Hilgardia

A JOURNAL OF AGRICULTURAL SCIENCE PUBLISHED BY
THE CALIFORNIA AGRICULTURAL EXPERIMENT STATION

Volume 62 • Numbers 2,3,4,5 • December 1995

Tree Taper Model Volume Equations

I. Bark Taper Equations for California Conifers
II. Tree Taper Models for Major Commerical California Conifers
III. Tip Length Models for Major Commercial California Conifers
IV. Tree Volume Equations for Major California Conifers

Lee C. Wensel and Craig M. Olson

End of Volume

UNIVERSITY OF CALIFORNIA DIVISION OF AGRICULTURE AND NATURAL RESOURCES

ABSTRACT

Upper-stem tree diameters are usually measured outside the bark with the only bark thickness measurements being made at breast height. The current study presents equations and coefficients for estimating the bark thickness in both the upper stem and at the stumps based upon the bark thickness at breast height, the size of the tree (DBH and total height), and the height to the measurement in question.

The upper-stem model presented is an extension of a previously published general hyperbolic ratio model. The model for bark ratio below breast height, a simple power function, is estimated as well. Both equations contain coefficients that account for the more rapid taper on trees with thicker bark.

The data used for fitting and testing the taper models consisted of measurements on over 3,000 conifer trees measured by members of the Northern California Forest Yield Cooperative and the USDA Forest Service. The data were split into two halves, one half for fitting and the other half for testing. The best upper-stem and below-DBH equations obtained from this analysis are discussed here; the remainder are listed in the Appendix.

THE AUTHORS:

Lee C. Wensel is Professor, Department of Environmental Science Policy and Management, University of California, Berkeley, CA 94720.

Craig M. Olson is Research Associate, Department of Environmental Science Policy and Management, University of California, Berkeley, CA 94720.

Bark Taper Equations for California Conifers[1]

INTRODUCTION

While we are usually interested in the tree diameter inside bark for estimating tree volume, it is usually outside-bark diameters that are observed, often using an optical device to estimate tree diameters at various heights above the ground. This leaves the problem of estimating the bark thickness for each outside-bark diameter measured along the stem. For many of the same conifer species considered here, Khan, Bell, and Berg (1977), Ritchie and Hann (1984), Dolph (1984, 1989), and Larsen and Hann (1985) developed expressions for inside-bark diameter as a function of outside bark diameter. These include linear and nonlinear regressions and ratio models. However, as noted by Assman (1970, p.73), within the same species bark thickness varies "according to site, age, and racial characteristics of the tree." Thus, improvements in the predictions of bark at any height in the tree can be expected with information on the bark thickness at breast height (4.5 feet) of each tree.

We examined alternative models for expressing the relative taper of the bark so that bark thickness observed at breast height can be used to estimate the bark thickness at various points along the stem. The equations considered included hyperbolic ratios by Grosenbaugh (1974) and Brickell (1970), and segmented polynomial models by Maguire and Hann (1990) and Max and Burkhart (1976).[2] This paper presents the best upper-stem and lower-stem (stump) models that resulted from that comparison, while the Appendix lists the models tested.

When measuring standing trees with an optical dendrometer, the usual process is to measure the bark thickness at breast height by either cutting into the stem with an ax or by using a bark gauge at 4.5 feet above the ground. In order to reduce the error in measuring bark thickness, and since bark thickness varies around the stem, typically two such measurements are taken at right angles to each other and added to estimate the double bark thickness at breast height, DBTBH. Bark taper models can then be used to express the reduction in bark thickness as one goes from breast height to the tip or to the stump of the tree. Thus, the measurement of bark thickness at breast height "localizes" the predictions of bark thickness at other points.

The conifer species considered include the following:

Code	Species
PP	ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.)
SP	sugar pine (*P. lambertiana* Dougl.)
DF	Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco)
WF	white fir (*Abies concolor* [Gord. & Glend.] Lindl. ex Hildebr.)
RF	red fir (*A. magnifica* A. Murr.)
IC	incense-cedar (*Calocedrus decurrens* [Torr.] Florin)

[1]Accepted for publication May 30, 1995.

[2]See also earlier work by Fuller (1969), Gallant and Fuller (1973), and Gallant (1974).

EQUATIONS

In this study, available bark thickness models were evaluated for their ability to predict the bark taper from felled tree data collected in five different studies of stem taper in California conifers (see "Data" below). The upper-stem (above breast height) and lower-stem (below breast height) bark taper equations evaluated are listed in Appendix tables A1 and A2. Coefficients and fit statistics for each data set are given in Appendix tables A3 to A6. Only the best model (model 6) is presented here. Each equation is formulated to predict the relative bark thickness and the variables used include the following:

DBH	diameter outside bark at breast height (4.5 feet)
DBT	double bark thickness at height h
DBTBH	double bark thickness at breast height
DIB	diameter inside bark at height h
DOB	diameter outside bark at height h
h	height to measurement
THT	total height of tree

Also, the following ratios are used:

RB	relative bark thickness, $\frac{DBT}{DBTBH}$
$\widehat{RB}$	predicted relative bark thickness, RB
RD	relative diameter, $\frac{DOB}{DBH}$

We assume that the bark thickness at breast height can be measured.

For the upper stem, the equation

$$\widehat{RB}_u = RD\left(\frac{b_1 - 1}{b_1 - RD^{b_2}}\right) - \left(\frac{RD^{b_3} - 1}{DBTBH}\right) \qquad (1)$$

for the variables defined above and the coefficients b_1, b_2, and b_3 were estimated for each species. However, to make equation (1) monotonic, it must be bounded. Thus, we have the conditional function RB'_u as follows

RB'_u is equal to $\widehat{RB}_{min}$ if $RD < \widehat{RD}_{min}$ or equal to $\widehat{RB}_u$ if $RD \geq \widehat{RD}_{min}$

where $\widehat{RD}_{min}$ = diameter ratio at which the minimum bark ratio ($\widehat{RB}_{min}$) occurs. The relationship between these minimum values and DBTBH is estimated by

$$\widehat{RD}_{min} = \frac{1}{a * DBTBH} \qquad (2)$$

where $\widehat{RD}_{min}$ is the estimated minimum relative diameter for each species as a function of DBTBH and the coefficient a is computed for each species.

For predicting bark ratios below breast height the equation used is

$$RB_s = 1 + c_1\left(\frac{DOB}{DBH} - 1\right)^{(c_2 + c_3\, DBTBH)} \qquad (3)$$

where c_1, c_2, and c_3 are coefficients estimated for each species. In other models tested, we observed that the models tended to underestimate the bark ratio in the tips for larger values of DBTBH. Thus, in both equations (1) and (3) the DBTBH component of the equation is designed to eliminate this observed bias.

DATA SOURCES

The bark taper data used here are taken from five separate sources where bark measurements along the tree stem were made as part of separate studies on tree taper or utilization. Each of these data sources is described briefly here and the number of trees in each data set is shown by species in Table 1.

TABLE 1. NUMBER OF TREES BY SPECIES AND DATA SETS

Species & Data Set	Trees
	no.
Ponderosa pine	
COOP	197
DOLPH	141
MILL	177
ALL	515
Sugar pine	
COOP	65
DOLPH	62
MILL	54
ALL	181
Douglas-fir	
COOP	186
DOLPH	44
ALL	230
White fir	
COOP	352
DOLPH	313
MILL	161
FIR STUDY	76
ALL	902
Red fir	
COOP	36
MILL	148
FIR STUDY	562
REGION 6	273
ALL	1019
Incense-cedar	
COOP	81
DOLPH	189
MILL	54
ALL	324

The "Coop" bark data set comes from a stem analysis data set developed by members of the Northern California Forest Yield Cooperative. Formed in 1978, this cooperative research group links the research staff at the University of California with various private forestry companies and public agencies to produce growth-prediction models for California conifers. A previous study (Biging 1984) used the inside-bark tree diameters to develop stem-taper equations for California conifers. Measurements on these same trees were also used for initial growth models for CACTOS, the California Conifer Timber Output Simulator (Wensel, Meerschaert, and Biging, 1987). The data came from industry forest lands in the north and central Sierra Nevada, the southern Cascades, the Shasta-Trinity mountains, and the Mendocino region in California.

The "Dolph" data set comes from a study of conifer trees in California's Sierra Nevada and was collected for the purpose of developing a California PROGNOSIS variant (Dolph 1984 and 1989). The "Fir Study" data set was contributed to this study by Bill Oliver (USFS, Redding) and was the basis for his growth studies on thinned true fir stands. "Region 6" refers to USDA Forest Service data from southern Oregon. These data were collected from sample trees in southern Oregon to adjust the regional gross volume inventory estimates for local utilization.

The "Mill Study" data set comes from a series of utilization studies conducted in California by the USDA Forest Service Pacific Northwest Forest Experiment Station. Sample trees were felled and scaled in the field, scaled again in the mill before being sent through the mill for conversion. Product recovery research results have been published by Ernst and Pong (1985), Pong (1982), and Pong and Cahill (1988) where these data are described in more detail.

The data were received from the various contributors and cooperators and stored in a common data base. The data were then retrieved from this data base using a screening process that eliminated trees and/or observations that were obviously in error or would result from forked, broken, or grossly malformed trees. Since field data sheets for most of the data were not readily available, there were no further changes made to the edited data. The mean, minimum, and maximum tree DBH and total height by species are given in Table 2.

TABLE 2. NUMBER OF TREES, MEAN, MINIMUM, AND MAXIMUM DIAMETER AT BREAST HEIGHT AND TOTAL HEIGHT USED TO FIT BARK TAPER MODELS BY SPECIES

		Diameter			Height		
Species	Trees	Mean	Min	Max	Mean	Min	Max
	no.		inches			feet	
Ponderosa pine	515	21.1	5.5	60.2	100.7	18.0	202.0
Sugar pine	181	24.1	3.5	62.5	94.8	9.0	204.0
Douglas-fir	230	15.4	5.5	31.2	86.7	25.5	150.6
White fir	902	17.6	5.5	62.9	80.2	18.6	204.0
Red fir	1019	20.9	3.0	57.4	85.6	10.7	195.0
Incense-cedar	324	13.8	3.4	50.8	49.5	7.4	155.0

RESULTS AND DISCUSSION

The SAS nonlinear fitting procedure, NLIN, was used with the Marquardt option (SAS Institute, 1985). Both the upper-stem and lower-stem (stump) equations were fitted to each of the six major conifer species considered. Table 3 gives the coefficients for the upper stem equations 1 and 2; Table 4 gives the coefficients for the stump, equation (3). Coefficients for other models tested appear in Appendix tables A3 and A4 with fit statistics for all models and data sets in Appendix tables A5 and A6. Equation (3) gave the smallest residual sums of squares for the testing half of all data sets.

The adjusted hyperbola used for the upper stem, using equations (1) and (2), is illustrated for Douglas-fir in Figure 1 for various bark thicknesses at breast height. The power function for the stump bark ratio, using equation (3), is illustrated for Douglas-fir in Figure 2. The addition of an exponent as a function of DBTBH in equation (3) reduced the overall correlation of predicted with residual relative bark ratios.

Our extensive look at conifer bark taper has resulted in the recommendation of the two new models for bark taper presented here. For upper stems the adjusted hyperbolic equation, equitation (1), is recommended; and for stump bark taper, the power equation (3) is recommended. Both represent distinct improvements in the way bark taper estimates have been handled by other models tested (see Appendix). However, these bark taper models only apply to trees with undamaged bark that have bark thickness decreasing from breast height to the tip and bark thickness increasing from breast height down to the stump. Trees that show damage due to fire and/or logging may not follow this pattern.

TABLE 3. COEFFICIENTS FOR UPPER STEM EQUATION (1) AND MINIMUM DIAMETER RATIO EQUATION (2)

	Equation (1)			Equation (2)
Species	b_1	b_2r	b_3	a
Ponderosa pine	2.8532	6.188	.150480	7.787
Sugar pine	4.9396	443.812	.098117	12.503
Douglas-fir	2.8350	13.625	.055268	15.078
White fir	2.6718	5.821	.090351	10.098
Red fir	6.1661	52.944	.095993	13.388
Incense-cedar	3.6087	9.350	.060086	15.883

TABLE 4. COEFFICIENTS CALCULATED FOR STUMP BARK RATION EQUATION (3)

Species	c_1	c_2	c_3
Ponderosa pine	1.73416	0.0*	0.475413
Sugar pine	1.0*	0.0*	0.678624
Douglas-fir	1.0*	0.0*	0.397823
White fir	1.0*	0.0*	0.555289
Red fir	0.880132	0.260076	0.225097
Incense-cedar	1.87591	0.559340	0.171258

*Fixed.

LITERATURE CITED

ASSMAN, E.
1970. The principles of forest yield study: studies in the organic production, structure, increment and yield of forest stands.

BIGING, G. S.
1984. Taper equations for second-growth mixed conifers of northern California. Forest Science 30 (4): 1103-17.

BRICKELL, J. E.
1970. Test of equations for predicting bark thickness of western Montana species, Research Note INT-107, USDA Forest Service, Intermountain Forest and Range Expt. Sta., Ogden, Utah.

DOLPH, K. L.
1984. Relationships of inside and outside bark diameters for young-growth mixed-conifer species in the Sierra Nevada. USDA Forest Service Research Note PSW-368.
1989. Nonlinear equations for predicting diameter inside bark at breast height for young-growth Red Fir in California and southern Oregon. USDA Forest Service Research Note PSW-409.

ERNST, S., and W. Y. PONG
1985. Lumber recovery from ponderosa pine in northern California. USDA Forest Service Research Paper PNW-333, Portland, Oregon.

FULLER, W. A.
1969. Grafted polynomials as approximating functions. Austr. J. Ag. Econ. 13: 35-46.

GALLANT, A. R.
1974. The theory of nonlinear regression as it relates to segmented polynomial regressions with estimated join points. Institute of Statistics Mimeograph Series No. 925, p. 25.

GALLANT, A. R., and W. A. FULLER
1973. Fitting segmented polynomial regression models whose join points have to be estimated. JASA 68: 144-47.

GROSENBAUGH, L. R.
1974. Tree content and value estimation using various sample designs, dendrometry methods, and V-S-L conversion coefficients. USDA Forest Service Research Paper SE-117.

KHAN, F. M., J. F. BELL, and A. B. BERG
1977. Estimating diameter inside bark at various heights in young Douglas-fir trees. Oregon State University Forest Research Lab Note 59.

KOZAK, A., D. D. MUNRO, and J. H. G. SMITH
1969. Taper functions and their application in forest inventory. For. Chron. 45(4): 278-83.

LARSEN, D. R., and D. W. HANN
1985. Equations for predicting diameter and squared diameter inside bark at breast height for six major conifers of Southwest Oregon. Oregon State University Forest Research Lab Note 77.

MAGUIRE, D. A., and D. W. HANN
1990. Bark thickness and bark volume in southwestern Oregon Douglas-fir. West. J. Appl. For. 5(1): 5-8.

MAX, T. A., and H. E. BURKHART
1976. Segmented polynomial regression applied to taper equations. For. Sci. 22(3): 283-89.

PONG, W. Y.
1982. Lumber recovery from young-growth red and white fir in northern California, Research Paper PNW-300, USDA Forest Service, Portland, Oregon.

PONG, W. Y., J. M. CAHIL
1988. Lumber recovery from incense cedar in central California. Research Paper PNW-393, USDA Forest Service, Portland, Oregon.

RITCHIE, M. W., and D. W. HANN
1984. Nonlinear equations for predicting diameter and squared diameter inside bark at breast height for Douglas-fir. Oregon State University Forest Research Lab Paper 47.

SAS INSTITUTE INC.
1985. SAS user's guide: statistics. Version 5.

WENSEL, L. C., W. J. MEERSCHAERT, and G. S. BIGING
1987. Tree height and diameter growth models for northern California conifers. University of California Agricultural Experiment Station. Hilgardia 55 (8). 20 pp.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the assistance of Ralph Warbington, Kevin Casey, Charles Stadelman, and LeRoy Dolph of the U.S. Forest Service in helping to accumulate the data sets used for this study and to Al Stangenberger, Kip Freytag, and Frieder Schurr for help in preparing the data for analysis. The current study is a cooperative effort between the University of California, the USDA Forest Service – Region 5 and Pacific Southwest Research Station, the California Department of Forestry and Fire Protection, Michigan-California Lumber Company, and Crane Mills.

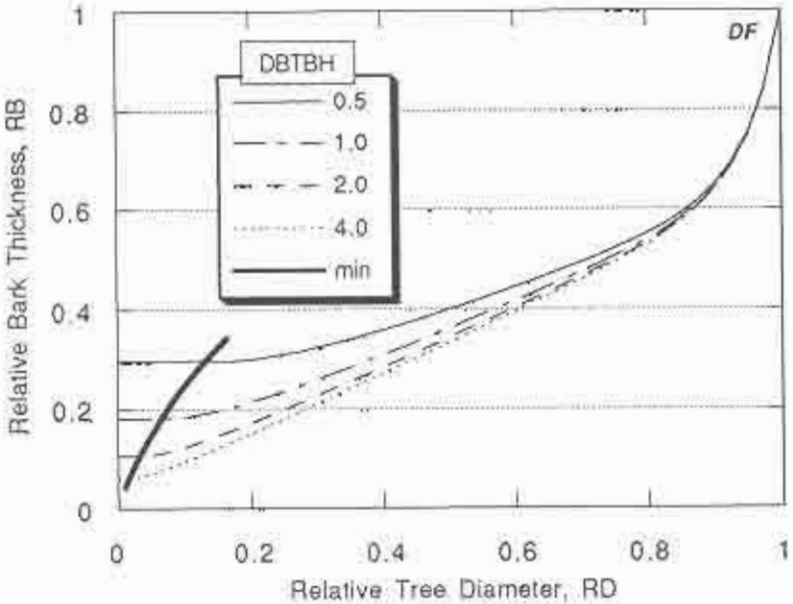

Fig. 1. Relative bark thickness for DBTBH = 0.5, 1.0, 2.0, and 4.0 as a function of relative diameter using equation (1) and minimum of each function from equations (2) and (1)—Douglas-fir.

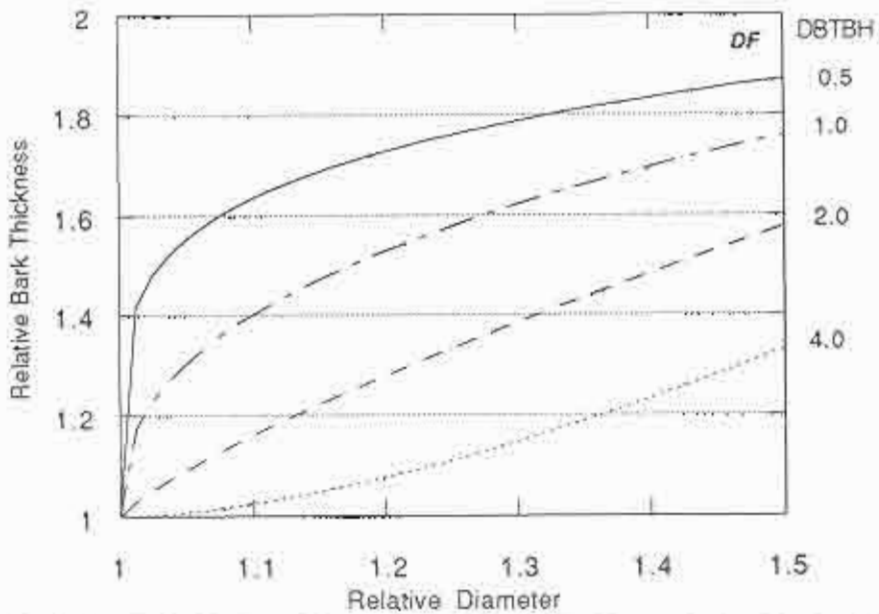

Fig. 2. Relative bark thickness below 4.5 feet for DBTBH = 0.5, 1.0, 2.0, and 4.0 as a function of relative tree diameter—Douglas-fir.

APPENDIX TABLE A1. HYPERBOLIC BARK TAPER EQUATIONS EVALUATED, WHERE Y IS THE PREDICTED BARK RATIO $\frac{DBT}{DBTBH}$.

Double bark thickness is then predicted by multiplying by DBTBH. Variable definitions are given in text.

No. 1 Hyperbolic ratio (Grosenbaugh 1974, option 2)

$$Y_1 = \left(\frac{DOB}{DBH}\right)\left(\frac{1}{2 - \frac{DOB}{DBH}}\right)$$

No. 2 No. 1 with coefficient fitted to data (Bricknell 1970, option 1)

$$Y_2 = \left(\frac{DOB}{DBH}\right)\left(\frac{b_2 - 1}{b_2 - \left(\frac{DOB}{DBH}\right)}\right)$$

No. 3 Brickell option 3

$$Y_3 = \left(\frac{DOB}{DBH}\right)^{b_1}\left(\frac{b_2 - 1}{b_2 - \left(\frac{DOB}{DBH}\right)^{b_3}}\right)^{b_4}$$

No. 4 Brickell option 4

$$Y_4 = \left(\frac{DOB}{DBH}\right)^{b_1}\left(\frac{b_2 - 1}{b_2 - \left(\frac{DOB}{DBH}\right)}\right)$$

No. 5 Variant between Brickell's options 3 and 4

$$Y_5 = \left(\frac{DOB}{DBH}\right)^{b_1}\left(\frac{b_2 - 1}{b_2 - \left(\frac{DOB}{DBH}\right)}\right)^{b_4}$$

No. 6 Adjusted hyperbolic ratio (text equation 1)

$$Y_6 = \left(\frac{DOB}{DBH}\right)\left(\frac{b_2 - 1}{b_2 - \left(\frac{DOB}{DBH}\right)b_3}\right) - \left(\frac{\left(\frac{DOB}{DBH}\right)^{b_5} - 1}{DBTBH}\right)$$

for DOB > D_{min} and $Y_6 = F_{min}$ otherwise where D_{min} and F_{min} denote the coordinates of the minimum of the above function.

APPENDIX TABLE A2. SEGMENTED POLYNOMIAL BARK TAPER EQUATIONS EVALUATED, WHERE Y IS THE PREDICTED BARK RATIO $\frac{DBT}{DBTBH}$.

Double bark thickness is then predicted by multiplying by DBTBH. Variable definitions are given in text.

No. 7 Localized two-segmented polynomial on relative height (Maguire and Hann 1990). Let $X = \frac{HT}{THT}$ and

$$a_1 = b_1 + b_2\left(\frac{THT}{DBH}\right) + b_3\left(\frac{THT}{DBH}\right)^2$$

then

$$Y_7 = 1 + z_1 + a_1 z_2 + a_2 z_3$$

for

$$z_1 = \left\{\frac{(X-1)}{k-1}\left[1 + \frac{(k-X)}{k-1}\right] - 1\right\}$$

$$z_2 = X + I\left\{\frac{(X-1)}{k-1}\left[X + \frac{k(k-X)}{k-1}\right] - X\right\}$$

$$z_3 = X^2 + I\left\{\frac{k(X-1)}{k-1}\left[2X - k + \frac{k(k-X)}{k-1}\right] - X^2\right\}$$

with $k = 0.3$ and $I = 1$ for X^3 k and zero otherwise. The coefficient a_2, b_1, and b_3 to be estimated.

No. 8 Localized two-segmented polynomial on relative diameter model as above but with $X = 1 - \frac{DOB}{DBH}$.

No. 9 Two-segmented polynomial on relative diameter (Max and Burkhart 1976).

where $X = 1 - \frac{DOB}{DBH}$, I_1 for X^2 a_1 (zero otherwise), and a_1, b_1, b_2 and b_3 are coefficients to be estimated.

No. 10 Three-segmented polynomial on relative diameter (Max and Burkhart 1976).

$$Y_{10} = Y_9 + b_4(a_2 - X)^2 I_2$$

where Y_9 is defined above, $I_2 = 1$ for X^2 a_2 (zero otherwise) and a_2 and b_4 are additional coefficients.

APPENDIX TABLE A3. COEFFICIENTS CALCULATED FROM THE "FIT" HALF OF THE DATA FOR HYPERBOLIC MODELS

Species	Model #	b_1	b_2	b_3	b_4	b_5
Ponderosa pine	2		2.05347*			
	3	.172435*	1.00677*	.029665*	.649123*	
	4	.095474	1.31635			
	5	.349935	1.09045		.388315	
	6		2.85323	6.18840		.150480
Sugar pine	2		3.35449			
	3	–.021007*	1.01705*	.031161*	1.10561*	
	4	.219662	1.46440			
	5	.679999	60.7655*		43.2687*	
	6		4.93961	443.812*		.098117
Douglas fir	2		1.65893			
	3	.721122	8.01472*	11.3072*	3.89232*	
	4	.193696	1.27256			
	5	.614854	1.00847		.150581	
	6		2.83504	13.6250		.055268
White fir	2		1.79431			
	3	.186981*	.989607*	–.062291*	.572898*	
	4	.077587	1.28022			
	5	.250571	1.14080		.575405	
	6		2.67181	5.82073		.090351
Red fir	2		3.46315			
	3	.256430	.944620	–.450786	.313750	
	4	.177066	1.48455			
	5	.641516	42.6754*		31.7995*	
	6		8.16610	52.9442		.095993
Incense-cedar	2		2.43416			
	3	.200062*	.996129*	–.012814*	.715154*	
	4	.381861	1.46319			
	5	.751977	1.00961		.105277	
	6		3.60876	9.34989		.060086

The * above implies that the fitted coefficient is not statistically significant; for b_2, it is not significantly different from 2 and, for the others, they are not different from 1.

APPENDIX TABLE A4. COEFFICIENTS CALCULATED FOR THE "FIT" HALF OF EACH DATA SET FOR THE SEGMENTED POLYNOMIAL MODELS

Species	Model #	a_1	a_2	a_3	a_4	b_1	b_2	b_3	b_4
Ponderosa pine	7	-2.83552	-.205678	.017598	5.91209				
	8	-2.68503	-.133710	.011663	4.50627				
	9	.352847				.173569*	-.649957	4.10060	
	10	.174750	.921401			49.8555*	-27.2028*	7.66930	27.5576*
Sugar pine	7	-2.68484	-.185314	.015244	5.56146				
	8	-2.39568	-.080486	.006466	3.75759				
	9	.235572				-.164997	-.501945	5.78076	
	10	.039684	.938852			73.5727*	-39.4965*	115.620*	39.5929*
Douglas-fir	7	-4.34707	.249995	-.012264	5.48281				
	8	-3.94069	.085076	-.002958	5.56035				
	9	.215982				-.155540	-.396021	9.47537	
	10	.185933	.948954			38.3031	-20.5246	10.8073	20.4324
White fir	7	-3.11532	-.077110	.010508	5.30685				
	8	-2.81758	-.143934	.011142	4.85128				
	9	.386240				.387050	-.757016	4.13236	
	10	.226295	.923448			52.2488	-28.4194	5.21484	28.7965
Red fir	7	-2.07456	-.140579	.009701	4.23880				
	8	-1.73861	-.222968	.015331	3.34266				
	9	.206937				-.298995	-.433534	6.05364	
	10	.124518	.941632			35.9460	-30.0884	11.7623	30.0820
Incense-cedar	7	-3.42176	-.163537	.024326	6.03113				
	8	-1.96023	-.293174	.027806	3.47811				
	9	.242376				-.451194	-.235204	5.24302	
	10	.214742	.968996			87.0817	-45.3019	5.56182	45.2831

The * above implies that the fitted coefficient is not statistically different from 1

APPENDIX TABLE A5. RESIDUAL SUM OF SQUARES (RSS) FOR TEST HALF OF DATA SETS FOR THE HYPERBOLIC BARK MODELS BY SPECIES AND DATA SETS

		Hyperbolic Models					
Species & Dataset	No. of Obs.	Model # 1	Model # 2	Model # 3	Model # 4	Model # 5	Model # 6
Ponderosa pine							
COOP	1232	42.40	42.10	33.30	33.80	33.30	29.70
DOLPH	836	8.47	8.56	5.54	5.40	5.54	5.05
MILL	673	17.37	17.52	13.91	14.08	13.92	13.07
ALL	2741	68.30	68.22	52.75	53.27	52.73	47.86
Sugar pine							
COOP	424	18.41	14.81	12.53	12.49	13.27	11.02
DOLPH	351	2.53	4.12	2.56	2.73	4.59	3.00
MILL	242	9.89	8.55	7.55	7.65	8.27	6.40
ALL	1017	30.83	27.49	22.64	22.87	26.13	20.95
Douglas-fir							
COOP	1164	27.30	26.50	18.90	20.70	18.90	17.60
DOLPH	237	3.32	2.65	1.47	1.43	1.48	1.41
ALL	1401	30.70	29.14	20.37	22.16	20.41	19.04
White fir							
COOP	2048	64.10	66.20	49.60	50.29	49.60	45.40
DOLPH	1988	24.90	21.90	15.50	15.22	15.50	15.40
MILL	514	11.69	11.34	9.87	9.88	9.87	10.26
FIR STUDY	441	6.70	6.05	4.12	4.12	4.11	3.88
ALL	4991	107.40	105.48	79.09	79.51	79.08	74.91
Red fir							
COOP	178	5.53	4.64	3.34	3.63	4.07	3.23
MILL	452	12.80	9.90	9.10	9.20	9.70	9.15
FIR STUDY	3607	68.80	64.00	44.00	46.80	60.60	42.50
REGION 6	1367	43.80	31.70	29.40	30.40	29.60	30.51
ALL	5604	130.60	110.35	85.84	90.03	104.04	85.38
Incense-cedar							
COOP	355	6.65	6.14	5.66	5.78	5.66	5.26
DOLPH	844	7.89	8.48	6.03	6.16	6.03	4.91
MILL	114	6.78	5.79	5.41	5.69	5.42	5.72
ALL	1313	21.32	20.41	17.10	17.61	17.11	15.89

APPENDIX TABLE A6. RESIDUAL SUM OF SQUARES (RSS) FOR TEST HALF OF DATA SETS FOR THE SEGMENTED POLYNOMIAL BARK MODELS BY SPECIES AND DATA SET

(The hyperbolic model #6 is included for comparison.)

Species & Dataset	Observations (no.)	*Model # 6*	Model # 7	Model # 8	Model # 9	Model # 10
Ponderosa pine						
COOP	1232	*29.70*	38.30	34.70	34.70	33.10
DOLPH	836	*5.05*	11.44	5.61	5.60	5.63
MILL	673	*13.07*	17.78	14.10	14.31	13.88
ALL	2741	*47.86*	67.50	54.40	54.63	52.61
Sugar pine						
COOP	424	*11.02*	14.46	12.90	12.77	11.87
DOLPH	351	*3.00*	6.92	2.88	2.93	3.73
MILL	242	*6.40*	7.48	7.11	7.14	7.07
ALL	1017	*20.95*	28.87	22.88	22.84	22.46
Douglas-fir						
COOP	1164	*17.60*	19.40	19.40	19.30	19.10
DOLPH	237	*1.41*	3.36	1.39	1.45	1.38
ALL	1401	*19.04*	22.75	20.75	20.76	20.48
White fir						
COOP	2048	*45.40*	59.20	52.40	52.00	49.80
DOLPH	1968	*15.40*	27.30	16.20	15.90	15.60
MILL	514	*10.26*	11.55	9.37	9.89	9.83
FIR STUDY	441	*3.88*	4.66	4.19	4.20	4.12
ALL	4991	*74.91*	102.70	82.07	81.99	79.29
Red fir						
COOP	178	*3.23*	3.96	3.57	3.49	3.30
MILL	452	*9.15*	9.72	9.10	9.20	9.10
FIR STUDY	3607	*42.50*	48.99	44.60	45.60	44.50
REGION 6	1367	*30.51*	37.07	28.28	29.30	29.20
ALL	5604	*85.38*	99.76	85.56	87.59	86.07
Incense-cedar						
COOP	355	*5.26*	6.99	5.83	5.70	5.64
DOLPH	844	*4.91*	12.93	5.75	6.10	6.06
MILL	114	*5.72*	6.17	4.94	5.33	5.35
ALL	1313	*15.89*	26.10	16.51	17.13	17.05

Hilgardia

A JOURNAL OF AGRICULTURAL SCIENCE PUBLISHED BY THE CALIFORNIA AGRICULTURAL EXPERIMENT STATION

Volume 62 • Number 3 • December 1995

Tree Taper Models for Major Commercial California Conifers

Lee C. Wensel and Craig M. Olson

UNIVERSITY OF CALIFORNIA DIVISION OF AGRICULTURE AND NATURAL RESOURCES

ABSTRACT

Equations are developed for eight conifer species to estimate the stem taper of inside-bark diameters from breast height to the tip of the tree. Separate equations are developed to estimate the diameter inside bark at the stump. Equations are fitted and tested on separate halves of a data set composed of tree taper data from previous studies, both from the forest industry and USDA Forest Service surveys. This composite data set extends from Southern California to the National Forests of southern Oregon.

After an extensive examination of existing taper equations, two taper equations were selected for further analysis, one by Biging and the other by Wensel and Krumland. Coefficients for both equations are given for the eight conifer species examined. Because of a lower residual sum of squares, and a lack of correlation of the residual with the available predictors, the Wensel and Krumland equation is recommended for use.

THE AUTHORS:

Lee C. Wensel is Professor, Department of Environmental Science Policy and Management, University of California, Berkeley, CA 94720.

Craig M. Olson is Research Associate, Department of Environmental Science Policy and Management, University of California, Berkeley, CA 94720.

Tree Taper Models for Major Commercial California Conifers[1]

INTRODUCTION

THE VOLUME OF standing trees must be estimated from measurements on these trees for general forest land planning (harvest scheduling) and for appraisal. Particularly for appraisal purposes, volumes must be estimated by log quality (grade) classes with appropriate deductions for defect. Whether one estimates volume in cubic or board foot scale, a flexible volume estimation process is made possible by use of tree taper equations—equations that predict the diameter inside-bark of a tree at any height. Given these estimated diameters, either board foot or cubic foot volumes can be computed for any section. This process of tree volume determination is beginning to replace the scaling of felled trees for U.S. Forest Service and private timber sales requiring a new look at the procedures used for such estimates.

The USDA Forest Service—Region 5 (California) has been using tree taper equations developed by Stadelman (1986) for this purpose while industry members of the California Forest Research Association have been using equations by Biging (1984) that have been incorporated in CACTOS, the California Conifer Timber Output Simulator (Wensel, Daugherty, and Meerschaert, 1986). These equations have different forms and they produce different predictions. While there is a "wealth" of tree taper data available from various sources, existing taper models were fit to only a small subset of the data presented in this paper.

Our original objective was to test these two taper models as well as other local equations for estimating tree taper and, if necessary, develop recommendations for both the best model form to use and the coefficients to use in each region within the state. It was our expectation that we would likely find local differences in which a model performed best and there would be local differences in coefficients due to measurement methods, elevation, site index, stand density, and other factors. Thus, the analysis of the various models was designed to test for such differences. A recommended model form is presented along with a discussion of attempts to localize the predictions.

Species considered are Douglas-fir (DF), *Pseudotsuga menziesii* (Mirb.) Franco; ponderosa pine (PP), *Pinus ponderosa* Dougl. ex Laws.; Jeffrey pine (JP), *P. jeffreyi* Grev. & Balf.; lodgepole pine (LP), *P. contorta* Dougl. ex Loud.; sugar pine (SP), *P. lambertiana* Dougl.; white fir (WF), *Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.; red fir (RF), *A. magnifica* A. Murr.; and incense-cedar (IC) *Calocedrus decurrens* (Torr.) Florin.

DATA SOURCES

Taper data for this study came from previous studies at the University of California, Berkeley, and from other researchers in California and Oregon. These

[1]Accepted for publication May 30, 1995.

data are of two types, either from stem analysis of felled trees or from optical measurements on standing trees with an optical dendrometer. In pooling the data for taper analysis, the origin of the data elements was preserved so we could look for differences in the performance of the various models to the individual data sets. The numbers of trees in the data set for each species by DBH size class are shown in Table 1.

TABLE 1. NUMBER OF TREES BY SPECIES AND DBH SIZE CLASSES

DBH Class	Species							
	DF	PP	SP	JP	LP	WF	RF	IC
(inches)	*no. of trees*							
5–10	203	316	69	36	52	373	92	161
10–20	1196	1890	486	308	434	2854	817	528
20–30	1032	1725	594	600	96	2460	576	493
30–40	450	712	385	1017	27	888	285	318
40–50	246	267	163	536	3	207	112	164
50 +	158	111	84	92		71	49	73

These data sets are described briefly as follows:[2]

BULLETIN 1883. These data were collected in 1976 from 598 standing trees using optical dendrometers. The data set is made up of data collected from lands then managed by American Forest Products, Southern Pacific Land Company, the Plumas National Forest, and the Stanislaus National Forest. The data were used to develop volume tables for young-growth conifers (Wensel 1977).

COOP. The Coop data come from a stem analysis study of 1044 trees by the members of the Northern California Forest Yield Cooperative on industry forest lands in the Sierra, Southern Cascade, Shasta-Trinity, and Mendocino regions of California. This Coop research group, formed in 1978 to produce growth-prediction models for California conifers, includes the University of California, Berkeley; private industry; and public forestry agencies. The inside-bark measurements in these data were used for the initial growth models for CACTOS (Wensel, Meerschaert, and Biging, 1987) and to produce stem taper models (Biging 1984).

DOLPH. Stem analysis measurements of 1486 trees, described by Dolph (1988 and 1989), were used for tree taper and growth studies in California's Sierra Nevada.

LEVITAN. Optical dendrometer measurements on 98 incense-cedar trees from the Klamath, Lassen, and Mendicino National Forests were collected by Jack Levitan in 1990.

LINDQUIST. Optical dendrometer measurements from 851 Douglas-fir trees were received from James Lindquist. The data were collected in northern California National Forests.

MICH-CAL. These data were collected by scaling 5464 felled trees and were used by the Michigan-California Lumber Company to compute new coefficients for the taper and volume equations developed by Biging (1984).

[2]The numbers of trees for each data set refer only to the number of trees used in the current study.

MILL STUDY. Stem taper data for 1735 trees came from a series of utilization studies conducted in California by the USFS PNW Research Station. Trees were felled and scaled in the field, then scaled again in the mill before being sent through the mill for conversion. The primary purpose of the collection was for lumber recovery to make adjustments in the timber sale appraisal process and get the highest value. Product recovery research results, where these data are described in more detail, have been published by Ernst and Pong (1985), Pong (1982), and Pong and Cahill (1988).

OLIVER. These data were received from Bill Oliver, USDA Forest Service. They were collected with an optical dendrometer from 589 trees located on National Forest lands of northern California to determine the growth responses to silviculture treatments (Oliver 1988).

TARIF. The TARIF data were collected from 1685 trees as a cooperative effort prior to the forming of the Northern California Forest Yield Cooperative. The data were collected from standing trees using optical dendrometers for the purpose of developing an "access table" for a Northern California TARIF system. Biging (1981) examined these data for a previous version of his taper equation.

USDA Forest Service—Region 5. These data were collected from 8763 sample trees located on 15 National Forests in California, with most of the data coming from the northern forests. Measurements were made using optical dendrometers for various regional studies and aggregated by Charles Stadelman, USDA Forest Service, San Francisco.[3]

USDA Forest Service—Region 6. The stem taper data come from felled-tree measurements from 1490 trees randomly chosen from clearcut operations in nine National Forests in southern Oregon. The purpose of the data collection was to adjust regional gross volume estimates for inventory to reflect local utilization. The data were received with the cooperation of Ralph Johnson, John Teply, and Susan Willits, USDA Forest Service.

TAPER EQUATIONS CONSIDERED

We examined the performance of existing tree taper models with their published coefficients for west coast conifers. Separate models were used for above versus below breast height diameters. Only the model forms for the recommended equations are given here.

Predictions Above Breast Height

The 9 upper stem taper models considered are shown in Table 2. These include models by Amidon (1984), Biging (1984), Kozak, Munroe, and Smith (1969), Kozak (1988), Max and Burkhart (1976),[4] McTague and Stansfield (1988), Stadelman (1986), Walters and Hann (1986), and Wensel and Krumland (1983). The range of model forms shown in Table 2, all for the purpose of predicting diameter inside bark at various heights, suggests that there is more than one way to do this. Each of the models was examined here. However, the Amidon and Kozak

[3]The data received from Stadelman were edited by the authors to remove duplicate data from related computer files.

[4]Coefficients for the Max and Burkhart model were fit by Biging (1984).

models were dropped from consideration early in the analysis. The Amidon model was discovered to have unreconcilable formulation problems; the Kozak (1988) model required the height to the inflection point at the base of the live crown, this information was not available for the sample trees.

TABLE 2. UPPER STEM TAPER EQUATIONS EVALUATED

Symbol

dib	diameter inside bark in inches at height HT
dibbh	diameter inside bark in inches at breast height (4.5 feet)
DBH	diameter outside bark in inches at breast height (4.5 feet)
HI	height to the inflection point from the ground
HT	height in feet
THT	total height in feet

various lower case letters and α are coefficients

Amidon (1984)

$$\text{dib} = b_1 \text{DBH}\left(\frac{\text{THT}-\text{HT}}{\text{THT}-\text{bh}}\right) + b_2 \frac{\left(\text{THT}^2-\text{HT}^2\right)\left(\text{HT}-\text{bh}\right)}{\text{THT}^2} \tag{1}$$

where bh is breast height (1.37 meters)

Biging (1984)

$$\text{dib} = \text{DBH}\left\{b_1 + b_2 \ln\left[1-\lambda\left(\frac{\text{HT}}{\text{THT}}\right)^m\right]\right\} \tag{2}$$

where $\lambda = 1-\exp\left(\frac{-b_1}{b_2}\right)$ and $m = \frac{1}{3}$

Kozak, et al. (1969)

$$\text{dib} = \sqrt{\text{DBH}\left(b_1\frac{\left(\text{HT}-\text{THT}\right)}{\text{THT}} + b_2\frac{\left(\text{HT}^2-\text{THT}^2\right)}{\text{THT}^2}\right)} \tag{3}$$

Kozak (1988)

$$\text{dib} = \left(a_0 \text{DBH}^{a_1} a_2^{\text{DBH}}\right)\left(X^{b_1 Z^2 + b_2 \ln\left(Z+0.0001\right) + b_3\sqrt{Z} + b_4 e^Z + b_5\left(\frac{\text{DBH}}{\text{THT}}\right)}\right) \tag{4}$$

where $X = \left(\frac{1-\sqrt{\frac{\text{HT}}{\text{THT}}}}{1-\sqrt{p}}\right)$; $p = \left(\frac{\text{HI}}{\text{THT}}\right)*100$; $Z = \frac{\text{HT}}{\text{THT}}$

(continued on page 5)

TABLE 2 (CONTINUED). UPPER STEM TAPER EQUATIONS EVALUATED

Max and Burkhart (1976)

$$\text{dib} = \text{DBH}\sqrt{b_1\left(R-1\right) + b_2\left(R^2-1\right) + b_3\left(a_1-R\right)^2 I_1 + b_4\left(a_2-R\right)^2 I_2} \tag{5}$$

where $R = \frac{\text{HT}}{\text{THT}}$, $I_i = 1$ for $R \le a_i$, else $I_i = 0$ for $R > a_i$, and $i = 1,2$

McTague and Stansfield (1988)

$$\text{dib} = \frac{b_0\left(\text{THT}-\text{HT}\right)^{b_1}\text{DBH}^{b_2}F^{b_3}}{\text{THT}^{b_4}} \tag{6}$$

where $F = b_5 + b_6\text{DBH}^2\text{THT} + \frac{b_7}{\text{DBH}^2\text{THT}}$

Stadelman (1986)

$$\text{dib} = a + b\,\text{DBH}^2 + c\,\text{DBH}\,L + d\,\text{DBH}^2\,L + eL + f\,Z + G\left(\text{THT}-\text{HT}\right) \tag{7}$$

where $L = \frac{\text{THT}-\text{HT}}{\text{THT}}$ and $Z = \ln\left(\text{log position}\right)$

Walters and Hann (1986)

$$\frac{\text{dib}}{\text{dbhib}} = Z_0 + \left[b_{10} + b_{11}\left(\frac{\text{THT}-4.5}{\text{DBH}}\right) + b_{12}\left(\frac{\text{THT}-4.5}{\text{DBH}}\right)^2\right]Z_1 + b_{20} \tag{8}$$

$$Z_0 = 1 - X + I_2\left\{X + I_1\left[\left(\frac{X-1}{k_1-1}\right)\left(1+\frac{k_1-X}{k_1-1}\right)-1\right]\right\} - (X-1)(X-I_2X)$$

$$Z_1 = I_2\left[X + I_1\left(\frac{X-1}{k_1-1}\right)\left(X + k_1\frac{k_1-X}{k_1-1}\right) - X\right] - (X-1)(X-I_2X)$$

$$Z_2 = I_2\left\{X^2 + I_1\left[k_1\left(\frac{X-1}{k_1-1}\right)\left(2X-k_1+k_1\left(\frac{k_1-X}{k_1-1}\right)\right) - X^2\right]\right\}$$

$k_1 = \left(\frac{\alpha\,\text{CB}-4.5}{\text{THT}-4.5}\right)$ $\quad X = \frac{\text{HT}-4.5}{\text{THT}-4.5}$ $\quad$ CB = height to live crown base

$I_1 = 0$ when $0 \le X \le k_1$ else $I_1 = 1$

$I_2 = 0$ when $k_1 \le 0$ else $I_2 = 1$

Wensel and Krumland (1983)

$$\text{dib} = \text{DBH}\left\{c_0 - f\ln\left[1-\left(\frac{\text{HT}-1}{\text{THT}-1}\right)^{c_1}\left[1-\exp\left(\frac{c_0}{f}\right)\right]\right]\right\} \tag{9}$$

where $f = c_2 + c_3\,\text{DBH} + c_4\,\text{THT}$.

