In this hot spot at Redwood Mountain, convection columns of heat rose high into the canopy, killed sequoia and fir needles, dried out sequoia cones, and apparently led to unusually heavy seed fall on an ideal seedbed. More than 40,000 seedlings per acre germinated on this site (photo by Harold Weaver).

Seedling *in a* GIANT SEQUOIA FOREST

BRUCE M. KILGORE

H. H. BISWELL

NATURAL FIRE is recognized by the National Park Service as one of the ecological factors contributing to the perpetuation of plants and animals in a given habitat. As such, fires in national parks resulting from natural causes may be allowed to run their course under specified conditions. Prescribed fire may be used as a substitute for natural fire where this can achieve approved vegetation or wildlife management objectives. To provide the facts upon which to base such a program, researchers at Sequoia and Kings Canyon National Parks are studying the role of fire in various plant communities; of greatest interest at this time are forests of the giant sequoia-mixed conifer type.

Research has indicated that fire plays an important role in the germination and survival of the giant sequoia. Studies at Whitaker's Forest, on the western slope of Redwood Mountain, show that in the absence of fire, shrubs have become increasingly scarce during the past 90 years, thus reducing the value of these areas for deer and other wildlife. Many such shrubs have hard seed coats which prevent germination unless cracked by fire. The present study records the impact of prescribed burning on germination of seedlings of sequoia and various shrub species.

In the first major effort, some 100 acres of giant sequoia forest were burned under prescribed conditions in late summer or early fall of 1969 on the ridge of Redwood Mountain in Kings Canyon National Park. The management objective was to reduce the fire hazard along this western boundary of the largest grove of giant sequoias (3,100 acres) and to help begin to restore natural conditions to the adjacent National Park environment. Data on germination of sequoia and shrub seedlings were collected on three burn plots and an adjacent control plot in mid-summer of 1970, one year after burning.

Before ignition, the 100-acre unit was divided into 13 sectors and each sector was surrounded by small, hand-built fire lines. In the three study units, relatively intensive pre-burn preparations were

germination following fire

Unburned forest (left) along the Redwood Mountain trail, July, 1966. The same site in June, 1970 (right) after burning. Note unusual fire scar on lefthand sequoia (Harold Weaver photos).

made. White fir and incense-cedar less than 9 inches dbh (diameter breast high) were felled and left to be consumed by the fire. Snags except sequoias were felled. Two-foot hand lines were built around most sequoias. Fire hose was run to all sectors, and charged lines were available for use at any point along the sector perimeter being burned.

In general, a prescription developed by Harry Schimke of the Forest Service Experiment Station in Berkeley was followed, with ignition taking place at the ridgetop at about noon. Occasionally strip burning was employed to speed up the process, but only short distances were found to be feasible without running risk of a hotter fire than desired.

Four transects were run through the study plots, three in burn plots and one in the control plot. A record was kept of the number of tree and shrub seedlings found in 4 ft × 4 ft microplots at 25-ft intervals along each transect. There were 50 microplots in each transect.

The numbers of sequoia and deerbrush seedlings which germinated on the four plots are shown in the table. On plot 3, which burned hottest, more than 40,000 sequoia seedlings per acre were found, while on the lighter burned plot 1, some 7,500 seedlings per acre were recorded. On the other hand, more than 6,500 deerbrush seedlings per acre were recorded on the lightly burned plot 1, with only 218 per acre on the heavy burned area. Not a single sequoia or shrub seedling was found on the control plot, while the three burn plots averaged nearly 22,000 sequoia seedlings per acre and more than 3,200 deerbrush seedlings per acre.

