Little Response of True Fir Saplings to Understory Shrub Removal

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ABSTRACT: *The ability of white fir and California red fir to become established, persist, and eventually dominate montane shrub fields is well known. When the firs have eventually dominated do the understory shrubs continue to inhibit growth? In a small study in the southern Cascade Range of northeastern California, we tested the growth response of a thinned stand of saplings to removal of a shrub understory. Also, we examined several commonly used predictors of the ability of saplings to respond to release. Results indicated a statistically significant increase in dbh and height growth following release that disappeared after 5 yr. The growth response that was probably too small to justify the cost of shrub removal was best predicted by the trees' height growth the 5 yr before release. West. J. Appl. For. 17(1):5–8.*

Key Words: White fir, California red fir, shrub competition, growth response.

Many stands of white fir (*Abies concolor*) and California red fir (*A. magnifica*) originate in brushfields resulting from wildfires. If a seed source is present, montane brushfields develop an understory stocking of true fir in the absence of fire. Usually growth is slow, with the result that 25- to 30-yr-old trees are often less than 3 ft tall and are still beneath their shrub canopy. Although information is not available for red fir, white fir may take as long as 75 to 100 yr to emerge and begin to shade out the shrubs (Conard and Radosevich 1982).

The ability of true fir to become established, persist, and eventually dominate old brushfields has been widely noted (Dunning 1923, Laacke 1990a, 1990b). Indeed, height growth of the emergent saplings and small poles seems rapid in spite of competition from a dense understory of woody shrubs. But early growth rates of seedlings planted in provenance studies suggest that height growth potentials are much greater than is generally believed. Red fir seedlings from a source at Latour Demonstration State Forest in the southern Cascade Range in northern California planted nearby at Swain Mountain Experimental Forest averaged 5.2 ft tall after eight growing seasons when kept free of competing vegetation (J. Jenkinson, USDA Forest Service, pers. com., October 1, 1981).

Leader growth of sapling white fir in the northern Sierra Nevada increased 150 to 200% 4 yr after a mixed shrub overstory was killed (Conard and Radosevich 1982). Nearly complete kill (80% reduction) of the competing shrubs was necessary to obtain this growth response. Increased soil moisture availability rather than decreased shade seemed to be the cause. No information is available on the expected growth responses from reducing an understory shrub layer in stands of larger true firs. If soil moisture availability is the key, growth increases after eliminating understory shrubs in such stands might be expected.

We began a study in 1986 on the Latour Demonstration State Forest to test the null hypothesis that growth of true fir saplings and poles is unaffected by an understory of woody shrubs. Specifically, we wished to compare the mean growth characteristics of diameter at breast height (dbh) and total height between trees in plots with understory shrubs killed and similar plots with understory shrubs untreated. Also, we wished to observe the effectiveness of several indicators of tree vigor on the ability of true firs to respond to release.

Methods

Six square, 0.05 ac plots with a 10 ft buffer were installed in a 40-yr-old stand of saplings and small poles that had emerged from shrubs on the Latour Demonstration State Forest, Shasta County, California (lat. 40º38¢N, long. 121º39¢W). The stand is on a gentle south-southwest facing slope at 6,100 ft elevation. The soil, a Typic Haploxeralf, classified as Lyonsville gravelly, sandy loam, 24 to 36 in. in depth (Gladish and Mallory 1964), supports true fir stands of low productivity—Site Index 40 (Dolph 1987, 1991). Stand density in the six plots before the study was installed was 1,910 stems per acre consisting of 48% red fir and 51% white fir. The average stand diameter at breast height (dbh) was 3.2 in. for red fir and 2.4 in. for white fir. Shrub crowns averaged 2.0 ft in height and covered 64% of the ground area. Species composition of the shrubs and their percent of the total by crown coverage were: bush chinquapin (*Castanopsis sempervirens*) 82%, greenleaf manzanita (*Arctostaphylos patula*) 13%, and tobacco brush (*Ceanothus velutinus*) 5%.

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Table 1. Tree characteristics immediately after thinning and releasing true fir saplings from a shrub understory and 10 yr later at Latour Demonstration State Forest, Shasta County, California.

