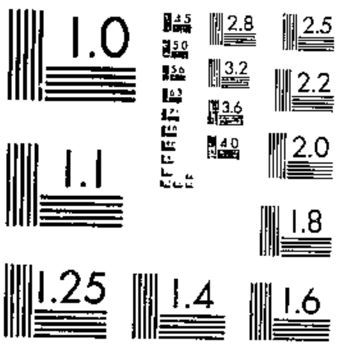
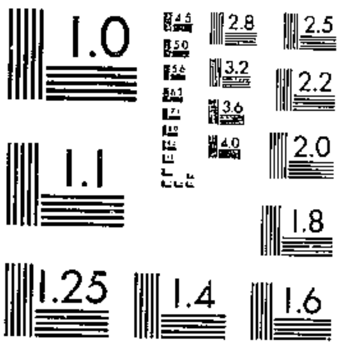
START



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TECHNICAL BULLETIN No. 283 MARCH, 1932

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

TIMBER GROWING AND LOGGING PRACTICE IN THE COAST REDWOOD REGION OF CALIFORNIA[1]

By S. B. SHOW

Regional Forester, California Region, Forest Service, United States Department of Agriculture

Introduction by R. Y. STUART, *Forester*

CONTENTS

INTRODUCTION

Forestry in the United States is no longer merely a theory or a subject for discussion; it has got down to concrete things in the woods. Nor is the growing of timber confined to public lands; it is gradually making headway on land in private ownership. It is becoming an art of land management, expressed in practical measures for protecting forest growth from fire and other destructive agencies, for logging timber so as to produce a new crop of wood, and for planting forest trees on cut-over or denuded areas. The value of timber, along with other economic considerations, is causing landowners more and more widely to study the possibility of profitable reforestation. These developments have created a general demand for information on timber-growing methods which are adapted to the various types of forest growth in the United States, and what these methods will cost.

Timber culture, like the growing of farm crops, is necessarily governed in any country by the soil and climate, by the requirements of the native forest trees, and by the national economic circum-

[1] The work on which this bulletin is based was done a number of years ago at the time when extensive planting on cut-over redwood lands was beginning. The manuscript prepared for publication at that time has been revised to include new data obtained by various investigators during the last five years. Major conclusions reached in the original investigation have not been materially modified.

85046°—32——1

stances. Lessons may be drawn from the experience of other countries, as the United States has drawn upon the forestry practice of Europe, but profitable methods of growing timber, particularly under the wide range of forest types and economic conditions in the United States, can be evolved only from our own experience and investigation, region by region. Hence, to meet the demand for information on practical ways and means of growing timber profitably in the various parts of the United States, it is important that the results of our own experience and investigation to date be brought together and set forth in the clearest possible way.

This the Forest Service has attempted to do in a series of publications dealing with the 12 principal forest regions of the United States. The information presented has been gathered from many different sources, including the experience, as far as it was obtainable, of landowners who have engaged in reforestation. An effort has been made to bring together all that any agency has yet learned or demonstrated about the growing of timber in the United States; and the results have been verified as far as possible by consultation with the forest industries, State foresters, and forest schools. These publications thus undertake to set forth in a simple form what are believed to be the soundest methods of reforestation as yet developed in our common experience and study in the United States.

Necessarily, the Forest Service claims no finality for the measures proposed. Timber growing in every country has come about through a gradual evolution in industrial methods and the use of land. All too little is yet known of the best methods of growing timber under American conditions. As time goes on, research and practical experience will add greatly to the success and certainty of the measures carried out in our woods; just as American agriculture has steadily become more highly developed, or just as our manufacturing processes have been perfected through experience and study. But we know enough now about growing timber in the forest regions of the United States to go right ahead. Believing that the forest landowners of the United States are ready to consider timber growing on a large scale, the Forest Service has endeavored to place before them in concise terms the best suggestions and guides which the experience of this country to date affords.

In these publications the measures proposed for a particular forest region have been arranged in two general groups. The first includes the first steps, or the minimum measures based on local physical conditions, that are needed to prevent timber-bearing lands from becoming barren. The second group of proposed measures constitutes what may be called the desirable forestry practice in the region concerned as far as our knowledge and experience to date enable us to determine it. These measures are designed to grow reasonably complete crops of the more valuable timber trees, making full use of the real productive capacity of the land. The recommendations are addressed primarily to the landowner who wishes to use his property up to its full earning power for timber culture. As Mr. Show will make clear in this discussion of the present status of timber growing in the redwood region, redwood operators and landowners are by now fairly well committed to a policy of keeping their lands productive. In this region, therefore,

there is no great need to urge minimum measures, such as will prevent denudation of timberland. Show has rather concentrated on a common-sense résumé of the various steps involved in a policy of intensive timber growing, such as the high timber yields in this region will warrant. His bulletin has been written primarily for the landowner and operator, to whom timber growing is a concrete business and logging problem.

It is impossible for a publication necessarily dealing in broad terms with the conditions existing over a large region to attempt any brass-tack conclusions on the cost and returns of timber growing. The approximate cost of the measures advocated is indicated as far as practicable and the extent to which they may be of benefit in connection with logging operations, but no attempt is made to segregate the items chargeable to harvesting one crop of timber from those which should be regarded as invested in a following crop. Conservative estimates of the future yields of timber that may be expected under the various practices recommended are given where the facts available appear to warrant them; but no forecasts of the profits to be derived from commercial reforestation are attempted. The financial aspects of forestry can not be dealt with in general terms. Here again expert advice must deal with the situation and with the problems of the individual forest owner or manufacturer.

As a broad conclusion, however, with the exception of limited situations which are dealt with region by region, the Forest Service has tremendous faith in the commercial promise of timber growing to American landowners. In the long-time pull, the law of supply and demand will work to create timber values which in large portions of the United States will pay fair returns on forestry as a business. The economic history of other countries that have passed through a cycle of virgin-forest depletion similar to that which the United States is now traversing points to the same inevitable conclusion. The time is fast approaching when forestry, and forestry alone, will supply the enormous quantities of wood demanded by American markets. The fundamental laws of business must in the nature of things so operate as to enable the markets of forest products to be supplied at a profit to the grower of timber. The returns already being obtained from this form of land employment at many points in the eastern United States show plainly enough that this relationship between the value of timber and the cost of producing it is already coming about to a marked degree.

To the men who own forest-producing land in the United States, or are engaged in industries which require raw material, forestry now, barring periods of wide-spread depression, offers a commercial opportunity in many localities. Satisfactory returns from forestry can not be promised in sweeping terms any more than returns from the manufacture of lumber or paper. But the opportunity for a profitable employment of capital and business talent in the growing of timber merits the same consideration and the same expert guidance as industrial opportunities in the conversion of timber. This applies with special force to the commercial institutions in the United States which have made large capital investments in manufacturing plants and distributing organizations, dependent for their mainte-

nance upon a future supply of forest-grown material. It applies equally to the owners of land in large tracts or farm wood lots, the earning capacity of which lies solely in the growing of trees, and which without tree growth will become either a doubtful asset or an outright liability.

During a period of pronounced depression, it is natural that new ventures, such as systematic timber-growing, should be accepted slowly by lumbermen. In this respect the lumber industry does not differ from other major industries. The imperative business need at such a time is for curtailment of expenditure, rather than expansion. The current condition of the forestry enterprise in the redwood region reflects this necessity. But it is doubtful whether the vigor of the forestry program already under way will be permanently blighted. Rather it is to be expected that a careful appraisal of methods previously used will be made and new methods offering promising possibilities will be studied.