To illustrate the statistics computed for each model/data set combination, the mean residual (observed minus predicted diameter) and standard deviation for the existing taper models are given for a subset of the data in Tables 3a, 3b, and 3c for Douglas-fir, ponderosa pine, and white fir, respectively.[5] Scanning the residuals for all of the data sets, of which a partial listing is given in Tables 3a to 3c, it became immediately apparent that each of the models performed well (low average residual and low standard error) for some diameter classes within some data sets. However, no model performed uniformly well across all diameter classes for all data sets.[6]

TABLE 3a. MEAN ($\bar{x}$), STANDARD DEVIATION (S) OF RESIDUAL (OBSERVED–PREDICTED INSIDE BARK DIAMETER), AND SAMPLE SIZE BY SIZE CLASS AND OWNERSHIP BY TAPER MODEL FOR DOUGLAS-FIR

DBH Class inches	5.5–18		18–30		30–40		40+		5.5–18		18–30		30–40		40+	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
	COOP								Eldorado NF							
no.	903		478		21				142		296		54		109	
STA	.1	.9	-.3	1.8	-.3	1.6			-.1	1.1	.0	1.9	-.1	2.6	3.7	5.7
BIG	.3	.9	.2	1.3	-.5	.7			.4	.8	.4	1.6	.5	2.3	.5	3.2
M&B	.4	1.0	.3	1.4	-.3	1.0			.6	.9	.7	1.6	-.1	2.3	.9	3.3
W&K	-.2	.9	.0	1.2	.3	.9			.1	.8	.4	1.7	.2	2.6	3.3	5.2
Kozak	.1	1.0	-.3	1.4	-1.1	1.0			.3	.8	.1	1.6	-.8	2.3	.0	3.2
W&H	.6	.9	.7	1.3	1.0	1.1			.6	.9	1.0	1.7	.7	2.5	2.9	4.6
	Michigan-Cal								Klamath NF							
no.	132		514		164		103		291		319		144		649	
STA	-.1	1.4	-.4	1.9	-.1	2.4	-.6	4.0	.2	1.0	-.4	1.5	-.8	2.6	.2	2.9
BIG	.8	1.0	.3	1.6	-.1	1.9	-1.7	3.4	.3	.7	-.1	1.1	-.8	2.3	-2.0	3.0
M&B	.9	1.0	.6	1.6	.3	1.9	-1.2	3.3	.5	.7	.1	1.1	-.4	2.3	-1.4	2.9
W&K	.4	.8	.4	1.6	1.0	1.9	1.7	3.5	-.1	.6	-.2	1.1	-.3	2.4	1.2	3.8
Kozak	.6	.9	.1	1.6	-.5	1.9	-2.5	3.4	.2	.7	-.4	1.1	-1.1	2.4	-2.7	3.5
W&H	.3	1.0	.1	1.9	.1	2.2	-1.2	4.5	.5	.8	.6	1.2	.0	2.7	-1.8	5.0
	Bulletin 1883								Six Rivers							
no.	205		253		164		70		74		94		14		33	
STA	.5	1.0	-.4	1.4	.0	1.9	.9	3.2	-.1	1.1	-.0	2.1	-1.6	2.0	-.5	3.5
BIG	.1	.8	-.2	1.2	-.3	1.4	-.6	2.1	.7	.7	.6	1.7	-1.6	2.2	-2.3	3.9
M&B	.3	.8	.1	1.2	.1	1.4	-.1	2.1	.8	.8	.9	1.8	-1.2	2.0	-1.7	3.7
W&K	-.3	.8	-.2	1.2	.6	1.8	1.4	2.8	.5	.6	.7	1.8	-.7	2.1	1.0	3.1
Kozak	-.1	.8	-.4	1.2	-.6	1.4	-1.1	2.1	.5	.7	.3	1.7	-2.0	2.3	-2.9	4.1
W&H	.6	.8	1.0	1.3	1.7	1.9	2.1	3.0	.7	.9	1.2	2.0	.1	2.4	.3	3.9

[5]A computer routine, TAPEVAL, was developed to evaluate each of the taper models against any of the data sets. The results given in Tables 4a to 4c represent only a subset of the combinations examined by the authors.

[6]The Wensel and Olson model, W&O, statistics are included in Tables 4a to 4c for comparison. This is the model that was fit to Wensel and Krumland's model form (1983) here in this study.

In Table 3a for Douglas-fir, it is immediately apparent that the models fall into three groups. Least accurate was the Stadelman model. Second, the "best" model/coefficient combinations are the Biging, Max and Burkhart, Walters and Hann, and Wensel and Krumland model/coefficient combinations. Third, the coast and interior British Columbia models/coefficients by Kozak, Munro, and Smith (1969) for Douglas-fir are not too far off target. This is surprising because their data sources in British Columbia are well outside the region studied here.

In Tables 3b and 3c for ponderosa pine and white fir, respectively, again the Biging, Max and Burkhart, and Walters and Hann models performed the best. No statistics appear here for the Wensel and Krumland model because their model was only fitted to Douglas-fir and redwood on California's north coast. The McTague and Stansfield (1988) model for ponderosa pine also proved to be competitive, even though the model was fitted to data well outside the area of study here.

The Walters and Hann (1986) model, W&H, while performing well for some data sets, resulted in uniformly larger residual errors than most models. Further, it has several disadvantages for the current application. First, it requires that one

TABLE 3b. MEAN ($\bar{x}$) STANDARD DEVIATION (S) OF RESIDUAL (OBSERVED–PREDICTED INSIDE BARK DIAMETER), AND SAMPLE SIZE BY SIZE CLASS AND OWNERSHIP BY TAPER MODEL FOR PONDEROSA PINE

DBH Class inches	5.5–18		18–30		30–40		40+		5.5–18		18–30		30–40		40+	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
	COOP								Eldorado NF							
no.	734		892		61				317		495		214		114	
STA	.0	1.1	-.2	1.5	-.3	2.7			-.2	1.4	-.7	1.9	-.2	2.4	-.0	4.4
BIG	.3	.7	.5	1.1	.7	2.2			.2	.7	.5	1.3	.5	2.0	2.0	2.9
M&B	.4	.7	.5	1.0	.6	2.2			.4	.7	.6	1.3	.6	1.9	2.0	2.8
Kozak	-.4	.7	-.7	1.2	-1.1	2.2			-.3	.7	-.5	1.3	-.9	2.0	.2	2.7
W&H	.7	.8	1.0	1.5	.9	2.3			.3	.9	1.0	1.5	1.0	2.4	2.5	3.7
	Michigan-Cal								Klamath NF							
no.	207		1007		439		82		389		459		54			
STA	-.4	1.8	-.5	1.7	-.9	2.3	-2.3	2.9	-.5	1.1	-2.1	1.5	-1.1	1.5		
BIG	.4	1.2	.3	1.2	.2	2.0	.0	2.2	-.1	.7	-.2	1.2	-.0	1.1		
M&B	.5	1.2	.2	1.2	.1	1.9	-.0	2.3	.0	.7	.2	1.4	.6	1.1		
Kozak	-.1	1.2	-.7	1.2	-1.2	2.0	-2.0	2.3	-.6	.8	-1.0	1.3	-1.3	1.3		
W&H	.0	1.4	.1	1.6	.2	2.3	.1	2.7	.3	.7	.5	1.3	.9	1.7		
	Bulletin 1883															
no.	150		211		102		33									
STA	-.5	1.4	-1.1	2.0	.2	2.4	-.6	4.1								
BIG	-.1	1.0	.0	1.4	1.0	1.7	1.4	3.0								
M&B	.0	1.0	.2	1.3	1.1	1.6	1.6	2.8								
Kozak	-.8	1.1	-1.0	1.5	-.5	1.8	-.7	2.9								
W&H	.5	1.0	1.1	1.6	1.9	2.3	3.3	4.0								

TABLE 3c. MEAN ($\bar{x}$), STANDARD DEVIATION (S) OF RESIDUAL (OBSERVED–PREDICTED INSIDE BARK DIAMETER), AND SAMPLE SIZE BY SIZE CLASS AND OWNERSHIP BY TAPER MODEL FOR WHITE FIR

DBH Class inches	5.5–18		18–30		30–40		40+		5.5–18		18–30		30–40		40+	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
	COOP								Eldorado NF							
no.	1548		894		39				351		515		199		111	
STA	-.5	1.1	-.5	2.0	-1.1	2.1			-.9	1.3	.1	2.2	-.3	2.8	.9	4.3
BIG	.3	.9	-.0	1.4	-1.0	1.3			.3	.9	.3	1.6	.3	2.1	-.1	3.9
M&B	.4	.8	.1	1.2	-.8	.9			.2	.9	.2	1.6	.2	2.3	-.3	4.1
W&H	.7	.9	.9	1.4	.7	1.2			.6	1.1	1.3	1.9	2.3	2.9	3.1	5.3
	Michigan-Cal								Klamath NF							
no.	719		1991		560		83		221		212		106			
STA	-.4	1.6	-.5	2.0	-1.3	2.3	-1.5	7.7	-.8	1.1	-.9	2.0	-2.1	2.0		
BIG	.6	1.0	.2	1.3	-.7	1.9	-1.2	8.2	.2	.8	-.5	1.7	-1.2	2.0		
M&B	.5	1.0	.2	1.4	-.5	1.9	-1.2	8.2	.2	.8	-.3	1.8	-.8	2.1		
W&H	.4	1.1	.4	1.6	.3	2.2	.6	8.8	.4	.9	.5	1.8	.3	2.1		
	Bulletin 1883								Six Rivers							
no.	128		313		125		6		125		168		129			
STA	-1.2	1.2	-.6	1.7	-.6	2.3	2.2	3.5	-.5	1.4	-.0	2.2	-.1	2.8		
BIG	-.5	1.1	-.5	1.4	-.4	2.0	2.2	2.7	.5	1.0	.1	1.7	.2	2.4		
M&B	-.4	1.0	-.4	1.3	-.2	2.0	2.5	3.6	.5	1.0	.1	1.6	.1	2.4		
W&H	.6	1.0	1.1	1.6	2.1	2.6	7.4	5.4	.7	1.1	1.3	1.7	1.8	2.8		

know, or estimate, the length of the live crown of the tree. Second, with the estimation of crown length, the model depends on 10 coefficients that must be estimated for each species.

The Wensel and Krumland (1983) equation, W&K, was developed for redwood and Douglas-fir on California's north coast. It is shown as equation (9) in Table 2. The coefficients were fit to measurements of both standing trees and felled trees and estimates the basis for tree taper computations in CRYPTOS, the Cooperative Redwood Yield Project's Timber Output Simulator (Wensel, Krumland, and Meerschaert, 1987).

The Biging (1984) model is a restricted version of the W&K model formed by fixing one of the coefficients so that it no longer changes with tree size, the BIG model. This equation, shown as equation (2) in Table 2, reduces the number of parameters to be estimated and makes it possible to integrate the taper equation for volume, making the taper and volume equations compatible. The relationship between equations (2) and (9) is seen by relating the following components in the two equations:

$$\left(\frac{HT-1}{THT-1}\right) \text{ versus } \left(\frac{HT}{THT}\right), c_0 \text{ vs. } b_1, c_1 \text{ vs. } m, \text{ and } c_2 + c_3DBH + c_4H \text{ vs. } -b_2$$

Biging fitted his coefficients to measurements taken from trees felled for stem analysis as part of the work of the Northern California Forest Yield Cooperative. Equation (2) is given particular attention here because it has been the principal taper model used in CACTOS, the California Conifer Timber Output Simulator, by Wensel, Daugherty, and Meerschaert (1986).

Biging also fitted coefficients to a segmented polynomial equation proposed by Max and Burkhart (1976), with statistics listed as the M&B model in Table 3a to 3c. Biging found both equation (2) and the M&B equation to perform about the same, but Biging's model is more parsimonious. It uses only two fitted coefficients for each species while the M&B model requires as many as 6 coefficients, depending on how many are fixed in any given solution. Biging's coefficients for both his and the M&B models were considered.

Predictions Below Breast Height

Predictions of tree diameters at points below breast height are useful for estimating total biomass. However, they are not needed for estimating board foot volume since the scaling volume of the first log is at the small end of the log, usually at 16.5, 20.5, or 33.0 feet above the stump. Researchers have used separate models for predicting the inside-bark diameter below breast height. Walters and Hann (1986) present methods for predicting diameter below breast height either when the height to crown base is known or when it must be predicted.

The below-DBH model used here was introduced for redwood and Douglas-fir by Wensel and Krumland (1983). The stump diameter, d_s, at height h_s is predicted by

$$d_s = (1 - b_0X)\, D_i e^{b_1(h_i - h_s)} \qquad (10)$$

where D_i is the measured diameter at height h_i, X is an indicator variable equal to 0 or 1, depending on whether the D_i is inside- or outside-bark, respectively, and b_0 and b_1 are coefficients. In cases where the bark thickness is measured, D_i is equal to DBH and h_i = 4.5 feet.

REFITTING COEFFICIENTS

Based upon the preceding evaluation, both the BIG and W&K models were selected for refitting here. The composite data set was divided into two subsets (every other tree) for each of the major species, one half for fitting and the other for testing. Bark thickness was predicted, where necessary, using the model developed by Wensel and Olson (1995). Wensel and Olson did not provide bark thickness models for Jeffrey pine or lodgepole pine, so the model for ponderosa pine was used for these species. The "fit" data set used, described in Table 4, was developed by combining all of the tree data available and then screening the data for completeness. This resulted in the tree taper measurements for fitting on over eight thousand trees yielding over 38 thousand individual upper stem (≥ 4.5 ft.) taper measurements.

TABLE 4. NUMBER OF TREES, MEAN, MINIMUM, AND MAXIMUM DIAMETER AT BREAST HEIGHT AND TOTAL HEIGHT, AND NUMBER OF OBSERVATIONS BELOW AND AT OR ABOVE BREAST HEIGHT USED TO FIT WENSEL AND KRUMLAND (1983) AND BIGING (1984) STEM TAPER MODELS BY SPECIES

		Diameter			Height			Number of observations	
								height	
Species	Number of trees	Mean	Min	Max	Mean	Min	Max	<4.5 ft	≥4.5 ft
Douglas-fir	995	22.5	5.5	87.9	106.6	25.5	265.0	902	5249
Ponderosa pine	1907	21.5	5.1	94.5	91.0	18.0	238.4	2038	8094
Jeffrey pine	945	30.8	5.2	80.9	83.9	14.0	175.8	1049	4951
Sugar pine	583	24.9	6.0	69.2	99.5	18.1	202.0	606	2487
Lodgepole pine	215	16.4	7.9	44.4	66.9	27.7	147.9	320	940
White fir	2384	21.1	5.2	75.7	91.4	18.9	249.5	2505	9640
Red fir	911	23.2	5.5	65.7	88.7	20.6	207.2	956	4432
Incense-cedar	645	22.5	5.2	73.0	73.0	10.7	211.6	666	2718
TOTAL	8585							9042	38511

Data Screening and Editing

The data were received from the various contributors and cooperators in this project and stored in a common data base. They were then retrieved from this data base using a screening process that eliminated trees and/or observations that were obviously in error or would result from grossly misformed trees. This eliminated trees that had forked or broken tops. Since field data sheets for much of the data were not readily available for checking questionable measurements, the data were not otherwise edited or corrected. Since measurement error can have the effect of moving an observation closer or further from the mean, outliers were not deleted as this would result in one-way bias.

Model Development

The modified Gauss-Newton method of nonlinear model parameter estimation was used to estimate coefficients for the BIG and W&K models considered. Projecting on to the solution surface for Wensel and Krumland's model, being a five parameter model, required searching a grid to ensure that the solution was indeed the global minimum residual sum of squares. Especially for white fir, there were several local minima quite close to the global minimum.

Coefficients for the Commercially Important Conifer Species

Upper stem

Tables 5 and 6 show the coefficients calculated using models developed for the BIG and W&K models for the eight species that are both commercially important

in California and for which there are sufficient numbers of observations for fitting. Table 5 gives the coefficients and mean squared error (MSE), corrected for degrees of freedom, calculated for Biging's model. The MSE ranged from a low, for lodgepole pine, of 1.78 sq. in. to 3.74 sq. in. for Jeffrey pine. Table 6 gives the coefficients calculated for the W&K model along with MSE. The MSE ranged from 2.91 sq. in. for sugar pine to 1.45 sq. in. for white fir. Douglas-fir lodgepole pine, and incense-cedar showed only small increase in the MSE for the BIG model relative to the W&K model (less than 15%), red and white fir show a 30% increase in MSE for the BIG model, with ponderosa pine showing the greatest increase in MSE.

Plots made of the residual errors for the BIG and W&K models failed to show any significant bias in the predictions relative to any of the predictors for any of the species tested.

There was considerable correlation between coefficients c_2, c_3, and c_4 as these are the coefficients that adjusted for the height-diameter relationship. However, for Douglas-fir, ponderosa pine, Jeffrey pine, and lodgepole pine, the c_4 coeffi-

TABLE 5. COEFFICIENTS AND MEAN SQUARE ERROR (MSE) FOR FIT OF STEM TAPER DATA, BREAST HEIGHT AND ABOVE, COLLECTED FROM THROUGHOUT CALIFORNIA TO THE MODEL DEVELOPED BY BIGING (1986)

Species	b_1	b_2	MSE
Douglas-fir	0.99007	0.32640	3.05
Ponderosa pine	1.04451	0.33229	1.98
Jeffrey pine*	1.00691	0.30606	3.74
Sugar pine	1.06171	0.37902	3.21
Lodgepole pine*	1.17304	0.45390	1.78
White fir	1.04442	0.33571	1.87
Red fir	1.01513	0.31803	1.85
Incense-cedar	1.00459†	0.40012	2.23

*Ponderosa pine bark model was used for converting outside-bark observations.
†Not significantly different from 1.0 at $\alpha = 0.05$

TABLE 6. COEFFICIENTS AND MEAN SQUARE ERROR (MSE) FOR FIT OF STEM TAPER DATA, BREAST HEIGHT AND ABOVE, COLLECTED FROM THROUGHOUT CALIFORNIA TO THE MODEL (EQUATION 1) DEVELOPED BY WENSEL AND KRUMLAND (1983)

Species	c_0	c_1	c_2	c_3	c_4	MSE
Douglas-fir	0.84292	.97062	−0.38163	−0.0074002	0.0	2.52
Ponderosa pine	0.87278	1.26066	−1.91214	0.020445	0.0	1.54
Jeffrey pine*	0.82932	1.50831	−4.08016	0.047053	0.0	2.95
Sugar pine	0.90051	0.91588	−0.92964	0.0077119	−0.0011019	2.91
Lodgepole pine*	1.0	0.84257	−0.98434	0.0	0.0	1.73
White fir	0.86039	1.45196	−2.42273	−0.15848	0.036947	1.45
Red fir	0.87927	0.91350	−0.56617	−0.014480	0.0037262	1.52
Incense-cedar	1.0	0.31550	0.34816	0.0	0.00939283	2.16

*Ponderosa pine bark model was used for converting outside-bark observations.

cients were found to be not significant in the model. In these species, the coefficient for total height (c_4) was set at zero, resulting in the other four coefficients becoming significant. For lodgepole pine, the coefficients for both DBH and total height (c_3 and c_4) were zero resulting in a model very similar to Biging's.

To test and compare the W&K and BIG models, the mean residual and the mean squared error was calculated using the observations withheld from the fitting data set. As one would expect with such large data sets, the results for the test data set were similar to those of the fitting data set.

The correlation, r, between the residual error and diameter at breast height is shown by species in Table 7 for the BIG and W&K models. The correlations were consistently low ($|r| < 0.1$) using the W&K model while the correlation using the BIG model was consistently higher.[7] For the W&K model, these correlation's are not high enough to be important. Also, for several of the species, the same can be said for the Biging model.

Stump model

The stump model proposed by Wensel and Krumland (1983) produced results with minimal bias and the least overall mean squared error. Although a linear model with a intercept term, using DBH and height as independent variables, was nearly as good at predicting stump diameters (less than 5 percent increase in MSE), such a model is conceptually inappropriate because of the intercept term.

The coefficients and mean squared error computed for Wensel and Krumland's stump model are shown in Table 8. Jeffrey pine and incense-cedar had MSE's in excess of 6.0 sq. in. while Lodgepole pine had a MSE of 1.51 sq. in. The error in predicting stump diameters was much greater than for predicting upper stem diameters. This is to be expected, as the magnitude of the observations was much

TABLE 7. CORRELATION BETWEEN RESIDUAL AND DBH FOR BIG AND W&K MODELS FOR THE "FIT" DATA SET

Species	BIG	W&K
Douglas-fir	−0.28	−0.09
Ponderosa pine	0.15	0.09
Jeffrey pine	0.12	0.10
Sugar pine	0.07	−0.09
Lodgepole pine	−0.12	−0.04
White fir	−0.12	−0.03
Red fir	−0.24	−0.09
Incense-cedar	−0.12	−0.02

[7]A 3-parameter version of Biging's model was developed for each species (with m estimated instead of being equal to $\frac{1}{3}$). Compared with the 2-parameter version, this had only slight reductions in the overall residual sums of squares and very little or no reduction in the correlations shown in Table 8. Thus, as discovered by Biging, there is little reason to prefer the 3-parameter version of this model over the 2-parameter version.

TABLE 8. COMPUTED COEFFICIENTS AND MEAN SQUARED ERRORS (MSE) FROM WENSEL AND KRUMLAND'S STUMP MODEL

Species	b_0	b_1	MSE
Douglas-fir	.1420	.04302	4.11
Ponderosa pine	.1031	.03068	2.50
Jeffrey pine	.1472	.03880	6.20
Sugar pine	.0743	.02936	3.91
Lodgepole pine	.0147	.03223	1.51
White fir	.0844	.03320	3.25
Red fir	.1105	.05061	4.37
Incense-cedar	.1177	.03894	6.33

larger, and there is greater variation in taper in the lower stem. However, the residual plots for equation (10) did not show any bias in the predictions.

INFLUENCE OF SITE AND LOCATION PARAMETERS

It is common practice to produce "localized" versions of tree volume and taper models because of perceived differences in the predicted relationships as one changes location. First, we discuss the effect of latitude and elevation followed by a discussion of the effect of site quality on the predictions.

Latitude and Elevation

One of the objectives of this study was to adjust taper predictions for each species for changes in geographic location and site quality, if appropriate. California stretches over 9 degrees of latitude; we have data from the San Bernardino National Forest at 34 degrees to the data from Oregon at 43 degrees. Because of this, latitude was used as a measure of relative geographic position. Other approaches to assessing the effect of geographic location on stem taper could have been investigated, such as nonparametric analyses based on the concept of local genetic variation, but these approaches were not possible with the existing information.

Trees in the database were assigned a latitude based upon either specific plot information or, if plot information was not specific with respect to latitude, a latitude was assigned approximating the geographic center of the ownership or National Forest that the tree came from. These approximated or "pseudo" latitudes were then used to determine the effect of latitude and geographic position on stem taper.

Elevation information was less readily available for trees in the database. No attempt was made to approximate elevations if they were absent from the plot data. For assessing the effect of elevation on stem taper, elevation was corrected for latitude. It is generally known that with increasing latitude there is a drop in elevation to maintain equivalent climatic zones. However, there is little reported

in the literature as to the specific altitudinal change per unit of latitudinal change for California. Daubenmire (1954) reported that timberline drops 360 feet per degree of latitude increase under a given type of climate regime for the Rocky, Coastal, and Appalachian Mountains. In the absence of a more definitive relationship, Daubenmire's 360 feet per degree of latitude relationship was used to adjust elevation for latitudinal differences in observations.

Correlations of latitude and elevation with residuals from the BIG and W&K models were computed. For this, actual latitude, pseudo-latitude, and latitude corrected for elevation were used. With correlations under 0.05 for Douglas-fir, and true firs and under 0.15 for ponderosa pine and incense-cedar, the examination of the residual plots showed no significant relationship, either linear or nonlinear, between the residuals and latitude and/or elevation. Further, plots of residuals on latitude for the W&K model showed no relationships. As a result, no local geographic adjustment was made to the taper models for each species.

Site Quality

To see if there was an effect of site quality on the taper of trees, an evaluation of site versus residuals was made. All observations for which a 50-year site was available were used to evaluate the relationship between site index and residuals. The correlations ranged from –0.15 for incense-cedar to 0.05 in Douglas-fir for the BIG and W&K models. These correlations, by inspection, did not appear high enough to warrant the further investigation of site index adjustments to the models. This is particularly true considering the wide range of site qualities present in the data. One cannot say, however, that the trees have the same taper regardless of site quality because the W&K models vary the taper by tree DBH and height, which will themselves vary by site quality.

DISCUSSION

Taper equations are used for appraisal work by estimating the scaling diameters of logs in the upper stem of trees. These diameters are used to get the scaling volume of trees which, when coupled with defect and log grade, are used to estimate the value of each tree. Here we have attempted to assess the reliability of various taper models that are currently being used for this purpose in California and to estimate the coefficients for two of the taper models.

The coefficients were fit to stem taper data collected throughout California as part of numerous previous individual studies of stem taper involving both felled and standing tree observations. The new models performed generally better throughout California on an overall basis, having generally less bias and variance compared to previously used models. However, other model forms could do as well or better for some species. Also, previously developed models perform well in some diameter size classes for certain data sets. The Wensel and Krumland model is a five-parameter model using relative height, diameter at breast height, and total height as predictive variables. The ability of this model to adjust for a larger range of diameters and heights appears to be the reason for its more

general applicability over the 9 degrees of latitude from southern California to central Oregon.

The Wensel and Krumland model has two predictive equations, one for breast height and above and one for breast height and below. The below breast height model is provided for those who wish to predict cubic volume, including the flare below breast height.

Latitude, elevation, and site quality as measured by site index were evaluated to see if there was any need to develop either local models or include these variables into the models. There was little or no relationship between model residual error and latitude corrected for elevation or between residual error and site. Thus, the same coefficients can be used throughout the region.

LITERATURE CITED

AMIDON, E. L.
1984. A general taper functional form to predict bole volume for five mixed conifer species in California. For. Sci. 30(1): 166-71.

BIGING, G. S.
1981. Volume tables for young-growth mixed conifers of northern California. Northern California Forest Yield Cooperative, University of California, Berkeley, Department of Forestry and Resource Management, Research Note No. 2, 56 pp.
1984. Taper equations for second-growth mixed conifers of northern California. For. Sci. 30 (4): 1103-17.

DAUBENMIRE, R. F.
1954. Alpine timberlines of the Americas and their interpretation. Butler Univ. Bot. Stud. 11: 119-36.

DOLPH, K. L.
1988. Prediction of periodic basal area increment for young-growth mixed conifers in the Sierra Nevada. USDA Forest Service Research Paper PSW-190.
1989. Nonlinear equations for predicting diameter inside bark at breast height for young-growth Red Fir in California and southern Oregon. USDA Forest Service Research Note PSW-409.

ERNST, S., and W. Y. PONG
1985. Lumber recovery from ponderosa pine in northern California. USDA Forest Service Research Paper PNW-333, Portland, Oregon.

KOZAK, A., D. D. MUNRO, and J. H. G. SMITH
1969. Taper functions and their application in forest inventory. For. Chron. 45(4): 278-83.

KOZAK, A.
1988. A variable-exponent taper equation. Can. J. For. Res. 18: 1363-68.

MAX, T. A., and H. E. BURKHART
1976. Segmented polynomial regression applied to taper equations. For. Sci. 22(3): 283-89.

McTAGUE, J. P., and W. F. STANSFIELD
1988. Total and merchantable volume equations and taper functions for southwestern ponderosa pine. West. J. Appl. For. 3(4):123-25.

OLIVER, W. W.
1988Ten-year growth response of a California red and white fir sawtimber stand to several thinning intensities. West. J. Appl. For. 3 (2): 41-43.

PONG, W. Y.
1982. Lumber recovery from young-growth red and white fir in northern California. Research Paper PNW - 300, USDA Forest Service, Portland, Oregon.

PONG, W. Y., and J. M. CAHIL
1988. Lumber recovery from incense cedar in central California. Research Paper PNW - 393, USDA Forest Service, Portland, Oregon.

STADELMAN, C.
1986. R5 Taper Equations. Working draft of the taper table equation development, R5, USDA Forest Service.

WALTERS, D. K., and D. W. HANN
1986. Taper equations for six conifer species in southwest Oregon. Oregon State University Forest Research Lab Research Bulletin 56, Corvallis, OR, 41 pp.

WENSEL, L. C.
1977. Volume tables for young-growth conifers in the northern regions of California. University of California, Division of Agricultural Sciences Bulletin 1883.
WENSEL, L.C., P.J. DAUGHERTY, and W.J. MEERSCHAERT
1986. CACTOS User's Guide: The California Conifer Timber Output Simulator. University of California, Division of Agricultural Sciences Bulletin 1920, 91pp.
WENSEL, L.C., and B. KRUMLAND
1983. Volume and taper relationships for redwood, Douglas-fir, and other conifers in California's north coast. University of California, Division of Agricultural Sciences Bulletin 1907.
WENSEL, L. C., B. E. KRUMLAND, and W. J. MEERSCHAERT
1987. CRYPTOS User's Guide: Cooperative Redwood Yield Project Timber Output Simulator. Bulletin 1924. Agricultural Experiment Station, University of California, Berkeley. 89 pp.
WENSEL, L.C., W.J. MEERSCHAERT, and G.S. BIGING
1987. Tree height and diameter models for Northern California conifers. Hilgardia 55 (8), 20 pp.
WENSEL, L. C. and C. M. OLSON
1995. Bark taper equations for California conifers. Hilgardia 62 (2), 14 pp. (Published concurrently and bound in this volume.)

ACKNOWLEDGMENTS

The authors gratefully acknowledge the assistance of Kevin Casey, LeRoy Dolph, Ralph Johnson, Charles Stadelman, and Ralph Warbington of the U.S. Forest Service in helping to accumulate the data sets used for this study and to Greg Biging, Kip Freytag, Frieder Schurr, and Al Stangenberger for help in preparing the data for analysis. Manuscript review comments from Greg Biging, LeRoy Dolph, and Eric Turnblom are gratefully acknowledged.

Hilgardia

A JOURNAL OF AGRICULTURAL SCIENCE PUBLISHED BY THE CALIFORNIA AGRICULTURAL EXPERIMENT STATION

Volume 62 • Number 4 • December 1995

Tip Length Models for Major Commercial California Conifers

Craig M. Olson and Lee C. Wensel

UNIVERSITY OF CALIFORNIA DIVISION OF AGRICULTURE AND NATURAL RESOURCES

ABSTRACT

Several models for predicting the length from the merchantable top to the tip of a tree are evaluated for major California conifers. A model reported by Wensel and Krumland (1983) was found to be the most useful because of its ability to predict for both total height or merchantable height. Coefficients are reported for eight commercially important conifers of California.

THE AUTHORS:

Craig M. Olson is Research Associate, Department of Environmental Science Policy and Management, University of California, Berkeley, CA 94720.

Lee C. Wensel is Professor, Department of Environmental Science Policy and Management, University of California, Berkeley, CA 94720.

Tip Length Models for Major Commercial California Conifers[1]

INTRODUCTION

FIELD MEASUREMENTS MAY provide only total height on the trees when height to a fixed merchantable diameter is needed for merchantable volume estimation. Alternatively, most stem taper equations are based upon knowing the total height of the tree (e.g., Max and Burkhart 1976; Biging 1984; Kozak 1988; McTague and Stansfield 1988; Wensel and Olson 1995), tree height is often measured in number of logs to a fixed (merchantable) inside-bark diameter. Therefore, the objective here is to provide equations and coefficients to enable one to predict the tip length to make easy conversions between total tree height and merchantable heights.

Wensel and Krumland (1983) developed a tip model for redwood and Douglas-fir for this very purpose. In this study we investigated using Wensel and Krumland's model, as well as several other models, so that whole tree taper models could be used to estimate diameters up the stem of a tree when only the height to some upper diameter is known. An alternative approach for finding the length of stem from a merchantable top to tip is to iteratively solve the taper function, finding that total height consistent with the merchantable top diameter, the merchantable height, and the diameter at breast height.

The objective here was to find the appropriate tip model and then calculate the coefficient values for the eight species listed below.

Species considered are Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco; ponderosa pine, *Pinus ponderosa* Dougl. ex Laws.; Jeffrey pine, *P. jeffreyi* Grev. & Balf.; lodgepole pine, *P. contorta* Dougl. ex Loud.; sugar pine, *P. lambertiana* Dougl.; white fir, *Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.; red fir, *A. magnifica* A. Murr.; and incense-cedar, *Calocedrus decurrens* (Torr.) Florin.

TIP LENGTH MODELS CONSIDERED

Several tip models were investigated for their use as predictors of stem length from a merchantable top to tip. The first was developed by Wensel and Krumland (1983):

$$\text{Tip} = b_0 \text{DTOP}^{b_1} \text{DBH}^{b_2} \quad (1)$$

where Tip = length in feet from merchantable top to tip, DTOP = merchantable top diameter in inches, and DBH = diameter in inches at breast height. Two alternative models included:

$$\text{Tip} = b_0 \text{DTOP}^{b_1} \text{MHT}^{b_2} \quad (2)$$

where MHT = height to the merchantable top diameter, and,

[1]Accepted for publication May 30, 1995.

$$\text{Tip} = b_0 \text{DTOP}^{b_1} \text{DBH}^{b_2} \left(\frac{\text{MHT}}{\text{DBH}}\right)^{b_3} \tag{3}$$

The MHT to DBH ratio was used expecting that short, fat trees would have a shorter top for a given diameter than tall, skinny trees of the same diameter. The models were fit in their nonlinear form using a least squares algorithm.

An alternative to using direct predictions of tip length is to use a stem taper equation, where total height (THT) in feet is predicted from merchantable height by an iterative process. If the taper equation is accurate at the top, this process would give adequate estimates of tip length. Using the stem taper function from Wensel and Olson (1995) we solved for total height, knowing the DBH, top diameter (dib) in inches, height to that diameter (HT) in feet, and species. Wensel and Krumland's model was used as the stem taper model using coefficients fitted by Wensel and Olson (1995):

$$\text{dib} = \text{DBH}\left(c_0 - f \ln\left(1 - R^{c_1}\left[1 - \exp\left(\frac{c_0}{f}\right)\right]\right)\right) \tag{4}$$

where c_i = the ith coefficient ($i = 0 \ldots 4$), $R = \frac{\text{HT}-1}{\text{THT}-1}$, $f = c_2 + c_3\,\text{DBH} + c_4\,\text{THT}$

and ln refers to the natural logarithm (base e). An initial THT was estimated and evaluated for consistency with the dib, HT, and DBH. If the estimated THT was too great for the corresponding dib, HT, and DBH the estimated THT minus HT length was halved and the new estimated THT evaluated. This process was continued until the estimated THT was consistent with the dib, HT, and DBH to within 0.1 feet.

DATA SOURCES

The data used in this study came from stem analysis of felled trees and optical dendrometer measurements on standing trees (Wensel and Olson 1995). Observations in this data set with top diameters from 4 to 9 inches and known total height were used to estimate and compare the various models (see Table 1). Table 1 shows the number of observations and the mean, minimum, and maximum for the top diameters, DBH, and total height for the eight conifer species considered here. Since tip length has little meaning in old-growth trees, which frequently go from 20 inches, say, to zero in only a short distance and often have multiple tops, these data are not included in the analysis. Further, these models are not intended for use with old-growth trees or trees with multiple or broken tops.

TABLE 1. NUMBER OF TREES, MEAN, MINIMUM, AND MAXIMUM TOP DIAMETER, DIAMETER AT BREAST HEIGHT, AND TOTAL HEIGHT USED TO EVALUATE STEM TIP MODELS

		Top diameter			DBH			Height		
Species	Trees	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
	no.		*inches*			*inches*			*feet*	
Douglas-fir	1098	6.7	4.0	9.0	26.6	11.0	78.7	121.3	51.7	265.0
Ponderosa pine	1915	6.4	4.0	9.0	22.0	11.0	58.4	100.4	34.2	200.0
Jeffrey pine	106	5.5	4.0	8.0	17.1	11.0	25.3	66.0	38.0	96.0
Sugar pine	713	8.9	4.0	9.0	26.5	11.3	60.0	107.4	41.0	202.0
Lodgepole pine	66	6.9	4.5	8.8	16.5	12.1	26.1	64.6	37.5	95.3
White fir	2655	6.4	4.0	9.0	20.8	11.0	45.0	92.8	39.1	206.2
Red fir	1120	6.5	4.0	9.0	20.4	11.0	48.0	83.9	38.0	164.9
Incense-cedar	622	6.1	4.0	9.0	26.1	11.0	64.0	82.2	24.4	155.0

RESULTS AND DISCUSSION

All four of the above equations were used to estimate stem tip lengths. The least-squares fit of equations (1), (2) and (3) produced a minimally biased model with respect to the predictor variables. The mean absolute deviation for all species was under five feet and the overall mean bias was under 0.02 feet for all species and models. Equation (1) also has the desirable property that tip length can be predicted without knowing the tree height. The coefficient values and the mean squared error from fitting these models to the eight species appears in Tables 2a, 2b, and 2c.

The mean squared errors for the eight species ranged from 6.7 to 38.0 ft^2, 7.9 to 42.9 ft^2, and 4.6 to 28.5 ft^2, for models (1), (2), and (3), respectively. However, in the case of Jeffrey pine and lodgepole pine there were very few observations and the magnitude of the MSE is larger, showing that it is more likely to be a function of the sample size than the quality of the model fit.

As one might expect, the greater the top diameter the greater the tip length, and conversely the greater the diameter at breast height the shorter the tip length. Equations (2) and (3) did not appreciably reduce the sums of squares or

TABLE 2a. FITTED COEFFICIENT VALUES FOR TIP MODEL (1) AND MEAN SQUARED ERROR (MSE) BY SPECIES

Species	b_0	b_1	b_2	MSE *feet²*
Douglas-fir	12.3427	0.94927	-0.35726	33.6
Ponderosa pine	14.7499	1.08778	-0.53401	31.1
Jeffrey pine	6.4090	1.22192	-0.40190	6.7
Sugar pine	10.0843	1.16455	-0.43810	38.0
Lodgepole pine	9.8857	0.94937	-0.36134	18.6
White fir	9.0558	1.00807	-0.34298	25.1
Red fir	11.6757	1.13426	-0.55298	16.8
Incense-cedar	9.2386	1.04472	-0.39884	27.7

TABLE 2b. FITTED COEFFICIENT VALUES FOR TIP MODEL (2) AND MEAN SQUARED ERROR (MSE) BY SPECIES

Species	b_0	b_1	b_2	MSE $feet^2$
Douglas-fir	14.8243	0.83418	−0.24537	37.7
Ponderosa pine	9.8907	0.86594	−0.18838	39.0
Jeffrey pine	4.1243	1.10247	−0.12720	7.9
Sugar pine	11.1419	1.02969	−0.28538	42.9
Lodgepole pine	9.3053	0.72138	−0.13705	19.1
White fir	7.2390	0.86098	−0.12553	27.5
Red fir	8.3651	0.88890	−0.20631	21.3
Incense-cedar	7.3864	0.89576	−0.18823	32.5

TABLE 2c. FITTED COEFFICIENT VALUES FOR TIP MODEL (3) AND MEAN SQUARED ERROR (MSE) BY SPECIES

Species	b_0	b_1	b_2	b_3	MSE $feet^2$
Douglas-fir	2.5614	0.94398	−0.14209	−0.57217	28.5
Ponderosa pine	1.4300	1.08793	−0.17646	−0.80562	21.3
Jeffrey pine	1.6451	1.21353	−0.23704	−0.67098	4.6
Sugar pine	0.9411	1.02399	−0.06041	−0.99471	27.1
Lodgepole pine	2.7171	0.85061	−0.05858	−0.46491	16.3
White fir	1.7117	1.00203	−0.11140	−0.84960	19.8
Red fir	2.5830	1.13955	−0.33157	−0.58589	12.7
Incense-cedar	1.2125	1.00026	−0.77524	−0.91325	17.6

reduce bias with respect to any of the predictor variables when compared to results from fitting equation (1). Since there was little or no improvement in model fit for equations (2) and (3), there was little advantage in knowing tree height for estimating tip length.

There is a systematic bias associated with tip estimates using the tree taper functions of Wensel and Olson (1995). Short tips (< 25 feet) are systematically overpredicted while long tips (> 25 feet) are consistently underpredicted. One can avoid such bias by using the tip models (1), (2), and (3), especially for the shorter trees (Figure 1). This bias existed for all eight species, particularly for trees of total height less than one hundred feet.

Results of using equation (4) can be seen in Figure 2. There is a systematic bias associated with iteratively solving the taper function to find the tip length. This bias is found for all eight species, particularly for trees of total height less than one hundred feet. Thus, not only is the iterative solution of the taper equation tedious, it is also biased. While we expect a similar result with other taper models, it is important to note that we only tested this with one taper model.

Finally, models (1), (2) and (3) were all found to work well for predicting tip lengths, but because of the ability of model (1) to predict merchantable height it is of more general use. The models fitted here are considered appropriate, for the species considered, for top diameters ranging from 4 to 9 inches in California.

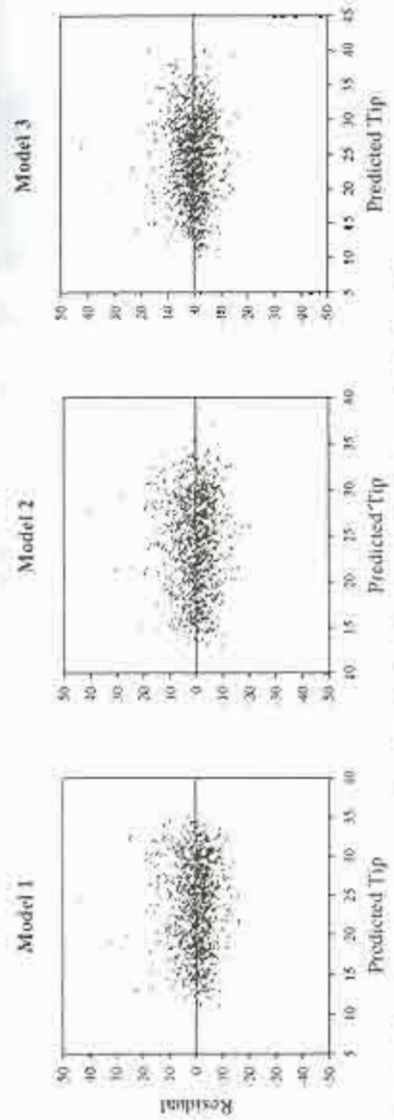

Fig. 1. Plot of residuals versus predicted tip (in feet) for Douglas-fir for tip models 1, 2, and 3.