	Trees (no./plot)		Ave. dbh (in.)				Ave. height (ft)			
			White fir		Red fir		White fir		Red fir	
Plot	White fir	Red fir	Initial	10 yr	Initial	10 yr	Initial	10 yr	Initial	10 yr
Released										
3	5	22	1.6	3.4	2.3	4.5	8.4	12.3	11.3	17.8
5	15	9	1.9	3.9	2.1	4.4	9.7	15.8	10.3	17.9
6	13	15	1.4	3.1	2.0	4.4	7.6	12.9	9.8	18.4
Unreleased										
1	7	19	2.8	4.8	3.1	5.6	13.4	18.8	16.0	21.6
2	11	15	1.5	2.8	2.5	4.5	7.8	11.3	11.9	16.4
4	8	22	2.4	4.0	2.5	4.4	10.6	13.8	12.1	17.1

After plot installation, all trees were inventoried for species and dbh and the shrubs quantified for species composition, mean height, and percent crown cover by the planer intercept method. Trees in all plots were thinned to a 9 by 9 ft spacing (about 27 trees/plot) leaving, in so far as possible, the most vigorous, well-formed codominant true firs 1 to 5 in. dbh (Table 1). Slash was left untreated. In fall 1985, shrubs were sprayed in the released plots by ground equipment with Garlon 4 herbicide applied at the rate of 4 lb/ac. Nearly all shrubs were killed. The few shrubs that weakly sprouted were resprayed 6 yr later in 1991. In spring 1986 before growth began, the leave trees were tagged, identified by species, and the following measurements recorded: (1) dbh to the nearest 0.1 in., (2) total height to the nearest 1 ft, (3) height from mean groundline to the base of living crown recorded to the nearest 1 ft, (4) total height 5 yr before treatment determined by counting back annual branch whorls, and (5) number of branches arising from the internode 1 yr before the present treatment. The trees were remeasured for dbh and total height after 2, 5, and 10 yr.

Periodic annual increments (PAIs) were calculated for dbh and total height for the periods 1–2, 5–10, and 1–10 yr after treatment. The influence of releasing the trees from competition from understory shrubs and possible differences between species in this response was tested by Analysis of Covariance (SPSS 1997). Because trees varied considerably in height and dbh within plots after treatment, we suspected that the brush treatment effect might be obscured by more rapid growth of the larger trees. Therefore, the covariate used when testing height growth response was initial total tree height and when testing dbh response the covariate used was initial dbh.

The ability of the following tree characteristics to predict growth rates following release was evaluated by linear regression: (1) percent live crown [((total tree height – height to living crown)/ total tree height) ¥100], (2) height growth for the 5 yr before treatment, and (3) number of branches on the internode 1 yr before treatment.

Results

The average tree responded immediately to release. Average PAI for white and California red fir the first 2 yr after treatment was 0.20 in. in dbh and 0.5 ft in height for released trees, whereas unreleased trees grew 0.17 in. in dbh and 0.3 ft in height (Table 2). Although these differences were small, Analysis of Covariance indicated that they were highly statistically ($P < 0.01$) significant (Table 3). These small differences in growth rates between released and unreleased trees narrowed with time. Five to 10 yr after release, PAI in dbh was identical—0.18 in.—for released and unreleased trees and in height less than 0.1 ft greater in released trees. Over the 10 yr period, however, dbh growth differences were highly significant ($P < 0.01$). Statistical significance ($P < 0.04$) for PAI height was somewhat less. PAIs were 0.21 in. in dbh and 0.6 ft in height for released trees, and 0.19 in. in dbh and 0.5 ft in height for unreleased trees. When a covariant for initial size was not used, these 10 yr responses were less significant statistically—$P < 0.02$ for PAI dbh but not significant for PAI height.

The two fir species seemed to respond differently to release from the shrub understory. Released California red firs grew 20% faster in dbh than did white firs during the first 2 yr and 26% faster over the 10 yr period ($P < 0.01$). Released red fir tended to grow more rapidly in height, as well, but the differences were not statistically significant (Table 3).

Three characteristics likely to predict the degree of response to release from brush competition were tested: (1) 5 yr

Table 2. Mean periodic annual increments for true fir saplings released and unreleased from a shrub understory at Latour Demonstration State Forest, Shasta County, California.

	Ave. dbh (in.)			Ave. height (ft)		
Period (yr)	White fir	Red fir	Both species	White fir	Red fir	Both species
Released						
1–2	0.18	0.21	0.20	0.48	0.56	0.53
5–10	0.16	0.20	0.18	0.53	0.76	0.66
1–10	0.18	0.23	0.21	0.51	0.76	0.66
Unreleased						
1–2	0.14	0.18	0.17	0.27	0.36	0.33
5–10	0.14	0.20	0.17	0.47	0.62	0.58
1–10	0.16	0.21	0.19	0.40	0.50	0.47

Table 3. Probability of higher *F*-values in Analyses of Covariance for periodic annual increments of dbh and height for the first 2 yr, for 2 to 5 yr, and for 10 yr after thinning and release of true fir saplings at Latour Demonstration State Forest, Shasta County, California.

