United States
Department of
Agriculture

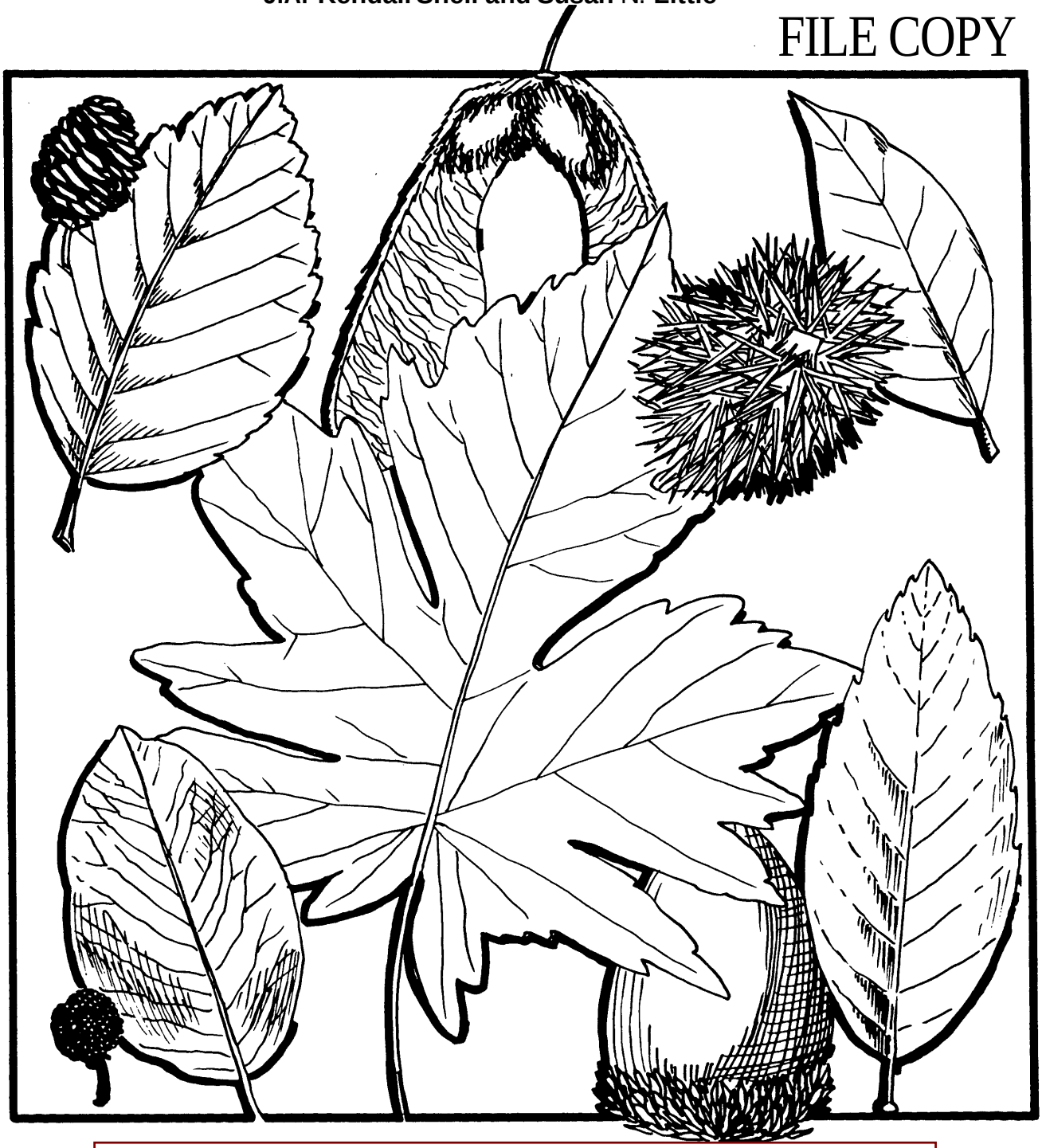
Forest Service

Pacific Northwest
Forest and Range
Experiment Station

General Technical
Report **PNW-151**
March 1983

Predicting Crown Weight and Bole Volume of Five Western Hardwoods

J.A. Kendall Snell and Susan N. **Little**



Authors

J.A. KENDALL SNELL is a forester, Pacific Northwest Region, U.S. Department of Agriculture, Forest Service, P.O. Box 3623, Portland, Oregon 97208. SUSAN N. LITTLE is a research forester, Pacific Northwest Forest and Range Experiment Station, U.S. Department of Agriculture, Forest Service, 809 N.E. Sixth Avenue, Portland, Oregon 97232.

