, compared to not treating (Table 1). This is the reverse of what was observed in 1982, where survival was poorest on plots that had two release treatments. The herbicide release treatments injured and killed some trees, however, surviving trees were able to grow quickly due to increases in resources and quickly dominated the site. Where shrubs were not controlled, ponderosa pine growth was slower and eventually some of the trees died. This is especially true on the fire and hydroax plots where survival declined by over 40% when no herbicides were applied. In general, the greater the level of soil disturbance and subsequent shrub control, the better the ponderosa pine survival.

Sugar pine survival was extremely poor in all plots (Table 1). Disease has killed most of the sugar pine found in these plots. There was better survival with two herbicide release treatments compared to the other treatments, and also the brush rake plots compared to the hydroax treatment. The reduction in weeds on these plots may have reduced alternative host plants for the disease, which killed the sugar pine. Sugar pine survival on the fire plots with two release treatments and the brush rake plots with one or two release treatments was greater than survival on other plots. Again, these plots had less competing weeds, which could have reduced the alternative host plants for the disease, which killed the sugar pine.

White fir survival was affected by the level of subsequent weed control following site preparation, but not by the site preparation method (Table 1). The first release treatment appeared to have decreased white fir survival to only 15 %. Two release treatments improved white fir survival about 10 % over the single release treatment, but still less survived than the average survival on the untreated plots. Similar to what was observed with ponderosa pine, white fir survival in 1982 declined between 1982 and 2000, by over 15% on plots that received 0 or 1 release treatment, but only 5% where two release treatments were applied.

Ponderosa pine diameter at breast height (dbh) was not affected by site preparation method but increased substantially with a single release treatment (Table 2). Two release treatments increased dbh growth only slightly compared to a single treatment. As with survival, dbh growth was best where shrubs were suppressed more effectively or for a longer period of time.

Sugar pine dbh was also not affected by site preparation method but increased substantially with a single release treatment and even more with two release treatments (Table 2). Maximum dbh was observed on the brush rake and hydroax plots that received two release treatments, but the single release treatment was best on the fire plots. The very low number of surviving trees makes data interpretation difficult with sugar pine.

White fir dbh was also increased substantially with a single release treatment and even more with two release treatments (Table 2). Unlike the other two conifers, white fir dbh was also affected by site preparation method, with trees on the fire plots having the smallest dbh and brush rake having the largest dbh.

Ponderosa pine height (ht) was least when no weed control was used after planting (Table 3). A growth increase (approx. 6 ft. in ht) in ponderosa pine was observed when a single herbicide treatment was used. Ponderosa pine ht was greatest when two yearly weed control treatments were used, with the increase over a single treatment of over 9 ft. Although site

preparation method did not significantly affect ponderosa pine ht, there was a 10 ft. difference between the brush rake and hydroax plot, with trees on brush rake plots being much larger, particularly where no or only one release treatment was used.

Sugar pine ht data should be regarded as less reliable than the other two species, due to the small number of surviving trees (Tables 1 and 3). Sugar pine ht was greatest when one or two herbicide release treatments were used. Height was also greater on brush rake plots compared to hydroax plots. Since the trends in the sugar data parallel the other two conifer species, with the exception of the fire plots that received one or two release treatments, it seems that these are an accurate representation of tree height growth response to the treatments.

White fir ht was least when no weed control or a single release treatment was used after planting (Table 3). A small height increase (1 ft) in white fir was observed when a single herbicide treatment was used. White fir ht was greatest when two yearly weed control treatments were used, with an increase over the single treatment of 4.6 ft. in height. Site preparation method did not statistically affect ht of white fir, but like the other conifer species, was best on the brush rake plots.

