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GROWTH OF RELEASED REDWOOD CROP SEEDLINGS ON THE REDWOOD EXPERIMENTAL FOREST

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Crop trees of seedling and sapling size usually benefit by release from competition with shrubs, herbs, and other young trees. Such work is aimed at optimizing stand development for full site occupancy by the best trees. It may be done soon after reproduction becomes well established, but can be deferred until trees reach sapling size. If weeding-release is not done, then an early thinning in sapling and pole size trees may be the best way to shape a stand for future growth.

To determine if selected 3- to 4-year-old redwood seedlings (*Sequoia sempervirens* [D. Don] Endl.) could benefit from weeding, trials were started on the Redwood Experimental Forest, north coastal California. Weeding was expected to reduce root competition and provide increased light for 1 or more years. Plots were set up on cutover lands, where the chief growing stock consisted of redwood seedlings and sprouts, and other conifer seedlings. Three release distances of radii 2, 3, and 4 feet were tested. Methods of release included basal and foliage spraying of competing plants with herbicides, and hoeing-cutting. By the end of the fourth growing season, I found that height growth was becoming much alike between treated and untreated redwood crop seedlings.

I know of no other trials of weeding in northern redwood stands. Fritz and Rydelius¹ reported on a trial in the southern redwood area. They found that overtopped seedling-sapling redwood and Douglas-fir (*Pseudotsuga menziesii* var. *menziesii* [Mirb.] Franco) responded dramatically to complete brush kill by the second summer, but the taller seedlings—those as tall as shrubs or taller—were not as responsive to treatment.

THE STUDY

Each crop seedling redwood to qualify for weeding had to be vigorous, healthy, and tallest at a specific

ABSTRACT: Potential redwood crop seedlings, 3 to 4 years old, were released from competition with shrubs and herbs in a trial on the Redwood Experimental Forest, North Coast California. The release distances tested were radii of 2, 3, and 4 feet; the methods used were basal spraying and foliage spraying with 2,4,5-T and 2,4-D mix, and hoeing-cutting. For the first 3 years, released seedlings grew faster than untreated seedlings. By the end of the fourth growing season, when competing vegetation had already reoccupied the weeded areas, height growth of all seedlings appeared to be equalizing. This age-class of redwood crop seedlings may not need weeding-release for satisfactory growth in environments similar to that where tested.

OXFORD: 174.7 *Sequoia sempervirens*:236.1.

RETRIEVAL TERMS: *Sequoia sempervirens*; seedling release; weeding.

minimum spacing (plus or minus a few feet). Furthermore, its competition by herbs, shrubs and other seedlings had to be 50 percent or more leafy crown coverage as viewed vertically. Within a block of each randomized block design, a plot consisting of 10 crop seedlings was randomly assigned a treatment. There were three replications each of method-of-release and radius-of-release treatments. The analyses were based on average height growth of equal number of seedlings in each treatment unit (block x treatment). This number was the least number alive in any treatment unit at the last measurement. Seedlings were randomly chosen in those units having more than the least number.

Radius-of-release treatment tested 2, 3, and 4-foot radii from which shrub and herbaceous competitors were basal sprayed with herbicide. A 3-foot release radius had been estimated to be about optimum release distance for the main competing species and for a short release period of 1 to 3 years. The 2- and 4-foot radii bracket the estimated optimum release radius. Red alder (*Alnus rubra* Bong.) were killed if within 6 feet because they are much faster growing and their crowns quickly spread over other vegetation. All competing vegetation growing within the specified distances were basal sprayed from June 16 to 25, 1964—about midway of the growing period. For example, thimbleberry will be flowering and height growth of redwood will be flushing rapidly by May 1.

The methods of release tested were foliage herbicide spray, basal herbicide spray, and hoeing-cutting. Each crop seedling was released a radial distance of 3 feet from its shrub and herbaceous competitors, and an average distance of 6 feet from alder competitors. Methods-of-release plots were installed August 17 to 28, 1964, when height growth of redwood was essentially complete, although later flushes may continue. The Australian fireweed and huckleberries begin to mature fruits and seeds in August.