Abstract

Snell, J.A. Kendall; Little, Susan N. Predicting crown weight and bole volume of five western hardwoods. Gen. Tech. Rep. PNW-151. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1983. 37 p.

Regression equations are presented for estimating biomass of five western hardwoods: red alder *(Alnus rubra* Bong.), giant chinkapin *(Castanopsis chrysophylla* (Dougl.) A. DC.), bigleaf maple *(Acer macrophyllum* Pursh), Pacific madrone *(Arbutus menziesii* Pursh), and tanoak *(Lithocarpus densiflorus* (Hook. & Arn.) Rehd.). Estimators are given for total crown biomass, cumulative proportions for separating crown weight into foliage and four timelag fuel diameter classes, bark weight, and bole volume (inside bark) to any specified top diameter. With one exception, the equations use diameter at breast height as the only independent variable.

Keywords: Crown weights, volume (log), volume determination methods, hardwoods, biomass.

Contents

Introduction

Estimates of the weight of tree foliage and branchwood and of bole volume are used for predicting total tree fiber content, for assessing wildfire hazard, and in modeling forest ecosystems. Much work has been done to quantify the weights and volumes of both conifers and hardwoods (Brown 1978, Gholz and others 1979, Grier and Logan 1977, Grier and Milne 1981, Woodard and others 1976, Young 1976, Zavitkovski and Stevens 1972). Work has also been done to separate tree biomass into timelag fuel classes which are required inputs to some wildfire behavior models (Albini 1976, Rothermel 1972). [1]/ Brown (1978) characterized 11 Rocky Mountain conifers by these fuel classes as did Loomis and Blank (1981) and Loomis and Roussopoulos (1978) for red oak ***(Quercus rubra*** L.) and aspen *(Populus* ***tremuloides*** Michx.) in Michigan and Minnesota. Wilcox and others (1982) developed a photo series for visual identification of forest residue loadings by fuel classes for the northern hardwood types. Although hardwoods comprise a large portion of the residues in the Pacific Northwest (Howard 1981), little work has been done to separate biomass of western hardwood trees into timelag fuel classes. This separation is needed for predicting wildfire behavior and for prescribing fire for site treatment.

Our objective was to develop regression equations for estimating: (1) weight of branchwood by diameter classes that correspond to timelag fuel classes, (2) weight of foliage, (3) weight of total crown, **(4)** volume of total bole (inside bark), and (5) volume of bole below any specified top diameter for five western hardwoods: red alder ***(Alnus rubra*** Bong.), giant chinkapin ***(Castanopsis chrysophylla*** (Dougl.) A. DC.), bigleaf maple ***(Acer macrophyllum*** Pursh), Pacific madrone ***(Arbutus menziesii*** Pursh), and tanoak ***(Lithocarpus densiflorws*** (Hook. & Arn.) Rehd.).

Methods

Study Area

The study was conducted on National Forest lands in western Washington, Oregon, and northern California. Sample trees were'selected from habitats common to the species being sampled. These habitats ranged from poor to good growing sites. Stocking densities around the sample trees ranged from 40 to 7,100 trees per acre.

[1]/ Timelag is the time interval in which dead and down woody material loses about two-thirds of its moisture content above an equilibrium moisture content under standard drying conditions of 20 percent relative humidity and 26.7°C (Fosberg 1971).

