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FACTORS AFFECTING INCOME FROM SECOND-GROWTH FORESTS IN THE WESTERN SIERRA NEVADA

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SECOND-GROWTH PONDEROSA PINE

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FACTORS AFFECTING INCOME FROM SECOND-GROWTH FORESTS IN THE WESTERN SIERRA NEVADA^{1, 2}

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SECOND-GROWTH pine forests along the western slope of the Sierra Nevada in California, dating back to logging operations during the boom days of the early gold rush, are destined to play an important part in the future economy of California. These young-growth stands, containing varying proportions of ponderosa pine, sugar pine, Douglas-fir, California incense-cedar, and white fir, cover an area of about 1,500,000 acres distributed along the Sierra Nevada as illustrated in figure 1. Located for the most part outside national forest boundaries, second-growth pine forests constitute the dominant cover type throughout the western Sierra Nevada foothills.

In the more rolling foothill region between elevations of about 1,500 to 3,000 feet, where logging operations were centered during the early gold-mining period of the 1850's and 1860's, many of the second-growth stands are of fairly even age. Throughout most of the region, however, particularly in the more rugged forest areas at higher elevations, the young-growth stands contain both young trees and residual old-growth timber left during the early logging. These widely distributed stands are of uneven age and mixed-species composition.

These young pine forests have considerable potential importance as the basic resource for future lumbering industries. However, the income-producing power of most young-growth stands is restricted by various production and marketing problems. A low density of stocking, for example, and a patchy distribution of forest cover reflect the prevalent limited utilization of the timber-growing capacity of forest lands. Recurrent forest and brush fires continue to accentuate understocking and to enlarge the deforested areas.

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² This investigation is a phase of a broad study of land utilization in the northern Sierra Nevada conducted coöperatively by the California Forest and Range Experiment Station and the Giannini Foundation of Agricultural Economics of the University of California. Much of the orientation for this study, the data on resources cited from the Forest Survey Division of the California Forest and Range Experiment Station, and certain data on timber utilization presented herein were developed during a more comprehensive study of land utilization to appear in another publication by the agencies mentioned above.

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Utilization of second-growth timber in small portable mills has become frequent as young-growth stands have matured sufficiently to make cutting economically feasible. The lumber produced in such mills is, however, usually poorly manufactured, graded, and seasoned, and con-

Fig. 1.—Second-growth stands in the western Sierra Nevada. These young-growth forests, which contain varying proportions of pine, Douglas-fir, white fir, and incense-cedar, cover about 1,500,000 acres.

sequently is salable only at low prices in restricted local markets. The common practice of cutting small trees also involves relatively high logging and milling costs per thousand board feet, limited margins for stumpage, and the sacrifice of forest values.

Because of widespread cutting of young-growth timber with little regard for future productivity, timber management is imperative to

insure selective cutting and more stable lumbering operations. Most forest owners have little knowledge of the techniques of sustained management and of potential incomes from timber production, and few young-growth stands are deliberately managed for timber crops. The large number of different owners of forest lands makes it difficult for individual lumbering operators to obtain control over sufficient forest areas to insure continuous management.

Many population groups have an interest in the permanent utilization of second-growth forests in the Sierra Nevada, since far-reaching and diversified benefits flow from productive natural resources. The many expenditures made by timber operators for management, taxes, logging, milling, transportation, and selling have economic significance as income to many persons in the form of wages and salaries, stumpage, payments for supplies, and interest and profits. Other incomes from secondary employment and unmeasurable benefits from stabilization of communities—not to mention such uses as recreation and watershed protection—also flow from the continuous use of productive forests.

The purpose of the following study is to present some basic information on factors that influence the profitability of forest management in second-growth pine stands of the Sierra Nevada. Included in this investigation are data on the yield of wood and the grades and quality of lumber obtainable from second-growth ponderosa pine stands. Economic factors influencing market demands, lumber prices, and production costs are analyzed, since the utilization practices of owners of timber and sawmills are determined in part by trends in these general economic conditions. Methods of cutting and stand management are likewise considered as important factors influencing timber yields and forest incomes. The combined effect of these various factors is illustrated finally by estimation of the probable timber growth, costs, and incomes involved in timber management and utilization on a specific forest property. The data presented herein are intended to aid in determining areas most suitable for forest use, in developing policies and practices that will make possible forest management for continuous production, and in providing background material for localized and more detailed investigations.

HISTORY OF THE SECOND-GROWTH PINE REGION

The present condition of forests in the western Sierra Nevada pine region reflects much of the historical and economic development of that region. Following the discovery of gold at Sutter's sawmill in 1848, the rapid influx of a large mining population brought about widespread and

intensive forest utilization. The increase in population was rapid; for example, El Dorado County, according to reports of the U. S. Bureau of the Census, acquired an estimated 40,000 persons by 1852, and Nevada County over 20,000 persons. Lumber requirements of the rapidly growing settlements were heavy, and in the early fifties an expansion of quartz mining led to additional extensive cutting for mine poles and timbers. Considerable timber was also used in the construction of flumes for delivering water to gold mines, particularly to the large hydraulic operations.

Numerous sawmills were quickly established throughout the foothills to meet the growing demands for sawed timber, several mills being set up in Yuba, Nevada, and El Dorado counties in 1849. During the following decade the number and size of mills increased rapidly, until by 1860 an estimated 250 sawmills were operating in the region from Madera County to Trinity County, cutting about 100 million board feet annually (6).⁴ These were small operations, usually poorly equipped for cutting large timber, and represented small capital investments.

The lumber produced by the early sawmills was used almost entirely in local building construction and in mines. Sales of lumber were often made for more than \$200 per thousand board feet at the mills during the early mining period, and even at that price the supply was frequently inadequate. As the number of mills increased, however, lumber prices dropped to \$25 or \$30 per thousand board feet.

With the reduction in mining activity during the 1860's, a long decline in foothill populations and markets set in, and lumbering activities were temporarily reduced. Large quantities of foothill timber were shipped by freight teams and flumes to Sacramento Valley markets for fencing and building, however, as settlements subsequently expanded in the agricultural valley areas.

Heavy cutting during the early mining period ultimately resulted in nearly complete utilization of the timber stands at low elevations, particularly near the mining settlements. Large areas undoubtedly were "clear cut," but the characteristic intermingling of groups of trees of various ages and the presence of scattered old-growth trees in most parts of the foothill region suggest the prevalence of selective cutting of the more valuable trees or groups of trees, particularly at higher elevations and in the less accessible canyon areas at lower elevations. The trees left standing provided a seed supply for restocking many of the cutover lands.

The establishment of the older stands of even-aged second-growth

⁴ Italic numbers in parentheses refer to literature cited at the end of this publication.

timber dates back to the period around 1860, and apparently followed a combination of widespread logging operations, extensive forest fires, heavy precipitation, and a good seed crop. Many of the existing second-growth forests date from the year 1861-62 (8), when in addition to the combination of factors mentioned above late spring rains in May and June favored the survival of pine seedlings.

The widespread early cutting of timber was accompanied by numerous fires, according to old reports and newspaper accounts. Forest fires swept over wide stretches of foothill and mountain lands, and, in the absence of protective organizations, often burned for days or weeks. The prevalence of forest fires in the early mining period is also indicated by the short life of many of the first sawmills. For example, the mills and lumber yards of 8 out of 20 lumbering operations established in Nevada County during the 1850's were reported as burned before 1860 (6).

"Range burning" became a common practice during the latter part of the nineteenth century. In many areas where stockmen resorted to fire as the least expensive method of extending range for cattle and sheep, large areas of forest cover were converted into brush, woodland, and grass types, apparently as a direct result of repeated burning. Forest fires resulted in heavy timber losses, particularly in the lower foothill region. Destruction of stands and invasion of brush resulted in a steady retreat of the lower margin of the timber belt to higher elevations.

The pattern of settlement and agricultural development in the region has influenced the distribution and condition of second-growth stands. Considerable timberland was cleared for agricultural crops, particularly during the early mining period from about 1850 to 1860, for the production of wheat, barley, oats, and hay. Many orchards, chiefly peach and apple, also were established to supply the foothill markets. Reports of the State Surveyor General (6) indicate that cultivated areas in the foothills were considerably more extensive in 1860 than in 1930. The decline in mining activity that set in during the 1860's, however, together with the development of competition from more fertile Sacramento Valley farms, resulted in the abandonment of many dry-farmed orchards and crop lands on foothill farms. Natural reseedling of ponderosa pine and other timber species subsequently gave rise to many stands of the "old field" type that are now from forty to seventy years of age.

Construction of the Central Pacific Railroad over the Sierra Nevada between 1862 and 1865 initiated heavy cutting in the adjacent forests of Placer and Nevada counties. During the early years of railroad operation considerable cutting for locomotive fuel wood took place, and on every suitable embankment along the railroad were fuel-loading plat-

forms. Excellent stands of second-growth, varying in composition from pure stands of pine in the lower foothills to pure stands of fir in the higher mountain areas, came in after this intensive cutting. Subsequent fires and clearing of land for crops and grazing at lower elevations, however, brought about a rather patchy distribution of the resulting stands.

The completion of the transcontinental railroad and the construction of feeder railroad lines in the interior valleys of California was the signal for rapid expansion of the lumber industry in the state. The small operations of the early mining era were overshadowed by larger and larger mills. For a few years timber was still logged with horses or small steam donkeys and there was still some degree of selective logging and protection of reproduction. About the beginning of the twentieth century, however, numerous multiple-band sawmills were constructed and huge additional investments were made in high-standard logging railroads to bring in timber for the hungry saws. An era of heavy cutting and destructive logging began. Powerful steam donkeys and elaborate "high-lead" skidding equipment were used in logging, effectively precluding selective cutting and silvicultural practices. Such logging destroyed residual timber and small trees while slash fires subsequently wiped out all reproduction, which resulted in numerous brushfields. The peak of this era was reached in the 1920's when high lumber prices stimulated heavy cutting for maximum production.

Logging practices changed again during the late 1920's when caterpillar tractors were introduced into the logging woods of the pine region. The practices of selective cutting and protection of residual stands that had been general before the period of steam donkeys once again became common. Most stands logged during the last decade thus have been cut by "economic selection" that reserves the smaller trees and poorer species, such as fir and cedar, and stands have been left in good condition for producing timber crops—although the removal of only the relatively high-value pines is significantly changing the composition of many forests.

A network of public roads also has been constructed in the region during recent decades, permitting the economic use of trucks for log and lumber transportation and making most forests accessible for frequent cutting. These changing techniques of logging and transportation have once again made small operations profitable and in recent years small portable sawmills have increased rapidly in number. Another period of small producing units has apparently been ushered in, particularly in the second-growth pine region. The growth of the small-mill industry has accentuated both the problems of conservative cutting and manage-

ment on small ownerships and the difficulty of marketing low-grade lumber in highly competitive markets.

The historical development of the foothill region has resulted in a present-day economic structure characterized by dependence on a combination of land uses, including irrigated agriculture, livestock production, mining, and lumbering. Farming areas (fig. 2) have been developed on occasional ridges where limited areas of good soils and available water supplies make possible fruit farming and other irrigated agriculture.

Fig. 2.—Characteristic forms of land use in the western Sierra Nevada foothills. Fruit orchards, meadowland, and young ponderosa pine stands are intermingled in varying patterns.

Livestock ranches utilize the more open grass types throughout the foothill region, the deforested lands, and to some extent the timbered mountain areas. Gold mining continues to be an important source of income and community support in many parts of the region. Subsistence farming, in which part-time work in lumbering, mining, and other local occupations provides necessary supplementary income, supports a sparse population scattered throughout the foothill area.

Lumbering operations both in the large remaining stands of old-growth timber and in young-growth forests represent one of the more important direct sources of population support. A considerable part of the local population, including full-time lumbering employees, seasonal laborers, and farmers, are supported chiefly or in part by income from the production of lumber, fuel wood, and other forest products. Even

after 90 years of indiscriminate forest utilization, numerous communities depend upon timber resources as a principal source of employment and income.

As a result of past land policies a complicated pattern of intermingled

Fig. 3.—Distribution of ownership of second-growth forest lands in the western Sierra Nevada, Amador to Butte counties, inclusive.
(Data from county records and the Forest Survey Division of the California Forest and Range Experiment Station.)

large and small ownerships has been created in the second-growth region of the western Sierra Nevada. Under various land laws providing for the patenting of land for settlement, minerals, and timber, about 80 per cent of the area supporting young-growth forests has passed into private ownership. Only about 20 per cent of the young-growth timber,

chiefly in national forests, is on land that is still federally owned, as shown in figure 3. Timber-operating and timber-holding companies now own about 16 per cent of the total young-growth-timber area, chiefly in the form of residual uneven-aged stands. Other corporations including railroad and mining companies own an additional 18 per cent of the total.

The largest single class of holdings is owned by nonresident individual investors who hold title to about 27 per cent of the young-growth timber, according to figure 3. Local farmers, subsistence ranchers, and other foothill residents own an additional 17 per cent of the total. Tax delinquency has been of minor importance, and only about 2 per cent of the young-growth-timber area has reverted to the State of California for nonpayment of taxes.

The patterns of ownership that have developed in different portions of the second-growth region vary widely; figure 3 shows only average conditions. In some areas mineral claims predominate, in others timber companies are most important, while in still other districts farm ownerships are most numerous. There is, however, a characteristic intermingling of holdings. Size of individual ownerships also varies, from about 20 acres to several thousand acres.

The young-growth forests in national forest ownership have been given fairly adequate protection and will ultimately be placed under more intensive forest management. Most of the timber-company holdings also receive effective fire protection and probably will be managed so as to insure future timber production. Management is usually lacking or inadequate, however, on the two thirds of the area owned by nonresidents, miscellaneous corporations, farmers, and local residents. There is need for forestry programs that will apply to all sizes of holdings in both farm and nonfarm ownerships.

FACTORS AFFECTING TIMBER YIELDS

The extent to which young-growth forests in the Sierra Nevada will contribute to the income of local populations depends partly on obtainable timber yields. Yields of timber, in turn, are significantly influenced by a number of factors such as the site quality of forest lands, age of stands, species composition, stand volumes and stocking, mortality, and growth rates.

SITE QUALITY

The "site quality" of forest lands, that is, the productivity resulting from local combinations of climatic and soil factors, is highly favorable for the growing of timber crops in the western Sierra Nevada. High timber yields result from a combination of relatively heavy precipitation,

moderately high temperatures during a long growing season, and fertile forest soils.

The site quality of particular forest areas may be expressed in terms of "site indexes," which ordinarily are based upon the height of dominant trees at a selected age. Thus areas having a site index of 175 produce dominant trees averaging 175 feet in height at three hundred years of

TABLE 1
AREAS OF YOUNG-GROWTH FORESTS IN THE WESTERN SIERRA NEVADA, AMADOR TO BUTTE COUNTIES, INCLUSIVE, BY AGE, STOCKING, AND SITE QUALITY*

Forest age class	Area by site index†				Proportion by age classes
	125	150	175	Total	
	<i>acres</i>	<i>acres</i>	<i>acres</i>	<i>acres</i>	<i>per cent</i>
Even-aged stands, 1-40 years:					
Well stocked.....	...	323	3,184	3,507	0.4
Poorly stocked.....	388	6,375	12,586	19,349	2.4
Even-aged stands, 41-80 years:					
Well stocked.....	17	12,998	100,289	113,304	14.2
Poorly stocked.....	4,268	79,610	170,407	254,285	31.9
Total.....	4,673	99,306	286,466	390,445	48.9
Uneven-aged stands.....	6,751	96,194	304,414	407,359	51.1
Total all ages.....	11,424	195,500	590,880	797,804‡	100.0
Per cent by site indexes.....	1.4	24.5	74.1	100.0	.....

* Data from Forest Survey Division, California Forest and Range Experiment Station; areas mapped 1932-1936.

† Site indexes were based upon the height of average dominant trees at 300 years of age. Small areas of site index 100 were combined with site index 125; small areas of site indexes 200 and 225 were combined with site index 175.

