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Top Utilization of Timber Cut in California, 1964

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ABSTRACT: Top utilization practices in harvesting California timber have not changed appreciably between 1945 and 1964. Factors affecting top utilization are largely related to the condition of old-growth timber stands currently harvested, and they appear to be independent of ownership and geographical strata. Characteristic differences between species do occur, especially in the larger diameter classes.

Most present day cruising for timber inventory and appraisal purposes is done by measuring tree diameter at breast height (d.b.h.) and height in number of logs. Tree volumes are then determined from tables which give board foot volumes for various combinations of d.b.h. and number of logs.

Volume tables used to estimate volumes of individual trees specify the top diameter inside bark (d.i.b.) to which the merchantable height in number of logs is measured. This top diameter varies between tables and species. For example, standard volume tables for white woods[1] used by the California Region of the Forest Service[2] are based on a top d.i.b. of 8 inches. Volume and taper tables for old-growth coastal redwood by Hallin[3] provide for several utilization standards. These include tables to a fixed top d.i.b. of 12 inches, and tables to variable top diameters of 50, 60, 70, 80, and 90 percent of d.i.b. 20 feet above upper ground line. Lindquist's and Palley's[4] tables for young-growth redwoods are based on an 8 inch top d.i.b. Form class volume tables by Bruce and Girard[5] are based on a variable top diameter which is 50 percent of the top diameter of the first 16-foot log, except that an 8-inch top is used for small trees. Fifty percent of the top d.i.b. of the first 16-foot log corresponds closely to 40 percent of d.b.h. Form class volume

[1] "White woods" includes all commercial conifers excepting coastal redwood and giant sequoia.

[2] U.S. Forest Service. Region 5 volume tables. San Francisco, Calif. (mimeo., 17 pp.) 1948.

[3] Hallin, William. Volume and taper tables for old-growth coastal redwood. U.S. Forest Serv. Calif. Forest & Range Expt. Sta., Berkeley, Calif. (mimeo., 79 pp.) 1941.

[4] Lindquist, James L., and Palley, Marshall N. Empirical yield tables for young-growth redwood. Calif. Agr. Expt. Sta. Bul. 796, tables 27 and 28 1963.

[5] Bruce, Donald, and Girard, James W. Tables for estimating board foot volume of trees scaled in 16 foot logs, based on diameter, form class, and tree height. Portland, Ore.: Mason, Bruce & Girard. 46 pp. (not dated).

and taper tables prepared by Clements, Stevens, and Roy[6] provide tree volumes for two utilization standards: a fixed top d. i. b. of 10 inches and also a variable top diameter representing average top utilization by d. b. h. classes on Forest Service timber sales in California in 1945.

Taper tables used by the California Region for timber appraisals of most white woods are based on log height to a fixed top diameter inside bark (d. i. b.) of 8 inches; those for Douglas-fir specify a top diameter of 10 inches. The cruiser, therefore, must determine tree height in number of logs to an equivalent top d. i. b. for computing cruise volumes and also for culling unmerchantable logs or missing (broken out) top logs.

Differences in top utilization affect both the volume and the stumpage value for an appraisal. Consequently the top utilization standards used in appraisal cruising should represent the average current utilization practices for the species and size of tree concerned. Information on utilization practices in California date from a 1945 study on National Forest timber sales--1,485 trees were measured, including ponderosa pine, sugar pine, Douglas-fir, and red and white fir--and from a study of old-growth redwood in 1950.[7]

To determine whether top utilization practices have changed since then, the California Region and the Pacific Southwest Station jointly investigated top utilization practices throughout California in 1964.

Objectives

The objectives of this study were: (1) to determine average utilized top diameters inside bark, by species and tree d. b. h., on logging operations on both public and private timber lands; and (2) to determine the factors affecting top utilization, such as breakage, rot, rough tops, broken out tops, spike and dead tops, forks, malformations, and disease cankers. We do not attempt in this note to indicate how the findings may be used in National Forest timber sales.

Scope

The study was limited to 1964 logging operations on commercial forest land. The Region obtained data on National Forest cuttings, and the Experiment Station obtained data from cutting operations on "other public" and private ownerships.

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[6] Clements, V. A., Stevens, C. W., and Roy, D. F. Form class volume tables for ponderosa pine, Douglas-fir, and white fir in California. U.S. Forest Serv. Calif. Forest & Range Expt. Sta. Res. Note 60. 1949.
Clements, V. A., Stevens, C. W., and Roy, D. F. Form class volume tables for sugar pine and red fir in California. U.S. Forest Serv. Calif. Forest & Range Expt. Sta. Res. Note 61. 1949.

