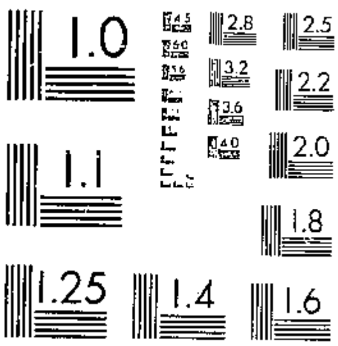
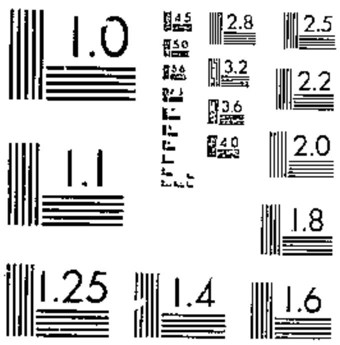
TB 354 (1933) USDA TECHNICAL BULLETINS UPDATA
PRELIMINARY YIELD TABLES FOR SECOND GROWTH STANDS IN THE CALIFORNIA
DUNNING, D. REINEKE, L.H. 1 OF 1

START



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



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

TECHNICAL BULLETIN No. 354 — JUNE, 1933

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

PRELIMINARY YIELD TABLES FOR SECOND-GROWTH STANDS IN THE CALIFORNIA PINE REGION

By DUNCAN DUNNING, *Silviculturist*, and L. H. REINEKE, *Associate Silviculturist, California Forest and Range Experiment Station*,[1] *Branch of Research, Forest Service*

CONTENTS

INTRODUCTION

The conifer forests of the California mountains are among the most valuable in North America. The character of the tree species forming the stands, the large dimensions attained by individual trees, the heavy yields, the extensive area occupied, and its comparative accessibility contribute to high values.

These high values have been hitherto associated almost entirely with virgin or old-growth stands. In recent years, however, second growth has begun to assume importance in the general scheme of forest economy. It is true that second growth has a present-utilization value in only rare instances of minor importance—the greater values still lie in the future; but for this very reason it has become desirable and is, indeed, becoming increasingly necessary to be able to forecast these values as accurately as possible.

Within the last 10 years two summaries of the forest situation, national in scope, have involved growth studies. In the management of the national forests a knowledge of second-growth yields is immediately useful in timber working-circle plans, in land exchange, in fire plans, in fire-damage appraisals, in cooperative fire-protection agreements with private landowners, and in other ways. To the

[1] Maintained in cooperation with the University of California.

158797°—33——1

State, yield data are of present value in formulating a land-use policy and in organizing fire protection for areas outside the national forests. Private timber owners may make use of yield tables in evaluating cut-over land for sale or exchange, in determining justifiable expenditures for fire protection, or in plans for continuous forest production. Such uses amply justify the attempt to put into convenient published form the data at present available, even though the complexity of yield-table construction for mixed stands and the difficulty in finding a sufficient number of adequate sample plots render these tables wholly tentative and preliminary in character.

THE FOREST TYPES

COMPOSITION

The stands to which the following tables apply are composed of ponderosa pine (*Pinus ponderosa* Laws.), sugar pine (*P. lambertiana* Dougl.), Douglas fir (*Pseudotsuga taxifolia* (Lam.) Britt.), white fir (*Abies concolor* Lindl. and Gord.), and red fir (*A. magnificia* A. Murray). Incense cedar (*Libocedrus decurrens* Torr.), although it also is almost invariably present (rare exceptions being in true fir stands) and frequently numerous, particularly in the younger age classes, rarely makes up more than 5 to 10 per cent of the volume of the stand.

The foregoing species appear in the stands in incalculably varying proportions, and yet, within clearly defined limits of altitude, latitude, and aspect, several types may be easily recognized. The types considered in this bulletin are shown in Table 1. The grouping of species into types is based on the arbitrary assumption that a species is a component of the type if it forms 20 per cent or more of the total basal area.

TABLE 1.—*Composition of types, by species, in percentage of total basal area*

Species group or type	Ponderosa pine	Sugar pine	Douglas fir	White fir	Incense cedar	Red fir
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Ponderosa pine–fir	40	3	30	20	7	--------
Ponderosa pine–sugar pine	40	37	3	10	10	--------
Ponderosa pine–sugar pine–fir	40	25	10	20	5	--------
Sugar pine–fir	5	33	20	35	7	--------
White fir–Douglas fir	5	3	45	45	2	--------
White fir–red fit	--------	3	--------	68	--------	29

RANGE AND OCCURRENCE

The types here discussed cover the west slope of the Sierra Nevada and Cascade Mountains from the Kern River at the south to Mount Shasta at the north, and extend along the northern inner coast ranges from the Oregon line to central Lake County. The east-slope sierra and northeast plateau forests, where ponderosa and Jeffrey pines predominate, are not included in the discussion. The redwood and other forests of the northern outer coast ranges are also excluded.

The altitudinal limits of commercial stands vary with latitude and aspect. In the southern sierra good stands are rarely found below 3,000 feet, but in the northern inner coast ranges stands occur at elevations of 1,000 feet or less. The upper limit is about 6,500 feet in the south, and 5,000 feet in the north.

At lower elevations and on southerly aspects at middle elevations, ponderosa pine occurs in pure stands or predominates in mixtures. Toward the north, particularly in canyon bottoms and on north aspects, Douglas fir is frequently the dominant species at lower elevations. The sugar and ponderosa pine mixtures predominate on south slopes and benches between 4,000 and 5,500 feet. The sugar-pine and fir type is rather closely confined to north and northeast aspects at elevations of 4,500 to 6,000 feet. Above 6,000 feet, true firs usually predominate.

The best stands are found at elevations of 4,500 to 5,500 feet along the middle west slopes of the sierra. Here occurs the most favorable combination of precipitation and seasonal temperatures.

In relatively few sections of this large region are the stands uniform in age. All age classes, however, are rarely present, as they would be in a true selection forest. Stands are usually made up of small even-aged groups, the ages of the groups differing by periods of 10 to 20 years or more. The limited occurrence of extensive even-aged stands renders the construction and application of yield tables difficult.

CONDITIONS OF ESTABLISHMENT OF SECOND GROWTH

The occurrence of even-aged second-growth stands, within the limits fixed by nature, is largely a result of human activities. During the gold rush, beginning in 1849, heavy cuttings were made in the stands accessible to the mines. Frequently burning followed cutting, by accident or by design. The stands were rarely clear-cut at one time over considerable areas, but cutting was repeated, and a source of seed remained for some years. During seasons of heavy precipitation, such as the winter of 1861–62, the establishment of seedlings was good. The majority of the best even-aged second growth dates from the decade 1861–1870. Since most of the mining activity was at lower elevations, the greater portion of this second growth is ponderosa pine and Douglas fir.

During construction of the Southern Pacific Railroad through the Sierra, 1862 to 1865, heavy cutting along the right of way was followed by some excellent stands of second growth, varying in composition from pure ponderosa pine to pure fir.

Following the gold rush, stock raising increased rapidly, and range burning became a common practice. Although these range fires converted vast areas of forest into worthless brush, in many instances where conditions were favorable, patches of even-aged second growth were established.

With improved transportation the manufacture of lumber for the general market became important. The cuttings were light, only the more valuable pines being taken, as a rule. The resulting second growth is irregular in age.

Light cutting continued generally until the advent of heavier logging machinery and wider markets, beginning about 1900. From 1900 to about 1925, cutting on private land became more intensive, logging damage increased, and slash burning was more common. The frequency of fires, the failure of seed crops, and the generally poor climatic conditions have resulted in irregular, scanty reproduction for the most part. On national forest selective cuttings since 1906, the second growth is naturally irregular in age. Since 1925, private cutting has generally been lighter, leaving the firs, cedar, and smaller pines. Reproduction in these areas will not be even-aged.

Thus the conditions favoring the establishment of larger areas of even-aged second growth have largely ceased to exist. Probably the future tendency will be toward selection rather than even-aged stands. On the private land heavily cut or burned between 1900 and 1925, with better fire protection and more abundant precipitation, considerable even-aged reproduction may be expected.

RELATIVE IMPORTANCE OF VIRGIN AND SECOND-GROWTH FOREST

The areas of various classes of forest land in the region, as shown by the type map being prepared by the California Forest and Range Experiment Station, are given in Table 2. The area of virgin timber constitutes about 41 per cent of the area of all commercial timber in California, including redwood.

TABLE 2.—*Areas of forested, restocking, and deforested lands in the California pine region*

Class of forest land	Area of class within pine region	
	Acres	*Per cent*
Virgin timber	4,663,400	47.8
Second growth	1,015,200	46.3
Restocking	869,100	49.7
Deforested	937,100	44.7

The virgin stands are not even-aged. The second growth includes all types of cut-over areas, and only a small percentage of it is even-aged. Restocking areas include mostly brush fields following early fires when the reproduction tends to be even-aged by groups and stocking is very irregular.