The herbicide was a recommended formulation to kill plants. No testing was made of different formulations, rates, nor season of application. The two herbicides used were 2,4,5-trichlorophenoxy acetic acid, propylene glycol butyl ether esters—4 lbs. a.e./gal. and 2,4-dichlorophenoxy acetic acid, butoxy ethanol ester—4 lbs. a.e./gal. Formulations were:

	Chemical		Solution	Diesel	Water	Total
	2,4,5-T	2,4,D				
	Gallon					
Foliage spray	0.5	0.5	0.5	8.5	10.0	
Basal spray	.5	.5	24.0	0	25.0	

Both basal and foliage sprays were applied with a pressure tank sprayer. To basal spray, enough herbicide solution was applied to wet to near runoff the basal portions of low weeds and up to 18 inches of the lower stems of shrubs, and unwanted trees. Care was taken to prevent the bases of the crop seedlings from being sprayed. The foliage spray was applied to near runoff on the upper leaf surfaces of the competing vegetation. But no special precautions were taken to protect these crop seedlings from being sprayed.

RESULTS

Radius of Release

Condition of crop seedlings

Some spray drift and concentrated spray vapor caused considerable damage to crop seedlings. At the end of the first growing season 27 percent of them had died and 55 percent were injured (*table 1*). On the control plots, 6.7 percent of the seedlings died from unknown causes. Deer were also responsible for injury to some. They browsed the control seedlings at a much higher rate than released seedlings.

By the end of the second growing season most spray-damaged seedlings had grown new terminals or were growing normally (*table 1*). Mortality increased slightly, and deer browsing continued to be low. Deer browsing, however, increased some on untreated seedlings. Most significant was the quick recovery of spray-damaged seedlings.

Changes in Plant Competition

Competing plants in the test plots included *Polystichum munitum* (Kaulf.) Presl., *Erechtites prenanthoides* (A. Rich.) DC., *Rubus spectabilis* Pursh., *Alnus rubra* (Bong.), *Vaccinium parvifolium* Sm. in Rees., *Baccharis pilularis* DC., *Anaphalis margaritacea* (L.) Benth. & Hook., *Oxalis oregana* Nutt. After three growing seasons, competing plants had largely reestablished themselves; more than 60 percent of them had regrown or reinvaded. Plants with aerial parts killed by basal spraying dropped from 68 percent after the first season to only 2 percent after the third season. Plants with aerial parts partially dead averaged about 40 percent for the three seasons.

Growth Response of Crop Seedlings

Even on control plots where herbicide injury was absent, little additional height growth could be expected for the rest of the first growing season,

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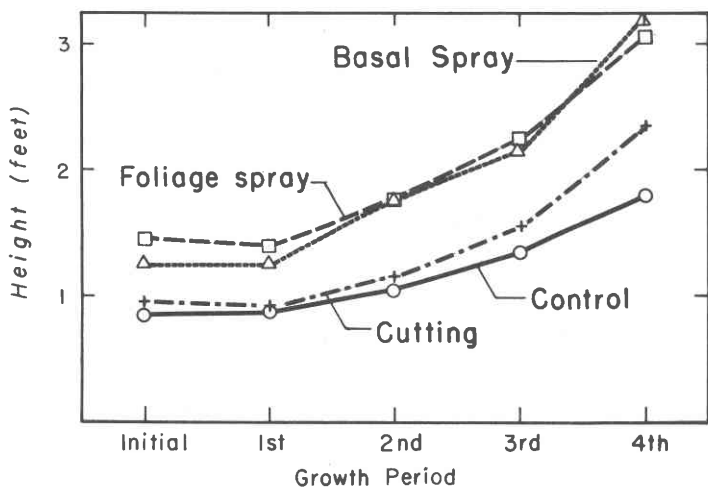


Figure 2—In the fourth growth period, annual height growth nearly doubled on all redwood crop seedlings both non-released and those released at a radius of 3 feet by different methods. Growth of released seedlings during the second and third periods was variable, but somewhat better than controls.

growing season. The herbicide-released seedlings lost in height because of killed terminals. The hoeing-released seedlings lost height because of browsing (*fig. 2*).

