Fuel Conditions And Fire Hazard Reduction Costs in a Giant Sequoia Forest

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IN RECENT PERIODS as long as 100 years, the groves of giant sequoia have been protected from destructive forces—including the fires which were once an integral part of their environment. There is today a growing concern that such protection, while of vital importance, is not of itself an adequate substitute for natural habitat conditions. Plant successions are changing conditions within the groves; the understory shade-tolerant trees, chiefly white fir, are increasing in number; and large amounts of debris are accumulating.

With the steady increase in fuel build-up, irreplaceable giants are faced with an ever increasing threat to their existence because even modern fire-fighting equipment and technology are not totally effective in suppressing wildfires in such areas. The fire-scarred trunks of giant sequoias attest to their ability to survive repeated ground fires. However, the sequoia trees may not withstand crown fires which are sure to occur if a fire burns uphill through the heavy fuel accumulations and understory trees during the dry season. Protection from wildfire is vital, but it is apparent that steps must be taken to insure a fire of relatively low intensity, if one should occur.

Tangle of debris from dead clones of Scouler willow create high fire hazard. Dense understory of white fir shown in background also adds to likelihood of disastrous fire. Base of large second-growth giant sequoia appears on right, white fir trunk on left.

Aesthetic values

Investigations of ways to reduce fuels and improve aesthetic values in giant sequoia groves are under way on Whitaker's Forest, a 320-acre forest owned by the University of California. Whitaker's Forest lies on the western slope of Redwood Mountain in Tulare County and adjoins the magnificent Redwood Mountain grove of giant sequoias in Kings Canyon National Park. Plant successions following logging of Whitaker's Forest in the 1870's have resulted in the development of extreme fire hazards. Dense stands of incense-cedar, Scouler willow, second-growth sequoia, and white fir became established following the logging, which removed most of the pines and about half of the orginal stand of giant sequoias.

Fuel conditions

In the dense second-growth stands, many of the incense-cedars which became established following the logging disturbance of the 1870's have succumbed to competition and are now dead, but still

Views of 1/10-acre test plot before (left) and after (right) clearing. Dense understory stand of white fir and incense-cedar blocks view of mass of Scouler willow debris on ground in photo to left. Hazards were greatly reduced and vistas opened up by treatment, as seen in photo to right.

standing. For example, on a photo plot of 33 × 33 ft there were 19 dead trees, the equivalent of 760 per acre. These dead trees help form a fuel bridge between the ground and the overhead canopy. Another fuel type which is characteristic of the second-growth stands is Scouler willow debris. This formerly abundant species grew in dense clones which have now been shaded out and killed. The slowly decaying stems form dense tangles of fuel. Much heavy debris from limbs and fallen trees of other species is found on the ground also. Such accumulations are especially prevalent where the relatively short-lived white fir stands are approaching maturity, or have succumbed to disease or insects.

Understory trees are found in great numbers on Whitaker's Forest as well as in many other giant sequoia groves. These trees, principally the shade-tolerant white fir, have increased steadily in numbers since the inception of protection from fires. Now they frequently form a continuous mass of fuel from the ground to near the tops of the tallest trees. Where these trees have grown high in the understory, with heavy debris accumulation below, serious fire hazards exist. Bear clover and manzanita occur as understory to pines on drier sites on Whitaker's Forest. When these shrubs are draped with pine needles they form a very flammable fuel.

Fuel reduction

In 1964 a manipulation program was started on Whitaker's Forest with the cooperation of the California Division of Forestry and its Miramonte Conservation Camp. A "minimum" treatment has been applied to about 60 acres. This treatment consists of the removal of understory white fir and incense-cedar trees between one and eleven feet tall, cutting of dead standing trees, and removal of heavy debris on the ground. The material is disposed of by burning in small piles below the canopy of larger trees in the fall and spring months when the danger of wildfire is minimal. Large amounts of material have been removed and the continuous vertical distribution of fuels broken up by this treatment. Because the treatment does not appreciably affect those trees in dominant- or subdominant-crown classes, the composition of the forest is not changed significantly for the present.

In the second phase of the manipulation (yet to be done) it is planned to remove some of the intermediate sized incense-cedars and white fir (which seeded in following the logging of the 1870's) growing within about 6 ft of sequoias. This will not be a thinning to promote growth of incense-cedars and firs; rather, the purpose will be to reduce competition to—and open up views of—the sequoias and to further reduce fire hazards.

At a later date prescribed burning will be tested in the different types of fuels on the forest floor. These treatments are designed to result in more pines in the forest and fewer incense-cedars, and to restore plant patterns and successions that prevailed in the primitive condition be-

Heavy fuels from white fir debris accumulated near a mature giant sequoia. Decadent stands of white fir are found in many groves of *Sequoia gigantea*.