[7] Kimmey, James W., and Hornibrook, E. M. Cull and breakage factors and other tree measurement tables for redwood. U.S. Forest Serv. Calif. Forest & Range Expt. Sta. Forest Survey Release 13, 28 pp., illus. 1952.

Procedure

Top utilization data were obtained by measuring trees that had been felled and bucked into logs on current operations. Logging operations sampled were selected to represent as wide a distribution by operators, tree species, and size classes as possible. Data were obtained on 15 National Forests and on 25 logging operations representing 18 different companies cutting on private lands, State lands, and Indian Reservations. On National Forests the distribution of the sample by species was proportional to the volumes of timber cut in 1963. Sampling on private and other public lands was somewhat lighter, but aimed for a minimum of 100 trees per species. Sampling objectives were achieved except in young-growth redwood, in which cutting was limited.

At each operation sampled, data were recorded on ownership and geographical strata.[8] Individual tree data included species, d.b.h., age class, d.i.b. at the last cut, and apparent reasons for stopping utilization at the last cut.

Measurements were obtained on 2,891 trees, predominantly old-growth, since present day cutting is largely in old-growth stands (table 1). Regression equations of top d.i.b. at the last cut as related to d.b.h. were developed separately by species, ownership, and geographic strata using electronic computer procedures.

Table 1.--*Number of trees measured for the top utilization study, by diameter group and species, California, 1964*

Diameter group, (inches)	Redwood		Douglas-fir	White fir	Red fir	Incense-cedar	Pine		
	Old-growth	Young-growth					Ponderosa & Jeffrey	Sugar	Lodge-pole
12- 20	--	13	77	52	39	26	61	16	40
21- 30	19	20	130	135	63	93	160	53	63
31--40	26	6	140	104	63	94	202	104	14
41- 50	29	3	124	79	34	43	136	103	1
51- 60	27	--	67	23	6	14	67	92	--
61- 70	23	--	23	3	5	7	15	40	--
71- 80	25	--	3	--	--	--	2	12	--
81- 90	19	--	2	--	--	--	1	5	--
91-100	18	--	--	--	--	--	--	1	--
101-110	10	--	--	--	--	--	--	--	--
111-120	6	--	--	--	--	--	--	--	--
121-130	6	--	--	--	--	--	--	--	--
131-140	1	--	--	--	--	--	--	--	--
141-150	3	--	--	--	--	--	--	--	--
Total	212	42	566	396	210	277	644	426	118

Total, all species: 2,891

[8] Four geographical strata were used: Eastside Sierra, westside Sierra, coast range pine, and redwood--Douglas-fir.

Results

Top utilization differed significantly between species, except in ponderosa and Jeffrey pine. Although variation between geographical and ownership strata was observed within a species, significance was not definitely established. Young-growth redwood proved to be significantly different from old-growth, which was to be expected. However, we did not have measurements on enough young-growth trees of other species to establish whether top utilization differed between age groups.

On the basis of the regression tests, all trees of each species were combined--disregarding ownership and geographical strata, and age class, except as noted above. Regression equations were computed for each, and the following information was compiled: (a) averaged utilized top diameter by species and d.b.h. classes, (b) utilized top d.i.b. as percent of d.b.h., and (c) top utilization data for old-growth redwood related to 20-foot diameter outside bark (d.o.b.) measurements (table 2, appendix).

Reasons for Non-Utilization

Breaks in sound wood and shattering of the upper bole made up the most important factor affecting utilization (table 3). Nearly 42 percent of all trees were affected by sound breaks. The amount is not surprising considering that timber currently harvested is predominantly large old-growth trees. Breakage is less prevalent among young-growth trees because of their smaller size, and perhaps because they are more flexible. Breaks in rotten wood and rot showing at the last cut ranked fourth among the several factors affecting utilization. It is to be expected that this factor is more prevalent among old-growth than young-growth trees.

Utilization to a 10-inch d.i.b. or smaller, was obtained in about one-fifth of the sample trees. Young-growth trees were utilized to a smaller top than mature timber. The difference appeared to be due largely to less breakage and less decay.