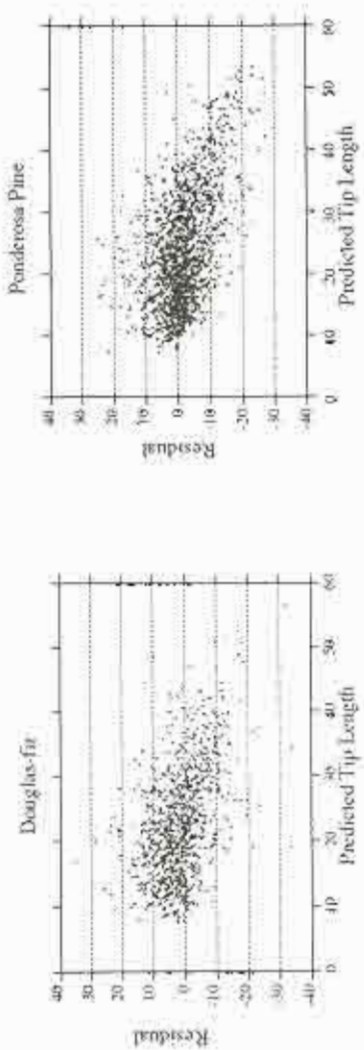

Fig. 2. Plot of residuals versus the predicted total height (in feet) using equation (4) for Douglas-fir and ponderosa pine.

LITERATURE CITED

BIGING, G. S.
1984. Taper equations for second-growth mixed conifers of northern California. For. Sci. 30 (4): 1103-17.
KOZAK, A.
1988. A variable-exponent taper equation. Can. J. For. Res. 18: 1363-68.
MAX, T. A., and H. E. BURKHART
1976. Segmented polynomial regression applied to taper equations. For. Sci. 22(3): 283-89.
McTAGUE, J. P., and W. F. STANSFIELD
1988. Total and merchantable volume equations and taper functions for southwestern ponderosa pine. West. J. Appl. For. 3(4):123-25.
WENSEL, L. C. and C. M. OLSON
1995. Tree taper models for major commercial California conifers. Hilgardia 62(3), 16 pp. (Published concurrently and bound in this volume.)
WENSEL, L. C. and B. KRUMLAND
1983. Volume and taper relationships for redwood, Douglas-fir, and other conifers in California's north coast. University of California, Division of Agricultural Sciences Bulletin 1907.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the assistance of Kevin Casey, LeRoy Dolph, Ralph Johnson, Charles Stadelman, and Ralph Warbington of the U.S. Forest Service in helping to accumulate the data sets used for this study.

Hilgardia

A JOURNAL OF AGRICULTURAL SCIENCE PUBLISHED BY THE CALIFORNIA AGRICULTURAL EXPERIMENT STATION

Volume 62 • Number 5 • December 1995

Tree Volume Equations for Major California Conifers

Lee C. Wensel and Craig M. Olson

UNIVERSITY OF CALIFORNIA DIVISION OF AGRICULTURE AND NATURAL RESOURCES

ABSTRACT

Equations and tables are given to estimate total tree board foot and cubic foot volume for eight major California conifer species. Using taper equations developed in another study, log dimensions were estimated for the trees used in the stem taper study; then coefficients for whole-tree volume equations were fitted to the resulting set. This produced Scribner and International $\frac{1}{4}$-inch board volume, and cubic volume equations for the eight important commercial conifer species in California. For board-foot volumes, separate equations are given for both total and merchantable heights to various merchantable tops.

THE AUTHORS:

Lee C. Wensel is Professor, Department of Environmental Science Policy and Management, University of California, Berkeley, CA 94720.

Craig M. Olson is Research Associate, Department of Environmental Science Policy and Management, University of California, Berkeley, CA 94720.

Tree Volume Equations for Major California Conifers[1]

INTRODUCTION

TIMBER APPRAISAL WORK requires that tree volumes be broken down by log and log position; such work depends upon the availability of accurate estimates of tree diameters at various points along the stem. The previous phase of the current study produced such taper equations (Wensel and Olson 1995). However, users often want volume equations, bypassing the use of taper equations. Unless the taper equations can be integrated mathematically, as are Biging's (1984) equations, they are not easily used for computing compatible whole cubic tree volumes. This suggests that, in addition to stem taper equations, whole tree volume equations are also needed.

The algorithm for computing the volume of the eight conifer species, reported here, as well as volume tables by species, log rule (cubic, Scribner, International $\frac{1}{4}$-inch), and either total or merchantable height is available from the authors.

DATA SOURCES

A complete listing of the numbers of trees used in the original taper study by species, DBH, and data source are given by Wensel and Olson (1995). Table 1 abbreviates this listing and gives the number of trees by species, DBH, and total height (tables begin on p. 4.) In creating the stem taper set (Wensel and Olson, 1995) there were only a few upper-stem diameter measurements for many of the trees. While this is sufficient for developing tree taper estimates, it is insufficient for tree volume estimation. This left us with two choices: (1) delete the trees with incomplete stem taper measurement and compute whole tree volumes for the remaining trees; or (2) use the stem taper equations to get upper stem diameters inside bark required to define the volume of the sample trees. It is this latter process that was used here.

Thus, the "data" used for computing the total volumes of each 2-inch DBH class and 10-foot height class were computed using the taper equations (Wensel and Olson 1995) and the log scaling rules discussed below. The small end diameter for a particular log was computed using the taper equations, then the log volumes were computed from the small end diameter and the log length using the appropriate log rule, and then the tree volumes were computed as the sum of the log volumes. The weight for each class was set equal to the number observations in that class. However, some combinations of DBH and height were considered to be "outliers" and were dropped from consideration. For example, a 14-inch DBH white fir with a height of 110 feet was beyond the reliability of the white fir taper equation and was dropped.

Scaling for board foot volume was done by 16-foot logs to 4-, 6-, and 8-inch merchantable tops, allowing a half-log at the top.[2] Scaling for cubic volume was

[1]Accepted for publication May 30, 1995.

[2]USDA Forest Service Region 5 scaling rules were used. These rules specify 16-foot logs with allowance for a possible $\frac{1}{2}$ log at the top. Trim allowance is 0.5 feet per 8- or 16-foot log.

done to both the tip and to a 4-inch merchantable top.[3] Trees that were projected to have less than one 16-foot log with the specified inside-bark top diameter were deleted from the analysis for the equation for that top diameter.

International metric units (SI) can be obtained by using conversions on the DBH and height entered and on the volumes computed. For example, if DBH is in centimeters and height is in meters and the volume is to be computed in cubic meters, the following conversion factors should be used with the resulting equations:

$$DBH_{inches} = \left(0.394 \frac{\text{inches}}{\text{centimeter}}\right) DBH_{centimeters}$$

$$height_{feet} = \left(3.28 \frac{\text{feet}}{\text{meter}}\right) height_{meters}$$

$$volume_{cubic\ meters} = \left(0.02832 \frac{\text{cubic meters}}{\text{cubic foot}}\right) volume_{cubic\ feet}$$

If another combination of measurement units is used only a portion of this conversion will be required. Also, Olson and Wensel (1995) provide a set of equations to estimate tip lengths for easily switching between total and merchantable heights.

MATHEMATICAL MODELS AND FITTING

While a number of model forms were investigated, two model forms and two fitting procedures were used here. The model (Bruce and Schumacher 1950)

$$V = b_0 D^{b_1} H^{b_2} \qquad (1)$$

produced good results in previous studies of California tree species (Wensel 1971, Wensel 1977a, and Wensel and Krumland 1983). In Equation (1), D is the breast height diameter and H is the total or merchantable height, whichever is being used to predict volume. When applied here, both in its nonlinear and its logarithmic form, equation (1) produced small but systematic over-estimates of the volumes of larger trees. To eliminate this apparent bias, another term was added to the model yielding

$$V = b_0 D^{b_1} H^{b_2} b_3^{D} \qquad (2)$$

This third term is added to enable the model to fit larger trees better. Fitting this model in its log-linearized form is the traditional approach for two reasons. First, the log transformation stabilizes the variance that would otherwise increase with untransformed tree heights and diameters. However, because the variance is already stabilized by the use of the taper model to estimate the whole tree volumes, this is not a consideration here. That is, for the taper models used here, the residual error is not a function of height or diameter. The second reason to

[3]Cubic scale was computed in 1-foot increments using Newton's rule. If computing cubic volumes on actual trees for comparison, see the generalization of Newton's rule by Wensel (1977b).

use the log-linearized form of equation (2) is to facilitate the estimation process. In the linear form, the coefficients can be estimated directly using a standard multiple linear regression process.

Unfortunately, however, the linearized form of the equation continued to have the systematic bias (though smaller) that was present in equation (1). Thus, the nonlinear form of equation (2) was fitted. This eliminated the sytematic bias for larger trees as well as reduced the overall mean squared error compared to model (1). The coefficients for model (2) for Scribner and International ¼-inch board-foot volumes and for cubic foot volumes are given in Tables 2–9 (pages 5–8) for each of the eight conifer species considered.

RELIABILITY

The reliability of the taper equations was reported by Wensel and Olson (1995). The ability of the tree volume equations to predict the volume obtained by taper equations is illustrated in Table 10 (page 9) that presents the ratios,

$$R = \frac{\text{volume equation volume prediction}}{\text{taper equation volume prediction}}$$

Ratios of 1.00, shown through most of the table, show differences of less than one-half percent. For the short small-diameter pine, the ratio was as large as 1.07 (showing differences as large as 7 percent). For extremely tall, thin trees the ratio was as low as 0.89. The few large and small ratios that exist are judged to be outliers.

Agreement outside the range of the data studied is not guaranteed for either the previous taper equations or the current total tree volumes.

APPENDIX TABLES

Tables are given in the Appendix for both Scribner board foot and cubic foot volumes for DBH and both total height and merchantable height to various tops. As illustrated in Table 11 (page 10), this yields a total of 72 tables found in Appendix A. These and additional tables are available on computer diskette. They include International ¼-inch versions of Appendix Tables A-1 through A-48 as well as total volumes by log height and log position.

Since the taper equations use total height, volumes to various merchantable heights require that we estimate the distance from the merchantable diameter (here it is 4, 6 or 8 inches) to the tip. These tip lengths are estimated using the equations from Olson and Wensel (1995).

A complete listing of these and the additional tables and programs available on a high density DOS computer diskette is given in Appendix B. This list includes all programs, coefficient files, and data sets necessary to compute the volume tables.

TABLE 1. NUMBER OF TREES BY SPECIES,* DBH CLASS,† AND HEIGHT CLASS‡

Species obs.	DBH	Height Class (midpoint in feet) 30	50	70	90	110	130	150	170	190	210	220+
DF	15		18	102	151	84	17	5				
937	25			2	42	118	102	39	10	2	3	
	35				7	7	42	27	32	10	2	1
	45					4	10	13	18	19	6	1
	55					1		3	10	8	7	2
	60+						2	1	1	4		4
PP	15	13	163	292	279	87	10	2	1			
1786	25		4	79	172	219	135	29	1	1		
	35			4	24	46	68	43	18	4		
	45				2	10	20	21	10	3		1
	55				1	2	8	3	3	2	2	
	60+							1	2	1		
JP	15	11	63	63	11	1		1				
927	25		28	122	119	13	1					
	35		1	67	191	68	10	2	2			
	45		1	5	44	60	21	4	1			
	55				2	7	8					
SP	15	2	32	75	65	12	1					
540	25		1	12	53	75	42	4				
	35				6	23	51	20	7			
	45					3	12	12	7	2		
	55					2	3	7	5	1	1	
	60+							2	1		1	
LP	15	6	75	75	21	5						
235	25	1	6	7	17	9	1	1				
	35			2	4	2		1				
	45			2								
WF	15	7	168	423	429	115	10					
2221	25	1	9	60	226	288	133	22	3			
	35			4	21	53	83	49	18	3		
	45				7	8	14	25	9	1	1	
	55				1		5	2	7	7	4	1
	60+							1	2	1		
RF	15	3	124	154	127	25						
886	25		4	42	118	82	26	3	1			
	35			2	28	44	35	14	2			
	45				2	5	15	12	6	3	1	
	55						1	2	3			
	60+				1			1				
IC	15	24	105	94	11	2						
554	25	1	12	47	70	26	2	1				
	35			6	28	42	19	3				
	45				4	18	21	5				
	55				2	2	6	1				
	60+					1					1	

*Two-letter species codes represent Douglas-fir, ponderosa pine, Jeffery pine, sugar pine, lodgepole pine, white fir, red fir, and incense-cedar, respectively.

†Ten-inch diameter classes are 10.0 to 19.9, 20.0 to 29.9,..., 50.0 to 59.9, and 60.0 inches and greater, respectively.

‡Twenty-foot height classes are 20 to 39.9, 40 to 59.9,..., 200.0 to 219.9, and 220.0 feet and taller, respectively.

TABLE 2. VOLUME EQUATION COEFFICIENTS FOR EQUATION (2) FOR DOUGLAS-FIR (1.0-FOOT STUMP)

Set No.	Top Height*	dib	Log rule	b_0	b_1	b_2	b_3	No. of trees	MSE
2.1	Total	8.0	Scribner	1.453E-04	2.4710	1.1371	0.99058	885	11.45
2.2	Total	6.0	Scribner	1.805E-04	2.3988	1.1370	0.99187	937	9.86
2.3	Total	4.0	Scribner	2.054E-04	2.3562	1.1372	0.99260	937	9.51
2.4	Merch.	8.0	Scribner	6.879E-04	2.0688	1.1161	0.99586	937	11.71
2.5	Merch.	6.0	Scribner	5.323E-04	2.1217	1.1210	0.99554	937	9.94
2.6	Merch.	4.0	Scribner	3.918E-04	2.1989	1.1239	0.99464	937	8.39
2.7	Total	8.0	Int'l 1/4	3.115E-04	2.2411	1.1338	0.99428	885	6.88
2.8	Total	6.0	Int'l 1/4	3.759E-04	2.1791	1.1334	0.99539	937	5.42
2.9	Total	4.0	Int'l 1/4	3.888E-04	2.1662	1.1345	0.99561	937	5.45
2.10	Merch.	8.0	Int'l 1/4	1.481E-03	1.8341	1.1152	0.99959	937	9.73
2.11	Merch.	6.0	Int'l 1/4	1.112E-03	1.8954	1.1201	0.99922	937	5.63
2.12	Merch.	4.0	Int'l 1/4	7.992E-04	1.9849	1.1194	0.99819	937	5.60
2.13	Total	4.0	Cubic	2.167E-03	1.9448	0.9969	0.99900	937	0.28
2.14	Total	0.0	Cubic	2.244E-03	1.9342	0.9964	0.99919	937	0.17
2.15	Merch.	4.0	Cubic	3.642E-03	1.8126	0.9906	1.00074	937	1.47

TABLE 3. VOLUME EQUATION COEFFICIENTS FOR EQUATION (2) FOR PONDEROSA PINE (1.0-FOOT STUMP)

Set No.	Top Height*	dib	Log rule	b_0	b_1	b_2	b_3	No. of trees	MSE
3.1	Total	8.0	Scribner	1.446E-04	2.4149	1.1515	0.99797	1621	12.25
3.2	Total	6.0	Scribner	1.798E-04	2.3406	1.1542	0.99945	1786	10.18
3.3	Total	4.0	Scribner	2.187E-04	2.2713	1.1550	1.00085	1786	9.09
3.4	Merch.	8.0	Scribner	6.901E-04	2.0415	1.1263	1.00107	1786	16.11
3.5	Merch.	6.0	Scribner	5.775E-04	2.0541	1.1338	1.00221	1782	11.52
3.6	Merch.	4.0	Scribner	4.176E-04	2.1383	1.1339	1.00150	1786	8.44
3.7	Total	8.0	Int'l 1/4	3.308E-04	2.1595	1.1484	1.00257	1621	8.19
3.8	Total	6.0	Int'l 1/4	3.910E-04	2.0987	1.1503	1.00377	1786	6.72
3.9	Total	4.0	Int'l 1/4	4.075E-04	2.0813	1.1521	1.00412	1786	6.60
3.10	Merch.	8.0	Int'l 1/4	1.411E-03	1.8181	1.1254	1.00491	1786	16.13
3.11	Merch.	6.0	Int'l 1/4	1.151E-03	1.8434	1.1302	1.00583	1782	9.73
3.12	Merch.	4.0	Int'l 1/4	8.072E-04	1.9367	1.1295	1.00511	1786	6.04
3.13	Total	4.0	Cubic	2.254E-03	1.8764	1.0005†	1.00647	1786	1.52
3.14	Total	0.0	Cubic	2.525E-03	1.8518	1.0004†	1.00791	1786	1.08
3.15	Merch.	4.0	Cubic	4.144E-03	1.7420	0.9909	1.00757	1786	3.43

†Not significantly different from 1.0

*Total height used in equation but volumes are to the tops specified. Merchantable heights are to the tops specified for volumes.

TABLE 4. VOLUME EQUATION COEFFICIENTS FOR EQUATION (2) FOR JEFFREY PINE (1.0-FOOT STUMP)

Set No.	Top Height*	dib	Log rule	b_0	b_1	b_2	b_3	No. of trees	MSE
4.1	Total	8.0	Scribner	1.137E-04	2.4250	1.2025	0.99562	907	7.43
4.2	Total	6.0	Scribner	1.334E-04	2.3642	1.2058	0.99690	927	7.11
4.3	Total	4.0	Scribner	1.539E-04	2.3078	1.2102	0.99800	927	6.97
4.4	Merch.	8.0	Scribner	5.120E-04	2.3111	1.0238	0.99434	927	12.62
4.5	Merch.	6.0	Scribner	4.050E-04	2.2883	1.0655	0.99611	927	10.21
4.6	Merch.	4.0	Scribner	3.185E-04	2.2488	1.1239	0.99761	927	9.68
4.7	Total	8.0	Int'l 1/4	2.117E-04	2.2303	1.2043	0.99888	907	4.00
4.8	Total	6.0	Int'l 1/4	2.422E-04	2.1768	1.2087	0.99996†	927	4.14
4.9	Total	4.0	Int'l 1/4	2.578E-04	2.1483	1.21198	1.00062†	927	4.02
4.10	Merch.	8.0	Int'l 1/4	1.112E-03	2.0446	1.0339	0.99932†	927	9.17
4.11	Merch.	6.0	Int'l 1/4	8.513E-04	2.0401	1.0722	1.00065†	927	6.92
4.12	Merch.	4.0	Int'l 1/4	5.508E-04	2.0751	1.1261	1.00067†	927	4.21
4.13	Total	4.0	Cubic	2.061E-03	1.9338	0.9949	1.00350	927	0.29
4.14	Total	0.0	Cubic	2.205E-03	1.9105	0.9951	1.00396	927	0.25
4.15	Merch.	4.0	Cubic	3.608E-03	1.8591	0.9481	1.00373	927	2.28

TABLE 5. VOLUME EQUATION COEFFICIENTS FOR EQUATION (2) FOR SUGAR PINE (1.0-FOOT STUMP)

Set No.	Top Height*	dib	Log rule	b_0	b_1	b_2	b_3	No. of trees	MSE
5.1	Total	8.0	Scribner	1.454E-04	2.5106	1.0857	0.99515	505	14.15
5.2	Total	6.0	Scribner	1.796E-04	2.4320	1.0898	0.99663	540	12.07
5.3	Total	4.0	Scribner	2.089E-04	2.3777	1.0922	0.99760	540	11.33
5.4	Merch.	8.0	Scribner	8.063E-04	2.0301	1.0910	1.0005†	540	17.37
5.5	Merch.	6.0	Scribner	6.610E-04	2.0611	1.0921	1.0012	540	12.32
5.6	Merch.	4.0	Scribner	4.203E-04	2.1861	1.0927	0.99972†	540	8.63
5.7	Total	8.0	Int'l 1/4	3.178E-04	2.2696	1.0825	0.99926	505	9.53
5.8	Total	6.0	Int'l 1/4	3.797E-04	2.2056	1.0848	1.00045†	540	8.31
5.9	Total	4.0	Int'l 1/4	3.938E-04	2.1868	1.0886	1.00080	540	8.14
5.10	Merch.	8.0	Int'l 1/4	1.673E-03	1.8136	1.0838	1.00414	540	15.46
5.11	Merch.	6.0	Int'l 1/4	1.257E-03	1.8766	1.0838	1.00419	540	8.98
5.12	Merch.	4.0	Int'l 1/4	7.080E-04	2.0389	1.0874	1.00195	540	5.83
5.13	Total	4.0	Cubic	2.256E-03	1.9884	0.9379	1.00316	540	0.95
5.14	Total	0.0	Cubic	2.377E-03	1.9719	0.9374	1.00346	540	0.80
5.15	Merch.	4.0	Cubic	4.190E-03	1.8215	0.9368	1.00495	540	1.72

†Not significantly different from 1.0

*Total height used in equation but volumes are to the tops specified. Merchantable heights are to the tops specified for volumes.

TABLE 6. VOLUME EQUATION COEFFICIENTS FOR EQUATION (2) FOR LODGEPOLE PINE (1.0-FOOT STUMP)

Set No.	Top Height*	dib	Log rule	b_0	b_1	b_2	b_3	No. of trees	MSE
6.1	Total	8.0	Scribner	2.360E-05	2.9391	1.2941	0.97912	170	1.77
6.2	Total	6.0	Scribner	4.692E-05	2.6326	1.3115	0.98812	235	1.55
6.3	Total	4.0	Scribner	8.907E-05	2.3617	1.3213	0.99593	235	1.87
6.4	Merch.	8.0	Scribner	5.851E-04	2.0105	1.1743	1.00446†	235	5.82
6.5	Merch.	6.0	Scribner	3.802E-04	2.1281	1.1860	1.00019†	235	3.10
6.6	Merch.	4.0	Scribner	3.120E-04	2.1813	1.1964	0.99847	235	1.86
6.7	Total	8.0	Int'l 1/4	6.843E-05	2.6117	1.2740	0.98579	170	2.08
6.8	Total	6.0	Int'l 1/4	1.017E-05	2.4274	1.2904	0.99099	235	1.50
6.9	Total	4.0	Int'l 1/4	1.085E-04	2.3985	1.2924	0.99181	235	1.54
6.10	Merch.	8.0	Int'l 1/4	7.510E-04	2.0720	1.1290	0.99848†	235	4.95
6.11	Merch.	6.0	Int'l 1/4	4.882E-04	2.1912	1.1422	0.99534	235	1.91
6.12	Merch.	4.0	Int'l 1/4	4.051E-04	2.2064	1.1585	0.99488	235	0.99
6.13	Total	4.0	Cubic	1.568E-03	2.1117	0.99395	0.99688	235	0.10
6.14	Total	0.0	Cubic	1.800E-03	2.0549	0.9959	0.99846	235	0.11
6.15	Merch.	4.0	Cubic	3.770E-03	1.9591	0.9193	1.00005†	235	1.10

TABLE 7. VOLUME EQUATION COEFFICIENTS FOR EQUATION (2) FOR WHITE FIR (1.0-FOOT STUMP)

Set No.	Top Height*	dib	Log rule	b_0	b_1	b_2	b_3	No. of trees	MSE
7.1	Total	8.0	Scribner	9.396E-05	2.4786	1.2537	0.98971	2030	9.97
7.2	Total	6.0	Scribner	1.170E-04	2.4000	1.2550	0.99131	2221	7.97
7.3	Total	4.0	Scribner	1.414E-04	2.3337	1.2553	0.99266	2221	7.72
7.4	Merch.	8.0	Scribner	5.811E-04	1.9949	1.2376	0.99580	2205	23.39
7.5	Merch.	6.0	Scribner	4.576E-04	2.0727	1.2194	0.99552	2221	13.65
7.6	Merch.	4.0	Scribner	3.001E-04	2.1649	1.2350	0.99440	2221	11.47
7.7	Total	8.0	Int'l 1/4	2.247E-04	2.2153	1.2410	0.99468	2030	7.56
7.8	Total	6.0	Int'l 1/4	2.667E-04	2.1533	1.2430	0.99589	2221	6.25
7.9	Total	4.0	Int'l 1/4	2.836E-04	2.1290	1.2445	0.99639	2221	6.39
7.10	Merch.	8.0	Int'l 1/4	1.322E-03	1.7387	1.2313	1.00057	2205	21.80
7.11	Merch.	6.0	Int'l 1/4	9.939E-04	1.8321	1.2137	0.99996†	2221	13.47
7.12	Merch.	4.0	Int'l 1/4	5.887E-04	1.9635	1.2266	0.99807	2221	9.90
7.13	Total	4.0	Cubic	1.687E-03	1.9475	1.0664	0.99932	2221	4.21
7.14	Total	0.0	Cubic	1.788E-03	1.9289	1.0653	0.99971	2221	4.15
7.15	Merch.	4.0	Cubic	3.399E-03	1.7722	1.0535	1.00161	2221	11.36

†Not significantly different from 1.0

*Total height used in equation but volumes are to the tops specified. Merchantable heights are to the tops specified for volumes.

TABLE 8. VOLUME EQUATION COEFFICIENTS FOR EQUATION (2) FOR RED FIR (1.0-FOOT STUMP)

Set No.	Top Height*	dib	Log rule	b_0	b_1	b_2	b_3	No. of trees	MSE
8.1	Total	8.0	Scribner	1.522E-04	2.1052	1.4253	0.99211	886	7.12
8.2	Total	6.0	Scribner	7.510E-05	2.2783	1.4369	0.99009	886	7.20
8.3	Total	4.0	Scribner	8.959E-05	2.2078	1.4345	0.99168	886	7.52
8.4	Merch.	8.0	Scribner	2.985E-04	2.0287	1.3600	0.99290	886	7.94
8.5	Merch.	6.0	Scribner	2.359E-04	2.0582	1.3724	0.99321	886	9.11
8.6	Merch.	4.0	Scribner	1.741E-04	2.0941	1.4007	0.99281	886	7.15
8.7	Total	8.0	Int'l 1/4	1.297E-04	2.1207	1.4323	0.99260	825	6.92
8.8	Total	6.0	Int'l 1/4	1.573E-04	2.0504	1.4343	0.99402	886	5.57
8.9	Total	4.0	Int'l 1/4	1.657E-04	2.0324	1.4335	0.99448	886	5.70
8.10	Merch.	8.0	Int'l 1/4	7.231E-04	1.7592	1.3493	0.99793	886	6.34
8.11	Merch.	6.0	Int'l 1/4	5.272E-04	1.8074	1.3679	0.99781	886	5.06
8.12	Merch.	4.0	Int'l 1/4	3.486E-04	1.8759	1.4002	0.99665	886	4.93
8.13	Total	4.0	Cubic	1.142E-03	1.8857	1.2033	0.99717	886	7.27
8.14	Total	0.0	Cubic	1.195E-03	1.8702	1.2034	0.99748	886	7.17
8.15	Merch.	4.0	Cubic	2.179E-03	1.7398	1.1771	0.99954	886	7.59

TABLE 9. VOLUME EQUATION COEFFICIENTS FOR EQUATION (2) FOR INCENSE-CEDAR (1.0-FOOT STUMP)

Set No.	Top Height*	dib	Log rule	b_0	b_1	b_2	b_3	No. of trees	MSE
9.1	Total	8.0	Scribner	4.384E-05	2.7966	1.1266	0.98661	512	4.88
9.2	Total	6.0	Scribner	6.144E-05	2.6885	1.1237	0.98855	554	4.29
9.3	Total	4.0	Scribner	7.882E-05	2.5998	1.1200	0.99016	554	4.73
9.4	Merch.	8.0	Scribner	2.391E-04	2.3627	1.1104	0.99124	554	10.51
9.5	Merch.	6.0	Scribner	2.540E-04	2.3454	1.0861	0.99289	554	5.84
9.6	Merch.	4.0	Scribner	1.944E-04	2.4106	1.0844	0.99241	554	4.74
9.7	Total	8.0	Int'l 1/4	1.038E-04	2.5355	1.1249	0.99065	512	3.11
9.8	Total	6.0	Int'l 1/4	1.447E-04	2.4291	1.1221	0.99255	554	2.60
9.9	Total	4.0	Int'l 1/4	1.472E-04	2.4209	1.1236	0.99267	554	2.60
9.10	Merch.	8.0	Int'l 1/4	4.887E-04	2.1489	1.1104	0.99440	554	8.68
9.11	Merch.	6.0	Int'l 1/4	4.845E-04	2.1559	1.0850	0.99563	554	4.10
9.12	Merch.	4.0	Int'l 1/4	3.544E-04	2.2354	1.0827	0.99496	554	2.33
9.13	Total	4.0	Cubic	1.749E-03	2.0973	0.9042	0.99790	554	0.25
9.14	Total	0.0	Cubic	1.930E-03	2.0677	0.9017	0.99848	554	0.20
9.15	Merch.	4.0	Cubic	3.516E-03	1.9292	0.8827	1.00030	554	1.11

*Total height used in equation but volumes are to the tops specified. Merchantable heights are to the tops specified for volumes.

TABLE 10. RATIO OF TREE VOLUME EQUATION TO STEM TAPER VOLUME BY SPECIES,* DBH CLASS,† AND HEIGHT CLASS‡

Species		Height Class (midpoint in feet)											
obs.	DBH	30	50	70	90	110	130	150	170	190	210	230
DF	15		1.01	1.02	1.00	1.00	1.00	1.00				
962	25			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	35				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	45					1.00	1.00	1.00	1.00	1.00	1.00	1.00
	55					1.00		1.00	1.00	1.00	1.00	1.00
	60+						1.00	1.00	1.00	1.00		1.00
PP	15	1.07	1.03	1.02	1.02	1.01	1.00	1.2	1.01			
1845	25		1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99		
	35			0.99	1.00	1.00	1.00	1.00	1.00	1.00		
	45				1.00	1.00	1.00	1.00	1.00	1.00		1.00
	55				1.00	1.00	1.00	1.00	1.00	1.00	1.01	
	60+							1.00	0.99	1.00		
JP	15	1.03	1.02	1.02	1.00	1.01		1.01				
993	25		1.00	1.00	1.00	1.00	1.00					
	35		1.00	1.00	1.00	1.00	1.00	1.00	1.00			
	45		1.00	1.00	1.00	1.00	1.00	1.00	1.00			
	55				1.00	1.00	1.00					
SP	15	1.06	1.04	1.02	1.01	1.00	1.00					
552	25		1.02	1.01	1.00	1.00	1.00	0.99				
	35				1.00	1.00	1.00	1.00	0.99			
	45					1.00	1.00	1.00	1.00	1.00		
	55					1.00	1.00	1.00	1.00	1.00	1.00	
	60+							1.00	1.00		1.01	
LP	15	1.02	1.00	1.00	1.00	1.00						
266	25	0.98	1.00	1.00	1.00	1.00	1.00	1.00				
	35			1.00	1.00	1.00		1.00				
	45			1.00								
WF	15	1.00	1.03	1.02	1.00	0.98	0.89					
2294	25	0.97	0.98	1.00	1.01	1.00	0.99	0.99	0.93			
	35		0.96	0.99	1.00	1.00	1.00	1.00	0.98	0.95		
	45				0.98	0.99	1.00	1.00	1.00	1.00	0.98	
	55				0.98		0.99	1.00	1.00	1.00	1.00	1.00
	60+							0.99	1.00	1.00		
RF	15	0.98	1.00	1.01	1.01	1.00						
904	25		0.96	0.99	1.00	1.00	0.99	0.97	0.94			
	35			0.96	0.99	1.01	1.01	0.99	0.98			
	45				0.99	1.00	1.01	1.01	1.00	0.98	0.94	
	55						1.00	1.01	1.01			
	60+				0.95			1.00				
IC	15	1.01	1.00	1.00	0.99	0.98						
573	25	1.03	1.01	1.00	1.00	1.00	1.00	0.99				
	35			1.01	1.00	1.00	1.00	1.00				
	45				1.00	1.00	1.00	1.00				
	55				1.00	1.00	1.00	1.00				
	60+					0.99					1.00	

*Two-letter species codes represent Douglas-fir, ponderosa pine, Jeffrey pine, sugar pine, lodgepole pine, white fir, red fir, and incense-cedar, respectively.

†Ten-inch diameter classes are 10.0 to 19.9, 20.0 to 29.9,..., 50.0 to 59.9, and 60.0 inches and greater, respectively.

‡Twenty-foot height classes are 20 to 39.9, 40 to 59.9,..., 200.0 to 219.9, and 220.0 feet and taller, respectively.

TABLE 11. APPENDIX A TABLES BY SPECIES, TOP DIAMETER (INCHES), MERCHANTABLE OR TOTAL HEIGHT, AND SCRIBNER BOARD FOOT OR CUBIC FOOT VOLUMES

			Species							
Volume	Top	Height	DF	PP	JP	SP	LP	WF	RF	IC
			Appendix A number							
Scribner	4	total	1	2	3	4	5	6	7	8
Scribner	6	total	9	10	11	12	13	14	15	16
Scribner	8	total	17	18	19	20	21	22	23	24
Scribner	4	merch	25	26	27	28	29	30	31	32
Scribner	6	merch	33	34	35	36	37	38	39	40
Scribner	8	merch	41	42	43	44	45	46	47	48
Cubic	0	total	49	50	51	52	53	54	55	56
Cubic	4	total	57	58	59	60	61	62	63	64
Cubic	4	merch	65	66	67	68	69	70	71	72

LITERATURE CITED

BIGING, G. S.
1984. Taper equations for second-growth mixed conifers of northern California. For. Sci. 30 (4): 1103-17.

BRUCE, D., and F. X. SCHUMACHER
1950. Forest Mensuration, 3rd edition. McGraw-Hill, N.Y.

OLSON, C. M., and L. C. WENSEL
1995. Tip length models for major commercial California conifers. Hilgardia 62(4), 6 pp. (Published concurrently and bound in this volume.)

WENSEL, L. C.
1971. Tree volume equations from measurements taken with a Barr and Stroud Optical Dendrometer. Hilgardia 41 (4): 55-64. University of California, Division of Agricultural Sciences.
1977a. Volume tables for young-growth conifers in the northern regions of California. University of California, Division of Agricultural Sciences Bulletin 1883.
1977b. A generalized prismoidal log volume equation. Biometrics Note No. 5, Department of Forestry and Conservation, University of California, Berkeley.

WENSEL, L. C. and B. KRUMLAND
1983. Volume and taper relationships for redwood, Douglas-fir, and other conifers in California's north coast. University of California, Division of Agricultural Sciences Bulletin 1907.

WENSEL, L. C. and C. M. OLSON
1995. Tree taper models for major commercial California conifers. Hilgardia 62(3), 16 pp. (Published concurrently and bound in this volume.)

ACKNOWLEDGMENTS

The authors gratefully acknowledge the assistance of Kevin Casey, LeRoy Dolph, Ralph Johnson, Charles Stadelman, and Ralph Warbington of the U.S. Forest Service in helping to accumulate the data sets used for this study. Recognition is also given to Ralph Warbington for securing the necessary funding to complete this phase of the tree taper study.

APPENDIX A-1. SCRIBNER BOARD FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—DOUGLAS-FIR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	4	5	5	6	7	8	9													
12	3	4	6	7	8	10	11	12	14	15												
14	4	6	8	10	12	14	15	17	19	21	24											
16	6	8	11	13	16	18	21	24	26	29	32	35										
18	8	11	14	17	20	24	27	31	34	38	41	45	49									
20	10	14	18	22	26	30	34	39	43	48	52	57	61	66								
22	12	17	22	27	32	37	42	48	53	59	64	70	76	82	87							
24	15	20	26	32	39	45	51	58	64	71	78	85	92	99	106	113						
26	17	24	31	38	46	53	61	69	77	85	93	101	109	117	126	134	143	151				
28	21	28	37	45	54	63	72	81	90	99	109	118	128	138	147	157	167	177	187			
30		33	42	52	62	73	83	93	104	115	126	137	148	159	171	182	194	206	217	229		
32		38	49	60	71	83	95	107	119	132	144	157	170	183	196	209	222	236	249	263	276	
34		43	55	68	81	95	108	122	136	150	164	179	193	208	223	238	253	268	283	299	314	330
36		48	62	77	92	107	122	137	153	169	185	201	218	234	251	268	285	302	319	337	354	372
38			70	86	102	119	136	154	171	189	207	225	244	262	281	300	319	338	357	377	396	416
40			78	96	114	133	152	171	190	210	230	251	271	292	312	333	355	376	397	419	441	463
42			86	106	126	147	168	189	211	232	255	277	300	322	345	369	392	415	439	463	487	511
44				116	138	161	184	208	231	256	280	304	329	354	380	405	431	457	483	509	535	562
46				127	151	176	202	227	253	280	306	333	360	388	415	443	471	500	528	557	586	615
48				138	165	192	220	247	276	304	333	363	392	422	452	483	513	544	575	607	638	670
50				150	179	208	238	268	299	330	362	394	426	458	491	524	557	590	624	658	692	726
52					193	225	257	290	323	357	391	425	460	495	530	566	602	638	674	711	748	785
54					208	242	277	312	348	384	421	458	495	533	571	609	648	687	726	766	805	845
56					224	260	297	335	374	413	452	492	532	572	613	654	696	738	780	822	865	907
58					239	278	318	359	400	442	484	526	569	612	656	700	745	789	834	880	925	971
60						297	340	383	427	471	516	561	607	654	700	747	795	842	890	939	987	1036
62						316	362	408	454	502	549	598	646	696	745	795	846	897	948	999	1051	1103
64						336	384	433	482	533	583	635	686	739	791	844	898	952	1006	1061	1116	1171
66							407	458	511	564	618	672	727	782	838	895	951	1008	1066	1124	1182	1241
68							430	485	540	596	653	711	769	827	886	946	1006	1066	1127	1188	1250	1312
70							454	511	570	629	689	750	811	872	935	998	1061	1124	1189	1253	1318	1384

Coefficient set 2.3 $b_0 = .20540E\text{-}03$ $b_1 = 2.35620$ $b_2 = 1.13720$ $b_3 = .99260$

APPENDIX A-2. SCRIBNER BOARD FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—PONDEROSA PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	4	5	6	6	7	8	9													
12	3	4	6	7	8	10	11	13	14	16												
14	5	6	8	10	12	14	16	18	20	22	25											
16	6	9	11	14	16	19	22	25	27	30	33	36										
18	8	11	14	18	21	25	28	32	36	40	44	47	51									
20	10	14	18	23	27	32	36	41	46	51	55	60	65	70								
22	13	18	23	28	34	39	45	51	57	63	69	75	81	88	94							
24	15	22	28	34	41	48	55	62	69	77	84	92	99	107	115	123						
26	19	26	34	41	49	58	66	75	83	92	101	110	119	129	138	147	157	166				
28	22	31	40	49	59	68	78	89	99	109	120	131	141	152	163	175	186	197	209			
30		36	47	58	69	80	92	104	116	128	140	153	166	179	191	205	218	231	244	258		
32		42	54	67	80	93	107	120	134	149	163	177	192	207	222	237	253	268	283	299	315	
34		48	62	77	92	107	122	138	154	171	187	204	221	238	255	273	290	308	326	344	362	380
36		55	71	87	104	122	140	158	176	195	214	233	252	271	291	311	331	351	372	392	413	434
38			80	99	118	138	158	179	199	221	242	264	285	307	330	352	375	398	421	444	468	491
40			90	111	133	155	178	201	224	248	272	297	321	346	371	396	422	448	474	500	526	553
42			101	125	149	174	199	225	251	278	305	332	359	387	415	444	472	501	530	559	589	619
44				139	166	194	222	251	280	309	339	370	400	431	462	494	526	558	590	623	656	689
46				154	184	215	246	278	310	343	376	409	443	478	512	547	583	618	654	690	727	763
48				170	203	237	271	306	342	378	415	452	489	527	565	604	643	682	722	761	802	842
50				187	223	260	298	337	376	416	456	497	538	579	621	664	707	750	793	837	881	925
52					244	285	326	369	412	455	499	544	589	634	680	727	774	821	868	916	965	1013
54					266	311	356	402	449	497	545	593	643	692	743	793	844	896	948	1000	1053	1106
56					290	338	388	438	489	540	593	646	699	753	808	863	919	975	1031	1088	1145	1203
58					314	367	420	475	530	586	643	700	758	817	876	936	997	1057	1119	1180	1243	1305
60						397	455	514	573	634	696	758	821	884	948	1013	1078	1144	1210	1277	1344	1412
62						428	491	554	619	684	751	818	885	954	1023	1093	1163	1234	1306	1378	1451	1524
64						461	528	597	666	737	808	880	953	1027	1102	1177	1253	1329	1406	1484	1562	1641
66							568	641	716	791	868	946	1024	1103	1183	1264	1346	1428	1510	1594	1678	1762
68							609	687	767	848	931	1014	1098	1183	1268	1355	1442	1530	1619	1709	1799	1889
70							651	735	821	908	996	1084	1174	1265	1357	1450	1543	1637	1732	1828	1924	2021

Coefficient set 3.3 b_0 = .21870E-03 b_1 = 2.27130 b_2 = 1.15500 b_3 = 1.00085

APPENDIX A-3. SCRIBNER BOARD FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—JEFFREY PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	3	4	5	6	7	8	9													
12	3	4	5	7	8	9	11	12	14	15												
14	4	6	8	9	11	13	15	17	20	22	24											
16	5	8	10	13	15	18	21	24	26	29	32	35										
18	7	10	13	17	20	24	27	31	35	38	42	46	50									
20	9	13	17	21	25	30	34	39	44	49	54	59	64	69								
22	11	16	21	26	32	37	43	49	55	61	67	73	79	86	92							
24	14	20	26	32	38	45	52	59	66	74	81	89	97	104	112	120						
26	17	23	31	38	46	54	62	71	80	88	97	107	116	125	135	144	154	164				
28	20	28	36	45	54	64	74	84	94	104	115	126	137	148	159	171	182	194	206			
30		32	42	53	64	75	86	98	110	122	134	147	160	173	186	199	213	226	240	254		
32		37	49	61	73	86	100	113	127	141	155	170	185	200	215	230	246	262	278	294	310	
34		43	56	70	84	99	114	130	145	162	178	195	212	229	246	264	282	300	318	336	355	374
36		49	64	79	96	112	130	147	165	184	202	221	240	260	280	300	320	341	361	382	403	425
38			72	90	108	127	146	166	186	207	228	250	271	293	316	338	361	384	408	431	455	479
40			80	100	121	142	164	186	209	232	256	280	304	329	354	379	405	431	457	484	510	537
42			90	112	135	158	183	208	233	259	285	312	339	367	395	423	451	480	510	539	569	599
44				124	150	176	203	230	258	287	316	346	376	407	438	469	501	533	565	598	631	664
46				137	165	194	224	254	285	317	349	382	415	449	483	517	552	588	624	660	696	733
48				150	181	213	246	279	313	348	384	419	456	493	531	569	607	646	685	725	765	805
50				165	198	233	269	306	343	381	420	459	499	540	581	622	664	707	750	793	837	881
52					216	254	293	333	374	415	458	501	544	588	633	679	724	771	818	865	913	961
54					235	276	319	362	406	451	497	544	591	639	688	737	787	838	888	940	992	1044
56					255	299	345	392	440	489	539	589	641	693	745	799	853	907	962	1018	1074	1131
58					275	323	373	423	475	528	582	636	692	748	805	863	921	980	1039	1100	1160	1222
60						348	402	456	512	569	627	685	745	806	867	929	992	1055	1120	1184	1250	1316
62						374	431	490	550	611	673	736	800	865	931	998	1066	1134	1203	1272	1343	1414
64						401	462	525	589	655	721	789	858	928	998	1070	1142	1215	1289	1364	1439	1515
66							494	562	630	700	771	844	917	992	1067	1144	1221	1299	1378	1458	1539	1620
68							527	599	672	747	823	900	979	1058	1139	1220	1303	1386	1471	1556	1642	1729
70							562	638	716	796	877	959	1042	1127	1213	1300	1388	1476	1566	1657	1748	1841