The spray-released crop seedlings recovered the second growing season and showed modest but erratic response to release (*fig. 2*), and maintained moderate growth differences from control seedlings the third season. The hoeing-released seedlings grew only slightly better than controls during the second and third periods. During the fourth growth period, when released crop seedlings were emerging above the competition that had become reestablished, height growth of controls and released seedlings nearly doubled (*fig. 2*). Although growth of the control seedlings was less than that of the others, the trend appears to be towards equality.

Differences in cumulative growth to the end of the fourth period, and in growth the last year, by treatment, were not statistically significant.

CONCLUSIONS

The weeding and release treatments in this study

did not enable the 3- to 4-year-old redwood crop seedlings to grow much faster or taller than the untreated seedlings. The growth patterns of all seedlings were much alike by the end of the fourth growing season, when competing vegetation had already reoccupied the test plots. Where they have topped out, both weeded and untreated seedlings should grow at about the same rate. Redwood crop seedlings of this age-class, competing with shrubs and herbs on the Redwood Experimental Forest, can grow reasonably well without one-time weeding.

As competing vegetation, red alder may be a special problem in redwood management. In this study, it was removed to a wider radius than other competing plants, but alder crowns quickly re-occupied the study plots. Their impact on future growth of redwood crop seedlings needs further study.

NOTE

¹Fritz, Emanuel, and James A. Rydelius. *Redwood reforestation problems*. An experimental approach to their solution. Found. Amer. Res. Manage. 130 p., illus. 1966.

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period nor the growth between the third and fourth period were statistically significant.

Methods of Release

Condition of Crop Seedlings

The different methods of removing the competing vegetation caused different responses in the redwood crop seedlings in the first two growing seasons (table 2). Basal spraying of competitors killed 20 percent of the seedlings, and foliage spraying 11 percent, the first year. Additional seedlings died the second year. More than 15 percent of crop seedlings died where competitors had been hoed or cut. Much of this mortality was caused by damage to roots of small seedlings that had been surrounded by dense herbaceous growth.

In the first growing season, cutting and hoeing seemed to have attracted deer as evidenced by browsing on 22 percent of crop seedlings (table 2). In contrast, few redwood seedlings released by other methods were browsed. In the second growing season, however, browsing of crop seedlings was similar on all test plots. Deer began to browse spray-released redwood much sooner than they did in the radius-of-release plots, less than ½ mile away. But again, deer avoided spray-released redwood the first year.

New terminal shoots grew back on many of the previously spray-damaged seedlings the second year

(table 2). In addition, the proportion of seedlings with normal growth totaled 44 to 59 percent. Thus by the end of the second year many of the released seedlings were growing well. The deer-browsed seedlings had fair growth.

Changes in Plant Competition

Both basal and foliage sprays killed all aerial parts of 70 to 85 percent of competing plants and partially killed the remainder in the first growing season. The hoeing-cutting was only moderately successful in killing competition. Additional characteristic competing plants to those listed previously were Douglas iris (*Iris Douglasiana* Herb.), thimbleberry (*Rubus parviflorus* Nutt.), salal (*Gaultheria shallon* Pursh.), and bracken (*Pteridium aquilinum* (L.) Kuhn.).

By the second season, regrowth was well underway. More than half the plants that had been weeded had regrown. Only one-third of the competition was classed as dead where either basal or foliage spray had been used. Most of the other plants were partially dead.

After the third season, competition had been essentially reestablished, although on the two sprayed plots more than 50 percent of the plants were still classified as partly dead.