The future of the old-growth forests is, of course, uncertain. The pure ponderosa pine and the ponderosa pine-sugar pine types will doubtless be cut out first because of high value and accessibility. The comparatively small area of sugar pine-fir type will be culled for the sugar pine rather early. Types with a heavier proportion of Douglas fir and true firs will probably not be cut extensively until the available pine types are exhausted. It is to be expected that the privately owned stands will be largely cut over by the end of the century. They are more accessible, better stocked, and have a larger proportion of pines than the public forests.

The treatment of the remaining virgin timber will determine the future of second growth. So long as virgin timber is available, little cutting of second growth is to be expected. No cutting of consequence has occurred in young growth to date. Indications are that the ponderosa pine stands established 60 to 70 years ago will be the first second-growth utilized extensively.

THE DATA

The chief source of the material used in this study was a group of 224 plots measured by Dunning and Show (1912–1923). Permanent sample plots established later by the California Forest Experiment Station and other plots measured by F. X. Schumacher, then of the University of California, were also used. The total number of plots finally selected for the study was 311.

In several ways these plots were not entirely satisfactory. The outstanding feature is the irregular distribution by age. (Table 4.) The great preponderance of plots between the ages of 50 and 69 years is due, as has been shown, to the cuttings and frequent fires of the gold-mining period. Stands of other age classes are of relatively infrequent occurrence and hard to find.

Then, again, truly normal stands were so rare that, to obtain a sufficient number, a wider range of density of stocking than would ordinarily be permitted was unavoidable. Still further variation in stocking was doubtless due to the great variation in composition, which affected to some extent the judgment used in the selection of plots.

The field technic used when the earlier measurements were made by Dunning and Show differed in some details from the standard technic of the present. Curves of height over diameter were not prepared, and the height used for site classification was the average height of the dominant trees, rather than the height corresponding to the average diameter of the dominant and codominant trees. In addition, some of the plots were rather small, containing less than 100 trees, the present acceptable minimum. Despite these deficiencies, however, the data were of enough value to justify the construction of yield tables.

METHODS USED IN ANALYSIS OF DATA

The types themselves, in the relationship between component species, present a complex problem not encountered in the pure stands that are the basis of most of the recent work on second-growth yield tables. Although Haig's (*5*)[2] yield tables for western white pine in the northern Rocky Mountain region deal with a mixed-species forest, the associated species introduce no great complications since with increasing age they tend to disappear. No such tendency is noted in the California pine types, the component species of any young stand having equal likelihood of predominance at maturity.

This tendency to maintain the original composition throughout life requires, for the correct determination of site quality, an analysis of the interrelationship between species. It also requires an evaluation of the relative influence each species exerts upon such stand measurements as basal area, number of trees, etc. Such an evaluation, complicated by the endless variations in the proportions of the different species, ranging from almost pure stands of each species (except incense cedar) to any combination of two or more species, is complicated further by variations in density of stocking which tend to mask the effects of composition. Obviously, some method of measuring, defining, and compensating for stand density must be employed.

In general, the method of analysis consisted in assigning values for density of stocking to each plot and then modifying the stand measurements to represent the average of well-stocked stands. These modified values were used as a basis for constructing tables for average stocking and composition by the standard technic (*3, 7*). The percentage deviations of the original individual plot values from this average table were then correlated with density of stocking and

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

percentage composition by species. (Based on species distribution of basal area.) The resulting multiple regression equations gave the

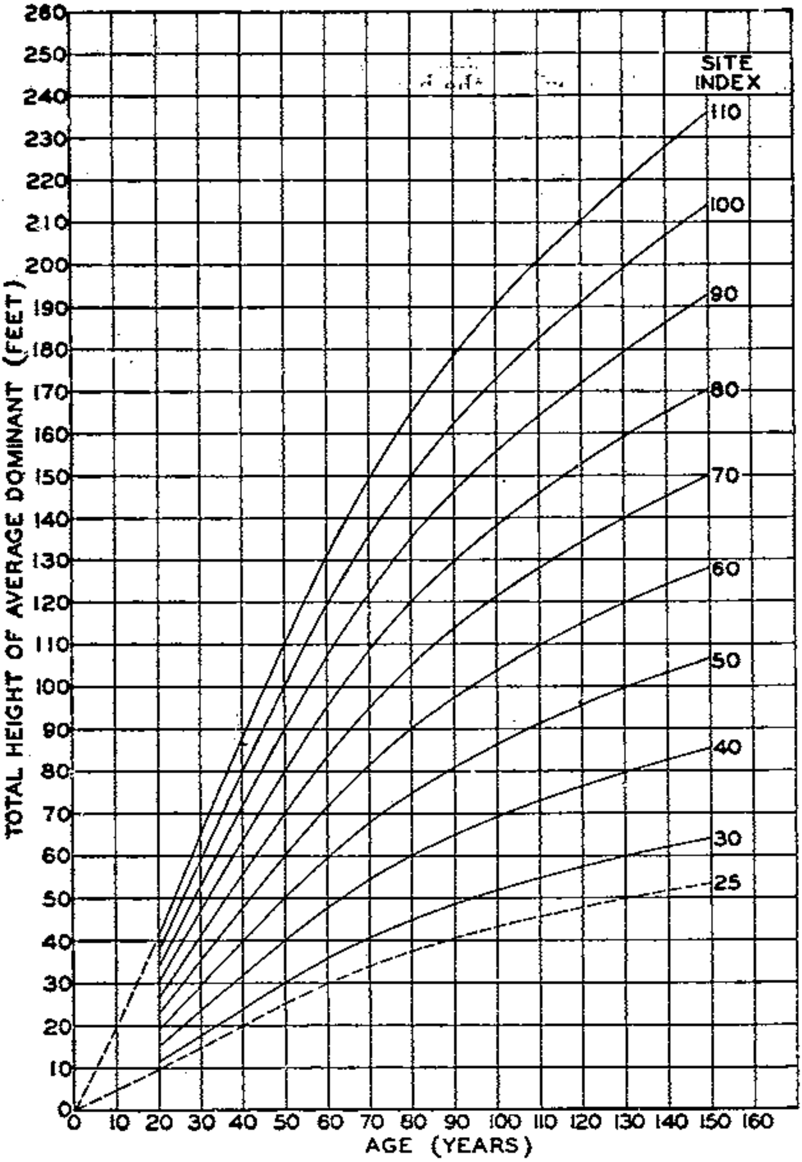


FIGURE 1.—Site-classification curves, based upon the total height of the dominant tree of average basal area, of ponderosa pine, white fir, Douglas fir, and red fir, separately or in combination

appropriate factors to apply to the average table for any conditions of stocking and composition.

A detailed description of those particulars wherein the technic differed from standard procedure is given in the appendix.

YIELDS

AGE

The ages of the stands sampled were determined by ring counts on borings, usually at breast height, of dominant and codominant trees, corrected for the number of years required for the trees to reach the height at which the borings were made. The average age of the trees bored was taken as the age of the stand; no allowance was made for the period between the removal of the original stand and the establishment of the new stand.

SITE INDEX (OR QUALITY)

The classification of the sample plots according to site quality is based on the relationship between age and the average height of the dominant trees. Ponderosa pine, white fir, red fir, and Douglas fir have essentially the same height-age relationship when growing in mixed stands, and dominant trees of all the species named should be used as they are present.

Figure 1 and Table 3 show this relationship between age and height of dominant trees. The various site qualities are denoted by a site index expressed in height in feet attained at an age of 50 years. Obviously, a complete series of 1-foot site indices could be given but, for convenience, curves and tabular values are given only for even 10-foot intervals, from which intermediate values may be ascertained by interpolation. The determination of site index is simple; the average dominant height is plotted over the age on Figure 1, and the site index taken either from the curve nearest to the plotted point or from an interpolated index curve.

TABLE 3.—*Total height in feet of average dominant tree*[1] *on all sites*

Age (years)	Height on—									
	Site index 25	Site index 30	Site index 40	Site index 50	Site index 60	Site index 70	Site index 80	Site index 90	Site index 100	Site index 110
20	9.4	11.3	15.0	18.8	22.6	26.3	30.1	33.9	37.8	41.4
30	14.6	17.5	23.4	29.2	35.1	40.9	46.8	52.6	58.4	64.3
40	19.9	23.9	31.8	39.8	47.8	55.7	63.7	71.7	79.6	87.6
50	25.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0
60	29.7	35.7	47.6	59.5	71.4	83.3	95.1	107	119	131
70	34.0	40.8	54.3	67.9	81.5	95.1	109	122	136	149
80	37.6	45.1	60.1	75.1	90.1	105	120	135	150	165
90	40.6	48.7	64.9	81.1	97.4	114	130	146	162	178
100	43.2	51.8	69.1	86.4	104	121	138	156	173	190
110	45.6	54.7	72.9	91.1	109	128	146	164	182	201
120	47.7	57.3	76.4	95.5	115	134	153	172	191	210
130	49.8	59.7	79.7	99.6	119	139	159	179	199	219
140	51.7	62.0	82.7	103	124	145	165	186	207	228
150	53.5	64.2	85.6	107	128	150	171	193	214	236

[1] Based on dominant ponderosa pine, Douglas fir, red fir, and white fir; all four species to be used when present in the stand.