Coefficient set 4.3 b_0 = .15390E-03 b_1 = 2.30780 b_2 = 1.21020 b_3 = .99800

APPENDIX A-4. SCRIBNER BOARD FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION–SUGAR PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	3	4	5	6	7	7	8													
12	3	4	5	7	8	9	10	11	13	14												
14	4	6	8	9	11	13	15	16	18	20	22											
16	6	8	11	13	15	18	20	22	25	27	30	32										
18	8	11	14	17	20	23	26	30	33	36	39	43	46									
20	10	14	18	22	26	30	34	38	42	46	50	55	59	63								
22	13	17	22	27	32	37	42	47	52	58	63	68	73	79	84							
24	15	21	27	33	39	45	51	58	64	70	77	83	90	96	103	110						
26	19	26	33	40	47	54	62	69	77	85	92	100	108	116	124	132	140	148				
28	22	30	39	47	56	65	73	82	91	101	110	119	128	138	147	157	166	176	185			
30		36	45	55	65	76	86	97	107	118	129	140	150	161	173	184	195	206	217	229		
32		41	53	64	76	88	100	112	124	137	149	162	175	187	200	213	226	239	252	265	278	
34		47	60	74	87	101	115	129	143	157	172	186	201	215	230	245	260	275	290	305	320	335
36		54	69	84	100	115	131	147	163	179	196	212	229	246	262	279	296	313	330	348	365	382
38			78	95	113	130	148	166	185	203	222	240	259	278	297	316	335	355	374	393	413	433
40			88	107	127	147	167	187	208	228	249	270	291	312	334	355	377	399	420	442	464	486
42			98	120	142	164	186	209	232	255	278	302	325	349	373	397	421	446	470	494	519	544
44				133	157	182	207	232	258	283	309	335	362	388	415	441	468	495	522	550	577	604
46				147	174	201	229	257	285	314	342	371	400	429	459	488	518	548	578	608	638	669
48				162	192	222	252	283	314	345	377	409	441	473	505	538	570	603	636	669	703	736
50				178	210	243	277	310	344	379	413	448	483	518	554	590	626	662	698	734	771	807
52					230	266	302	339	376	414	452	490	528	566	605	644	683	723	762	802	842	882
54					250	289	329	369	410	450	492	533	575	617	659	701	744	787	830	873	917	960
56					271	314	357	400	444	489	533	578	624	669	715	761	807	854	901	947	995	1042
58					293	340	386	433	481	529	577	626	675	724	773	823	873	924	974	1025	1076	1127
60						366	417	467	519	570	622	675	728	781	834	888	942	996	1051	1106	1161	1216
62						394	448	503	558	614	670	726	783	840	898	955	1014	1072	1131	1190	1249	1308
64						423	481	540	599	659	719	779	840	902	963	1025	1088	1151	1213	1277	1340	1404
66							515	578	641	705	770	834	900	965	1032	1098	1165	1232	1299	1367	1435	1503
68							550	617	685	753	822	892	961	1032	1102	1173	1244	1316	1388	1461	1533	1606
70							587	658	730	803	877	951	1025	1100	1175	1251	1327	1403	1480	1557	1635	1713

Coefficient set 5.3 $b_0 = .20890E\text{-}03$ $b_1 = 2.37770$ $b_2 = 1.09220$ $b_3 = .99760$

APPENDIX A-5. SCRIBNER BOARD FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—LODGEPOLE PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	3	4	5	6	8	9	10													
12	3	4	5	7	8	10	11	13	15	17												
14	4	6	8	10	12	14	16	19	21	24	27											
16	5	8	10	13	16	19	22	26	29	33	36	40										
18	7	10	13	17	21	25	29	34	38	43	47	52	57									
20	9	13	17	22	27	32	37	43	48	54	60	66	73	79								
22	11	16	21	27	33	39	46	53	60	67	75	83	90	99	107							
24	13	19	26	33	40	48	56	65	73	82	91	101	110	120	130	140						
26	16	23	31	39	48	58	67	77	88	98	109	121	132	144	156	168	180	193				
28	19	27	37	47	57	68	79	91	104	116	129	142	156	170	184	199	213	228	243			
30		32	43	54	67	79	93	107	121	136	151	166	182	198	215	232	249	266	284	302		
32		37	49	63	77	92	107	123	140	157	174	192	210	229	248	268	288	308	328	349	370	
34		42	56	72	88	105	123	141	160	179	199	220	241	262	284	307	329	352	376	400	424	448
36		48	64	81	100	119	139	160	182	204	226	250	273	298	323	348	374	400	427	454	481	509
38			72	92	113	134	157	180	205	230	255	281	308	336	364	392	421	451	481	511	542	574
40			81	103	126	150	176	202	229	257	286	315	345	376	407	439	472	505	538	572	607	642
42			90	114	140	167	196	225	253	286	318	351	384	418	453	489	525	562	599	637	676	715
44				127	155	185	217	249	282	317	352	388	425	463	502	541	581	622	663	705	748	791
46				140	171	204	239	274	311	349	388	428	468	510	553	596	640	685	731	777	824	872
48				153	188	224	262	301	341	383	425	469	514	560	606	654	702	751	801	852	904	956
50				167	205	245	286	328	373	418	465	512	561	611	662	714	767	821	875	931	987	1044
52					223	266	311	357	405	455	505	557	611	665	721	777	835	893	953	1013	1074	1136
54					242	289	337	388	440	493	548	605	662	721	781	843	905	968	1033	1098	1165	1232
56					261	312	364	419	475	533	592	653	716	779	844	911	978	1047	1116	1187	1259	1332
58					282	336	393	451	512	574	638	704	771	840	910	981	1054	1128	1203	1279	1357	1435
60						361	422	485	550	617	686	757	829	903	978	1055	1133	1212	1293	1375	1458	1542
62						387	452	520	590	661	735	811	888	967	1048	1130	1214	1299	1386	1473	1563	1653
64						414	484	556	630	707	786	867	950	1034	1120	1208	1298	1389	1481	1575	1671	1767
66							516	593	672	754	838	925	1013	1103	1195	1289	1384	1481	1580	1680	1782	1885
68							549	631	716	803	892	984	1078	1174	1272	1372	1473	1577	1682	1788	1897	2006
70							583	670	760	853	948	1045	1145	1247	1351	1457	1565	1675	1786	1900	2015	2131

Coefficient set 6.3 $b_0 = .89070E\text{-}04$ $b_1 = 2.36170$ $b_2 = 1.32130$ $b_3 = .99594$

APPENDIX A-6. SCRIBNER BOARD FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—WHITE FIR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	4	5	6	7	8	9	10													
12	3	4	6	7	9	10	12	14	16	17												
14	4	6	8	10	12	15	17	20	22	25	27											
16	6	8	11	14	17	20	23	26	30	33	37	40										
18	8	11	14	18	22	26	30	34	38	43	47	52	57									
20	9	14	18	23	27	32	38	43	48	54	60	66	72	78								
22	12	17	22	28	34	40	46	53	60	67	74	81	88	95	103							
24	14	20	27	34	41	48	56	64	72	80	89	97	106	115	124	134						
26	17	24	32	40	48	57	66	76	85	95	105	116	126	137	148	159	170	181				
28	20	28	37	47	57	67	78	89	100	112	124	136	148	160	173	186	199	212	226			
30		33	43	54	66	78	90	103	116	129	143	157	171	186	200	215	230	246	261	277		
32		37	49	62	75	89	103	118	133	148	164	180	196	213	229	246	264	281	299	317	335	
34		42	56	70	85	101	117	134	151	168	186	204	222	241	260	280	299	319	339	360	381	401
36		48	63	79	96	114	132	151	170	189	209	230	251	272	293	315	337	359	382	405	428	452
38			71	89	108	127	147	168	190	212	234	257	280	304	328	352	377	402	427	453	479	505
40			78	98	119	141	164	187	211	235	260	285	311	337	364	391	419	446	475	503	532	561
42			86	109	132	156	181	206	233	260	287	315	343	372	402	432	462	493	524	556	587	620
44				119	145	171	199	227	256	285	315	346	377	409	441	474	508	541	576	610	645	681
46				131	158	187	217	248	279	312	345	378	412	447	483	518	555	592	629	667	705	744
48				142	172	204	236	270	304	339	375	412	449	487	525	564	604	644	685	726	767	810
50				154	187	221	256	292	330	368	406	446	486	527	569	612	654	698	742	787	832	877
52					202	239	277	316	356	397	439	482	525	570	615	660	707	754	801	849	898	948
54					217	257	298	340	383	427	472	518	565	613	661	711	760	811	862	914	967	1020
56					233	275	319	364	411	458	507	556	606	657	709	762	816	870	925	981	1037	1094
58					249	295	341	390	439	490	542	595	648	703	759	815	872	930	989	1049	1109	1170
60						314	364	416	469	523	578	634	692	750	809	869	930	992	1055	1118	1183	1247
62						334	387	442	498	556	615	675	736	798	861	925	990	1056	1122	1190	1258	1327
64						355	411	469	529	590	652	716	781	846	913	981	1050	1120	1191	1262	1335	1408
66							435	497	560	625	691	758	826	896	967	1039	1112	1186	1261	1337	1413	1491
68							460	525	592	660	730	801	873	947	1022	1098	1175	1253	1332	1412	1493	1575
70							485	553	624	696	769	844	921	998	1077	1157	1239	1321	1404	1489	1574	1661

Coefficient set 7.3 b_0 = .14140E-03 b_1 = 2.33370 b_2 = 1.25530 b_3 = .99266

APPENDIX A-7. SCRIBNER BOARD FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—RED FIR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	4	5	6	7	8	10	11													
12	3	4	5	7	9	11	12	14	17	19												
14	4	5	7	10	12	15	17	20	23	26	29											
16	5	7	10	13	16	19	23	26	30	34	38	43										
18	6	9	12	16	20	24	29	34	39	44	49	55	60									
20	7	11	15	20	25	30	36	42	48	54	61	68	75	82								
22	9	14	19	24	30	37	44	51	58	66	74	82	91	100	109							
24	11	16	22	29	36	44	52	60	69	79	88	98	108	119	129	140						
26	13	19	26	34	43	52	61	71	81	92	103	115	127	139	152	165	178	192				
28	15	22	30	39	49	60	71	82	94	107	120	133	147	161	176	191	206	222	238			
30		25	35	45	56	68	81	94	108	122	137	152	168	185	201	219	236	254	273	292		
32		29	39	51	64	77	92	107	122	139	155	173	191	209	228	248	268	288	309	331	352	
34		32	44	58	72	87	103	120	138	156	175	194	215	235	257	279	301	324	348	372	396	421
36		36	50	64	80	97	115	134	153	174	195	217	239	263	287	311	336	362	388	415	442	470
38			55	71	89	108	128	148	170	193	216	240	265	291	318	345	372	401	430	460	490	521
40			60	79	98	119	140	163	187	212	238	265	292	321	350	380	410	442	474	506	540	574
42			66	86	107	130	154	179	205	232	261	290	320	351	383	416	449	484	519	554	591	628
44				94	117	142	168	195	224	253	284	316	349	383	417	453	490	527	565	604	644	685
46				102	127	154	182	212	243	275	308	343	378	415	453	492	531	572	613	656	699	743
48				110	137	166	196	229	262	297	333	370	409	448	489	531	574	618	662	708	755	802
50				118	147	179	211	246	282	319	358	399	440	483	527	571	618	665	713	762	812	863
52					158	191	227	264	302	343	384	427	472	518	565	613	662	713	765	817	871	926
54					169	205	242	282	323	366	411	457	504	553	604	655	708	762	817	874	931	990
56					180	218	258	300	344	390	438	487	537	590	643	698	754	812	871	931	992	1055
58					191	232	274	319	366	415	465	517	571	626	683	742	802	863	925	989	1054	1121
60						246	291	338	388	439	493	548	605	664	724	786	850	914	981	1048	1118	1188
62						260	308	358	410	465	521	580	640	702	766	831	898	967	1037	1109	1182	1256
64						274	324	377	433	490	550	611	675	741	808	877	948	1020	1094	1169	1246	1325
66							341	397	455	516	579	644	711	779	850	923	997	1073	1151	1231	1312	1394
68							359	417	478	542	608	676	746	819	893	969	1048	1128	1209	1293	1378	1465
70							376	437	501	568	637	709	782	858	936	1016	1098	1182	1268	1355	1445	1536

Coefficient set 8.3 b_0 = .89590E-04 b_1 = 2.20780 b_2 = 1.43450 b_3 = .99168

APPENDIX A-8. SCRIBNER BOARD FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—INCENSE-CEDAR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	1	2	2	3	3	4	4	5	5													
12	2	3	4	4	5	6	7	8	9	10												
14	3	4	5	6	8	9	10	11	13	14	15											
16	4	6	7	9	11	12	14	16	18	19	21	23										
18	5	8	10	12	14	16	19	21	23	26	28	31	33									
20	7	10	12	15	18	21	24	27	30	33	36	40	43	46								
22	9	12	16	19	23	27	30	34	38	42	46	50	54	58	62							
26	13	18	23	29	34	39	45	51	56	62	68	74	80	86	92	98	104	110				
28	16	22	28	34	40	47	53	60	67	74	81	88	95	102	109	116	123	131	138			
30		25	32	40	47	55	63	70	78	86	95	103	111	119	128	136	145	153	162	170		
32		29	38	46	55	64	73	82	91	100	110	119	129	138	148	158	168	178	188	198	208	
34		34	43	53	63	73	83	94	104	115	126	137	148	159	170	181	192	204	215	227	238	250
36		38	49	60	72	83	95	107	119	131	143	156	168	181	193	206	219	232	245	258	271	284
38			55	68	81	94	107	120	134	148	162	175	190	204	218	233	247	262	276	291	306	321
40			62	76	90	105	120	135	150	165	181	197	212	228	244	260	277	293	310	326	343	360
42			69	85	101	117	133	150	167	184	201	219	236	254	272	290	308	326	345	363	382	400
44				94	111	129	148	166	185	204	223	242	262	281	301	321	341	361	381	402	422	443
46				103	123	142	162	183	203	224	245	266	288	309	331	353	375	397	420	442	465	487
48				113	134	156	178	200	223	246	269	292	315	339	363	387	411	435	459	484	509	534
50				123	146	170	194	218	243	268	293	318	344	369	395	421	448	474	501	528	555	582
52					159	185	211	237	264	291	318	345	373	401	429	458	486	515	544	573	602	632
54					172	200	228	256	285	314	344	373	403	434	464	495	526	557	588	620	651	683
56					185	215	245	276	307	339	370	402	435	467	500	533	567	600	634	668	702	736
58					199	231	264	297	330	364	398	432	467	502	537	573	609	645	681	717	754	791
60						247	282	318	353	389	426	463	500	538	575	613	652	690	729	768	807	847
62						264	301	339	377	416	455	494	534	574	614	655	696	737	778	820	862	904
64						281	321	361	402	443	484	526	568	611	654	697	741	785	829	873	918	962
66							341	383	427	470	514	559	604	649	695	741	787	833	880	927	974	1022
68							361	406	452	498	545	592	640	688	736	785	834	883	932	982	1033	1083
70							382	429	478	527	576	626	676	727	778	829	881	933	986	1039	1092	1145

Coefficient set 9.3 $b_0 = .78820E\text{-}04$ $b_1 = 2.59980$ $b_2 = 1.12000$ $b_3 = .99016$

APPENDIX A-9. SCRIBNER BOARD FOOT VOLUME TO A 6-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—DOUGLAS-FIR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	4	4	5	6	7	8	9													
12	3	4	5	7	8	9	11	12	13	15												
14	4	6	8	10	11	13	15	17	19	21	23											
16	6	8	10	13	15	18	20	23	26	28	31	34										
18	8	11	14	17	20	23	27	30	33	37	40	44	48									
20	10	13	17	21	25	30	34	38	42	47	51	56	60	65								
22	12	17	21	26	31	37	42	47	52	58	63	69	75	80	86							
24	15	20	26	32	38	44	51	57	64	70	77	84	90	97	104	111						
26	17	24	31	38	45	53	60	68	76	84	92	100	108	116	124	133	141	150				
28	20	28	36	45	53	62	71	80	89	98	108	117	127	136	146	156	166	176	186			
30		33	42	52	62	72	82	93	103	114	125	136	147	158	170	181	192	204	216	227		
32		38	48	60	71	83	95	107	119	131	144	156	169	182	195	208	221	234	248	261	275	
34		43	55	68	81	94	108	121	135	149	163	178	192	207	222	237	252	267	282	297	313	328
36		48	62	77	91	106	121	137	152	168	184	201	217	233	250	267	284	301	318	335	353	370
38			70	86	102	119	136	153	171	189	206	225	243	261	280	299	318	337	356	376	395	415
40			78	95	114	132	151	170	190	210	230	250	270	291	312	333	354	375	396	418	440	461
42			86	105	126	146	167	189	210	232	254	276	299	322	345	368	391	415	438	462	486	510
44				116	138	161	184	207	231	255	279	304	329	354	379	405	430	456	482	508	535	561
46				127	151	176	201	227	253	279	306	333	360	387	415	443	471	499	528	556	585	614
48				138	165	192	219	247	276	304	333	363	392	422	452	483	513	544	575	606	638	669
50				150	179	208	238	268	299	330	362	393	426	458	491	524	557	590	624	658	692	726
52					193	225	257	290	323	357	391	425	460	495	530	566	602	638	674	711	748	785
54					208	242	277	312	348	384	421	458	495	533	571	609	648	687	726	766	805	845
56					224	260	297	335	374	413	452	492	532	572	613	654	696	738	780	822	865	907
58					239	278	318	359	400	442	484	526	569	612	656	700	745	789	834	880	925	971
60						297	340	383	427	471	516	561	607	654	700	747	795	842	890	939	987	1036
62						316	362	408	454	502	549	598	646	696	745	795	846	896	948	999	1051	1103
64						336	384	433	482	532	583	634	686	738	791	844	898	952	1006	1061	1116	1171
66							407	458	511	564	618	672	727	782	838	894	951	1008	1066	1123	1182	1240
68							430	484	540	596	653	710	768	827	886	945	1005	1065	1126	1187	1249	1311
70							453	511	569	629	688	749	810	872	934	997	1060	1124	1188	1252	1317	1382

Coefficient set 2.2 $b_0 = .18050E\text{-}03$ $b_1 = 2.39880$ $b_2 = 1.13700$ $b_3 = .99187$

APPENDIX A-10. SCRIBNER BOARD FOOT VOLUME TO A 6-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—PONDEROSA PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	4	4	5	6	7	8	9													
12	3	4	5	7	8	9	11	12	14	15												
14	4	6	8	10	12	14	15	17	19	22	24											
16	6	8	11	13	16	18	21	24	27	29	32	35										
18	8	11	14	17	21	24	28	31	35	39	42	46	50									
20	10	14	18	22	27	31	36	40	45	50	54	59	64	69								
22	12	17	23	28	33	39	44	50	56	62	68	74	80	86	92							
24	15	21	28	34	41	47	54	61	68	76	83	90	98	106	113	121						
26	18	26	33	41	49	57	65	74	82	91	100	109	118	127	136	146	155	164				
28	22	30	39	49	58	68	78	88	98	108	119	129	140	151	162	173	184	195	207			
30		36	46	57	68	80	91	103	115	127	140	152	165	177	190	203	216	229	243	256		
32		42	54	66	79	93	106	120	134	148	162	177	191	206	221	236	251	267	282	297	313	
34		48	62	76	91	107	122	138	154	170	187	203	220	237	254	272	289	307	325	342	361	379
36		55	71	87	104	122	139	157	176	194	213	232	251	271	290	310	330	350	371	391	412	432
38			80	99	118	138	158	178	199	220	242	263	285	307	329	352	374	397	420	443	467	490
40			90	111	133	155	178	201	224	248	272	296	321	346	371	396	422	447	473	499	526	552
42			101	125	149	174	199	225	251	278	305	332	359	387	415	444	472	501	530	559	589	618
44				139	166	194	222	251	280	309	339	370	400	431	462	494	526	558	590	623	656	689
46				154	184	215	246	278	310	343	376	410	444	478	513	548	583	618	654	690	727	763
48				170	203	237	272	307	342	378	415	452	490	527	566	604	643	682	722	762	802	842
50				187	223	260	298	337	376	416	456	497	538	580	622	664	707	750	793	837	881	926
52					244	285	327	369	412	455	499	544	589	635	681	727	774	821	869	917	965	1014
54					267	311	357	403	449	497	545	594	643	693	743	793	845	896	948	1000	1053	1106
56					290	338	388	438	489	540	593	646	699	753	808	863	919	975	1031	1088	1145	1203
58					315	367	420	475	530	586	643	700	758	817	876	936	996	1057	1118	1180	1242	1304
60						397	455	514	573	634	695	757	820	883	947	1012	1077	1143	1209	1276	1343	1411
62						428	490	554	618	684	750	817	884	953	1022	1092	1162	1233	1304	1376	1448	1521
64						461	528	596	665	736	807	879	952	1025	1099	1174	1250	1326	1403	1481	1559	1637
66							566	640	714	790	866	943	1022	1101	1180	1261	1342	1424	1506	1589	1673	1757
68							607	685	765	846	928	1010	1094	1179	1264	1351	1438	1525	1614	1703	1792	1882
70							649	733	818	904	992	1080	1170	1260	1352	1444	1537	1630	1725	1820	1916	2012

Coefficient set 3.2 b_0 = .17970E-03 b_1 = 2.34060 b_2 = 1.15420 b_3 = .99945

APPENDIX A-11. SCRIBNER BOARD FOOT VOLUME TO A 6-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—JEFFREY PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	3	4	5	6	7	8	9													
12	3	4	5	6	8	9	10	12	13	15												
14	4	6	7	9	11	13	15	17	19	21	23											
16	5	8	10	12	15	18	20	23	26	29	32	35										
18	7	10	13	16	20	23	27	30	34	38	41	45	49									
20	9	13	17	21	25	29	34	38	43	48	53	58	63	68								
22	11	16	21	26	31	37	42	48	54	60	66	72	78	84	91							
24	14	19	25	32	38	45	52	58	66	73	80	88	95	103	111	119						
26	16	23	30	38	46	54	62	70	79	87	96	105	115	124	133	143	152	162				
28	19	28	36	45	54	64	73	83	93	104	114	125	136	147	158	169	180	192	203			
30		32	42	53	63	74	86	97	109	121	133	146	159	171	184	198	211	224	238	252		
32		37	49	61	73	86	99	113	126	140	154	169	184	198	214	229	244	260	275	291	307	
34		43	56	70	84	99	114	129	145	161	177	194	211	228	245	262	280	298	316	334	353	371
36		49	64	79	96	112	129	147	165	183	202	220	240	259	279	298	319	339	359	380	401	422
38			72	90	108	127	146	166	186	207	228	249	270	292	315	337	360	383	406	429	453	477
40			81	101	121	142	164	186	209	232	255	279	303	328	353	378	403	429	455	482	508	535
42			90	112	135	159	183	208	233	259	285	311	338	366	394	422	450	479	508	537	567	596
44				124	150	176	203	230	258	287	316	345	375	406	437	468	499	531	563	596	628	662
46				137	165	194	224	254	285	317	349	381	414	448	482	516	551	586	622	658	694	730
48				151	182	213	246	279	313	348	383	419	455	492	529	567	605	644	683	723	762	803
50				165	199	234	269	306	343	381	419	459	498	539	579	621	663	705	748	791	834	878
52					217	255	293	333	374	415	457	500	543	587	632	677	722	769	815	862	910	958
54					235	277	319	362	406	451	497	543	590	638	686	735	785	835	886	937	988	1040
56					255	300	345	392	440	488	538	588	639	691	743	796	850	904	959	1014	1070	1127
58					275	323	373	423	475	527	581	635	690	746	803	860	918	976	1036	1095	1156	1216
60						348	401	456	511	568	625	684	743	803	864	926	988	1051	1115	1179	1244	1310
62						374	431	489	549	610	671	734	798	863	928	994	1061	1129	1197	1266	1336	1406
64						401	462	524	588	653	719	787	855	924	994	1065	1137	1209	1282	1356	1431	1507
66							493	560	628	698	769	841	914	987	1062	1138	1215	1292	1371	1450	1529	1610
68							526	597	670	744	820	896	974	1053	1133	1214	1295	1378	1462	1546	1631	1717
70							560	636	713	792	872	954	1037	1121	1206	1292	1379	1467	1555	1645	1736	1827

Coefficient set 4.2 b_0 = .13340E-03 b_1 = 2.36420 b_2 = 1.20580 b_3 = .99686

APPENDIX A-12. SCRIBNER BOARD FOOT VOLUME TO A 6-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—SUGAR PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	3	4	5	6	6	7	8													
12	3	4	5	6	7	9	10	11	12	13												
14	4	6	7	9	11	12	14	16	18	19	21											
16	6	8	10	13	15	17	19	22	24	27	29	31										
18	8	11	14	17	20	23	26	29	32	35	38	42	45									
20	10	14	17	21	25	29	33	37	41	45	49	53	58	62								
22	12	17	22	27	31	36	41	46	51	57	62	67	72	77	83							
24	15	21	27	33	39	45	51	57	63	69	76	82	89	95	102	108						
26	18	25	32	39	47	54	61	69	76	84	91	99	107	115	123	130	138	146				
28	22	30	38	47	55	64	73	82	91	100	109	118	127	136	146	155	164	174	183			
30		35	45	55	65	75	86	96	107	117	128	139	149	160	171	182	193	204	215	227		
32		41	52	64	76	87	99	112	124	136	148	161	174	186	199	212	225	237	250	263	277	
34		47	60	74	87	101	114	128	142	157	171	185	200	214	229	244	258	273	288	303	318	333
36		54	69	84	99	115	131	147	163	179	195	211	228	245	261	278	295	312	329	346	363	381
38			78	95	113	130	148	166	184	203	221	240	258	277	296	315	334	353	373	392	412	431
40			88	107	127	147	167	187	207	228	249	270	291	312	333	355	376	398	419	441	463	485
42			98	120	142	164	186	209	232	255	278	302	325	349	373	397	421	445	469	493	518	543
44				133	158	182	207	232	258	284	309	335	362	388	414	441	468	495	522	549	576	603
46				147	174	202	229	257	285	314	342	371	400	429	459	488	518	547	577	607	638	668
48				162	192	222	253	283	314	346	377	409	441	473	505	538	570	603	636	669	702	736
50				178	211	244	277	311	345	379	414	448	484	519	554	590	626	662	698	734	770	807
52					230	266	303	340	377	414	452	490	528	567	606	644	684	723	762	802	842	882
54					251	290	330	370	410	451	492	534	575	617	659	702	744	787	830	873	917	960
56					272	315	358	401	445	489	534	579	624	670	715	761	808	854	901	947	995	1042
58					294	340	387	434	482	529	578	626	675	724	774	824	874	924	974	1025	1076	1127
60						367	417	468	519	571	623	676	728	781	835	888	942	996	1051	1106	1160	1216
62						395	449	504	559	614	670	727	783	841	898	956	1014	1072	1130	1189	1248	1308
64						424	482	540	600	659	719	780	841	902	964	1025	1088	1150	1213	1276	1339	1403
66							516	578	642	706	770	835	900	965	1031	1098	1164	1231	1298	1366	1434	1502
68							551	618	685	754	822	892	961	1031	1102	1172	1244	1315	1387	1459	1531	1604
70							587	659	731	803	876	950	1024	1099	1174	1250	1325	1402	1478	1555	1632	1710

Coefficient set 5.2 $b_0 = .17960E\text{-}03$ $b_1 = 2.43200$ $b_2 = 1.08980$ $b_3 = .99663$

APPENDIX A-13. SCRIBNER BOARD FOOT VOLUME TO A 6-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—LODGEPOLE PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	2	3	4	5	6	7	7	8													
12	2	4	5	6	7	9	10	12	13	15												
14	4	5	7	9	11	13	15	17	20	22	24											
16	5	7	10	12	15	18	21	24	27	31	34	37										
18	7	10	13	16	20	24	28	32	36	41	45	50	55									
20	9	12	17	21	26	31	36	41	47	52	58	64	70	76								
22	11	16	21	27	32	39	45	52	59	66	73	81	88	96	104							
24	13	19	26	33	40	47	55	64	72	81	90	99	108	118	128	137						
26	16	23	31	39	48	57	67	77	87	97	108	119	130	142	154	166	178	190				
28	19	27	37	47	57	68	79	91	103	116	128	141	155	168	182	197	211	226	241			
30		32	43	54	67	79	93	106	121	135	150	166	181	197	214	230	247	264	282	300		
32		37	50	63	77	92	107	123	140	157	174	192	210	228	247	266	286	306	326	347	367	
34		42	57	72	88	105	123	141	160	179	199	219	240	261	283	305	328	350	373	397	421	445
36		48	65	82	100	120	140	160	182	203	226	249	273	297	321	346	372	398	424	451	478	505
38			73	92	113	135	157	180	204	229	254	280	307	334	362	390	418	448	477	507	538	568
40			81	103	126	150	176	202	228	256	284	313	343	373	404	436	468	500	533	567	601	635
42			90	114	140	167	195	224	254	284	316	348	381	414	449	484	519	555	592	629	667	705
44				126	155	184	215	247	280	314	348	384	420	457	495	534	573	613	653	694	736	778
46				139	170	202	236	271	307	344	382	421	461	502	544	586	629	673	717	762	808	854
48				151	185	221	258	296	335	376	418	460	504	548	594	640	687	735	783	832	882	933
50				165	202	240	280	322	365	409	454	500	548	596	645	696	747	799	851	905	959	1014
52					218	260	303	348	395	442	491	542	593	645	699	753	808	865	922	980	1039	1098
54					235	280	327	376	426	477	530	584	639	696	753	812	872	932	994	1056	1120	1184
56					253	301	352	404	457	513	569	628	687	748	809	873	937	1002	1068	1135	1203	1272
58					271	323	376	432	490	549	610	672	736	801	867	934	1003	1073	1144	1216	1289	1363
60						344	402	461	523	586	651	717	785	855	925	997	1071	1145	1221	1298	1376	1455
62						367	428	491	557	624	693	764	836	910	985	1062	1140	1219	1300	1381	1464	1548
64						389	454	521	591	662	735	811	887	966	1046	1127	1210	1294	1379	1466	1554	1644
66							481	552	625	701	779	858	939	1022	1107	1193	1281	1370	1461	1552	1646	1740
68							508	583	661	741	822	906	992	1080	1169	1260	1353	1447	1543	1640	1738	1838
70							535	614	696	780	867	955	1046	1138	1232	1328	1426	1525	1626	1728	1832	1937

Coefficient set 6.2 $b_0 = .46920E\text{-}04$ $b_1 = 2.63260$ $b_2 = 1.31150$ $b_3 = .98812$

APPENDIX A-14. SCRIBNER BOARD FOOT VOLUME TO A 6-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—WHITE FIR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	4	5	6	7	8	9	10													
12	3	4	6	7	8	10	12	13	15	17												
16	6	8	11	13	16	19	22	26	29	32	36	39										
18	7	11	14	18	21	25	29	33	38	42	46	51	55									
20	9	13	18	22	27	32	37	42	48	53	59	64	70	76								
22	11	16	22	27	33	39	46	52	59	65	72	79	87	94	101							
24	14	20	26	33	40	48	55	63	71	79	88	96	105	114	123	132						
26	17	24	31	40	48	57	66	75	85	94	104	115	125	135	146	157	168	179				
28	19	28	37	46	56	67	77	88	99	111	123	134	147	159	172	184	197	210	224			
30		32	43	54	65	77	90	102	115	129	142	156	170	184	199	214	229	244	259	275		
32		37	49	62	75	89	103	117	132	147	163	179	195	212	228	245	262	280	298	315	334	
34		42	56	70	85	101	117	133	150	168	185	203	222	240	259	279	298	318	338	359	379	400
36		48	63	79	96	114	132	150	169	189	209	229	250	271	292	314	336	359	381	404	427	451
38			70	89	107	127	147	168	189	211	234	256	280	303	327	352	376	401	427	452	478	504
40			78	98	119	141	164	187	211	235	260	285	311	337	364	391	418	446	474	503	531	561
42			86	109	132	156	181	206	233	260	287	315	343	372	402	432	462	493	524	555	587	619
44				119	145	171	199	227	256	285	315	346	377	409	441	474	508	541	576	610	645	681
46				131	159	187	217	248	280	312	345	378	413	447	483	519	555	592	629	667	705	744
48				142	173	204	236	270	304	339	375	412	449	487	525	564	604	644	685	726	768	810
50				154	187	221	256	293	330	368	407	446	487	528	569	612	655	698	742	787	832	878
52					202	239	277	316	356	397	439	482	525	570	615	660	707	754	801	850	898	948
54					217	257	298	340	383	427	472	518	565	613	661	711	760	811	862	914	967	1020
56					233	275	319	364	411	458	506	556	606	657	709	762	815	870	925	980	1036	1093
58					249	294	341	390	439	490	541	594	648	703	758	815	872	930	988	1048	1108	1169
60						314	364	415	468	522	577	633	691	749	808	868	929	991	1054	1117	1181	1246
62						334	387	441	498	555	614	673	734	796	859	923	988	1054	1120	1188	1256	1325
64						354	410	468	528	589	651	714	779	844	911	979	1048	1117	1188	1259	1332	1405
66							434	495	558	623	689	756	824	893	964	1036	1109	1182	1257	1332	1409	1486
68							458	523	589	657	727	798	870	943	1018	1094	1170	1248	1327	1407	1487	1569
70							483	551	621	693	766	840	916	994	1072	1152	1233	1315	1398	1482	1567	1653

Coefficient set 7.2 $b_0 = .11700E\text{-}03$ $b_1 = 2.40000$ $b_2 = 1.25500$ $b_3 = .99131$

APPENDIX A-15. SCRIBNER BOARD FOOT VOLUME TO A 6-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—RED FIR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	4	5	6	7	8	10	11													
12	3	4	5	7	9	10	12	14	16	19												
14	4	5	7	10	12	14	17	20	23	26	29											
16	5	7	10	13	16	19	23	27	30	34	39	43										
18	6	9	13	16	20	25	29	34	39	44	50	55	61									
20	8	11	16	20	25	31	36	42	49	55	62	69	76	83								
22	9	14	19	25	31	37	44	52	59	67	75	84	92	101	111							
24	11	17	23	30	37	45	53	62	71	80	90	100	110	121	132	144						
26	13	19	27	35	43	53	62	73	83	94	106	118	130	143	156	169	182	196				
28	15	23	31	40	50	61	72	84	97	109	123	137	151	165	181	196	212	228	245			
30		26	36	46	58	70	83	97	111	126	141	157	173	190	207	225	243	262	281	300		
32		29	41	53	66	80	94	110	126	143	160	178	196	216	235	255	276	297	319	341	363	
34		33	46	59	74	90	106	123	142	160	180	200	221	243	265	287	311	334	359	383	409	434
36		37	51	66	83	100	118	138	158	179	201	224	247	271	296	321	347	373	400	428	456	485
38			56	73	92	111	131	153	175	199	223	248	274	300	328	356	384	414	444	475	506	538
40			62	81	101	122	145	168	193	219	246	273	302	331	361	392	424	456	489	523	557	593
42			68	89	111	134	159	185	212	240	269	299	330	363	396	429	464	500	536	573	611	649
44				97	120	146	173	201	231	261	293	326	360	395	431	468	506	544	584	624	666	708
46				105	131	158	187	218	250	283	318	354	391	429	468	508	549	591	633	677	722	767
48				113	141	171	203	236	270	306	343	382	422	463	505	548	593	638	684	732	780	829
50				122	152	184	218	253	291	329	370	411	454	498	543	590	637	686	736	787	839	892
52					163	197	234	272	312	353	396	441	487	534	582	632	683	736	789	844	899	956
54					174	211	249	290	333	377	423	471	520	570	622	675	730	786	843	901	961	1021
56					185	224	266	309	354	402	451	501	554	607	663	719	777	837	898	960	1023	1088
58					197	238	282	328	376	427	479	532	588	645	704	764	826	889	953	1019	1086	1155
60						252	299	348	399	452	507	564	622	683	745	809	874	941	1009	1079	1150	1223
62						266	316	367	421	477	535	595	658	721	787	854	923	994	1066	1140	1215	1292
64						281	333	387	444	503	564	627	693	760	829	900	973	1048	1124	1201	1281	1361
66							350	407	467	529	593	660	729	799	872	947	1023	1102	1181	1263	1346	1431
68							367	427	490	555	622	692	764	839	915	993	1074	1156	1240	1325	1413	1502
70							384	447	513	581	652	725	801	878	958	1040	1124	1210	1298	1388	1480	1573

Coefficient set 8.2 $b_0 = .75100E\text{-}04$ $b_1 = 2.27830$ $b_2 = 1.43690$ $b_3 = .99009$

APPENDIX A-16. SCRIBNER BOARD FOOT VOLUME TO A 6-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—INCENSE-CEDAR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	1	2	2	3	3	4	4	5	5													
12	2	3	3	4	5	6	7	8	8	9												
14	3	4	5	6	7	9	10	11	12	14	15											
16	4	6	7	9	10	12	14	16	17	19	21	23										
18	5	7	10	12	14	16	19	21	23	26	28	31	33									
20	7	10	12	15	18	21	24	27	30	33	36	40	43	46								
22	9	12	16	19	23	27	30	34	38	42	46	50	54	58	62							
24	11	15	19	24	28	33	38	42	47	52	57	62	67	72	77	82						
26	13	18	24	29	34	40	46	51	57	63	69	75	81	87	93	99	105	112				
28	16	22	28	34	41	48	54	61	68	75	82	89	96	104	111	118	126	133	141			
30		26	33	41	48	56	64	72	80	88	97	105	113	122	131	139	148	157	166	175		
32		30	38	47	56	65	74	84	93	103	112	122	132	142	152	162	172	182	193	203	213	
34		34	44	54	64	75	85	96	107	118	129	140	152	163	175	186	198	210	221	233	245	257
36		39	50	62	73	85	97	110	122	135	147	160	173	186	199	212	226	239	252	266	280	293
38			57	70	83	96	110	124	138	152	166	181	195	210	225	240	255	270	285	300	316	331
40			64	78	93	108	123	139	155	171	187	203	219	236	252	269	286	303	320	337	354	372
42			71	87	104	121	138	155	172	190	208	226	244	263	281	300	319	337	356	376	395	414
44				97	115	133	152	171	191	210	230	250	270	291	311	332	353	374	395	416	437	459
46				106	126	147	168	189	210	232	254	276	298	320	343	366	388	412	435	458	481	505
48				117	139	161	184	207	230	254	278	302	326	351	376	401	426	451	476	502	528	553
50				127	151	176	200	226	251	277	303	329	356	383	410	437	464	492	519	547	575	604
52					164	191	218	245	273	301	329	358	386	416	445	474	504	534	564	594	625	655
54					178	206	235	265	295	325	356	387	418	449	481	513	545	578	610	643	676	709
56					191	222	254	286	318	351	384	417	450	484	518	553	588	622	657	693	728	764
58					205	239	272	307	341	376	412	448	484	520	557	594	631	668	706	744	782	820
60						256	292	328	365	403	441	479	518	557	596	636	675	715	756	796	837	878
62						273	311	350	390	430	471	511	553	594	636	678	721	764	807	850	893	937
64						290	331	373	415	458	501	544	588	632	677	722	767	813	859	905	951	998
66							352	396	441	486	532	578	624	671	719	766	814	863	911	960	1009	1059
68							372	419	467	515	563	612	661	711	761	812	862	914	965	1017	1069	1121
70							393	443	493	544	595	646	699	751	804	857	911	965	1019	1074	1129	1185

Coefficient set 9.2 b_0 = .61440E-04 b_1 = 2.68850 b_2 = 1.12370 b_3 = .98855

APPENDIX A-17. SCRIBNER BOARD FOOT VOLUME TO AN 8-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—DOUGLAS-FIR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	3	4	5	6	7	7	8													
12	3	4	5	6	8	9	10	11	13	14												
14	4	6	7	9	11	13	14	16	18	20	22											
16	6	8	10	12	15	17	20	22	25	27	30	33										
18	7	10	13	16	19	23	26	29	32	36	39	43	46									
20	9	13	17	21	25	29	33	37	41	46	50	54	59	63								
22	12	16	21	26	31	36	41	46	51	57	62	68	73	79	84							
24	14	20	25	31	37	43	50	56	62	69	75	82	89	96	102	109						
26	17	24	30	37	45	52	59	67	75	82	90	98	106	114	122	131	139	147				
28	20	28	36	44	53	61	70	79	88	97	106	116	125	135	144	154	164	174	184			
30		32	42	51	61	71	81	92	102	113	124	135	146	157	168	179	191	202	214	225		
32		37	48	59	70	82	94	106	118	130	142	155	168	180	193	206	219	233	246	259	273	
34		43	55	67	80	93	107	121	134	148	162	177	191	206	220	235	250	265	280	295	311	326
36		48	62	76	91	106	121	136	152	168	184	200	216	232	249	266	283	300	317	334	351	369
38			69	85	102	118	135	153	170	188	206	224	242	261	279	298	317	336	355	374	394	413
40			77	95	113	132	151	170	190	209	229	249	270	290	311	332	353	374	395	417	439	460
42			86	105	126	146	167	188	210	232	254	276	299	321	344	367	391	414	438	462	486	510
44				116	138	161	184	207	231	255	279	304	329	354	379	404	430	456	482	508	534	561
46				127	151	176	201	227	253	279	306	333	360	387	415	443	471	499	528	556	585	614
48				138	165	192	220	247	276	304	333	363	392	422	452	483	513	544	575	607	638	670
50				150	179	208	238	269	299	330	362	394	426	458	491	524	557	591	624	658	692	727
52					194	225	258	290	324	357	391	426	460	496	531	567	602	639	675	712	749	786
54					209	243	277	313	349	385	422	459	496	534	572	610	649	688	727	767	806	846
56					224	261	298	336	374	413	453	492	532	573	614	655	697	739	781	823	866	909
58					240	279	319	359	400	442	484	527	570	613	657	701	746	790	835	881	926	972
60						297	340	383	427	472	517	562	608	654	701	748	795	843	891	940	988	1038
62						317	362	408	455	502	550	598	647	696	746	796	846	897	948	1000	1052	1104
64						336	384	433	483	533	583	635	687	739	792	845	898	952	1007	1061	1116	1172
66							407	458	511	564	618	672	727	782	838	894	951	1008	1066	1124	1182	1241
68							430	484	540	596	653	710	768	826	885	945	1005	1065	1126	1187	1249	1310
70							453	510	569	628	688	748	809	871	933	996	1059	1123	1187	1251	1316	1381