Field Procedures

Trees were sampled as follows:

Number of trees sampled	D.b.h. (Inches)	Age (Years)	Number of locations	Area
53 red alder	1-25	5-95	18	Western Oregon and Washington
30 giant chinkapin	1-24	18-195	9	Southwest Oregon and northwest California
16 bigleaf maple	2-18	12-114	8	Western Washington
31 Pacific madrone	1-25	31-208	12	Southwest Oregon and northwest California
31 tanoak	1-26	15-200	12	Southwest Oregon and northwest California

All trees in a stand at each location that were not dead, open grown, severely defoliated, or suffering from severe physical damage were candidates for sampling. Trees were sampled from late June to early September in 1979 and 1980. Increases in leaf weight caused by growth during the summer months were assumed negligible. For each sample tree, all limbs were removed before the tree was felled to avoid loss of branch material. (Because bigleaf maple and Pacific madrone have deliquescent branches, the largest limb was identified as the main bole.) As each limb was cut from the bole, the narrowest diameter at its base was measured with calipers and recorded. The limbs were then separated into live and dead branches.

Three sample branches were selected from each tree — the largest lateral branch and two randomly selected lateral branches. These sample branches were divided into leaves and into branchwood by diameter classes of 0 to 0.25, 0.25 to 1.0, 1.0 to 3.0, and 3.0 inches and larger. [2/] All other live branches were weighed as a unit. All dead branches were divided into the same diameter classes, and each class was weighed separately.

Once the limbs had been removed from the bole, lengths were measured along the bole between the top of the tree and bole diameters of 1, 3, 4, 6, 7, 8, and 9 inches. The two smaller diameter classes correspond to fuel size classes, and the others correspond to timber harvest merchantability limits. For trees with diameters greater than 9 inches at ground level, additional diameters and lengths were recorded where noticeable changes in taper occurred between the 9-inch diameter point and the ground.

Disks about 1 inch thick were cut from the lower, middle, and upper portions of the bole. All bark was removed from each disk, and both the wood and bark were ovendried at 102°C for 24 hours. The weights of ovendried wood and bark were then used to determine a ratio of bark weight to wood weight.

[2/] 1-, 10-, 100-, and 1,000-hour timelag fuel classes are represented by piece diameters of 0 to 0.25, 0.25 to 1.0, 1.0 to 3.0, and 3.0 to 8 inches, respectively (Deeming and others 1977).

Samples were taken from branch components (the leaves and each size class of branchwood) of each sample branch and from each diameter class of the dead branches to determine moisture content. All samples were ovendried at 102°C for 24 hours and weighed to the nearest 0.1 gram. Any volatiles lost from foliage and bark were considered negligible.

Calculations

The crown weight was calculated as follows: (1) The ovendry weights of sample branch components were calculated from moisture samples collected for these components. (2) These weights were regressed separately on their branch basal diameters. (3) From these regressions, the weight of each component for every branch from each tree was estimated. (4) The weight of each component was summed for all branches on each tree. (5) The total weights of these components were used as weighting factors to estimate a weighted moisture content for the whole tree. These weighted moisture percentages were then used to convert the green crown weight to estimates of ovendry weight. A similar procedure has been used by Brown (1978). Because all the dead branchwood was separated into diameter classes, the moisture samples taken from each class were used to convert them to ovendry weight. All analyses were done on ovendry weights.

For both live and dead crown, a logarithmic transformation was used to linearize the relationship between weight of the crown and d.b.h. (diameter at breast height outside bark) and to homogenize the variance about the regression line. After plotting the transformed data, the error term was assumed to be additive. The data were fit to the following model which has been commonly used in other biomass studies (Brown 1978, Gholz and others 1979, Schlaegel 1975):

$$\ln(w(i)) = A + B \ln(d); \quad (1)$$

where

w(i) = i^{th} weight; w(1)=total weight of live crown **(lb),** w(2)=total weight of dead crown (lb);
A and B = regression coefficients;
d = diameter at breast height (inches).

From the iive weight of each component for each tree, cumulative fractions f(i) were calculated as:

$$f(i) = T(i)/T(5); \quad (2)$$

where

f(i) = i^{th} cumulative fraction of live branchwood — i=I to 4;
T(I) = total weight of leaves;
T(2) = T(1)+ live branchwood less than 0.25 inch in diameter;
T(3) = T(1)+ live branchwood less than 1.0 inch in diameter;
T(4) = T(1)+ live branchwood less than 3.0 inches in diameter; and
T(5) = T(1)+ all live branchwood.