Table 4 shows how the 311 sample plots used are distributed as to age and site quality, and illustrates the preponderance of plots in the 50–59 year and 60–69 year age classes.

TABLE 4.—*Distribution of plots by age and site index*

Age (years)	Number of plots on—									
	Site indices 25–29	Site indices 30–39	Site indices 40–49	Site indices 50–59	Site indices 60–69	Site indices 70–79	Site indices 80–89	Site indices 90–99	Site indices 100–109	All sites
40 to 49				2	7	5	4	1		19
50 to 59	1	1	8	27	54	34	19	13	6	163
60 to 69		1	10	25	26	17	4	4		87
70 to 79			1		3	3	3			10
80 to 89			1		3					4
90 to 99		1		1	5	1	3			11
100 to 109					2				1	3
110 to 119				1	2	2	3			8
120 to 129					1	1				2
130 to 139						1				1
140 to 149				1		2				3
All ages	1	3	20	57	103	66	36	18	7	311

DENSITY OF STOCKING AND STAND-DENSITY INDEX

The criterion adopted for evaluating the density of the stand, or stocking, is the relationship between the number of trees per acre and their average diameter, shown by the solid line of Figure 2. This is a reference curve used for determining a stand-density index.[3] The series of broken-line curves parallel to the reference curve serve a similar purpose to the curves in Figure 1 in supplying a ready means of estimating stand-density index. The number of trees per acre shown by each curve at an average diameter of 10 inches is the stand-density index of that curve. For a given stand, the line lying nearest the point defined by number of trees per acre plotted over average diameter can be read as the stand-density index. For example, the plotted point representing a stand with 350 trees per acre and an average diameter by basal area of 15 inches will fall nearest the curve representing a stand-density index of 700. By interpolating between the curves, a more precise index of 670 may be obtained.

The stand-density indices of the sample plots of this study ranged from 230 to 850, with an average value of 479. Taking 800 as a fair index for full stocking in these mixed-conifer stands, the average stand-density index of 479 represents approximately 60 per cent of full stocking. Individual plots ranged from 29 to 106 per cent. The distribution of the plots by stand-density index is given below:

Stand-density index:	Number of plots
200 to 299	6
300 to 399	49
400 to 499	102
500 to 599	80
600 to 699	50
700 to 799	18
800 to 899	6
Total	311

TOTAL BASAL AREA

Total basal area, or the sum of the breast-high cross-section areas of all trees 2 inches and larger in diameter is shown in Table 5 and Figure 3 for the average of well-stocked stands and average composi-

[3] REINEKE, L. H. PERFECTING A STAND-DENSITY INDEX FOR EVEN-AGED STANDS. (Unpublished manuscript.)

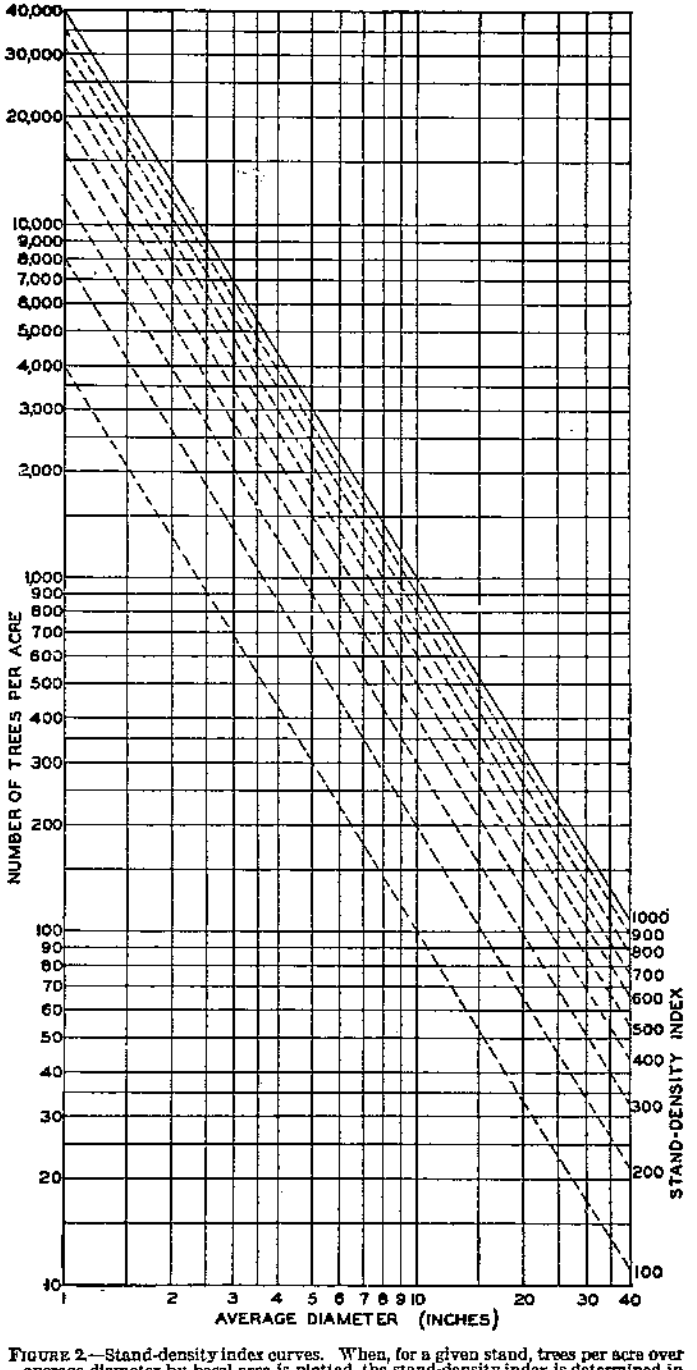


FIGURE 2.—Stand-density index curves. When, for a given stand, trees per acre over average diameter by basal area is plotted, the stand-density index is determined in round numbers by the nearest curve, or more exactly by interpolation

158797°—33——2

tion. The modification of this table for any condition of stocking and composition is effected by substituting the appropriate values in the regression equation given under the table and applying the resulting percentage to the values given in Table 5.

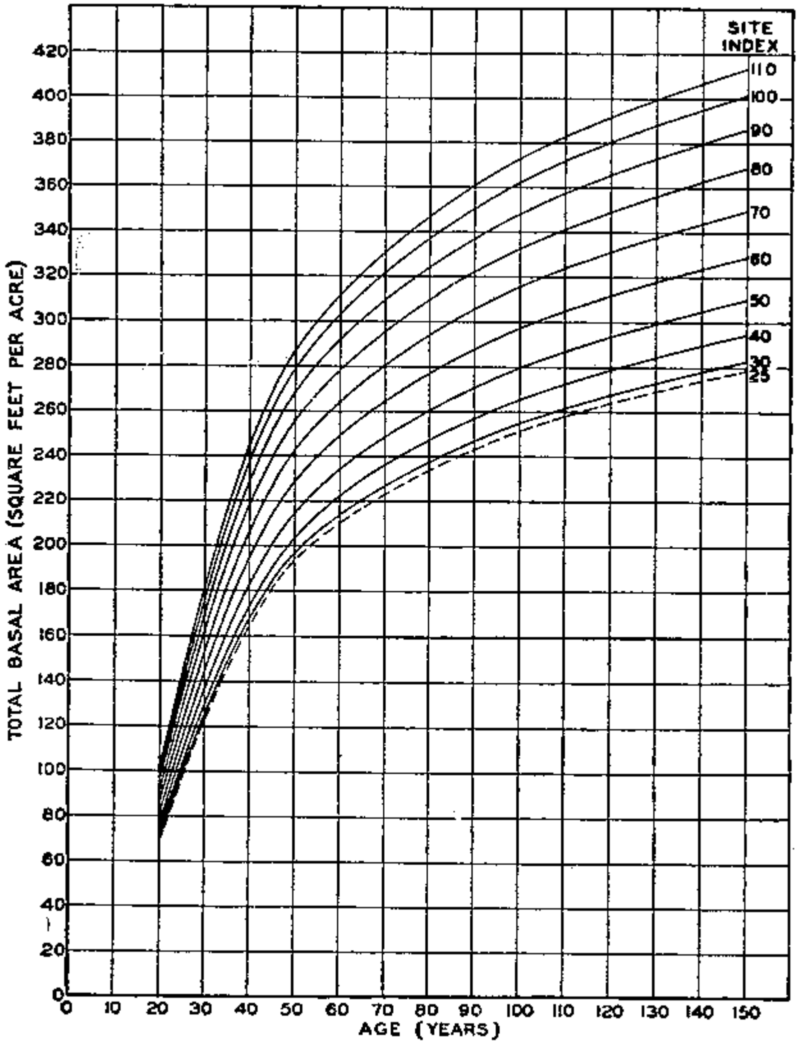


FIGURE 3.—Relationship between age, site index, and total basal area for average well-stocked stands of average composition

For convenience, the percentage corrections for various stand-density indices, by types, are given in Table 6. Minor differences in composition from that given for these types will not change the correction percentage appreciably.