‡ Additional areas capable of growing timber crops, but in deforested condition, totaled 466,770 acres, including 267,260 acres of chaparral and woodland, 160,000 acres of grass, and 39,510 acres of cultivated and residential areas.

age.⁵ Site indexes ranging from about 50 to 225 are found in the ponderosa pine region of the western United States, according to data collected by Meyer (15). The higher sites, however, are found almost exclusively in the western Sierra Nevada, where, as shown in table 1, practically all the young-growth forests fall within the 150 to 200 site-index classes.

AGE OF STANDS

Slightly more than half the young-growth forests in the western Sierra Nevada are classified as uneven-aged, as indicated in table 1. In these

⁵ Areas of site index 175 produce dominant trees averaging 80 feet in height at fifty years, 102 feet at seventy years, and 117 feet at ninety years of age. (Data from an unpublished manuscript by D. Dunning and V. A. Clements, California Forest and Range Experiment Station.)

uneven-aged forests, numerous old-growth trees are sprinkled throughout the stands of immature trees that have developed after selective logging or fire. Even-aged second-growth stands account for the remaining 49 per cent of the young-growth forests. They occur mainly at lower elevations where heavy cutting and forest fires were common in early mining days, and usually consist of a mixture of even-aged groups of various age classes. Practically all of these even-aged stands originated during the period from 1860 to 1900. The prevalence of older age classes and of mature trees scattered throughout the young-growth forests favors selective timber management and often makes possible immediate and continuous forest incomes.

STAND COMPOSITION

In many young-growth forests less valuable species than ponderosa and sugar pine constitute a large proportion of the stand volumes and, unless controlled by cutting, often increase at the expense of pine. Nearly pure stands of ponderosa pine (*Pinus ponderosa*) are common near the lower limits of tree growth, where rainfall is more limited, temperatures higher, and fires more frequent than at higher elevations. However, other species such as California incense-cedar (*Libocedrus decurrens*), white fir (*Abies concolor*), Douglas-fir (*Pseudotsuga taxifolia*), and sugar pine (*Pinus Lambertiana*) are abundant in the stands at higher elevations and on the cooler slopes of the rugged foothill canyons. A small volume of black oak (*Quercus Kelloggii*) is also present in many young-growth pine stands. In recent years intensive fire protection and "economic selective" cutting that leaves stands containing a large volume of unmerchantable white fir and incense-cedar have furthered the development of young-growth stands consisting chiefly of low-value timber.

The mixed composition of the young-growth forests is illustrated by inventories of stands at elevations of 2,000 to 3,000 feet, where ponderosa and sugar pine made up 74 per cent of the stand volume; Douglas-fir, 14 per cent; and incense-cedar, 12 per cent. At higher elevations, a smaller proportion of pine is found in most second-growth stands. Surveys in the Oroville region, for example, showed that above 3,000 feet ponderosa pine and sugar pine made up an average of only 41 per cent of the timber volume of young-growth forests, compared with 27 per cent Douglas-fir, 26 per cent white and red fir, and 6 per cent incense-cedar.^o

Since stand composition materially influences timber yields and financial earnings, relatively heavy cutting of species such as incense-cedar and white fir is desirable when economically feasible, particularly at

^o Data from Forest Survey Division, California Forest and Range Experiment Station.

higher elevations where climatic conditions favor these more tolerant species. Low-value timber such as white fir is useful for construction and other purposes (12), but better markets and prices are needed to make silvicultural cutting practicable in most stands.

REQUIREMENTS FOR PINE REPRODUCTION

The quantity and proportions of ponderosa pine and other timber reproduction vary considerably throughout the forests of the western

Fig. 4.—Ponderosa pine seedlings invading a cleared field. To obtain satisfactory pine reproduction, brush and grass competition must be limited, and there must be freedom from repeated fires.

Sierra Nevada. At the lower elevations where there remain only scattered stands of ponderosa pine, reproduction of timber species is almost entirely lacking. At higher elevations pine reproduction is usually present on cutover or cleared areas, but there is considerable competition between ponderosa pine and other low-value species such as incense-cedar, white fir, and Douglas-fir.

Ponderosa pine reproduction becomes established most readily in stand openings where light is abundant and where there is little competition from ground vegetation (figs. 4 and 5). In abandoned orchards, road cuts, and occasionally in burned areas where there is little competition from brush, favorable conditions of soil moisture and light result in good pine reproduction. Rainfall distribution and soil moisture are

also important factors, and late spring rains appear necessary for widespread survival of pine seedlings.

On unshaded areas the relatively high light requirements of ponderosa pine and its resistance to heat and frost give pine the advantage over incense-cedar and fir. On the cooler slopes and under forest canopies, however, advance reproduction of these latter more tolerant species tends to fill in. In forests at about 2,500 feet elevation, for example, reproduction of Douglas-fir, incense-cedar, and white fir occurred over

Fig. 5.—A relatively large clearing in a second-growth ponderosa pine stand. Reproduction usually is lacking where openings in the stand are large, surrounding trees are immature, and the cover of grass and weeds is heavy.

about 60 per cent of the area of sample properties, compared with 24 per cent on which there was ponderosa pine. Incense-cedar reproduction is usually particularly abundant in young-growth forests, but subsequent mortality of seedlings and young trees of this species is heavy.

Where there is a dense cover of brush or grass, reproduction of pine is particularly difficult to establish. The older stands of second-growth timber are found on lands that, according to reports of old settlers, supported open stands without much underbrush. Some advance seedlings may have been present at the time of cutting in the early mining period, and the absence of brush competition permitted early establishment and widespread survival of pine. Where brush species such as *Chamaebatia foliosa* (commonly known as bear-clover, bearmat, or mountain

misery), manzanita (*Arctostaphylos* spp.), and ceanothus (*Ceanothus* spp.) form a dense growth, as they do now in much of the region, pine reproduction is uncertain and inadequate unless the brush cover is destroyed.

Frequent and uncontrolled fires, which have been common in the foothills, often destroy both reproduction and older seed-producing trees, resulting in understocked stands and deforested areas of brush (23). Reproduction and survival of ponderosa pine and other timber species are improbable without protection from uncontrolled and indiscriminate burning of forest lands.

Relatively large pine trees are required for adequate seed production, since trees under approximately 20 inches in diameter produce only small quantities of seed. Heavy cone crops are produced by ponderosa pine trees every three or four years; little seed is produced during the intervening years, but large crops may not occur in all parts of the foothills in the same year. Timing of cutting operations to open up stands during good seed years is usually a desirable cutting practice for obtaining pine reproduction. The large dominant trees that constitute the best seed producers are usually removed under prevailing cutting practices, but reserving some of the larger trees is usually necessary to insure pine reproduction. Selective group cuttings to create small openings free of heavy brush and grass cover and surrounded by large seed-producing pine trees will, during favorable seed years, usually result in good stocking and maintenance of a high proportion of pine.

STAND VOLUMES

The volumes of young-growth stands in the western Sierra Nevada vary widely. Understocked conditions in most forests indicate the need for management practices that will build up stand density and timber volumes. In the selected second-growth stands described in figure 6, stand volumes varied from 9,000 to 33,000 board feet per acre, and averaged 19,000 board feet. The average number of trees over 6 inches in diameter on these different tracts varied from 73 to 190 per acre, with an average of 149. About 72 per cent of the trees were from 6 to 12 inches in diameter. In young-growth forests of the Oroville region, as indicated in table 2, stand volumes averaged nearly 16,000 board feet per acre in even-aged pine stands. At higher elevations, uneven-aged pine stands averaged about 18,000 board feet per acre, compared with 25,000 board feet per acre in uneven-aged pine-fir stands.

In most young-growth forests there is a wide range of tree diameters, as illustrated in figure 6, and a considerable proportion of stand vol-

umes is found in large mature and overmature trees. In even-aged stands of the Oroville region, for example, 38 per cent of the stand volume was classified as mature or overmature, as can be calculated from the data in table 2, compared with 51 per cent in the uneven-aged pine stands,

Fig. 6.—Variation in number of trees and volumes per acre, by diameter classes and species, on six sample properties of second-growth timber in the western Sierra Nevada. Second-growth stands characteristically vary widely in range of diameters, distribution of volumes, and species composition. (Field data collected by the U. S. Soil Conservation Service.)

and 61 per cent in the pine-fir stands. Many of the remnant trees remaining from earlier selective cutting or culling operations are of relatively low value because of limbiness and defects, and show little or no increment in volume and value.

Fully stocked pine stands produce yields considerably in excess of existing average-stand volumes. Even-aged stands on site index 175, for example, can produce up to 54,000 board feet per acre, International log rule,⁷ at seventy years, and about 76,000 board feet per acre at one hundred years, as indicated in table 3. On favorably located properties of even-aged second-growth timber under protection and management, it is estimated that stand volumes averaging approximately 70 per cent of

TABLE 2

TIMBER VOLUMES IN BOARD FEET PER ACRE IN SECOND-GROWTHS OF THE OROVILLE FOREST REGION, BY TREE DIAMETERS AND AGE CLASSES*

Tree diameter (inches) at breast height	Even-aged pine stands (40-70 years)			Uneven-aged pine stands			Uneven-aged pine-fir stands		
	Young trees	Mature and over-mature trees	Total	Young trees	Mature and over-mature trees	Total	Young trees	Mature and over-mature trees	Total
8-10.....	485	...	485	...	...	...	...	...	...
12-14.....	1,220	...	1,220	1,665	...	1,665	1,060	...	1,060
16-18.....	1,705	...	1,705	1,285	...	1,285	1,340	...	1,340
20-22.....	2,105	20	2,125	1,300	...	1,300	2,570	60	2,630
24-26.....	1,855	90	1,945	1,530	50	1,580	1,480	620	2,100
28-30.....	1,145	145	1,290	1,260	200	1,460	1,260	670	1,930
32-34.....	810	635	1,445	775	645	1,420	480	710	1,190
36-38.....	180	560	740	535	225	760	1,150	1,990	3,140
40 and over....	80	4,550	4,630	600	8,190	8,790	460	11,240	11,700
Total..	9,585	6,000	15,585	8,950	9,310	18,260	9,800	15,290	25,090

* Data from Forest Survey Division, California Forest and Range Experiment Station; area of 114,760 acres sampled by 345 plots of 0.2 acre each. Volumes by the Scribner log rule.

the optimum yields shown in table 3, or about 50,000 board feet per acre for stands one hundred years old, could be attained on site index 175. Such well-stocked stands would yield some additional timber volumes which are normally lost through mortality but which can be utilized for fuel wood and posts where markets for thinnings are available.

Understocking of foothill forests, indicated by relatively low timber volumes, open stands, and the presence of intermingled areas of chaparral, woodland, and grass types, is especially prevalent at lower elevations where fires, brush invasion, and land clearing have been common. On the sample properties described in figure 6, for example, stand volumes varied from about 30 to 90 per cent of the normal board-foot volumes

⁷ Volumes by the International log rule approximate more closely the actual volumes obtained from small timber under close utilization than volumes indicated by other rules, such as the commonly used Scribner log rule.

found in fully stocked stands. Of the even-aged second-growth forests in the foothills, about 30 per cent are well stocked, according to table 1, and about 70 per cent are poorly stocked stands of only 10 to 40 per cent of normal crown density. In stands of uneven age at higher elevations, stocking averages somewhat higher, but throughout the foothills stocking probably does not average more than 40 to 45 per cent of normal, according to available survey data. Not only is productivity low in

TABLE 3

YIELD IN BOARD FEET PER ACRE OF FULLY-STOCKED EVEN-AGED STANDS OF PONDEROSA PINE, BY AGE, SITE INDEX, AND LOG RULE*

Age of stands (years)	Site index 150		Site index 175		Site index 200	
	Scribner log rule	Inter- national log rule	Scribner log rule	Inter- national log rule	Scribner log rule	Inter- national log rule
50.....	8,000	18,000	20,000	35,000	39,000	58,000
60.....	14,000	25,000	28,000	45,000	51,000	72,000
70.....	19,000	32,000	36,000	54,000	62,000	84,000
80.....	25,000	38,000	44,000	62,000	73,000	95,000
90.....	30,000	44,000	51,000	69,000	83,000	106,000
100.....	35,000	48,000	57,000	76,000	93,000	115,000

* Data adapted by the Forest Survey Division of the California Forest and Range Experiment Station from: Meyer, W. H. Yield of even-aged stands of ponderosa pine. U. S. Dept. Agr. Tech. Bul. 407:1-64. 1934.

Site indexes are based on the height of average dominant trees at 300 years. Volumes by Scribner rule include trees 11.6 inches and over, diameter breast height; $\frac{1}{4}$ -inch saw kerf; and 8-inch top diameter. Volumes by International rule include trees 6.6 inches and over, diameter breast height; $\frac{1}{8}$ -inch saw kerf; and 6-inch top diameter.

understocked stands, but the wood formed on open-grown trees of rapid growth frequently shows numerous defects after seasoning, which results in lower prices than are obtained for timber grown in denser stands.

There are also extensive deforested areas in the foothills, estimated at about 500,000 acres, that are capable of growing timber crops. Woodland and chaparral types, of little use for either livestock or timber production, cover about 58 per cent of these deforested lands, and grass about 32 per cent. Settlements and cultivated crops are found on the other 10 per cent of the area. Since deforested lands can usually be converted to timber only at considerable expense for clearing and planting, there is little immediate prospect of utilization of these lands for timber growing.

The understocked stands and deforested lands in the Sierra Nevada represent forest resources producing at considerably less than physical capacity. The density and volume of many second-growth forests in this region can be materially increased, however, through more intensive fire protection, preservation of enough seed trees, and conservative cutting.

MORTALITY

Mortality in timber stands of the Sierra Nevada pine region normally results from several causes. Losses in selectively cut pine stands in California during the first twenty years after logging resulted chiefly from insects, wind, and fire, in the order named, and eliminated an average of about one third of the gross volume increment.⁸ The mortality rate for the smaller trees tends to be considerably lower than for the large

Fig. 7.—Area formerly covered with second-growth ponderosa pine and sugar pine, converted to brush by fire.

mature trees, according to studies of Pearson (19) in the Southwest. In this region mortality losses in selectively cut pine stands eliminated only 5 to 10 per cent of the trees under 25 inches in diameter during the twenty-year period after logging. In the immature and thrifty second-growth stands of the Sierra Nevada, losses can normally be held to a fairly low level, according to available data and observations, although uncontrolled large fires, insect epidemics, and windfall frequently cause serious damage.

Numerous fires continue to destroy large volumes of timber, particularly at lower elevations where climatic factors are comparatively unfavorable for tree growth (fig. 7). The typical understocking of second-

⁸ Unpublished data by D. Dunning and V. A. Clements of the California Forest and Range Experiment Station.

growth forests and the prevalence of chaparral and woodland types on forest sites indicate the damage that has resulted from repeated uncontrolled fires. Destruction of timber on burned areas has at least partly

Fig. 8.—Areas burned in the western Sierra Nevada, 1931–1937. Fires frequently burn over large areas in this region, particularly in the foothills where remnant patches of timber, brush, and woodland are predominant vegetation types.

offset growth in the unburned young-growth stands. Fire losses in second-growth timber have often been heavy, since young stands having a continuous crown canopy are especially susceptible to destruction by forest fires.

Gradually improving fire protection has been given foothill lands by the California State Division of Forestry and the United States For-

est Service, but mortality from fire nevertheless continues to be serious, as illustrated in figure 8. During the period 1931–1937, for example, an average area of 47,170 acres of timber and 164,900 acres of brush and grassland was burned over annually in the western Sierra Nevada (5). Approximately 3 per cent of the State-protected zone of intermingled watershed, range, and timberlands in the foothills have been burned over each year, and about 0.5 per cent of the national forest areas, where conditions are less hazardous, have been burned over annually.

A land-use philosophy favoring burning persists in many parts of the foothill region, and incendiary “brush” fires to improve grazing are numerous. Carelessness on the part of the public also accounts for many fires that result in heavy timber losses. Logging and slash fires have caused considerable damage in the past, but selective logging practices and increased fire protection in recent years have materially reduced mortality from slash burning. Further reduction of timber losses in second-growth forests will require more rigid fire protection, elimination of slash in areas of high fire hazard, and better understanding of the relative losses and benefits from burning brush and forest lands.