Plots of f(i) against d.b.h. were visually examined, and many regression models were fit to the data. Of the models fit, the one with the smallest residual mean square was:

$$f(i) = 1/(A + B\ (d)^{C}). \quad (3)$$

The measures of variability may be low because the cumulative fractions are based on indirect measurements of component weights for the whole tree.

A log transformation of the dependent variable was used to linearize the relationship between the cumulative fractions of dead branchwood and d.b.h. for red alder, giant chinkapin, and bigleaf maple, and the following regression model was used:

$$\ln(df(i)) = A + B\ (d); \quad (4)$$

where

df(i) = i^{th} cumulative fraction of dead branchwood — i = 1 to 3. Calculation of df(i) was similar to calculation of f(i).

This model did not work well for Pacific madrone and tanoak. Because a single model was not found that described the df(i) for these two species, different models were used for each cumulative fraction to achieve the best fit for our data. The df(i)'s are based on direct measurements of component weights of dead branchwood, and the variance should not be considered low as was the variance for the f(i)'s.

Smalian's formula (Avery 1967) was used for calculating the volume of each bole segment, except the section 0 to 1 inch in diameter for which a cone formula was used. Total bole volume was then obtained by summing the volume of the individual segments.

Equations for estimating the ratio (R) of bole volume below a specified top diameter to total bole volume were developed from measures of bole volumes below diameters of 1, 3, **4,** 6, 7, 8, and 9 inches. The following model was used for each species:

$$R = 1 + (A(t^{B})(d^{C})); \quad (5)$$

where

R = ratio of bole volume below a specified top diameter to total bole volume;
t = specified top diameter (inches);
A, B, and C = regression coefficients.

This model was introduced by Burkhart (1977), and it compared favorably with other published models when tested by Cao and others (1980). Variability of R increases greatly as t becomes greater than d. The data were constrained to those observations with R greater than 0.5 by excluding all observations where t was equal to or greater than d.

Results

The regression equations allow users to estimate total live and dead crown weights (tables 1 and 2) for each species.[3/] The weights obtained from tables 1 and 2 may be separated into foliage or branchwood weights by diameter class (see footnote 2) by calculating the fraction of each class for a given size (d.b.h.) tree from tables 3 and 4 and then multiplying this fraction by the results obtained from tables 1 or 2 for the same tree. For estimates of individual fractions, the cumulative fractions must be subtracted from one another; for example, for fraction (F) of live branchwood weight 0 to 0.25 inch in diameter: F = f(2)-f(1) (see table 3).

3/ Appendix 3 presents all equations in metric units.

Table 1 — Regression equations for estimating ovendry weight of live crown for red alder, giant chinkapin, bigleaf maple, Pacific madrone, and tanoak

$$\ln (w) = A + B \ln(d)$$

Species	A	B	n	r^2	s^2
Red alder	-1.3290	2.6232	53	0.94	1.5563
Giant chinkapin	-.8032	2.2699	30	.94	1.0469
Bigleaf maple	-.0582	2.1505	16	.93	.7252
Pacific madrone	-.7881	2.4839	31	.89	2.6295
Tanoak	-.3169	2.2774	31	.94	1.0114

Note: w = ovendry weight of live crown (lb); d = diameter at breast heiyht (inches); s^2 = mean square error of the residuals.

Table 2 — Regression equations for estimating dead branchwood weight of red alder, giant chinkapin, bigleaf maple, Pacific madrone, and tanoak

$$\ln (dw) = A + B \ln(d)$$

Species	A	B	n	r^2	s^2
Red alder	-4.3788	2.6243	53	0.63	13.597
Giant chinkapin	-2.2095	2.3038	30	.88	2.390
Bigleaf maple	-3.3678	2.5033	16	.78	3.466
Pacific madrone	-2.3938	2.2936	31	.88	2.397
Tanoak	-2.4895	2.0374	31	.75	4.071

Note: dw = ovendry weight of dead branchwood weight (lb); d = diameter at breast height (inches); s^2 = mean square error of the residuals.