TABLE 5.—*Total basal area, average stands* [1]

Age (years)	Basal area (square feet per acre) by site-index classes									
	Site 25	Site 30	Site 40	Site 50	Site 60	Site 70	Site 80	Site 90	Site 100	Site 110
30	124	126	131	138	146	155	164	172	178	184
40	165	168	175	184	196	208	219	229	238	245
50	194	197	205	216	230	244	257	269	280	288
60	210	213	222	234	248	264	278	291	303	311
70	223	226	236	248	264	280	295	309	321	331
80	234	237	247	260	277	294	310	324	337	347
90	243	247	257	271	288	305	322	337	350	361
100	252	255	266	280	298	316	333	349	363	373
110	258	262	273	287	305	324	342	358	372	383
120	264	268	279	294	312	332	350	366	381	392
130	269	273	285	300	319	338	357	374	388	400
140	274	278	290	305	324	344	363	380	395	407
150	278	282	294	310	329	350	369	386	401	413

[1] For specific stands, substitute in the following equation and apply resulting percentage to the tabular values: Total basal area (in percentage of composite table) = 2.0303 (percentage stocking) + 0.1493 (ponderosa pine per cent) + 0.1645 (sugar pine per cent) + 0.0541 (Douglas fir per cent) + 0.0980 (white fir per cent) + 0.1229 (incense cedar per cent) + 0.1883 (red fir per cent) − 8.1511.

TABLE 6.—*Percentage correction of values in Table 5 for different types* [1]

Stand-density index	Ponderosa pine–fir	Ponderosa pine–sugar pine	Ponderosa pine–sugar pine–fir	Sugar pine–fir	White fir–Douglas fir	White fir–red fir
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
200	43.33	46.51	45.40	43.67	40.76	37.92
250	53.49	56.07	55.56	53.82	50.91	48.07
300	63.64	66.82	65.71	63.98	61.06	58.22
350	73.79	76.97	75.86	74.13	71.21	68.37
400	83.94	87.12	86.01	84.28	81.36	78.52
450	94.09	97.27	96.16	94.43	91.51	88.67
500	104.24	107.42	106.31	104.58	101.66	98.82
550	114.39	117.58	116.47	114.73	111.82	108.98
600	124.55	127.73	126.62	124.88	121.97	119.13
650	134.70	137.88	136.77	135.04	132.12	129.28
700	144.85	148.03	146.92	145.19	142.27	139.43
750	155.00	158.18	157.07	155.34	152.42	149.58
800	165.15	168.33	167.22	165.49	162.57	159.73

[1] Aggregate deviation, less than 0.5 per cent; average percentage deviation, 5.22 per cent.

NUMBER OF TREES PER ACRE

The number per acre of all trees 2 inches or more in breast-high diameter is given in Table 7 and Figure 4 for average stocking and composition. Modification for specific stocking and composition is made as for total basal area. Table 8 gives the percentages for the six types.

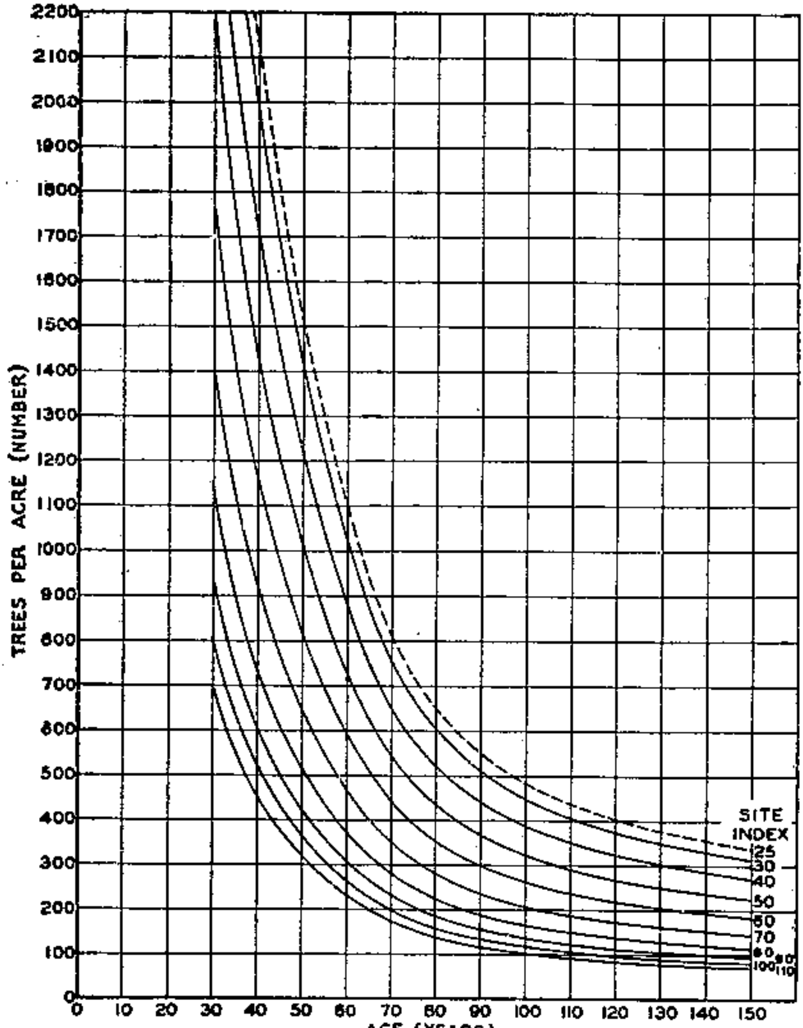


FIGURE 4.—Relationship between age, site index, and number of trees per acre for average well-stocked stands of average composition

TABLE 7.—*Number of trees, average stands* [1]

Age (years)	Number of trees per acre, by site index class									
	Site 25	Site 30	Site 40	Site 50	Site 60	Site 70	Site 80	Site 90	Site 100	Site 110
30	3,260	3,030	2,620	2,175	1,770	1,400	1,120	922	790	690
40	2,110	1,960	1,695	1,405	1,145	906	723	596	511	446
50	1,500	1,395	1,205	1,000	814	645	515	424	364	318
60	1,095	1,020	879	730	594	470	375	309	265	232
70	807	750	648	538	438	347	277	228	196	171
80	648	602	520	432	351	278	222	183	157	137
90	547	509	439	365	297	235	188	155	133	116
100	481	447	386	321	261	207	165	126	117	102
110	437	406	351	291	237	188	150	123	106	92
120	403	374	323	268	218	173	138	114	98	85
130	377	350	303	251	204	162	129	107	91	80
140	350	331	286	237	193	153	122	101	86	75
150	337	313	270	224	182	145	115	95	82	71

[1] For specific stands, substitute in the following equation and apply resulting percentage to the tabular values: Number of trees (in percentage of composite table) = 2.0058 (percentage of stocking) − 0.3166 (ponderosa pine per cent) − 0.2973 (sugar pine per cent) − 0.0159 (Douglas fir per cent) − 0.1355 (white fir per cent) − 0.1358 (incense cedar per cent) − 0.0905 (red fir per cent) + 19.3572.

TABLE 8.—*Percentage correction of values in Table 7 for different types* [1]

Stand-density index	Ponderosa pine–fir	Ponderosa pine–sugar pine	Ponderosa pine–sugar pine–fir	Sugar pine–fir	White fir–Douglas fir	White fir–red fir
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
200	41.78	33.05	35.83	42.07	49.91	46.74
250	51.81	43.08	45.86	52.10	59.94	56.77
300	61.84	53.11	55.89	62.13	69.97	66.80
350	71.87	63.14	65.92	72.16	80.00	76.83
400	81.90	73.16	75.94	82.18	90.03	86.86
450	91.92	83.19	85.97	92.21	100.06	96.89
500	101.95	93.22	96.00	102.24	110.09	106.92
550	111.98	103.25	106.03	112.27	120.12	116.95
600	122.01	113.28	116.06	122.30	130.15	126.97
650	132.04	123.31	126.09	132.33	140.17	137.00
700	142.07	133.34	136.12	142.36	150.20	147.03
750	152.10	143.37	146.15	152.39	160.23	157.06
800	162.13	153.40	156.18	162.42	170.26	167.09

[1] Aggregate deviation, less than 0.5 per cent; average percentage deviation, 18.4 per cent.

AVERAGE DIAMETER OF THE STAND

The average breast-high diameter of the stand is the diameter of the tree of average basal area as determined by dividing total basal area by number of trees. Table 9 and Figure 5 give these values for stands of average stocking and composition. For stands of other than average stocking or composition, average breast-high diameter should be derived by dividing the corrected total basal area by the corrected number of trees and converting the resultant average basal area into its equivalent diameter.

