SEEDLING SURVIVAL
In a Giant Sequoia Forest

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THE STAND STRUCTURE and species composition of giant sequoia forests have changed remarkably during the past one hundred years. While white fir has increased in abundance there has been little or no increase in giant sequoia and in many areas fire hazards have increased. Because of early haphazard logging and the more recent exclusion of fire, the open and parklike forests dominated by giant sequoia, pine, and fir have become dense, debris-laden stands with white fir and incense-cedar crowding the understory. Researchers at Whitaker's Forest are investigating ways to restore the primitive open forest. This study is concerned with the establishment of seedlings following various forest management practices.

TABLE 1. RESIDUAL TREES ON THE VISTA PLOT WHITAKER'S FOREST, 1968

Species	Number*	Average DBH†	Basal Area sq. ft.	Equivalent B.A. per acre
Bigtree	63	20.7	164.3	256.7
White fir	6	15.6	8.8	13.8
Incense-cedar	24	12.3	20.8	32.5
Sugar pine	24	2.6	1.3	2.1
Ponderosa pine	9	13.5	10.1	15.7
Live oak	9	0.7	<0.1	<0.1
White alder	1	16.3	1.4	2.3
TOTAL			206.8	323.2

* Trees less than 4.5 ft tall: Bigtree 2, White fir 7, Incense-cedar 3, Sugar pine 8, Ponderosa pine 1, and Live oak 9.
† Diameter at breast height.

Whitaker's Forest is adjacent to the western boundary of Kings Canyon National Park, on the western slope of Redwood Mountain in Tulare County. It was willed to the University of California in 1910 with the stipulation that no living giant sequoia trees should be cut or felled. During the summer of 1964, a project was initiated to reduce fire hazards, to lessen competition to the big trees, to improve scenery, and to help wildlife. Since that time, a low thinning operation has removed the heavy debris and many of the white fir and incense-cedar trees in the understory of selected stands. Two of these stands are the working areas for this study. The data were collected in late spring and late summer of 1968, a year of abundant germination of giant sequoia and white fir seedlings.

Two plots

The study was conducted on two plots. The "Vista Plot" is located on a 0.64 acre plot that was manipulated August 11, 1964, for hazard reduction and scenic improvement. No fire was used in the manipulation, and in the late summer of 1964 all small seedlings were removed from this plot. After the removal of 4,051 trees, most of which were small white fir, a total of 172 trees were left with a basal area of 302 sq ft per acre. During the summer of 1968 the residual trees were measured again. In addition, all the seedlings that had become established since 1964 were counted in late June and mid-October. The seedlings were segregated by species and by age.

The other plot in the study was adjacent to the Vista Plot and was manipulated in 1967. Fire was used in scattered locations in the burning of excess fuel, and a sampling procedure was designed to investigate differences in seedling establishment and mortality between burned and unburned areas. A total of thirty mil-acre areas were measured, fifteen of which were burned and fifteen unburned. Only those seedlings that had emerged since the 1967 manipulation were observed, and these first-year seedlings were counted and separated by species within each area. All areas were measured in June and remeasured in September and October to determine seasonal changes in the seedling population.

Reproduction

The establishment of reproduction over a four-year period in the Vista Plot is shown in tables 1 and 2. Table 1 lists the trees more than four years old on the plot and table 2 the trees fours years old or less. There were few substantial changes in the numbers of larger trees present, although one large ponderosa pine died and was removed, causing a decline in basal area for that species. There was a total increase of equivalent basal area per acre on the plot from 302 sq ft to 323.2 sq ft. The greatest increase in basal area was found in giant sequoia, which increased almost 20 sq ft on the plot. The largest percentage increase was found in the six white fir trees which increased in basal area 35 per cent since 1964.

There were numerous seedlings on the plot in June, as shown in table 2, most of

TABLE 2. NUMBERS OF FIRST-YEAR AND SECOND- TO FOURTH-YEAR SEEDLINGS ON THE VISTA PLOT

Species	White fir		Bigtree		Incense-cedar		Ponderosa pine		Sugar pine		Black oak		Live oak		White alder		Total seedlings	
Age Class	1	2–4	1	2–4	1	2–4	1	2–4	1	2–4	1	2–4	1	2–4	1	2–4	1	2–4
June	951	239	730	0	10	49	15	6	5	13	0	30	0	22	0	0	1711	359
October	383	220	5	0	2	38	3	2	2	13	0	25	0	21	2	0	397	319