Table 3 — Regression equations for estimating cumulative fractions (f(i)) of live crown component weights for red alder, giant chinkapin, bigleaf maple, Pacific madrone, and tanoak

$$f(i)=1/(A + B\ (d)^{C})$$

Fraction	A	B	C	n	s^2	Condition
			RED ALDER			
f(1)	2.7638	0.2155	1.3364	53	0.0006	None
f(2)	1.2860	.1016	1.3525	53	.0026	None
f(3)	.8847	.0441	1.3021	53	.0057	If d < 2.1 f(3)=1
f(4)	.9550	.0013	1.9736	41	.0077	If d < 6.1 f(4)=1
			GIANT CHINKAPIN			
f(1)	1.6048	.5630	.6828	30	.0008	None
f(2)	1.0700	.2525	.7637	30	.0020	None
f(3)	.7312	.1691	.6118	30	.0034	If d < 2.1 f(3)= 1
f(4)	.9669	.0036	1.1786	22	.0010	If d < 6.6 f(4)= 1
			BIGLEAF MAPLE			
f(1)	4.6762	.1091	2.0390	16	.0005	None
f(2)	3.3212	.0777	2.0496	16	.0009	None
f(3)	.9341	.0158	2.1627	16	.0137	If d < 1.9 f(3)=1
f(4)	.8625	.0093	1.7070	15	.0092	If d < 4.8 f(4)=1
			PACIFIC MADRONE			
f(1)	1.6013	.3591	1.3090	31	.0045	None
f(2)	1.0357	.2263	1.3567	31	.0115	None
f(3)	1.0281	.0084	2.1850	30	.0118	None
f(4)	.8778	.0115	1.6394	27	.0132	If d < 4.2 f(4)=1
			TANOAK			
f(1)	1.7936	.5952	.7239	31	.0013	None
f(2)	.9940	.4229	.6520	31	.0034	None
f(3)	.8759	.0927	.7843	31	.0061	If d < 1.5 f(3)=1
f(4)						f(4)=1.0 for all d

Note:
f(i) = cumulative fraction for the i^{th} component;
f(1) = fraction of leaf weight;
f(2) = f(1) + (fraction of 0 to 0.25 inch in d.o.b. live branchwood);
f(3) = f(1) + (fraction of 0 to 1.0 inch in d.o.b. live branchwood);
f(4) = f(1) + (fraction of 0 to 3.0 inches in d.o.b. live branchwood);
d = diameter at breast height (inches); and
s^2 = mean square error of residuals.

Table 4 — Regression equations for estimating cumulative fractions (df(i)) of dead crown components for red alder, giant chinkapin, bigleaf maple, Pacific madrone, and tanoak

Fraction	n	r^2	s^2	Conditions
RED ALDER				
$\ln(df(1)) = -0.6880 - 0.1532(d)$	52	0.43	1.3243	None
$\ln(df(2)) = 0.2134 - 0.0869(d)$	48	.47	.3574	If d < 2.5 df(2) =1
$\ln(df(3)) = 0.3473 - 0.0315(d)$	30	.34	.0512	If d < 11.0 df(3)=1
GIANT CHINKAPIN				
$\ln(df(1)) = -0.7695 - 0.0828(d)$	30	.60	.1737	None
$\ln(df(2)) = 0.2022 - 0.0564(d)$	29	.72	.0469	If d < 3.6 df(2)=1
$\ln(df(3)) = 0.1352 - 0.0160(d)$	19	.28	.0226	If d < 8.5 df(3)=1
BIGLEAF MAPLE				
$\ln(df(1)) = -1.0444 - 0.1892(d)$	16	.51	.7589	None
$\ln(df(2)) = 0.0553 - 0.0660(d)$	15	.53	.0767	If d < 1.0 df(2)=1
$\ln(df(3)) = 0.0083 - 0.0033(d)$	12	.03	.0064	If d < 2.5 df(3)=1
PACIFIC MADRONE				
$df(1) = -0.0632 + 0.7214(d)^{0.25} - 0.4655(\ln(d))$	31	.56	.0187	If d < 0.4 df(1)=1
$df(2) = 1.2671 - 0.1686(d)^{0.5}$	30	.49	.0321	If d < 2.5 df(2)=1
$df(3) = \exp(0.0281 - 0.0004714(d)^2)$	20	.34	.0127	If d < 7.6 df(3)=1
TANOAK				
$df(1) = -0.1424 + 0.7684(d)^{0.25} - 0.4730(\ln(d))$	31	.54	.0156	If d < 0.4 df(1)=1
$df(2) = \exp(-2.810 + 4.379(d)^{0.25} - 1.691(d)^{0.5})$	31	.81	.0464	If d < 4.1 df(2)=1
$df(3) = 1.027 - 0.003439(d)$	18	.16	.0023	If d < 7.9 df(3)=1