Coefficient set 2.1 b_0 = .14530E-03 b_1 = 2.47100 b_2 = 1.13710 b_3 = .99058

APPENDIX A-18. SCRIBNER BOARD FOOT VOLUME TO AN 8-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—PONDEROSA PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	3	4	5	6	7	7	8													
12	3	4	5	6	8	9	10	11	13	14												
14	4	6	7	9	11	13	15	17	18	20	22											
16	6	8	10	13	15	18	20	23	25	28	31	34										
18	8	10	14	17	20	23	27	30	34	37	41	44	48									
20	10	13	17	21	26	30	34	39	43	48	52	57	62	66								
22	12	17	22	27	32	37	43	48	54	60	66	71	77	83	89							
24	15	21	27	33	40	46	53	60	66	73	81	88	95	102	110	117						
26	18	25	32	40	48	56	64	72	80	89	97	106	115	124	133	142	151	160				
28	21	30	39	48	57	66	76	86	96	106	116	126	137	147	158	169	180	190	201			
30		35	45	56	67	78	89	101	113	124	136	149	161	173	186	198	211	224	237	250		
32		41	53	65	78	91	104	117	131	145	159	173	187	202	216	231	246	261	276	291	306	
34		47	61	75	90	105	120	135	151	167	183	199	216	233	249	266	283	301	318	336	353	371
36		54	70	86	103	120	137	155	173	191	209	228	247	266	285	305	324	344	364	384	404	424
38			79	98	116	136	156	176	196	217	238	259	280	302	324	346	368	390	413	435	458	481
40			89	110	131	153	175	198	221	244	268	292	316	340	365	390	415	440	465	491	517	543
42			100	123	147	172	197	222	248	274	300	327	354	381	409	437	465	493	521	550	579	608
44				137	164	191	219	247	276	305	334	364	394	425	455	486	518	549	581	613	645	678
46				152	182	212	243	274	306	338	371	404	437	471	505	539	574	609	644	680	715	751
48				168	201	234	268	303	338	373	409	446	483	520	557	595	634	672	711	750	790	829
50				185	221	257	295	333	371	410	450	490	530	571	613	654	696	739	781	824	868	911
52					241	282	323	364	406	449	493	536	581	626	671	716	762	809	856	903	950	998
54					263	307	352	397	443	490	537	585	634	683	732	782	832	882	933	985	1037	1089
56					286	334	383	432	482	533	584	636	689	742	796	850	905	960	1015	1071	1127	1184
58					311	362	415	468	523	578	633	690	747	805	863	921	981	1040	1100	1161	1222	1283
60						391	448	506	565	624	685	746	807	870	932	996	1060	1124	1189	1255	1321	1387
62						422	483	546	609	673	738	804	870	937	1005	1074	1143	1212	1282	1353	1424	1495
64						454	520	587	655	724	794	864	936	1008	1081	1154	1229	1303	1379	1455	1531	1608
66							558	629	702	776	851	927	1004	1081	1160	1238	1318	1398	1479	1560	1642	1725
68							597	674	752	831	911	993	1075	1158	1241	1326	1411	1497	1583	1670	1758	1846
70							637	720	803	888	973	1060	1148	1236	1326	1416	1507	1599	1691	1784	1878	1972

Coefficient set 3.1 $b_0 = .14460E\text{-}03$ $b_1 = 2.41490$ $b_2 = 1.15150$ $b_3 = .99797$

APPENDIX A-19. SCRIBNER BOARD FOOT VOLUME TO AN 8-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—JEFFREY PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	2	3	4	5	6	6	7	8													
12	3	4	5	6	7	9	10	11	13	14												
14	4	5	7	9	11	12	14	16	18	20	22											
16	5	7	10	12	15	17	20	22	25	28	31	34										
18	7	10	13	16	19	23	26	30	33	37	41	44	48									
20	9	13	16	20	25	29	33	38	42	47	52	57	62	67								
22	11	16	21	26	31	36	42	47	53	59	65	71	77	83	89							
24	14	19	25	31	38	44	51	58	65	72	79	87	94	102	109	117						
26	16	23	30	38	45	53	61	70	78	87	95	104	113	122	132	141	151	160				
28	19	27	36	45	54	63	73	83	93	103	113	124	134	145	156	167	179	190	201			
30		32	42	52	63	74	85	97	108	120	133	145	158	170	183	196	209	223	236	250		
32		37	49	61	73	86	99	112	126	140	154	168	183	197	212	227	243	258	274	289	305	
34		43	56	70	84	98	113	129	144	160	177	193	210	227	244	261	279	296	314	332	351	369
36		49	64	79	95	112	129	147	164	183	201	220	239	258	278	297	317	337	358	378	399	420
38			72	90	108	127	146	166	186	206	227	248	270	292	314	336	359	381	404	428	451	475
40			81	101	121	142	164	186	209	232	255	279	303	327	352	377	402	428	454	480	506	533
42			90	112	135	159	183	208	233	258	285	311	338	365	393	421	449	478	506	536	565	595
44				125	150	176	203	230	258	287	316	345	375	405	436	467	498	530	562	594	627	660
46				138	166	194	224	254	285	317	349	381	414	447	481	515	550	585	620	656	692	729
48				151	182	214	246	279	313	348	383	419	455	492	529	567	605	643	682	721	761	801
50				165	199	234	269	306	343	381	419	458	498	538	579	620	662	704	746	789	833	876
52					217	255	294	333	374	415	457	500	543	587	631	676	721	767	814	860	908	955
54					236	277	319	362	406	451	496	543	590	637	685	734	784	833	884	935	986	1038
56					255	300	345	392	440	488	537	588	638	690	742	795	848	902	957	1012	1067	1123
58					276	324	373	423	475	527	580	634	689	745	801	858	916	974	1033	1092	1152	1213
60						348	401	455	511	567	624	683	742	801	862	923	985	1048	1111	1175	1240	1305
62						374	431	489	548	609	670	733	796	860	925	991	1058	1125	1193	1261	1331	1401
64						400	461	523	587	652	717	784	852	921	990	1061	1132	1204	1277	1351	1425	1499
66							492	559	627	696	766	838	910	984	1058	1133	1209	1286	1364	1442	1522	1602
68							525	596	668	742	817	893	970	1048	1127	1208	1289	1371	1454	1537	1622	1707
70							558	633	710	789	868	949	1031	1115	1199	1284	1370	1458	1546	1635	1724	1815

Coefficient set 4.1 $b_0 = .11370E\text{-}03$ $b_1 = 2.42500$ $b_2 = 1.20250$ $b_3 = .99562$

APPENDIX A-20. SCRIBNER BOARD FOOT VOLUME TO AN 8-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—SUGAR PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	2	3	4	5	5	6	7	7													
12	3	4	5	6	7	8	9	10	12	13												
14	4	6	7	9	10	12	14	15	17	19	20											
16	6	8	10	12	14	17	19	21	23	26	28	30										
18	8	10	13	16	19	22	25	28	31	34	37	40	44									
20	10	13	17	21	25	28	32	36	40	44	48	52	56	60								
22	12	17	21	26	31	36	41	45	50	55	60	66	71	76	81							
24	15	21	26	32	38	44	50	56	62	68	75	81	87	93	100	106						
26	18	25	32	39	46	53	61	68	75	83	90	98	105	113	121	128	136	144				
28	22	30	38	46	55	64	72	81	90	99	108	117	126	135	144	153	162	172	181			
30		35	45	55	65	75	85	95	106	116	127	137	148	159	170	180	191	202	213	224		
32		41	52	64	75	87	99	111	123	135	148	160	172	185	197	210	223	236	248	261	274	
34		47	60	73	87	100	114	128	142	156	170	184	199	213	228	242	257	272	286	301	316	331
36		54	69	84	99	115	130	146	162	178	194	211	227	244	260	277	294	310	327	344	361	378
38			78	95	113	130	148	166	184	202	221	239	258	276	295	314	333	352	371	391	410	429
40			88	107	127	147	167	187	207	228	249	269	290	311	333	354	375	397	418	440	462	484
42			99	120	142	164	187	209	232	255	278	301	325	349	372	396	420	444	468	492	517	541
44				134	158	183	208	233	258	284	310	336	362	388	414	441	467	494	521	548	575	602
46				148	175	202	230	258	286	314	343	372	400	430	459	488	518	547	577	607	637	667
48				163	193	223	253	284	315	346	378	409	441	473	506	538	570	603	636	669	702	735
50				179	212	245	278	312	346	380	415	449	484	519	555	590	626	662	698	734	770	807
52					231	267	304	341	378	415	453	491	529	568	606	645	684	723	762	802	842	881
54					252	291	331	371	411	452	493	534	576	618	660	702	745	787	830	873	916	960
56					273	316	359	402	446	491	535	580	625	670	716	762	808	854	901	947	994	1041
58					296	342	388	435	483	531	579	627	676	725	774	824	874	924	974	1025	1075	1126
60						368	419	469	521	572	624	676	729	782	835	888	942	996	1050	1105	1159	1214
62						396	450	505	560	615	671	727	784	841	898	955	1013	1071	1129	1188	1247	1306
64						425	483	541	600	660	720	780	841	902	963	1025	1087	1149	1211	1274	1337	1400
66							517	579	642	706	770	834	899	965	1030	1096	1163	1229	1296	1363	1430	1498
68							551	618	686	753	822	891	960	1030	1100	1170	1241	1312	1383	1455	1527	1599
70							587	658	730	802	875	949	1022	1097	1171	1246	1322	1397	1473	1550	1626	1703

Coefficient set 5.1 b_0 = .14540E-03 b_1 = 2.51060 b_2 = 1.08570 b_3 = .99515

APPENDIX A-21. SCRIBNER BOARD FOOT VOLUME TO AN 8-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—LODGEPOLE PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	1	2	3	3	4	5	6	6	7													
12	2	3	4	5	7	8	9	11	12	13												
14	3	5	6	8	10	12	14	16	18	20	22											
16	5	7	9	12	14	17	20	23	26	29	32	35										
18	6	9	12	16	19	23	27	31	35	39	43	47	52									
20	8	12	16	21	25	30	35	40	45	51	56	62	68	73								
22	11	15	21	26	32	38	44	51	57	64	71	78	86	93	101							
24	13	19	26	32	40	47	55	63	71	79	88	97	106	115	125	134						
26	16	23	31	39	48	57	66	76	86	96	107	118	129	140	151	163	175	187				
28	19	28	37	47	57	68	79	91	103	115	127	140	153	167	180	194	208	223	237			
30		33	43	55	67	80	93	107	121	135	150	165	180	196	212	228	245	261	278	296		
32		38	50	64	78	93	108	123	140	156	173	191	209	227	245	264	283	303	323	343	363	
34		43	58	73	89	106	123	141	160	179	199	219	239	260	281	303	325	347	370	392	416	439
36		49	65	83	101	120	140	160	182	203	225	248	271	295	319	343	368	393	419	445	471	498
38			74	93	114	135	157	180	204	228	253	279	305	331	358	386	414	442	471	500	530	560
40			82	104	127	151	175	201	227	254	282	311	340	369	399	430	461	493	525	558	591	624
42			91	115	140	167	194	222	252	282	312	344	376	409	442	476	510	545	581	617	653	690
44				126	154	183	213	244	277	309	343	378	413	449	486	523	561	599	638	678	718	759
46				138	168	200	233	267	302	338	375	413	451	491	531	571	613	655	698	741	785	829
48				150	183	217	253	290	328	367	407	448	490	533	576	621	666	711	758	805	852	901
50				162	198	235	274	314	355	397	440	485	530	576	623	671	720	769	819	870	921	974
52					213	253	294	337	382	427	474	521	570	620	670	722	774	827	881	936	991	1047
54					228	271	315	361	409	458	507	559	611	664	718	773	829	886	944	1002	1062	1122
56					243	289	336	385	436	488	541	596	651	708	766	825	885	945	1007	1069	1133	1197
58					258	307	357	410	464	519	575	633	692	753	814	877	940	1005	1070	1137	1204	1272
60						325	379	434	491	549	609	671	733	797	862	928	996	1064	1133	1204	1275	1347
62						343	400	458	518	580	643	708	774	842	910	980	1051	1123	1197	1271	1346	1422
64						361	421	482	545	610	677	745	815	886	958	1032	1106	1182	1259	1337	1417	1497
66							441	506	572	641	710	782	855	930	1005	1083	1161	1241	1322	1404	1487	1571
68							462	530	599	670	744	818	895	973	1052	1133	1215	1299	1383	1469	1556	1644
70							482	553	625	700	776	854	934	1016	1098	1183	1268	1356	1444	1534	1624	1716

Coefficient set 6.1 b_0 = .23600E-04 b_1 = 2.93910 b_2 = 1.29410 b_3 = .97912

APPENDIX A-22. SCRIBNER BOARD FOOT VOLUME TO AN 8-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—WHITE FIR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	3	4	5	6	7	8	9													
12	3	4	5	7	8	10	11	13	14	16												
14	4	6	8	10	12	14	16	18	20	23	25											
16	5	8	10	13	16	19	22	25	28	31	34	38										
18	7	10	14	17	21	25	28	32	37	41	45	49	54									
20	9	13	17	22	26	31	36	41	46	52	57	63	69	74								
22	11	16	21	27	33	39	45	51	58	64	71	78	85	92	99							
24	14	20	26	33	40	47	54	62	70	78	86	95	103	112	121	130						
26	16	24	31	39	47	56	65	74	84	93	103	113	123	134	144	155	166	177				
28	19	28	37	46	56	66	77	87	98	110	121	133	145	158	170	183	195	208	222			
30		32	43	54	65	77	89	102	114	128	141	155	169	183	198	212	227	242	257	273		
32		37	49	62	75	88	102	117	132	147	162	178	194	210	227	244	261	278	296	314	332	
34		42	56	70	85	100	116	133	150	167	185	203	221	240	258	278	297	317	337	357	378	398
36		48	63	79	96	113	131	150	169	189	208	229	249	270	292	313	335	358	380	403	426	450
38			70	89	107	127	147	168	189	211	233	256	279	303	327	351	376	401	426	451	477	503
40			78	98	119	141	164	187	211	235	260	285	311	337	363	390	418	446	474	502	531	560
42			87	109	132	156	181	207	233	260	287	315	343	372	402	432	462	493	524	555	587	619
44				120	145	172	199	227	256	285	316	346	378	409	442	474	508	541	576	610	645	680
46				131	159	188	218	248	280	312	345	379	413	448	483	519	555	592	629	667	706	744
48				142	173	204	237	270	305	340	376	412	449	487	526	565	604	645	685	726	768	810
50				154	187	221	257	293	330	368	407	447	487	528	570	612	655	699	743	787	832	878
52					202	239	277	316	356	397	439	482	526	570	615	661	707	754	802	850	899	948
54					218	257	298	340	383	428	473	519	566	613	662	711	761	811	862	914	966	1019
56					233	276	320	365	411	458	507	556	606	657	709	762	815	869	924	980	1036	1093
58					249	295	341	390	439	490	541	594	648	702	758	814	871	929	988	1047	1107	1168
60						314	364	415	468	522	577	633	690	748	807	867	928	990	1052	1115	1179	1244
62						333	386	441	497	554	613	672	733	795	858	921	986	1052	1118	1185	1253	1322
64						353	410	467	527	587	649	713	777	842	909	977	1045	1114	1185	1256	1328	1401
66							433	494	557	621	686	753	821	891	961	1032	1105	1178	1252	1328	1404	1481
68							457	521	587	655	724	795	866	939	1014	1089	1165	1243	1321	1400	1481	1562
70							481	548	618	689	762	836	912	989	1067	1146	1226	1308	1390	1474	1558	1644

Coefficient set 7.1 b_0 = .93960E-04 b_1 = 2.47860 b_2 = 1.25370 b_3 = .98971

APPENDIX A-23. SCRIBNER BOARD FOOT VOLUME TO AN 8-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—RED FIR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	5	6	8	9	11	13	15													
12	3	5	7	9	11	13	16	18	21	24												
14	4	7	9	12	15	18	22	25	29	32	36											
16	6	9	12	16	20	24	28	33	37	42	47	53										
18	7	11	15	20	25	30	35	41	47	53	60	66	73									
20	9	14	19	24	30	37	43	50	58	65	73	82	90	99								
22	11	16	23	29	37	44	52	61	70	79	88	98	108	119	129							
24	13	19	27	35	43	52	62	72	82	93	104	116	128	140	153	166						
26	15	23	31	40	50	61	72	84	96	108	122	135	149	163	178	193	209	225				
28	17	26	36	46	58	70	83	96	110	125	140	155	171	188	205	222	240	258	277			
30		30	41	53	66	80	94	110	125	142	159	177	195	214	233	253	273	294	315	337		
32		33	46	60	74	90	106	123	141	160	179	199	220	241	263	285	308	332	355	380	405	
34		37	51	67	83	100	119	138	158	179	201	223	246	270	294	319	345	371	398	425	453	481
36		42	57	74	92	112	132	153	176	199	223	248	273	300	327	354	383	412	441	472	502	534
38			63	82	102	123	145	169	194	219	246	273	301	330	360	391	422	454	487	520	554	589
40			69	90	112	135	160	185	212	240	269	299	330	362	395	428	463	498	534	570	608	646
42			75	98	122	147	174	202	232	262	294	327	360	395	431	467	505	543	582	622	663	704
44				106	132	160	189	220	251	285	319	355	391	429	468	507	548	590	632	675	719	764
46				115	143	173	204	237	272	308	345	383	423	464	505	548	592	637	683	730	778	826
48				123	154	186	220	255	293	331	371	413	455	499	544	590	638	686	735	786	837	890
50				132	165	199	236	274	314	355	398	443	488	535	584	633	684	736	789	843	898	954
52					176	213	252	293	335	380	426	473	522	572	624	677	731	787	843	901	960	1020
54					188	227	269	312	358	405	454	504	556	610	665	721	779	838	899	960	1023	1087
56					199	241	285	332	380	430	482	536	591	648	706	766	828	891	955	1020	1087	1155
58					211	256	302	351	403	456	511	568	626	687	749	812	877	944	1012	1081	1152	1224
60						270	320	372	426	482	540	600	662	726	791	859	927	998	1070	1143	1218	1294
62						285	337	392	449	508	569	633	698	766	835	906	978	1052	1128	1205	1284	1365
64						300	355	412	472	535	599	666	735	806	878	953	1029	1107	1187	1268	1351	1436
66							373	433	496	561	629	699	772	846	922	1001	1081	1163	1247	1332	1419	1508
68							391	454	520	588	660	733	809	887	967	1049	1133	1219	1307	1396	1487	1581
70							409	475	544	616	690	767	846	928	1011	1097	1185	1275	1367	1461	1556	1654

Coefficient set 8.1 b_0 = .15220E-03 b_1 = 2.10520 b_2 = 1.42530 b_3 = .99211

APPENDIX A-24. SCRIBNER BOARD FOOT VOLUME TO AN 8-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—INCENSE-CEDAR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	1	2	2	2	3	3	4	4	5													
12	2	2	3	4	5	5	6	7	8	9												
14	3	4	5	6	7	8	9	10	12	13	14											
16	4	5	7	8	10	11	13	15	16	18	20	22										
18	5	7	9	11	13	16	18	20	22	25	27	29	32									
20	7	9	12	15	17	20	23	26	29	32	35	38	41	44								
22	9	12	15	19	22	26	29	33	37	41	45	48	52	56	60							
24	11	15	19	23	28	32	37	41	46	51	55	60	65	70	75	80						
26	13	18	23	28	34	39	45	50	56	62	67	73	79	85	91	97	103	109				
28	15	21	27	34	40	47	53	60	67	74	81	88	95	102	109	116	124	131	138			
30		25	32	40	47	55	63	71	79	87	95	104	112	120	129	137	146	155	163	172		
32		29	38	46	55	64	73	83	92	101	111	121	130	140	150	160	170	180	191	201	211	
34		34	44	54	64	74	85	95	106	117	128	139	150	162	173	185	196	208	220	232	243	255
36		39	50	61	73	85	97	109	121	134	146	159	172	185	198	211	224	238	251	265	278	292
38			56	69	82	96	109	123	137	151	166	180	195	209	224	239	254	269	284	299	315	330
40			63	78	93	108	123	138	154	170	186	202	219	235	252	268	285	302	319	337	354	371
42			71	87	103	120	137	154	172	190	208	226	244	262	281	299	318	337	356	375	395	414
44				96	115	133	152	171	191	210	230	250	270	291	311	332	353	374	395	416	438	459
46				106	126	147	168	189	210	232	254	276	298	320	343	366	389	412	435	459	482	506
48				116	138	161	184	207	230	254	278	302	327	351	376	401	426	452	477	503	529	555
50				127	151	176	201	226	251	277	303	330	357	383	410	438	465	493	521	549	577	605
52					164	191	218	245	273	301	330	358	387	416	446	476	505	535	566	596	627	658
54					178	206	236	265	295	326	357	388	419	451	482	514	547	579	612	645	678	711
56					191	222	254	286	318	351	384	418	451	485	520	554	589	624	659	695	731	767
58					205	239	273	307	342	377	413	448	485	521	558	595	633	670	708	746	785	823
60						256	292	329	366	403	442	480	519	558	597	637	677	717	758	799	840	881
62						273	311	351	390	430	471	512	553	595	637	680	722	765	809	852	896	940
64						290	331	373	415	458	501	545	589	633	678	723	768	814	860	906	953	1000
66							351	396	440	486	532	578	625	672	719	767	815	864	912	962	1011	1061
68							372	419	466	514	563	611	661	711	761	812	863	914	966	1017	1070	1122
70							392	442	492	543	594	645	698	750	803	857	911	965	1019	1074	1129	1185

Coefficient set 9.1 $b_0 = .43840E\text{-}04$ $b_1 = 2.79660$ $b_2 = 1.12660$ $b_3 = .986621$

APPENDIX A-25. SCRIBNER BOARD FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—DOUGLAS-FIR

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	3	4	5	6	7	8	9	10	12													
12	4	5	7	9	10	12	14	15	17	19												
14	6	8	10	12	14	17	19	21	24	26	29											
16	7	10	13	16	19	22	25	28	31	35	38	41										
18	9	13	17	20	24	28	32	36	40	44	49	53	57									
20	12	16	21	25	30	35	40	45	50	55	61	66	71	77								
22	14	20	25	31	37	43	49	55	61	68	74	80	87	93	100							
24	17	24	30	37	44	51	59	66	74	81	89	96	104	112	120	128						
26	20	28	36	44	52	61	69	78	87	96	105	114	123	132	141	151	160	170				
28	23	32	42	51	61	71	81	91	101	111	122	132	143	154	165	176	187	198	209			
30		37	48	59	70	81	93	104	116	128	140	152	165	177	190	202	215	228	240	253		
32		43	55	67	80	93	106	119	133	146	160	174	188	202	216	231	245	260	274	289	304	
34		48	62	76	90	105	120	135	150	165	181	196	212	228	244	261	277	293	310	327	343	360
36		54	69	85	101	118	134	151	168	185	203	220	238	256	274	292	311	329	348	366	385	404
38			77	95	113	131	149	168	187	207	226	246	265	285	305	326	346	367	387	408	429	450
40			85	105	125	145	166	186	207	229	250	272	294	316	338	361	383	406	429	452	475	498
42			94	116	137	160	182	205	228	252	276	300	324	348	373	397	422	447	472	498	523	549
44				127	151	175	200	225	250	276	302	328	355	381	408	435	463	490	518	546	573	602
46				138	164	191	218	245	273	301	329	358	387	416	445	475	505	535	565	595	626	656
48				150	178	207	237	267	297	327	358	389	420	452	484	516	548	581	614	646	680	713
50				162	193	224	256	288	321	354	387	421	455	489	524	558	593	629	664	700	735	772
52					208	242	276	311	346	382	418	454	491	527	565	602	640	678	716	755	793	832
54					224	260	297	334	372	410	449	488	527	567	607	647	688	729	770	811	853	894
56					240	279	318	358	399	440	481	523	565	608	651	694	737	781	825	869	914	958
58					256	298	340	383	426	470	514	559	604	649	695	741	788	834	882	929	976	1024
60						318	363	408	454	501	548	596	644	692	741	790	840	889	940	990	1041	1092
62						338	385	434	483	533	583	633	684	736	788	840	893	946	999	1053	1107	1161
64						358	409	460	512	565	618	672	726	781	836	891	947	1003	1060	1117	1174	1231
66							433	487	542	598	654	711	769	826	885	943	1003	1062	1122	1182	1243	1304
68							457	515	573	632	691	751	812	873	935	997	1059	1122	1185	1249	1313	1377
70							482	543	604	666	729	792	856	921	986	1051	1117	1183	1250	1317	1384	1452

Coefficient set 2.6 $b_0 = .39180E\text{-}03$ $b_1 = 2.19890$ $b_2 = 1.12390$ $b_3 = .99464$

APPENDIX A-26. SCRIBNER BOARD FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—PONDEROSA PINE

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	3	4	5	6	7	8	10	11	12													
12	4	6	7	9	11	12	14	16	18	20												
14	6	8	10	12	15	17	20	22	25	27	30											
16	8	11	14	17	20	23	26	30	33	37	40	44										
18	10	14	18	22	26	30	34	38	43	47	52	56	61									
20	12	17	22	27	32	37	43	48	54	59	65	71	76	82								
22	15	21	27	33	40	46	53	59	66	73	80	87	94	101	108							
24	18	25	33	40	48	56	64	72	80	88	97	105	114	122	131	140						
26	22	30	39	48	57	66	76	85	95	105	115	125	135	145	156	166	177	187				
28	26	35	46	56	67	78	89	100	112	123	135	147	159	171	183	195	208	220	233			
30		41	53	65	78	91	103	117	130	143	157	171	185	199	213	227	241	256	270	285		
32		47	61	75	90	104	119	134	150	165	181	197	213	229	245	261	278	295	311	328	345	
34		54	70	86	102	119	136	153	171	188	206	224	243	261	280	298	317	336	355	375	394	414
36		61	79	97	116	135	154	174	194	214	234	254	275	296	317	338	360	381	403	425	447	469
38			89	110	131	152	174	196	218	241	263	286	310	333	357	381	405	429	454	478	503	528
40			100	123	146	170	194	219	244	269	295	321	347	373	400	426	453	480	508	535	563	591
42			111	137	163	189	216	244	272	300	328	357	386	415	445	475	505	535	565	596	627	658
44				151	180	210	240	270	301	332	364	395	428	460	493	526	559	593	626	660	694	729
46				167	199	231	264	298	332	366	401	436	472	507	544	580	617	654	691	728	766	804
48				183	218	254	290	327	365	402	441	479	518	558	597	637	677	718	759	800	841	883
50				201	239	278	318	358	399	440	482	524	567	610	654	697	741	786	831	876	921	966
52					261	303	347	391	435	480	526	572	619	666	713	761	809	857	906	955	1004	1054
54					283	330	377	425	473	522	572	622	673	724	775	827	879	932	985	1038	1092	1146
56					307	358	409	460	513	566	620	674	729	785	840	897	953	1010	1068	1126	1184	1242
58					332	387	442	498	555	612	670	729	788	848	909	969	1031	1092	1155	1217	1280	1343
60						417	476	537	598	660	723	786	850	915	980	1045	1112	1178	1245	1313	1380	1449
62						448	513	578	643	710	778	846	915	984	1054	1125	1196	1267	1340	1412	1485	1559
64						481	550	620	691	762	835	908	982	1056	1132	1207	1284	1361	1438	1516	1594	1673
66							589	664	740	817	894	973	1052	1132	1212	1293	1375	1457	1540	1624	1708	1792
68							630	710	791	873	956	1040	1124	1210	1296	1383	1470	1558	1647	1736	1826	1916
70							672	758	844	932	1020	1110	1200	1291	1383	1476	1569	1663	1757	1853	1948	2045

Coefficient set 3.6 b_0 = .41760E-03 b_1 = 2.13830 b_2=1.13390 b_3 = 1.00150

APPENDIX A-27. SCRIBNER BOARD FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—JEFFREY PINE

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	3	3	4	5	7	8	9	10	11													
12	4	5	7	8	10	11	13	15	16	18												
14	5	7	9	12	14	16	18	21	23	25	28											
16	7	10	13	16	19	22	25	28	31	34	37	40										
18	9	13	16	20	24	28	32	36	40	44	48	52	57									
20	12	16	21	26	30	35	40	45	50	56	61	66	71	77								
22	14	20	26	31	37	43	50	56	62	69	75	81	88	95	101							
24	17	24	31	38	45	53	60	68	75	83	91	99	107	115	123	131						
26	21	29	37	45	54	63	72	81	90	99	108	118	127	137	146	156	166	175				
28	24	34	43	53	63	74	84	95	105	116	127	138	149	161	172	183	195	206	218			
30		39	50	62	74	86	98	110	122	135	148	161	174	187	200	213	226	240	253	267		
32		45	58	71	85	99	112	127	141	155	170	185	200	215	230	245	260	276	291	307	323	
34		52	66	81	97	112	128	144	161	177	194	211	228	245	262	280	297	315	332	350	368	386
36		58	75	92	109	127	145	163	182	201	219	239	258	277	297	316	336	356	376	396	417	437
38			84	103	123	143	163	184	204	225	247	268	290	311	333	356	378	400	423	446	468	491
40			94	116	137	160	182	205	228	252	275	299	324	348	372	397	422	447	472	498	523	549
42			105	128	153	177	202	228	254	280	306	333	359	386	414	441	469	497	525	553	581	609
44				142	169	196	224	252	280	309	338	367	397	427	457	487	518	549	580	611	642	673
46				156	185	215	246	277	308	340	372	404	437	470	503	536	570	603	637	672	706	741
48				171	203	236	269	303	338	372	407	443	478	514	551	587	624	661	698	736	773	811
50				186	222	257	294	331	368	406	444	483	522	561	601	640	681	721	762	802	844	885
52					241	280	319	360	400	441	483	525	567	610	653	696	740	784	828	872	917	962
54					261	303	346	390	434	478	523	569	614	661	707	754	801	849	897	945	993	1042
56					282	327	374	421	468	516	565	614	664	714	764	815	866	917	969	1021	1073	1126
58					303	353	403	453	504	556	609	661	715	768	823	877	932	988	1043	1099	1156	1212
60						379	432	487	542	597	654	710	768	825	884	942	1001	1061	1120	1181	1241	1302
62						406	463	521	580	640	700	761	822	884	947	1010	1073	1136	1200	1265	1330	1395
64						434	495	557	620	684	749	814	879	945	1012	1079	1147	1215	1283	1352	1421	1491
66							528	594	662	730	798	868	938	1008	1079	1151	1223	1296	1369	1442	1516	1590
68							562	633	704	777	850	923	998	1073	1149	1225	1302	1379	1457	1535	1613	1692
70							597	672	748	825	903	981	1060	1140	1220	1301	1383	1465	1547	1630	1714	1798

Coefficient set 4.6 b_0 = .31850E-03 b_1 = 2.24880 b_2 = 1.12390 b_3 = .99761

APPENDIX A-28. SCRIBNER BOARD FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—SUGAR PINE

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
											ten board feet											
10	3	4	5	6	7	8	9	10	11													
12	4	5	7	8	10	12	13	15	16	18												
14	6	8	10	12	14	16	18	21	23	25	27											
16	7	10	13	16	19	22	25	28	31	34	37	40										
18	10	13	17	20	24	28	32	36	39	43	47	51	55									
20	12	16	21	26	30	35	40	45	50	55	60	65	70	75								
22	15	20	26	32	37	43	49	55	61	67	73	80	86	92	98							
24	18	24	31	38	45	52	59	67	74	81	89	96	104	111	119	127						
26	21	29	37	45	54	62	71	79	88	97	106	114	123	132	142	151	160	169				
28	25	34	44	53	63	73	83	93	103	114	124	135	145	156	166	177	188	199	210			
30		40	51	62	73	85	96	108	120	132	144	156	169	181	193	206	218	231	244	256		
32		46	58	71	84	98	111	125	138	152	166	180	194	208	222	237	251	266	280	295	310	
34		52	67	81	96	111	127	142	158	174	189	205	221	238	254	270	287	303	320	336	353	370
36		59	75	92	109	126	143	161	179	196	214	233	251	269	287	306	325	343	362	381	400	419
38			85	104	123	142	161	181	201	221	241	262	282	303	323	344	365	386	407	429	450	471
40			95	116	137	159	180	202	225	247	270	292	315	338	362	385	408	432	455	479	503	527
42			106	129	152	176	201	225	250	275	300	325	351	376	402	428	454	480	506	533	559	586
44				143	169	195	222	249	276	304	332	360	388	416	445	473	502	531	560	590	619	648
46				157	186	215	245	274	304	335	365	396	427	459	490	522	553	585	617	649	682	714
48				172	204	236	268	301	334	367	401	435	469	503	537	572	607	642	677	712	748	783
50				188	223	258	293	329	365	401	438	475	512	550	587	625	663	701	740	778	817	856
52					243	281	319	358	397	437	477	517	558	598	639	681	722	764	806	848	890	932
54					263	305	346	389	431	474	518	561	605	650	694	739	784	829	874	920	966	1012
56					285	330	375	421	467	513	560	607	655	703	751	799	848	897	946	995	1045	1095
58					307	356	405	454	504	554	605	656	707	759	810	863	915	968	1021	1074	1128	1181
60						383	435	489	542	596	651	706	761	816	872	929	985	1042	1099	1156	1214	1272
62						411	467	525	582	640	699	758	817	877	937	997	1058	1119	1180	1241	1303	1365
64						440	501	562	624	686	748	812	875	939	1003	1068	1133	1198	1264	1330	1396	1463
66							535	601	667	733	800	868	936	1004	1073	1142	1211	1281	1351	1422	1492	1563
68							571	641	711	782	854	926	998	1071	1144	1218	1292	1367	1442	1517	1592	1668
70							608	682	757	833	909	986	1063	1140	1219	1297	1376	1455	1535	1615	1695	1776

Coefficient set 5.6 $b_0 = .42030E\text{-}03$ $b_1 = 2.18610$ $b_2 = 1.09270$ $b_3 = .99972$

APPENDIX A-29. SCRIBNER BOARD FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—LODGEPOLE PINE

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
											ten board feet											
10	3	4	5	6	8	9	10	12	13													
12	4	6	7	9	11	13	15	17	19	21												
14	6	8	10	13	16	18	21	24	27	30	33											
16	8	11	14	17	21	24	28	32	36	40	44	48										
18	10	14	18	22	27	31	36	41	46	51	56	61	67									
20	12	17	22	28	34	39	45	51	58	64	70	77	84	90								
22	15	21	28	34	41	48	56	63	71	79	86	94	103	111	119							
24	18	25	33	41	50	58	67	76	85	95	104	114	124	134	144	154						
26	21	30	39	49	59	69	80	90	101	112	124	135	147	159	171	183	195	207				
28	25	35	46	57	69	81	93	106	119	132	145	158	172	186	200	214	228	243	257			
30		41	54	67	80	94	108	123	138	153	168	184	199	215	232	248	265	281	298	315		
32		47	61	76	92	108	124	141	158	175	193	211	229	247	266	285	304	323	342	362	382	
34		54	70	87	105	123	141	160	180	199	219	240	260	281	302	324	346	367	389	412	434	457
36		60	79	98	118	139	160	181	203	225	248	271	294	318	342	366	390	415	440	465	490	516
38			89	110	133	155	179	203	228	253	278	304	330	356	383	410	438	465	493	522	550	579
40			99	123	148	173	200	226	254	282	310	339	368	397	427	457	488	519	550	582	613	645
42			110	136	164	192	221	251	281	312	344	376	408	441	474	507	541	575	610	645	680	716
44				150	181	212	244	277	311	345	379	414	450	486	523	560	597	635	673	712	750	790
46				165	199	233	268	304	341	379	417	455	494	534	574	615	656	697	739	782	824	867
48				181	217	255	293	333	373	414	456	498	541	584	628	673	718	763	809	855	902	949
50				197	237	278	320	363	407	451	497	543	589	637	685	733	782	831	881	932	983	1034
52					257	302	347	394	442	490	539	589	640	691	743	796	849	903	957	1012	1067	1123
54					278	327	376	426	478	530	584	638	693	748	805	862	919	977	1036	1095	1155	1216
56					300	352	406	460	516	572	630	688	748	808	868	930	992	1055	1118	1182	1247	1312
58					323	379	437	495	555	616	678	741	805	869	935	1001	1068	1135	1204	1272	1342	1412
60						407	469	532	596	661	728	795	864	933	1003	1074	1146	1219	1292	1366	1440	1516
62						436	502	569	638	708	779	852	925	999	1074	1150	1227	1305	1383	1463	1543	1623
64						466	536	608	682	757	833	910	988	1068	1148	1229	1311	1394	1478	1563	1648	1734
66							572	649	727	807	888	970	1054	1138	1224	1311	1398	1487	1576	1666	1757	1849
68							608	690	774	858	945	1032	1121	1211	1302	1394	1488	1582	1677	1773	1870	1967
70							646	733	822	912	1003	1096	1191	1286	1383	1481	1580	1680	1781	1883	1986	2089

Coefficient set 6.6 $b_0 = .31200E\text{-}03$ $b_1 = 2.18130$ $b_2 = 1.19640$ $b_3 = .99847$

APPENDIX A-30. SCRIBNER BOARD FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—WHITE FIR

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	3	4	5	7	8	9	11	12	14													
12	4	6	8	10	12	14	16	18	20	22												
14	6	8	11	13	16	19	22	25	28	31	34											
16	7	11	14	17	21	25	29	33	37	41	45	50										
18	9	13	18	22	27	32	37	42	47	52	58	63	69									
20	12	17	22	28	33	39	46	52	58	65	72	79	86	93								
22	14	20	27	34	41	48	55	63	71	79	87	96	104	113	121							
24	17	24	32	40	48	57	66	75	85	94	104	114	124	135	145	156						
26	20	29	38	47	57	67	78	89	100	111	122	134	146	158	171	183	196	208				
28	23	33	44	55	66	78	90	103	116	129	142	156	170	184	198	212	227	242	257			
30		38	50	63	76	90	104	118	133	148	163	179	195	211	227	244	261	278	295	312		
32		43	57	71	86	102	118	134	151	168	186	203	221	240	258	277	296	316	335	355	375	
34		49	64	81	97	115	133	151	170	190	209	229	250	270	291	313	334	356	378	401	423	446
36		55	72	90	109	129	149	169	190	212	234	257	279	303	326	350	374	399	423	448	474	499
38			80	100	121	143	165	188	212	236	260	285	311	336	362	389	416	443	471	498	526	555
40			88	111	134	158	183	208	234	260	288	315	343	372	401	430	459	490	520	551	582	613
42			97	122	147	174	201	229	257	286	316	346	377	408	440	472	505	538	571	605	639	674
44				133	161	190	219	250	281	313	346	379	412	447	481	517	552	588	625	662	699	737
46				145	175	207	239	272	306	341	376	412	449	486	524	562	601	641	680	721	761	802
48				157	190	224	259	295	332	370	408	447	487	527	568	610	652	695	738	781	825	870
50				170	205	242	280	319	359	399	441	483	526	570	614	659	704	750	797	844	892	940
52					221	260	301	343	386	430	474	520	566	613	661	709	758	808	858	908	960	1012
54					237	279	323	368	414	461	509	558	607	658	709	761	813	867	920	975	1030	1085
56					254	299	346	394	443	493	545	597	650	704	758	814	870	927	985	1043	1102	1161
58					270	319	369	420	473	526	581	637	693	751	809	868	928	989	1051	1113	1175	1239
60						339	393	447	503	560	618	678	738	799	861	924	988	1053	1118	1184	1251	1318
62						360	417	475	534	595	656	719	783	848	914	981	1049	1117	1187	1257	1328	1399
64						382	441	503	566	630	695	762	830	898	968	1039	1111	1183	1257	1331	1406	1482
66							467	531	598	666	735	805	877	950	1023	1098	1174	1251	1329	1407	1487	1567
68							492	561	631	702	775	849	925	1002	1080	1158	1238	1319	1401	1484	1568	1653
70							518	590	664	739	816	894	974	1055	1137	1220	1304	1389	1475	1563	1651	1740

Coefficient set 7.6 $b_0 = .30010E\text{-}03$ $b_1 = 2.16490$ $b_2 = 1.23500$ $b_3 = .99440$

APPENDIX A-31. SCRIBNER BOARD FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—RED FIR

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	4	5	6	8	9	11	13	15													
12	3	5	7	9	11	13	16	18	21	24												
14	5	7	9	12	15	18	22	25	29	32	36											
16	6	9	12	16	20	24	28	33	37	42	47	52										
18	8	11	16	20	25	30	36	41	47	53	59	66	73									
20	9	14	19	25	31	37	44	51	58	65	73	81	89	98								
22	11	17	23	30	37	45	53	61	70	79	88	98	107	118	128							
24	13	20	27	35	44	53	62	72	82	93	104	115	127	139	151	164						
26	16	23	32	41	51	61	72	84	96	108	121	134	148	162	176	191	206	222				
28	18	27	37	47	59	71	83	97	110	125	139	155	170	187	203	220	237	255	273			
30		30	42	54	67	80	95	110	126	142	159	176	194	212	231	251	270	290	311	332		
32		34	47	61	75	91	107	124	142	160	179	199	219	240	261	283	305	328	351	375	399	
34		38	53	68	84	102	120	139	159	179	201	223	245	268	292	316	341	367	393	419	446	473
36		43	58	75	94	113	133	154	176	199	223	247	272	298	325	352	379	407	436	466	496	526
38			65	83	103	125	147	170	195	220	246	273	301	329	358	388	419	450	482	514	547	581
40			71	91	113	137	161	187	214	241	270	300	330	361	393	426	459	494	529	564	600	637
42			77	100	124	149	176	204	233	263	295	327	360	394	429	465	502	539	577	616	655	696
44				108	135	162	191	222	253	286	320	355	391	428	466	505	545	585	627	669	712	756
46				117	146	176	207	240	274	310	346	384	423	463	504	546	589	633	678	724	770	818
48				126	157	189	223	259	295	334	373	414	456	499	544	589	635	683	731	780	830	881
50				136	168	203	239	278	317	358	401	445	490	536	584	632	682	733	785	837	891	946
52					180	217	256	297	339	383	429	476	524	574	624	677	730	784	840	896	954	1012
54					192	232	273	317	362	409	457	508	559	612	666	722	778	836	896	956	1017	1080
56					204	247	291	337	385	435	487	540	595	651	709	768	828	890	953	1017	1082	1149
58					217	262	308	357	409	461	516	573	631	690	752	814	878	944	1011	1079	1148	1218
60						277	326	378	432	488	546	606	667	731	795	862	929	999	1069	1141	1215	1289
62						292	345	399	456	516	577	640	705	771	840	910	981	1054	1129	1205	1282	1361
64						308	363	421	481	543	608	674	742	813	885	958	1034	1111	1189	1269	1351	1434
66							382	442	505	571	639	709	780	854	930	1007	1087	1168	1250	1334	1420	1507
68							400	464	530	599	670	743	819	896	976	1057	1140	1225	1312	1400	1490	1582
70							419	486	555	627	702	779	858	939	1022	1107	1194	1283	1374	1466	1561	1657

Coefficient set 8.6 $b_0 = .17410E\text{-}03$ $b_1 = 2.09410$ $b_2 = 1.40070$ $b_3 = .99281$

APPENDIX A-32. SCRIBNER BOARD FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—INCENSE-CEDAR

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	3	4	5	5	6	7	8													
12	3	4	5	6	7	8	9	10	12	13												
14	4	6	7	9	10	12	13	15	17	18	20											
16	5	8	10	12	14	16	18	20	22	25	27	29										
18	7	10	13	15	18	21	24	27	29	32	35	38	41									
20	9	12	16	19	23	26	30	34	37	41	45	49	52	56								
22	11	15	20	24	28	33	37	42	46	51	56	60	65	70	74							
24	14	19	24	29	34	40	45	51	56	62	67	73	79	84	90	96						
26	16	22	29	35	41	48	54	61	67	74	81	87	94	101	108	115	122	128				
28	19	26	34	41	48	56	64	71	79	87	95	103	111	119	127	135	143	151	160			
30		31	39	48	56	65	74	83	92	101	110	120	129	138	148	157	166	176	186	195		
32		35	45	55	65	75	85	95	106	116	127	138	148	159	170	181	192	202	213	225	236	
34		40	51	63	74	85	97	109	121	133	145	157	169	181	193	206	218	231	243	256	269	281
36		46	58	71	84	97	110	123	136	150	164	177	191	205	219	233	247	261	275	289	304	318
38			65	79	94	108	123	138	153	168	183	199	214	230	245	261	277	293	309	325	341	357
40			73	88	104	121	137	154	171	187	204	222	239	256	274	291	309	326	344	362	380	398
42			80	98	116	134	152	170	189	208	227	245	265	284	303	322	342	361	381	401	421	440
44				108	128	147	167	188	208	229	250	270	291	313	334	355	377	398	420	442	463	485
46				118	140	162	184	206	228	251	274	296	320	343	366	389	413	436	460	484	508	532
48				129	153	176	200	225	249	274	299	324	349	374	399	425	451	476	502	528	554	580
50				140	166	192	218	244	271	297	324	352	379	406	434	462	490	518	546	574	602	631
52					179	207	236	264	293	322	351	381	410	440	470	500	530	560	591	621	652	683
54					194	224	254	285	316	347	379	411	442	475	507	539	572	604	637	670	703	737
56					208	241	273	306	340	373	407	441	476	510	545	580	615	650	685	721	756	792
58					223	258	293	328	364	400	437	473	510	547	584	621	659	697	734	772	811	849
60						276	313	351	389	428	467	506	545	584	624	664	704	744	785	825	866	907
62						294	334	374	415	456	497	539	581	623	665	708	751	793	837	880	923	967
64						312	355	398	441	485	529	573	618	662	707	753	798	844	889	935	982	1028
66							376	422	468	514	561	608	655	703	750	798	846	895	943	992	1041	1090
68							398	447	495	544	594	643	693	744	794	845	896	947	999	1050	1102	1154
70							421	472	523	575	627	679	732	785	839	892	946	1000	1055	1109	1164	1219