The fundamentals necessary for successful forestry ventures by private owners remain unchanged—rapid growth, intrinsically valuable species, and accessibility to permanent markets. The means suggested in this bulletin for capitalizing these fundamentals are deserving of study and test by the individual landowner. Timber-growing practices in the redwood region have not yet been tested for a long enough time to justify broad and categorical conclusions. The need still exists for trying a variety of methods, and studying carefully just what each accomplishes. Some degree of uncertainty regarding the exact outcome of each method should not, however, obscure the basic fact that positive attention to timber growing will undoubtedly yield positive returns that would not otherwise be obtained.

The redwood region, moreover, still has such large areas and volumes of virgin stumpage, that abundant opportunity remains to place the industry as a whole on a sustained-yield basis, without curtailment of existing cut. This fortunate fact further adds to the attractiveness of the private-forestry venture.

The Forest Service earnestly asks the forest landowners of the United States to determine for themselves, with the same care with which they would approach any other business problem, whether timber growing does not offer a commercial opportunity which should be grasped. It commends this series of publications to them, not as a complete or authoritative scheme that can forthwith be followed with profit in their own woods, but as a starting point in utilizing the opportunities that forestry may hold out.

R. Y. Stuart.

STATUS OF TIMBER GROWING IN THE REDWOOD REGION

Decided progress has already been made in timber growing in the redwood region. Operators have carried the practice much further there than in most other regions in the country (*9*).[2] The chief reason is that the soil and climate and the characteristics of the principal tree of the region all favor rapid growth and large yields of timber.

[2] Italic numbers in parentheses refer to Literature Cited, p. 21.

As logging has progressed and the area of virgin forests diminished, redwood operators, like operators in other regions, have recognized that they were becoming to an ever-increasing extent holders of cut-over land, and engaged in what might be called "the cut-over-land business." That is, they were acquiring as a by-product of the lumber-producing business a great deal of land producing no immediate revenue and potentially of value chiefly, and in many instances solely, for forest growing. They found, however, that, except in instances of unusual abuse, their cut-over land would renew its growth of redwood to an appreciable extent and in a remarkably short period of time without any assistance from them. If an owner wished to invest in a second timber crop, the cut-over land would go at times as much as a third of the way with him, leaving but two-thirds of an extremely quick and profitable crop dependent upon his own efforts.

This situation, as long ago as 1920, induced a number of operators to investigate the possibilities of profitable timber growing, including the advisability of trying to obtain fully stocked stands of second growth, and the chances of being able to incorporate their cut-over lands in a system of continuous timber production and permanent logging operation. They found that, although much basic information was and is lacking regarding the redwoods and associated species, the more immediately important silvicultural facts were fairly self-evident, or at least were discernible after short study; and on the strength of these data they did not hesitate to make plans involving considerable investments in the growing of future timber crops.

By 1922, the redwood operators were, as a group, committed to the handling of their cut-over lands for fairly continuous timber production.[3] Owners representing about 70 per cent of the production had by that date started definitely to restock and to protect their lands, in the endeavor to obtain full stands of young growth and to remain permanently in the lumber business. The forestry program took the form of planting, plus fire control, on cut-over areas. For a number of years, until about 1928, the output of the several large redwood nurseries ran up to several million trees a year, and during that time approximately 25,000 acres of old and new cut-over land were planted (*12*).

From 1928 to 1931 financial depression and possibly other factors caused a substantial curtailment of planting operations. In addition, the economic depression of 1930–31 compelled the operators to give attention to improvement of logging methods and resulted in detailed studies of logging costs. In these studies the primary purpose was to determine what trees and logs are handled at a profit, or at least at no loss, and to increase the net return from lumber through changes in cutting and log-selection practices.

The detailed results of these studies are not yet available, but apparently they follow the general pattern of similar investigations in other forest regions, indicating the economic undesirability of cutting the smaller trees. A change of cutting practice to leave such

[3] In a mimeographed report entitled "California Redwood," circulated in 1922 by six lumber companies in the redwood region.

trees will, of course, automatically introduce a form of selection cutting including the leaving of many more seed trees than heretofore.

With the excellent yields possible in the region, there can be little question that intensive timber growing to produce full timber crops will be more profitable than any halfway measures. And this appears to be the present common understanding among the operators. The adoption of definite plans for reforestation with the principal emphasis on planting, the employment of foresters to direct such work, and actual planting on a considerable scale—all point to an intention to strive for the greatest possible return from the investment.

While concentrating, however, on methods and practices to keep cut-over lands fully productive, the industry has not on the whole given enough attention to the other half of a complete forestry program—the adjustment of annual cut to what the land can be expected to produce. Systematic planning for sustained yield is just as necessary in the long run as is the commendable attention given by the industry to the condition of cut-over lands.

The emphasis of this bulletin will be laid on the measures necessary to obtain full timber crops in the redwood region, taking into consideration the chief characteristics of the region and its forests, and the condition of the forest lands as a result of past and present methods of handling them. Much information of importance to the operators is yet to be gathered; the endeavor here will be to present all that is available and to define as completely as possible the lines of further research that must be followed by private and public agencies as rapidly as opportunities are presented.[4]

CHARACTERISTICS OF THE REGION AND FORESTS

The redwood region is a narrow, irregular strip along the Pacific coast, running from Del Norte County, near the Oregon State line, southward through Humboldt, Mendocino, Sonoma, Marin, San Mateo, and Santa Cruz Counties to a point some distance south of San Francisco Bay, where it finally pinches out. This is a region of frequent fogs and favorable soil; and, indeed, its breadth of 35 miles and less is sharply defined throughout, on the east by the ridges that stop the ocean fogs, and on the west by the sandy soil of the immediate coast line, where redwood and its associates will not grow.

The original redwood area, according to Forest Service estimates, was 1,454,000 acres, of which, by 1925, 543,000 acres had been cut over, leaving 911,000 acres of virgin timber. Of the cut-over land, about 143,000 acres has been put to agricultural use or has been denuded. Approximately 400,000 acres is producing timber in some degree (*8*).[5]

---

[4] Acknowledgment is made to Donald Bruce and Woodbridge Metcalf, formerly professors in the University of California Forest School, to Emanuel Fritz, professor in that school, and to D. T. Mason, consulting forest engineer, for many of the data employed in this bulletin. Their findings are in all instances corroborated by research of members of the Forest Service.

[5] The reference in this instance is to an independent estimate made by Mason in 1922, which placed the remaining area of virgin forest at 960,000 acres, and the total virgin stand at 60,000,000,000 feet, board measure, of which 50,000,000,000 was redwood. An independent determination of cut-over areas by A. N. Weber (1925) places the total at 427,810 acres, but this does not apparently include all of the area of cut-over land that has been cleared for agricultural use. The same author gives 841,251 acres as the total of virgin timber left in Del Norte, Humboldt, Mendocino, and Sonoma Counties in 1925.

The average rate of cutting up to 1925 was about 600,000,000 board feet a year, representing 10,000 acres of mature forest. The indications are that this output will not be rapidly increased, and it is accordingly estimated that many of the operators have a sufficient reserve of merchantable timber to last 40 to 50 years, or until second growth becomes large enough to cut. Also, there are several large holdings on which operations have not yet started. Conditions in the region are in fact extremely favorable for intensive timber growing as a definite part of a permanent timber business.

COMPOSITION OF THE FORESTS

For the purposes of this bulletin the redwood type and the redwood region are held to be identical, and distinctions in treatment because of type differences are regarded as unnecessary. The virgin redwood forests show, however, a considerable variety in composition. Generally, redwood (*Sequoia sempervirens*) is mixed with other species, including Douglas fir (*Pseudotsuga taxifolia*), lowland fir (*Abies grandis*), Sitka spruce (*Picea sitchensis*), and western hemlock (*Tsuga heterophylla*) as the most important conifers; and tanbark oak (*Lithocarpus densiflora*), California-laurel (*Umbellularia californica*), and red alder (*Alnus rubra*) as the most important hardwoods.