Note:
df(i) = cumulative fraction for the i^{th} component;
df(1) = fraction of 0- to 0.25-inch in d.o.b. dead branchwood;
df(2) = fraction of 0- to 1.0-inch in d.o.b. dead branchwood;
df(3) = fraction of 0- to 3.0-inch in d.o.b. dead branchwood;
d = diameter at breast height (inches);
s^2 = mean square error of residuals.

Table 5 — Regression equations for estimating total bole volume inside bark for red alder, giant chinkapin, bigleaf maple, Pacific madrone, and tanoak

$$\ln(v) = A + B \ln(d)$$

Species	A	B	n	r^2	s^2
Red alder	-2.9326	2.4999	53	0.98	0.8995
Giant chinkapin	-3.2199	2.5169	30	.99	.3938
Bigleaf maple	-2.7268	2.3050	16	.97	7.0254
Pacific madrone	-2.8331	2.2969	31	.97	1.3162
Tanoak	-3.2751	2.5010	31	.98	.9376

Note:
v = total bole volume (ft^3);
d = diameter at breast height (inches); and
s^2 = mean square error of residuals.

To obtain ovendry weight, multiply wood volume by wood density (density of red alder is 25.58 lb/ft^3; giant chinkapin, 26.21; bigleaf maple, 29.95; Pacific madrone, 40.31; tanoak, 41.62).

All dead crown weight came from branches less than 3 inches in d.o.b. (diameter outside bark) for all but two giant chinkapin and two bigleaf maple trees. This accounts for the low r^2 (0.28 for giant chinkapin and 0.03 for bigleaf maple) of the estimators for df(3) in table 4. It appears, therefore, that few giant chinkapin and bigleaf maple trees within the range of the data have dead branchwood larger than 3 inches in d.o.b.

The volume of the entire bole may be estimated from d.b.h. alone (table 5). The volume of the bole to any top diameter may be estimated by multiplying the fraction obtained from the equations in table 6 by the volume obtained from the equations in table 5. The volume may be changed to approximate weight by using average densities (Resch and Huang 1965, U.S. Forest Products Laboratory 1974).

The model presented for R in table 6 allows flexibility to estimate bole volume to any top diameter. This model gives an unbiased fit for red alder, giant chinkapin and bigleaf maple. The ratios for Pacific madrone and tanoak are slightly underestimated by the equations in table 6 for trees with d.b.h. larger than 10 inches. The estimates of variance given in table 6 provide only an indication of fit at mean d.b.h. because the variance decreased as d.b.h. increased for all species.

Table 6 — Regression equations for estimating the ratio of bole volume below a specified top diameter to total bole volume for red alder, giant chinkapin, bigleaf maple, Pacific madrone, and tanoak

$$R=1+(A(t^B)(d^C))$$

Species	A	B	C	n	s^2
Red alder	-0.4280	3.465	-3.269	258	0.000828
Giant chinkapin	-.3741	3.642	-3.406	133	.000744
Bigleaf maple	-.4270	2.348	-2.276	74	.002014
Pacific madrone	-.2391	2.951	-2.512	127	.001032
Tanoak	-.2792	3.038	-2.603	137	.001407

Note:
R = the fraction of bole volume below a specified top diameter;
t = specified top diameter (inches);
d = diameter at breast height (inches); and
s^2 = mean square error of residuals.

The ratio of bark weight to wood weight calculated from analysis of disks collected in the field were plotted against disk diameter, and no apparent linear relation was found on the scatter plot. By use of the ratio of bark weight to wood weight, a mean-of-ratios estimator was calculated for each species. Estimates of these ratios and their 95-percent confidence intervals about the mean are: 0.18 ± 0.011 for red alder, 0.22 ± 0.016 for giant chinkapin, 0.14 ± 0.019 for bigleaf maple, 0.05 ± 0.009 for Pacific madrone, and 0.24 ± 0.028 for tanoak.