Table 3.--*Reasons for stopping utilization at the last cut, California, 1964*

Reason	Proportion of trees		
	Young-growth	Old-growth	All trees
	Percent		
Breaks in sound wood	25.1	43.7	41.7
Top d.i.b. 10 inches or smaller	44.3	17.8	20.7
No apparent reason	13.4	18.3	17.7
Rot showing at last cut or rotten break (cull above)	2.1	6.8	6.3
Large limbs--rough top	6.5	6.0	6.1
Top missing (broken out during past)	2.1	3.2	3.0
Forked, crooked and/or stem terminated	3.4	2.2	2.3
Dead and/or spike top	.7	1.7	1.6
Other reasons[1]	2.4	.3	.6
Total	100.0	100.0	100.0

[1]Includes disease and mistletoe cankers, mechanical injuries, and porcupine and lightning damage.

In nearly 14 percent of the trees, top utilization was restricted as a result of large limbs, missing tops, dead and spike tops, forks, crooked tops, and damage due to disease, porcupines, lightning, and mechanical injuries.

Some additional material could have been utilized in 13 percent of the young-growth and 18 percent of the old-growth trees. The reasons why more of the usable material in sound tops was not removed are not always obvious. A number of factors, however, influence utilization practice. Usable material left in tops usually would yield only a short log--considerably less than 16 feet in length. Utilization of this material under a sawlog economy presents serious problems. Current sawlog bucking practice is to cut 16-foot or 20-foot logs or multiples thereof. Removal of additional top material would result in either unusually long lengths or very short logs. Very few sawmills have carriages that will handle logs longer than 22 feet or shorter than 10 feet. Therefore longer or shorter logs are unacceptable. Short logs are uneconomical to log and to mill with equipment designed for big timber. Short length lumber is difficult to market.

Discussion

The major factors affecting top utilization are independent of ownership and geographical location. In old-growth timber, top utilization is governed to a high degree by: dead, distorted, decayed, forked, and missing tops; breakage due to brashness and topography; sawmill and logging equipment limitations; and economic considerations.

Utilization appeared to be to slightly smaller top diameters in 1964 than in 1945. The observed differences could hardly be classed as important differences and would have very little effect on inventories or appraisals. The differences between 1945 and 1964 data did not appear to be greater than could be expected between different mathematical treatments of data or between two random samples of the same population. Linear regression formulae were applied to all the 1945 data whereas curvelinear formulae were applied to 1964 data where curvelinearity was indicated. Red and white fir were combined in 1945. However, in 1964, utilization was definitely different between these two species. Red fir was utilized to a smaller top diameter than white fir.

Differences in utilization are not pronounced between white wood species in the lower diameter classes. However, differences between species do become greater with increasing diameters. Caution should be exercised in application of utilization values beyond the limits of adequate basic data shown in table 1.

Utilization of old-growth redwood is quite similar to that reported for 1950[9] except for diameters above 100 inches. The observed differences above this point may be due largely to free hand curving in 1950 versus a mathematically derived curve for 1964 data.

[9] Kimmey and Hornibrook, *op. cit.*

Use of top utilization values given in table 2 (appendix) to adjust taper volume tables that are based on hypothetical top log diameter(s) should result in closer conformity between the appraisal estimated volume and the actual volume cut, other things being equal.

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Appendix

Table 2.--*Average diameter inside bark, of the top log utilized, by diameter class and species, California, 1964*

D.b.h. class (inches)	PONDEROSA & JEFFREY PINE		SUGAR PINE		LODGEPOLE PINE	
	Average utilized top		Average utilized top		Average utilized top	
	D.i.b. (curved)	Proportion of d.b.h.	D.i.b. (curved)	Proportion of d.b.h.	D.i.b. (curved)	Proportion of d.b.h.
	Inches	*Percent*	*Inches*	*Percent*	*Inches*	*Percent*
12	10.0	83.3	9.0	75.0	9.2	76.7
14	10.1	72.1	9.3	66.4	9.6	68.6
16	10.2	63.8	9.7	60.6	10.0	62.5
18	10.4	57.8	10.0	55.6	10.4	57.8
20	10.5	52.5	10.4	52.0	10.8	54.0
22	10.8	49.1	10.8	49.1	11.2	50.9
24	11.0	45.8	11.1	46.2	11.6	48.3
26	11.3	43.5	11.5	44.2	12.0	46.2
28	11.6	41.4	11.9	42.5	12.4	44.3
30	12.0	40.0	12.3	41.0	12.8	42.7
32	12.4	38.8	12.8	40.0	13.3	41.6
34	12.8	37.6	13.4	39.4	13.7	40.3
36	13.2	36.7	13.9	38.6	14.1	39.2
38	13.7	36.1	14.4	37.9	14.5	38.2
40	14.2	35.5	14.9	37.2	14.9	37.2
42	14.7	35.0	15.4	36.7	15.3	36.4
44	15.3	34.8	15.9	36.1	15.7	35.7
46	15.9	34.6	16.4	35.7	16.1	35.0
48	16.5	34.4	16.9	35.2	16.5	34.4
50	17.2	34.4	17.4	34.8	16.9	33.8
52	17.9	34.4	17.9	34.4	17.3	33.3
54	18.6	34.4	18.4	34.1	17.7	32.8
56	19.3	34.5	18.9	33.8		
58	20.1	34.7	19.4	33.4		
60	21.0	35.0	19.9	33.2		
62	21.8	35.2	20.4	32.9		
64	22.7	35.5	20.9	32.7		
66	23.6	35.8	21.4	32.4		
68	24.5	36.0	21.9	32.2		
70	25.5	36.4	22.4	32.0		
72	26.5	36.8	22.9	31.8		
74	27.6	37.3	23.4	31.6		
76	28.6	37.6	23.9	31.4		
78	29.7	38.1	24.4	31.3		
80	30.9	38.6	24.9	31.1		
82			25.4	31.0		
84			25.9	30.8		
86			26.4	30.7		
88			26.9	30.6		
90			27.4	30.4		