Redwood is rarely found in pure stands, save on those partially stocked cut-over lands where powerful logging machinery and repeated fires have destroyed all seed trees of Douglas fir and associated species.

Douglas fir occurs throughout the entire region as the principal associate of redwood, gradually increasing in importance at greater distances from the coast, until on the eastern edge of the redwood belt it becomes the principal species and the forest type changes to Douglas fir with only an occasional redwood.

Lowland fir and hemlock, absent in the southern portions of the range, are of considerable importance in Mendocino, Humboldt, and Del Norte Counties, and Sitka spruce is important in the last two counties. Here pure stands of Douglas fir or of spruce, or of the two in mixture, are not uncommon. In the sandy soil of the immediate coast pure stands of Bishop pine (*Pinus muricata*) prevail.

Next in importance to the associated softwoods is tanbark oak, a hardwood of established value as a source of tanning material. Tanbark oak will be present in the new forests, for it has sprouting ability, but whether to the extent of being a material factor in raising the degree of stocking on intensively managed cut-over lands is as yet uncertain. The prejudice among operators generally against second-growth tanbark oak is almost certain to be removed in time, for with the disappearance of eastern chestnut, which has furnished over half of the domestic tanning material, tanbark oak will offer new possibilities. Experiments by the Forest Products Laboratory prove the technical qualities of the wood to be high and the obstacles to its proper seasoning to be by no means insurmountable.

YIELD CAPACITY OF REDWOOD LANDS

The opportunities for private timber growing in any region depend above all on the growth rate, and in this respect the redwood lands

are exceptional. Redwood at an early age reaches a size which is considered merchantable in most forest regions. On Site I (the best sites) at 20 years of age the average redwood is 8 inches in diameter and 51 feet high. On Site II (good sites) at 25 years of age the average tree is 9 inches in diameter and 53 feet high. At this rate of growth the probable cutting rotation for the redwood timber crop will usually be 50 years or less. Within 50 years a satisfactory merchantable forest will be produced. Moreover, the wood, though consisting largely of common lumber and railroad ties, will be comparable in quality to similar grades from old-growth timber. Short rotations are anticipated at first because of the financial desirability of an early second cut. As land policies are worked out, however, the probable tendency will be to hold stands longer for the quality and price increment.

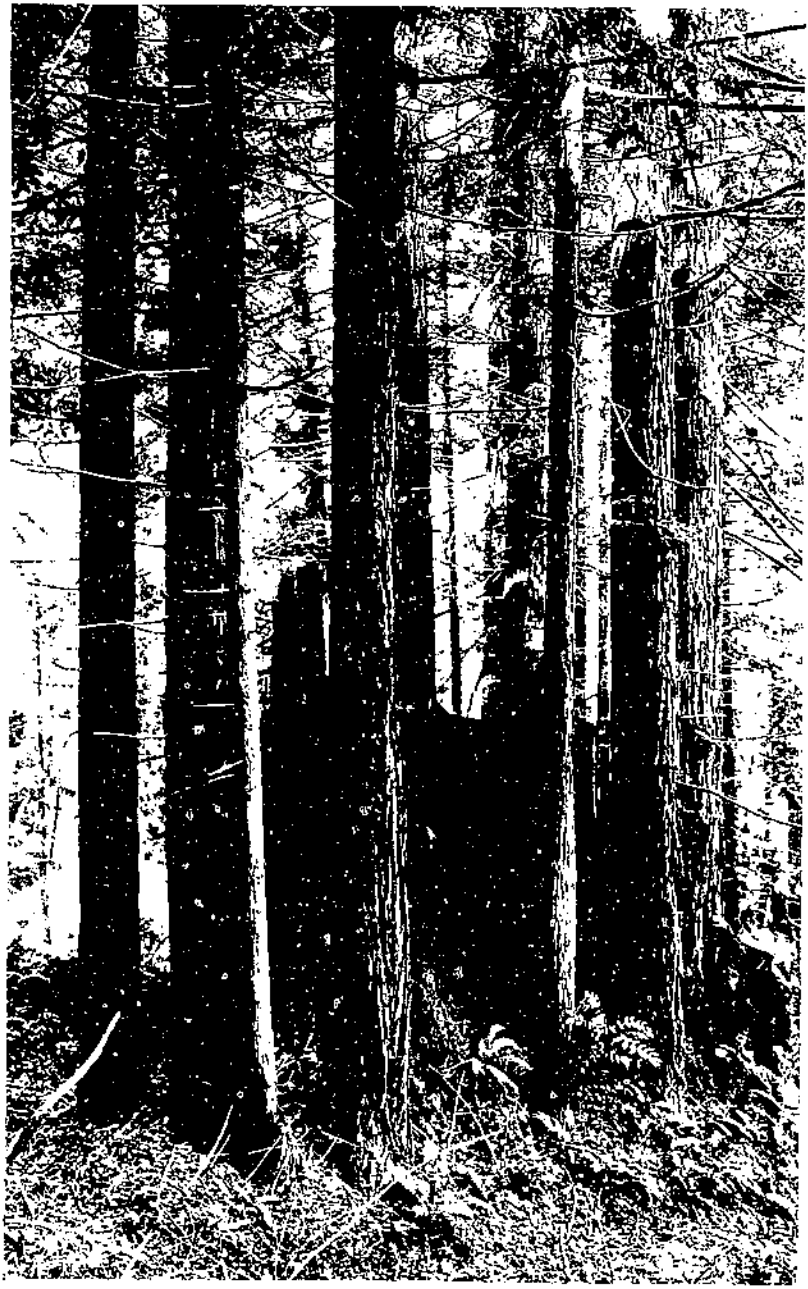
The yields of fully stocked forests in this region (*2*) exceed anything known among other American conifers, even surpassing the Douglas fir of the Northwest (*7*). At 50 years of age the yield of full stands of second-growth timber is 116,000 board feet per acre on the best sites (Site I). This is the estimate by the Clark international rule, which gives 95,000 board feet to the acre on good sites (Site II) and 76,000 feet on medium sites (Site III). A mill tally of the trees from a typical second-growth stand shows that by careful sawing these yields can be attained to within 3 or 4 per cent. Even if measured by the Scribner decimal C rule, which underruns seriously when applied to small timber, the indicated yields at 50 years of age for these three sites would be not less than 80,000, 65,000, and 50,000 board feet to the acre, respectively.

Poor sites (Sites IV and V) probably occur here and there, but most of the region is rated as Site II or III.

Because of the ability of redwood to sprout, the minimum stand obtained after cutting is not less than 25 per cent complete, except where repeated fires have occurred. (Pl. 1.) Often the stand is as much as 35 per cent complete. Such a stand will cut 20,000 to 35,000 board feet an acre at 50 years. Associated species, except hemlock, grow as rapidly as redwood, at least up to 50 or 60 years, and where seed trees of such species as Douglas fir are left to seed in part of the cut-over land, stands from 60 to 80 per cent complete can be counted on to yield 45,000 to 80,000 board feet per acre. Indeed, mixed second-growth stands commonly yield as great a cut as do pure redwood forests. Even pure stands of Douglas fir in the redwood region produce as much lumber as does redwood. In utilizing fully the remarkable growing capacity of the forest land, pure or mixed stands are equally valuable.