Coefficient set 9.6 b_0 = .19440E-03 b_1 = 2.41060 b_2 = 1.08440 b_3 = .99241

APPENDIX A-33. SCRIBNER BOARD FOOT VOLUME TO A 6-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—DOUGLAS-FIR

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	3	4	5	7	8	9	10	12	13													
12	4	6	8	10	12	13	15	17	19	21												
14	6	8	11	13	16	18	21	24	26	29	32											
16	8	11	14	18	21	24	28	31	35	38	42	45										
18	10	14	18	22	26	31	35	39	44	48	53	58	62									
20	13	18	23	28	33	38	43	49	54	60	66	71	77	83								
22	15	21	27	33	40	46	53	59	66	73	80	87	94	101	108							
24	18	25	33	40	47	55	63	71	79	87	95	103	112	120	128	137						
26	22	30	38	47	56	65	74	83	93	102	112	121	131	141	151	161	171	181				
28	25	35	44	54	65	75	86	96	107	118	129	141	152	163	175	186	198	210	222			
30		40	51	62	74	86	98	111	123	136	148	161	174	187	201	214	227	241	254	268		
32		45	58	71	84	98	112	126	140	154	169	183	198	213	228	243	258	274	289	304	320	
34		51	65	80	95	110	126	142	158	174	190	207	223	240	257	274	291	308	326	343	361	378
36		57	73	89	106	123	141	159	176	195	213	231	250	269	287	307	326	345	364	384	403	423
38			81	99	118	137	157	176	196	216	237	257	278	299	320	341	362	383	405	427	448	470
40			90	110	131	152	173	195	217	239	261	284	307	330	353	376	400	424	448	471	496	520
42			98	121	144	167	190	214	238	263	287	312	337	363	388	414	440	466	492	518	545	571
44				132	157	182	208	234	261	287	314	342	369	397	425	453	481	509	538	567	596	625
46				144	171	199	227	255	284	313	342	372	402	432	462	493	524	555	586	617	649	681
48				156	186	215	246	277	308	339	371	404	436	469	502	535	568	602	636	670	704	738
50				169	201	233	266	299	333	367	401	436	471	507	542	578	614	651	687	724	761	798
52					216	251	286	322	358	395	432	470	508	546	584	623	662	701	740	780	820	860
54					232	269	307	346	385	424	464	504	545	586	627	669	710	752	795	837	880	923
56					248	288	329	370	412	454	497	540	583	627	671	716	760	805	851	896	942	988
58					265	308	351	395	440	485	531	577	623	670	717	764	812	860	908	957	1006	1055
60						328	374	421	469	517	565	614	663	713	763	814	865	916	967	1019	1071	1124
62						348	398	447	498	549	600	652	705	758	811	865	919	973	1028	1083	1138	1194
64						369	421	474	528	582	637	692	747	803	860	917	974	1032	1090	1148	1207	1266
66							446	502	558	616	673	732	791	850	910	970	1030	1091	1153	1215	1277	1339
68							471	530	590	650	711	773	835	897	961	1024	1088	1152	1217	1282	1348	1414
70							496	558	621	685	749	814	880	946	1012	1079	1147	1215	1288	1352	1421	1490

Coefficient set 2.5 b_0 = .53230E-03 b_1 = 2.12170 b_2 = 1.12100 b_3 = .99554

APPENDIX A-34. SCRIBNER BOARD FOOT VOLUME TO A 6-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—PONDEROSA PINE

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	3	4	6	7	8	10	11	12	14													
12	5	6	8	10	12	14	16	18	20	22												
14	6	9	11	14	17	19	22	25	28	31	34											
16	8	12	15	18	22	26	29	33	37	41	44	48										
18	11	15	19	24	28	33	37	42	47	52	57	62	67									
20	13	19	24	29	35	41	47	53	59	65	71	77	83	90								
22	16	23	29	36	43	50	57	64	72	79	86	94	102	109	117							
24	20	27	35	43	51	60	68	77	86	95	104	113	122	131	141	150						
26	23	32	42	51	61	71	81	91	102	112	123	134	145	156	167	178	189	200				
28	27	38	49	60	71	83	95	107	119	131	144	156	169	182	195	208	221	234	248			
30		44	56	69	82	96	110	124	138	152	166	181	196	211	226	241	256	271	287	302		
32		50	65	79	95	110	126	142	158	174	191	208	224	242	259	276	294	311	329	347	364	
34		57	73	90	108	125	143	161	180	198	217	236	255	275	294	314	334	354	374	394	415	435
36		64	83	102	122	141	162	182	203	224	245	267	288	310	332	355	377	400	422	445	468	492
38			93	115	136	159	181	204	228	251	275	299	324	348	373	398	423	449	474	500	526	552
40			104	128	152	177	202	228	254	281	307	334	361	389	416	444	472	501	529	558	587	616
42			115	142	169	197	225	253	282	312	341	371	401	432	462	493	525	556	588	619	651	684
44				157	187	217	248	280	312	344	377	410	443	477	511	545	580	614	649	685	720	756
46				173	206	239	273	308	343	379	415	451	488	525	562	600	638	676	715	753	792	831
48				189	225	262	300	338	376	415	455	495	535	575	616	658	699	741	783	826	868	911
50				207	246	286	327	369	411	454	497	540	584	629	673	718	764	810	856	902	949	995
52					268	312	356	402	447	494	541	588	636	684	733	782	832	881	931	982	1033	1084
54					291	338	387	436	486	536	587	638	690	743	796	849	903	957	1011	1066	1121	1176
56					315	366	419	472	526	580	635	691	747	804	861	919	977	1035	1094	1154	1213	1273
58					340	395	452	509	567	626	686	746	807	868	930	992	1055	1118	1181	1245	1310	1374
60						426	487	549	611	674	739	803	869	935	1001	1068	1136	1204	1272	1341	1410	1480
62						458	523	589	657	725	793	863	933	1004	1076	1148	1220	1293	1367	1441	1515	1590
64						491	561	632	704	777	851	925	1001	1077	1153	1230	1308	1386	1465	1545	1624	1705
66							600	676	753	831	910	990	1071	1152	1234	1316	1400	1483	1568	1653	1738	1824
68							641	722	804	888	972	1057	1143	1230	1318	1406	1495	1584	1674	1765	1856	1948
70							683	770	857	946	1036	1127	1219	1311	1405	1499	1593	1689	1785	1882	1979	2077

Coefficient set 3.5 $b_0 = .57750E\text{-}03$ $b_1 = 2.05410$ $b_2 = 1.13380$ $b_3 = 1.00221$

APPENDIX A-35. SCRIBNER BOARD FOOT VOLUME TO A 6-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—JEFFREY PINE

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	3	4	5	6	7	8	9	10	11													
12	4	6	7	9	11	12	14	15	17	19												
14	6	8	10	13	15	17	19	22	24	26	29											
16	8	11	14	17	20	23	26	29	32	36	39	42										
18	11	14	18	22	26	30	34	38	42	46	50	54	59									
20	13	18	23	28	33	38	43	48	53	58	64	69	74	79								
22	16	22	28	34	41	47	53	59	66	72	78	85	91	98	104							
24	20	27	34	42	49	57	64	72	79	87	95	103	111	118	126	134						
26	24	32	41	50	59	67	76	86	95	104	113	122	132	141	151	160	170	179				
28	28	38	48	58	69	79	90	101	111	122	133	144	155	166	177	188	199	211	222			
30		44	56	68	80	92	104	117	129	142	155	167	180	193	206	219	232	245	258	271		
32		51	64	78	92	106	120	134	149	163	178	192	207	222	237	251	266	281	296	311	327	
34		58	73	89	105	121	137	153	170	186	203	219	236	253	270	287	304	321	338	355	372	389
36		65	83	101	119	137	155	173	192	210	229	248	267	286	305	324	343	363	382	401	421	440
38			93	113	133	153	174	195	215	236	257	279	300	321	343	364	386	407	429	451	473	495
40			104	126	148	171	194	217	240	264	287	311	334	358	382	406	430	454	479	503	527	552
42			115	140	165	190	215	241	267	293	319	345	371	397	424	451	477	504	531	558	585	612
44				154	182	210	238	266	294	323	352	381	410	439	468	497	527	556	586	616	646	676
46				169	200	230	261	292	323	355	386	418	450	482	514	546	579	611	644	677	709	742
48				185	218	252	286	319	354	388	422	457	492	527	562	598	633	669	704	740	776	812
50				202	238	274	311	348	385	423	460	498	536	574	613	651	690	728	767	806	845	884
52					258	298	338	378	418	459	500	541	582	623	665	707	748	791	833	875	917	960
54					279	322	365	409	452	496	540	585	629	674	719	764	810	855	901	947	992	1038
56					301	347	394	441	488	535	583	631	679	727	776	824	873	922	971	1021	1070	1120
58					324	373	423	474	524	575	627	678	730	782	834	886	939	991	1044	1097	1151	1204
60						400	454	508	562	617	672	727	782	838	894	950	1007	1063	1120	1177	1234	1291
62						428	486	543	601	660	719	778	837	896	956	1016	1077	1137	1198	1259	1320	1381
64						457	518	580	642	704	767	830	893	957	1020	1084	1149	1213	1278	1343	1408	1473
66							552	617	683	749	816	883	951	1018	1086	1154	1223	1292	1361	1430	1499	1569
68							586	656	726	796	867	938	1010	1082	1154	1227	1299	1372	1445	1519	1593	1666
70							621	695	769	844	919	995	1071	1147	1224	1300	1378	1455	1533	1610	1689	1767

Coefficient set 4.5 $b_0 = .40500E\text{-}03$ $b_1 = 2.28830$ $b_2 = 1.06550$ $b_3 = .99611$

APPENDIX A-36. SCRIBNER BOARD FOOT VOLUME TO A 6-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—SUGAR PINE

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	3	4	6	7	8	9	10	12	13													
12	5	6	8	10	12	13	15	17	19	21												
14	6	9	11	14	16	19	21	24	26	29	31											
16	8	11	15	18	21	24	28	31	35	38	42	45										
18	11	15	19	23	27	31	36	40	44	49	53	58	62									
20	13	18	23	28	34	39	44	50	55	61	66	72	77	83								
22	16	22	28	35	41	47	54	61	67	74	81	88	94	101	108							
24	20	27	34	42	49	57	65	73	81	89	97	105	113	121	130	138						
26	23	32	40	49	58	67	77	86	95	105	114	124	134	144	153	163	173	183				
28	27	37	47	57	68	79	89	100	111	122	134	145	156	168	179	191	202	214	226			
30		43	54	66	79	91	103	116	129	141	154	167	180	194	207	220	234	247	261	274		
32		49	62	76	90	104	118	133	147	162	177	192	207	222	237	252	268	283	298	314	330	
34		55	71	86	102	118	134	151	167	184	201	218	235	252	269	286	304	321	339	357	374	392
36		62	80	97	115	133	151	170	189	207	226	245	265	284	303	323	343	362	382	402	422	442
38			89	109	129	149	170	190	211	232	254	275	297	318	340	362	384	406	428	451	473	495
40			100	121	144	166	189	212	235	259	283	306	330	355	379	403	428	452	477	502	527	552
42			110	135	159	184	210	235	261	287	313	340	366	393	420	447	474	501	529	556	584	612
44				149	176	203	231	259	288	317	346	375	404	433	463	493	523	553	583	614	644	675
46				163	193	223	254	285	316	348	380	412	444	476	509	542	575	608	641	674	708	741
48				179	211	244	278	312	346	381	415	450	486	521	557	593	629	665	701	738	775	811
50				195	230	267	303	340	377	415	453	491	529	568	607	646	685	725	765	804	844	885
52					250	290	329	370	410	451	492	534	575	617	660	702	745	788	831	874	918	961
54					271	314	357	400	444	489	533	578	623	669	715	761	807	854	900	947	994	1042
56					293	339	386	433	480	528	576	625	674	723	772	822	872	922	973	1023	1074	1125
58					316	365	415	466	517	569	621	673	726	779	832	886	939	994	1048	1103	1157	1213
60						393	447	501	556	611	667	723	780	837	894	952	1010	1068	1126	1185	1244	1303
62						421	479	537	596	656	716	776	837	898	959	1021	1083	1145	1208	1271	1334	1398
64						451	512	575	638	702	766	830	895	961	1026	1092	1159	1226	1293	1360	1428	1496
66							547	614	681	749	818	887	956	1026	1096	1167	1238	1309	1381	1453	1525	1597
68							583	655	726	799	872	945	1019	1094	1168	1244	1319	1395	1472	1548	1625	1703
70							621	696	773	850	928	1006	1084	1164	1243	1323	1404	1485	1566	1648	1730	1812

Coefficient set 5.5 $b_0 = .66100E\text{-}03$ $b_1 = 2.06110$ $b_2 = 1.09210$ $b_3 = 1.00117$

APPENDIX A-37. SCRIBNER BOARD FOOT VOLUME TO A 6-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—LODGEPOLE PINE

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	3	4	6	7	8	10	11	13	14													
12	4	6	8	10	12	14	16	19	21	23												
14	6	9	11	14	17	20	23	26	29	32	35											
16	8	11	15	19	22	26	30	34	38	43	47	51										
18	10	15	19	24	29	34	39	44	49	55	60	66	72									
20	13	18	24	30	36	42	49	55	62	69	76	83	90	97								
22	16	23	30	37	44	52	60	68	76	84	93	101	110	119	128							
24	19	27	36	44	53	62	72	82	91	101	112	122	132	143	154	165						
26	23	32	42	52	63	74	85	97	108	120	132	145	157	170	182	195	208	222				
28	27	38	49	61	74	87	100	113	127	141	155	169	184	199	214	229	244	259	275			
30		44	57	71	86	100	116	131	147	163	180	196	213	230	247	265	283	301	319	337		
32		50	66	82	98	115	133	151	169	187	206	225	245	264	284	304	324	345	366	387	408	
34		57	75	93	112	131	151	171	192	213	235	256	278	301	323	346	369	393	416	440	464	488
36		65	85	105	126	148	171	194	217	241	265	290	314	340	365	391	417	444	470	497	524	552
38			95	118	142	166	192	217	244	270	297	325	353	381	410	439	468	498	528	558	588	619
40			106	132	158	186	214	242	272	302	332	363	394	425	457	490	522	556	589	623	657	691
42			117	146	176	206	237	269	302	335	368	402	437	472	508	544	580	617	654	691	729	767
44				161	194	228	262	297	333	370	407	444	483	521	561	600	640	681	722	763	805	847
46				177	213	250	288	327	366	406	447	489	531	573	617	660	704	749	794	839	885	931
48				194	234	274	316	358	401	445	490	535	581	628	675	723	771	820	869	919	969	1020
50				212	255	299	344	391	438	486	535	584	634	685	737	789	842	895	949	1003	1058	1113
52					277	325	374	425	476	528	581	635	690	745	801	858	915	973	1032	1091	1150	1210
54					301	353	406	460	516	573	630	689	748	808	869	930	992	1055	1118	1182	1247	1312
56					325	381	439	498	558	619	681	744	808	873	939	1005	1072	1140	1209	1278	1348	1418
58					350	411	473	536	601	667	734	802	871	941	1012	1084	1156	1229	1303	1377	1453	1529
60						442	509	577	646	717	789	863	937	1012	1088	1165	1243	1322	1401	1481	1562	1644
62						474	545	619	693	770	847	925	1005	1086	1167	1250	1333	1418	1503	1589	1675	1763
64						507	584	662	742	824	906	990	1076	1162	1249	1338	1427	1517	1608	1700	1793	1887
66							624	707	793	880	968	1058	1149	1241	1334	1429	1524	1621	1718	1816	1915	2015
68							665	754	845	938	1032	1128	1225	1323	1422	1523	1625	1727	1831	1936	2042	2148
70							707	802	899	998	1098	1200	1303	1408	1513	1620	1729	1838	1949	2060	2173	2286

Coefficient set 6.5 $b_0 = .38020E\text{-}03$ $b_1 = 2.12810$ $b_2 = 1.19600$ $b_3 = 1.00019$

APPENDIX A-38. SCRIBNER BOARD FOOT VOLUME TO A 6-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—WHITE FIR

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	3	5	6	8	9	11	12	14	16													
12	5	7	9	11	13	16	18	21	23	26												
14	6	9	12	15	18	21	25	28	31	35	39											
16	8	12	16	20	24	28	32	37	41	46	50	55										
18	11	15	20	25	30	35	41	46	52	58	64	70	76									
20	13	19	25	31	37	44	50	57	64	71	79	86	94	101								
22	16	23	30	37	45	53	61	69	77	86	95	104	113	122	132							
24	19	27	35	44	53	62	72	82	92	102	113	123	134	145	156	168						
26	22	31	41	51	62	73	84	96	108	120	132	144	157	170	183	196	210	223				
28	26	36	48	59	72	84	97	111	124	138	152	167	182	196	211	227	242	258	274			
30		41	54	68	82	96	111	127	142	158	174	191	208	225	242	259	277	295	313	331		
32		47	62	77	93	109	126	143	161	179	197	216	235	254	274	294	314	334	354	375	396	
34		53	69	86	104	123	142	161	181	201	222	243	264	286	308	330	353	375	398	422	445	469
36		59	77	96	116	137	158	180	202	225	248	271	295	319	343	368	393	419	444	470	497	523
38			86	107	129	152	175	199	224	249	275	300	327	354	381	408	436	464	493	521	550	580
40			94	118	142	167	193	220	247	274	303	331	360	390	420	450	481	512	543	575	607	639
42			103	129	156	184	212	241	271	301	332	363	395	427	460	493	527	561	595	630	665	701
44				141	170	200	231	263	295	328	362	396	431	466	502	538	575	612	650	688	726	765
46				153	185	218	251	286	321	357	393	431	468	507	546	585	625	665	706	747	789	831
48				166	200	236	272	309	347	386	426	466	507	549	591	633	677	720	764	809	854	900
50				179	216	254	293	334	375	417	459	503	547	592	637	683	730	777	824	873	921	970
52					232	273	315	359	403	448	494	541	588	636	685	734	784	835	886	938	990	1043
54					249	293	338	384	432	480	529	579	630	682	734	787	841	895	950	1005	1061	1118
56					266	313	361	411	461	513	566	619	673	729	784	841	898	956	1015	1074	1134	1194
58					283	333	385	438	492	547	603	660	718	777	836	896	958	1019	1082	1145	1209	1273
60						355	409	465	523	581	641	702	763	826	889	953	1018	1084	1150	1217	1285	1354
62						376	434	494	555	617	680	744	809	876	943	1011	1080	1150	1220	1291	1363	1436
64						398	460	523	587	653	720	788	857	927	998	1070	1143	1217	1291	1367	1443	1520
66							485	552	620	689	760	832	905	979	1054	1130	1207	1285	1364	1444	1524	1605
68							512	582	654	727	801	877	954	1032	1112	1192	1273	1355	1438	1522	1607	1693
70							539	613	688	765	843	923	1004	1086	1170	1254	1340	1426	1514	1602	1691	1781

Coefficient set 7.5 $b_0 = .45760E\text{-}03$ $b_1 = 2.07270$ $b_2 = 1.21940$ $b_3 = .99552$

APPENDIX A-39. SCRIBNER BOARD FOOT VOLUME TO A 6-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—RED FIR

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	3	4	5	7	9	10	12	14	16													
12	4	6	8	10	12	15	17	20	23	26												
14	5	8	11	14	17	20	24	27	31	35	39											
16	7	10	14	18	22	26	31	35	40	45	51	56										
18	9	13	17	22	27	33	38	44	51	57	64	71	78									
20	10	15	21	27	33	40	47	54	62	70	78	86	95	104								
22	13	19	25	32	40	48	57	65	75	84	94	104	114	125	135							
24	15	22	30	38	47	57	67	77	88	99	111	122	135	147	160	173						
26	17	26	35	45	55	66	78	90	102	115	129	142	157	171	186	201	216	232				
28	20	29	40	51	63	76	89	103	117	132	148	164	180	196	214	231	249	267	285			
30		33	45	58	72	86	101	117	134	151	168	186	204	223	243	263	283	303	324	346		
32		38	51	66	81	97	114	132	151	170	189	210	230	252	274	296	319	342	366	390	414	
34		42	57	73	90	109	128	148	168	190	212	234	257	281	306	331	356	382	409	435	463	491
36		47	63	81	100	121	142	164	187	210	235	260	286	312	339	367	395	424	453	483	514	544
38			70	90	111	133	156	181	206	232	259	287	315	344	374	405	436	467	500	533	566	600
40			76	98	121	146	171	198	226	254	284	314	345	377	410	443	478	512	548	584	621	658
42			83	107	132	159	187	216	246	277	309	343	377	411	447	484	521	559	598	637	677	718
44				116	144	173	203	234	267	301	336	372	409	447	485	525	566	607	649	692	735	779
46				126	155	187	219	253	289	325	363	402	442	483	525	568	611	656	701	748	795	842
48				135	167	201	236	273	311	350	391	433	476	520	565	611	658	706	755	805	856	907
50				145	179	215	253	293	334	376	420	464	511	558	606	656	706	758	810	864	918	973
52					192	230	271	313	357	402	449	497	546	597	648	701	755	810	866	924	982	1041
54					205	246	289	334	380	429	478	530	582	636	691	748	805	864	924	985	1047	1110
56					217	261	307	355	404	456	509	563	619	676	735	795	856	919	982	1047	1113	1180
58					231	277	326	376	429	483	539	597	656	717	779	843	908	974	1041	1110	1180	1251
60						293	344	398	454	511	570	631	694	758	824	891	960	1030	1102	1174	1248	1323
62						309	363	420	479	539	602	666	733	800	870	941	1013	1087	1162	1239	1317	1396
64						326	383	442	504	568	634	702	771	843	916	991	1067	1145	1224	1305	1387	1470
66							402	465	530	597	666	738	811	886	963	1041	1121	1203	1287	1371	1458	1545
68							422	488	556	626	699	774	850	929	1010	1092	1176	1262	1350	1439	1529	1621
70							442	510	582	656	732	810	891	973	1057	1144	1232	1322	1413	1506	1601	1697

Coefficient set 8.5 $b_0 = .23590E\text{-}03$ $b_1 = 2.05820$ $b_2 = 1.37240$ $b_3 = .99321$

APPENDIX A-40. SCRIBNER BOARD FOOT VOLUME TO A 6-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—INCENSE-CEDAR

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	4	4	5	6	7	8	9													
12	3	4	6	7	8	9	11	12	13	14												
14	5	6	8	10	11	13	15	17	18	20	22											
16	6	8	11	13	15	18	20	22	25	27	30	32										
18	8	11	14	17	20	23	26	29	32	36	39	42	45									
20	10	14	17	21	25	29	33	37	41	45	49	53	57	61								
22	12	17	21	26	31	36	41	45	50	55	60	65	71	76	81							
24	15	20	26	32	37	43	49	55	61	67	73	79	85	92	98	104						
26	18	24	31	38	44	51	58	65	72	80	87	94	101	109	116	124	131	139				
28	21	28	36	44	52	60	68	77	85	93	102	110	119	128	136	145	154	163	172			
30		33	42	51	60	70	79	89	99	108	118	128	138	148	158	168	178	189	199	209		
32		38	48	58	69	80	91	102	113	124	135	147	158	170	181	193	205	216	228	240	252	
34		43	55	66	79	91	103	116	128	141	154	167	180	193	206	219	232	246	259	273	286	300
36		48	61	75	89	102	116	131	145	159	174	188	203	217	232	247	262	277	292	307	322	338
38			69	84	99	115	130	146	162	178	194	210	227	243	260	277	293	310	327	344	361	378
40			76	93	110	127	145	162	180	198	216	234	252	271	289	307	326	345	364	382	401	420
42			85	103	122	141	160	179	199	219	239	259	279	299	319	340	360	381	402	423	444	465
44				113	134	155	176	197	219	241	262	284	307	329	351	374	396	419	442	465	488	511
46				124	147	169	193	216	239	263	287	311	335	360	384	409	434	458	483	508	534	559
48				135	160	185	210	235	261	287	313	339	365	392	419	445	472	499	527	554	581	609
50				147	173	200	228	255	283	311	339	368	396	425	454	483	512	542	571	601	631	660
52					187	216	246	276	306	336	367	397	428	460	491	522	554	586	617	649	682	714
54					202	233	265	297	329	362	395	428	461	495	529	562	596	631	665	699	734	769
56					217	250	284	319	354	389	424	460	495	531	568	604	640	677	714	751	788	825
58					232	268	304	341	379	416	454	492	530	569	607	646	685	725	764	804	844	883
60						286	325	364	404	444	485	525	566	607	648	690	732	774	816	858	900	943
62						304	346	388	430	473	516	559	603	646	690	735	779	824	868	913	959	1004
64						323	367	412	457	502	548	594	640	686	733	780	827	875	922	970	1018	1066
66							389	437	484	532	581	629	678	727	777	827	877	927	977	1028	1079	1130
68							412	462	512	563	614	665	717	769	821	874	927	980	1033	1087	1141	1195
70							434	487	540	594	648	702	757	812	867	922	978	1034	1090	1147	1204	1261

Coefficient set 9.5 b_0 = .25400E-03 b_1 = 2.34540 b_2 = 1.08610 b_3 = .99289

APPENDIX A-41. SCRIBNER BOARD FOOT VOLUME TO AN 8-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—DOUGLAS-FIR

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	3	5	6	7	9	10	12	13	15													
12	5	7	9	11	13	15	17	19	21	23												
14	7	9	12	15	17	20	23	26	29	32	35											
16	9	12	16	19	23	27	30	34	38	42	46	50										
18	11	15	20	24	29	34	38	43	48	53	58	63	68									
20	14	19	25	30	36	41	47	53	59	65	71	77	84	90								
22	17	23	30	36	43	50	57	64	71	79	86	93	101	108	116							
24	20	27	35	43	51	59	68	76	85	93	102	111	120	129	138	147						
26	23	32	41	50	60	70	79	89	99	109	119	130	140	151	161	172	183	193				
28	27	37	48	58	69	80	92	103	115	126	138	150	162	174	186	199	211	223	236			
30		42	54	67	79	92	105	118	131	145	158	172	185	199	213	227	241	256	270	284		
32		48	62	76	90	104	119	134	149	164	179	195	210	226	242	258	274	290	306	322	339	
34		54	69	85	101	117	134	150	167	184	201	219	236	254	272	290	308	326	344	362	381	399
36		60	77	95	113	131	149	168	187	206	225	244	264	283	303	323	343	364	384	404	425	446
38			86	105	125	145	165	186	207	228	249	271	292	314	336	358	381	403	426	448	471	494
40			95	116	138	160	182	205	228	251	275	299	323	347	371	395	420	445	469	495	520	545
42			104	127	151	175	200	225	250	276	302	328	354	380	407	434	461	488	515	543	570	598
44				139	165	192	218	246	273	301	329	358	386	415	444	474	503	533	562	592	623	653
46				151	179	208	238	267	297	327	358	389	420	451	483	515	547	579	611	644	677	710
48				164	194	226	257	289	322	355	388	421	455	489	523	558	592	627	662	698	733	769
50				177	210	243	278	312	347	383	418	455	491	528	565	602	639	677	715	753	791	830
52					226	262	299	336	374	412	450	489	528	567	607	647	687	728	769	810	851	892
54					242	281	320	360	401	441	483	524	566	608	651	694	737	781	824	868	912	957
56					259	300	342	385	428	472	516	560	605	651	696	742	788	835	881	928	975	1023
58					276	320	365	411	457	503	550	598	646	694	742	791	840	890	940	990	1040	1091
60						340	388	437	486	535	585	636	687	738	790	842	894	947	1000	1053	1107	1160
62						361	412	464	516	568	621	675	729	783	838	893	949	1005	1061	1118	1174	1232
64						383	436	491	546	602	658	715	772	830	888	946	1005	1064	1124	1184	1244	1304
66							461	519	577	636	695	755	816	877	938	1000	1062	1125	1188	1251	1315	1379
68							487	547	609	671	734	797	861	925	990	1055	1121	1187	1253	1320	1387	1454
70							512	576	641	707	773	839	906	974	1042	1111	1180	1249	1319	1390	1460	1531

Coefficient set 2.4 b_0 = .68790E-03 b_1 = 2.06880 b_2 = 1.11610 b_3 = .99586

APPENDIX A-42. SCRIBNER BOARD FOOT VOLUME TO AN 8-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—PONDEROSA PINE

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	4	5	6	8	9	11	12	14	15													
12	5	7	9	11	13	16	18	20	22	25												
14	7	10	13	15	18	21	24	27	31	34	37											
16	9	13	17	20	24	28	32	36	40	44	48	53										
18	12	16	21	26	31	36	41	46	51	56	62	67	73									
20	15	20	26	32	38	44	51	57	64	70	77	83	90	97								
22	18	25	32	39	47	54	62	70	77	85	93	102	110	118	126							
24	21	30	38	47	56	65	74	83	93	102	112	122	131	141	151	161						
26	25	35	45	55	66	76	87	98	109	121	132	143	155	167	179	190	202	214				
28	30	41	52	64	77	89	102	115	128	141	154	167	181	194	208	222	236	250	264			
30		47	61	74	88	103	117	132	147	162	178	193	209	224	240	256	272	288	305	321		
32		54	69	85	101	117	134	151	168	185	203	221	238	256	275	293	311	330	348	367	386	
34		61	78	96	115	133	152	171	191	210	230	250	270	291	311	332	353	374	395	416	438	459
36		69	88	109	129	150	171	193	215	237	259	282	305	328	351	374	398	421	445	469	493	517
38			99	121	144	168	192	216	240	265	290	315	341	367	393	419	445	471	498	525	552	579
40			110	135	161	187	213	240	267	295	323	351	379	408	437	466	495	525	554	584	614	644
42			122	150	178	207	236	266	296	327	357	389	420	452	484	516	548	581	613	646	680	713
44				165	196	228	260	293	326	360	394	428	463	498	533	568	604	640	676	712	749	786
46				181	215	250	286	322	358	395	432	470	508	546	585	624	663	702	742	782	822	862
48				198	235	273	312	352	391	432	472	514	555	597	639	682	724	768	811	855	898	943
50				215	256	298	340	383	426	470	515	559	605	650	696	742	789	836	883	931	979	1027
52					278	323	369	416	463	511	559	607	656	706	756	806	857	908	959	1011	1062	1115
54					301	350	400	450	501	553	605	657	711	764	818	873	927	982	1038	1094	1150	1206
56					325	378	431	486	541	597	653	710	767	825	883	942	1001	1060	1120	1181	1241	1302
58					350	407	464	523	582	642	703	764	826	888	951	1014	1078	1142	1206	1271	1336	1402
60						437	499	562	625	690	755	820	887	954	1021	1089	1157	1226	1295	1365	1435	1506
62						468	534	602	670	739	809	879	950	1022	1094	1167	1240	1314	1388	1463	1538	1613
64						500	572	644	716	790	865	940	1016	1093	1170	1248	1326	1405	1484	1564	1644	1725
66							610	687	765	843	923	1003	1084	1166	1248	1331	1415	1499	1584	1669	1755	1841
68							650	731	814	898	983	1068	1155	1242	1330	1418	1507	1597	1687	1778	1869	1961
70							691	778	866	955	1045	1136	1228	1320	1414	1508	1602	1698	1794	1890	1987	2085

Coefficient set 3.4 b_0 = .69010E-03 b_1 = 2.04150 b_2 = 1.12630 b_3 = 1.00107

APPENDIX A-43. SCRIBNER BOARD FOOT VOLUME TO AN 8-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—JEFFREY PINE

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	3	4	5	7	8	9	10	11	12													
12	5	7	8	10	12	13	15	17	18	20												
14	7	9	12	14	16	19	21	24	26	28	31											
16	9	12	16	19	22	25	28	32	35	38	41	45										
18	12	16	20	24	29	33	37	41	45	50	54	58	62									
20	15	20	25	31	36	41	47	52	57	62	68	73	78	84								
22	19	25	31	38	44	51	57	64	70	77	84	90	97	103	110							
24	23	30	38	46	54	61	69	77	85	93	101	109	117	125	133	141						
26	27	36	45	54	64	73	82	92	101	111	120	130	139	149	158	168	177	187				
28	31	42	53	64	75	86	97	108	119	130	141	152	163	174	185	197	208	219	230			
30		49	61	74	87	99	112	125	138	151	163	176	189	202	215	228	241	254	267	280		
32		56	71	85	100	114	129	143	158	173	188	202	217	232	247	262	277	292	306	321	336	
34		64	80	97	113	130	146	163	180	197	213	230	247	264	281	298	315	332	349	366	383	400
36		72	91	109	128	146	165	184	203	222	241	260	279	298	317	336	355	374	393	413	432	451
38			101	122	143	164	185	206	227	248	270	291	312	334	355	376	398	419	441	462	484	505
40			113	136	159	183	206	230	253	277	300	324	348	371	395	419	443	467	491	514	538	562
42			125	151	176	202	228	254	280	306	332	358	385	411	437	464	490	516	543	569	596	622
44				166	194	223	251	280	308	337	366	395	424	452	481	510	539	569	598	627	656	685
46				182	213	244	275	306	338	369	401	432	464	496	527	559	591	623	655	687	719	751
48				198	232	266	300	334	369	403	437	472	506	541	575	610	645	680	714	749	784	819
50				215	252	289	326	363	400	438	475	513	550	588	625	663	701	738	776	814	852	890
52					273	313	353	393	433	474	514	555	595	636	677	718	758	799	840	881	922	963
54					294	338	381	424	468	511	555	599	642	686	730	774	818	862	907	951	995	1039
56					317	363	409	456	503	550	597	644	691	738	785	833	880	927	975	1022	1070	1118
58					339	389	439	489	539	589	640	690	741	791	842	893	943	994	1045	1096	1147	1198
60						416	469	523	577	630	684	738	792	846	900	955	1009	1063	1118	1172	1227	1281
62						444	501	558	615	672	730	787	845	902	960	1018	1076	1134	1192	1250	1308	1367
64						472	533	593	654	715	776	837	899	960	1022	1083	1145	1207	1268	1330	1392	1454
66							566	630	695	759	824	889	954	1019	1085	1150	1215	1281	1347	1412	1478	1544
68							599	667	736	804	873	942	1011	1080	1149	1218	1287	1357	1426	1496	1566	1635
70							633	706	778	850	923	996	1069	1142	1215	1288	1361	1435	1508	1582	1655	1729

Coefficient set 4.4 b_0 = .51200E-03 b_1 = 2.31110 b_2 = 1.02380 b_3 = .99434

APPENDIX A-44. SCRIBNER BOARD FOOT VOLUME TO AN 8-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—SUGAR PINE

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	4	5	6	8	9	10	12	13	15													
12	5	7	9	11	13	15	17	19	21	23												
14	7	10	12	15	18	21	23	26	29	32	35											
16	9	13	16	20	23	27	31	34	38	42	46	50										
18	12	16	21	25	30	34	39	44	48	53	58	63	68									
20	15	20	25	31	37	42	48	54	60	66	72	78	84	90								
22	18	24	31	38	45	52	59	66	73	80	88	95	102	110	117							
24	21	29	37	45	53	62	70	79	87	96	105	113	122	131	140	149						
26	25	34	43	53	63	73	83	93	103	113	123	134	144	155	165	176	186	197				
28	29	40	51	62	73	84	96	108	119	131	143	155	168	180	192	205	217	229	242			
30		46	58	71	84	97	111	124	138	151	165	179	193	207	221	235	250	264	279	293		
32		52	66	81	96	111	126	142	157	173	188	204	220	236	252	269	285	301	318	334	351	
34		59	75	92	109	126	143	160	178	195	213	231	249	268	286	304	323	341	360	379	397	416
36		66	85	103	122	141	161	180	200	220	240	260	280	301	321	342	363	384	405	426	447	468
38			94	115	136	158	179	201	223	245	268	290	313	336	359	382	405	429	452	475	499	523
40			105	128	151	175	199	223	248	273	298	323	348	373	399	424	450	476	502	528	554	581
42			116	141	167	194	220	247	274	301	329	356	384	412	441	469	497	526	555	584	613	642
44				156	184	213	242	272	301	331	362	392	423	454	485	516	547	579	610	642	674	706
46				170	202	233	265	298	330	363	396	430	463	497	531	565	599	634	669	703	738	773
48				186	220	255	290	325	360	396	432	469	505	542	579	617	654	692	730	768	806	844
50				202	239	277	315	353	392	431	470	510	550	590	630	671	711	752	793	835	876	918
52					259	300	341	383	425	467	510	553	596	639	683	727	771	815	860	905	950	995
54					280	324	369	414	459	505	551	597	644	691	738	786	833	881	929	978	1026	1075
56					302	349	397	446	495	544	594	644	694	744	795	847	898	950	1002	1054	1106	1159
58					325	376	427	479	532	585	638	692	746	800	855	910	965	1021	1077	1133	1189	1245
60						403	458	514	570	627	684	742	800	858	917	976	1035	1095	1154	1215	1275	1335
62						431	490	550	610	671	732	794	856	918	981	1044	1107	1171	1235	1299	1364	1429
64						460	523	587	651	716	781	847	913	980	1047	1114	1182	1250	1319	1387	1456	1525
66							557	625	694	763	833	903	973	1044	1116	1187	1260	1332	1405	1478	1552	1625
68							593	665	738	811	885	960	1035	1111	1186	1263	1340	1417	1494	1572	1650	1728
70							629	706	783	861	940	1019	1099	1179	1260	1341	1422	1504	1586	1669	1752	1835

Coefficient set 5.4 $b_0 = .80630E\text{-}03$ $b_1 = 2.03010$ $b_2 = 1.09100$ $b_3 = 1.00048$

APPENDIX A-45. SCRIBNER BOARD FOOT VOLUME TO AN 8-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—LODGEPOLE PINE

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	3	5	6	8	9	11	12	14	16													
12	5	7	9	11	13	16	18	20	23	25												
14	7	10	12	15	18	22	25	28	31	35	38											
16	9	13	16	20	24	28	33	37	41	46	50	55										
18	11	16	21	26	31	36	42	47	53	59	64	70	76									
20	14	20	26	32	39	45	52	59	66	73	80	87	95	102								
22	18	25	32	40	47	55	64	72	81	89	98	107	116	125	134							
24	21	30	38	48	57	67	76	87	97	107	118	128	139	150	161	173						
26	25	35	45	56	67	79	91	103	115	127	140	152	165	178	191	205	218	231				
28	29	41	53	66	79	92	106	120	134	149	163	178	193	209	224	240	255	271	287			
30		47	62	76	92	107	123	139	156	172	189	207	224	242	260	278	296	314	333	351		
32		55	71	88	105	123	141	160	179	198	218	237	257	278	298	319	340	361	382	404	425	
34		62	81	100	120	140	161	182	204	226	248	271	293	317	340	363	387	411	436	460	485	510
36		70	91	113	136	159	182	206	231	256	281	306	332	358	385	411	438	466	493	521	549	577
38			103	127	153	179	205	232	260	287	316	344	374	403	433	463	493	524	555	586	617	649
40			115	142	171	200	229	260	290	322	353	385	418	451	484	518	552	586	620	655	690	726
42			128	159	190	222	255	289	323	358	393	429	465	502	539	576	614	652	690	729	768	808
44				176	211	246	283	320	358	396	436	475	515	556	597	638	680	722	765	808	851	895
46				194	232	272	312	353	395	437	481	524	568	613	658	704	750	797	844	891	939	987
48				213	255	299	343	388	434	481	528	576	625	674	724	774	825	876	928	980	1032	1085
50				233	280	327	376	425	475	527	578	631	684	738	793	848	903	959	1016	1073	1130	1188
52					305	357	410	464	519	575	632	689	747	806	865	925	986	1047	1109	1171	1234	1297
54					332	389	446	505	565	626	687	750	813	877	942	1007	1073	1140	1207	1275	1343	1412
56					361	422	485	548	613	679	746	814	883	952	1022	1093	1165	1237	1310	1384	1458	1533
58					391	457	525	594	664	735	808	881	956	1031	1107	1184	1261	1340	1419	1498	1579	1660
60						493	567	641	717	794	873	952	1032	1114	1196	1279	1363	1447	1533	1619	1705	1793
62						532	611	691	773	856	940	1026	1113	1200	1289	1378	1468	1560	1652	1744	1838	1932
64						572	657	743	831	921	1011	1103	1196	1291	1386	1482	1579	1677	1776	1876	1977	2078
66							705	798	892	988	1086	1184	1284	1385	1488	1591	1695	1800	1907	2014	2121	2230
68							755	855	956	1059	1163	1269	1376	1484	1594	1704	1816	1929	2043	2157	2273	2389
70							808	914	1022	1132	1244	1357	1472	1587	1705	1823	1942	2063	2185	2307	2431	2555

Coefficient set 6.4 $b_0 = .58510E\text{-}03$ $b_1 = 2.01050$ $b_2 = 1.17430$ $b_3 = 1.00447$

APPENDIX A-46. SCRIBNER BOARD FOOT VOLUME TO AN 8-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—WHITE FIR

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	4	5	7	9	11	12	14	16	19													
12	5	8	10	12	15	18	21	23	26	29												
14	7	10	13	17	20	24	28	32	36	40	44											
16	9	13	17	22	26	31	36	41	46	51	57	62										
18	12	17	22	27	33	39	45	51	58	64	71	78	85									
20	14	20	27	33	40	48	55	63	71	79	87	95	104	112								
22	17	24	32	40	48	57	66	75	85	94	104	114	124	135	145							
24	20	29	38	47	57	67	78	89	100	111	123	135	147	159	171	184						
26	23	33	44	55	67	78	91	103	116	130	143	157	171	185	199	214	229	244				
28	27	38	50	63	76	90	104	119	134	149	165	180	196	213	229	246	263	280	298			
30		44	57	72	87	103	119	135	152	170	187	205	223	242	261	280	299	319	339	359		
32		49	65	81	98	116	134	153	172	191	211	231	252	273	294	316	338	360	382	405	428	
34		55	72	91	110	130	150	171	192	214	236	259	282	306	329	353	378	403	428	453	479	505
36		61	80	101	122	144	167	190	214	238	263	288	314	340	366	393	420	448	475	504	532	561
38			89	111	135	159	184	210	236	263	290	318	346	375	404	434	464	494	525	556	588	620
40			98	122	148	175	202	230	259	289	319	349	380	412	444	477	510	543	577	611	646	681
42			107	134	162	191	221	252	283	315	348	382	416	450	485	521	557	594	630	668	706	744
44				146	176	208	240	274	308	343	379	415	452	490	528	567	606	646	686	727	768	809
46				158	191	225	260	297	334	372	411	450	490	531	572	614	657	700	743	787	832	877
48				170	206	243	281	320	360	401	443	486	529	573	618	663	709	755	802	850	898	947
50				183	222	261	302	345	388	432	477	523	569	617	665	713	763	813	863	914	966	1018
52					238	280	324	370	416	463	511	560	610	661	713	765	818	871	926	980	1036	1092
54					254	300	347	395	445	495	547	599	653	707	762	818	874	932	990	1048	1108	1167
56					271	320	370	421	474	528	583	639	696	754	812	872	932	993	1055	1118	1181	1245
58					288	340	393	448	504	561	620	679	740	802	864	927	991	1056	1122	1189	1256	1324
60						361	417	475	535	596	658	721	785	850	917	984	1052	1121	1191	1261	1333	1405
62						382	442	503	566	631	696	763	831	900	970	1042	1114	1187	1261	1335	1411	1487
64						403	467	532	598	666	736	806	878	951	1025	1100	1177	1254	1332	1411	1490	1571
66							492	561	631	702	776	850	926	1003	1081	1160	1241	1322	1404	1487	1571	1656
68							518	590	664	739	816	895	974	1055	1138	1221	1306	1391	1478	1565	1654	1743
70							544	620	697	777	858	940	1024	1109	1195	1283	1372	1462	1553	1645	1738	1832