In addition to fire as a principal cause of timber losses in second-growth stands, insect attacks also contribute to mortality. Losses from both insects and disease have been rather small in vigorous stands of young-growth timber, but in recent years sporadic outbreaks of bark-beetle attack have occurred. Observations during the late 1930's, for example, showed numerous small clumps of trees dying from attack by engraver beetles (*Ips* spp.) and western pine beetles (*Dendroctonus brevicomis*). Infestations often occur following fires, windfall, and logging, or they may occur without apparent reason (13).

Salvage cutting or destruction of insect-infested and susceptible trees probably will become of importance in foothill timber management as economic conditions improve. Trees attacked by bark beetles can be identified by a change in the color of their foliage from green to brown and by reddish-brown pitch tubes on the bark. Spreading of an infestation often may be stopped by cutting trees before the beetle broods emerge, that is, while the foliage is still a yellow green, and then burning the bark. Where frequent light cutting is possible, losses from insect attacks, as well as from light fires or windfall, may be reduced by salvage of the infested trees for lumber, fuel wood, veneer bolts, or other timber products.

Disease is a factor of relatively minor importance in second-growth pine stands of the Sierra Nevada foothills. Losses ordinarily are confined to residual old-growth trees of Douglas-fir, white fir, and incense-

cedar. White pine blister rust has not as yet invaded the forests of this region, but it is possible that control measures may be required in the future to protect the sugar pine.

GROWTH RATES

Rates of growth vary widely in foothill stands, according to the forest site, age of stands, stocking, and other factors. In the even-aged stands indicated in table 2, current annual growth averaged about 270 board feet per acre.⁹ In the uneven-aged stands at higher elevations annual growth averaged about 420 board feet per acre. Current annual growth in the selected young-growth stands described in figure 6 varied from about 200 to nearly 500 board feet per acre.

These more or less typical growth rates average considerably less than the growth attainable in fully stocked stands. In even-aged forests on site index 150, for example, mean annual growth over a rotation may amount to as much as 485 board feet per acre annually, according to table 3. On site index 175 mean annual growth of about 780 board feet per acre can be realized, while on site index 200 annual growth may average as much as 1,200 board feet per acre. If an average stocking of 70 per cent of normal were maintained, even-aged stands on site index 175 would yield more than 500 board feet per acre annually.¹⁰ The volumes and growth rates actually found in many foothill stands indicate that in the absence of unusual mortality from large fires or insect epidemics, average growth rates of more than 400 board feet per acre per year might conservatively be expected from well-stocked second-growth forests in the Sierra Nevada foothills.

Rates of diameter increment of different trees vary widely in second-growth stands. Increment borings from second-growth ponderosa pine and incense-cedar trees in the stands described in figure 6, for example, showed diameter growth varying from about 0.3 to 4.0 inches in ten

⁹ Growth estimates, made by the Forest Survey Division of the California Forest and Range Experiment Station, were calculated for even-aged stands from age class, stocking, and yield tables adapted from W. H. Meyer (15). Growth in uneven-aged stands was calculated from alignment charts prepared by D. Dunning and V. A. Clements of the California Forest and Range Experiment Station and based on the variables of site index, reserve stand per acre, percentage of volume in sugar pine and white fir, average volume per tree, and percentage of reserve volume in Dunning's (7) tree class 1. (For definition of tree class, see footnote 11.)

¹⁰ The relatively high productivity of second-growth pine stands in the western Sierra Nevada is illustrated by a comparison with growth in other regions. Under approximately similar conditions of stocking, ponderosa pine stands of the east slope of the Sierra Nevada and of the northern Rocky Mountains, for example, show estimated growth rates of about 240 board feet per acre, Douglas-fir stands of the Pacific Northwest 830 board feet per acre, southern pine stands 425 board feet per acre, and northern hardwood stands of the Lake States about 200 board feet per acre (24).

years. The time required for these second-growth trees to grow 2 inches in diameter thus varied from five to more than fifty years. However, the faster-growing trees that will form the main forest crop from these stands grew at the rate of 2 inches in from eight to thirteen years.

The diameter growth of reserved trees in selectively cut pine stands often increases sharply after stand competition is reduced, according to various studies (16, 21). Diameter growth of residual trees in one second-growth stand, after logging by the characteristic practice that removes large dominant trees, averaged 178 per cent of the rate before logging. In a more heavily logged stand, reserve trees showed diameter increment averaging 286 per cent of the rate before logging. Acceleration of diameter growth occurs to some extent in all parts of the stem of released trees, according to studies of Schumacher (21). Increased volume increment on reserved trees may at least partially compensate for the lack of tree growth in stand openings during the period before reproduction has become established.

The diameter growth of class 1 pine trees¹¹ in selectively logged stands of the California pine regions on areas of site index 175 averaged about 2 inches in eight years during the twenty-year period after logging.¹² Class 2 trees, which usually make up a large proportion of the trees reserved during selective logging of second-growth forests, grew at an average rate of 2 inches in about thirteen years. Class 6 trees grew 2 inches in diameter in about eighteen years. In most second-growth stands of the western Sierra Nevada, however, somewhat higher diameter growth rates are usually observed in reserve stands. Available data indicate that diameter growth approximating 2 inches in ten years may be sustained in second-growth forests with frequent selective cutting to maintain well-distributed vigorous trees. Moreover, selective logging at frequent intervals is conducive to the production of wood of even growth and uniform quality.

QUALITY OF LUMBER

Lumber cut from second-growth ponderosa pine trees often differs from old-growth lumber in quality and appearance. Abundance of knots, conspicuous growth rings, and hardness of wood characterize much of the young-growth timber. The lumber produced from second-growth trees consists chiefly of the better Common grades (fig. 9). As shown

¹¹ Class 1 trees, according to Dunning's classification (7) are young full-crowned dominant trees; class 2 trees are usually codominants; and class 6 trees include young intermediate and suppressed trees.

¹² According to data of D. Dunning and V. A. Clements of the California Forest and Range Experiment Station.

Fig. 9.—Second-growth ponderosa pine lumber. *A*, Common grades cut for local building construction; *B*, Common and Shop grades cut for box lumber.

in table 4, of the lumber cut at a small portable mill, about 42 per cent was No. 1 and No. 2 Common, 38 per cent was No. 3 Common, and 8 per cent was No. 4 and No. 5 Common. Shop and D Select grades accounted for 7 per cent, while Dimension lumber cut from defective and top logs accounted for 5 per cent of the total.¹³ Practically all of the Dimension grades if cut to different size would be graded as Nos. 1, 2, and 3 Common.

Most second-growth trees cut for lumber are only from about 16 to 30 inches in diameter and have not attained sufficient size to yield much

TABLE 4
PROPORTION OF LUMBER GRADES OBTAINED IN A MILL-RUN SAMPLE OF SECOND-GROWTH
PONDEROSA PINE LOGS CUT AT A SMALL PORTABLE MILL
IN THE SIERRA NEVADA FOOTHILLS

Lumber grades	Pieces	Board feet	Per cent of total footage by grades
D Select.....	8	120	0.6
No. 1 and No. 2 Shop.....	67	1,131	6.2
Subtotal.....	75	1,251	6.8
No. 1 and No. 2 Common.....	489	7,626	41.6
No. 3 Common.....	405	6,996	38.2
No. 4 and No. 5 Common.....	89	1,466	8.0
Subtotal.....	983	16,088	87.8
No. 1 and No. 2 Dimension.....	72	985	5.4
Total all grades.....	1,130	18,324	100.0

lumber that is free of knots. The larger trees yield some lumber of Select and Shop grades, but such quality in the larger trees frequently is offset by a relatively large proportion of loose-knotted No. 4 and No. 5 Common grades.

The lumber cut from second-growth sugar pine trees also consists chiefly of high Common grades. At one operation at which box lumber was cut from trees 16 to 35 inches in diameter, more than 95 per cent of the lumber produced was Nos. 1, 2, and 3 Common. Sugar pine lumber cut from second-growth trees is often particularly well suited for such uses as knotty-pine interior finish. Second-growth Douglas-fir trees usually yield rather coarse-grained tight-knotted lumber, most of which is suitable for high Dimension and Common grades.

¹³ Lumber cut from old-growth timber in the California pine region, according to estimates of the California Forest and Range Experiment Station, averages about 15 per cent Select and Clear grades, 35 per cent Shop, 35 per cent Common, and 15 per cent Box grades.

Second-growth sugar pine and Douglas-fir lumber seasons well, but considerable degrade and cull occur during the seasoning of second-growth ponderosa pine lumber (fig. 10), particularly in lumber cut from the butt logs of trees of rapid growth.¹⁴ According to estimates of mill owners, marked twisting or bowing is present in about 15 per cent of the second-growth ponderosa pine lumber cut from timber growing at low elevations, where trees frequently grow rapidly in understocked

Fig. 10.—Twisting, bowing, and checking of second-growth ponderosa pine timbers during seasoning. Poor piling in uncovered piles has accentuated seasoning defects that are characteristic in timber of rapid growth.

stands. Small seasoning checks also often appear during the drying of rapidly grown wood unless the lumber is properly piled and cared for.

Most young-growth timber seasons well, however, when proper methods are used. Bowing, twisting, and checking often may be avoided or reduced by slow seasoning in covered piles, by the use of sufficient stickers in the piles, and by trimming of boards to shorter lengths than the standard 16 feet. Since wide rings are more prevalent near the centers

¹⁴ The explanation for the shrinkage and warping of second-growth ponderosa pine lumber may be the same as that indicated by B. H. Paul (18) in his studies of southern yellow pine. Extreme longitudinal shrinkage in southern pines, often exceeding 1.0 per cent in second-growth timber containing less than 4 rings per inch, was attributed to the low density of the spring wood and the arrangement of the elements making up the fiber walls in the wood.

of trees, taper-sawing to leave a wedge-shaped piece of wide-ringed wood might eliminate some of the waste from bowing. Utilization of the rapidly grown timber for products other than lumber, including veneer bolts or piling, for example, may often be desirable. Silvicultural measures are also of considerable importance, for even and moderate rates of growth and desirable quality of wood appear obtainable when well-stocked stands are maintained and timber is cut selectively.

ECONOMIC FACTORS AFFECTING TIMBER VALUES

Financial returns from second-growth stands depend not only upon the amount and quality of timber yields but also upon numerous economic factors. Utilization and marketing practices, price movements for lumber and stumpage, and trends in production costs are consequently indicated in the following sections to suggest the economic outlook and to provide data for estimating local incomes from second-growth forests.

MARKETS FOR LUMBER

Lumber Uses and Location of Markets.—Lumber is the chief product cut in both old-growth and second-growth stands of the Sierra Nevada, although mine poles, veneer bolts, piling, fence posts, fuel wood, and shakes are important minor products. Ponderosa pine, the most important timber species logged, has accounted for nearly half the lumber marketed in recent decades. Sugar pine has made up nearly 30 per cent of the total lumber production; Douglas-fir and white fir, about 10 per cent each; and incense-cedar 4 per cent.

Markets for lumber cut in the Sierra Nevada have expanded widely since the early development of lumbering in the mining centers that flourished in the foothills after 1848. Following the establishment of large band mills during the early 1900's, lumber has been shipped to eastern states and to many foreign countries as well as to urban and rural markets in California. Lumber produced and marketed by these large mills now accounts for about three fourths of the total output of approximately 300 million board feet cut annually in the region.

The lumber marketed in eastern states comprises mainly Select, Shop, and high Common grades of old-growth ponderosa and sugar pine, together with partly remanufactured millwork. Box grades of pine are remanufactured into shook, chiefly by box factories operated in conjunction with the large sawmills, for use in the fruit-producing areas of California. White fir construction lumber has been marketed in California and in eastern states to some extent, and white fir box lumber has been used in California, although the cut of this species has declined

materially from the high point reached during the 1920's. Both white fir and Douglas-fir lumber entering the rural and urban markets of California encounter strong competition from low-priced Douglas-fir lumber shipped in by ocean freighters from the Pacific Northwest. A relatively small cut of incense-cedar lumber is marketed, largely in California, and mainly for use in pencil manufacture.

Fig. 11.—Portable sawmill in the foothills of Nevada County. Such mills have increased rapidly in number throughout the western Sierra Nevada pine region. At many of these mills low standards of lumber manufacturing and seasoning, limited output, and small variety of grades and sizes of lumber result in relatively low lumber prices and limited returns from timber production.

Numerous portable sawmills in the western Sierra Nevada produce lumber chiefly for local markets (fig. 11). The lumber cut by these mills, consisting mainly of old-growth pine and Douglas-fir, is used in foothill mines, building construction, and flumes. Increasing quantities have also been marketed in the Sacramento Valley for construction purposes and for remanufacture into box shooks. A marked expansion of timber utilization and marketing by these portable mills occurred during the 1930's, in large measure as a result of the revival of gold mining activity and increased foothill prosperity. Between 1929 and 1937, the number of small mills practically doubled, while output increased from about 15 per cent to 24 per cent of the total lumber production in the western Sierra Nevada pine region.

Second-growth ponderosa pine timber was utilized and marketed by the small mills in steadily increasing quantities during the gold mining boom of the 1930's. Output increased to approximately 4 million board feet in 1937, and to an estimated 8 million board feet in 1939. During the period 1934 to 1939, 36 of the 77 portable mills in the western Sierra Nevada obtained part or all of their cut from second-growth pine stands. Local mines, building construction, and box manufacture were the most important outlets for the second-growth lumber cut at these mills. Mining demands have decreased, however, and most box factories do not use young-growth timber because of the availability of old-growth, the undependability of many small mills cutting second-growth box lumber, the greater relative hardness of second-growth timber, and its tendency to split when nailed. Nevertheless, second-growth box shooks is of sufficiently high quality for many types of boxes, and may be used in greater quantity in the future.

Effect of Utilization and Marketing Practices.—The utilization and marketing practices at many small mills cutting second-growth pine timber often result in relatively low incomes. There is keen competition both among the small circular mills and the large band mills to supply limited markets, and efforts to lower costs often result in cutting methods that destroy stand productivity and the possibility of future incomes. Low manufacturing standards limit the competitive strength of many mills. In one apparently typical portable mill, for example, only 29 per cent of a sample of 427 boards was cut exactly to size. Boards cut to less than standard thickness made up 59 per cent and boards cut to more than standard thickness made up 12 per cent of the total. Widths also varied considerably, only 63 per cent of the boards in the sample being cut to standard widths. Variations in thickness and width are often even greater, although accurately manufactured lumber is produced in many portable mills equipped with good sawing and planing equipment. Low standards of lumber seasoning are also common, and frequently result in considerable degrading of pine lumber and correspondingly reduced returns.

The lumber produced in small mills is usually marketed at low prices, partly because of its low grade and poor manufacture or seasoning, and partly because of inadequate marketing organization that necessitates selling small lots of ungraded lumber in restricted local markets. The selling strength of individual portable mill outfits is limited, since output usually is small, varying from about 2,000 to 30,000 board feet per day and from about 20,000 to 5,000,000 board feet annually. Financial resources of most small mills are inadequate for proper manufacture and

seasoning of lumber, for carrying of adequate yard stocks, and for maintenance of a sales organization. As a result of utilization and marketing difficulties and the low quality of much of the available timber, the small-mill industry has been characterized by poor financial condition, intermittent operation, and frequent shifts in ownership and location.

In addition to strong local competition between large and small mills in the pine region, the importation of Douglas-fir lumber and timbers from the Pacific Northwest also represents an important market factor. Imported Douglas-fir, frequently marketed even in the foothill region for lower prices than Douglas-fir and pine produced locally, is used mainly for building construction, railroad ties, and mining timbers. Approximately 80 per cent of the large quantities of timbers used in gold mines of the foothill area during recent years, for example, has been Douglas-fir from Oregon and Washington. California markets absorb large quantities of Douglas-fir lumber from the Pacific Northwest mainly because of the relatively high quality, desirable properties, and low prices of the imported material.