	DOUGLAS-FIR		WHITE FIR		RED FIR	
12	9.4	78.3	9.0	75.0	8.0	66.7
14	9.5	67.9	9.2	65.7	8.4	60.0
16	9.7	60.6	9.5	59.4	8.8	55.0
18	9.9	55.0	9.8	54.4	9.2	51.1
20	10.1	50.5	10.2	51.0	9.7	48.5
22	10.4	47.3	10.5	47.7	10.1	45.9
24	10.6	44.2	11.0	45.8	10.5	43.8
26	10.9	41.9	11.4	43.8	10.9	41.9
28	11.2	40.0	11.9	42.5	11.4	40.7
30	11.6	38.7	12.5	41.7	11.8	39.3

Table 2.--*Average diameter inside bark, of the top log utilized, by diameter class and species, California, 1964, continued*

D.b.h. class (inches)	DOUGLAS-FIR		WHITE FIR		RED FIR	
	Average utilized top		Average utilized top		Average utilized top	
	D.i.b. (curved)	Proportion of d.b.h.	D.i.b. (curved)	Proportion of d.b.h.	D.i.b. (curved)	Proportion of d.b.h.
	Inches	*Percent*	*Inches*	*Percent*	*Inches*	*Percent*
32	11.9	37.2	13.0	40.6	12.2	38.1
34	12.3	36.2	13.7	40.3	12.7	37.4
36	12.7	35.3	14.3	39.7	13.1	36.4
38	13.2	34.7	15.0	39.5	13.5	35.5
40	13.6	34.0	15.7	39.2	13.9	34.8
42	14.1	33.6	16.5	39.3	14.4	34.3
44	14.6	33.2	17.3	39.3	14.8	33.6
46	15.1	32.8	18.1	39.3	15.2	33.0
48	15.7	32.7	19.0	39.6	15.6	32.5
50	16.2	32.4	19.9	39.8	16.1	32.2
52	16.8	32.3	20.8	40.0	16.5	31.7
54	17.5	32.4	21.8	40.4	16.9	31.3
56	18.1	32.3	22.8	40.7	17.4	31.1
58	18.8	32.4	23.8	41.0	17.8	30.7
60	19.5	32.5	24.9	41.5	18.2	30.3
62	20.2	32.6	26.1	42.1	18.6	30.0
64	20.9	32.7	27.2	42.5	19.1	29.8
66	21.7	32.9	28.4	43.0	19.5	29.5
68	22.4	32.9	29.7	43.7	19.9	29.3
70	23.2	33.1	30.9	44.1	20.3	29.0
72	24.1	33.5	32.2	44.7	20.8	28.9
74	24.9	33.6	33.6	45.4	21.2	28.6
76	25.8	33.9	35.0	46.1	21.6	28.4
78	26.7	34.2	36.4	46.7	22.1	28.3
80	27.6	34.5	37.9	47.4	22.5	28.1
82	28.6	34.9				
84	29.5	35.1				
86	30.5	35.5				
88	31.5	35.8				
90	32.6	36.2				
	INCENSE-CEDAR		YOUNG-GROWTH REDWOOD		OLD-GROWTH REDWOOD	
12	9.0	75.0	8.4	70.0		
14	9.2	65.7	8.9	63.6		
16	9.5	59.4	9.4	58.8		
18	9.8	54.4	9.9	55.0		
20	10.0	50.0	10.4	52.0	10.6	53.0
22	10.2	46.4	10.9	49.5	11.4	51.8
24	10.5	43.8	11.4	47.5	12.3	51.2
26	10.8	41.5	11.8	45.4	13.1	50.4
28	11.0	39.3	12.3	43.9	14.0	50.0
30	11.3	37.7	12.8	42.7	14.8	49.3
32	11.5	35.9	13.3	41.6	15.6	48.8
34	11.8	34.7	13.8	40.6	16.5	48.5
36	12.1	33.6	14.3	39.7	17.3	48.1
38	12.4	32.6	14.8	38.9	18.2	47.9
40	12.8	32.0	15.2	38.0	19.0	47.5
42	13.3	31.7	15.7	37.4	19.9	47.4
44	13.7	31.1	16.2	36.8	20.7	47.0
46	14.2	30.9	16.7	36.3	21.5	46.7
48	14.8	30.8	17.2	35.8	22.4	46.7
50	15.4	30.8	17.7	35.4	23.2	46.4
52	16.1	31.0	18.2	35.0	24.1	46.3
54	16.7	31.0	18.6	34.4	24.9	46.1
56	17.4	31.0	19.1	34.1	25.8	46.1
58	18.0	31.0	19.6	33.8	26.6	45.9
60	18.6	31.0	20.1	33.5	27.4	45.7