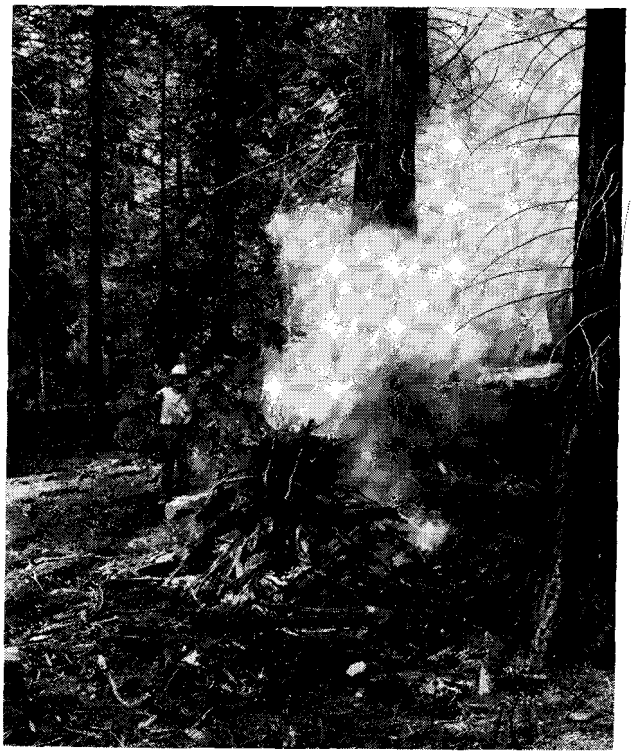
TABLE 3. NUMBERS OF NEW SEEDLINGS ON ONE-YEAR OLD MANIPULATED PLOT

	BURNED AREAS				UNBURNED AREAS			
	Bigtree	White fir	Incense-cedar	Total	Bigtree	White fir	Incense-cedar	Total
June	1253	184	1	1438	278	136	1	415
September	112	80	1	193	6	53	0	59
October	96	71	0	167	0	41	0	41

Fire in seedbed preparation (including ash from burning debris), appears to be essential for giant sequoia seedling survival, and was beneficial to survival of white fir seedlings in these tests at Whitaker's Forest, Tulare County.

Giant Sequoia White Fir

FIRST YEAR SEEDLINGS



The ash left from this pile of burning debris creates ideal conditions for the germination of seedlings. In this giant sequoia stand with a dense overstory, however, low survival of seedlings may be expected—photo by Harold Weaver.

which were first-year giant sequoia and white fir. The total number of seedlings declined during the season, so that by October only 716 of the 2070 seedlings survived. Most of the mortality occurred in the abundant first-year seedlings. The two- to four-year-old seedlings, being better established, showed less change.

Of the two abundant species of seedlings, white fir is more tolerant of present growing conditions than is giant sequoia. The white fir declined less in numbers of first-year seedlings than the sequoia, and survival of its older seedlings was substantial. The giant sequoia first-year seedlings, although abundant in the spring, had all but disappeared by October, and there were no older seedlings left in the plot.

The second part of the study was concerned with the number of first-year seedlings found in burned and unburned areas of the second plot (see table 3). The data were analyzed with the use of the student's 't' test for significant differences between sample means, and all differences noted are significant at the 95 per cent level.

In both burned and unburned areas there was a significantly greater number of total seedlings in June than in September, but no further significant differences between the count in September and the count made at the end of the growing season in October. This seasonal decline is normal, and it can also be expected that the greatest decline will occur by September. The burned areas had a significantly higher survival rate, however, than the unburned areas. The total numbers of giant sequoia and white fir seedlings were significantly greater in burned areas than in unburned areas in June, September, and October—except for white fir numbers in June, which were not significantly different between burned and unburned areas.

Relative numbers

The relative numbers of giant sequoia to white fir also changed throughout the season. In the burned areas in June, the numbers of giant sequoia were significantly greater than the numbers of white fir. However, by September, and continuing into October, there were no significant differences in seedling numbers between the two species. Most of the remaining sequoias were found in an area that received spring drainage, showing the beneficial influence of adequate soil moisture on seedling survival. Giant sequoia on the burned areas showed a decline in seedling numbers relative to white fir.

In the unburned areas, there was no significant difference between the numbers of giant sequoia and white fir seedlings in June, although there were more giant sequoia seedlings. By September, the count of white fir seedlings was significantly greater than giant sequoia seedlings and by October the trend had continued to the point where all of the giant sequoia seedlings on the unburned areas had died.

The study in both plots shows a marked mortality of first-year seedlings, especially giant sequoia seedlings. The Vista Plot, which was not burned in manipulation in 1964, had almost 100 per cent mortality of first-year sequoia seedlings, and no seedlings had lived past the first season; the unburned areas in the second plot showed a 100 per cent mortality of first-year seedlings. Only on the areas that were burned was there much survival of first-year sequoia seedlings, but whether or not these seedlings will survive the first year is unknown.

White fir tolerates conditions in the unburned areas better than giant sequoia, and good survival past the first year is evidenced by the large number of older seedlings in the Vista Plot. But in the second plot, survival of white fir in burned spots was better than in the unburned spots. These results suggest that both species benefit from seedbed preparation by fire, and that for giant sequoia establishment it is essential.

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