Natural Reproduction in Certain Cutover Pine-Fir Stands of California

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NATURAL REPRODUCTION must provide future crops of timber on most of the forest land being placed under management in California. Relatively few acres will be planted or seeded in the near future because planting costs are high, facilities for undertaking large-scale planting are inadequate, and direct seeding has not yet proved satisfactory. In the pine region it is desirable that reproduction stands be adequately stocked with vigorous pine seedlings. How promising is the outlook for natural restocking? The degree of success in one important locality is the subject of this paper. It reports mainly seedling occurrence on cutover land between 1923 and 1947. The results are part of a more general study of forest regeneration in this and other localities in California.

The Study Area

The study area is located on the west slope of the Sierra Nevada in the Stanislaus National Forest. Data are from 640 milacre quadrats in five plots totaling about 50 acres. The plots range in altitude from 5,500 to 6,000 feet. The timber type is sugar pine—fir and sugar pine—ponderosa pine—fir.[2] On the basis of the average height of the dominant trees at maturity, the plots rate high in quality: Site I.

Observations were begun on the quadrats before logging. Each plot was logged once during the period of study, but the year of cutting differed for the several plots, being either 1923, 1928, or 1929. Records were continued annually or periodically from the year of logging until 1947. Because year of cutting, location, and type of cutting varied among the plots, no detailed analysis based on years after cutting is attempted. Instead the data are summarized by calendar years to show the numbers and species composition of the reproduction and the ground cover conditions on which reproduction occurred. Data relating to the changes caused by logging are summarized as "before logging," and "after logging" without regard to calendar years.

Prior to cutting, the average stand on the plots was 74,600 board feet per acre.[3] The intensity of cutting differed on the five plots, varying from a selection cut in which 40 percent of the volume was removed to a heavy cut in which 90 percent was removed. The residual volume ranged from 6,700 feet to 37,000 feet and averaged 13,700 feet. These reserve stands are considered representative of the range found after logging in the vicinity. Owing to the grouped occurrence of the original old-growth, cutting varied locally within the plots from complete clearing in small patches to removal of single trees. Logs were ground skidded with tractors except on 10 acres, where donkeys were used. The slash was piled and burned in the first winter after logging.

Species in the old-growth volume before and after logging were:

	Before logging	After logging
	Percent	*Percent*
Ponderosa pine	18	14
Sugar pine	34	29
Fir	39	48
Incense-cedar	9	9

Seed trees.—The number of seed trees within range of the quadrats indicates the possibility of reproduction better than the reserve volume. Seed-fall records show the effective seeding distance of sugar pine, the species with the heaviest seed, to be about 1½ chains for seed trees 18 to 30 inches in diameter, and 2½ chains for trees larger than 30 inches.

Within 1½ chains on either side of the line of quadrats there were 210 trees over 18 inches in diameter, or an average of 11 trees per acre (Table 1); within 2½ chains there were 114 trees over 30 inches, an average of 3.6 per acre.

TABLE 1.—NUMBER OF SEED TREES WITHIN RANGE OF QUADRATS

Species	Trees over 18 inches within 1½ chains		Trees over 30 inches within 2½ chains	
	Total	Per acre	Total	Per acre
Ponderosa pine	21	1.1	6	0.2
Sugar pine	49	2.5	26	0.8
Fir	101	5.3	60	1.9
Incense-cedar	39	2.1	22	0.7
Totals	210	11.0	114	3.6

The proportion of quadrats within 1½ chains of a pine seed tree 18 inches d.b.h. and over was 76 percent; within 2½ chains of a 30-inch pine, 67 percent; within 1½ chains of any 18-inch tree, 96 percent; and within 2½ chains of any 30-inch tree, 94 percent. Thus nearly every quadrat was within range of at least one seed of some species and more than three-fourths were exposed to at least one pine.

Considering the period as a whole, failure of seed crops probably was not a limiting factor in reproduction. Heavy pine seed crops occurred in 1933, 1934, 1936, and 1941; light crops were borne in about half the remaining years. It is considered significant that the first good crop did not occur until 4 to 10 years after logging. Also, in the absence of measures to control rodents, good seed crops are not complete assurance that adequate seed was available for germination.