Although the virgin redwood forest is commonly said to be thousands of years old, nothing is further from the fact (*4*). On the contrary, the forest is many aged, approaching a true selection forest in character. On one 30-acre plot, for example, the following very wide range of ages above 200 years was found:

Age class	Number of trees	Age class	Number of trees
201 to 300 years	108	701 to 800 years	38
301 to 400 years	89	801 to 900 years	34
401 to 500 years	81	901 to 1,000 years	31
501 to 600 years	102	More than 1,000 years	17
601 to 700 years	67		



REDWOOD SPROUTS ASSURE PARTIAL REFORESTATION F 1799

Sprouts bring an element of hope for new stands of timber. Groups of redwood sprouts such as this surround the parent stumps and their rapid growth soon makes it evident that partial restocking is assured. Within 40 or 50 years after the virgin forest is cut, provided fire is kept out, a partly stocked forest will be ready for the ax. The main immediate problem of timber growing in the redwoods is to supplement this sprout forest with other trees of valuable species, either by planting or natural reproduction. Only thus can a full timber crop be obtained from the land

F159281 F159280 F191460

THREE CHAPTERS IN THE STORY OF REDWOOD REGENERATION UNDER PRESENT CUTTING CONDITIONS

A, In accordance with custom the trees have been felled and the area broadcast burned before skidding; all young trees have been destroyed; redwood sprouts will appear in scattered clumps but other species grown from seed will be absent; the result will be far below the yield of the dense virgin forest shown in the background. B, The area under skidding shows little promise for the future; in spite of the desolation caused by the slash fires a quantity of débris remains as fuel for later fires. C, Finally the scattered clumps of redwood sprouts reclaim the land, but unaided will yield something less than one-third of the possible timber harvest; the planting crew is filling in the larger gaps with planted redwood; the result will be a single-species, limited-use crop that is little justified either silviculturally or commercially.

As a forest, the typical virgin redwood stand is not overmature, but has a wide representation of age and size classes. It is in fact a true selection forest. Because of this fact, and because of the ability of redwood to live and to continue growth to a great age, the redwood selection forest appears to afford a natural and inviting opportunity for some form of selection cutting.

IMPORTANT FACTS ABOUT NATURAL REPRODUCTION

The basic facts about natural reproduction in the coast redwood region of California may be briefly summarized as follows:

Advance reproduction is not a factor in restocking cut-over redwood lands; the new forests, both of redwood and associated species, start after logging.

Redwood sprouts from the stump when cut at any season of the year. In most cases the sprouting ability is not lost even in extreme old age. Redwood stumps sprout repeatedly if the sprouts are killed back, though this ability may in time be lost.

Redwood reproduction from root suckers is not of material importance on the slopes, which constitute probably over 90 per cent of the present timbered area of the region.

Except on moist flats constituting only a small percentage of the total area, extensive fully stocked second-growth stands of pure sprout redwood do not and will not occur. As has already been stated, sprout stands of redwood under favorable conditions average from 25 to 35 per cent fully stocked.

Redwood bears seed abundantly, but seedling reproduction is found only under a very narrow range of conditions, such as the combination of fresh mineral soil on cut-over and burned-over lands near a cutting edge; that is, where virgin timber adjacent to cut-over lands has afforded protection. On most cut-over areas examined all redwood second growth was obviously from sprouts.

On the contrary, Douglas fir reproduction from seed is equally and widely distributed; and, because of the ample moisture, mortality of seedlings is low. Apparently this reproduction comes from seed trees remaining after the logging operation. Examination of many cut-over areas has revealed reproduction from seed trees now alive as well as from trees which were wind-thrown some years after logging. This reproduction is sometimes as far as one-quarter of a mile from the seed trees.

EFFECTS OF PAST AND CURRENT TREATMENT OF FOREST LAND

CUT-OVER LAND

Until about 1919 little attention was paid to cut-over land as being in any sense forest land. Indeed, throughout the history of redwood logging, cut-over lands have been regarded both by lumber companies and by ranchers as potential farm or grazing lands, chiefly valuable for anything but timber production. This attitude was evident in repeated burning to prevent perpetuation of the forest.

Certain areas originally heavily timbered with spruce, chiefly flats or rolling lands along the coast, have been turned into profitable farm lands of high quality, and on the redwood slopes much feed has been raised on cut-over lands. Such success has encouraged

attempts at more general exploitation of these lands, and it has been characteristic for operators in the past to sow grass seed on cut-over lands immediately after yarding was completed. Excellent feed for stock for a few years was thus obtained, but within two years after logging brush usually appeared and spread rapidly. Such areas were frequently reburned in a fruitless attempt to control the brush.

It has become evident that the redwood region, unlike the pine region, does not take kindly to grazing land and timber production on the same areas. Grazing soon becomes impossible if cut-over lands are protected from fire, and the burning that is intended to make grazing possible wipes out reproduction of all nonsprouting species and frequently destroys also the source of the seed. Burning has also had the effect of inducing erosion, which in turn has probably reduced soil fertility and the rate of growth of new forests. Thousands of acres of the older cut-over redwood lands which were burned after logging are covered with a dense stand of brush and have but 15 to 35 per cent of a full stand of redwood.

The significant fact for redwood-land owners is that their property, except for a negligible area of deep-soil flats, has a greater value for timber growing than for any agricultural use. The cost of seeding cut-over lands for grazing varies from $3 to more than $10 per acre, with an average of about $6. The amount of feed obtained thereby is relatively small, and the practice represents a low type of agriculture.

A study by A. N. Weber (1925) showed that on an average it required 35.4 acres of cut-over land to furnish grazing for one cow for one year. The average annual rental value for grazing is only from $0.09 to $0.15 per acre per year. The carrying capacity for sheep was found to be one head to 3 to 5 acres.

W. T. Clarke, of the University of California College of Agriculture, after an intensive study of the agricultural possibilities in this region (*3, p. 185*) says:

> There are serious handicaps to successful agriculture in cut-over redwood lands. These handicaps are so great that in a very large portion of the area the use of the lands for ordinary agricultural purposes would be an economic blunder.

He says also (*3, p. 186*): "The farmer of such lands will meet many extraordinary difficulties not present in ordinary unforested agricultural sections."

In support of such statements is the fact that clearing these lands of brush and stumps has cost up to $400 an acre, and the clearing of stumps up to 2 feet in diameter has cost $150 an acre. Very little land in the region, in Clarke's opinion, can possibly justify such expenditures.

That such facts are now appreciated is evident in the operators' efforts to grow timber on the land left after logging. With the adoption of plans for restocking these acres, operators have generally abandoned the old traditions of repeated burning after logging.

LOGGING AND SLASH DISPOSAL

Except locally and in the early days, machinery has been used almost entirely in logging in the redwood region. The extraor-

dinary size of the timber and the steepness of the country except the relatively small flats along streams and near the coast have both made power logging necessary.

As in the pine region, logging engines have developed rapidly in the evolution of power and line speed, and several new methods of logging have been extensively used, particularly in recent years. The high-lead method, in which the main lead block is placed on a spar tree up to 200 feet high, is commonly employed. Several variations of the sky-line method, such as that in which logs are transported by an underslung trolley on a fixed line anchored high above the ground at both ends, are also in use. More recently the caterpillar tractor has been used in yarding.

The general practice is to clear-cut redwood and to leave much of the Douglas fir and most of the white fir standing. Cutting of these other species varies with market conditions. Usually some of the uncut trees are smashed in falling the redwoods, and others in yarding. Those that escape are a valuable source of seed if they can be saved through later steps in logging. It is probable that the systems of yarding now in use need not in any instance be fatal to seed production on these areas, if reasonable care is exercised in the conduct of the operation. It is doubtful if falling and yarding at their worst are ever so destructive to the seed trees as is the general custom of slash disposal.

Timber is felled usually months, and often a year or more, in advance of yarding. In current practice, after falling and limbing are completed, most companies peel the logs and then fire the enormous accumulations of bark, limbs, and tops while the logs are still on the ground. (Pl. 2.) This practice results in serious loss of merchantable material, for much of the sapwood and big chunks of shattered but merchantable logs are burned. The loss is placed by competent observers at 15 to 40 per cent of all merchantable material, averaging 25 per cent. The delay in yarding commonly results in serious deterioration of the sapwood of the Douglas fir, amounting in many cases to unmerchantability.