All the crown weight equations include bark. Extrapolation of the bark estimators to branchwood should be tested as the bark estimators are based on data collected from the bole only. If estimates of the amount of bark in the crown are critical, the user should develop local estimates based on samples taken from the crown.

Example

The following example illustrates how to estimate the 100-hour component weight (1 to 3 inches in diameter) of a red alder tree with d.b.h. of 12 inches. It consists of three basic steps: (1) predicting total weight of live crown, dead crown, and bole; (2) predicting the fraction of the component in each total in step 1; and (3) multiplying the fractions in step 2 by the total weights in step 1.

Step 1 — predicting total weight of live crown, dead crown, and bole:

Estimated total weight of:	Use equations in table:	Estimates for red alder:
Live crown	1	179.4 lb
Dead crown	2	8.5 lb
Bole volume	5	26.6 ft^3

Bole weight = 26.6 ft^3 × 25.58 lb/ft^3 (density of red alder, U.S. Forest Products Laboratory 1974)
= 680.4 lb.

Step 2 — predicting the fraction of the component in each total in step 1:

Estimated fraction of component from:	Use equations in table:	Estimates for red alder:
Live crown	3	(f4-f3) = 0.38
Dead crown	**4**	(df3-df2) = 0.53
Bole —		
fraction to a 1-inch top	6	0.9993
fraction to a 3-inch top	6	-0.9943
fraction of component		0.0050

Step 3 — multiplying the fractions in step 2 by the total weights in step 1:

Estimated component weight from:	Estimates for red alder:
Live crown	(179.4 lb × 0.38) = 68.2 lb
Dead crown	(8.5 lb × 0.53) = 4.5 lb
Bole	(680.4 lb × 0.005) = 3.4 lb
Bole + bark	(3.4 lb × 1.18) = 4.0 lb

Total 100-hour component weight from a red alder tree 12 inches in d.b.h. is then the sum of these weights: 68.2 + **4.5** + 4.0 = 76.7 lb. Foliage and other branchwood components may also be calculated by following this procedure using the appropriate equations from the tables.

Approximate Conversions to Metric Units

When you know:	multiply by:	to find:
inches	2.540	centimeters
feet	0.305	meters
pounds	0.454	kilograms
pounds per square foot	4.883	kilograms per square meter
pounds per cubic foot	16.019	kilograms per cubic meter
tons per acre	2.242	metric tonnes per hectare
cubic feet per acre	0.070	cubic meters per hectare

Literature Cited

Albini, Frank A. Computer-based models of wildland fire behavior: a user's manual. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1976. 68 p.

Avery, T. Eugene. Forest measurements. New York, NY: McGraw-Hill Book Company; 1967.290 p.

Brown, James K. Weight and density of crowns of Rocky Mountain conifers. Res. Pap. INT-197. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1978. 56 p.

Burkhart, Harold E. Cubic-foot volumes of loblolly pine to any merchantable top limit. South. J. Appl. For. 1: 7-9; 1977.

Cao, Quang V.; Burkhart, Harold E.; Max, Timothy A. Evaluation of two methods for cubic-volume prediction of loblolly pine to any merchantable limit. For. Sci. 26(1): 71-80; 1980.

Deeming, John E.; Burgan, Robert E.; Cohen, Jack D. The National Fire-Danger Rating System - 1978. Gen. Tech. Rep. INT-39. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977.66 p.

Fosberg, Michael A. Moisture content calculations of the 100-hour timelag fuel in fire danger rating. Res. Note RM-199. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1971. 7 p.

Gholz, H.L.; Grier, C.C.; Campbell, A.G.; Brown, A.T. Equations for estimating biomass and leaf area of plants in the Pacific Northwest. Res. Pap. 41. Corvallis, OR: Oregon State University School of Forestry; 1979. 40 p.

Grier, Charles C.; Logan, Robert S. Old-growth *Pseudotsuga menziesii* communities of a western Oregon watershed: biomass distribution and production budgets. Ecol. Monogr. 47(4): 373-400; 1977.