Table 2.--*Average diameter inside bark, of the top log utilized, by diameter class and species, 1964, continued*

D.b.h. class (inches)	INCENSE-CEDAR		OLD-GROWTH REDWOOD		20-ft. d.o.b. class (inches)	OLD-GROWTH REDWOOD	
	Average utilized top		Average utilized top			Average utilized top	
	D.i.b. (curved)	Proportion of d.b.h.	D.i.b. (curved)	Proportion of d.b.h.		D.i.b. (curved)	Proportion of 20-ft. d.o.b.
	Inches	*Percent*	*Inches*	*Percent*		*Inches*	*Percent*
62	19.2	31.0	28.3	45.6	16	10.1	63.1
64	19.8	31.0	29.1	45.5	18	11.4	63.3
66	20.5	31.0	30.0	45.5	20	12.7	63.5
68	21.1	31.0	30.8	45.3	22	14.0	63.6
70	21.7	31.0	31.7	45.3	24	15.2	63.3
72	22.3	31.0	32.5	45.1	26	16.3	62.7
74	22.9	31.0	33.4	45.1	28	17.5	62.5
76	23.6	31.0	34.2	45.0	30	18.5	61.7
78	24.2	31.0	35.0	44.9	32	19.5	60.9
80	24.8	31.0	35.9	44.9	34	20.4	60.0
82			36.7	44.8	36	21.4	59.4
84			37.6	44.8	38	22.1	58.2
86			38.4	44.7	40	23.0	57.5
88			39.3	44.7	42	23.8	56.7
90			40.1	44.6	44	24.5	55.7
92			40.9	44.5	46	25.2	54.8
94			41.8	44.5	48	26.0	54.2
96			42.6	44.4	50	26.7	53.4
98			43.5	44.4	52	27.4	52.7
100			44.3	44.3	54	28.1	52.0
102			45.2	44.3	56	28.9	51.6
104			46.0	44.2	58	29.6	51.0
106			46.8	44.2	60	30.3	50.5
108			47.7	44.2	62	31.0	50.0
110			48.5	44.1	64	31.8	49.7
112			49.4	44.1	66	32.5	49.2
114			50.2	44.0	68	33.2	48.8
116			51.1	44.1	70	33.8	48.3
118			51.9	44.0	72	34.6	48.1
120			52.7	43.9	74	35.2	47.6
122			53.6	43.9	76	35.9	47.2
124			54.4	43.9	78	36.6	46.9
126			53.3	43.9	80	37.3	46.6
128			56.1	43.8	82	37.9	46.2
130			57.0	43.8	84	38.6	46.0
132			57.8	43.8	86	39.3	45.7
134			58.6	43.7	88	40.0	45.5
136			59.5	43.8	90	40.6	45.1
138			60.3	43.7	92	41.3	44.9
140			61.2	43.7	94	42.0	44.7
142			62.0	43.7	96	42.7	44.5
144			62.9	43.7	98	43.3	44.2
146			63.7	43.6	100	44.0	44.0
148			64.6	43.6	102	44.7	43.8
150			65.4	43.6	104	45.4	43.7
					106	46.1	43.5
					108	46.7	43.2
					110	47.4	43.1
					112	48.1	42.9
					114	48.8	42.8
					116	49.4	42.6
					118	50.1	42.5
					120	50.8	42.3