[1]The authors are indebted to Duncan Dunning, in charge, division of forest management research at this station, for assistance in the preparation of the report. The observations reported here were started by him and have been continued under his supervision.

[2]Sugar pine, *Pinus lambertiana*, Dougl.; ponderosa pine, *P. ponderosa*, Laws. Fir refers to white fir, *Abies concolor* (Gord. and Glend.) Hoopes. Incense-cedar refers to California incense-cedar, *Libocedrus decurrens*, Torr.

[3]The data on volumes are from manuscript progress reports on methods-of-cutting plots, by various members of the California Forest and Range Experiment Station staff.

TABLE 2.—SPECIES COMPOSITION (PERCENT) OF ADVANCE GROWTH

Time of examination	Sugar pine	Ponderosa pine	Fir	Incense-cedar
Before logging	8	1	61	30
Immediately after logging	10	1	55	34
1947	10	1	54	35

Advance reproduction.—A potentially effective stand of advance reproduction was much reduced by logging. Advance growth, comprising trees less than 3.5 inches in diameter, occurred at the rate of 4,258 trees per acre. Logging destroyed 72 percent of these trees, leaving 1,205 survivors. Losses from other causes gradually reduced this stand to 935 trees by 1947. Species representation in the advance growth showed little change (Table 2).

Ground vegetation and surface conditions. — Ground vegetation and surface conditions on the quadrats which might affect the establishment and survival of natural reproduction were charted periodically. These conditions were grouped in four general classes: (1) Bare ground; (2) brush; (3) litter; and (4) logs, rocks, stumps, and heavy trash (Table 3). The term bare ground signifies merely exposure of the mineral soil. As the minimum area charted was 0.01 milacre—about 8 inches square—this classification does not necessarily denote freedom from competition. The area classified as brush was delineated by projection of the shrub crowns. The principal brush species were *Ceanothus integerrimus, C. parvifolius, C. cordulatus, Arctostaphylos patula, Castanopsis sempervirens,* and *Chamaebatia foliolosa.* Litter consisted of needles, duff, and small dead branches. Logs, rocks, stumps, and heavy trash were mapped by their areas as projected on the ground. Where these solid materials were inclined or raised, it was possible for seedlings to become established under them.

TABLE 3.—SURFACE CONDITIONS ON QUADRATS AFTER LOGGING

Surface condition	Immediately after logging	1935	1947
		Percent	
Bare ground	22	8	2
Brush	17	50	58
Litter	39	25	24
Logs, etc	22	17	16

Reproduction Since Logging

In the 18 to 24 years since logging, many fir and cedar, but very few pine seedlings, appeared on the study plots. Contrary to expectations, no wave of new pine seedlings came in after the stand was opened and the soil exposed under an apparently adequate number of seed trees. Brush soon invaded the open areas. Conditions now are unfavorable for much more reproduction.

TABLE 4.—INCIDENCE OF SEEDLINGS BY GROUND SURFACE CONDITIONS IN PERCENT OF TOTAL FOR EACH SPECIES

Surface condition	Sugar pine	Ponderosa pine	White fir	Incense-cedar	All species
From Year of Logging to End of 1935					
Bare ground	0	27	8	2	3
Brush	49	31	34	48	45
Litter	34	31	51	44	45
Logs, etc.	17	11	7	6	7
From Year of Logging to End of 1947					
Bare ground	2	18	9	1	3
Brush	54	46	45	51	50
Litter	29	26	40	41	40
Logs, etc.	15	10	6	7	7

Time of seeding incidence.—In no year did pine seedlings occur in sufficient numbers to form more than a minor part of the stand. The greatest number found in any year was only 85 seedlings per acre. Fir and particularly cedar, however, occurred at frequent intervals and in great numbers. Of the 10,092 seedlings found per acre during the period of observation, 84 percent were cedar, 13 percent were fir, and only 3 percent were pine. No doubt other seedlings died soon after germination and escaped detection in the usually late seasonal quadrat examinations. Because counts were not made every year, only the survivors of the years skipped were found. Previous studies[4] have indicated that cutworms cause large early losses, which are greater for incense-cedar and white fir than for the pines. The proportion of incense-cedar and white fir recorded probably would have been increased if complete germination counts had been possible.