It is probable that marketing of lumber cut in small sawmills could be improved and returns from timber production increased through the organization of coöperative marketing associations. Lumber trucked from several mills to central lumber-concentration yards could be remanufactured, graded, and sold in relatively large quantities. Such a procedure, already approximated by a few box factories that purchase box lumber from several mills, might be developed for marketing the entire production of scattered small sawmills.

Potential Demand for Second-Growth Lumber.—During the past two decades consumption and prices of lumber have shown considerable fluctuation, reflecting depression conditions, a slowing up of national industrial and agricultural expansion, and various technological changes in numerous fields of wood utilization. It seems probable, however, that replacement demands will continue to absorb large quantities of lumber. Further migration of population to California also may strengthen local markets for timber produced in the second-growth pine region. Consumption of wood for box shooks has been maintained at fairly high levels, even though considerable competition from fiber products has been encountered.

Consumption of second-growth lumber will be influenced by the amount and accessibility of remaining stands of old-growth pine and other timber species, and by the rate at which the old-growth timber is cut. Commercially available stands of old-growth timber in the California pine region comprise about 7,800,000 acres, and a total volume of

about 116 billion board feet.¹⁵ Old-growth ponderosa pine timber is estimated at 50 billion board feet, sugar pine 19 billion board feet, and Douglas-fir, white fir, and incense-cedar about 47 billion board feet. Second-growth stands have an estimated volume of about 6 billion board feet. Commercially available timber stands in the redwood region of California comprise an additional 46 billion board feet.

The annual production of lumber in California is shown in figure 12; since 1920 it has averaged about 700 million board feet of ponderosa pine, 300 million board feet of sugar pine, and 600 million board feet of other California species. Insects and fires have caused an additional

Fig. 12.—Production of ponderosa pine lumber in California and in the United States and of softwood lumber in California, 1904–1940. (Data from U. S. Bureau of the Census.)

depletion of pine timber amounting in epidemic years to as much as 700 million board feet. The total annual depletion of ponderosa pine timber in California has thus amounted to as much as 1,400 million board feet. At this rate the remaining old-growth ponderosa pine timber in California would be exhausted in forty years or less. However, it is probable that reduced losses from insects and fire, increased dependence on other species, and growth in residual stands may extend the period of cutting in old-growth pine forests. Logging the remaining stands of less accessible old-growth timber undoubtedly will result in higher production costs, however, and thereby stimulate cutting in accessible second-growth timber stands, where operating costs ordinarily are relatively low.

Similar relations between old-growth timber resources and depletion obtain for the entire ponderosa pine region. Remaining stands of pon-

¹⁵ Unpublished data from files of the California Forest and Range Experiment Station.

derosa pine in the western states are estimated by the United States Forest Service at about 225 billion board feet, sufficient at the rates of depletion shown in figure 12 to last for decades. Increased cutting in young-growth stands and increased dependence on other species undoubtedly will also precede the exhaustion of the pine timber in these old-growth stands.

The marketing of large quantities of Douglas-fir lumber from the Pacific Northwest in California markets in competition with California woods suggests the important market influence of remaining supplies of this species. Old-growth Douglas-fir stands in the coast region of the Pacific Northwest comprise the major part of a total volume of approximately 602 billion board feet of saw timber.¹⁶ With depletion of old-growth Douglas-fir averaging about 7 billion board feet annually, and all species 9½ billion board feet annually, heavy shipments to California markets may be expected for some time. Exhaustion of the accessible timber supplies in the Pacific Northwest, however, should result in higher lumber prices, and increased local consumption of pine and Douglas-fir lumber produced in California.

The accessibility of second-growth pine stands in the western Sierra Nevada suggests the prospect of considerable cutting of these young-growth stands in competition with old-growth pine and Douglas-fir timber. However, premature utilization of the small, low-quality trees in most young-growth stands will yield relatively limited returns, and the sale of lumber from such trees will tend to depress the market prices of the low Common grades obtained from old-growth timber. Continued cutting of mature and overmature timber and deferred cutting of rapidly growing second-growth trees would apparently be economically and socially desirable.

MARKETS FOR MINOR PRODUCTS

Although lumber constitutes the chief forest product of the Sierra Nevada foothills, minor timber products are important sources of forest income. Forest products such as mine timbers represent the principal income from many forests, and in nearly all stands a portion of the yield is suitable for fuel wood, posts, or other products.

Mine Timbers.—Round mine timbers of Douglas-fir and ponderosa pine have been cut in many parts of the foothills more or less continuously for nearly a century (fig. 13). In recent years forest utilization for mining timbers has been restricted somewhat by importation of

¹⁶ Data from a statistical report of the U. S. Forest Service to the Joint Congressional Committee. 1939. 14 p. (Processed.)

Douglas-fir timbers from the Pacific Northwest, and confined largely to areas such as those adjoining the operating mines of Nevada County, northern El Dorado County, and Amador County. Within these regions mine poles have been obtained chiefly from Douglas-fir stands in the canyon areas at low elevations and from forests of mixed species at higher elevations. The cutting of mine poles usually represents a supplementary occupation for farmers and other local residents. At foothill mines prices

Fig. 13.—Douglas-fir mine props cut from second-growth stands. Near the foothill mining centers, selective cutting for mine timbers has long been an important form of forest utilization.

for 16-foot poles ranging from 6 to 16 inches in diameter have varied from about 40 cents to \$4 per pole, and have averaged about \$22 per thousand board feet. Stumpage prices have varied from about 8 to 40 cents per pole. Trends in mining activity indicate that second-growth pine and Douglas-fir mine timbers may be utilized in significant quantities in the future only in forests near the principal mining centers.

Fence Posts.—Fence posts cut from old-growth incense-cedar trees have been produced for many years for use on local foothill farms and in the Sacramento Valley. Prices in the foothill region usually average about 15 cents a post. Utilization of small incense-cedar and ponderosa pine trees as fence posts has also become economically possible since the development of low-cost preservative treatment with creosote or zinc chloride (11). Where landowners require posts for their own use or

where markets are available, thinning of stands for fence posts can yield income and at the same time improve stand composition, stand structure, and growth rates.

Piling.—Utilization of second-growth timber for piling was initiated in the foothills in 1939. Selected young-growth trees of Douglas-fir, and limited quantities of ponderosa pine and white fir have been cut in a number of foothill counties mainly for use in waterfront structures in the San Francisco Bay region. Timber owners have received from $\frac{3}{4}$

Fig. 14.—Fuel wood cut in a second-growth pine stand. Thinning stands for fuel wood yields income and usually is good forestry practice; but extensive clear cutting and cutting of the more vigorous trees sacrifice values and frequently result in deforestation.

to 2 cents per lineal foot for stumpage. Delivered prices for piling in the Bay area have varied from about 18 to 25 cents per lineal foot.

Because of the accessibility of the young-growth forests in the western Sierra Nevada, cutting of piling is likely to be an important forest occupation in this region in the future. Although stands often may be advantageously thinned for piling, cutting should be carefully managed to avoid the depletion of growing stock and the sacrifice of trees that are more valuable for saw timber.

Fuel Wood.—Utilization of oak, pine, and Douglas-fir trees for fuel wood accounts for an important part of the income from many second-growth forests (fig. 14). Although consumption of fuel wood has been reduced considerably by the increased use of oil and gas in recent years, large amounts of fuel wood are still used, particularly by farmers and

other rural residents. In the foothill towns oak cordwood makes up about two thirds of the fuel wood used, the remainder being pine and Douglas-fir cordwood together with mill blocks from local sawmills and box factories. Sacramento markets consume only small quantities of pine cordwood, estimated by wood dealers at less than 5 per cent of the total fuel wood consumption. Considerably less pine than oak is used, chiefly because oak wood is superior in heating qualities and is readily available. Live oak (*Quercus Wislizenii*) is preferred in valley markets, and black oak (*Quercus Kelloggii*), which grows as a common associate of ponderosa pine, is sold mainly in the foothill settlements.

Fuel-wood prices average about \$1 per cord for ponderosa pine stumpage and \$1.50 per cord for oak stumpage. For fuel wood delivered in foothill markets prices average about \$7.50 per cord for pine and \$10.50 per cord for oak, compared with \$11 for pine and \$15 for oak in the Sacramento Valley.

Under current utilization practices fuel-wood cutting is often limited to the larger pine trees, above 20 and 24 inches in diameter, since the output per day is greater and the wood is considered more desirable than that cut from small trees. However, thinning the smaller suppressed pine, oak, and other species from second-growth stands for fuel wood is important in forest management, since the removal of inferior trees not only produces income but also builds up the growth and value increment of the remaining stand.

Box Veneer.—Production of veneer bolts from second-growth ponderosa pine trees has recently developed into a significant form of timber utilization in the western Sierra Nevada. Many young-growth stands contain full-crowned trees of rapid growth that have grown along meadows or in stand openings where lack of competition has resulted in the development of long internodes. Although trees of this type are of relatively poor quality for lumber, they are well suited for box veneer.

At one small operation, bolts of 15 to 27 inches in length were cut from the clear internodes of second-growth trees from 18 to 36 inches in diameter at breast height (fig. 15). Knotty sections 7 to 20 inches in length and occasional long butts were unsuitable for veneer, but usually such sections could be utilized for fuel wood. Measurements of trees cut for veneer bolts showed a fairly high degree of utilization, bolts making up nearly 60 per cent of the cubic volume, compared with about 30 per cent in the knotty sections, and 12 per cent in the top and stump. Shortly after logging, the veneer bolts were run through a lathe, and veneer about $\frac{1}{2}$ inch in thickness was peeled off until only cores of brittle heartwood 8 to 10 inches in diameter remained. The cores were then

sawed into cleats and used with veneer slats to make tops for orange, vegetable, and similar types of boxes.

The stumpage prices paid for veneer bolts amounted to \$2 per thousand board feet.¹⁷ Additional costs for logging, transportation, manufacturing, and selling were covered by an average price of about \$45 per thousand board feet of veneer. With efficient production equipment, second-growth ponderosa pine box veneer can apparently be produced

Fig. 15.—Veneer bolts cut from the internodes of a rapidly grown second-growth ponderosa pine tree. The sections containing whorls of knots can often be utilized for fuel wood.

profitably in competition with veneer cut from other woods such as old-growth pine, spruce, and hemlock.

Timber utilization for box veneer, like that for other minor products, is of particular significance to individual farmers and local landowners, since bolts can be cut and delivered on a small scale. Although manufacture has been restricted to the period from about April to December because of logging and seasoning difficulties in the winter months, timber utilization for veneer provides part-time and seasonal employment for foothill workers and landowners. Both stumpage and labor income from the production of minor products are important sources of supplementary farm income.

¹⁷ Scaled as bolts by the Spaulding log rule. Volumes of bolts per tree approximated log volumes by the Scribner log rule.

LUMBER PRICES

Mill Prices by Species.—Prices of ponderosa pine lumber cut in California sawmills have shown trends similar in general to those of average wholesale prices for all commodities. During the war-inflation period prior to 1920, ponderosa pine lumber prices increased somewhat more slowly than the all-commodity wholesale price index, but during the height of the post-war building boom in 1923 pine lumber prices were swept up to an index of 126 per cent of the general price level. Prices gradually declined during the 1920's, but after 1929 the drop was rapid and somewhat greater than the average decline of the wholesale price index. In 1923 prices for ponderosa pine lumber averaged nearly \$40 per thousand board feet, as shown in table 5, compared with less than \$19 per thousand board feet in 1932. During the late 1930's, ponderosa pine lumber prices recovered moderately to an average of nearly \$24 per thousand board feet.

Prices for other species of lumber produced in the California pine region have exhibited trends similar to those for ponderosa pine, although ponderosa and sugar pine lumber prices have fluctuated somewhat more widely, as indicated in table 5. Douglas-fir and white fir lumber prices reached a peak in 1920 but subsequently showed fairly steady downward trends to the extreme depression lows, with a subsequent recovery to levels of about \$19 per thousand board feet for the Douglas-fir and \$17 for white fir. Prices for the limited quantities of incense-cedar cut in the foothill region averaged about \$20 per thousand board feet during the late 1930's.

Partly as a result of declining prices, Douglas-fir and white-fir lumber has been cut in diminishing quantities since the boom years of the 1920's and in 1937 made up less than 20 per cent of the total lumber produced in the western Sierra Nevada. Heavy cutting of pine and the consequent conversion of old-growth forests into stands having a high proportion of white fir, incense-cedar, and Douglas-fir indicate that price levels for these low-value species will become of increasing importance for future timber production.

Second-growth ponderosa pine lumber prices have averaged considerably less than prices for old-growth lumber, chiefly because of the low grade of most second-growth timber, the practice of selling small mill-run lots, and characteristically poor manufacturing and seasoning practices at the small mills cutting young-growth timber. Second-growth pine lumber cut in the foothills in 1937 sold for an average of about \$15 per thousand board feet, whereas prices of old-growth ponderosa pine

lumber averaged about \$20 per thousand board feet at small mills and \$26 at large band mills.

The considerable drop in lumber prices from the peak levels of the 1920's reflected sharply declining demands for lumber for building

TABLE 5

AVERAGE MILL PRICES PER THOUSAND BOARD FEET FOR LUMBER PRODUCED IN CALIFORNIA SAWMILLS, BY SPECIES, 1919-1940*

Year	Ponderosa pine	Sugar pine	Douglas- fir	White fir	Incense- cedar
	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>
1940.....	24.74	29.23	20.99	18.12	21.76
1939.....	23.65	28.92	18.85	16.38	21.01
1938.....	22.68	29.49	19.85	17.24	21.18
1937.....	25.35	35.00	18.99	18.01	19.73
1936.....	23.42	31.18	18.24	16.60	18.08
1935.....	21.32	29.43	17.56	16.22	18.04
1934.....	22.31	28.08	18.12	16.33	17.11
1933.....	20.04	26.75	16.11	17.87	19.00
1932.....	18.52	26.66	15.53	11.69	18.46
1931.....	24.41	29.33	20.18	16.34	19.15
1930.....	27.83	38.52	18.98	18.21	22.14
1929.....	31.67	44.22	20.61	21.19	22.27
1928.....	32.41	39.87	20.11	20.17	24.22
1927.....	31.88	43.67	21.14	21.02	23.50
1926.....	31.47	48.96	19.98	20.67	21.57
1925.....	30.94	44.99	21.63	23.78	21.28
1924.....	33.06	40.99	20.61	22.46	22.01
1923.....	39.95	47.40	25.28	24.38	25.49
1922.....	34.39	44.62	22.82	21.69	23.19
1921.....	33.23	37.96	21.04	23.26	30.84
1920.....	37.50	49.20	30.50	30.05	31.68
1919.....	30.38	36.35	25.01	27.50	23.50
1918.....	21.28	28.52	20.32	19.98	19.14
1917.....	22.50	25.00	18.00	18.00	17.50
1916.....	15.40	16.87	12.84	13.05	13.05
1915.....	14.89	.....	10.27	.....	12.08
1914.....	14.99	.....	.....	.....	.....
1913.....	17.52	.....	.....	.....	.....
1912.....	13.85	.....	12.54	.....	.....
1911.....	14.40	15.05	12.74	11.11	11.39
1910.....	15.04	15.30	13.76	11.99	.....

* Source of data: U. S. Bureau of the Census, Census of Manufacturers.

construction and other purposes, as well as a general price deflation. Changes in lumber demands and national purchasing power brought about a reduction in the annual consumption of lumber in the United States from about 40 billion board feet in 1925 to 12 billion board feet in 1932, and 23 billion board feet in 1936 (20). Lumber consumption in

California declined from about 3.8 billion board feet in 1925 to 2.6 billion board feet in 1936. Demands from construction and wood-using industries, levels of national income, and trends in general price levels, as well as lumber supplies, may be expected to be of prime importance in determining future levels of lumber prices.