Growth Response of Crop Seedlings

Weeding was done in August, hence additional height growth was not expected the remainder of the

Table 2—Condition of redwood crop seedlings at end of successive growing seasons after treatments of competing vegetation, Redwood Experimental Forest, California, 1964-1965

Treatment of plant competition	Crop seedlings, by treatment group, that were—					
	Killed by spray or other causes	Terminal killed by spray	Terminal curled; other damage	New terminal grown	Browsed by deer	Normal growth
	<i>Percent</i>					
	FIRST GROWING SEASON					
Basal spray	20.0	13.3	3.3	—	1.1	62.3
Foliage spray	11.1	10.0	7.8	—	0	71.1
Hoeing-weeding	15.6	—	0	—	22.2	62.2
Control	1.2	—	2.5	—	5.0	91.3
	SECOND GROWING SEASON					
Basal spray	¹ 22.2	6.7	2.2	14.4	10.0	44.5
Foliage spray	¹ 15.6	3.3	0	5.6	17.8	57.7
Hoeing	¹ 20.0	—	3.3	2.2	15.6	58.9
Control	¹ 5.0	—	0	0	16.2	78.8

¹Cumulative percent. Original number of seedlings used as divisor throughout to permit comparison of changes.

Table 1—Condition of redwood crop seedlings at the end of two growing seasons in which competing vegetation had been basal sprayed or left untreated, Redwood Experimental Forest, California, 1964-1965

Seedlings	Killed by spray or other causes	Terminal killed by spray	Terminal curled; other damage	New terminal grown	Browsed by deer	Normal growth
	Percent					
	FIRST GROWING SEASON					
Treated	¹ 26.7	43.3	12.2	—	1.1	16.7
Untreated	6.7	—	3.3	—	10.0	80.0
	SECOND GROWING SEASON					
Treated	² 27.8	1.1	0	48.9	1.1	21.1
Untreated	² 6.7	—	0	6.7	13.3	73.3

¹Includes 2.2 percent killed by road debris.

²Cumulative percent. Original number of seedlings used as divisor throughout to enable direct comparisons with values in the first growing season.

because plots were not established until late June. Because many of the released seedlings had dead and curled terminals, two groups averaged small losses and one gained slightly (fig. 1).

During the second growing season the released seedlings were growing normally including regrowth of new terminals. The average height growth of seedlings released 3 and 4 feet from competition was over 1½ times that of the controls (fig. 1). While for the 2-foot release group it was nearly the same.

During the third growth period, height growth of

all released groups increased some, then increased a little more the fourth period (fig. 1). Height growth of control seedlings dropped slightly the third period, then almost doubled the fourth period. By the end of the fourth period many seedlings were topping out over low shrubs and herbs, which had reestablished around the crop seedlings. Thus height growth of released and control seedlings is becoming alike with the similar competition.

Neither the differences on cumulative growth between the various treatments through the fourth

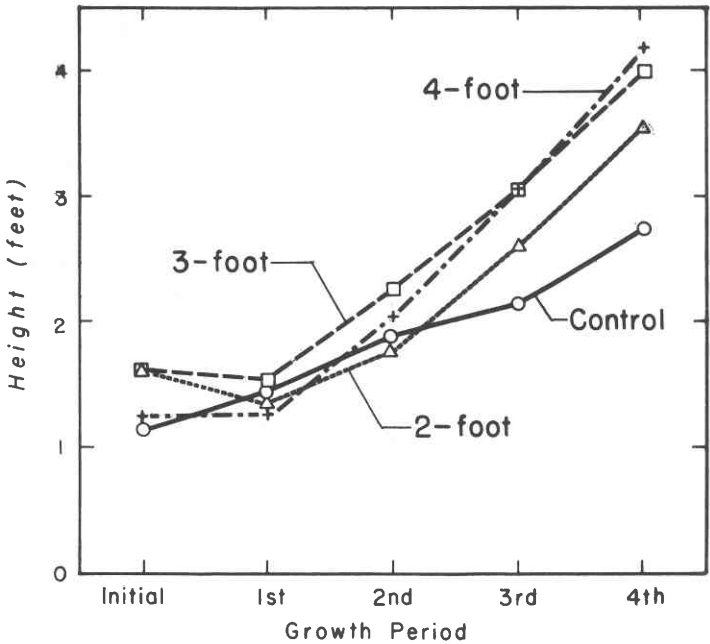


Figure 1—Height growth after four growing periods was similar between redwood crop seedlings not released and those released from competition by basal spraying at radial distance of 2, 3, and 4 feet. During the second and third periods, growth of released seedlings varied from the same to three times that of controls.



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