Place of seedling incidence.—Considering all species together, seedling incidence was about in the order that the different ground conditions occurred. Of seedlings recorded between the year of logging and the end of 1935, 3 percent appeared on bare ground and 45 percent under brush (Table 4). For the entire period of study, seedlings were distributed among the surface-condition classes in about the same proportions as in the period ending in 1935.

Certain conditions apparently were more favorable for some species than for others. Ponderosa pine appeared more frequently on bare areas than did other species. Litter was less favorable for the pines than for cedar and fir. So few pines occurred, however, that these indications are not well substantiated.

Why so few seedlings were found on bare ground raises questions

[4]Fowells, H. A. Cutworm damage to seedlings in California pine stands. Jour. Forestry 38: 590-591. 1940.

TABLE 5.—SURVIVAL OF SEEDLINGS IN PERCENT OF INCIDENCE UNDER VARIOUS SURFACE CONDITIONS, BY SPECIES, 1947

Surface conditions	Sugar pine	Ponderosa pine	Fir	Incense-cedar	All species
Bare ground	50[1]	75[1]	32	20	36
Brush	18	22	49	30	32
Litter	25	18	38	23	25
Logs, etc.	7	0[1]	20	10	11
All conditions	20	30	42	25	28

[1]Based on very few seedlings.

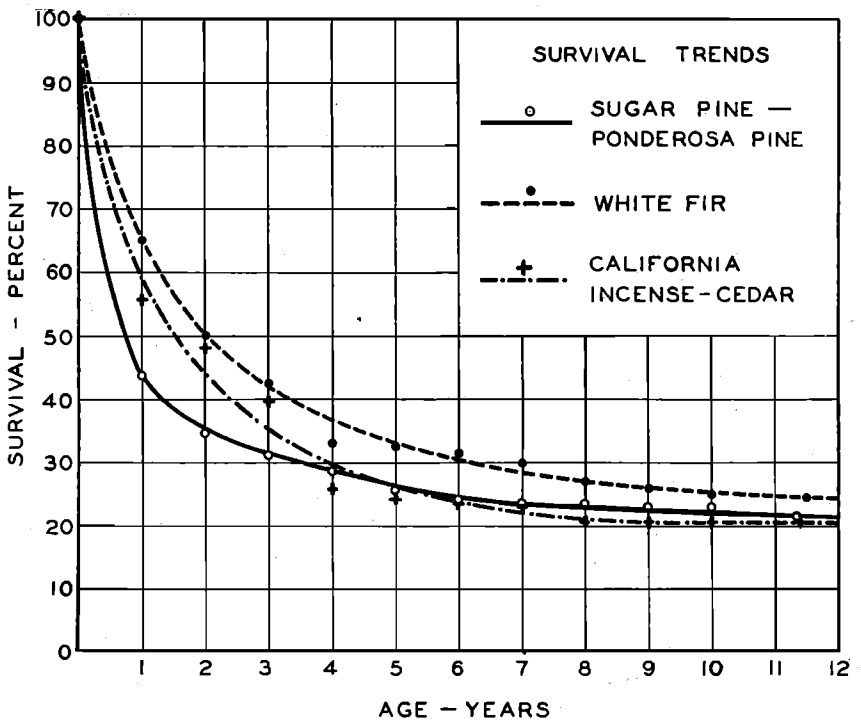

FIG. 1.—Percent of seedlings alive in successive years after germination.

which cannot be answered fully by this study, although the answers may be inferred in part. The records do not show differences in germination and early mortality between surface conditions; only a single, late-season examination was made in most years and none in some. The bare surface may have permitted germination of seedlings which did not survive to the date of examination. Located mostly in skid trails, the bare areas were heavily trampled by deer, livestock, and other animals—a rather severe treatment for any young seedling. Further, the condition of the areas classed as bare ground no doubt changed during the period of study. By the end of 1935 bare ground had decreased from 22 percent of the surface to 8 percent while brush had increased from 17 percent to 50 percent. It is possible that soil still exposed was thoroughly invaded by roots of surrounding trees and brush. Any initial advantage in favor of the bare areas, resulting from decreased competition, would have been lost by 1935. Not to be overlooked in this connection is the fact that seed—particularly pine seed—was deficient just after logging.