MATERIALS REMOVED, LABOR REQUIRED, AND CALCULATED COSTS OF MANIPULATION ON FOUR TENTH-OF-AN-ACRE PLOTS IN SECOND-GROWTH GIANT SEQUOIA.

Material removed	Plot 1	Plot 2	Plot 3	Plot 4
Number of live trees cut	41	125	93	119
Number of dead standing trees cut	17	55	36	112
Total trees cut	58	180	129	231
Estimated weight of dead material (lbs)	3,225	3,965	5,070	1,770
Estimated weight of live material (lbs)	20	1,235	730	1,600
Total weight of material burned	3,245	5,200	5,800	3,370
Man-hours of labor				
Man-hours required to cut standing trees* (with chain saw)	0.42	0.83	1.33	1.50
Man-hours required to buck up material (with chain saw)	1.67	0.84	1.67	0.74
Man-hours to pile material on fires	1.30	1.96	1.43	1.45
Man-hours to tend fires and complete burning	0.37	0.97	0.45	0.47
Total man-hours	3.76	4.60	4.88	4.16
Number of fires built on plots	7	9	5	7
Calculated costs (Labor at $2.38 per hour, chain saw at $2.00/hr.)				
Labor to cut standing trees	$1.00	$1.98	$3.16	$3.57
Chain saw costs for standing trees	0.84	0.84	1.32	1.50
Total thinning costs	$1.84	$2.82	$4.48	$5.07
Labor for bucking up material	3.97	2.00	3.97	1.76
Chain saw costs for bucking up	1.68	0.84	1.68	0.74
Total bucking up costs	$5.65	$2.84	$5.65	$2.50
Labor for piling material	3.09	4.66	3.40	3.45
Labor for tending fires	0.88	2.31	1.07	1.12
Total costs (supervisory costs not included)	$11.46	$12.63	$14.60	$12.14
Cost per ton of material removed	7.07	4.85	5.03	7.23

* A two-man crew on chain saw with the exception of cutting standing trees on plot 1 where only one man was needed.

fore the white man intervened. Increasing the reproduction of giant sequoia is not a special objective of the manipulation on this forest, although some may result from the disturbances. The forest is well stocked with second-growth redwood, far more than are necessary to replace those which were logged off.

To determine the man-hours of labor required to perform the minimum treatment, four tenth-of-an-acre plots were marked off for manipulation. Plots were selected where debris, dead trees, or understory trees were fairly representative of maximum conditions encountered. A careful record was made of the time required to perform each step in the manipulation operation. Weight of material to be burned was estimated, after a period of training with scales.

The results obtained are presented in the table. Assuming a labor cost of $2.38 per hour and chain-saw cost of $2.00 per hour, the calculated cost ranged from $114 to $146 per acre. This does not include costs of supervision, etc. These figures approach the maximum cost since few areas would have more material to dispose of. The average amount of fuel removed from the four plots was 44,040 lbs per acre. The average number of trees cut per acre were: living, 945; dead, 550.

While the cost of treatment appears high, it should be borne in mind that the manipulation removed 80 years' accumulation of debris and lowered the fire hazard conditions for many years to come. Also, there has been an improvement in aesthetic values. No monetary value can be placed on giant sequoias because they are a priceless heritage to be preserved at almost any cost.

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GREENHOUSE DIAGNOSE PROBLEMS

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Greenhouse tests point to potassium deficiency as the probable cause of "bronzing" of sugar beets in Delta soils, and indicate that responses to lime may be due in part to increased uptake of nitrates because of enhanced microbial activity.

BRONZING SYMPTOMS in sugar beets grown on acid organic soils of the Sacramento-San Joaquin Delta have been observed for many years. As these symptoms develop, sugar beet leaves are commonly smaller than normal, dark bluish-green in color, and may show a graininess when held up to bright sunlight. Later, leaves develop a brownish or bronze color, and older leaves may die prematurely. Often, brown necrotic areas occur around the margins of leaf blades.

For study of the bronzing problem in the greenhouse, an Egbert muck soil was collected from an area in a sugar beet field where bronzing symptoms had appeared. The characteristics of the soil were: pH, 5.0; exchangeable potassium, 80 ppm; and water-soluble phosphorus, 0.5 ppm. The potassium and phosphorus values are below critical levels for beets.

For greenhouse assay, the soil was divided into lots which received the following treatments: check—untreated; 200 ppm phosphorus (dry-soil basis) as mono calcium phosphate; 200 ppm potassium as potassium sulfate; and phosphorus plus potassium. Lime—calcium carbonate—at the rate of 10,000 ppm was added to half of each treatment. These test soils were placed in 6-inch clay pots and sugar beets grown in them. Nitrogen was applied to all pots several times in an attempt to maintain an adequate supply during the growing period. The initial N application was as ammonium sulfate; subsequent additions were as ammonium nitrate.