TABLE 9.—*Average breast-high diameter in inches of average stands, by site-index classes*

Age (years)	Site 25	Site 30	Site 40	Site 50	Site 60	Site 70	Site 80	Site 90	Site 100	Site 110
30	2.64	2.76	3.03	3.41	3.89	4.51	5.18	5.85	6.43	6.99
40	3.79	3.96	4.35	4.90	5.60	6.49	7.45	8.39	9.24	10.0
50	4.57	5.09	5.59	6.29	7.20	8.33	9.56	10.8	11.9	12.9
60	5.93	6.19	6.81	7.67	8.75	10.1	11.7	13.1	14.5	15.7
70	7.12	7.43	8.17	9.19	10.5	12.2	14.0	15.8	17.3	18.6
80	8.14	8.50	9.33	10.5	12.0	13.9	16.0	18.0	19.8	21.5
90	9.02	9.43	10.4	11.7	13.3	15.4	17.7	20.0	22.0	23.9
100	9.80	10.2	11.2	12.6	14.5	16.7	19.2	21.7	23.9	25.9
110	10.4	10.9	11.9	13.5	15.4	17.8	20.4	23.1	25.4	27.6
120	11.0	11.5	12.6	14.2	16.2	18.8	21.6	24.3	26.7	29.0
130	11.4	12.0	13.1	14.8	16.9	19.6	22.5	25.3	28.0	30.3
140	11.9	12.4	13.6	15.4	17.5	20.3	23.4	26.3	29.0	31.5
150	12.3	12.9	14.2	15.9	18.2	21.0	24.3	27.3	29.9	32.7

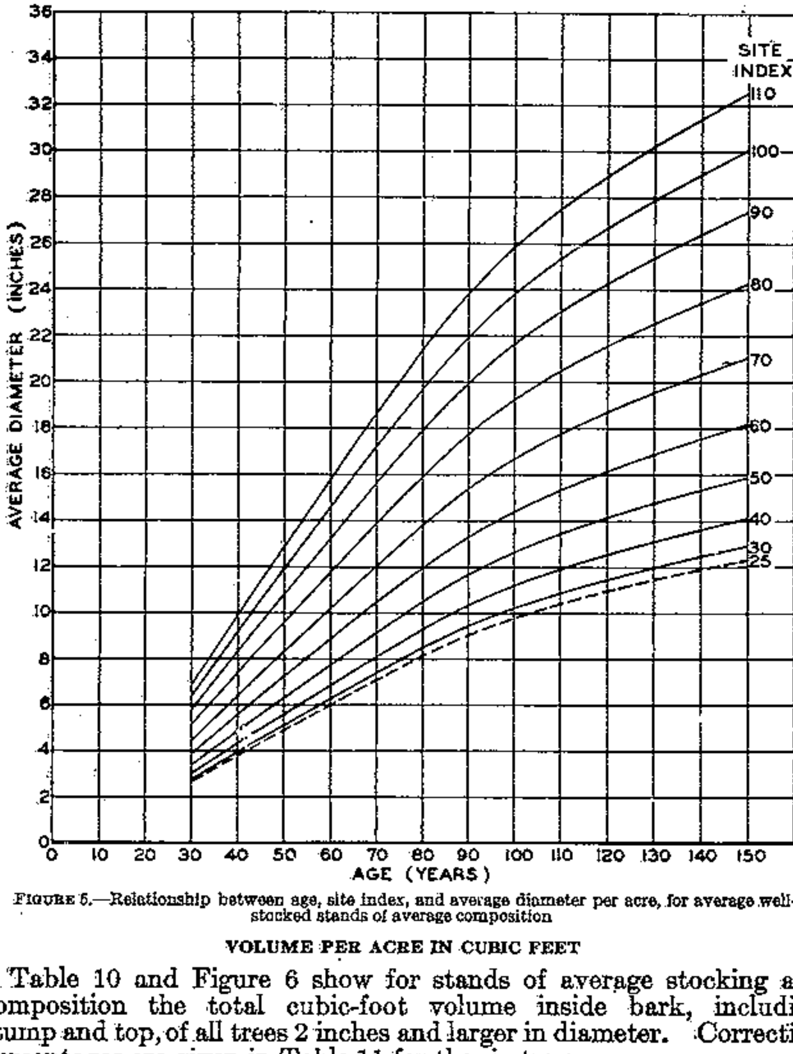


FIGURE 5.—Relationship between age, site index, and average diameter per acre, for average well-stocked stands of average composition

VOLUME PER ACRE IN CUBIC FEET

Table 10 and Figure 6 show for stands of average stocking and composition the total cubic-foot volume inside bark, including stump and top, of all trees 2 inches and larger in diameter. Correction percentages are given in Table 11 for the six types.

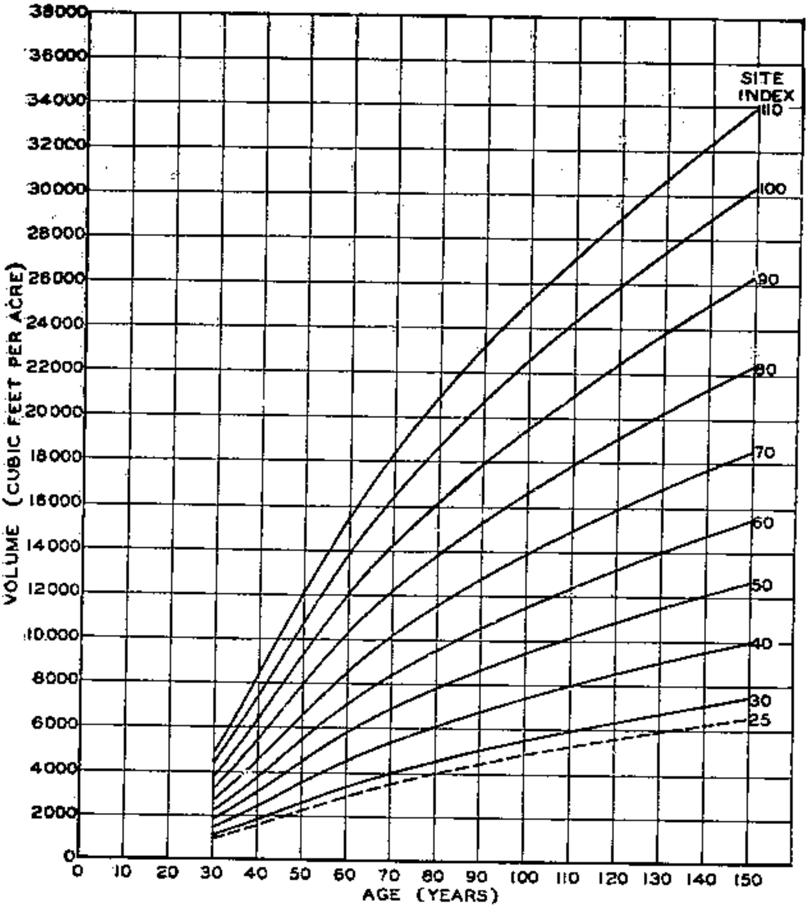


FIGURE 6.—The volumes in cubic feet (inside bark, stump and top included, for average well-stocked stands of average composition

TABLE 10.—*Volume per acre in cubic feet, average stands* [1]

Age (years)	Volume in cubic feet per acre on site index—									
	25	30	40	50	60	70	80	90	100	110
30	930	1,060	1,420	1,800	2,200	2,650	3,200	3,770	4,380	4,850
40	1,590	1,800	2,410	3,090	3,770	4,550	5,500	6,500	7,450	8,450
50	2,260	2,590	3,480	4,440	5,420	6,560	7,940	9,300	10,700	12,000
60	2,950	3,350	4,510	5,790	7,020	8,550	10,300	12,100	13,900	15,500
70	3,500	4,000	5,350	6,850	8,450	10,200	12,200	14,300	16,500	18,400
80	4,000	4,540	6,100	7,800	9,520	11,500	13,800	16,200	18,600	20,900
90	4,420	5,000	6,750	8,600	10,500	12,700	15,200	17,800	20,700	23,100
100	4,830	5,500	7,400	9,450	11,500	13,900	16,000	19,500	22,600	25,200
110	5,200	5,950	8,000	10,200	12,300	14,900	17,900	21,000	24,250	27,200
120	5,600	6,390	8,550	10,800	13,200	16,000	19,100	22,500	26,000	29,000
130	5,900	6,700	9,050	11,500	14,000	16,900	20,300	24,000	27,500	30,700
140	6,220	7,070	9,550	12,100	14,750	17,750	21,400	25,200	29,000	32,400
150	5,550	7,430	10,000	12,700	15,450	18,550	22,400	26,400	30,400	34,000

[1] For specific stands, substitute in the following equation and apply resulting percentage to the tabular values: Volume in cubic feet (in percentage of composite table) = 1.5251 (percentage of stocking) − 0.7170 (ponderosa pine per cent) − 0.7740 (sugar pine per cent) − 0.9398 (Douglas fir per cent) − 1.0704 (white fir per cent) − 0.8427 (incense cedar per cent) − 1.1996 (red fir per cent) + 126.7553.