Seedling survival—As of 1947, survival of all seedlings found after logging was 28 percent. This rate is undoubtedly higher than actual survival because, as pointed out before, some seedlings germinated and died between plot examinations. Of the 2,749 surviving seedlings per acre, 2.6 percent were ponderosa and sugar pines, 19.6 percent were fir, and 77.8 percent were incense-cedar. During the period of 18 to 24 years, pines became established at the rate of only 70 per acre.

Conditions favored fir more than the other species. Of the firs recorded, 42 percent lived through 1947, whereas only 20 percent of the sugar pine, 30 percent of the ponderosa pine, and 25 percent of the cedar seedlings were alive at the last examination (Table 5).

Ultimate success of the reproduction perhaps is best indicated by trends in survival with age; that is, the proportion of seedlings alive in successive years after germination (Fig. 1). General averages by calendar years include seedlings of all ages and hence obscure such trends. Mortality was high in the first 2 years of life, when one-third to two-thirds of the seedlings died. By the tenth year after germination, only 22 percent of the pine seedlings, 21 percent of the cedar, and 25 percent of the fir were alive. The decline in survival had almost leveled off by about the tenth year. Long term survival apparently may be expected to range from 20 to 25 percent of the seedlings which came in during the first two decades after logging.

Seedling growth.—Growth of the seedlings was very slow. The average height for each species at the end of 5 years was hardly 6 inches. The ponderosa pine seedlings grew more rapidly after the fifth year and by the tenth year were 3 feet tall. The other species were barely more than a foot tall at 10 years. Measurements of a few cedar and fir seedlings older than 15 years showed that growth had increased after the tenth year. Apparently tree reproduction after selective cutting cannot dominate shrubs 3 to 5 feet high in less than 10 to 20 years.

The Reproduction Stand

The composite stand of advance growth and post-logging reproduction amounted to 3,680 trees to the acre in 1947. The quality and probable development of this young growth can be judged to some extent from trends in composition and dominance, and from the distribution of the seedlings.

Species composition.—Species composition changed appreciably during the period of observation. The two pines constituted 12 percent of the reproduction in 1929, but only 5 percent in 1947; fir declined from 55 percent to 29 percent in the same time (Fig. 2). These changes resulted primarily from an increase of cedar. This species formed 35 percent of the stand in 1929, rose to a peak of nearly 80 percent in 1938, and then declined to 66 percent in 1947.

Dominance.—The species composition of the dominants probably is more significant than composition expressed in terms of all seedlings. Considering as dominants the tallest seedlings in each quadrat in 1947, 49 percent of the dominants were fir, 38 percent were cedar, and 13 percent were pine. The proportion of dominant pines

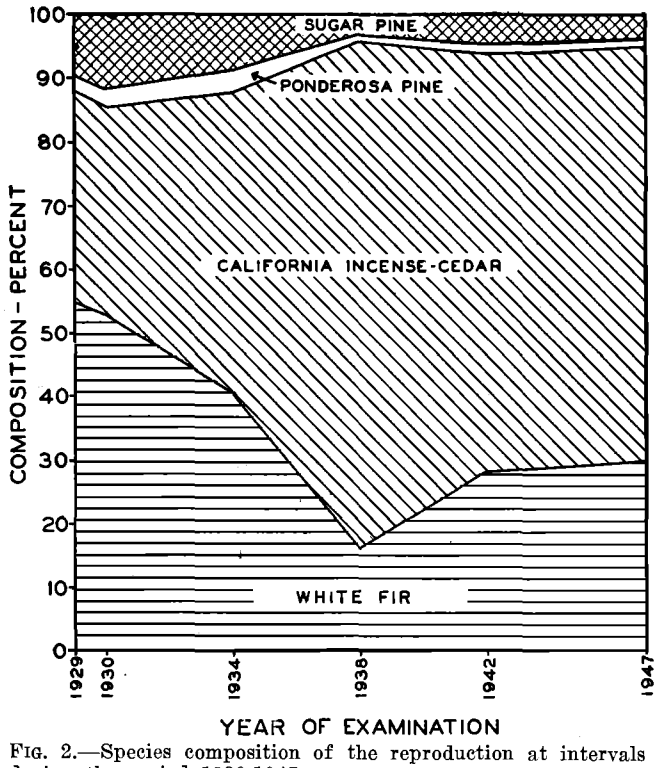

FIG. 2.—Species composition of the reproduction at intervals during the period 1929-1947.