	Probability of higher *F*-value							
	PAI dbh				PAI height			
Source	1–2 yr	2–5 yr	5–10 yr	1–10 yr	1–2 yr	2–5 yr	5–10 yr	1–10 yr
Treatment	0.002**[1]	0.005**	0.240	0.005**	0.019*[2]	0.044*	0.123	0.032*
Species	0.067	0.016*	0.011*	0.003**	0.786	0.349	0.012*	0.494

[1] Values followed by 2 asterisks are highly significant at $P < 0.01$.
[2] Values followed by 1 asterisk are significant at $P < 0.05$.

height growth before release, (2) number of internodal branches produced 1 yr before release, and (3) percent live crown at time of release. All pretreatment characteristics were significantly related ($P < 0.01$) to PAI height and dbh over the 10 yr observation period for both white and California red fir (Table 4). The predictor, 5 yr height growth before release explained the most variation in dbh (77%) and height (60%) growth. Species differences among the three predictors in ability to predict 10-yr growth following release were small (Table 4).

Discussion

Both white and California red fir responded immediately to release from a shrub understory in the southern Cascade Range of northern California. Differences in PAI between released and unreleased trees, although largest during the first 2 yr, were only 0.04 in. in dbh and 0.2 ft in height. Even these small differences lessened in subsequent years. Over the 10 yr period of observation, releasing these true fir poles from shrub competition increased PAI dbh by only 0.02 in. for both white and red fir. The increase in height was only 0.15 ft for white fir and 0.20 ft for red fir. Most of the increase came during the first 2 yr. During the period 5 to 10 yr after release, white fir grew only 0.02 in. annually, and no difference in dbh growth was observed for red fir. Annual height growth response for the two species was 0.06 ft for white fir and 0.14 ft for red fir.

The small response to release from understory shrubs, although surprising, may have been the result of an overwhelming response to the thinning. Trees released from understory shrubs grew more in height for the 10 yr period after treatment installation than they did for the 5 yr period before treatment installation (Table 4), but because all plots were thinned sorting out the effects of shrub release from that of thinning release is not possible. Nevertheless, the behavior of true fir in this study seems to run counter to that of ponderosa pine in its warmer and drier environment. We have observed, as have others, little growth increase after thinning if sapling stands of ponderosa pine have a dense understory of shrubs. A conservative response might have been expected because the average size for the unreleased trees at the beginning of the study was larger than was the size of released trees—0.5 in. in dbh and 2.5 ft in height, and it is well-known that larger saplings usually grow faster than do smaller saplings. Nevertheless, the growth response reported here brings into question the economic benefits of understory shrub removal in sapling true fir stands.

In choosing trees to keep in the thinned stand, we were able to reaffirm that 5 yr height growth before thinning and release is strongly related to postrelease growth rates. It explained twice as much variation in posttreatment growth rates as did the number of branches on the internode 1 yr before release and three times as much as percent live crown at time of release. The superiority of 5 yr height growth before release, either singly or in combination with percent live crown at time of release, is now well-established for true firs in the West (Ferguson and Adams 1980, Helms and Standiford 1985, McCaughey and Schmidt 1982, Oliver 1986, Seidel 1985,Tesch and Korpela 1993). These studies reported response to release from a tree overstory rather than a shrub understory as reported in this study. The mechanism of suppression, competition for moisture and nutrients (Conard and Radosevich 1982) was probably the same, however.

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Table 4 Predictors of the ability of true fir saplings to respond to release from understory shrubs at Latour Demonstration State Forest, Shasta County, California.

	10 yr diameter growth				10 yr height growth			
	White fir		Red fir		White fir		Red fir	
Response predictor	R^2	SE	R^2	SE	R^2	SE	R^2	SE
Mean height growth for 5 yr before release	0.649	0.038	0.792	0.035	0.520	0.224	0.610	0.236
Number of branches on internode 1 yr before release	0.351	0.052	0.209	0.069	0.358	0.259	0.189	0.341
Percent live crown at time of release	0.210	0.057	0.213	0.068	0.226	0.285	0.240	0.330

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