TABLE 6

AVERAGE MILL PRICES PER THOUSAND BOARD FEET FOR PONDEROSA PINE LUMBER
PRODUCED IN LARGE CALIFORNIA SAWMILLS, BY GRADES, 1918-1940*

Year	No. 1 and No. 2 Clear	C Select	D Select	No. 3 Clear	No. 1 Shop	No. 2 Shop	No. 3 Shop	No. 1 and No. 2 Com- mon	No. 3 Com- mon	No. 4 Com- mon	Box
	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>
1940.....	61.08	57.53	40.91	33.96	32.13	23.75	18.12	29.19	21.72	16.61	14.96
1939.....	66.20	62.85	43.73	40.10	36.35	22.76	16.73	29.27	20.72	14.05	15.92
1938.....	71.02	65.43	47.11	40.03	35.49	21.21	14.40	28.41	18.75	14.68	15.44
1937.....	74.25	71.08	56.08	47.38	44.31	28.37	18.74	32.18	21.56	16.69	15.38
1936.....	59.38	54.16	40.20	33.50	31.69	22.19	17.22	27.55	18.83	14.28	13.63
1935.....	54.00	49.31	38.87	32.42	29.65	21.14	16.51	26.86	20.48	15.32	14.80
1934.....	53.63	49.31	41.50	33.61	32.99	23.74	17.83	24.45	19.95	14.93	14.91
1933.....	40.71	41.74	34.47	30.64	27.44	19.78	17.64	22.86	16.55	11.71	14.37
1932.....	48.21	41.25	30.70	29.66	26.37	18.20	15.87	22.94	13.69	9.14	16.44
1931.....	63.70	56.99	33.17	35.30	27.92	19.28	17.22	26.92	17.67	12.36	17.72
1930.....	71.39	64.21	44.43	40.07	34.36	20.96	19.65	29.94	21.32	14.66	19.36
1929.....	79.10	70.38	52.25	48.50	43.06	31.16	24.67	33.01	23.99	17.40	19.57
1928.....	77.98	66.57	51.35	48.98	38.29	25.67	19.78	31.77	23.79	16.83	21.95
1927.....	80.69	69.15	56.79	55.09	43.81	27.15	21.34	29.39	23.12	16.77	20.42
1926.....	91.06	72.70	55.61	59.14	48.12	29.38	22.20	29.97	22.57	16.06	20.16
1925.....	93.27	75.97	58.16	63.45	52.44	31.59	22.16	28.78	23.11	18.12	19.11
1924.....	97.75	80.50	59.00	61.75	48.25	32.50	21.25	29.00	23.00	18.50	20.25
1923.....	109.00	95.00	77.25	76.50	60.25	42.75	27.50	34.75	26.50	21.75	23.75
1922.....	103.75	90.25	70.25	77.00	61.25	45.25	27.50	28.25	21.50	15.25	19.50
1921.....	97.50	85.00	67.00	65.00	48.50	32.50	24.00	28.00	18.50	.....	19.75
1920.....	99.00	95.00	.....	82.00	73.50	61.50	45.00	46.50	36.50	.....	34.00
1919.....	58.00	53.00	.....	47.50	40.30	31.00	24.60	31.75	.....	.....	26.00
1918.....	52.00	50.00	.....	45.00	37.50	25.50	20.80	26.50	.....	.....	20.00

* Data from U. S. Forest Service, California Region. Data prior to 1939 are gross mill prices; that is, allowances for commissions, discounts, and freight adjustments (averaging from 6 to 9 per cent of the reported prices) have not been deducted.

Excess production capacity in the lumber industry and keen competition to supply available lumber markets have also strongly influenced lumber prices. During the 1920's the capacity of lumbering industries in the United States expanded to such an extent that the 1929 output of 37 billion board feet represented only 70 per cent of the estimated installed capacity (17). Throughout the subsequent decline in lumber consumption, excess production capacity persisted. In the western Sierra

Nevada actual output of lumber has averaged considerably less than the estimated capacity of the local sawmills.

Control of production capacity, of lumber output, and of prices has not been effective in the lumber industry, partly because of wide distribution of timber supplies, large numbers of timber owners and manufacturing plants, and strong competition among various timber species

TABLE 7

MILL PRICES PER THOUSAND BOARD FEET OF LUMBER CUT BY
LARGE BAND MILLS AND BY SMALL PORTABLE MILLS IN
THE WESTERN SIERRA NEVADA, 1928-1940*

Year	Ponderosa pine		Douglas-fir	
	Large mills	Small mills	Large mills	Small mills
	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>
1940.....	25.05	19.37	19.02	18.83
1939.....	23.39	19.72	23.41	19.56
1938.....	24.36	19.75	20.45	19.80
1937.....	26.26	19.58	21.44	18.72
1936.....	23.92	18.86	20.00	18.08
1935.....	21.48	17.44	18.77	18.47
1934.....	22.27	18.26	18.58	19.15
1933.....	23.42	15.91	15.85	16.46
1932.....	18.83	15.20	16.10	15.47
1931.....	22.15	20.65	18.86	20.29
1930.....	29.49	21.00	17.44	20.08
1929.....	34.27	23.28	24.26	23.44
1928.....	37.49	21.92	20.62	22.01
Average.....	25.61	19.30	19.65	19.29

* Data from: U. S. Bureau of the Census and the California Forest and Range - Experiment Station.

and substitute materials. If depreciation and obsolescence result in decreased sawmill capacity and reduced competition in lumber markets, it is possible that the trend of lumber prices will be toward higher levels. The shifting of logging operations to less accessible areas of old-growth timber where production costs are relatively high may also be reflected in somewhat higher lumber prices.

Prices by Lumber Grades.—Prices for various grades of ponderosa pine lumber show considerable differentials. Select and Shop grades, which make up a large proportion of the cut from old-growth timber, are of relatively high value, whereas the Common grades that predominate in second-growth timber are of low value. The present small output of second-growth lumber is not marketed by standard grades, but as

larger quantities are cut the differences in grade prices undoubtedly will become of increasing importance to timber operators.

Prices for No. 1 and No. 2 Clear lumber in 1939 averaged about \$66 per thousand board feet, as shown in table 6, compared with \$36 for No. 1 Shop, \$29 for No. 1 and No. 2 Common, \$21 for No. 3 Common, and \$14 for No. 4 Common. Prices for different grades have shown considerable fluctuation from year to year, particularly for the better grades. Prices for No. 1 and No. 2 Common lumber also have shown an upward trend in comparison with other grade prices as a result of increased demands for knotty-pine lumber for interior finish.

Prices in Relation to Size of Mill.—Lumber prices vary widely in different mills of the Sierra Nevada foothills. Average mill prices received by a sample group of 42 sawmills in 1937, for example, varied from \$12.50 to about \$30 per thousand board feet. Prices of ponderosa pine lumber averaged nearly \$7 per thousand board feet higher at the large mills than at small mills during the period 1928–1939, inclusive, as shown in table 7. Douglas-fir lumber prices, however, averaged only about 35 cents per thousand board feet more at large mills than at small mills. The higher prices received by the larger mills result in part from the better quality of timber usually logged and in part from greater care in manufacturing and seasoning. Cutting of large quantities of lumber also permits segregation of grades and more advantageous selling in general lumber markets.

STUMPAGE PRICES

Prices of old-growth ponderosa pine stumpage in the California pine region since 1918 have fluctuated around an average level of approximately \$3 per thousand board feet, as shown in table 8.¹⁸ Sugar pine stumpage prices have averaged about \$3.50 per thousand board feet. Small quantities of relatively high-quality timber of Douglas-fir have sold for prices averaging about \$1.50 per thousand board feet, compared with about \$1.25 for accessible incense-cedar and white-fir timber. Prices of second-growth ponderosa pine stumpage have shown an upward trend since 1929 to levels exceeding \$2 per thousand board feet. Most of the

¹⁸ The average stumpage prices shown in table 8 for tracts of timber actually sold indicate general trends in value, but do not reveal the full range in value of timber throughout the pine region. Most of the more accessible and higher-value stands are owned by operating lumber companies, and such timber is rarely sold. Inaccessible stands, on the other hand, have no prospective conversion value for many years, and the discounted stumpage value obtained after deduction of carrying costs and a margin for risk is negligible. Sales of national forest timber are often made at prices somewhat higher than those for private sales, but payments are for timber as cut and thus represent only stumpage conversion values for the portions of tracts actually logged.

relatively small quantities of second-growth pine timber sold has been acquired by owners of small mills for logging within a year or two after purchase, and the prices paid have consequently tended to approxi-

TABLE 8
AVERAGE STUMPAGE PRICES PER THOUSAND BOARD FEET FOR
SALES OF PRIVATELY OWNED TIMBER IN THE CALIFORNIA
PINE REGION, 1914-1940*

Year	Ponderosa pine		Sugar pine, old growth	Douglas- fir, old growth	Incense- cedar, old growth
	Old growth	Second growth			
	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>
1940.....	3.40	1.84	3.87	1.45	1.53
1939.....	3.02	2.08	3.21	1.42	1.53
1938.....	3.52	2.61	3.85	2.27	1.82
1937.....	3.28	2.12	2.81	1.53	1.80
1936.....	3.27	2.37	3.28	1.48	1.66
1935.....	2.72	1.51	3.79	0.87	0.99
1934.....	3.09	1.49	3.74	1.93	1.81
1933.....	2.44	1.88	3.27	1.71	1.03
1932.....	2.58	1.50	2.38	2.24	0.67
1931.....	3.30	2.14	2.62	1.89	0.56
1930.....	3.46	2.00	5.47	1.64	1.46
1929.....	2.58	1.01	4.31	1.08	1.04
1928.....	3.25	....	3.87	1.68	1.97
1927.....	4.67	....	3.60	1.62	1.36
1926.....	3.39	....	4.60	1.62	1.40
1925.....	2.72	....	3.94	0.59	1.05
1924.....	2.33	....	2.51	....	....
1923.....	3.85	....	4.51	1.26	1.25
1922.....	2.75	....	3.48	1.57	....
1921.....	2.64	....	2.50	1.00	2.41
1920.....	3.16	....	2.88	....	2.07
1919.....	3.25	....	....	....	....
1918.....	2.23	....	2.00	0.75	0.75
1917.....	1.33	....	1.33	1.32	....
1916.....	1.00	....	1.14	1.73	1.39
1915.....	2.12	....	....	....	....
1914.....	2.42	....	2.94	1.81	0.58

* Prices of ponderosa pine and sugar pine for the period 1914-1934, from: Steer, H. B. Stumpage prices of privately owned timber in the United States. U. S. Dept. Agr. Tech. Bul. 626:92, 1938.

Other data from California Forest and Range Experiment Station.

mate stumpage conversion values.¹⁰ Although prices for second-growth lumber have been considerably lower than for old-growth timber, log-

¹⁰ Stumpage conversion values represent the residuals between lumber values and all logging, milling, and selling costs. Deduction from stumpage conversion values of expenses for protection, taxes, and management indicates the net land incomes obtained from timber growing.

ging and milling costs also have been low enough to permit significant net margins for stumpage.

The actual stumpage values of different tracts of timber, as well as of individual trees, vary widely; they are influenced by such factors as lumber price levels, quality and quantity of timber, logging and milling costs, risks of loss from fire and insects, length of period before income can be realized, and bargaining power of buyers and sellers. The combined effect of such factors has resulted in the stumpage values for second-growth pine timber shown in table 8. Forest landowners have particular interests in stumpage returns, for these represent the gross incomes accruing to forest-land ownership.

PRODUCTION COSTS

Lumber-Manufacturing Costs.—Logging and milling costs in the California pine region have been somewhat more stable than lumber prices; this has resulted in a considerable short-term fluctuation in stumpage conversion values and in profits realized by operating lumber companies. Between 1928 and 1938, for example, average direct lumber production costs at large band mills varied only between about \$18 and \$22 per thousand board feet, according to United States Forest Service data, whereas prices varied considerably more, as shown in tables 5 and 7. In small circular mills, average direct operating costs varied between about \$11 and \$17 per thousand board feet in the same period.

Lumber manufacturing costs are usually lower in the small portable mills than in the large band mills, chiefly because of poorer manufacturing, lower wage levels, smaller marketing expenses, and lower depreciation charges for the relatively poor equipment used. Prices for the grades and quality of lumber produced, however, are also generally lower than those received by the large mills. Mills operating in second-growth stands of the Sierra Nevada show production costs below the average for the California pine region, partly because of easy logging conditions and accessibility of timber from numerous roads. Direct production costs in six small mills cutting second-growth lumber during 1937, for example, averaged about \$12 per thousand board feet, compared with approximately \$14 for small mills and \$20 for large band mills operating in old-growth stands.

Cost of lumber manufacture in the California pine region has declined from the relatively high levels reached during the early 1920's. Lower costs, particularly at the large band mills, have resulted in considerable measure from economies associated with the substitution of logging tractors for steam donkeys, the use of log trucking in place

of railroad transportation, and the increasing prevalence of selective logging. The development of trucking as an efficient method of transporting lumber from mills to markets has also resulted in lower lumber-distributing costs, especially for the small-mill operations. As more roads are constructed and improved in the mountains, further declines in logging costs and lumber distribution costs may occur. The relatively accessible second-growth pine region is in an unusually favorable position for producing and marketing lumber at low cost.

Management Costs.—Production of timber crops involves certain management and landholding costs that must be paid from stumpage conversion values before any net land income or forest rent is available. Costs are incurred for fire protection, for example, although in the Sierra Nevada region expenses for protection are borne largely by Federal and State fire-protection agencies. In the second-growth belt outside the national forests, where the protection problem is particularly difficult, estimated fire-protection expenditures of the California State Division of Forestry averaged about 4 cents per acre annually during the 1930's. Fire-protection expenditures, however, have not been adequate, as evidenced by numerous damaging fires. Increased protection outlays, as well as a greater public consciousness of fire danger, appear necessary to reduce timber losses.

Property taxes on second-growth timberlands varied from about 4 to 20 cents per acre annually, exclusive of irrigation district assessments, in different parts of the foothills during the 1930's, with an average of about 7 cents per acre annually.²⁰ Local property taxes on young-growth timberland are usually based on rather uniform assessed values applied to all cutover lands regardless of stand volumes, cover types, or income produced. Tax exemption has been granted immature timber stands by a State Constitutional amendment²¹ which was enacted to provide a safeguard against burdensome taxation of immature forests and thus to stimulate protection and management of cutover lands. Although of problematical importance to date, this amendment might provide substantial inducements to forestry in case assessed values or tax rates were materially increased.

²⁰ Data from an unpublished manuscript by Wade DeVries on taxation and public finance problems in foothill counties in California. California Forest and Range Experiment Station.

²¹ Article XIII, section 12¾, adopted in 1926, automatically exempts from taxation all immature forest trees or natural growth upon land from which the merchantable original-growth timber to the extent of 70 per cent of all trees above 16 inches in diameter has been removed. Timber is considered mature, hence taxable, at such time after forty years from the time of planting or removal of the original timber as shall be determined by majority vote of a board representing the State Board of Forestry, the State Board of Equalization, and the county assessor.

Costs of administering forest properties are additional items of expense in producing timber crops. For such landowners as farmers, who have timber on part of an operated farm, administration costs are negligible. On many forest properties, however, the costs of administration, expenditures for land and timber surveys, legal expenses, and other items are estimated at 20 to 50 cents per acre annually. Both management costs and land-holding costs are fairly low in relation to stumpage returns in most parts of the foothill region, indicating a relatively favorable position of second-growth forests for producing net forest land incomes.

MANAGEMENT FACTORS AFFECTING FOREST INCOMES

In addition to timber yields and economic trends in markets and prices, methods of timber utilization and management also influence incomes from production of second-growth timber. The financial returns obtained from forest land depend to a large extent upon the local variations in value of different tree sizes, the financial maturity of timber, and the practices of stand improvement.

TREE SIZE IN RELATION TO VALUE

The importance of tree size as a factor influencing both the costs of producing lumber and the value of lumber and stumpage has been brought out by numerous logging and milling studies made throughout the United States. Studies of Brundage and associates (4) at a large-scale lumbering operation in the western Sierra Nevada, for example, indicated that production of lumber from ponderosa pine trees 16 inches in diameter entailed costs 52 per cent greater than for 30-inch trees, and 68 per cent greater than for 40-inch trees. Higher production costs for the smaller trees, together with lower values for the lumber produced, resulted in operating loss of nearly \$8 per thousand board feet for 16-inch trees, compared with a net margin exceeding \$5 per thousand board feet for 30-inch trees.