Coefficient set 7.4 $b_0 = .58110E\text{-}03$ $b_1 = 1.99490$ $b_2 = 1.23760$ $b_3 = .99580$

APPENDIX A-47. SCRIBNER BOARD FOOT VOLUME TO AN 8-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—RED FIR

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	3	4	6	8	10	12	14	16	18													
12	4	6	9	11	14	16	19	22	25	28												
14	6	9	12	15	18	22	26	30	34	38	43											
16	8	11	15	19	24	29	34	39	44	50	55	61										
18	9	14	19	24	30	36	42	49	55	62	69	77	84									
20	12	17	23	30	36	44	51	59	67	76	85	94	103	112								
22	14	20	28	35	44	52	61	71	81	91	101	112	123	134	146							
24	16	24	32	42	51	62	72	83	95	107	119	132	145	158	171	185						
26	19	28	38	48	59	71	84	97	110	124	138	153	168	183	199	215	231	248				
28	22	32	43	55	68	82	96	111	126	142	158	175	192	210	228	246	265	284	304			
30		36	49	63	77	93	109	126	143	161	179	198	218	238	258	279	301	322	344	367		
32		41	55	70	87	104	122	141	161	181	202	223	245	267	290	314	338	362	387	412	438	
34		45	61	79	97	116	136	157	179	202	225	249	273	298	324	350	376	404	431	460	488	517
36		50	68	87	107	129	151	174	198	223	249	275	302	330	358	387	417	447	478	509	540	573
38			75	96	118	141	166	192	218	245	274	303	332	363	394	426	459	492	525	560	595	630
40			82	105	129	155	182	210	239	269	299	331	364	397	431	466	502	538	575	612	650	689
42			89	114	140	168	198	228	260	292	326	360	396	432	469	507	546	585	626	666	708	750
44				123	152	182	214	247	281	317	353	390	429	468	508	550	592	634	678	722	767	813
46				133	164	197	231	267	303	342	381	421	463	505	549	593	638	684	731	779	828	877
48				143	176	212	248	287	326	367	409	453	497	543	590	637	686	735	786	837	889	942
50				153	189	227	266	307	349	393	438	485	533	581	631	682	735	788	842	897	953	1009
52					202	242	284	328	373	420	468	518	569	621	674	729	784	841	898	957	1017	1077
54					215	257	302	349	397	447	498	551	605	661	717	775	835	895	956	1019	1082	1147
56					228	273	321	370	421	474	529	585	642	701	761	823	886	950	1015	1081	1149	1217
58					241	289	339	392	446	502	560	619	680	742	806	871	938	1005	1074	1145	1216	1288
60						305	358	414	471	530	591	654	718	784	851	920	990	1062	1135	1209	1284	1360
62						322	378	436	496	558	623	689	756	826	897	969	1043	1119	1195	1274	1353	1434
64						338	397	458	522	587	655	724	795	868	943	1019	1097	1176	1257	1339	1422	1507
66							417	481	547	616	687	760	835	911	990	1070	1151	1234	1319	1405	1493	1582
68							436	504	573	645	720	796	874	954	1036	1120	1206	1293	1381	1472	1563	1657
70							456	527	599	675	752	832	914	998	1084	1171	1261	1352	1444	1539	1635	1732

Coefficient set 8.4 $b_0 = .29850E\text{-}03$ $b_1 = 2.02870$ $b_2 = 1.36000$ $b_3 = .99290$

APPENDIX A-48. SCRIBNER BOARD FOOT VOLUME TO AN 8-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—INCENSE-CEDAR

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	ten board feet																					
10	2	3	4	5	6	7	7	8	9													
12	3	5	6	7	9	10	11	13	14	16												
14	5	6	8	10	12	14	16	18	20	22	24											
16	6	9	11	14	16	19	21	24	27	30	32	35										
18	8	11	15	18	21	24	28	31	35	38	42	46	49									
20	10	14	18	22	27	31	35	40	44	48	53	57	62	67								
22	13	18	23	28	33	38	43	49	54	60	65	71	76	82	88							
24	15	21	27	33	40	46	52	59	65	72	79	85	92	99	106	113						
26	18	25	32	40	47	54	62	70	77	85	93	101	109	117	126	134	142	150				
28	21	29	38	46	55	64	73	82	91	100	109	119	128	137	147	157	166	176	186			
30		34	44	54	63	74	84	94	105	116	126	137	148	159	170	181	192	204	215	226		
32		39	50	61	73	84	96	108	120	132	144	157	169	182	195	207	220	233	246	259	272	
34		44	57	69	82	96	109	122	136	150	164	178	192	206	221	235	250	264	279	294	309	324
36		50	64	78	93	107	122	138	153	169	184	200	216	232	248	264	281	297	314	330	347	364
38			71	87	103	120	137	154	171	188	206	223	241	259	277	295	314	332	350	369	388	406
40			79	97	115	133	152	170	190	209	228	248	267	287	307	327	348	368	389	409	430	451
42			87	107	127	147	167	188	209	230	252	273	295	317	339	361	383	406	428	451	474	497
44				117	139	161	183	206	229	252	276	300	323	347	372	396	420	445	470	495	520	545
46				128	151	176	200	225	250	276	301	327	353	379	406	432	459	486	513	540	567	595
48				139	165	191	217	244	272	299	327	355	383	412	441	470	499	528	557	587	616	646
50				150	178	206	235	265	294	324	354	384	415	446	477	508	540	571	603	635	667	699
52					192	223	254	285	317	349	382	414	447	481	514	548	582	616	650	684	719	754
54					206	239	272	306	341	375	410	445	481	516	552	588	625	661	698	735	772	810
56					221	256	292	328	365	402	439	477	514	553	591	630	669	708	748	787	827	867
58					236	273	311	350	389	429	469	509	549	590	631	672	714	756	798	840	883	926
60						291	332	373	414	456	499	542	585	628	672	716	760	805	849	894	940	985
62						309	352	396	440	484	530	575	621	667	713	760	807	854	902	950	998	1046
64						327	373	419	466	513	561	609	657	706	755	805	855	905	955	1006	1057	1108
66							394	443	492	542	593	643	695	746	798	850	903	956	1009	1063	1117	1171
68							415	467	519	572	625	678	732	787	842	897	952	1008	1064	1121	1177	1234
70							437	491	546	601	657	714	771	828	886	944	1002	1061	1120	1179	1239	1299

Coefficient set 9.4 $b_0 = .23910E\text{-}03$ $b_1 = 2.36270$ $b_2 = 1.11040$ $b_3 = .99124$

APPENDIX A-49. CUBIC FOOT VOLUME TO A 0-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—DOUGLAS-FIR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	6	8	9	11	13	15	17	19	21													
12	8	11	13	16	19	21	24	27	29	32												
14	11	14	18	22	25	29	32	36	40	43	47											
16	14	19	23	28	33	37	42	46	51	56	60	65										
18	18	23	29	35	41	47	52	58	64	70	76	81	87									
20	21	29	36	43	50	57	64	71	78	86	93	100	107	114								
22	26	34	43	51	60	69	77	86	94	103	111	120	128	137	145							
24	30	41	51	61	71	81	91	101	111	121	131	141	152	162	172	182						
26	36	47	59	71	83	94	106	118	130	141	153	165	177	188	200	212	223	235				
28	41	55	68	82	95	109	122	136	149	163	176	190	203	217	231	244	258	271	285			
30		62	78	93	109	124	140	155	170	186	201	217	232	248	263	278	294	309	325	340		
32		70	88	105	123	140	158	175	193	210	228	245	263	280	297	315	332	350	367	385	402	
34		79	99	118	138	158	177	197	216	236	256	275	295	314	334	354	373	393	412	432	451	471
36		88	110	132	154	176	198	219	241	263	285	307	329	351	372	394	416	438	460	481	503	525
38			122	146	170	195	219	243	267	292	316	340	364	389	413	437	461	485	509	534	558	582
40			134	161	188	215	241	268	295	322	348	375	402	428	455	482	508	535	562	588	615	642
42			147	177	206	236	265	294	324	353	382	411	441	470	499	529	558	587	616	646	675	704
44				193	225	257	289	321	353	385	417	449	481	513	545	577	609	641	673	705	737	769
46				210	245	280	315	350	385	419	454	489	524	559	593	628	663	698	732	767	802	837
48				228	266	304	341	379	417	455	492	530	568	606	643	681	719	756	794	832	869	907
50				246	287	328	369	410	450	491	532	573	614	654	695	736	776	817	858	899	939	980
52					309	353	397	441	485	529	573	617	661	705	749	792	836	880	924	968	1012	1056
54					332	379	427	474	521	568	615	663	710	757	804	851	898	945	992	1039	1087	1134
56					356	406	457	508	558	609	659	710	760	811	861	912	962	1013	1063	1113	1164	1214
58					380	434	488	542	596	650	704	758	812	866	920	974	1028	1082	1136	1190	1244	1297
60						463	520	578	636	693	751	808	866	923	981	1038	1096	1153	1211	1268	1326	1383
62						492	554	615	676	737	799	860	921	982	1043	1105	1166	1227	1288	1349	1410	1471
64						523	588	653	718	783	848	913	978	1043	1108	1173	1238	1302	1367	1432	1497	1562
66							623	692	761	830	898	967	1036	1105	1174	1243	1311	1380	1449	1518	1586	1655
68							659	732	805	877	950	1023	1096	1169	1242	1314	1387	1460	1532	1605	1678	1751
70							696	773	850	927	1003	1080	1157	1234	1311	1388	1465	1541	1618	1695	1772	1848

Coefficient set 2.14 $b_0 = .22440E\text{-}02$ $b_1 = 1.93420$ $b_2 = .99640$ $b_3 = .99919$

APPENDIX A-50. CUBIC FOOT VOLUME TO A 0-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—PONDEROSA PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	6	8	10	12	13	15	17	19	21													
12	8	11	14	16	19	22	25	27	30	33												
14	11	15	18	22	26	30	33	37	41	44	48											
16	14	19	24	29	34	38	43	48	53	58	62	67										
18	18	24	30	36	42	48	55	61	67	73	79	85	91									
20	22	30	37	45	52	60	67	75	82	90	97	105	112	119								
22	27	36	45	54	63	72	81	90	99	108	117	126	135	145	154							
24	32	43	54	65	75	86	97	108	118	129	140	151	161	172	183	194						
26	38	51	63	76	89	101	114	127	139	152	165	177	190	202	215	228	240	253				
28	44	59	74	88	103	118	132	147	162	177	191	206	221	236	250	265	280	294	309			
30		68	85	102	119	136	153	170	187	204	220	237	254	271	288	305	322	339	356	373		
32		77	97	116	136	155	174	194	213	233	252	271	291	310	330	349	368	388	407	427	446	
34		88	110	132	154	176	198	220	242	264	286	308	330	352	374	396	418	440	462	484	506	528
36		99	124	149	173	198	223	248	273	297	322	347	372	397	421	446	471	496	521	546	570	595
38			139	167	194	222	250	278	306	333	361	389	417	445	472	500	528	556	584	611	639	667
40			155	186	217	248	279	310	341	372	403	434	465	496	527	558	589	620	651	682	713	744
42			172	206	241	275	309	344	378	413	447	482	516	550	585	619	654	688	722	757	791	826
44				228	266	304	342	380	418	456	494	532	570	608	646	684	722	760	798	836	875	913
46				251	293	335	377	419	460	502	544	586	628	670	712	754	795	837	879	921	963	1005
48				275	321	367	413	459	505	551	597	643	689	735	781	827	873	919	965	1011	1057	1102
50				301	352	402	452	502	552	603	653	703	753	804	854	904	954	1005	1055	1105	1156	1206
52					383	438	493	548	602	657	712	767	822	876	931	986	1041	1096	1150	1205	1260	1315
54					417	476	536	596	655	715	774	834	893	953	1013	1072	1132	1191	1251	1311	1370	1430
56					452	517	581	646	711	775	840	905	969	1034	1098	1163	1228	1292	1357	1422	1486	1551
58					489	559	629	699	769	839	909	979	1049	1119	1189	1259	1329	1399	1469	1538	1608	1678
60						604	679	755	830	906	981	1057	1132	1208	1284	1359	1435	1510	1586	1661	1737	1812
62						651	732	813	895	976	1058	1139	1220	1302	1383	1464	1546	1627	1709	1790	1871	1953
64						700	787	875	962	1050	1137	1225	1312	1400	1487	1575	1663	1750	1838	1925	2013	2100
66							845	939	1033	1127	1221	1315	1409	1503	1597	1691	1785	1879	1973	2067	2161	2255
68							906	1006	1107	1208	1309	1409	1510	1611	1711	1812	1913	2013	2114	2215	2316	2416
70							969	1077	1185	1292	1400	1508	1616	1723	1831	1939	2047	2154	2262	2370	2478	2585

Coefficient set 3.14 b_0 = .25250E-02 b_1 = 1.85180 b_2 = 1.00040 b_3 = 1.00701

APPENDIX A-51. CUBIC FOOT VOLUME TO A 0-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—JEFFREY PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	6	7	9	11	13	15	16	18	20													
12	8	10	13	16	18	21	23	26	29	31												
14	11	14	18	21	25	28	32	35	39	42	46											
16	14	18	23	28	32	37	41	46	50	55	60	64										
18	17	23	29	35	41	46	52	58	64	69	75	81	87									
20	22	29	36	43	50	57	64	71	78	86	93	100	107	114								
22	26	35	43	52	61	69	78	86	95	103	112	121	129	138	146							
24	31	41	52	62	72	82	93	103	113	123	133	144	154	164	174	184						
26	36	48	61	73	85	97	109	121	133	145	157	169	181	193	205	217	229	240				
28	42	56	70	84	98	112	126	140	154	168	182	196	210	224	238	251	265	279	293			
30		65	81	97	113	129	145	161	177	193	209	225	241	257	273	289	305	321	337	353		
32		74	92	110	129	147	165	184	202	220	239	257	275	293	311	330	348	366	384	403	421	
34		84	104	125	146	167	187	208	229	249	270	291	311	332	353	373	394	414	435	456	476	497
36		94	117	141	164	187	210	234	257	280	303	327	350	373	396	420	443	466	489	512	535	559
38			131	157	183	209	235	261	287	313	339	365	391	417	443	469	495	521	547	572	598	624
40			146	175	204	233	261	290	319	348	377	406	435	464	492	521	550	579	608	636	665	694
42			161	193	225	257	289	321	353	385	417	449	481	513	545	577	609	640	672	704	736	768
44				213	248	283	319	354	389	424	460	495	530	565	600	635	670	706	741	776	811	846
46				234	272	311	350	388	427	466	504	543	581	620	659	697	736	774	813	851	890	928
48				255	298	340	382	425	467	509	551	593	636	678	720	762	804	846	888	931	973	1015
50				278	324	371	417	463	509	555	601	647	693	739	785	830	876	922	968	1014	1060	1106
52					352	403	453	503	553	603	653	703	753	802	852	902	952	1002	1052	1102	1151	1201
54					382	436	490	545	599	653	707	761	815	869	923	977	1031	1085	1139	1193	1247	1301
56					413	471	530	588	647	705	764	822	881	939	998	1056	1114	1173	1231	1289	1348	1406
58					445	508	571	634	697	760	823	886	949	1012	1075	1138	1201	1264	1327	1390	1453	1515
60						546	614	682	750	818	885	953	1021	1089	1156	1224	1292	1359	1427	1495	1562	1630
62						586	659	732	805	877	950	1023	1096	1168	1241	1313	1386	1459	1531	1604	1676	1749
64						628	706	784	862	940	1018	1095	1173	1251	1329	1407	1484	1562	1640	1718	1795	1873
66							754	838	921	1004	1088	1171	1254	1337	1421	1504	1587	1670	1753	1836	1919	2002
68							805	894	983	1072	1161	1250	1338	1427	1516	1605	1693	1782	1871	1959	2048	2136
70							858	952	1047	1142	1237	1331	1426	1520	1615	1709	1804	1898	1993	2087	2182	2276

Coefficient set 4.14 b_0 = .22050E-02 b_1 = 1.91050 b_2 = .99510 b_3 = 1.00396

APPENDIX A-52. CUBIC FOOT VOLUME TO A 0-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—SUGAR PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	6	7	9	11	12	14	16	17	19													
12	8	11	13	15	18	20	23	25	27	30												
14	11	14	18	21	24	28	31	34	37	40	44											
16	14	19	23	28	32	36	40	45	49	53	57	61										
18	18	24	30	35	41	46	51	57	62	67	72	78	83									
20	23	30	37	43	50	57	64	70	77	83	90	96	103	109								
22	28	36	45	53	61	69	77	85	93	101	109	117	125	133	140							
24	33	43	53	63	73	83	92	102	111	121	130	140	149	158	168	177						
26	39	51	63	74	86	98	109	120	131	143	154	165	176	187	198	209	219	230				
28	45	59	73	87	100	114	127	140	153	166	179	192	205	218	230	243	256	268	281			
30		68	84	100	116	131	146	162	177	192	207	222	236	251	266	280	295	310	324	338		
32		78	97	115	132	150	167	185	202	219	236	253	270	287	304	321	337	354	371	387	404	
34		89	110	130	150	170	190	210	229	249	268	288	307	326	345	364	383	402	421	439	458	477
36		100	123	146	169	192	214	236	259	280	302	324	346	367	389	410	432	453	474	495	516	537
38			138	164	190	215	240	265	290	314	339	363	387	411	436	460	483	507	531	555	578	602
40			154	183	211	239	267	295	323	350	377	404	432	458	485	512	539	565	592	618	644	670
42			171	203	234	265	296	327	358	388	418	448	478	508	538	568	597	626	656	685	714	743
44				224	258	293	327	361	395	428	462	495	528	561	594	626	659	691	724	756	788	820
46				246	284	322	360	397	434	471	507	544	580	617	653	689	724	760	796	831	866	902
48				269	311	353	394	435	475	516	556	596	636	675	715	754	793	832	871	910	949	987
50				294	339	385	430	474	519	563	607	650	694	737	780	823	866	908	951	993	1035	1078
52					369	419	467	516	564	612	660	707	755	802	848	895	942	988	1034	1080	1126	1172
54					401	454	507	560	612	664	716	767	818	870	920	971	1022	1072	1122	1172	1222	1272
56					433	491	549	605	662	718	774	830	885	941	996	1050	1105	1160	1214	1268	1322	1376
58					468	530	592	653	714	775	836	896	955	1015	1074	1134	1192	1251	1310	1368	1426	1484
60						571	637	703	769	834	899	964	1029	1093	1157	1220	1284	1347	1410	1473	1536	1598
62						613	684	756	826	896	966	1036	1105	1174	1242	1311	1379	1447	1515	1582	1649	1717
64						657	734	810	886	961	1036	1110	1184	1258	1332	1405	1478	1551	1624	1696	1768	1840
66							785	867	948	1028	1108	1188	1267	1346	1425	1503	1582	1660	1737	1815	1892	1969
68							838	925	1012	1098	1184	1269	1353	1438	1522	1606	1689	1772	1855	1938	2020	2103
70							894	987	1079	1171	1262	1353	1443	1533	1623	1712	1801	1890	1978	2066	2154	2242

Coefficient set 5.14 b_0 = .23770E-02 b_1 = 1.97190 b_2 = .93740 b_3 = 1.00946

APPENDIX A-53. CUBIC FOOT VOLUME TO A 0-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—LODGEPOLE PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	6	8	10	12	14	16	18	20	22													
12	9	11	14	17	20	23	26	29	31	34												
14	12	16	20	24	27	31	35	39	43	47	51											
16	15	21	26	31	36	41	46	51	56	62	67	72										
18	20	26	33	39	46	52	59	65	72	78	85	91	98									
20	24	32	40	49	57	65	73	81	89	97	105	113	121	129								
22	30	39	49	59	69	78	88	98	108	117	127	137	147	156	166							
24	35	47	59	70	82	93	105	117	128	140	152	163	175	186	198	210						
26	41	55	69	82	96	110	124	137	151	164	178	192	205	219	233	246	260	274				
28	48	64	80	96	112	128	143	159	175	191	207	223	238	254	270	286	302	318	333			
30		73	92	110	128	146	165	183	201	219	238	256	274	292	310	329	347	365	383	401		
32		84	104	125	146	167	188	208	229	250	270	291	312	333	353	374	395	415	436	457	477	
34		94	118	141	165	188	212	235	259	282	305	329	352	376	399	422	446	469	492	516	539	562
36		106	132	159	185	211	237	264	290	316	342	369	395	421	447	473	500	526	552	578	604	630
38			147	177	206	235	264	294	323	352	381	411	440	469	498	527	557	586	615	644	673	702
40			163	196	228	261	293	325	358	390	423	455	487	520	552	584	617	649	681	713	746	778
42			180	216	251	287	323	359	394	430	466	501	537	573	608	644	679	715	751	786	822	857
44				236	276	315	354	393	432	472	511	550	589	628	667	706	745	784	823	863	902	941
46				258	301	344	387	430	472	515	558	601	643	686	729	771	814	857	899	942	985	1027
48				281	328	374	421	467	514	561	607	654	700	746	793	839	886	932	979	1025	1071	1118
50				305	355	406	456	507	557	608	658	709	759	809	860	910	960	1011	1061	1111	1162	1212
52					384	439	493	548	602	657	711	766	820	875	929	983	1038	1092	1147	1201	1255	1310
54					414	472	531	590	649	707	766	825	883	942	1001	1059	1118	1177	1235	1294	1352	1411
56					444	507	571	634	697	760	823	886	949	1012	1075	1138	1201	1264	1327	1390	1453	1516
58					476	544	611	679	747	814	882	949	1017	1084	1152	1219	1287	1354	1422	1489	1557	1624
60						581	654	726	798	870	943	1015	1087	1159	1231	1303	1375	1448	1520	1592	1664	1736
62						620	697	774	851	928	1005	1082	1159	1236	1313	1390	1467	1544	1621	1697	1774	1851
64						660	742	824	906	988	1070	1152	1233	1315	1397	1479	1561	1643	1724	1806	1888	1970
66							788	875	962	1049	1136	1223	1310	1397	1484	1571	1658	1745	1831	1918	2005	2092
68							835	927	1020	1112	1204	1296	1389	1481	1573	1665	1757	1849	1941	2033	2125	2217
70							883	981	1079	1176	1274	1372	1469	1567	1664	1762	1859	1957	2054	2151	2249	2346

Coefficient set 6.14 b_0 = .18000E-02 b_1 = 2.05490 b_2 = .99590 b_3 = .99846

APPENDIX A-54. CUBIC FOOT VOLUME TO A 0-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—WHITE FIR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	6	8	10	12	14	16	18	20	23													
12	8	11	14	17	20	23	26	29	32	35												
14	11	15	19	23	27	31	35	39	43	47	52											
16	14	19	24	29	35	40	45	51	56	61	67	72										
18	18	24	30	37	43	50	57	63	70	77	84	91	98									
20	22	29	37	45	53	61	69	78	86	94	103	111	120	128								
22	26	35	45	54	64	74	83	93	103	113	123	133	144	154	164							
24	31	42	53	64	75	87	99	110	122	134	146	158	170	182	194	206						
26	36	48	61	75	88	101	115	129	142	156	170	184	198	212	226	240	255	269				
28	41	56	71	86	101	117	132	148	164	180	196	212	228	245	261	277	294	310	327			
30		64	81	98	116	133	151	169	187	205	224	242	261	279	298	316	335	354	373	392		
32		72	92	111	131	151	171	192	212	233	253	274	295	316	337	358	379	401	422	444	465	
34		81	103	125	147	170	192	215	238	261	285	308	331	355	379	402	426	450	474	498	523	547
36		90	115	139	164	189	215	240	266	292	318	344	370	396	423	449	476	502	529	556	583	610
38			127	155	182	210	238	266	295	323	352	381	410	439	469	498	528	557	587	617	647	677
40			140	171	201	232	263	294	325	357	389	421	453	485	517	550	582	615	648	681	714	747
42			154	187	221	254	288	323	357	392	427	462	497	532	568	604	639	675	711	747	784	820
44				205	241	278	315	353	390	428	467	505	543	582	621	660	699	738	778	817	857	896
46				223	263	303	343	384	425	466	508	550	592	634	676	718	761	804	847	890	933	976
48				242	285	329	372	417	461	506	551	596	642	688	733	779	826	872	919	965	1012	1059
50				262	308	355	403	451	499	547	596	645	694	743	793	843	893	943	993	1044	1094	1145
52					332	383	434	486	538	590	642	695	748	801	855	909	962	1016	1071	1125	1180	1234
54					357	412	467	522	578	634	691	747	804	861	919	977	1035	1093	1151	1209	1268	1327
56					383	441	500	560	620	680	740	801	862	924	985	1047	1109	1171	1234	1297	1359	1422
58					409	472	535	599	663	727	792	857	922	988	1054	1120	1186	1253	1319	1387	1454	1521
60						504	571	639	707	776	845	914	984	1054	1124	1195	1265	1337	1408	1479	1551	1623
62						536	608	680	753	826	899	973	1047	1122	1197	1272	1347	1423	1499	1575	1651	1728
64						570	646	723	800	877	956	1034	1113	1192	1272	1351	1432	1512	1593	1674	1755	1836
66							685	766	848	931	1013	1097	1180	1264	1349	1433	1518	1603	1689	1775	1861	1947
68							725	811	898	985	1073	1161	1249	1338	1428	1517	1607	1698	1788	1879	1970	2061
70							766	857	949	1041	1134	1227	1321	1415	1509	1604	1699	1794	1890	1986	2082	2179

Coefficient set 7.14 b_0 = .17880E-02 b_1 = 1.92890 b_2 = 1.06530 b_3 = .99971

APPENDIX A-55. CUBIC FOOT VOLUME TO A 0-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—RED FIR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	5	7	10	12	14	17	19	22	25													
12	7	10	13	17	20	24	27	31	35	38												
14	10	14	18	22	27	31	36	41	46	51	56											
16	12	17	23	28	34	40	46	52	59	65	72	78										
18	15	22	28	35	42	50	57	65	73	81	89	97	106									
20	18	26	34	43	51	60	69	79	88	98	108	118	128	138								
22	22	31	41	51	61	71	82	93	105	116	128	140	152	165	177							
24	26	36	48	59	71	84	96	109	123	136	150	164	178	193	207	222						
26	30	42	55	68	82	97	111	126	142	157	173	190	206	223	239	257	274	291				
28	34	48	63	78	94	110	127	145	162	180	198	217	235	254	274	293	313	333	353			
30		54	71	88	107	125	144	164	183	204	224	245	267	288	310	332	354	377	400	423		
32		61	80	99	120	140	162	184	206	229	252	275	299	323	348	373	398	423	449	474	500	
34		68	89	111	133	156	180	205	230	255	281	307	333	360	388	415	443	471	500	529	558	587
36		75	98	123	148	173	200	227	254	282	311	340	369	399	429	460	491	522	553	585	617	650
38			108	135	162	191	220	249	280	311	342	374	406	439	472	506	540	575	609	644	680	715
40			119	148	178	209	241	273	306	340	375	410	445	481	517	554	592	629	667	706	744	784
42			129	161	194	228	262	298	334	371	408	446	485	524	564	604	645	686	727	769	811	854
44				175	210	247	285	323	363	403	443	485	527	569	612	656	700	744	789	835	881	927
46				189	228	267	308	350	392	435	479	524	569	615	662	709	757	805	854	903	952	1002
48				204	245	288	332	377	422	469	516	565	613	663	713	764	815	867	920	973	1026	1080
50				219	263	309	356	404	454	504	555	606	659	712	766	820	875	931	988	1044	1102	1160
52					282	331	381	433	486	539	594	649	705	762	820	878	937	997	1057	1118	1180	1242
54					301	353	407	462	518	576	634	693	753	814	875	938	1001	1065	1129	1194	1260	1326
56					321	376	434	492	552	613	675	738	802	867	932	999	1066	1134	1202	1272	1341	1412
58					341	400	461	523	587	651	717	784	852	921	991	1061	1132	1205	1277	1351	1425	1500
60						424	488	555	622	691	760	831	903	976	1050	1125	1201	1277	1354	1432	1511	1590
62						448	517	587	658	731	804	879	956	1033	1111	1190	1270	1351	1433	1515	1598	1682
64						474	546	619	695	771	849	929	1009	1090	1173	1256	1341	1426	1513	1600	1688	1776
66							575	653	732	813	895	979	1063	1149	1236	1324	1413	1503	1594	1686	1779	1872
68							605	687	770	855	942	1030	1119	1209	1301	1393	1487	1582	1677	1774	1871	1970
70							635	721	809	898	989	1081	1175	1270	1366	1463	1562	1661	1762	1863	1965	2069

Coefficient set 8.14 b_0 = .11950E-02 b_1 = 1.87020 b_2 = 1.20340 b_3 = .99748

APPENDIX A-56. CUBIC FOOT VOLUME TO A 0-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—INCENSE-CEDAR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	5	6	8	9	10	12	13	14	15													
12	7	9	11	13	15	17	19	21	22	24												
14	10	12	15	18	20	23	26	28	31	33	36											
16	12	16	20	23	27	30	34	37	40	44	47	50										
18	16	21	25	30	34	38	43	47	51	55	60	64	68									
20	20	26	31	37	42	48	53	58	64	69	74	79	84	89								
22	24	31	38	45	51	58	64	71	77	83	90	96	102	108	114							
24	29	37	45	53	61	69	77	85	92	100	107	114	122	129	136	144						
26	34	44	53	63	72	81	90	99	108	117	126	135	143	152	160	169	177	186				
28	39	51	62	73	84	94	105	116	126	136	146	156	167	177	186	196	206	216	226			
30		58	71	84	96	109	121	133	145	157	168	180	191	203	214	226	237	248	259	270		
32		66	81	95	110	124	138	151	165	178	192	205	218	231	244	257	270	283	296	308	321	
34		75	92	108	124	140	156	171	186	202	217	232	247	261	276	291	305	320	334	348	362	377
36		84	103	121	139	157	175	192	209	226	243	260	277	293	310	326	342	359	375	391	407	423
38			115	135	155	175	195	214	233	252	271	290	308	327	345	364	382	400	418	436	453	471
40			127	150	172	194	216	237	258	280	301	321	342	362	383	403	423	443	463	483	503	522
42			140	165	190	214	238	262	285	308	331	354	377	400	422	444	467	489	511	533	554	576
44				181	208	235	261	287	313	338	364	389	414	439	463	488	512	536	561	585	608	632
46				198	227	257	285	314	342	370	398	425	452	479	506	533	560	586	613	639	665	691
48				216	248	279	311	342	372	403	433	463	492	522	551	580	609	638	667	696	724	752
50				234	269	303	337	371	404	437	469	502	534	566	598	630	661	692	723	754	785	816
52					290	328	364	401	437	472	508	543	578	612	647	681	715	749	782	816	849	882
54					313	353	393	432	471	509	547	585	622	660	697	734	770	807	843	879	915	951
56					337	380	422	464	506	547	588	629	669	709	749	789	828	867	906	945	984	1022
58					361	407	453	498	542	587	630	674	717	760	803	845	888	930	971	1013	1055	1096
60						435	484	532	580	627	674	721	767	813	859	904	949	994	1039	1083	1128	1172
62						464	516	568	619	669	719	769	818	867	916	965	1013	1061	1108	1156	1203	1250
64						494	550	604	659	712	766	819	871	923	975	1027	1078	1129	1180	1230	1281	1331
66							584	642	700	757	814	870	926	981	1036	1091	1145	1200	1254	1307	1361	1414
68							619	681	742	803	863	922	982	1040	1099	1157	1215	1272	1329	1386	1443	1500
70							655	721	786	850	913	976	1039	1101	1163	1225	1286	1347	1407	1468	1528	1587

Coefficient set 9.14 b_0 = .19300E-02 b_1 = 2.06770 b_2 = .90170 b_3 = .99848

APPENDIX A-57. CUBIC FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—DOUGLAS-FIR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	6	7	9	11	13	15	17	19	20													
12	8	11	13	16	19	21	24	26	29	32												
14	11	14	18	21	25	29	32	36	39	43	46											
16	14	19	23	28	32	37	42	46	51	55	60	65										
18	17	23	29	35	41	46	52	58	64	70	75	81	87									
20	21	28	36	43	50	57	64	71	78	85	92	99	106	113								
22	26	34	43	51	60	68	77	85	94	102	111	119	128	136	145							
24	30	40	51	61	71	81	91	101	111	121	131	141	151	161	171	181						
26	35	47	59	71	82	94	106	118	129	141	153	164	176	188	199	211	223	235				
28	41	54	68	81	95	108	122	135	149	163	176	189	203	216	230	243	257	270	284			
30		62	77	93	108	124	139	155	170	185	201	216	232	247	262	278	293	309	324	339		
32		70	88	105	123	140	158	175	192	210	227	245	262	280	297	314	332	349	367	384	401	
34		79	98	118	138	157	177	196	216	236	255	275	294	314	333	353	373	392	412	431	451	470
36		88	110	132	154	175	197	219	241	263	285	306	328	350	372	394	416	437	459	481	503	525
38			122	146	170	194	219	243	267	291	316	340	364	388	412	437	461	485	509	533	557	581
40			134	161	188	214	241	268	295	321	348	375	401	428	455	481	508	535	561	588	615	641
42			147	177	206	235	265	294	323	353	382	411	440	470	499	528	557	587	616	645	674	704
44				193	225	257	289	321	353	385	417	449	481	513	545	577	609	641	673	705	737	769
46				210	245	280	315	349	384	419	454	489	524	558	593	628	663	697	732	767	802	836
48				228	265	303	341	379	417	454	492	530	568	605	643	681	718	756	794	831	869	907
50				246	287	328	369	409	450	491	532	572	613	654	695	735	776	817	858	898	939	980
52					309	353	397	441	485	529	573	617	661	704	748	792	836	880	924	968	1011	1055
54					332	379	426	474	521	568	615	662	709	757	804	851	898	945	992	1039	1086	1133
56					355	406	457	507	558	608	659	709	760	810	861	911	962	1012	1063	1113	1164	1214
58					380	434	488	542	596	650	704	758	812	866	920	974	1028	1082	1136	1189	1243	1297
60						463	520	578	635	693	750	808	866	923	981	1038	1096	1153	1210	1268	1325	1383
62						492	553	615	676	737	798	859	921	982	1043	1104	1165	1226	1288	1349	1410	1471
64						522	587	652	717	782	847	912	977	1042	1107	1172	1237	1302	1367	1432	1497	1562
66							622	691	760	829	898	967	1036	1104	1173	1242	1311	1380	1448	1517	1586	1654
68							658	731	804	877	950	1022	1095	1168	1241	1314	1386	1459	1532	1604	1677	1750
70							695	772	849	926	1003	1080	1156	1233	1310	1387	1464	1541	1617	1694	1771	1848

Coefficient set 2.13 b_0 = .21670E-02 b_1 = 1.94480 b_2 = .99690 b_3 = .99900

APPENDIX A-58. CUBIC FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—PONDEROSA PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	6	8	9	11	13	15	17	19	21													
12	8	11	13	16	19	22	24	27	30	32												
14	11	15	18	22	26	29	33	37	40	44	47											
16	14	19	24	29	33	38	43	48	52	57	62	67										
18	18	24	30	36	42	48	54	60	66	72	78	84	90									
20	22	30	37	44	52	59	67	74	82	89	96	104	111	119								
22	27	36	45	54	63	72	81	90	99	108	117	126	135	144	153							
24	32	43	54	64	75	86	96	107	118	129	139	150	161	171	182	193						
26	38	50	63	76	88	101	113	126	139	151	164	177	189	202	214	227	240	252				
28	44	59	73	88	103	117	132	147	161	176	191	206	220	235	250	264	279	294	308			
30		68	85	102	118	135	152	169	186	203	220	237	254	271	288	305	322	339	356	372		
32		77	97	116	135	155	174	194	213	232	252	271	290	310	329	348	368	387	407	426	445	
34		88	110	132	154	176	198	220	242	264	286	308	330	351	373	395	417	439	461	483	505	527
36		99	124	149	173	198	223	248	272	297	322	347	372	396	421	446	471	496	520	545	570	595
38			139	167	194	222	250	278	305	333	361	389	417	444	472	500	528	556	583	611	639	667
40			155	186	217	248	279	310	341	372	403	434	465	496	527	558	589	620	651	682	713	744
42			172	206	241	275	309	344	378	413	447	481	516	550	585	619	653	688	722	757	791	825
44				228	266	304	342	380	418	456	494	532	570	608	646	684	722	760	798	836	874	912
46				251	293	335	377	418	460	502	544	586	628	670	712	753	795	837	879	921	963	1005
48				275	321	367	413	459	505	551	597	643	689	735	781	827	873	919	965	1010	1056	1102
50				301	351	402	452	502	552	603	653	703	753	804	854	904	954	1005	1055	1105	1155	1206
52					383	438	493	547	602	657	712	767	821	876	931	986	1041	1095	1150	1205	1260	1314
54					417	476	536	595	655	714	774	834	893	953	1012	1072	1131	1191	1251	1310	1370	1429
56					452	516	581	646	710	775	839	904	969	1033	1098	1162	1227	1292	1356	1421	1485	1550
58					489	559	629	698	768	838	908	978	1048	1118	1188	1258	1328	1397	1467	1537	1607	1677
60						603	679	754	829	905	980	1056	1131	1207	1282	1358	1433	1509	1584	1659	1735	1810
62						650	731	812	894	975	1056	1137	1219	1300	1381	1463	1544	1625	1706	1788	1869	1950
64						699	786	873	961	1048	1135	1223	1310	1398	1485	1572	1660	1747	1835	1922	2009	2097
66							843	937	1031	1125	1219	1312	1406	1500	1594	1688	1781	1875	1969	2063	2157	2250
68							904	1004	1105	1205	1306	1406	1506	1607	1707	1808	1908	2009	2109	2210	2310	2411
70							967	1074	1181	1289	1396	1504	1611	1719	1826	1934	2041	2149	2256	2364	2471	2579

Coefficient set 3.13 b_0 = .23540E-02 b_1 = 1.87640 b_2 = 1.00050 b_3 = 1.00647

APPENDIX A-59. CUBIC FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—JEFFREY PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	5	7	9	11	13	14	16	18	20													
12	8	10	13	15	18	21	23	26	28	31												
14	11	14	17	21	24	28	31	35	38	42	45											
16	14	18	23	27	32	36	41	45	50	54	59	63										
18	17	23	29	35	40	46	52	57	63	69	74	80	86									
20	21	28	36	43	50	57	64	71	78	85	92	99	106	113								
22	26	34	43	52	60	69	77	86	94	103	111	120	128	137	145							
24	31	41	51	61	72	82	92	102	112	122	133	143	153	163	173	183						
26	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	227	239				
28	42	56	70	84	98	112	126	140	153	167	181	195	209	223	237	251	264	278	292			
30		65	81	97	113	129	145	161	177	193	209	225	240	256	272	288	304	320	336	352		
32		74	92	110	129	147	165	183	201	220	238	256	274	293	311	329	347	365	383	402	420	
34		83	104	125	146	166	187	208	228	249	269	290	311	331	352	372	393	414	434	455	475	496
36		94	117	140	164	187	210	233	257	280	303	326	349	373	396	419	442	465	488	511	535	558
38			131	157	183	209	235	261	287	313	339	365	391	416	442	468	494	520	546	572	598	623
40			146	175	203	232	261	290	319	348	377	406	434	463	492	521	550	578	607	636	665	693
42			161	193	225	257	289	321	353	385	417	449	481	513	544	576	608	640	672	704	735	767
44				213	248	283	319	354	389	424	459	494	530	565	600	635	670	705	740	775	810	845
46				234	272	311	350	388	427	465	504	543	581	620	658	697	735	774	812	851	889	928
48				255	298	340	382	425	467	509	551	593	635	678	720	762	804	846	888	930	972	1014
50				278	324	371	417	463	509	555	601	647	692	738	784	830	876	922	968	1014	1059	1105
52					352	403	453	503	553	603	652	702	752	802	852	902	952	1002	1051	1101	1151	1201
54					382	436	490	544	599	653	707	761	815	869	923	977	1031	1085	1139	1193	1247	1301
56					412	471	530	588	647	705	764	822	880	939	997	1056	1114	1172	1230	1289	1347	1405
58					445	508	571	634	697	760	823	886	949	1012	1075	1138	1200	1263	1326	1389	1452	1515
60						546	614	682	749	817	885	953	1020	1088	1156	1223	1291	1358	1426	1493	1561	1628
62						586	659	731	804	877	949	1022	1095	1167	1240	1312	1385	1457	1530	1602	1675	1747
64						627	705	783	861	939	1017	1094	1172	1250	1328	1405	1483	1561	1638	1716	1793	1871
66							754	837	920	1003	1086	1170	1253	1336	1419	1502	1585	1668	1751	1834	1917	2000
68							804	893	982	1070	1159	1248	1336	1425	1514	1602	1691	1779	1868	1956	2045	2133
70							856	951	1046	1140	1235	1329	1423	1518	1612	1707	1801	1895	1989	2084	2178	2272

Coefficient set 4.13 b_0 = .20610E-02 b_1 = 1.93380 b_2 = .99490 b_3 = 1.00350

APPENDIX A-60. CUBIC FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—SUGAR PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	6	7	9	11	12	14	15	17	19													
12	8	10	13	15	18	20	22	25	27	29												
14	11	14	18	21	24	27	31	34	37	40	43											
16	14	19	23	27	32	36	40	44	48	52	57	61										
18	18	24	29	35	40	46	51	56	61	67	72	77	82									
20	23	30	36	43	50	57	63	70	76	83	89	96	102	108								
22	27	36	44	53	61	69	77	85	93	101	108	116	124	132	140							
24	33	43	53	63	73	82	92	101	111	120	130	139	148	158	167	176						
26	39	51	63	74	86	97	108	120	131	142	153	164	175	186	197	208	219	229				
28	45	59	73	86	100	113	127	140	153	166	179	191	204	217	230	242	255	268	280			
30		68	84	100	115	131	146	161	176	191	206	221	236	250	265	280	294	309	323	338		
32		78	96	114	132	150	167	184	202	219	236	253	270	287	303	320	337	353	370	386	403	
34		89	109	130	150	170	190	209	229	248	268	287	306	325	344	363	382	401	420	439	457	476
36		100	123	146	169	191	214	236	258	280	302	324	345	367	388	410	431	452	473	495	516	537
38			138	164	189	215	240	265	289	314	338	363	387	411	435	459	483	507	530	554	578	601
40			154	183	211	239	267	295	322	350	377	404	431	458	485	512	538	565	591	618	644	670
42			171	202	234	265	296	327	357	388	418	448	478	508	538	567	597	626	655	685	714	743
44				223	258	293	327	361	395	428	461	495	528	561	593	626	659	691	724	756	788	820
46				246	284	322	359	397	434	471	507	544	580	616	652	688	724	760	795	831	866	902
48				269	311	352	394	434	475	515	556	596	635	675	715	754	793	832	871	910	949	987
50				294	339	385	430	474	518	563	606	650	693	737	780	823	866	908	951	993	1035	1078
52					369	418	467	516	564	612	660	707	754	802	848	895	942	988	1034	1081	1127	1172
54					400	454	507	560	612	664	716	767	818	869	920	971	1022	1072	1122	1172	1222	1272
56					433	491	548	605	662	718	774	830	885	941	996	1050	1105	1160	1214	1268	1322	1376
58					467	530	592	653	714	775	835	895	955	1015	1074	1134	1192	1251	1310	1368	1427	1485
60						570	637	703	769	834	899	964	1028	1093	1157	1220	1284	1347	1410	1473	1536	1598
62						613	684	755	826	896	966	1035	1105	1174	1242	1311	1379	1447	1515	1582	1649	1717
64						657	733	810	885	961	1035	1110	1184	1258	1332	1405	1478	1551	1623	1696	1768	1840
66							785	866	947	1028	1108	1187	1267	1346	1425	1503	1581	1659	1737	1814	1892	1969
68							838	925	1011	1097	1183	1268	1353	1437	1521	1605	1689	1772	1855	1937	2020	2102
70							893	986	1078	1170	1261	1352	1442	1532	1622	1711	1800	1889	1977	2065	2153	2241