In addition to the loss in merchantable timber must be reckoned the Douglas fir trees which would have survived falling and yarding. Many of these and sometimes all are killed by the slash fires, which are commonly set at the foot of slopes and spread uphill with terrific heat. These fires seem to be employed in most instances to an unnecessary degree, and in a needlessly destructive manner. Nor are they entirely effective, for a very large accumulation of débris remains on the ground after yarding, offering fuel for subsequent fires.

In a few instances an effort has been made to improve on these practices. On some operations the burning is done before peeling, in order that the bark may protect the wood. This is preferable in that there is less actual loss of timber; but some loss is still evident, and the damage to seed trees is of course the same. Only one operation has been noted so far on which an effort has been made to yard without burning (5). In general it may be said that the current logging methods, though efficient in getting logs out cheaply, frequently leave so few seed trees that full or nearly full stands of new growth can not be expected without planting.

The development of a process, now about to be put on the market, for the manufacture of pressed board and insulation board from redwood bark will change radically the apparent need for wholesale slash burning. To use the bark most efficiently it must be brought to the mill on the log, and fire must be kept out of the woods prior to yarding.

Caterpillar tractors have recently been employed in conjunction with donkey engines in the region, and the results give some indication that logging costs can be reduced materially thereby. If further study proves such reductions to be possible, the result may be to decrease the apparent need for wholesale use of fire in advance of yarding.

MEASURES NECESSARY TO PRODUCE FULL TIMBER CROPS

Many phases of intensive timber growing for full crops demand more study than it has as yet been possible to give them. These include consideration of how to complete the open and scattered stands on the older cuttings when dense brush has come in; whether to work for pure stands of second-growth redwood, or for mixed stands of redwood, fir, and spruce; and how to handle the valuable tanbark oak in the new forest, both as a source of tanning material and for lumber. All these require answers in the near future.

It is, however, already obvious that, to capitalize fully the remarkable productive capacity of the redwood lands and to obtain full stands promptly after logging, the landowner must take active measures to assist the natural processes of reforestation. Also, the general outline of the measures necessary is not difficult to trace.

As has been shown, young growth required to complete redwood stands can be obtained by saving seed trees of associated species, by planting with nursery stock, or by a combination of the two methods. Planting is the solution generally favored by the redwood operators; but the alternative possibility of saving the needed seed trees through more careful logging operation and protection from fire is attractive, because of the possibility of much lower cost.

FULL STANDS BY PLANTING

As a means of closing the gap between the partial forests which follow current logging methods and the complete stands which give the largest return to the operator, planting is the method which has been given the most thorough test.

In deciding whether the safer course is to use redwood as the principal planting species and so to develop large areas of nearly pure redwood, or to employ fir and spruce as well and so to continue the present mixed stands, the experience of other countries may be a guide. Experience with spruce in Saxony indicates how disastrous may be the results of creating pure stands on the lands formerly occupied by mixed forests. Wholly unanticipated disasters from insects and diseases have overtaken such artificial forests, and an even more unfortunate result has been that the soil itself has deteriorated to a serious degree. Although it is only by experience that the future of extensive pure stands of redwood in this country can be determined, the results abroad at least indicate the need for caution. Another consideration of interest to the operator is that redwood lumber is

not suited for all uses and that Douglas fir is a general utility species. By continuing to produce fir, the redwood operator will avoid the dangers of a single-crop market.

In the long run, it would appear that fairly high percentages of Douglas fir, spruce, and lowland fir can well be retained in mixture with second-growth redwood. All are valuable, and the possible dangers of disaster to pure stands are sufficiently great to be seriously considered. Port Orford cedar, western red cedar, and California-nutmeg should also be tested; likewise, the possibility and desirability of growing hardwoods, particularly tanbark oak, as an integral part of the new forests.

The technic of raising nursery stock and of planting in the redwood region, although not yet completely worked out, has had the advantage of considerable preliminary work (*11*). Further, the results of eight years of experience with large-scale planting (*12*)[6] now give a fair indication of the costs of planting and of survival under different conditions. The comprehensive data obtained by the Forest Service in the Douglas fir region are also available and may in large measure be applicable in the redwood region (*6*).

In large-scale redwood plantations about 500 trees per acre on an average are set out, the range being from 350 to 740. The average costs of planting stock are: For 1–0 stock, $7.50 per M; for 2–0 stock, $9; for 1–1 stock, $10. Some companies have used seedling stock (1–0) almost entirely; others have used all or principally transplant stock (1–1).

Planting labor cost has varied from $2 to $3.50 per acre, the average output per man-day varying from 400 to 800 trees, depending on the class of stock and the character of planting area. Additional costs of $2.50 per acre, including supervision, surveying, preparation of area, and overhead, bring the total cost per acre to $7.50 to $10. Those who have handled the large-scale jobs believe some further reductions in costs are possible.

Survival of different plantations of redwood has varied greatly, depending on numerous factors. The more important causes of death of planted stock (*12*) have been given as:

	Per cent
Poor stock and poor planting	10
Rodents	10
Grazing animals	20
Soil, site, drought	25
Root competition and shading	35

The average survival over a period of seven years in the study made by Gibbs was 67 per cent, and in Schofield's study, 50 per cent. The survival varies somewhat from year to year, depending principally on amount and distribution of rainfall.

Survival on south slopes has proven rather uncertain, and some plantations have been failures. Gibbs reports that the average survival on south slopes over a period of seven years was 54 per cent and 62 per cent for 1–0 and 1–1 redwood stock, respectively, and 76 and 84 per cent on the north slopes. An average survival of 50 per cent, if it can be attained consistently and based on planting 500 trees per acre, should give a fair and reasonably full stand.

[6] In addition to Schofield's work the writer had access to a manuscript report of a similar study (1931) by W. H. Gibbs on redwood reforestation by the Caspar Lumber Co.

Another study showed that on south slopes the percentage survival of thrifty redwood trees planted in the open was from 0 to 22 per cent of the total set out; the corresponding figures, where the trees were set so that they received some shade from the south, east, and west, were 70 to 90 per cent. This finding of the extreme importance of some protection to the individual plant on the more difficult sites is in close harmony with planting experience in the California pine region.

The same study showed that on north slopes the survival without individual shade was 63 per cent; with shade from three sides, 90 per cent. No detailed data are available on relative survival when planting was done soon after logging, as compared to planting older cuttings on which brush was thoroughly established. The table of causes of loss given above indicates that root competition and shading are the most important causes of loss. It seems evident that planting of the older cut-over lands, largely occupied by heavy stands of brush, is a problem of considerable difficulty, comparable with brush-field planting in the Sierra region.

Experience has also shown (*12*) that areas of thin and rocky soil, originally bearing a relatively light stand of timber, will encourage little or no survival.

Experiments (*12*) in planting other conifers native to the region (Douglas fir, Sitka spruce, Port Orford cedar) resulted in survival generally comparable with that of redwood. On most sites there is no apparent necessity for planting redwood alone.

It has been found that several years must elapse after planting before trees become thoroughly established and begin rapid height growth. Sprouts, of course, grow rapidly from the very start. In all probability the yields from stands containing a high percentage of planted stock will be lower at a given age than where the trees originated from sprouts (*1*). At 50 years of age, the volume per acre of stands from seedlings is 74 per cent that of sprouts. Experience does not yet indicate whether improper setting of the trees in the hole will have the serious aftereffects that have developed in other forest regions.