Investigations of logging and milling costs for smaller-sized timber cut in pine stands of the southern states showed similar results, according to Garver and Miller (9). Thus lumber cut from 8-inch trees cost twice as much per thousand board feet as that cut from 24-inch trees. Moreover, the low grades and small sizes of lumber cut from the small trees were worth only three fourths as much per thousand board feet as that cut from the larger trees.

A study of utilization costs and values of second-growth ponderosa pine lumber cut in a small mill in the foothills showed similar variations

in net value according to size of trees. Time requirements and production costs at this mill²² varied considerably according to tree size, as shown in table 9, although such factors as tree height or logging conditions affected time requirements for individual trees within a given size class. The average time requirements for all operations of lumber manufacture amounted to about 1,030 man-minutes per thousand board feet for 14-inch trees, compared with about 760 man-minutes for 22-inch trees, and about 720 man-minutes for 30-inch trees.

TABLE 9

AVERAGE TIME REQUIREMENTS, COSTS, AND MARGINS FOR LOGGING AND MILLING
SECOND-GROWTH PONDEROSA PINE AT A SMALL SAWMILL IN THE SIERRA
NEVADA FOOTHILLS, BY OPERATIONS AND TREE DIAMETERS*

Tree diameter at breast height (inches)	Time requirements (man-minutes) per thousand board feet					Costs (dollars) per thousand board feet					Margin (dollars) per thousand board feet	
	Log- making	Skid- ding	Mill- ing	Yard	Total	Log- making	Skid- ding	Mill- ing	Yard	Total	Total†	Stump- age‡
14	228	176	434	189	1,027	1.89	1.87	5.21	1.51	10.48	2.02	0.37
18	188	136	364	189	877	1.56	1.44	4.36	1.51	8.87	3.63	1.98
22	148	100	322	189	759	1.23	1.06	3.86	1.51	7.66	4.84	3.19
26	125	92	302	189	708	1.04	0.98	3.63	1.51	7.16	5.34	3.69
30	118	87	328	189	722	0.98	0.92	3.94	1.51	7.35	5.15	3.50

* Time requirements based on complete time-study data for 16 second-growth trees. Costs based on a wage rate of \$3 per day.

† Available for slash disposal, interest, profit and stumpage; calculated by deducting direct costs from a mill value of \$12.50 per thousand board feet.

‡ Calculated from the total margin by deducting 40 cents per thousand board feet for slash disposal and \$1.25 per thousand board feet for interest and profit.

Lumber production costs for trees of various diameters, shown in table 9, showed correspondingly wide variations. Cutting lumber from 14-inch trees, for example, entailed average direct costs of about \$10.48 per thousand board feet, compared with about \$7.16 per thousand board feet for 26-inch trees. At this operation trees above 28 inches in diameter involved increasing costs per thousand board feet, since the mill equipment used was not adapted for sawing large logs. The lumber production costs at this operation also were below the average for small mills in the foothills, chiefly because of low wage rates and unusual accessibility that permitted direct skidding of timber to the mill. Nevertheless, the

²² The "even-aged" stand of second-growth timber logged at this operation contained trees averaging about sixty-seven years of age and varying in diameter from 5 to 34 inches. Stand volumes averaged about 16 thousand board feet per acre, about 75 per cent of the stand volume being in trees 19 to 24 inches in diameter. Logs were skidded in tree lengths by tractor directly to a small mill having a single circular saw. A three-man woods crew and a six-man mill and yard crew produced an average of 4,500 board feet of 6/4 box lumber per day from logs 5 to 24 inches in diameter.

general variability of costs according to tree diameter as shown by other logging and milling studies was confirmed.

Net margins per thousand board feet available for stumpage, interest and profit, and slash disposal also varied considerably, as shown in table 9, even when differences in grades and sizes of lumber obtained from various tree sizes were disregarded, as is the practice at small mills where lumber is sold mill-run. These margins, obtained by deducting production costs for each diameter class from a mill-run value of \$12.50 per thousand board feet obtained for the box lumber produced, averaged about \$2.00 per thousand board feet for 14-inch trees, compared with \$5.34 per thousand board feet for 26-inch trees. After estimated expenses for interest and profit and slash disposal were deducted, the residual margin for stumpage averaged about 37 cents per thousand board feet for 14-inch trees, compared with \$3.70 per thousand board feet for 26-inch trees. The "zero-margin" trees, that is, trees having only sufficient value to pay their production costs, averaged somewhat less than 14 inches. However, the zero-margin size of tree in most second-growth stands undoubtedly averages more than 14 inches, since wages, logging costs, and transportation costs were unusually low at this operation.

The stumpage conversion values indicated in table 9 also showed smaller differentials for trees of different sizes than were indicated in other logging and milling studies, partly because of the practice, customary at many small mills in Sierra Nevada, of selling lumber mill-run, or at a flat price for the total cut. When lumber is sold according to grade and size, higher values per thousand board feet are usually obtained for the larger trees. Margins for stumpage would thus tend to be correspondingly greater for the larger tree sizes than indicated in table 9. Differential prices for various lumber grades, and thus for various tree sizes, might be obtained by small mill owners through some such device as a coöperative marketing organization.

The marked relation between tree size and both utilization costs and timber values, as described above, suggests the important influence of selective cutting methods on the net income obtained from timber production. Harvesting only the larger and more mature trees yields relatively high net returns per thousand board feet of timber cut.

VALUE INCREMENT OF TIMBER

Selective cutting of stands not only harvests the high-value timber but also can maintain a productive residual forest growing stock made up of the smaller trees of relatively low or even negative stumpage conversion value. Such immature trees are capable of increasing rapidly in value.

The potentially high rates of value increment obtainable on the capital values represented by second-growth pine trees of the kind that may be reserved in selectively cut foothill stands are illustrated in table 10 and figure 16. Assuming conditions similar to those prevailing at the small operation referred to in table 9, second-growth trees of 14 inches in diameter, for example, have a value of about 37 cents per thousand board feet, or 5 cents per tree. With estimated diameter growth averaging 2

TABLE 10

RATES OF VOLUME AND VALUE INCREMENT OF SECOND-GROWTH PONDEROSA PINE TREES UNDER SELECTED CONDITIONS OF GROWTH AND VALUE

Tree diameter	Volume per tree (site index 175)	Volume increment			Stumpage value		Value increment		
		Total	Annual*	Average rate†	Per M bd. ft.‡	Per tree§	Total	Annual*	Average rate¶
<i>inches</i>	<i>bd. ft.</i>	<i>bd. ft.</i>	<i>bd. ft.</i>	<i>per cent</i>	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>	<i>dollars</i>	<i>per cent</i>
12	75	...	...	...	...	...	...	...	...
14	125	50	6.3	6.3	0.37	0.05	0.05	0.006	...
16	190	65	8.1	5.1	1.22	0.23	0.18	0.023	16.4
18	270	80	10.0	4.3	1.98	0.54	0.31	0.039	10.3
20	375	105	13.1	4.1	2.65	0.99	0.45	0.056	7.3
22	500	125	15.6	3.6	3.19	1.60	0.61	0.076	5.9
24	650	150	18.8	3.3	3.55	2.31	0.71	0.089	4.6
26	820	170	21.3	2.9	3.69	3.03	0.72	0.090	3.4
28	1,015	195	24.4	2.7	3.73	3.79	0.76	0.095	2.8
30	1,230	215	26.9	2.4	3.75	4.61	0.81	0.101	2.4

* Calculated by assuming diameter growth at the rate of 2 inches in eight years.

† Annual volume increment from one diameter class to the next, divided by the average volume of the two classes.

‡ Based on values prevailing at a small sawmill cutting second-growth timber in the Sierra Nevada foothills.

§ Tree volume multiplied by stumpage value per thousand board feet.

¶ Annual value increment from one diameter class to the next, divided by the average value for the two classes.

inches in eight years, 14-inch trees increase in value at an average rate of 16.4 per cent annually to 22 cents per tree at 16 inches. Estimated rates of value increment subsequently decline as the size and stumpage conversion value of trees increase. In this example, annual rates of value increment average 7.3 per cent for 19-inch trees, 4.6 per cent for 23-inch trees, and 2.4 per cent for 29-inch trees. Such decline in the rate of value increment would be somewhat slower, provided growth rates were maintained, if stumpage values continued to increase with tree diameters rather than level off as shown in table 10.

This example of the high rates of value growth obtained on the smaller and more vigorous trees demonstrates the financial desirability of retaining in the forest, rather than liquidating, the capital values represented by the smaller sizes of young-growth timber.

Rates of value increment of trees exceed rates of volume increment, as illustrated in figure 16, because of the increasingly higher stumpage values per thousand board feet obtained for larger tree sizes.²³ Since trees thus increase more rapidly in value than in volume, 21-inch trees, for example, show an annual value increment of 5.8 per cent when annual volume increment averages only 3.6 per cent. Rates of volume and value increment of trees coincide only when the same stumpage value per thousand board feet is obtained for consecutive tree sizes.

Fig. 16.—Annual increment in volume and value of second-growth ponderosa pine trees growing on an area of site index 175 at the rate of 2 inches in diameter in eight years, and valued as indicated in table 10. Tree value increases more rapidly than tree volume because of the relatively high prices obtained for the larger diameters. For the same reason, percentage increments in value exceed the rates of volume growth.

The rates of value increment shown in table 10 obtain under selected conditions, and it must be emphasized that the rates at which trees in other areas increase in value depend upon local stumpage conversion values for different diameter classes and upon current rates of volume growth. The rates of value increment indicated in table 10 and figure 16 apply only with the assumed conditions of growth and the average stumpage conversion values prevailing at one small sawmill in the Sierra Nevada foothills. With lower stumpage values, for example, the zero-margin size of trees would be larger than indicated, and the curve of

²³ To realize the full differential net values per thousand board feet for various tree sizes, timber owners must sell logs or lumber at prices based on size and quality.

value percentage in figure 16 would be shifted toward the larger sizes. Also of considerable importance is the fact that rates of value increment would decline somewhat more slowly than shown if stumpage values continued to increase with tree diameter. Higher rates of value increment for the larger sizes of trees might be obtained by producers of second-growth timber through the use of efficient production equipment and the marketing of lumber by grades and sizes.

The rates of diameter and volume growth likewise would influence the position of the curve of value increment shown in figure 16. The rates of value increment shown obtain specifically only on areas of site index 175 with trees showing an average diameter growth of 2 inches in eight years, or 8 rings per inch of radial cross section. With this growth rate the annual increase in value of 21-inch trees amounts to 5.8 per cent, whereas 21-inch trees growing at 11 rings per inch, for example, would show a rate of value increment of only 4.3 per cent. Forest management to maintain stands of well-spaced vigorous trees showing consistently high rates of growth thus is also essential for producing potential increment in the value of forest capital.

Rates of value increment of stands of timber show trends similar to those for individual trees. Fully stocked forests of second-growth ponderosa pine on areas of site index 175, for example, increase in value at a rate of 4 per cent at seventy years and 2 per cent at one hundred years, when increment is calculated with the stumpage values shown in table 10. Since selective cutting is feasible in the young-growth pine stands of the Sierra Nevada, however, rates of value increment of trees are of greater importance in determining cutting methods than rates of value increment of stands.

The value increment of trees and stands, as discussed above, represents gross earnings on the value of forest capital before deduction of costs for taxes, protection, and administration. In well-stocked pine forests that have been built up to produce a steady output of the larger and more valuable tree sizes, it is estimated on the basis of attainable growth and current management costs in the foothill region of the western Sierra Nevada that gross rates of value increment of approximately 4.5 per cent would yield net rates exceeding 3 per cent after deduction of expenses for management.

FINANCIAL MATURITY OF TIMBER

Financial maturity of trees may be considered as attained when the rate of value increment drops below the rate of interest obtainable in alternative investments of comparable risk. If the value increment of

trees drops to 2 per cent, for example, and the tree values can be realized and converted into alternative investments yielding a larger percentage return, individual landowners will profit by shifting their forest capital into the alternative investments. The funds obtained from the cutting of timber that is earning at low rates may be used for investment in other nonforest enterprises or they may be used in the purchase of additional forest lands.

The lowest rate of earnings on forest capital that landowners will accept is influenced by numerous factors, including the local risk of loss from fire and other hazards, the frequency and permanence of forest incomes, and the general levels of interest rates. Thus more effective fire protection in the foothill region would reduce risks of timber growing and thereby enhance the attractiveness of forest investments. In recent years foothill forests have become more and more accessible, and frequent incomes through light selective cutting have become increasingly attainable. Downward trends in interest rates and lack of attractive investment alternatives indicated by conditions in capital markets have also been significant developments. It is suggested that net rates of value increment approximating 3 per cent, after estimated allowance for non-insurable risks have been made, may reasonably be assumed as marginal rates for calculating the financial maturity of timber. The average rates of earnings obtained on forest capital will exceed such a marginal rate at which trees become "mature," since rates of value increment decline with increasing tree size.

Trees that are financially mature usually consist of large trees showing low rates of value increment, or suppressed trees that show little if any net growth. An economic basis for cutting such mature timber is provided by the principle of determining financial maturity from current rates of value increment. Diameter growth can be determined by boring or chopping into trees, and stumpage values can be estimated by local appraisal. However, modifications to meet local conditions often may be necessary in actual logging operations. When stands are logged only once in a ten-year period, for example, and a minimum cut such as 3 or 4 thousand board feet per acre is needed to make logging economically feasible, removal of some trees earning at slightly higher or lower rates than the accepted minimum may be necessary. Removal of groups of trees or reservation of large trees also is often required to obtain pine reproduction. In the practical task of marking timber for cutting, moreover, it will be necessary to estimate the financial maturity of most trees, although such estimating can be checked by analyses such as outlined in table 10.

SELECTIVE CUTTING

Both the characteristic variation in tree values according to tree diameter and the rapid rates of value increment of small rapidly growing trees in second-growth stands point to the economic desirability of selective management of forests in the Sierra Nevada, as in other forest regions (2, 3, 14). By cutting selectively to remove chiefly the larger tree sizes, production costs per thousand board feet can be held at low levels, and

Fig. 17.—Partially completed clear cutting of a second-growth pine stand for lumber and fuel wood. Small trees capable of rapid increment in value were sacrificed along with the more mature trees. Compare this area with that shown in the frontispiece, where thrifty trees left after selective cutting of the large dominants showed diameter growth averaging 178 per cent of the rate prevailing before logging.

relatively high-value lumber can be produced. Removal of financially mature trees that are no longer increasing in value at satisfactory rates of increment tends to stimulate rates of growth and value increment by concentrating the productive capacity of forest sites on the vigorous reserve trees left as growing stock. (See fig. 17 and frontispiece.) The value increment on financial investments in well-stocked forests may be realized at frequent intervals when stands are cut selectively.

Selective cutting of pine forests in the foothill region also makes possible some control over stand density and species composition. By judicious cutting, an even distribution of vigorous trees can be maintained over a forest area, in contrast to the densely stocked clumps of trees

alternating with open spaces that now frequently occur. In many forests, large, defective old-growth trees of white fir, incense-cedar, and Douglas-fir take up considerable growing space but show low or negative volume and value increment. At the same time such trees produce abundant seed that tends to restock the forest with species that are less desirable than pine. Where local markets for fuel wood, posts, or lumber of these species are available, removal by selective cutting would tend to improve stand composition. Similarly, low-quality and limby pine trees should be removed, when economically practicable, to permit the development of more vigorous and higher-quality young-growth trees. A desirable distribution of tree diameters may also be built up by selective cutting, and thus make available a steady flow of merchantable timber from a given forest area.

Selective cutting of timber stands is also strongly favored by present-day economic conditions and logging practices. Frequent light cutting is made possible by the availability of efficient tractors and trucks for logging, the mobility of small mills, and the accessibility of second-growth forests. A well-developed road system, built largely by public funds, facilitates low-cost production and marketing of timber. Selective cutting can yield immediate and continuous incomes from many well-stocked pine forests, and thus make permanent management of forest resources more feasible and attractive.