Conclusions: At 21 years after transplanting, ponderosa pine survival was about 55%, white fir about 24%, and sugar pine less than 5%, of the original number of planted trees. On many of the plots, which received two herbicide treatments, conifers had achieved canopy closure and shrub growth was minimal. However, if tree survival was poor, the shrubs continued to significantly compete with the remaining conifers. It appears that the brush rake treatments reduced shrub re-growth better than fire and hydro ax treatments, which has improved survival and growth. Although there were consistent conifer growth benefits associated with herbicide treatments, there also appeared to be some conifer injury, based on the reduction in white fir survival. Where survival is high, trees are competing more with each other than other vegetation, as they are planted on a 6 ft X 6 ft grid.

Table 1. Survival (%) of conifer species (Sept. 2000), in relation to site preparation method and number of herbicide applications made after planting. Survival in 1982 is indicated in parenthesis following the 2000 value.

Treatment	# Herb. Treat.	Ponderosa	Sugar Pine	White Fir
		----------(%)----------		
Brush rake	0	66 (85)	3 (50)	40 (52)
	1	65 (84)	4 (48)	13 (36)
	2	71 (83)	4 (47)	35 (45)
Fire	0	34 (80)	2 (34)	26 (45)
	1	57 (84)	2 (45)	19 (39)
	2	69 (72)	7 (46)	27 (36)
Hydroax	0	26 (74)	0 (27)	24 (41)
	1	43 (75)	0 (23)	12 (33)
	2	62 (59)	1 (11)	15 (11)
Brush rake		67 (84)	4 (48)	29 (44)
Fire		53 (79)	3 (42)	24 (40)
Hydroax		44 (69)	0.3 (20)	17 (28)
		*	**	NS
O releases		42 (80)	2 (37)	30 (46)
1 release		55 (81)	2 (39)	15 (33)
2 releases		67 (71)	4 (35)	26 (31)
		**	**	*

Table 2. Diameter at breast height (cm) in September 2000, of conifer species in relation to site preparation method and number of yearly herbicide applications made after planting. Diameter at breast height (cm) in 1982 is indicated in parenthesis following the 2000 value.

Treatment	# Herb. Treat.	Ponderosa	Sugar Pine	White Fir
		----------(cm)----------		
Brush rake	0	15.4	9.6	6.7
	1	18.6	8.5	7.1
	2	22.5	12.7	9.2
Fire	0	9.0	3.0	3.5
	1	18.9	9.9	4.9
	2	20.9	7.2	5.8
Hydroax	0	10.6	3.4	3.9
	1	20.6	7.0	5.8
	2	20.6	10.6	8.8
Brush rake		18.8	10.3	7.7
Fire		16.3	6.7	4.7
Hydroax		17.3	7.0	6.2
		NS	NS	*
O releases		11.7 (0.9)	5.3 (0.5)	4.7 (0.9)
1 release		19.4 (1.7)	8.5 (0.8)	6.0 (1.0)
2 releases		21.4 (2.6)	10.2 (1.2)	7.9 (1.4)
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Table 3. Height (ft.) in September 2000, of conifer species in relation to site preparation method and number of yearly herbicide applications made after planting. Height (ft.) in 1982 is indicated in parenthesis following the 2000 value.

Treatment	# Herb. Treat.	Ponderosa	Sugar Pine	White Fir
		----------(feet)----------		
Brush rake	0	24.2	17.2	13.6
	1	30.8	15.6	14.3
	2	37.2	23.9	19.2
Fire	0	17.7	8.6	9.5
	1	27.2	26.5	11.7
	2	32.8	14.5	13.0
Hydroax	0	14.6	8.5	8.6
	1	15.9	13.4	8.7
	2	31.2	18.4	16.5
Brush rake		30.7	18.9	15.7
Fire		25.9	16.5	11.4
Hydroax		20.6	13.4	11.3
		NS	NS	NS
O releases		18.8 (1.1)	11.4 (0.7)	10.6 (1.0)
1 release		24.6 (1.6)	18.5 (0.9)	11.6 (1.0)
2 releases		33.7 (2.0)	18.9 (1.1)	16.2 (1.2)
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