Coefficient set 5.13 $b_0 = .22560E\text{-}02$ $b_1 = 1.98840$ $b_2 = .93790$ $b_3 = 1.00316$

APPENDIX A-61. CUBIC FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—LODGEPOLE PINE

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	6	8	10	12	13	15	17	19	21													
12	8	11	14	17	20	22	25	28	31	33												
14	12	15	19	23	27	31	35	38	42	46	50											
16	15	20	25	30	36	41	46	51	56	61	66	71										
18	19	26	32	39	45	52	58	65	71	77	84	90	97									
20	24	32	40	48	56	64	72	80	88	96	104	112	120	128								
22	29	39	49	59	68	78	88	97	107	117	126	136	146	155	165							
24	35	47	58	70	82	93	105	116	128	139	151	162	174	185	197	209						
26	41	55	69	82	96	110	123	137	150	164	178	191	205	218	232	245	259	272				
28	48	64	80	96	112	127	143	159	175	191	206	222	238	254	269	285	301	317	332			
30		74	92	110	128	146	165	183	201	219	237	255	273	292	310	328	346	364	382	400		
32		84	105	125	146	167	187	208	229	249	270	291	311	332	353	373	394	415	435	456	476	
34		95	118	141	165	188	212	235	258	282	305	328	352	375	398	422	445	468	491	515	538	561
36		106	132	159	185	211	237	264	290	316	342	368	394	421	447	473	499	525	551	577	603	629
38			147	177	206	235	264	294	323	352	381	410	439	468	498	527	556	585	614	643	672	701
40			163	196	228	260	293	325	357	390	422	454	487	519	551	583	615	648	680	712	744	776
42			180	216	251	287	323	358	394	429	465	501	536	572	607	643	678	713	749	784	820	855
44				236	276	315	354	393	432	471	510	549	588	627	666	704	743	782	821	860	899	938
46				258	301	343	386	429	471	514	556	599	642	684	726	769	811	854	896	939	981	1024
48				281	327	373	420	466	512	559	605	651	697	744	790	836	882	928	974	1021	1067	1113
50				304	354	404	455	505	555	605	655	705	756	806	856	906	956	1006	1056	1106	1155	1205
52					382	437	491	545	599	653	707	762	816	870	924	978	1032	1086	1140	1194	1247	1301
54					412	470	528	587	645	703	761	820	878	936	994	1052	1110	1168	1226	1284	1343	1401
56					442	504	567	630	692	755	817	880	942	1004	1067	1129	1191	1254	1316	1378	1441	1503
58					473	540	607	674	741	808	874	941	1008	1075	1142	1208	1275	1342	1408	1475	1542	1608
60						576	648	719	791	862	933	1005	1076	1147	1219	1290	1361	1432	1504	1575	1646	1717
62						614	690	766	842	918	994	1070	1146	1222	1298	1374	1450	1526	1601	1677	1753	1829
64						652	733	814	895	976	1056	1137	1218	1299	1379	1460	1541	1621	1702	1782	1863	1943
66							777	863	949	1035	1120	1206	1292	1377	1463	1548	1634	1719	1805	1890	1975	2061
68							823	914	1004	1095	1186	1277	1367	1458	1548	1639	1729	1820	1910	2001	2091	2181
70							869	965	1061	1157	1253	1349	1444	1540	1636	1731	1827	1922	2018	2114	2209	2304

Coefficient set 6.13 $b_0 = .15680E\text{-}02$ $b_1 = 2.11170$ $b_2 = .99400$ $b_3 = .99688$

APPENDIX A-62. CUBIC FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—WHITE FIR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	6	8	10	12	14	16	18	20	22													
12	8	11	14	17	20	23	26	29	32	35												
14	11	15	18	22	26	31	35	39	43	47	51											
16	14	19	24	29	34	40	45	50	56	61	66	72										
18	17	24	30	37	43	50	56	63	70	77	83	90	97									
20	21	29	37	45	53	61	69	77	85	94	102	111	119	127								
22	26	35	44	54	63	73	83	93	103	113	123	133	143	153	164							
24	30	41	52	64	75	87	98	110	122	133	145	157	169	181	193	206						
26	36	48	61	74	88	101	115	128	142	156	170	184	198	212	226	240	254	268				
28	41	56	71	86	101	117	132	148	164	180	196	212	228	244	260	277	293	310	326			
30		64	81	98	115	133	151	169	187	205	223	242	260	279	298	316	335	354	373	392		
32		72	91	111	131	151	171	191	212	232	253	274	295	316	337	358	379	401	422	444	465	
34		81	103	125	147	169	192	215	238	261	284	308	331	355	379	402	426	450	474	498	523	547
36		90	115	139	164	189	214	240	266	291	317	344	370	396	423	449	476	503	529	556	583	610
38			127	154	182	210	238	266	295	323	352	381	410	440	469	498	528	558	587	617	647	677
40			140	170	201	232	263	294	325	357	389	421	453	485	517	550	583	615	648	681	714	747
42			154	187	221	254	288	323	357	392	427	462	497	533	568	604	640	676	712	748	784	821
44				205	241	278	315	353	391	429	467	505	544	582	621	660	700	739	778	818	858	897
46				223	263	303	343	384	425	467	508	550	592	634	677	719	762	805	848	891	934	977
48				242	285	329	373	417	461	506	551	597	642	688	734	780	826	873	920	966	1013	1060
50				261	308	355	403	451	499	547	596	645	694	744	794	844	894	944	994	1045	1096	1146
52					332	383	434	486	538	590	643	696	749	802	855	909	963	1017	1072	1126	1181	1236
54					357	412	467	522	578	634	691	748	805	862	919	977	1035	1093	1152	1210	1269	1328
56					383	441	500	560	620	680	740	801	862	924	986	1048	1110	1172	1235	1298	1361	1424
58					409	472	535	598	663	727	792	857	922	988	1054	1120	1187	1253	1320	1387	1455	1522
60						503	571	638	707	775	845	914	984	1054	1124	1195	1266	1337	1408	1480	1552	1624
62						536	607	680	752	826	899	973	1047	1122	1197	1272	1348	1423	1499	1576	1652	1729
64						569	645	722	799	877	955	1034	1113	1192	1271	1351	1432	1512	1593	1674	1755	1837
66							684	766	847	930	1013	1096	1180	1264	1348	1433	1518	1603	1689	1775	1861	1947
68							724	810	897	984	1072	1160	1249	1338	1427	1517	1607	1697	1788	1878	1970	2061
70							765	856	948	1040	1133	1226	1319	1413	1508	1602	1698	1793	1889	1985	2081	2178

Coefficient set 7.13 $b_0 = .16870E\text{-}02$ $b_1 = 1.94750$ $b_2 = 1.06640$ $b_3 = .99932$

APPENDIX A-63. CUBIC FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—RED FIR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	5	7	9	12	14	17	19	22	24													
12	7	10	13	17	20	23	27	31	34	38												
14	10	13	18	22	26	31	36	41	46	51	56											
16	12	17	23	28	34	40	46	52	58	65	71	78										
18	15	21	28	35	42	49	57	64	72	80	88	97	105									
20	18	26	34	42	51	60	69	78	88	97	107	117	127	138								
22	22	31	40	50	61	71	82	93	104	116	128	139	152	164	176							
24	26	36	47	59	71	83	96	109	122	136	149	163	178	192	206	221						
26	30	42	55	68	82	96	111	126	141	157	173	189	205	222	239	256	273	290				
28	34	48	63	78	94	110	127	144	162	179	198	216	235	254	273	292	312	332	352			
30		54	71	88	106	125	144	163	183	203	224	245	266	287	309	331	353	376	399	421		
32		61	80	99	119	140	161	183	206	228	251	275	299	323	347	372	397	422	448	473	499	
34		68	89	111	133	156	180	204	229	254	280	306	333	360	387	414	442	470	499	528	557	586
36		75	98	122	147	173	199	226	254	282	310	339	369	398	429	459	490	521	553	584	617	649
38			108	135	162	190	219	249	279	310	342	374	406	439	472	505	539	574	608	643	679	714
40			119	148	178	209	240	273	306	340	374	409	445	480	517	554	591	628	666	705	744	783
42			129	161	194	227	262	298	334	371	408	446	485	524	563	604	644	685	727	768	811	853
44				175	210	247	285	323	362	402	443	484	526	569	612	655	699	744	789	834	880	926
46				189	227	267	308	349	392	435	479	524	569	615	661	708	756	804	853	902	951	1001
48				203	245	288	331	376	422	469	516	564	613	662	713	763	815	866	919	972	1025	1079
50				219	263	309	356	404	453	503	554	606	658	711	765	820	875	930	987	1044	1101	1159
52					282	331	381	433	485	539	593	649	705	762	819	878	937	996	1056	1117	1179	1241
54					301	353	407	462	518	575	633	692	752	813	875	937	1000	1064	1128	1193	1258	1325
56					320	376	433	492	552	613	675	737	801	866	932	998	1065	1133	1201	1270	1340	1411
58					340	400	460	523	586	651	717	783	851	920	990	1060	1131	1203	1276	1350	1424	1499
60						424	488	554	621	690	760	830	902	975	1049	1124	1199	1276	1353	1431	1509	1588
62						448	516	586	657	730	803	878	954	1032	1110	1189	1269	1349	1431	1513	1596	1680
64						473	545	619	694	770	848	927	1008	1089	1171	1255	1339	1424	1511	1598	1685	1774
66							574	652	731	812	894	977	1062	1148	1234	1322	1411	1501	1592	1683	1776	1869
68							604	686	769	854	940	1028	1117	1207	1298	1391	1484	1579	1674	1771	1868	1966
70							634	720	808	897	987	1080	1173	1268	1364	1461	1559	1658	1758	1860	1962	2065

Coefficient set 8.13 $b_0 = .11420E\text{-}02$ $b_1 = 1.88570$ $b_2 = 1.20330$ $b_3 = .99717$

APPENDIX A-64. CUBIC FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—INCENSE-CEDAR

	Total Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	5	6	7	9	10	11	13	14	15													
12	7	9	11	13	15	16	18	20	22	24												
14	9	12	15	17	20	23	25	28	30	33	35											
16	12	16	19	23	26	30	33	36	40	43	46	49										
18	16	20	25	29	34	38	42	46	51	55	59	63	67									
20	19	25	31	36	42	47	53	58	63	68	73	78	83	88								
22	24	31	38	44	51	57	64	70	77	83	89	95	101	107	113							
24	28	37	45	53	61	69	76	84	92	99	106	114	121	128	136	143						
26	33	43	53	62	72	81	90	99	108	117	125	134	143	151	160	168	177	185				
28	39	50	61	72	83	94	105	115	125	136	146	156	166	176	186	196	205	215	225			
30		58	71	83	96	108	120	132	144	156	168	179	191	202	214	225	236	248	259	270		
32		66	81	95	109	123	137	151	164	178	191	205	218	231	244	257	270	282	295	308	320	
34		75	91	108	124	139	155	171	186	201	216	231	246	261	276	290	305	319	334	348	362	377
36		84	102	121	139	157	174	192	209	226	243	260	276	293	310	326	342	359	375	391	407	423
38			114	135	155	175	194	214	233	252	271	290	308	327	345	364	382	400	418	436	454	472
40			127	149	172	194	215	237	258	279	300	321	342	362	383	403	423	443	463	483	503	523
42			140	165	189	214	238	261	285	308	331	354	377	400	422	445	467	489	511	533	555	577
44				181	208	235	261	287	313	338	364	389	414	439	464	488	513	537	561	585	609	633
46				198	227	256	285	314	342	370	398	425	453	480	507	534	560	587	614	640	666	692
48				215	247	279	310	342	372	403	433	463	493	522	552	581	610	639	668	697	725	754
50				233	268	303	337	371	404	437	470	502	535	567	599	630	662	693	725	756	787	818
52					290	327	364	401	437	472	508	543	578	613	647	682	716	750	784	817	851	884
54					313	353	393	432	471	509	547	585	623	660	698	735	771	808	844	881	917	953
56					336	379	422	464	506	547	588	629	670	710	750	790	829	868	908	947	985	1024
58					360	406	452	497	542	587	631	674	718	761	804	846	889	931	973	1015	1056	1098
60						435	483	532	580	627	674	721	767	813	859	905	950	995	1040	1085	1129	1174
62						464	516	567	618	669	719	769	818	868	917	965	1013	1062	1109	1157	1205	1252
64						493	549	604	658	712	765	818	871	923	976	1027	1079	1130	1181	1232	1282	1332
66							583	641	699	756	813	869	925	981	1036	1091	1146	1200	1254	1308	1362	1415
68							618	680	741	802	862	922	981	1040	1099	1157	1215	1272	1330	1387	1444	1500
70							654	719	784	848	912	975	1038	1100	1162	1224	1285	1346	1407	1468	1528	1588

Coefficient set 9.13 b_0 = .17490E-02 b_1 = 2.09730 b_2 = .90420 b_3 = .99790

APPENDIX A-65. CUBIC FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—DOUGLAS-FIR

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	7	9	11	14	16	18	21	23	25													
12	10	13	16	19	22	25	29	32	35	38												
14	13	17	21	25	30	34	38	42	46	50	55											
16	16	22	27	32	38	43	48	54	59	64	70	75										
18	20	27	34	40	47	53	60	67	73	80	86	93	100									
20	25	33	41	49	57	65	73	81	89	97	105	113	121	129								
22	29	39	48	58	68	77	87	96	106	115	125	134	144	153	163							
24	34	45	57	68	79	90	102	113	124	135	146	157	168	180	191	202						
26	40	53	66	79	92	105	118	131	143	156	169	182	195	208	221	234	246	259				
28	45	60	75	90	105	120	135	150	164	179	194	209	223	238	253	268	282	297	312			
30		68	85	102	119	136	153	170	186	203	220	237	254	270	287	304	320	337	354	371		
32		77	96	115	134	153	172	191	210	229	248	267	285	304	323	342	361	380	398	417	436	
34		86	107	129	150	171	192	214	235	256	277	298	319	340	361	382	403	424	445	466	487	508
36		96	119	143	167	190	214	237	261	284	308	331	354	378	401	425	448	471	495	518	541	565
38			132	158	184	210	236	262	288	314	340	366	391	417	443	469	495	521	546	572	598	624
40			145	174	202	231	259	288	316	345	373	402	430	459	487	515	544	572	600	629	657	685
42			159	190	221	253	284	315	346	377	409	440	471	502	533	564	595	626	657	688	719	750
44				207	241	275	309	343	377	411	445	479	513	547	581	614	648	682	716	750	783	817
46				225	262	299	336	373	409	446	483	520	557	594	630	667	704	740	777	814	850	887
48				243	283	323	363	403	443	483	523	563	602	642	682	722	761	801	841	880	920	959
50				262	305	348	392	435	478	521	564	607	650	692	735	778	821	864	906	949	992	1035
52					328	375	421	467	514	560	606	652	698	745	791	837	883	929	975	1021	1067	1113
54					352	402	452	501	551	600	650	699	749	798	848	897	947	996	1045	1095	1144	1193
56					377	430	483	536	589	642	695	748	801	854	907	960	1013	1065	1118	1171	1224	1276
58					402	459	516	572	629	685	742	799	855	912	968	1024	1081	1137	1193	1250	1306	1362
60						489	549	609	670	730	790	850	911	971	1031	1091	1151	1211	1271	1331	1391	1451
62						519	583	648	712	776	840	904	968	1032	1096	1159	1223	1287	1351	1414	1478	1542
64						551	619	687	755	823	891	959	1027	1094	1162	1230	1298	1365	1433	1500	1568	1635
66							655	728	800	872	943	1015	1087	1159	1231	1302	1374	1446	1517	1589	1660	1732
68							693	769	845	921	997	1073	1149	1225	1301	1377	1453	1528	1604	1680	1755	1831
70							731	812	892	973	1053	1133	1213	1293	1373	1453	1533	1613	1693	1773	1853	1932

Coefficient set 2.15 b_0 = .36420E-02 b_1 = 1.81260 b_2 = .99060 b_3 = 1.00074

APPENDIX A-66. CUBIC FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—PONDEROSA PINE

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
											cubic feet											
10	7	10	12	14	17	19	21	24	26													
12	10	13	17	20	23	26	30	33	36	40												
14	13	18	22	26	31	35	39	44	48	52	57											
16	17	23	28	34	39	45	51	56	62	67	73	78										
18	21	28	35	42	49	56	63	70	77	84	91	98	105									
20	26	34	43	51	60	68	77	85	94	102	111	119	128	136								
22	31	41	51	62	72	82	92	102	112	123	133	143	153	163	173							
24	37	49	61	73	85	97	109	121	133	145	157	169	181	192	204	216						
26	43	57	71	85	99	113	127	141	155	169	183	197	211	225	239	252	266	280				
28	49	66	82	98	114	131	147	163	179	195	211	227	243	260	276	292	308	324	340			
30		75	94	112	131	149	168	186	205	223	242	260	279	297	315	334	352	371	389	407		
32		85	107	128	149	170	191	212	233	254	275	296	317	337	358	379	400	421	442	463	484	
34		96	120	144	168	192	215	239	263	286	310	334	357	381	404	428	451	475	499	522	546	569
36		108	135	162	188	215	241	268	295	321	348	374	401	427	453	480	506	533	559	585	612	638
38			150	180	210	240	269	299	329	358	388	417	447	476	506	535	565	594	624	653	682	712
40			167	200	233	266	299	332	365	398	430	463	496	529	562	594	627	660	692	725	758	790
42			185	221	258	294	330	367	403	439	476	512	548	584	621	657	693	729	765	801	837	873
44				243	284	324	364	404	444	484	524	564	604	643	683	723	763	803	842	882	922	962
46				267	311	355	399	443	487	531	575	618	662	706	749	793	837	880	924	968	1011	1055
48				292	340	388	436	484	532	580	628	676	724	772	819	867	915	963	1010	1058	1106	1153
50				318	371	423	476	528	580	632	685	737	789	841	893	945	997	1049	1101	1153	1205	1257
52					403	460	517	574	631	687	744	801	858	914	971	1027	1084	1141	1197	1253	1310	1366
54					437	499	560	622	684	745	807	868	930	991	1053	1114	1175	1237	1298	1359	1420	1481
56					473	539	606	673	740	806	873	939	1006	1072	1138	1205	1271	1337	1404	1470	1536	1602
58					510	582	654	726	798	870	942	1014	1085	1157	1229	1300	1372	1443	1515	1586	1658	1729
60						627	705	782	860	937	1014	1092	1169	1246	1323	1400	1477	1554	1631	1708	1785	1862
62						674	757	841	924	1007	1090	1173	1256	1339	1422	1505	1588	1671	1754	1836	1919	2002
64						723	813	902	991	1081	1170	1259	1348	1437	1526	1615	1704	1793	1881	1970	2059	2148
66							870	966	1062	1157	1253	1348	1444	1539	1634	1730	1825	1920	2015	2110	2205	2300
68							931	1033	1135	1238	1340	1442	1544	1646	1748	1850	1952	2053	2155	2257	2358	2460
70							994	1103	1212	1322	1431	1540	1649	1758	1866	1975	2084	2192	2301	2410	2518	2627

Coefficient set 3.15 b_0 = .41440E-02 b_1 = 1.74200 b_2 = .99090 b_3 = 1.00757

APPENDIX A-67. CUBIC FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—JEFFREY PINE

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
											cubic feet											
10	7	9	11	13	15	17	19	21	23													
12	10	13	16	19	21	24	27	30	33	36												
14	13	17	21	25	29	33	37	40	44	48	52											
16	17	22	27	32	37	42	47	52	57	62	67	72										
18	21	27	34	40	47	53	59	66	72	78	84	90	96									
20	26	34	42	49	57	65	73	80	88	95	103	110	118	125								
22	31	40	50	59	69	78	87	97	106	115	124	133	142	151	160							
24	37	48	59	70	82	93	103	114	125	136	147	157	168	179	189	200						
26	43	56	69	82	95	108	121	134	146	159	171	184	196	209	221	233	246	258				
28	49	65	80	95	110	125	140	155	169	184	198	213	227	241	256	270	284	298	312			
30		74	92	109	126	143	160	177	194	210	227	244	260	276	293	309	325	342	358	374		
32		84	104	124	143	163	182	201	220	239	258	277	295	314	333	351	370	388	406	425	443	
34		95	118	140	162	184	205	227	248	270	291	312	333	354	375	396	417	438	458	479	500	520
36		107	132	157	181	206	230	254	278	302	326	350	373	397	420	444	467	490	513	537	560	583
38			147	174	202	229	256	283	310	336	363	389	416	442	468	494	520	546	572	598	624	649
40			163	193	224	254	284	314	343	373	402	432	461	490	519	548	577	605	634	662	691	719
42			179	213	247	280	313	346	379	411	444	476	508	540	572	604	636	668	699	731	762	794
44				234	271	308	344	380	416	452	488	523	558	594	629	664	699	733	768	803	837	872
46				256	297	337	376	416	455	494	533	572	611	650	688	726	764	803	841	878	916	954
48				279	323	367	410	454	496	539	582	624	666	708	750	792	834	875	917	958	999	1040
50				304	352	399	446	493	540	586	632	678	724	770	815	861	906	951	996	1041	1086	1131
52					381	432	483	534	585	635	685	735	785	834	884	933	982	1031	1080	1128	1177	1225
54					412	467	523	577	632	686	740	794	848	902	955	1008	1061	1114	1167	1219	1272	1324
56					444	504	563	622	681	740	798	856	914	972	1029	1087	1144	1201	1258	1314	1371	1427
58					477	542	606	669	733	796	858	921	983	1045	1107	1169	1230	1291	1352	1413	1474	1535
60						581	650	718	786	854	921	988	1055	1121	1188	1254	1320	1386	1451	1517	1582	1647
62						622	696	769	842	914	986	1058	1130	1201	1272	1343	1413	1484	1554	1624	1694	1764
64						665	744	822	900	977	1054	1131	1207	1283	1359	1435	1510	1586	1661	1736	1810	1885
66							793	877	960	1042	1124	1206	1288	1369	1450	1531	1611	1692	1772	1852	1931	2011
68							845	934	1022	1110	1197	1285	1371	1458	1544	1630	1716	1802	1887	1972	2057	2141
70							898	993	1087	1180	1273	1366	1458	1550	1642	1733	1825	1915	2006	2097	2187	2277

Coefficient set 4.15 b_0 = .36080E-02 b_1 = 1.85910 b_2 = .94810 b_3 = 1.00373

APPENDIX A-68. CUBIC FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—SUGAR PINE

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
											cubic feet											
10	7	9	11	14	16	18	20	22	24													
12	10	13	16	19	22	25	28	31	34	36												
14	13	17	21	25	29	33	37	41	45	49	53											
16	17	22	28	33	38	43	48	53	58	63	68	72										
18	21	28	35	41	47	54	60	66	72	79	85	91	97									
20	26	34	42	50	58	66	73	81	89	96	104	111	118	126								
22	32	41	51	60	70	79	88	97	106	115	124	133	142	151	160							
24	37	49	60	71	82	93	104	115	126	137	147	158	168	179	189	200						
26	44	57	70	83	96	109	122	135	147	160	172	184	197	209	221	233	246	258				
28	50	66	81	96	111	126	141	156	170	185	199	213	227	242	256	270	284	298	312			
30		75	93	110	128	145	161	178	195	211	228	244	260	277	293	309	325	341	357	373		
32		86	106	125	145	164	183	202	221	240	259	277	296	314	333	351	369	387	405	423	442	
34		97	119	141	163	185	207	228	250	271	292	313	334	354	375	396	416	437	457	478	498	518
36		108	134	158	183	208	232	256	280	303	327	351	374	397	420	444	467	490	512	535	558	581
38			149	177	204	231	258	285	312	338	364	391	417	443	469	494	520	546	571	597	622	647
40			165	196	226	256	286	316	346	375	404	433	462	491	520	548	577	605	633	661	690	718
42			182	216	250	283	316	349	381	414	446	478	510	542	573	605	636	668	699	730	761	792
44				238	275	311	347	383	419	455	490	526	561	596	630	665	700	734	768	803	837	871
46				260	301	341	380	420	459	498	537	576	614	652	690	728	766	804	841	879	916	954
48				284	328	372	415	458	501	544	586	628	670	712	753	795	836	877	918	959	1000	1041
50				309	357	405	452	499	545	591	637	683	729	774	820	865	910	954	999	1044	1088	1132
52					387	439	490	541	591	642	691	741	791	840	889	938	987	1035	1084	1132	1180	1228
54					419	475	530	585	640	694	748	802	855	909	962	1015	1067	1120	1172	1224	1277	1328
56					452	512	572	631	690	749	807	865	923	981	1038	1095	1152	1208	1265	1321	1378	1434
58					487	551	616	680	743	806	869	931	994	1056	1117	1179	1240	1301	1362	1423	1483	1543
60						592	661	730	798	866	934	1001	1067	1134	1200	1266	1332	1398	1463	1528	1593	1658
62						635	709	783	856	929	1001	1073	1144	1216	1287	1358	1428	1498	1568	1638	1708	1777
64						680	759	838	916	994	1071	1148	1225	1301	1377	1453	1528	1603	1678	1753	1828	1902
66							811	895	978	1061	1144	1226	1308	1390	1471	1552	1632	1713	1793	1873	1952	2032
68							864	954	1043	1132	1220	1308	1395	1482	1568	1655	1741	1826	1912	1997	2082	2166
70							920	1016	1111	1205	1299	1392	1485	1578	1670	1762	1853	1944	2035	2126	2216	2307

Coefficient set 5.15 $b_0 = .41900E\text{-}02$ $b_1 = 1.82150$ $b_2 = .93680$ $b_3 = 1.00495$

APPENDIX A-69. CUBIC FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—LODGEPOLE PINE

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
											cubic feet											
10	8	10	13	15	17	19	21	24	26													
12	11	15	18	21	24	28	31	34	37	40												
14	15	20	24	29	33	37	42	46	50	54	58											
16	20	26	31	37	43	48	54	59	65	70	76	81										
18	25	32	40	47	54	61	68	75	82	89	95	102	109									
20	30	40	49	58	66	75	84	92	101	109	117	125	134	142								
22	37	48	59	69	80	90	101	111	121	131	141	151	161	171	181							
24	44	57	70	82	95	107	120	132	144	156	168	179	191	203	214	226						
26	51	66	81	96	111	125	140	154	168	182	196	210	224	237	251	264	278	291				
28	59	77	94	111	128	145	162	178	194	211	227	243	259	274	290	306	321	337	352			
30		88	108	127	147	166	185	204	223	241	260	278	296	314	332	350	368	386	403	421		
32		100	122	145	167	188	210	231	253	274	295	315	336	356	377	397	417	438	458	478	498	
34		112	138	163	188	212	237	261	284	308	332	355	378	401	424	447	470	493	515	538	560	583
36		126	154	182	210	237	265	292	318	345	371	397	423	449	475	500	526	551	577	602	627	652
38			171	203	234	264	294	324	354	383	413	442	471	499	528	556	585	613	641	669	697	725
40			190	224	258	292	325	358	391	424	456	488	520	552	584	615	647	678	709	740	771	802
42			209	247	284	321	358	394	431	466	502	537	573	608	642	677	712	746	780	814	848	882
44				270	311	352	392	432	472	511	550	589	627	666	704	742	780	817	855	892	929	966
46				295	340	384	428	471	515	557	600	642	684	726	768	809	851	892	933	973	1014	1054
48				320	369	417	465	513	559	606	652	698	744	789	835	880	925	969	1014	1058	1102	1146
50				347	400	452	504	555	606	657	707	757	806	855	904	953	1002	1050	1098	1146	1194	1242
52					432	488	544	600	655	709	763	817	871	924	977	1029	1082	1134	1186	1238	1290	1341
54					465	526	586	646	705	764	822	880	937	995	1052	1108	1165	1221	1277	1333	1389	1444
56					500	565	629	693	757	820	883	945	1007	1068	1129	1190	1251	1311	1372	1432	1491	1551
58					535	605	674	743	811	878	946	1012	1078	1144	1210	1275	1340	1405	1469	1534	1598	1661
60						647	721	794	867	939	1011	1082	1153	1223	1293	1363	1432	1502	1570	1639	1707	1776
62						690	769	847	924	1001	1078	1154	1229	1304	1379	1454	1528	1601	1675	1748	1821	1894
64						734	818	901	984	1066	1147	1228	1308	1388	1468	1547	1626	1704	1783	1860	1938	2015
66							869	957	1045	1132	1218	1304	1390	1475	1559	1643	1727	1810	1893	1976	2059	2141
68							921	1015	1108	1200	1292	1383	1474	1564	1653	1742	1831	1920	2008	2095	2183	2270
70							975	1074	1173	1271	1368	1464	1560	1655	1750	1844	1938	2032	2125	2218	2311	2403

Coefficient set 6.15 $b_0 = .37700E\text{-}02$ $b_1 = 1.95910$ $b_2 = .91930$ $b_3 = 1.00005$

APPENDIX A-70. CUBIC FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—WHITE FIR

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	7	10	13	15	18	21	23	26	29													
12	10	14	17	21	25	29	32	36	40	44												
14	13	18	23	28	33	38	43	48	53	58	63											
16	17	23	29	35	42	48	54	61	67	74	80	87										
18	21	29	36	44	52	59	67	75	83	91	99	107	115									
20	26	35	44	53	62	72	81	91	100	110	120	129	139	149								
22	30	41	52	63	74	85	97	108	119	131	142	154	165	177	189							
24	36	48	61	74	87	100	113	126	140	153	166	180	193	207	221	234						
26	41	56	70	85	100	115	131	146	161	177	192	208	224	239	255	271	287	303				
28	47	64	80	97	115	132	149	167	185	202	220	238	256	274	292	310	328	346	365			
30		72	91	110	130	150	169	189	209	229	250	270	290	311	331	352	372	393	414	434		
32		81	103	124	146	168	191	213	235	258	281	303	326	349	372	395	419	442	465	489	512	
34		91	115	139	163	188	213	238	263	288	313	339	365	390	416	442	468	494	520	546	572	598
36		101	127	154	181	209	236	264	292	320	348	376	405	433	462	490	519	548	577	606	635	664
38			140	170	200	230	261	291	322	353	384	415	447	478	510	541	573	605	637	669	701	733
40			154	187	220	253	287	320	354	388	422	456	491	525	560	595	630	665	700	735	770	805
42			169	205	241	277	313	350	387	424	462	499	537	575	613	651	689	727	765	804	842	881
44				223	262	302	342	382	422	462	503	544	585	626	667	709	750	792	834	876	918	960
46				242	284	327	371	414	458	502	546	590	635	680	724	769	815	860	905	951	996	1042
48				262	308	354	401	448	495	543	591	639	687	735	784	832	881	930	979	1028	1078	1127
50				282	332	382	433	483	534	586	637	689	741	793	845	898	950	1003	1056	1109	1162	1215
52					357	411	465	520	575	630	685	741	797	853	909	965	1022	1079	1136	1193	1250	1307
54					383	441	499	557	616	676	735	795	855	915	975	1036	1096	1157	1218	1279	1341	1402
56					410	472	534	597	660	723	786	850	914	979	1043	1108	1173	1238	1303	1369	1434	1500
58					437	503	570	637	704	772	840	908	976	1045	1114	1183	1252	1322	1391	1461	1531	1602
60						536	607	678	750	822	894	967	1040	1113	1187	1260	1334	1408	1482	1557	1632	1706
62						570	646	721	798	874	951	1028	1106	1184	1262	1340	1418	1497	1576	1655	1735	1814
64						605	685	766	846	928	1009	1091	1174	1256	1339	1422	1505	1589	1673	1757	1841	1925
66							726	811	897	983	1069	1156	1243	1331	1419	1507	1595	1683	1772	1861	1950	2040
68							768	858	949	1040	1131	1223	1315	1408	1500	1594	1687	1781	1875	1969	2063	2158
70							811	906	1002	1098	1194	1291	1389	1487	1585	1683	1782	1881	1980	2079	2179	2279

Coefficient set 7.15 b_0 = .33990E-02 b_1 = 1.77220 b_2 = 1.05350 b_3 = 1.00161

APPENDIX A-71. CUBIC FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—RED FIR

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	7	9	12	15	18	21	24	27	30													
12	9	13	16	20	24	28	33	37	41	46												
14	12	16	21	26	32	37	43	48	54	60	66											
16	15	21	27	33	40	47	54	61	68	75	83	90										
18	18	25	33	41	49	57	66	75	83	92	102	111	120									
20	22	30	40	49	59	69	79	90	100	111	122	133	144	156								
22	26	36	47	58	69	81	93	106	118	131	144	157	170	184	197							
24	30	42	54	67	81	94	108	123	137	152	167	182	198	213	229	245						
26	34	48	62	77	93	108	125	141	158	175	192	209	227	245	263	282	300	319				
28	39	54	71	88	105	123	142	160	179	199	218	238	258	279	299	320	341	362	384			
30		61	80	99	119	139	159	180	202	224	246	268	291	314	337	360	384	408	432	456		
32		69	89	111	133	155	178	202	226	250	275	300	325	351	377	403	429	456	483	510	538	
34		76	99	123	147	172	198	224	251	278	305	333	361	389	418	447	477	506	536	566	597	628
36		84	109	135	162	190	218	247	276	306	337	367	398	430	462	494	526	559	592	625	659	693
38			120	149	178	209	240	271	303	336	369	403	437	472	507	542	577	613	650	686	723	760
40			131	162	195	228	262	296	331	367	404	440	478	515	553	592	631	670	710	750	790	830
42			143	177	212	248	285	322	361	399	439	479	519	560	602	644	686	729	772	815	859	903
44				191	229	268	308	349	391	433	475	519	563	607	652	697	743	789	836	883	931	978
46				207	248	290	333	377	422	467	513	560	607	655	704	753	802	852	902	953	1004	1056
48				222	266	312	358	405	454	502	552	602	653	705	757	810	863	917	971	1026	1081	1136
50				238	286	334	384	435	486	539	592	646	701	756	812	869	926	983	1041	1100	1159	1219
52					306	358	411	465	520	576	633	691	750	809	869	929	990	1052	1114	1177	1240	1304
54					326	382	438	496	555	615	676	737	800	863	927	991	1056	1122	1188	1255	1323	1391
56					347	406	467	528	591	655	719	785	851	918	986	1055	1124	1194	1265	1336	1408	1480
58					369	431	495	561	627	695	764	833	904	975	1047	1120	1194	1268	1343	1419	1495	1572
60						457	525	594	665	737	810	883	958	1034	1110	1187	1265	1344	1424	1504	1584	1666
62						484	555	629	703	779	856	934	1013	1093	1174	1256	1338	1422	1506	1591	1676	1762
64						510	586	664	743	823	904	986	1070	1154	1240	1326	1413	1501	1590	1679	1769	1860
66							618	700	783	867	953	1040	1128	1217	1307	1398	1489	1582	1676	1770	1865	1961
68							650	736	824	913	1003	1094	1187	1280	1375	1471	1567	1665	1763	1863	1963	2064
70							683	774	866	959	1054	1150	1247	1345	1445	1545	1647	1749	1853	1957	2062	2168

Coefficient set 8.15 b_0 = .21790E-02 b_1 = 1.73980 b_2 = 1.17710 b_3 = .99954

APPENDIX A-72. CUBIC FOOT VOLUME TO A 4-INCH TOP WITH A 1-FT. STUMP FROM VOLUME EQUATION—INCENSE-CEDAR

	Merchantable Height (feet)																					
DBH	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
	cubic feet																					
10	6	8	9	11	13	14	16	17	19													
12	9	11	13	16	18	20	23	25	27	29												
14	12	15	18	21	24	27	30	33	36	39	42											
16	15	19	23	28	32	36	39	43	47	51	55	58										
18	19	24	29	35	40	45	50	54	59	64	69	73	78									
20	23	30	36	42	49	55	61	67	73	78	84	90	95	101								
22	28	36	43	51	59	66	73	80	87	94	101	108	115	121	128							
24	33	42	51	60	69	78	86	95	103	111	120	128	136	144	152	159						
26	38	49	60	71	81	91	101	111	121	130	140	149	159	168	177	186	195	204				
28	44	57	69	81	93	105	117	128	139	150	161	172	183	194	204	215	225	236	246			
30		65	79	93	107	120	133	146	159	172	184	197	209	221	234	246	258	270	281	293		
32		74	90	106	121	136	151	166	180	195	209	223	237	251	265	278	292	306	319	332	346	
34		83	101	119	136	153	170	186	203	219	235	251	267	282	298	313	328	344	359	374	389	404
36		93	113	133	152	171	190	208	227	245	263	280	298	315	333	350	367	384	401	418	434	451
38			125	147	169	190	211	231	252	272	292	311	331	350	369	389	408	426	445	464	482	501
40			139	163	186	210	233	255	278	300	322	344	365	387	408	429	450	471	492	512	533	553
42			152	179	205	231	256	281	306	330	354	378	402	425	449	472	495	518	541	563	586	608
44				196	224	252	280	307	334	361	388	414	440	465	491	516	542	567	592	617	641	666
46				214	245	275	305	335	365	394	422	451	479	507	535	563	591	618	645	672	699	726
48				232	266	299	332	364	396	428	459	490	521	551	582	612	642	671	701	730	759	788
50				251	288	324	359	394	429	463	497	530	564	597	630	662	695	727	759	790	822	854
52					310	349	388	425	463	500	536	572	608	644	679	715	750	784	819	853	887	921
54					334	376	417	458	498	538	577	616	655	693	731	769	807	844	881	918	955	991
56					359	403	448	491	534	577	619	661	703	744	785	825	866	906	946	985	1025	1064
58					384	432	479	526	572	618	663	708	752	797	840	884	927	970	1013	1055	1097	1139
60						461	512	562	611	660	708	756	804	851	898	944	990	1036	1082	1127	1172	1217
62						492	546	599	652	704	755	806	857	907	957	1006	1056	1104	1153	1201	1249	1297
64						523	581	637	693	748	803	858	911	965	1018	1071	1123	1175	1227	1278	1329	1380
66							616	677	736	795	853	911	968	1024	1081	1137	1192	1247	1302	1357	1411	1465
68							653	717	780	842	904	965	1026	1086	1146	1205	1264	1322	1380	1438	1496	1553
70							691	759	825	891	957	1021	1085	1149	1212	1275	1337	1399	1461	1522	1583	1643

Coefficient set 9.15 b_0 = .35160E-02 b_1 = 1.92920 b_2 = .88270 b_3 = 1.00030

APPENDIX B. LIST OF PACKED MS-DOS FILES CONTAINING TABLES AND PROGRAMS

A diskette with the computer files used in the preparation of the volume tables is available from the authors. The contents of the diskette include the the following "zipped" files. To access these files use pkunzip.exe, for example:

pkunzip ucvolume.zip [return].

PKUNZIP.EXE	Program to decompress the following compressed files.
UCVOLUME.ZIP	Program and source code for computing volume tables.
LOGVOL.ZIP	Volume tables by number of logs, top diameter, log rule, species, and DBH.
LOGVOLPR.ZIP	Program and source code for computing tables in LOGVOL.ZIP.
POSVOL.ZIP	Volume tables by number of logs, log position, top diameter, log rule, DBH, and species.
POSPROG.ZIP	Program and source code for computing tables in POSVOL.ZIP.
TOTALPR.ZIP	Program and source code for computing tables in TOTALHT.ZIP.
MHTPROG.ZIP	Program and source code for computing tables in MERCHHT.ZIP.
MERCHHT.ZIP	Volume tables by DBH, merchantable height, top diameter, log rule, and species.
TOTALHT.ZIP	Volume tables by DBH, total height, top diameter, log rule, and species.
COUNT.ZIP	Tables of number of trees by species, DBH, and total height.

Directories of Zipped files:

LOGVOL.ZIP
- LOG4INT.OUT
- LOG4SCR.OUT
- LOG6INT.OUT
- LOG6SCR.OUT
- LOG8INT.OUT
- LOG8SCR.OUT

LOGVOLPR.ZIP
- COFILTAP
- COFILTIP.PRN
- PROGMHT3.EXE
- PROGMHT3.FOR
- SCRIBNER.PRN
- TAPER.FOR
- TOTALHT.FOR
- VOL_INTL.FOR
- VOL_SCRB.FOR
- VOL_SCRB.FOR

MERCHHT.ZIP
- MHT4CUB.OUT
- MHT4INT.OUT
- MHT4SCR.OUT
- MHT6INT.OUT
- MHT6SCR.OUT
- MHT8INT.OUT
- MHT8SCR.OUT

MHTPROG.ZIP
- COFILTAP
- COFILTIP.PRN
- CUBIC.FOR
- MHT_V_D.EXE
- MHT_V_D.FOR
- SCRIBNER.PRN
- TAPER.FOR
- TOTALHT.FOR
- VOL_INTL.FOR

POSPROG.ZIP
- COFILTAP
- COFILTIP.PRN
- PROGMHT4.EXE
- PROGMHT4.FOR
- SCRIBNER.PRN
- TAPER.FOR
- TOTALHT.FOR
- VOL_INTL.FOR

POSVOL.ZIP
- POS4INT.OUT
- POS4SCR.OUT
- POS6INT.OUT
- POS6SCR.OUT
- POS8INT.OUT
- POS8SCR.OUT

TOTALHT.ZIP
- THT0CUB.OUT
- THT4CUB.OUT
- THT4INT.OUT
- THT4SCR.OUT
- THT6INT.OUT
- THT6SCR.OUT
- THT8INT.OUT

TOTALPR.ZIP
- COFILTAP
- COFILTIP.PRN
- CUBIC.FOR
- MERCHHT5.FOR
- SCRIBNER.PRN
- TAPER.FOR
- THT_V_D.EXE
- TOTALHT.FOR
- VOL_INTL.FOR
- VOL_SCRB.FOR

UCVOLUME.ZIP
- COFILTAP
- COFILTIP.PRN
- CUBIC.FOR
- MERCHHT5.FOR
- MHT_V_D.FOR
- SCRIBNER.PRN
- TAPER.FOR
- THT_V_D.FOR
- TOTALHT.FOR
- UCVOLUME.EXE
- UCVOLUME.FOR
- VOLRATIO.FOR
- VOLTAB.FOR
- VOL_COEF
- VOL_INTL.FOR
- VOL_SCRB.FOR

COUNT.ZIP
- INCENCED.CNT
- JEFFPINE.CNT
- LODGEPOL.CNT
- PONDPINE.CNT
- README.CNT
- REDFIR.CNT
- SUGARPIN.CNT
- WHITEFIR.CNT

HILGARDIA Editorial Board

Edward S. Sylvester, Chairman, Berkeley
(entomology, insecticides, ecology, environmental toxicology)

Peter Berck, Associate Editor, Berkeley
(economics, statistics, resource management)

Donald J. Durzan, Associate Editor, Davis
(tree fruit and nut crops)

Walter G. Jennings, Associate Editor, Davis
(food science, nutrition, and chemistry)

John Letey, Associate Editor, Riverside
(soils, plant nutrition, agronomy, agricultural engineering, water)

Irwin P. Ting, Associate Editor, Riverside
(botany, plant physiology, biochemistry)

_____
(animal science, physiology, breeding, zoology, genetics)

Janet White, Managing Editor, Oakland

The Journal HILGARDIA is published irregularly. Number of pages and number of issues vary per annually numbered volume. Address: Agriculture and Natural Resources Publications, University of California, 300 Lakeside Drive, 6th Floor, Oakland, CA 94612-3550.