STAND IMPROVEMENT

Few investments in building up the volume and quality of second-growth stands have been made by owners of forest land. Stand improvement should become an increasingly important management factor influencing forest incomes, however, as maturing second-growth forests become increasingly valuable and as the depletion of old-growth forests stimulates a more intensive use of the highly productive forest sites.

Thinning operations for fuel wood, posts, mine timbers, and other commercially valuable products have been profitable in many foothill forests. Investments in the form of additional thinning, which involves some cash outlays, will often yield ultimate returns in the form of accelerated value increment on the reserved trees that are benefitted by thinning operations. Thinning to improve species composition and stand density often requires relatively small cash outlays, since the products obtained usually can be sold to cover at least a portion of the costs.²⁴

²⁴ Costs of stand-improvement work may be estimated at varying amounts for landowners investing their own labor. In the absence of alternative employment, even small returns from labor expended in forest improvement may be preferred to leisure.

Pruning of selected vigorous trees in second-growth stands may also be expected to yield ultimate returns. The marketing of second-growth lumber by grades appears probable in the near future, and lumber from trees that have been pruned will then bring higher prices than lumber obtained from limby trees. Dead branches and branch stubs tend to persist on ponderosa pine trees for long periods, even under fairly dense stand conditions, precluding or postponing the formation of clear lumber of high quality. While few data on returns from pruning are available, experience with species in other regions, such as white pine in New England stands (10), indicates that pruning of selected crop trees in second-growth pine forests of the Sierra Nevada is of great potential importance.

Little planting of ponderosa pine or other timber species has been done in this region chiefly because of high planting costs and uncertain survival. Planting stock has been available only at high prices, and from nurseries located in other climatic regions. Risks of losing the relatively large investments in plantations by recurring fires, and the long period of waiting before receipt of income have also tended to discourage tree planting. Under such conditions natural reproduction and intensive protection of existing forests must be relied upon for the most part in obtaining well-stocked second-growth stands. It may be profitable, however, to plant small areas of productive sites where protection is adequate, or to plant scattered pine trees or groups of trees throughout open stands particularly where other species such as incense-cedar create conditions favoring natural pruning.

INCOME FROM A SELECTED FOREST PROPERTY

The analyses of yields, economic trends, and management factors in the preceding sections suggest wide variations in financial returns from second-growth forests. To show the combined application and importance of these various factors, and to demonstrate a method of calculating forest incomes, an illustration of potential costs and returns for a selected young-growth pine stand is presented in the following pages.

The pine forest considered in this example, comprising about 250 acres of uneven-aged timber on an area of site index 175, was located in the elevational zone where pine reproduction ordinarily is adequate and usually fairly easily obtained. The stand was made up of second-growth trees with a sprinkling of old-growth timber. Ponderosa pine and sugar pine averaged about 26,400 board feet per acre. Additional volumes of incense-cedar, occasional Douglas-fir trees, and scattered black oak trees were also present. Volumes in this stand were considerably heavier than

TABLE 11
TIMBER VOLUMES, GROWTH, AND VALUES IN A SELECTED WELL-STOCKED SECOND-GROWTH PONDEROSA PINE STAND
IN THE SIERRA NEVADA FOOTHILLS

Tree diameter at breast height	Stumpage value per M bd. ft.*	Cut per acre		Reserved per acre		Stand per acre after ten years†		Cut per acre after ten years†		Stand per acre after twenty years‡	
		Volume	Value	Trees	Volume	Value	Volume	Value	Volume	Value	Volume
inches	dollars	bd. ft.*	dollars	no.	bd. ft.	dollars	bd. ft.	dollars	bd. ft.	dollars	bd. ft.
2-6 .....	....	....	....	21.0	....	....	....	....	....	....	....
8-10 .....	....	....	....	25.6	....	....	....	....	....	....	....
12-14 .....	....	....	....	21.7	2,770	....	2,500	....	....	....	2,160
16-18	0.60	360	0.22	18.3	4,580	2.75	4,680	2.81	....	....	4,070
20-22	1.92	1,080	2.07	6.6	3,120	5.99	4,630	8.89	330	0.63	6,980
24-26	2.62	1,760	4.61	3.9	3,190	8.36	3,000	7.86	1,020	2.67	3,660
28-30	2.70	2,180	5.89	....	....	....	2,680	7.24	1,340	3.62	2,000
32-34	2.75	2,000	5.50	0.6	780	2.15	990	2.72	490	1.35	860
36 and over	2.75	3,560	9.79	0.6	1,940	5.34	2,000	5.50	1,000	2.75	1,620
Total .....	....	10,940	28.08	98.3	16,380§	24.59	20,480¶	35.02	4,180	11.02	21,300||
											37.57

* Adapted from values prevailing at a nearby portable mill.

† Growth rates estimated to average 2 inches in diameter in ten years; mortality estimated to eliminate 10 per cent of trees 22 inches and under.

‡ Estimated for illustrative purposes.

§ Includes 1,655 board feet of sugar pine and 885 board feet of Douglas-fir per acre. Additional volumes of incense-cedar were also present in the stand.

¶ First ten-year volume increment, 4,100 board feet; value increment, \$10.43.

|| Second ten-year volume increment, 5,000 board feet; value increment, \$13.57.

average for the typically understocked and immature second-growth forests of the region and low-value species such as cedar and fir were less abundant than in most stands. However, volumes and growth conditions in this forest appeared representative of those that are obtainable on at least portions of many properties by deferring utilization of immature timber and building up stocking and stand structure through protection and selective timber management.

UTILIZATION PRACTICES

Selective cutting according to principles outlined in the preceding sections was assumed as the appropriate system of logging. Trees classified for cutting were largely the residual old-growth, suppressed, and competing trees whose removal would liquidate values showing little increment and at the same time improve growing conditions for the remaining stand. Scattered trees already attacked by bark beetles or apparently susceptible to attack were also marked for logging. The volume of pine marked for an initial cut, as shown in table 11, averaged 10,940 board feet per acre, or 41 per cent of the total pine stand. Most of the incense-cedar was marked for removal, in case markets could be developed for fence posts, pencil stock, lumber, or other products, in order to release residual pine trees and to encourage reproducing of ponderosa pine in the stand. Timber reserved as forest growing stock averaged about 16,400 board feet per acre and included rapidly growing young trees and a few of the vigorous mature trees capable of producing large seed crops.

The indicated initial cut in this selected stand was somewhat greater than would be appropriate in most existing understocked second-growth forests, mainly because of the relatively heavy stand volumes. It is expected, however, that such a proposed cutting would maintain a stand of vigorous pine trees and improve species composition by removing cedar trees and opening up the stand for pine reproduction. Furthermore, except for the large pine trees retained for seed production, capital values would be realized from the trees showing relatively low rates of financial earnings.

Utilization of the timber on this sample tract would require the establishment of a small mill on or near the selected property, since log markets at central mills do not exist at present in the Sierra Nevada. After the relatively heavy initial cutting, an annual production averaging only about 100,000 board feet could be sustained permanently on this property. Maintaining a permanent mill of efficient size would therefore necessitate drawing on additional properties for timber. Current prac-

tice in the region is to shift small mills frequently to different properties wherever stumpage can be purchased, but the consequent lack of stability of operations and employment emphasizes the desirability of developing somewhat larger and more centralized industries which would manufacture and market the output of many small timber producers. Forest-owner associations possibly might be established to insure sufficient timber supplies for stable lumbering operations.

The proposed first cut of about 10,900 board feet per acre of pine from this selected property would yield a stumpage income of about \$28 per acre, as shown in table 11. These stumpage returns are calculated from the volume cut in each diameter class and conversion values adapted from those prevailing at the nearby portable mill referred to in table 9. The reserve stand, consisting mainly of young vigorous trees and averaging about 16,400 board feet per acre, would represent additional stumpage values of nearly \$25 per acre and constitute a growing stock capable of rapid increment in value.

On other local second-growth forests of the foothills the amount and proportion of stand values that should be realized by cutting will depend upon many local conditions, including stand volumes and stocking, size and quality of trees, species composition of the stand, tree values by diameters, and rates of growth.

VOLUME AND VALUE INCREMENT

Volume growth of the reserved trees, calculated from the diameter distribution of the reserve stand and estimated average diameter growth rates of 2 inches in ten years, was calculated to average about 410 board feet per acre annually during the ten years after logging and about 500 board feet per acre annually during a subsequent ten year period, as indicated in table 11. Such net growth rates were calculated on the assumption that normal mortality would eliminate only about 10 per cent of the reserve trees 22 inches and under during the ten-year period after cutting. In view of the accessibility of the area, it is expected that injured and dying trees of large size could be economically salvaged. In other stands where salvage for lumber or other products is not possible, available growth might average somewhat less.

The estimates of growth in table 11 compare favorably with actual current growth in many second-growth pine stands. Uncertainty as to actual mortality and growth in selectively cut stands under management, however, points to the need for controlled studies in experimental forests of second-growth pine. The method of forecasting growth illustrated in table 11 has been applied in various other investigations (3,

14), but these methods should be verified in experimental forests. Where fire protection is adequate, however, and stand density, composition, and volumes have been built up through management, growth rates approximating the increment for this selected well-stocked pine stand appear attainable throughout most of the second-growth belt of the Sierra Nevada.

The estimated annual growth of about 410 board feet per acre during the ten-year period following the initial logging represents an annual value increment of about \$1.04 per acre with the indicated stumpage conversion values. During the second ten-year period value increment is calculated at \$1.36 per acre. Such annual forest earnings are equivalent to a gross return of 3.5 per cent and 4.4 per cent, respectively, on the average capital value of the reserve growing stock. Management of stands to obtain forest incomes such as indicated above involves certain forest production costs, however. Taxes, for example, amount to about 15 cents per acre annually on this selected property. Fire protection in this region is provided largely by public agencies, but administration costs are estimated at possibly 25 cents per acre annually. When such production costs are deducted from average stumpage incomes, average net forest land incomes of from 65 cents to nearly \$1.00 per acre annually are indicated. Income equivalent to such value increment may be realized at the end of each cutting cycle, or a portion of the increment may be retained in the forest if it is desirable to build up stand volumes and diameter distributions.

The financial returns obtained from any particular second-growth forest depend to a large extent upon the scale of stumpage values for various tree sizes prevailing in the given locality. Thus the incomes indicated in table 13, for example, illustrate results of using stumpage conversion values adapted from those prevailing at one small portable mill. On the basis of these figures, the average value of the relatively large sizes of timber marked for cutting on the selected property would amount to approximately \$2.50 per thousand board feet, whereas stumpage prices for the relatively small quantities of second growth pine timber cut in recent years have averaged about \$2 per thousand board feet, as shown in table 9. Stand volumes on the selected property also were considerably above the average for the foothill region and returns from more open and younger stands undoubtedly would be less than indicated. Realization of income from immediate selective cutting was also considered possible, although immaturity of most second-growth timber would prevent immediate widespread utilization of young-growth stands. Since available markets for second-growth lumber and other

forest products also are limited at present, expansion of the currently small production from second-growth pine stands would depend upon expanded outlets and favorable timber prices.

Calculations of the forest land incomes obtainable from specific properties rest not only upon local stumpage values and markets but also upon the variables of growth and mortality. Most well-stocked forests of the foothill region could produce an average annual growth of at least 400 board feet per acre annually, as indicated previously. A normal growing stock required to maintain such an output would amount to possibly 16,000 to 20,000 board feet per acre, judging from European experience (14). Where an approximately normal distribution of tree diameters and volumes has been built up, there would be available a steady output of the larger tree sizes having more than average stumpage values. Should future stumpage values for the larger mature trees that would be removed under selective timber management be higher than the \$2.50 per thousand board feet indicated above, stumpage incomes would average more than \$1.00 per acre annually. This would ordinarily be adequate to cover taxes and management costs and still leave sufficient net land income for capitalizing into significant land values. Where stands are poorly stocked or are made up of low-value species, as many foothill stands are, correspondingly lower forest incomes are to be expected.

CONCLUSIONS AND SUGGESTED MEASURES TO INCREASE FOREST INCOMES

The data and estimates of forest incomes presented in the preceding sections indicate the potential earning power of well-stocked stands of second-growth pine in the western Sierra Nevada. The excellent timber-growing conditions in this region, the economic accessibility of stands, and the feasibility of selective timber management all are conducive to realizing attractive forest incomes from well-stocked young-growth pine stands that have been built up to include a wide distribution of tree sizes. Most of the 1,500,000 acres of young-growth forests here are of high site quality and capable of producing relatively heavy timber yields. Stands are composed mainly of young vigorous trees growing rapidly in volume and value. At the same time the remnant old-growth trees scattered throughout second-growth forests often make it possible to obtain immediate incomes from selective cutting. Well-stocked pine stands produce yields estimated at more than 400 board feet per acre annually, which indicates the high potential importance of second-growth forests as a basic resource for future forest industries.

Actual growth and value increment in most young-growth forests, however, is considerably less than potentially obtainable. Poor stocking is characteristic of about 70 per cent of the even-aged pine stands, for example, as indicated in table 1. In the more heavily stocked uneven-aged stands, low-value species and defective trees are abundant. Throughout the second-growth belt are scattered areas capable of producing forest crops but which are now supporting chaparral and woodland types of little value. Since optimum volume and value growth are obtained in stands that are approximately fully stocked, the aim of management in second-growth forests should be to build up and maintain stands that are well stocked with the more desirable high-value species of timber. As means of increasing volume growth and forest incomes in second-growth pine stands, the following measures are suggested.

INTENSIVE FIRE PROTECTION

A primary essential for increasing yields in these second-growth forests, as emphasized by Show (22), is more intensive fire protection. The frequent burning of large areas of timberland in the foothill region must be restricted in order to preserve and to build up second-growth forests for the production of potential timber crops. Reduction of losses from fire will require increased protection by fire-suppression agencies and greater efforts to prevent fires on the part of the foothill population and the general public. Protection of forests from insects and disease, largely through sanitation and salvage cutting, is also desirable in the management of many pine forests.

DEFERRED UTILIZATION OF IMMATURE STANDS

In many second-growth stands that are made up chiefly of immature trees, understocking and low growth rates are maintained because of a lack of sufficient seed production. The density of such immature forests may be expected to increase as trees mature, particularly in areas in which fire protection is adequate and cutting practices insure the preservation of sufficient large seed-producing trees. In many understocked stands, however, brush types and inferior tree species are so abundant that the removal of competing vegetation around natural seedlings or widely spaced planting of desired species must be resorted to in order to increase stand density.

Utilization of immature timber also should be deferred in order that trees reach financial maturity and stand volumes become large enough to make logging operations economically feasible. Premature utilization of second-growth timber yields relatively low forest incomes, and at the

same time sacrifices a resource increasing rapidly in value. In many parts of the Sierra Nevada management will become more attractive financially only as existing stands become more mature. Nevertheless, thinning stands for fuel wood and other minor products, and stand improvement such as pruning, are often both economically possible and desirable on good sites. Pressures to utilize second-growth timber may be expected to increase as local supplies of old-growth timber diminish and as the dependence of small mills on young-growth stands increases. However, widespread heavy cutting of rapidly growing immature stands of second-growth timber should be discouraged.

SELECTIVE TIMBER MANAGEMENT

Cutting practices which maintain stand density and harvest only financially mature timber are essential for satisfactory growth and financial earnings in second-growth pine stands. Stumpage conversion values vary widely with tree size, net margins at one portable mill, for example, ranging from 37 cents per thousand board feet for 14-inch pine trees to about \$3.70 per thousand board feet for 26-inch trees. Such wide variations in value favor selective cutting to remove only the high-value and suppressed or decadent trees that are no longer increasing in value at satisfactory rates of interest. Typically wide variations in tree sizes, as well as accessibility of stands and availability of mobile logging equipment, also favor selective timber management in second-growth pine stands of the Sierra Nevada.