Further research in methods of growing and planting forest trees in the region is needed. In particular the early plantations should be watched carefully for years to determine the loss rate under different methods of planting, the relative vigor and rate of growth of young trees grown from seed of different sources, and the effect of spacing in plantations. Improper planting may have far-reaching consequences, and no effort should be spared to develop practices as nearly correct as possible at the very beginning of extensive planting.

FULL STANDS FROM NATURAL REPRODUCTION

Enough has already been said regarding the value of associated species in the redwood region to indicate the desirability, and often the necessity, of leaving seed trees of these nonsprouting species, especially of Douglas fir, when the redwood is clear cut. Even if it is planned to plant redwood to fill in the blanks in the new forest, reservation and preservation of seed trees of the other species are probably just as important as though no planting at all were in-

tended. The more natural reproduction thus obtained, the less expense will be necessary for planting, and the more generally will mixed stands prevail. Adjustment of cutting practice to this end is no difficult matter.

Little investigation is needed to show that an average of even one Douglas fir seed tree to an acre of cut-over land may add as many trees to the new forest as will sprout from redwood stumps. Two or three trees to an acre reserved from and left intact by the logging operation should accordingly be sufficient in most instances to insure approximately complete stocking. Even now, when Douglas fir and associated species are cut nearly as clean as the redwood, it is usually true that a number of small trees or of very large defective trees, such as might be suitable for seed trees, are passed by. In many instances these alone would be sufficient to seed the area satisfactorily.

The saving of seed trees therefore appears to be practicable, provided some degree of care is exercised in falling, yarding, and slash burning. It is never likely to prove very costly. The result will make all the difference between a natural stand of redwood alone, at best 25 to 35 per cent complete, and a mixed stand 80 per cent or more complete. What planting may still be needed to get full stands in some instances will be very much less than if no seed trees were left to aid in reforesting the cut-over land.

Naturally, groups of seed trees are more effective than isolated individuals, and are less subject to windthrow, which must be recognized as an ever-present threat to scattered trees.

THE CONTROL OF FIRE

Until planting technic has been completely worked out, systematic fire protection is the prime essential to improve the condition of the older cut-over areas. (Pl. 3.) Such protection presents unusual difficulties in this region, however, because of the well-established custom of burning over the logged-off land and the general opinion of many local people that cut-over land is valuable rather for grazing than for timber growing. The systematic protection of these lands against fire, beginning immediately after the completion of yarding, involves not only the development of an organization for putting out fires, but also recognition of the primary value of cut-over lands for growing timber and the correction of the existing local habit of thought upon this subject. Continued and systematic law enforcement and education are essential parts of the fire-protection program, and only as these are included can there be hope for a reduction in the number of fires. Before the burning and reburning of cut-over lands will be successfully checked, public opinion must accept the fact that growing timber is a more profitable use of the land than grazing and that fire is hostile to that use.

Public education, an adequate general protection system, and special protection measures are all of them important, whether the cut-over lands are to be planted or are to be restocked by natural reproduction of associated species. Next in importance perhaps to public education is general protection, and toward this substantial advances have already been made by the redwood operators.

THE GENERAL FIRE-PROTECTION SYSTEM

The first organized protection work in the redwood region was undertaken by the Mendocino County Redwood Fire Protective Association, which since 1912 has protected about 75,000 acres of virgin timber. The State division of forestry, within the past few years, has built up a force of 25 rangers, lookouts, and fire guards in the redwood counties and has made considerable progress in organizing an effective system of protection on both virgin forests and cut-over lands. Several individual lumber companies as well have initiated systematic protection. Undoubtedly, now that a land policy is decided on, systematic protection will be extended, probably by a cooperative State and private-owner combination, aided possibly by Federal contributions made under the Clarke-McNary law. At present, protection on both virgin forest and cut-over land is generally below the needs of the region.

Because of the limited experience in the region, neither the necessary degree of protection nor its cost is known with exactness. In the virgin forest, where fires spread less rapidly than in the pine region, an organization capable of putting suppression forces on fires within 1½ to 2 hours after the discovery of fire—or what is termed 1½ to 2 hour control—will be ample to keep the burned area at a low figure, at an annual expenditure of about 2 cents an acre each year. Direct protection such as this can be obtained by the installation of additional lookouts, the building of new telephone lines, roads, and trails, the employment of more fire guards, and the active aid of woods foremen in reporting and suppressing fires. For this purpose the type of organization developed on the national forests in California can well be employed, unless study and experience demonstrate that mobile patrols are superior.

For cut-over lands, until the new stands are at least 20 to 30 years old, intensity of protection should be doubled. In practice the virgin and second-growth forests can not always be handled separately and, with large areas of cut-over land accumulating, the annual cost for all forests will be nearer 4 than 2 cents an acre.

CARE WITH FIRE IN LOGGING

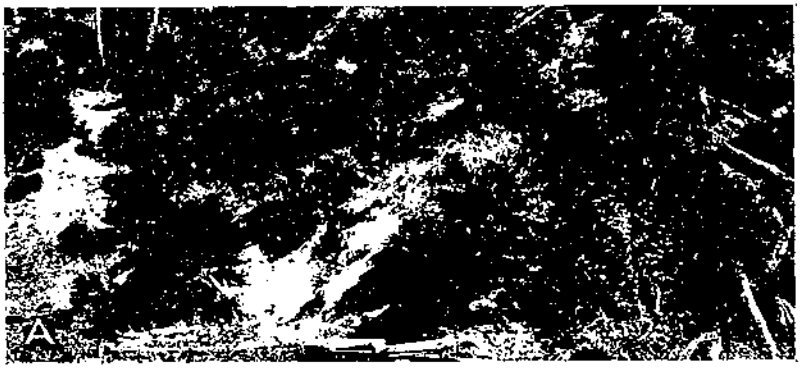
Care with fire on the logging operations is also essential to protect the young forests. Fires started by donkey and railroad engines frequently spread to areas cut in previous years, on which new growth is established.

Measures of demonstrated merit in reducing fires on logging operations include:

The use of oil-burning instead of wood-burning railroad engines: Oil burners sometimes set fires, but very much less frequently than wood burners.

The use of spark arresters with wood-burning engines: Very satisfactory spark arresters are now available at moderate cost and, if consistently used and systematically inspected and kept in order, are an important means of preventing fires.

Care in use of fire in the woods by employees: Fires from this source can be absolutely stopped if a concerted effort is made. Care is particularly needed in smoking, and in lighting fires for warmth.



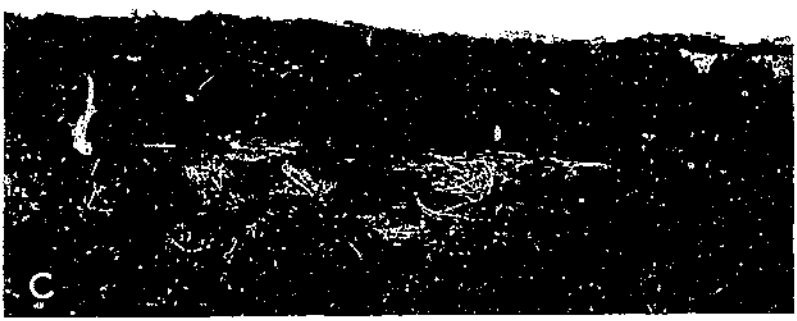


FIGURE 9.—F-[illegible]

THE IMPORTANCE OF FIRE CONTROL

A, Brush of various species, usually led by the highly inflammable fireweed, soon appears on cutting areas, threatening the new forest with fires that will kill back the redwood sprouts and destroy the seedlings of associated species; B, it is soon evident that where seedlings and seed trees of associated species are destroyed by fire little can be expected of redwood sprouts alone beyond one-fourth or one-third of a desirable stocking of the area; C, such a partially stocked stand is not only low in yield possibilities but high in fire hazard.