TABLE 11.—*Percentage correction of Table 10 for different types* [1]

Stand density index	Ponderosa pine-fir	Ponderosa pine-sugar pine	Ponderosa pine-sugar pine-fir	Sugar pine-fir	White fir-Douglas fir	White fir-red fir
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
200	74.01	79.90	76.21	67.97	61.21	49.36
250	81.64	87.61	83.83	75.60	68.83	56.99
300	89.27	95.24	91.46	83.22	76.46	64.61
350	96.89	102.87	99.08	90.85	84.08	72.24
400	104.52	110.49	106.71	98.47	91.71	79.86
450	112.14	118.12	114.34	106.10	99.33	87.43
500	119.77	125.74	121.96	113.72	106.96	95.11
550	127.39	133.37	129.59	121.35	114.58	102.74
600	135.02	140.99	137.21	128.98	122.21	110.36
650	142.64	148.62	144.84	136.60	129.84	117.99
700	150.27	156.24	152.46	144.23	137.46	125.61
750	157.89	163.87	160.09	151.85	145.09	133.24
800	165.52	171.49	167.71	159.48	152.71	140.87

[1] Aggregate deviation, less than 0.5 per cent; average percentage deviation, 16.4 per cent.

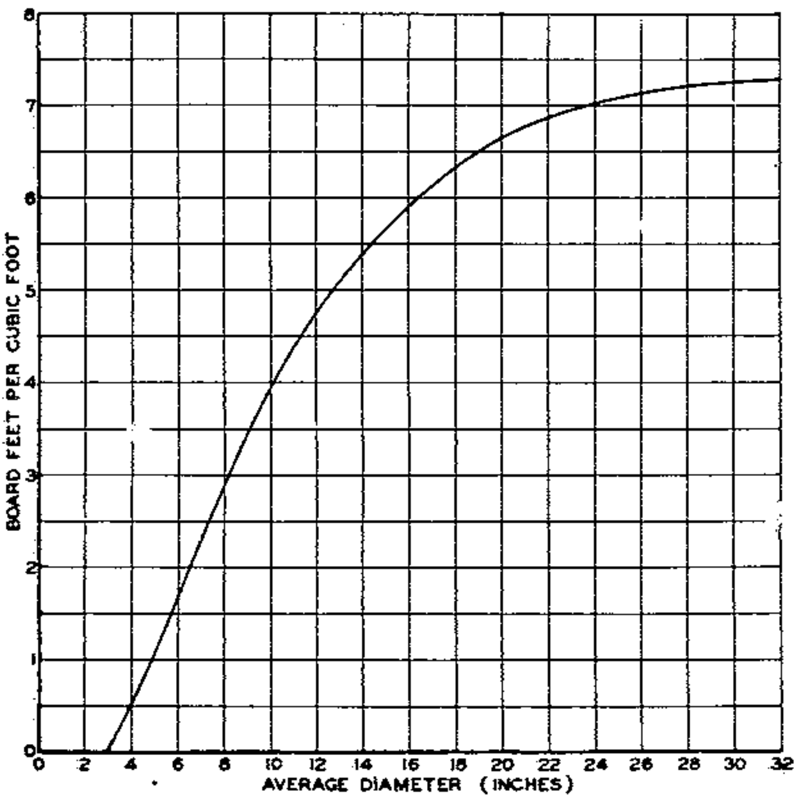


FIGURE 7.—The ratio of volume of stand in board feet to volume in cubic feet, in relation to average diameter of stand

RATIO OF BOARD FEET TO CUBIC FEET

The ratio of board feet to cubic feet is closely correlated with average diameter and is independent of age and site quality. In the standard yield-table technic, this relationship is applied to the table of volume in cubic feet to obtain the table of volume in board feet. Table 12 and Figure 7 give the board foot-cubic foot ratios used. The values given are ratios of volume in board feet of trees 8 inches and larger to the volume in cubic feet of all trees 2 inches and larger.

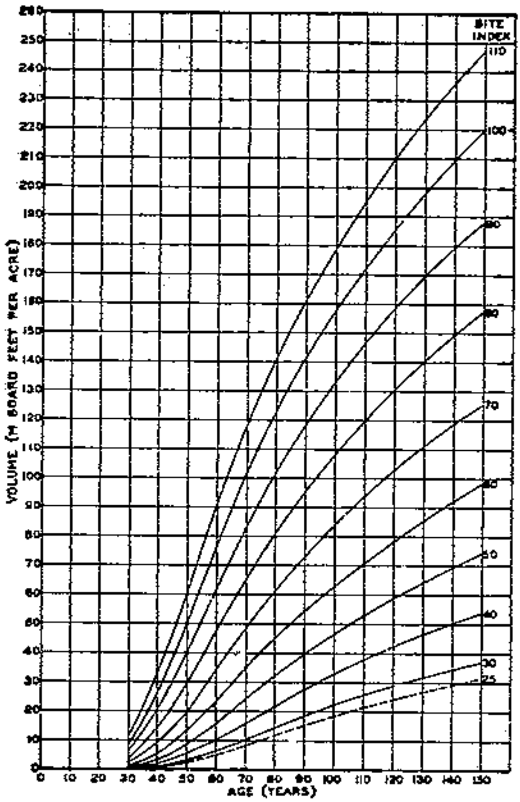


FIGURE 8.—Volume in board feet by the international rule (¼-inch kerf), trees 8 inches and larger, average of well-stocked stands, average composition.

TABLE 12.—*Board-foot conversion table*

Age (years)	Board feet per cubic foot by site-index classes									
	Site 25	Site 30	Site 40	Site 50	Site 60	Site 70	Site 80	Site 90	Site 100	Site 110
30			0.06	0.25	0.50	0.80	1.20	1.60	1.98	2.29
40	0.44	0.52	.72	1.04	1.47	2.00	2.60	3.16	3.60	3.96
50	1.02	1.15	1.45	1.87	2.44	3.10	3.76	4.31	4.72	5.06
60	1.60	1.82	2.21	2.72	3.35	4.01	4.65	5.12	5.52	5.82
70	2.38	2.56	2.98	3.55	4.19	4.80	5.36	5.82	6.19	6.40
80	2.98	3.20	3.60	4.19	4.76	5.36	5.90	6.32	6.60	6.81
90	3.50	3.70	4.14	4.65	5.17	5.75	6.30	6.65	6.87	7.01
100	3.85	4.05	4.47	4.96	5.49	6.06	6.52	6.84	7.00	7.12
110	4.14	4.35	4.76	5.24	5.75	6.30	6.71	6.96	7.10	7.19
120	4.39	4.58	4.96	5.44	5.94	6.40	6.83	7.04	7.16	7.23
130	4.58	4.76	5.12	5.60	6.11	6.59	6.92	7.10	7.20	7.26
140	4.72	4.90	5.26	5.75	6.24	6.68	6.98	7.15	7.23	7.27
150	4.87	5.06	5.41	5.87	6.36	6.78	7.04	7.18	7.25	7.29

VOLUME PER ACRE IN BOARD FEET

Volumes in board feet of all trees 8 inches and larger in diameter, for stands of average stocking and composition, are given in Table 13 and Figure 8. The log rule used is the International, ⅛-inch kerf, and the volume is of that part of the stem between a stump 1 foot high and a top diameter inside bark of 5 inches.

TABLE 13.—*Volume per acre in board feet (International rule, ⅛-inch kerf), average stands*

Age (years)	Board feet per acre on site index—									
	25	30	40	50	60	70	80	90	100	110
30			85	450	1,100	2,120	3,840	6,030	8,670	11,110
40	700	940	1,740	3,210	5,540	9,100	14,300	20,500	26,800	33,450
50	2,300	2,980	5,050	8,300	13,200	20,340	29,850	40,100	50,500	60,700
60	4,720	6,100	9,970	15,750	23,500	34,300	47,900	61,950	76,750	90,200
70	8,330	10,250	15,950	24,300	35,400	48,950	65,400	83,250	102,100	118,900
80	11,900	14,550	21,950	32,700	45,300	61,650	81,400	102,400	122,800	142,300
90	15,450	18,500	27,950	40,000	54,300	73,000	95,750	118,400	142,200	161,900
100	18,600	22,300	33,100	46,850	63,150	84,250	108,200	133,400	158,200	179,400
110	21,550	25,900	38,100	53,450	70,700	93,850	120,100	146,200	172,200	195,800
120	24,600	29,250	42,400	58,750	78,400	103,400	130,500	158,400	186,200	209,700
130	27,000	31,900	46,350	64,400	85,550	111,400	140,500	170,400	198,000	222,900
140	29,350	34,650	50,250	69,800	92,050	118,600	149,400	180,200	209,700	235,500
150	31,900	37,600	54,400	74,550	98,250	125,800	157,700	189,600	220,400	247,900

This table was constructed in the usual manner, by multiplying cubic-foot volume for any age and site index by the board foot-cubic foot ratio corresponding to the average diameter for that age and site index.

This average table is corrected for specific stocking and composition in a similar manner. The corrected average diameter is first determined, and the corresponding board foot-cubic foot ratio is then multiplied by the corrected volume in cubic feet, giving the corrected volume in board feet.

MEAN ANNUAL INCREMENT

Table 14 and Figure 9 show the mean annual increment in cubic feet, for stands of average stocking and composition. These values were derived by dividing the values in Table 10 by the corresponding ages. Mean annual increment culminates at 70 years for any site quality.