Selective cutting in these stands not only utilizes trees of relatively high value but also tends to maintain a productive forest growing stock. Reserving and protecting the smaller trees during modern tractor logging operations involve little or no sacrifice of current income but result in accelerated increment on reserve stands. High rates of volume and value increment can be maintained on trees of good form and species, with resulting attractive financial returns from well-stocked forests. The more valuable species such as ponderosa pine, sugar pine, and Douglas-fir may be favored in many stands by cutting that removes incense-cedar and white fir trees, releases pine trees from competition, and creates openings for pine reproduction.

Estimates of growth and incomes for selectively managed forests that are well-stocked with pine timber indicate potential net forest earnings approximating nearly \$1 per acre annually. To attain such incomes, however, stand density of the typically understocked and immature second-growth forests must be built up through adequate protection and conservative selective cutting.

CENTRALIZED MANAGEMENT AND UTILIZATION

Utilization of second-growth pine forests has increased gradually in the western Sierra Nevada as the result of expanded markets for second-growth products such as lumber, veneer bolts, and piling. Diminishing local supplies of old-growth timber and low logging and manufacturing costs in second-growth forest areas have favored the expansion of second-growth timber utilization. The small sawmills which have begun to use second-growth timber obtained about \$15 per thousand board feet for second-growth lumber during the period 1935-1939. Stumpage conversion values for the rather limited areas of second-growth timber logged since 1929 have risen to levels approximating \$2 per thousand board feet. Returns to operators and owners of second-growth timber in general have been relatively low, however, largely because of the small size and low quality of second-growth trees, the lack of forest management, poor manufacturing and seasoning, and inadequate marketing organization.

In order to obtain more efficient management and higher incomes from the large number of timber holdings in miscellaneous ownerships there is need for centralized management of forest properties, possibly organized by public forest agencies or privately organized as in other regions (1). Under present conditions effective administration of forests and support of stable industries are often precluded by complicated patterns of land ownerships. Unless the various owners of forest land control utilization through selective timber management, the cutting practices followed by numerous portable sawmills may lead to overcutting in many second-growth stands. The limited available markets may thus be flooded with second-growth lumber, resulting in low prices and restricted forest incomes.

Selective logging of timberlands for continuous and permanent yields also requires the shifting of logging operations over a relatively large area in order to obtain sufficient timber for an efficient milling operation. To provide a stable annual cut of 5 million board feet, for example, for a mill in the second-growth region would require approximately 12,000 acres of well-stocked producing stands, according to the foregoing analysis of yields, or a correspondingly larger area of understocked stands. Where forest properties are of insufficient size to support stable lumbering operations, associations of various landowners, or coöperative public-private sustained yield units, may be developed to insure permanent forest management.

Low prices for lumber, and limited forest incomes from second-growth stands, frequently may be traced to poor manufacturing and lumber

seasoning standards. Lumber prices may often be increased through use of better milling equipment, cutting lumber to exact size, separation of grades, and more care in piling and seasoning. Most second-growth lumber now produced consists of Common grades, including both high Common and Box grades, but a larger proportion of the higher-value Shop and Select grades could be obtained by careful manufacture, utilization of only the larger trees, and maintenance of well-stocked stands.

The concentration of the lumber cut in small sawmills either in central yards or in large mills may make possible efficient remanufacture, grading, and marketing in relatively large quantities through efficient marketing organizations. Such practices also might increase incomes from second-growth forests. The western Sierra Nevada pine region is in a favorable competitive position for timber growing, because of rapid growth, low production costs, and accessible markets; but to obtain satisfactory incomes from forest lands will necessitate good lumber manufacture and efficient marketing.

FOREST RESEARCH

The financial earnings obtained in second-growth pine forests depend to a large extent on available knowledge with respect to reforestation, stand improvement, growth rates, methods of cutting, lumber manufacturing, and marketing of forest products. Although this publication indicates measures needed to protect and build up the value of second-growth forest resources, considerable economic and silvicultural information is needed for efficient management in local areas. To this end investigations should be initiated in experimental forests of second-growth timber to determine and demonstrate economically practicable management practices. There is also need for the development of markets for the low-quality species and minor forest products available in second-growth pine forests in order to increase returns and to make stand improvement and management economically more attractive.

The possibilities of obtaining income from second-growth pine forests in the Sierra Nevada, and the various measures outlined above for increasing forest production, are of direct concern to many population groups. Forest landowners, mill operators, forest workers, subsistence ranchers, foothill communities, and even urban populations depend upon the continued production and manufacture of such natural resources as timber. Since second-growth stands represent the basic resource for lumbering industries of the future, all the groups mentioned have an interest in their more effective protection, management, and utilization.

PROCEDURES IN SELLING TIMBER

The owner of a small tract of forest land who wishes to make a sale of his timber may fail to realize all the income obtainable unless he observes certain precautions. He must be sure that a fair method is used for scaling or measuring the timber sold, that payments for timber cut

TABLE 12

AVERAGE VOLUMES OF SECOND-GROWTH PONDEROSA PINE TREES, BY DIAMETER AT BREAST HEIGHT AND TOTAL HEIGHT OF TREES*

Tree diameter at breast height (inches)	Board foot volume (Scribner log rule) by total tree height in feet									
	60	70	80	90	100	110	120	130	140	150
12.....	50	60	80	100	110	120	140	150	...	...
14.....	80	110	130	150	180	200	220	240	260	...
16.....	120	160	180	210	240	270	300	340	360	...
18.....	170	210	240	290	340	370	410	460	500	...
20.....	220	270	320	370	440	480	530	580	640	...
22.....	270	340	410	470	540	600	670	740	810	890
24.....	330	420	500	580	660	740	830	910	1,000	1,090
26.....	410	510	600	690	790	900	1,000	1,090	1,190	1,290
28.....	480	590	700	820	940	1,060	1,170	1,270	1,380	1,480
30.....	560	690	810	960	1,090	1,220	1,340	1,450	1,570	1,670
32.....	...	800	950	1,100	1,240	1,380	1,510	1,630	1,750	1,860
34.....	...	910	1,090	1,240	1,400	1,540	1,680	1,810	1,940	2,060
36.....	...	1,040	1,230	1,380	1,560	1,710	1,850	1,990	2,130	2,260
38.....	...	1,170	1,370	1,520	1,720	1,880	2,030	2,180	2,320	2,470
40.....	...	1,300	1,500	1,670	1,880	2,040	2,210	2,370	2,520	2,680
42.....	...	.....	.....	1,820	2,030	2,210	2,380	2,560	2,730	2,890
44.....	...	.....	.....	1,970	2,180	2,380	2,570	2,750	2,930	3,090
46.....	...	.....	.....	2,110	2,340	2,550	2,750	2,940	3,130	3,290
48.....	...	.....	.....	2,250	2,490	2,720	2,930	3,130	3,330	3,500
50.....	...	.....	.....	2,400	2,640	2,890	3,110	3,320	3,530	3,710

* Data from: Meyer, W. H. Yield of even-aged stands of ponderosa pine. U. S. Dept. Agr. Tech. Bul. 630:51. 1938.

will be received promptly, and that steps are taken to protect residual forest values. The timber owner must also weigh the relative advantages of selling the land and timber outright, selling all the merchantable trees, or cutting selectively to remove only financially mature trees.

Alternative Methods of Selling Timber.—Forest landowners have the choice in disposing of timber by selling for a lump sum; by selling on the basis of a log scale at an agreed upon price per thousand board feet; and by selling on the basis of a mill tally of the actual lumber produced from the logs by a sawmill. In each case he must take certain measures to protect his interests.

Selling timber outright for a lump sum is perhaps the simplest method of sale. Owner and buyer agree upon a total price for the property and sign a contract specifying terms of payment. To determine the lump sum that represents a fair value of a property, however, the owner ordinarily requires a "cruise" of the standing timber to determine the tree species, sizes, and volumes of timber on the area. Where such an inven-

TABLE 13
CONTENTS OF LOGS IN BOARD FEET, BY LOG DIAMETER AND LENGTH;
SCRIBNER LOG RULE*

Log diameter inside bark at small end (inches)	Board feet contents, by log length in feet			
	10	12	14	16
6.....	10	10	10	20
8.....	20	20	20	30
10.....	30	30	40	60
12.....	50	60	70	80
14.....	70	90	100	110
16.....	100	120	140	160
18.....	130	160	190	210
20.....	170	210	240	280
22.....	210	250	290	330
24.....	250	300	350	400
26.....	310	370	440	500
28.....	360	440	510	580
30.....	410	490	570	660
32.....	460	550	640	740
34.....	500	600	700	800
36.....	580	690	810	920
38.....	670	800	930	1,070
40.....	750	900	1,050	1,200
42.....	840	1,010	1,170	1,340
44.....	930	1,110	1,290	1,480

* Data from: Munns, E. N., and R. M. Brown. Volume tables for the important timber trees of the United States. 159 p. U. S. Dept. Agr. Forest Service, 1925.

tory is needed as the basis of sale, measurements are taken of the diameters and heights of standing trees and the approximate volumes then determined from a "volume table" such as shown in table 12. Employment of a consulting forester may often be desirable to obtain a fair estimate of the standing timber and to draw up stipulations to protect other interests of the timber owner.

Selling on a log-scale basis involves the sale of timber at an agreed upon price per thousand board feet log scale. The amount of timber sold is determined by a log rule such as the Scribner log rule in table 13, or the Spaulding log rule, the standard rule in California. There should

be agreement in the sales contract as to the place of scaling, preferably in the woods, and on minimum standards as to size and quality of logs to be removed from the sale area. Since this method of selling requires scaling by the timber owner or his agent, it may be practicable only on relatively large sales or where logs are periodically accumulated in the woods or at the mill. Furthermore, inspection of logging will ordinarily be required to see that no logs regarded as merchantable in the contract are left in the woods and that no unscaled logs are removed.

Selling on a mill tally basis is a relatively simple method of sale preferred by many buyers. Payment is based on an agreed-upon price per thousand board feet for each species and a tally made at the mill of the lumber actually manufactured from the purchased logs. Such practice of determining the amount of timber sold requires that sellers have access to books of the sawmill operators or that they have faith in the integrity of the purchaser. The sales contract, furthermore, should protect the seller by specifying minimum log sizes and the closeness of utilization of trees in the woods and logs at the mill. Otherwise the buyer could take to the mill only the better and more profitable logs and waste even the lower grades of these.

Collection of Payments.—The seller of timber should protect himself in some way to assure payment for timber cut under any of the methods of sale discussed in the foregoing. A good plan is to stipulate in the contract that specified sums be deposited in a designated bank to the account of the seller, and that when the value of timber cut approaches the sum deposited cutting must cease unless further deposit is made. Payment in advance of cutting is desirable to protect the seller's interests.

Protection of Reserve Values.—As part of every timber sale agreement where the land is retained by the seller, the landowner should include provisions to prevent unnecessary waste or damage to immature trees during falling, skidding, and slash disposal. The contract should include requirements that the purchaser avoid the accumulation of slash around reserved trees, and that slash be disposed of by scattering, burning, or other means that will prevent damage to the young stand. Other clauses should be included requiring the purchaser to protect the area from fire and to have specified fire fighting equipment at designated places in order to protect the owner's interests and adjoining property. Penalties should also be specified for excessive logging damage and for damage resulting from fires attributable to the lumbering operation.

Inspection of Operations.—The landowner or his agent must periodically inspect most sales to see that the purchaser is complying with all

provisions of the contract. Where landowners are interested in future incomes from forest properties, it may be desirable to employ a trained forester—either full time or part time—to cruise and mark timber, scale logs, inspect cutting practices, slash disposal, etc. Many questions regarding timber sales and logging operations also may be answered by state, federal, or university forestry agencies.

Selective Logging.—The plan of selling only the logs from selected trees deserves serious consideration from timber owners. Under such selective logging owners sell only the larger and more mature merchantable timber and retain the remainder of the trees for future value increment. Although less timber will be removed by such an initial cut, immediate returns may be nearly as large as those obtainable from heavier cutting because of the relatively higher stumpage values of the larger trees, as indicated in table 9. Trees marked by the seller may be selected to yield log grades that are considerably more valuable than the average of the stand. By leaving a larger residual stand comprising both the immature and the smaller merchantable trees, prospects of future incomes are considerably enhanced.

Timber Sale Contracts.—Owners of timberland are likely to make more satisfactory business deals if an adequate written agreement is used to avoid the possibilities of misunderstanding and nonpayment of debts. Terms of sale, methods of cutting, and other provisions as indicated above should be included in such an agreement. For most small timber sales, the following form of contract, adapted of course to the specific conditions of a given sale, should provide equitable and adequate protection of the interests of both the seller and purchaser of timber.

SAMPLE TIMBER SALE CONTRACT

This agreement entered into this day of, 19.....
between of (county).....,
..... (state)....., hereinafter called the Seller, and
of (county)....., (state)....., hereinafter called the Purchaser,
witnesseth,

ARTICLE I. The Seller agrees to sell to the Purchaser, upon the terms and conditions hereinafter stated, the living timber, and the merchantable dead timber, estimated at board feet, more or less, marked or designated by the Seller on that parcel of land owned by the Seller and consisting of acres, more or less, situated in T..... R..... S..... in County, State of

ARTICLE II. The Purchaser agrees to pay the Seller for said timber on the basis of (*Scribner log scale, mill tally, or inventory of standing timber*) at the rate of Dollars (\$.....) per thousand board feet for (ponderosa pine)..... and Dollars (\$.....) per thousand board feet for

.....(other species)....., and it is further understood and agreed that payment for all timber will be made prior to the time of cutting in amounts sufficient to pay for the anticipated cut during the week(s) subsequent to payment, and that said payments shall be deposited to the account of the Seller in the Bank located in(city, county, state).....

ARTICLE III. The purchaser further agrees to cut and remove said timber in strict accordance with the following conditions:

1. Except for mutually designated trees, all(ponderosa pine and sugar pine)..... trees above(twenty)..... inches in diameter, and all(other species)..... above(twenty-two)..... inches in diameter shall be cut.
2. Stumps shall be cut so that the mean height of any stump will not exceed one half its diameter, provided that the minimum height required will be twelve inches.
3. All trees shall be utilized in their tops to minimum diameters of(ten)..... inches for ponderosa pine and sugar pine, and(twelve)..... inches for other species.
4. Logs which are(eight)..... feet or more in length, plus a trimming allowance of four inches, and(ten)..... inches or more in diameter inside the bark at the small end, and(forty)..... per cent or more sound shall be considered merchantable.
5. Logs shall be sealed by(Scribner)..... log rule in the woods prior to removal by the purchaser.
6. Immature timber and reproduction shall be protected against unnecessary injury during logging; undesigned live trees which are cut or injured through carelessness in logging or fire protection shall be paid for at double the rates specified in Article II.
7. Tops of all felled trees and limbs of unmerchantable logs shall be lopped and scattered; care shall be taken to prevent accumulation of slash around reserved trees and in patches of reproduction.
8. Slash shall be piled and burned for a reasonable distance around any sawmill or camp that may be established by mutual agreement on the said property by the Purchaser.
9. All reasonable precaution against fire shall be exercised, and fires occurring on or threatening the said property during the period between the start of logging and the removal of all timber cut shall be fought by the employees of the Purchaser with equipment, including(shovels, axes, etc.)..... to be provided by the Purchaser.

ARTICLE IV. It is further mutually agreed by the parties hereto that:

1. All timber included in this agreement shall remain the property of the Seller and shall not be cut or removed from the property of the Seller until paid for in full.
2. Unless extension of time is granted, all timber shall be cut, paid for, and removed from the land of the Seller before, 19.....
3. Upon termination of the sale, or in the event the sale is terminated by mutual consent, any deposit made by the Purchaser in excess of the amount required to pay for timber cut will be refunded by the Seller.
4. The Seller shall have the right to terminate all operations of the Purchaser upon the land of the Seller if any of the aforementioned provisions of the contract are not observed.

5. This contract shall be binding upon the heirs, administrators, executors, successors, or assigns of both parties.

In witness whereof the parties hereto have hereunto set their hands and seals this

..... day of, 194....

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Witnesses

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