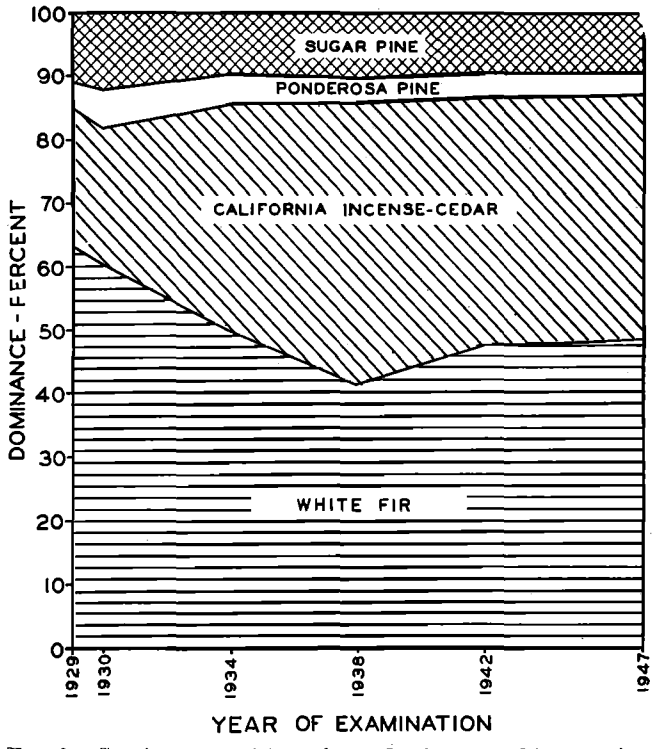

FIG. 3.—Species composition of the dominant seedlings at intervals during the period 1929-1947.

was fairly constant from 1929 to 1947 (Fig. 3). On the assumption that the dominants effectively characterize the future stand, the pine component assumes greater importance than the mere 5 percent of all seedlings would indicate.

Distribution of seedlings.—The average of 3,680 seedlings per acre does not mean that stocking was uniformly adequate. Actually, distribution was very irregular. Some 39 percent of the quadrats had no seedlings at all, and 19 percent had only one each; 21 percent had 2 or 3; and the remaining 21 percent contained more than 3 seedlings each.

Progress towards stocking to the desired standard of one tree per milacre has been slow. In 1929, 44 percent of the quadrats had at least one seedling each. By 1934, 50 percent were stocked. In 1938, after the wave of cedar reproduction, 59 percent contained seedlings. In the last 9 years, seedlings became established on only 2 percent more of the quadrats. In view of present cover conditions, it seems improbable that there will be much increase in the proportion of quadrats stocked.

Summary and Discussion

In Site I sugar pine—fir and sugar pine — ponderosa pine — fir types of the central west slope of the Sierra Nevada, seedling occurrence was recorded from 1927 to 1947, following typical cuttings. Seed trees were thought to be sufficient for adequate sugar and ponderosa pine reproduction. Pine seed trees over 18 inches in diameter were left at the rate of 3.6 per acre. One pine over 30 inches was left per acre, on the average. Seed bearing was poor in the first few years after logging but was ample for the period as a whole. Seed-eating rodents were not controlled.

In spite of the number of pine seed trees, no wave of pine reproduction followed the logging disturbance. In a period of nearly 20 years, pines became established at the rate of only 70 per acre. White fir and California incense-cedar seeded in to such an extent that pines were only 5 percent of the reproduction in 1947. A somewhat larger proportion of the dominant seedlings, 13 percent, was pine.

More than 72 percent of the advance reproduction was destroyed by logging. Of that surviving in 1947, 11 percent, or 100 seedlings per acre, were pines.