A possible relationship with seed source is clear from the table, which shows more than nine sequoia greater than 6 ft dbh per acre on burn plot 3, compared with fewer than 3 per acre for burn plot 1. Thus, the most productive burn plot had both the greatest numbers of large sequoias per acre and the hottest burning conditions. It appears that the rising convection column of heat, which dried out and killed sequoia needles more than 100 ft up in three trees on plot 3, may have also caused drying and opening of sequoia cones on several of these same trees and hence contributed to very heavy seed fall in the area of the hottest burn. The extremely large numbers of sequoia seed-

SEQUOIA AND DEERBRUSH SEEDLING RESPONSE TO 1969 BURNING AT REDWOOD MOUNTAIN

Plot No.	Size	Mature sequoia*		Seedling sequoia		Seedling deerbrush	
	acres	no. per plot	no. per acre	no. per transect	no. per acre	no. per transect	no. per acre
Burn #1	3.75	11	2.9	138	7,514	120	6,534
Burn #2	6.10	28	4.6	337	18,350	53	2,886
Burn #3	6.25	58	9.3	737	40,130	4	218
Burn plots totals	16.10	97		1,212		177	
Means			6.0		21,998		3,213
Control	5.30	31	5.8	...	.....	...	....

* Trees more than six feet diameter at a height of 4.5 ft.

lings germinating in plot 3 were probably related to both ideal seedbed conditions and heavy seedfall. From 50 to more than 200 seedlings were counted in a number of the 4-ft-square microplots. The greater numbers of deerbrush seedlings on the lightly burned area is explained by the fact that heavy burning conditions destroy seeds, while lesser temperatures crack seed coats and allow germination.

In addition to deerbrush, smaller numbers of littleleaf ceanothus and greenleaf manzanita were also found on the burn plots. A few seedling white fir germinated in each burn area, thus confirming earlier findings that white fir also benefit by conditions following burning. For giant sequoia, however, such conditions are almost essential.

Dry weight samples of ground fuels from unburned sites adjacent to the burned plots indicated that more than 12 tons of flash fuels and 36 tons of duff are found per acre in this giant sequoia forest, prior to burning. This does not include logs more than 12 inches in diameter. After burning, samples from heavy and moderately burned segments of the burn plots indicated about 2 tons of flash fuels per acre and 7½ tons of duff per acre remained. This is an 80 per cent decrease in ground fuels, presumably resulting in a considerable decrease in fire hazard in the area.

These results confirm the importance of fire in the early stages of establishment of giant sequoia and various brush species found in the mixed conifer forest in California. The Park Service policy of trying to restore natural environmental processes to natural areas of the national parks should (1) aid the re-establishment of shrubs as a significant part of the habitat of these montane forests, (2) insure a continual supply of young sequoias to replace the 2,000-year-old mature trees, and (3) decrease the unnaturally high fire hazard in these forests.

Bruce M. Kilgore is Research Biologist, Office of Natural Science Studies, National Park Service; and Harold H. Biswell is Professor, School of Forestry and Conservation, University of California, Berkeley.

The extreme density of sequoia seedlings which germinated in certain areas after burning is shown in this photo of a 1-sq-ft sampling frame. More than 50 seedlings are shown here.

MECHANICAL FOR IN

HARVEST TRIALS were started in Ventura County in February, 1970 using several citrus varieties at various stages of fruit maturity. Some tests were made with the catching frame shaker, but most of the trials were with the Mono-Boom trunk shaker (see photos). Both shakers were manufactured by Orchard Machinery Corp.

Variations in shaker frequency of stroke, duration and number of shakes, plus different tree attachment heights were tried. The amount of fruit removal varied between varieties and even between different trees of the same variety. The amount of crop on the tree and the maturity, length, and structure of main scaffold branches, plus the length of the fruit-bearing twig itself, affected ease of removal. Where crops of both ripe fruit and young fruit occurred on the tree at the same time—as in Valencias, lemons, and young grapefruit—there was often excessive damage and loss of the next season's crop.

Amount of fruit damage varied with variety. Navels showed the most rind damage from limb punctures. Rind damage and rot while in storage was fairly high for lemons. Damage to Valencias and grapefruit—while higher than for hand-picked fruit — was commercially acceptable. Stem separation on all varieties was generally acceptable. Very often the break occurred at, or just inside the button. Most shake-harvested fruit retained the button, except grapefruit.

Since most of California's citrus is sold fresh, methods of mechanical harvest should not cause excessive rind damage. Numerous trials with fungicides to in-