TABLE 14.—*Mean annual growth in cubic feet per acre, average stands*

Age (years)	Mean annual growth in cubic feet per acre on site index—									
	25	30	40	50	60	70	80	90	100	110
30	31.00	35.33	47.33	60.00	73.33	88.33	106.67	125.67	146.00	161.67
40	39.75	45.00	60.25	77.25	94.25	113.75	137.50	162.50	186.25	211.25
50	45.20	51.80	69.60	88.80	108.40	131.20	158.80	186.00	214.00	240.00
60	49.17	55.83	75.17	96.50	117.00	142.50	171.67	201.67	231.67	258.33
70	50.00	57.14	76.43	97.86	120.71	145.71	174.29	204.29	235.71	262.86
80	50.00	56.75	76.25	97.50	119.00	143.75	172.50	202.50	232.50	201.25
90	49.11	55.56	75.00	95.56	116.67	141.11	168.89	197.78	230.00	256.67
100	48.30	55.00	74.00	94.50	115.00	139.00	166.00	195.00	226.00	252.00
110	47.27	54.09	72.73	92.73	111.82	135.45	162.73	190.91	220.45	247.27
120	46.67	53.25	71.25	90.00	110.00	133.33	159.17	187.50	216.67	241.67
130	45.38	51.54	69.62	88.46	107.69	130.00	156.15	184.62	211.54	236.15
140	44.43	50.50	68.21	86.43	105.36	126.79	152.86	180.00	207.14	231.43
150	43.67	49.53	66.67	84.67	103.00	123.67	149.33	170.00	202.07	226.67

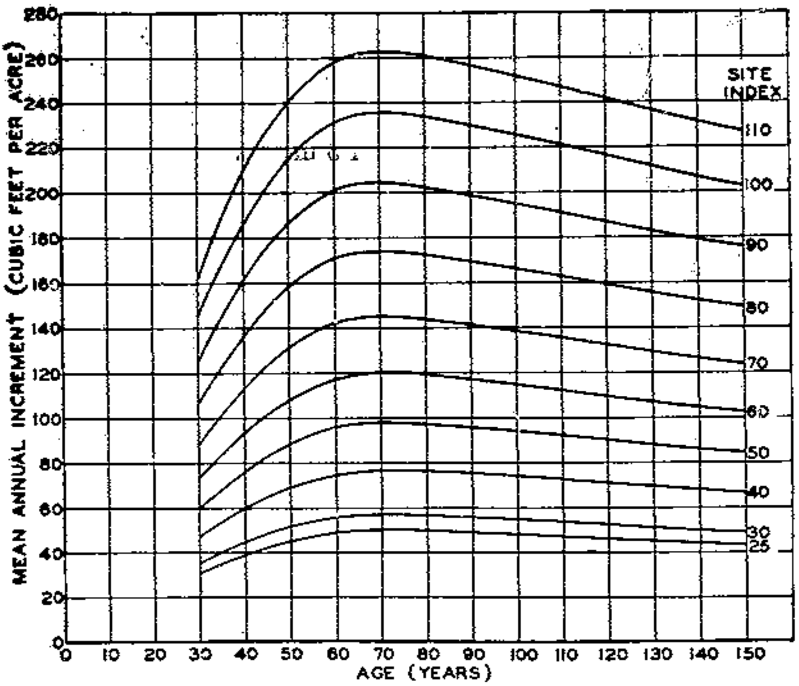


FIGURE 9.—Mean annual increment in cubic-foot volume culminates at 70 years on all sites

Table 15 and Figure 10 show the mean annual increment in board feet. The age of culmination varies with site quality, from 95 years for site index 110 to over 150 years for site index 30. For site index 70 the age of culmination is about 120 years.

TABLE 15.—*Mean annual growth in board feet per acre (international rule, ⅛-inch kerf), average stands*

Age (years)	Mean annual growth in board feet per acre on site index—									
	25	30	40	50	60	70	80	90	100	110
30			2.8	15.0	36.7	70.7	128.0	201.0	289.0	370.3
40	17.5	23.5	43.5	80.2	138.5	227.5	357.5	512.5	670.0	836.2
50	46.0	59.6	101.0	186.0	264.0	406.8	597.0	802.0	1,010.0	1,214.0
60	78.7	101.7	166.2	262.5	391.7	571.7	798.3	1,032.5	1,279.2	1,503.3
70	119.0	146.4	227.9	347.1	505.7	699.3	934.3	1,189.3	1,458.6	1,698.6
80	148.8	181.9	274.4	408.8	566.2	770.6	1,017.5	1,280.0	1,536.0	1,768.8
90	171.7	205.6	310.6	444.4	603.3	811.1	1,063.9	1,315.6	1,580.0	1,778.5
100	186.0	223.0	331.0	468.5	631.5	842.5	1,082.0	1,334.0	1,582.0	1,794.0
110	195.9	235.5	346.4	485.9	642.7	853.2	1,091.3	1,329.1	1,565.5	1,778.2
120	205.0	243.8	353.3	489.0	653.3	861.7	1,087.5	1,320.0	1,551.7	1,747.5
130	207.7	245.4	356.5	495.4	658.1	855.9	1,080.8	1,310.8	1,523.1	1,714.6
140	209.6	247.5	358.9	497.1	657.5	847.1	1,067.1	1,287.1	1,497.9	1,682.1
150	212.7	250.7	362.7	497.0	655.0	838.7	1,051.3	1,264.0	1,469.3	1,652.7

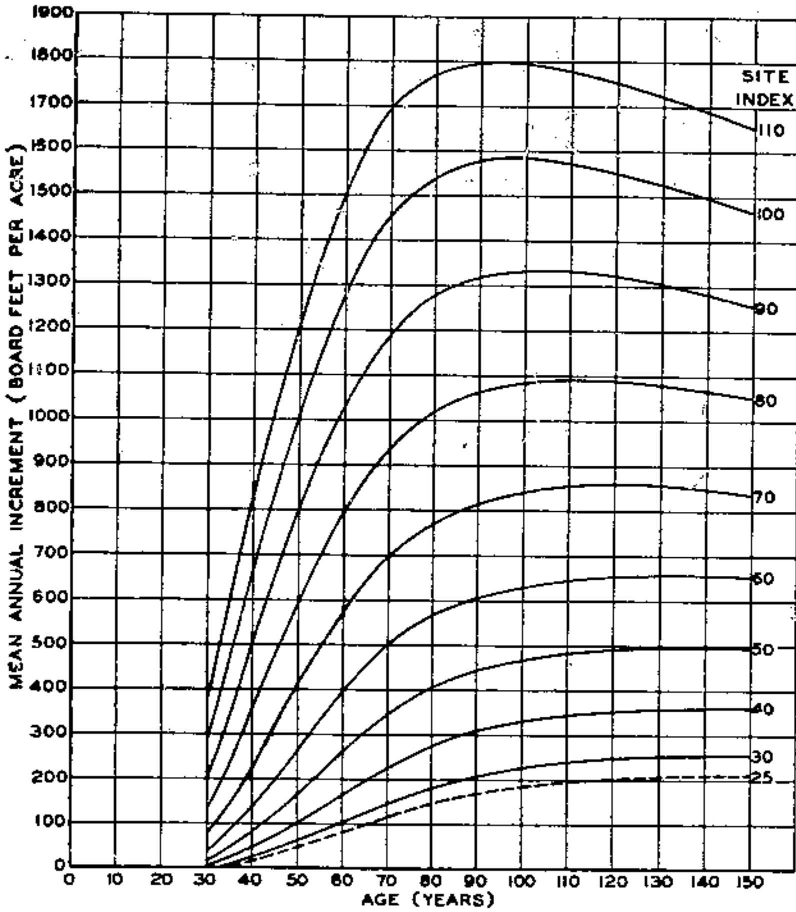


FIGURE 10.—Mean annual increment in board feet culminates at 95 years on the best sites and at 150 years and more on the poorest sites

SUMMARY

With the continued depletion of old-growth stands in the very important mixed conifer type of California there is increasing need for adequate tables of the second-growth timber that is rapidly coming in on many cut-over areas in this region. The tables here presented are based in the main on intensive studies of 311 sample plots which were selected as supplying reasonably representative, although inevitably incomplete data. The position, range, and occurrence of the second-growth mixed conifer stands is described as well as the conditions for their establishment and the relative importance of virgin and second-growth forest in this type.

In view of the number of unusual features that were involved in this yield study a careful explanation of the technic employed in the preparation of the tables is included as an appendix.

LITERATURE CITED

(1) BAKER, F. S.
1923. NOTES ON THE COMPOSITION OF EVEN-AGED STANDS. Jour. Forestry 21: 712–717, illus.

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

(3) ———
1926. A METHOD OF PREPARING TIMBER-YIELD TABLES. Jour. Agr. Research 32: 543–557, illus.

(4) BRUCE D. and REINEKE, L. H.
1929. THE USE OF ALINEMENT CHARTS IN CONSTRUCTING FOREST STAND TABLES. Jour. Agr. Research 38: 289–308, illus.

(5) HAIG, I. T.
1932. SECOND-GROWTH YIELD, STAND, AND VOLUME TABLES FOR THE WESTERN WHITE PINE TYPE. U. D. Dept. Agr. Tech. Bul. 323, 68 p., illus.