The reproduction and advance growth were not well distributed; on the basis of stocked milacre quadrats, 39 percent of the area was unstocked in 1947. Progress towards complete stocking was very slow. Brush filled the openings so that there is little hope for establishment of additional seedlings.

Growth of the seedlings was disappointingly slow; the average height attained in 5 years was only 6 inches; at the end of 10 years the pines reached 3 feet. After selection cuttings, reproduction apparently requires 10 to 20 years to overtop brush 3 to 5 feet high.

The data reported here confirm the findings and predictions of Dunning[5] over 25 years ago as to inadequacy of pine reproduction, the increase in fir and cedar, and the invasion of openings by brush. However, earlier expectations that adequate pine reproduction would gradually appear if time enough

[5]Dunning, Duncan. Some results of cutting in the Sierra forests of California. U. S. Dept. Agric. Bul. 1176. 28 pp illus. 1923.

elapsed, are not confirmed. After 20 years, it seems unlikely that pine will continue to filter in and become dominant, forming a larger proportion of the stand. Either retreatment to encourage natural seeding or partial planting probably will be necessary to restore pines in desirable proportions.

Silvicultural methods for the mixed-conifer types must be modified if natural reproduction is to produce desirable stands in periods short enough to permit intensive forestry. Modifications designed to improve regeneration are now being tested by the California Forest and Range Experiment Station[6] and the administrative branch of the Forest Service.

[6]Dunning, Duncan. *In*, A sugar pine regeneration cutting experiment. West Coast Lumberman 76:62, 64. 1949.

A Summary of Forest Taxation Laws by States

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FOR MANY YEARS it has been recognized that forest properties have certain characteristics which in many cases demand for them special tax laws in order to distribute equitably the tax burden among all types of property. Several forms of special taxation or other legislation have been suggested and attempted. The merits of these various forest tax principles have been written and discussed at length and no attempt will be made to do so here. The intent of this paper is to indicate to what extent the various forms of forest tax laws have been applied by state governments.

Questionnaires were sent to state tax commissions and state foresters requesting information in regard to any special legislation in force or recently enacted with respect to forest properties. In many cases copies of the laws or reports in connection with them were returned. Using the above sources and the *State Forest Tax Law Digest of 1945* prepared by the Division of Forest Economics, U. S. Forest Service, it was possible to compile a table of the forest tax laws (Table 1), if any, for all of the states as of December 31, 1949.

This table is published as a general source of information on state tax laws applying specifically to forest property. The points of interest in each law are outlined only briefly. The provisions are in no way to be considered official in any state. Copies of the laws may be obtained by writing to the Sate Tax Commission of any state in question.

With the advance of forest management in the United States, more and more forest land owners have been able to determine precisely the effects of the usual property taxing methods upon the business of growing and harvesting timber. States in which privately owned forests and their products are a major part of the economy have made the most rapid advances in the search for equitable taxation of these extraordinary types of investment and earning power. Due to the demands of the forest owners and in order to preserve this important part of the economy these states were compelled to make tax adjustments. The important timber growing states in this category are Washington, Oregon, Idaho, Alabama, Louisiana, Mississippi, Connecticut, Massachusetts, New Hampshire, New York, Michigan, Minnesota, and Wisconsin. It may be noted in the Table 1 that these states have enacted laws specifically intended to ease the tax burden on the forest owners, mainly by taxing lightly until a harvest of products enables them to pay their just share.

Numerous states in which timber is a less important part of the economy or in which most of the forest land is government-owned have other forms of special tax laws originating in the theory that tax reductions are a force in furthering resource conservation. These states have made tree culture almost tax free or even profitable for the land owners. The names of the special laws in these states are exemption, bounty, fixed assessment, and differential assessment as described in the table.

Other states have passed tax laws for the specific purpose of obtaining revenue from forest products to aid in fire protection and in other conservation measures undertaken by the state governments. These laws are not listed in the summary.

It may be concluded from this brief analysis that the important factors in determining what forest tax law has been applied in each state are the condition of the forest properties, types of land ownership, and the other characteristics of the forest economies of each individual state.

[1]The author wishes to express his appreciation to Robert F. Keniston of Oregon State College under whose guidance this study was undertaken.