F162000 F193992

DESIRABLE REDWOOD STANDS, OLD AND NEW

The old giants of the redwood forest (A) are beautiful to behold but unprofitable to grow; they will probably never be equaled in grandeur by the new forest, but fully as profitable stands can be grown where (B) seed trees of Douglas fir and other species have been allowed to survive and have filled in the gaps between the redwood clumps with seedlings; the result is a neat completely stocked stand with brush shaded out, the fire hazard decreased, and a promised yield closely approaching the maximum productivity of the land.

Control of use of lands by campers, hunters, and fishermen: The application of a camp-fire permit system and "no smoking" rules would greatly aid in controlling fires from outside use.

Besides these measures designed to prevent the start of fires, additional special steps can well be taken to handle fires that start. Among the most important are the following:

Placing responsibility for initiating action on fires: On all but the smaller operations a camp firewarden is advisable. He should be commissioned a deputy State firewarden and should be given responsibility for organizing the camps for fire control, teaching the men their duties on fires, enforcing regulations about smoking in the woods, care of spark arresters, time and manner of burning slash, etc. He should be a man of intelligence and energy, and be accustomed to handling men. He should, in short, be specifically charged with fire-control activities on the entire operation and be free from other duties. In addition, some individual at each point of danger should be designated to start action on fires, such as the engineer or fireman at donkey engines, or the hook tender in the woods. The characteristic of logging fires is the long delay in attack due to failure to fix responsibility for starting action. Delay is avoided if a camp-warden system is in effect.

A properly equipped patrol following trains: This method insures prompt detection and suppression of fires starting along rights of way, and is particularly needed for older cutting areas on which the young forest has a good start.

Equipment of donkey engines with pumps, hose, and fire-fighting tools: Where this has been done, serious fires starting from donkey engines have been practically eliminated.

SLASH DISPOSAL

The problem of disposing of the great accumulation of inflammable slash present in the redwood region after falling and bucking is a difficult one. Its solution is perhaps the key step in saving seed trees of associated species and in preventing escape of fires to adjacent young forests. Broadcast burning is generally regarded as the only solution for this problem, but not necessarily haphazard and promiscuous burning.

Care in broadcast burning is essential because of the great loss in seed trees which follows the usual clean-up fire. Many of these trees could be saved by relatively slight and probably inexpensive changes in present slash-firing methods, such as have been made on national-forest cuttings in the Northwest, and with a more than corresponding reduction in cost of timber growing and the avoidance of a good deal of unnecessary planting.

Setting fires at the top instead of the bottom of slopes, clearing slash from around seed trees, burning only at seasons or at times of the day when fires will spread slowly; in short, following the methods and practices employed in most progressive slash disposal in the Douglas fir region, will largely help to solve the problem of preserving seed trees. These simple steps have not, so far as known, been taken systematically in the redwood region.

Despite the immediate reduction of hazard through broadcast burning, the practice probably tends to an actual increase in hazard in the end. Such burning apparently stimulates seed germination of the various brush species, particularly Ceanothus, and thereby creates the dense and highly inflammable stands of brush so characteristic of cut-over and burned-over lands in the region.

A plan well worth trying and with a good chance of success, is the fire-line compartment system recently developed in the Sierra region. Under this method, the area is blocked out into units of 40 to 160 acres by fire lines from 50 to 125 feet wide. On the lines the débris is destroyed, either by broadcast burning or by piling and burning. Elsewhere the slash and débris is left undisturbed. When supplemented by intensive patrol and quick handling of fires this plan has worked very effectively in the pine region. It might well be equally successful in the redwood region.

Besides destroying actual or potential seed trees, the broadcast burning of slash, as now practiced, cleans the ground so thoroughly that serious erosion commonly occurs in the first winter after logging. The presence of erosion is obvious in almost any reasonably careful examination of recent cuttings, but no specific data have been collected on the amount of topsoil lost, or on the more important question, What effect does this loss have on the obtaining of reproduction and the subsequent growth of young trees? The only basis on which a speculative answer to this question may be given is that in other forest regions loss of topsoil, particularly if repeated, has tended to reduce the fertility and productivity of the forest soil.

Detailed studies [7] in parts of the redwood region have led to the conclusion that fire with and after logging has made the second-growth stands open, consisting principally of redwood sprouts, and has caused soil deterioration to a marked degree.

SELECTIVE LOGGING AS A POSSIBILITY

Both past and present practice in the region (with limited exceptions in the early days) involve practically clear-cutting the area and starting the new crop from bare ground. The survival of trees through the logging operation is usually an incident or an accident, rather than something definitely planned.

The plan herein proposed, involving deliberate saving of seed trees of associated species, particularly Douglas fir, does not differ essentially in this regard from the existing method. The new crop will still come from seedlings, sprouts, and planted stock, all starting after logging. The proposal has, however, various apparent advantages over existing practice in obtaining desirable mixtures of species at probably less than the cost of planting. Nevertheless, a full rotation of, say, 50 to 60 years must elapse before the new stand can be cut. (Pl. 4.)

The yields from well-stocked, even-aged second-growth stands are so high that volume production alone has generally been regarded as the goal of forestry in the region. The data [8] on quality of lumber

[7] At the California Forest Experiment Station, under direction of A. E. Wieslander, 1926–1930 (data unpublished).

[8] Unpublished data obtained by E. Fritz, University of California Forest School, has been kindly made available for this discussion. The data are contained in Second Growth Redwood Cutting Experiment, Big River, Mendocino County, Calif., project 688, of July 23, 1923, and Properties and Uses of Second Growth Redwood, project 688.

produced by young even-aged stands as well as by trees reserved in the first cut, and harvested years later, give an approximation of the quality obtainable from the clear cutting and selection systems. Trees on selected plots were followed in detail through the mill, and lumber as sawn out was recorded in the standard lumber grades now in use. The results for second-growth redwood only were as follows, with grades arranged in order from highest to lowest quality:

Grade	Per cent of total	Grade	Per cent of total
Clear	0	No. 2 (construction)	56.8
Sap clear	2.3	No. 3	19.6
Select	.2	No. 1 ties	4.5
Standard	1.6	No. 2 ties	9.3
No. 1 (extra merchantable)	.9	No. 3 ties	4.8

This tabulation shows 4.1 per cent of total number in uppers (the four top grades); 57.7 per cent in No. 1 and No. 2; and 38.2 per cent in the lower and less valuable grades.

On the same area, the lumber produced from a small number of trees left in the original cutting, presumably because they were unmerchantable at that time, was:

Grade	Per cent of total	Grade	Per cent of total
Clear	5.0	No. 2	35.0
Sap clear	19.1	No. 3	25.0
Select	2.0	No. 1 ties	2.1
Standard	4.0	No. 2 ties	2.7
No. 1	4.0	No. 3 ties	1.1

The total of the four top grades is 30.1 per cent; that of the lowest but 30.9 per cent. Average selling price per thousand feet is much higher for the old reserved trees than for the second growth.

Recent studies indicate (*10*) that redwoods 34 inches and less in diameter do not on an average pay their way in logging.

Analyses of stumps of trees left in the older cuttings in the region show unmistakably that redwood possesses to a high degree the capacity for accelerated growth after release by logging. The smaller trees which from an immediate economic standpoint can not be logged and manufactured with profit will, as a group, not only produce wood rapidly if left standing but will also produce the high-quality grades of lumber which are so conspicuously absent from young second-growth trees. It is obviously desirable from the operator's viewpoint to produce in, say, 50 years, the complete range of lumber grades, if for no other reason than that second-growth stands of 1980 will probably still be competing against remnants of virgin stumpage. It seems altogether likely that the selling prices of the present higher grades will remain relatively as much above common lumber in the future.