(6) MEYER, W. H.
1930. DIAMETER DISTRIBUTION SERIES IN EVEN-AGED FOREST STANDS. Yale Univ. School Forestry Bul. 28, 105 p., illus.

(7) REINEKE, L. H.
1927. A MODIFICATION OF BRUCE'S METHOD OF PREPARING TIMBER-YIELD TABLES. Jour. Agr. Research 35: 843–856, illus.

(8) SCHUMACHER, F. X.
1926. YIELD, STAND, AND VOLUME TABLES FOR WHITE FIR IN THE CALIFORNIA PINE REGION. Calif. Agr. Expt. Sta. Bul. 407, 26 p., illus.

APPENDIX

SPECIAL TECHNIC USED IN THE PREPARATION OF THE TABLES

SITE INDEX

The mixed-conifer types present a problem in the determination of site quality by reason of their variation in composition. If dominant trees of a given species were invariably present, the height of trees of that species alone could be used as the index of site quality. Since this is not the case, the relative height growths of the various species must be compared, to determine which species it is desirable to use and to what extent the heights of each depart from the heights of the other species.

The actual analysis showed a simple solution for the problem. The height of the average dominant tree of each species on a plot was first determined. Using all plots for which such values could be determined for two or more species, it was found that white fir was common to nearly all. Accordingly, dominant heights of other species on each plot were expressed as a percentage of the dominant height of white fir. The percentages so derived were then plotted over age, by species. The resultant curves were horizontal straight lines and passed through 98 per cent for ponderosa pine and Douglas fir, 100 per cent for red fir, and 90 per cent for sugar pine. (No data were available for incense cedar, rarely dominant.) This is in close agreement with the values obtained by Schumacher (*8*) and by Bruce (*2*).

These results indicate that site index can be determined directly from white fir, ponderosa pine, Douglas fir, and red fir, alone or in any combination. Naturally, the use of as many of these species as are present will give a more accurate value of site index.

STAND-DENSITY INDEX

In any even-aged stand, the curve of number of trees by breast-high diameter classes has a definite characteristic form, often approaching that of the normal frequency curve (*1*, *4*, *6*). Such a curve can be mathematically described in several ways, a description commonly used being the statement of the mean or average diameter and the standard deviation (*3*). For even-aged stands, however, the numerical value of the standard deviation is positively correlated with the average diameter. Therefore, average diameter alone may be used to describe stands of similar frequency-curve form where extreme accuracy is not needed.

If, then, a large number of stands of the same description, that is, of the same average diameter, be compared as to number of trees per acre, it is obvious that the stand with most trees is the most fully stocked. If this be taken to represent the maximum or complete stocking, the number of trees in each of these stands expressed as a percentage of this maximum will give the percentage stocking of the stand.

The number of trees per acre for complete stocking varies with the average diameter of the stand. The curve representing the relationship between number of trees per acre and average diameter corresponds (*8*) to the formula

$$\text{log number of trees} = -1.605 \text{ log average diameter breast high} + k$$

where k is a constant varying with species. This formula plots as a straight line on logarithmic graph paper (the solid line of Figure 2).

Since the constant k differs with species, it would be impractical to determine its value for the innumerable mixtures of the mixed-conifer types, nor would differences for the common proportions of those species be sufficiently great to justify the attempt. For simplicity then, k was taken as 4.605 to give a curve passing through 1,000 trees per acre at 10 inches average diameter. This curve is used as a reference curve; its elevation is of no importance aside from the convenience of its round-number coordinates (10, 1,000).

The reference curve, thus arbitrarily chosen, is somewhat high for the mixed-conifer stands of this study, though it is not too high for stands of certain other species. It was deemed more desirable, however, to refer stocking to a standard curve suitable for many species than to a curve applicable only to the species of this study. Since this reference curve is higher than the curve representing maximum stocking for the mixed-conifer types, percentage stocking values based on it will be higher than the true percentage stocking. Although this distortion could be easily cared for in any computations involved, it would be somewhat confusing in making mental comparisons. For this reason, the stand-density index was devised.

Any curve representing a constant percentage of the reference curve will plot as a straight line parallel to the reference curve. The curves corresponding to all possible percentages thus constitute an infinite series of parallel curves. Since their slopes are identical, the position of any curve of the series may be defined by any one ordinate and abscissa. If the same abscissa be used for all curves, each curve may be defined by ordinate alone. Accordingly, an abscissa of 10 inches average diameter was chosen, and the ordinate (number of trees per acre) corresponding to this abscissa is termed "stand-density index."

Stand-density index, as here conceived, is obviously independent of species variation in elevation of the curve of maximum number of trees, since it is an absolute, not a relative measure.

The effect of age and site quality on the relationship between number of trees and average diameter is very small. Multiple correlation coefficients for various species ranged from 0.141 ± 0.050 to 0.251 ± 0.049. These are not significant. The corresponding alienation coefficients were 0.990 and 0.968, respectively. For all practical purposes, therefore, no correction need be made for age or site quality.

ADJUSTMENT OF PLOT VALUES FOR STOCKING IN CONSTRUCTION OF TABLES FOR AVERAGE STOCKING

Having a measure of stocking, it should be possible to eliminate the effects of variation in stocking by converting individual plot values to a uniform-stocking basis, thus reducing the dispersion of the plotted points and eliminating the effect of any irregular distribution of stocking. As a result the required curves of the various stand measures for average stocking and composition should be well defined and easily fitted.

The individual plot values for total basal area, number of trees, and cubic-foot volume were accordingly modified by straight proportion between plot stand-density index and average stand-density index (479). Thus, the values for a plot of stand-density index 700 were reduced by the proportion of 700 to 479, and a plot of stand-density index 450 increased by the proportion 450 to 479. The usual pairs of average curves (*7*) such as total basal area over age and percentage of average total basal area over site index, were fitted to the modified values. As expected, the dispersion of the values thus derived was reduced materially, and the trends of the curves were more consistent and better defined.

Since modification for stocking was effected by increasing or decreasing the number of trees of a given average diameter, the average diameter values of the individual plots were not changed. The average curves were based on these original plot values of diameter and checked through the modified total basal area and modified number of tree curves; the agreement between them was very close.

The board-foot tables are derived from the cubic-foot tables and the curve of board foot–cubic foot ratio; board-foot values, therefore, were not modified for stocking.

ANALYSIS OF EFFECT OF COMPOSITION AND STOCKING

By using the table of total basal area for stands of average stocking and composition, the tabular value corresponding to the age and site index of each sample plot was determined. The basal area of each plot was then expressed as a percentage of this tabular value. These percentages were used as the dependent-variable values in a multiple linear correlation, with percentage stocking and composition by species as the independent variables. The resulting multiple-regression equation was—

Total basal area per cent
=2.0303 (stand-density index) +0.1493 (ponderosa pine per cent) +0.1545 (sugar pine per cent) +0.0541 (Douglas fir per cent) +0.0980 (white fir per cent) +0.1229 (incense cedar per cent) +0.1883 (red fir per cent) −8.1511.

The regression coefficients, in combination with the numerical values of the variables, indicate that variations in stocking account for the greatest part of the variation in basal area, the effect of composition being relatively small.

A similar correlation was made for number of trees per acre, resulting in the regression equation—

Number of trees per cent
=2.0058 (stand-density index) −0.3166 (ponderosa pine per cent) −0.2973 (sugar pine per cent) −0.0159 (Douglas fir per cent) −0.1355 (white fir per cent) −0.1358 (incense cedar per cent) −0.0905 (red fir per cent) +19.3572.

Here, also, the greatest effect is assignable to variation in stand density.

A third correlation was made, in a similar manner, for volume in cubic feet. The resulting regression equation was—

Cubic-foot volume per cent
=1.5251 (stand-density index) −0.7170 (ponderosa pine per cent) −0.7740 (sugar pine per cent) −0.9398 (Douglas fir per cent) −1.0704 (white fir per cent) −0.8427 (incense cedar per cent) −1.1996 (red fir per cent) +128.7553.

STATISTICAL MEASURES

The various statistical measures employed in the computations are given in Table 16.

TABLE 16.—*Statistical measures*

Dependent variable (per cent)	Alienation index	Correlation index	Standard error of average table	Standard error of average table and regression equation combined	Average percentage deviation [1]	
					From average table only	From average table and regression equation combined
			Per cent	*Per cent*	*Per cent*	*Per cent*
Total basal area	0.2486	0.9686	26.24	6.52	21.0	5.22
Number of trees	.6926	.7213	32.19	22.29	25.8	17.8
Volume, cubic feet	.7442	.6680	27.52	20.48	22.0	16.4
Volume, board feet	.7224	.6915	36.46	26.34	29.2	21.1

[1] Average percentage deviation $=\frac{\text{standard error.}}{1.25}$

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

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

This bulletin is a contribution from

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

U. S. GOVERNMENT PRINTING OFFICE: 1933

For sale by the Superintendent of Documents, Washington, D.C. - - - - - - - - Price 5 cents

END