Taking into account the age composition of the redwood forest, the negative value for immediate exploitation of the smaller diameter trees, the ability of such trees to produce wood rapidly after release, the relatively high percentage of upper lumber grades produced by such reserves as compared with true second growth, and the possibility of an intermediate cut before the second growth shall have attained merchantable size, the results indicate that some form of selection cutting may in the long run well prove to be the most successful and profitable for the operator.

In fact, the attention that is being given in the region to selective logging as a means of increasing net return per thousand feet cut is operating unmistakably in favor of that method of cutting. Unfortunate as the depression has been for the operators, and in causing curtailment of planting, the search for means of weathering the crisis has apparently opened new possibilities for increasing both immediate profits and the long-term return from manufacture, and at the same time for decreasing the cost of reforestation.

MAKING THE CUT CONTINUOUS

In addition to the problems directly involved in obtaining full stands, the operator who is practicing intensive timber growing faces another major problem in adopting a policy of permanent operation. He must adjust his operation so that the supply of virgin timber will last until extensive areas of second growth are large enough for cutting. For example, it may be 35 years before the second growth is ready for logging, while at the present rate of cutting the virgin forest may be gone in 30 years. Under such circumstances, a slight decrease in present cut or an increase in holdings is desirable in order to avoid a shutdown of the operation for several years. The possibility of thinning in second-growth stands is worthy of study as a potential aid in making the cut continuous.

The loss of personnel, maintenance depreciation on mill and railroad, loss of established markets, costs on equipment, and similar items involved in a shutdown, make it obviously necessary to maintain the cut continuously. Protection of the investment is a goal of major importance. The operator should determine how long his virgin stumpage will last at the present rate of cutting and plan to prolong the cutting of virgin timber until the time when the second-growth cut can begin. Such a plan is an integral part of the operation, and is nearly or quite as important as obtaining full stands of timber.

SUMMARY

With the all-important problem of a land policy settled for most of the redwood region, attention can be devoted to the constructive task of growing full crops of timber.

Planting, relatively easy in the redwood region and already under way on a large scale, is one solution. Parallel with the planting program should go an intensive program of research to determine nursery and field-planting technic, the proper spacing to employ, and above all the comparative losses from different methods of putting the young trees into the ground. Natural reproduction is readily obtained in the redwood region. The opportunities for utilizing this method of reforestation have not been thoroughly tested. It appears true that slight modifications in cutting practice, in yarding, and in slash burning can be made to save the seed trees needed to supplement redwood sprouts and to obtain mixed stands of second growth. Research is needed in this field as well. Selective cutting appears as a definite possibility deserving study and experiment.

Regardless of whether planting or natural reforestation or both are used, fire protection on cut-over lands is required. To attain this, the habit of burning, which has been prevalent in the region, must

be modified. Through education and law enforcement, the essential truth must be taught that most redwood cut-over lands are more valuable for timber growing than for grazing or agriculture.

In addition to the economic importance of the notable progress in industrial forestry in the redwood region, the example set is significant. Where the factors of growth, early returns, and rising values are balanced against taxes, compound interest, and fire hazard, and the net return is compared with the probable loss if timber is not grown, sound business judgment is likely to find that the gains from timber growing more than offset the obstacles. Profitable perpetuation of a going concern by deliberate timber growing is chosen rather than the alternative of dismantling the business as soon as the virgin forest is cut.

It is obvious that much more detailed study of this possibility is needed at once. It is equally clear that current logging and slash-disposal practices require modification before selective logging can be adopted. The recent discoveries of economic means for utilizing redwood bark will, as applied, tend in the direction of saving uncut trees from destruction by fire. Surely, it can be expected that the industry, which has already gone so far in intensive-forestry practices, will not overlook the apparent advantages of selective logging.

LITERATURE CITED

(1) BARNES, J. S.
1925. RELATIVE VOLUME PRODUCTION OF REDWOOD SPROUTS AND SEEDLINGS. Timberman 26 (3) : 146, 148.

(2) BRUCE, D.
1923. PRELIMINARY YIELD TABLES FOR SECOND-GROWTH REDWOOD. Calif. Agr. Expt. Sta. Bul. 361, p. [425]–467, illus.

(3) CLARKE, W. T.
1922. AGRICULTURE IN CUT-OVER REDWOOD LANDS. Calif. Agr. Expt. Sta. Bul. 350, p. [167]–186, illus.

(4) FRITZ, E.
1929. SOME POPULAR FALLACIES CONCERNING CALIFORNIA REDWOOD. Madroño 1 : 221–224.

(5) HERZIG, A. S.
1923. FIRE PROTECTION FOR THE REDWOODS. Timberman 24 (11) : 172, 175, illus.

(6) HOFMANN, J. V.
1924. NATURAL REGENERATION OF DOUGLAS FIR IN THE PACIFIC NORTHWEST. U. S. Dept. Agr. Bul. 1200, 63 p., illus.

(7) MCARDLE, R. E., and MEYER, W. H.
1930. THE YIELD OF DOUGLAS FIR IN THE PACIFIC NORTHWEST. U. S. Dept. Agr. Tech. Bul. 201, 64 p., illus.

(8) MASON, D. T.
1922. FOREST MANAGEMENT FOR THE REDWOODS. Timberman 23 (7) : 34. illus.

(9) ———
1923. ATTITUDE OF REDWOOD LUMBERMEN TOWARD REFORESTATION. Commonwealth Club Calif. Trans. 18 (4) : 178–180.

(10) MERRILL, E. D.
1930. FORESTRY. Calif. Agr. Expt. Sta. Ann. Rpt. 1928–29 : 74–79.

(11) METCALF, W.
1924. ARTIFICIAL REPRODUCTION OF REDWOOD (SEQUOIA SEMPERVIRENS). Jour. Forestry 22 : 873–893.

(12) SCHOFIELD, W. R.
1929. REFORESTATION IN THE HUMBOLDT REDWOOD BELT. Jour. Forestry 27 : [168]–175.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary of Agriculture	ARTHUR M. HYDE.
Assistant Secretary	R. W. DUNLAP.
Director of Scientific Work	A. F. WOODS.
Director of Regulatory Work	WALTER G. CAMPBELL.
Director of Extension Work	C. W. WARBURTON.
Director of Personnel and Business Administration.	W. W. STOCKBERGER.
Director of Information	M. S. EISENHOWER.
Solicitor	E. L. MARSHALL.
Weather Bureau	CHARLES F. MARVIN, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Bureau of Dairy Industry	O. E. REED, *Chief.*
Bureau of Plant Industry	WILLIAM A. TAYLOR, *Chief.*
Forest Service	R. Y. STUART, *Chief.*
Bureau of Chemistry and Soils	H. G. KNIGHT, *Chief.*
Bureau of Entomology	C. L. MARLATT, *Chief.*
Bureau of Biological Survey	PAUL G. REDINGTON, *Chief.*
Bureau of Public Roads	THOMAS H. MACDONALD, *Chief.*
Bureau of Agricultural Engineering	S. H. MCCRORY, *Chief.*
Bureau of Agricultural Economics	NILS A. OLSEN, *Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Plant Quarantine and Control Administration	LEE A. STRONG, *Chief.*
Grain Futures Administration	J. W. T. DUVEL, *Chief.*
Food and Drug Administration	WALTER G. CAMPBELL, *Director of Regulatory Work, in Charge.*
Office of Experiment Stations	JAMES T. JARDINE, *Chief.*
Office of Cooperative Extension Work	C. B. SMITH, *Chief.*
Library	CLARIBEL R. BARNETT, *Librarian.*

This bulletin is a contribution from

Forest Service	R. Y. STUART, *Chief.*
Branch of Research	EARLE H. CLAPP, *Assistant Forester, in Charge.*

U. S. GOVERNMENT PRINTING OFFICE: 1932

END