Grier, Charles C.; Milne, W.A. Regression equations for calculating component biomass of young *Abies amabilis* (Dougl.) Forbes. Can. J. For. Res. 11: 184-187; 1981.

Howard, James O. Logging residues in the Pacific Northwest: characteristics affecting utilization. Res. Pap. PNW-289. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1981. 41 p.

Loomis, Robert M.; Blank, Richard W. Estimating northern red oak crown component weights in the Northeastern United States. Res. Pap. NC-194. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1981. 9 p.

Loomis, Robert M.; Roussopoulos, Peter J. Estimating aspen crown fuels in northeastern Minnesota. Res. Pap. NC-156. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1978. 40 p.

Resch, Helmuth; Huang, Shui-mu. Properties and drying procedures for chinkapin in California. For. Prod. Lab. 40. Berkeley, CA: California Forestry and Forest Products, University of California, School of Forestry; 1965. 8 p.

Rothermel, Richard C. A mathematical model for predicting fire spread in wildland fuels. Res. Pap. INT-115. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1972. 40 p.

Schlaegel, Bryce E. Estimating aspen volume and weight for individual trees, diameter classes, or entire stands. Gen. Tech. Rep. NC-20. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1975. 16 p.

U.S. Forest Products Laboratory. Wood handbook: Wood as an engineering material. Agric. Handb. 72, rev. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory; 1974: 4-41 to 4-48.

Wilcox, Frederick; McCarty, John; Bungland, Barry. Photo series for quantifying forest residues in the: northern hardwood type, oak hickory type. NA-FR-22. Broomall, PA: Pennsylvania Department of Environmental Resources, Bureau of Forestry; 1982. 43 p.

Woodard, Paul M.; Pickford, S.G.; Martin, R.E. Predicting weights of Douglas-fir slash for material up to 3 inches in diameter. Fire Manage. Notes. Washington, DC: U.S. Department of Agriculture, Forest Service; 1976; 37(3): 8-9.

Young, Harold E. A summary and analysis of weight tables studies. Oslo, Norway: Working Party of the Mensuration of the Forest Biomass, S4.01 16th IUFRO Congress; 1976. 29 p.

Zavitkovski, J.; Stevens, R.D. Primary productivity of red alder ecosystems. Ecology. 53(2): 235-242; 1972.

Appendix 1. Tables for Predicting Crown Weight and Bole Volume

Tables 7-27 give estimates of total crown weight, weight of branchwood by diameter class, weight of foliage, bole weight, and tip weight for red alder, giant chinkapin, bigleaf maple, Pacific madrone, and tanoak. All weights are ovendry and are presented by 1-inch d.b.h. classes.

Total live and dead crown weights are separated into fuel classes (see footnote 2, p. 2) in tables 7-11. Tables 12-16 give the weight of bole above specified top diameters (tip weight). This weight is divided into timelag fuel classes for material less than 3 inches in d.o.b. The weight of the bole below these specified top diameters (merchantable weight) is given in tables 17-21. The top diameters in these tables (4, 5, 6, and 8 inches) are those measured in the field. Estimates for other top diameters can be developed from the equations in table 6.

Total residue weights, defined as the total crown (live and dead) weight and the weight of that portion of the bole above the specified top diameter, are given in tables 22-26.

Total tree weights for individual trees by d.b.h. class are given in table 27. These weights include the bole, bark, live crown, and dead crown.

Table 7 — Live and dead crown weight of red alder by diameter at breast height and fuel class

D.b.h.	Live crown					Dead crown				Total crown weight
	Leaves	Branchwood diameter (inches)				Branchwood diameter (inches)				
		0-0.24	0.25-0.99	1-2.99	≥3	0-0.24	0.25-0.99	1-2.99	≥3	
Inches	Ovendry pounds									
1	0.1	0.1	0.1	0	0	0	0	0	0	0.3
2	.5	.6	.6	0	0	0	0	0	0	1.7
3	1.3	1.4	1.7	.3	0	.1	.1	0	0	4.9
4	2.4	2.7	3.6	1.3	0	.1	.3	.1	0	10.5
5	3.9	4.4	6.2	3.5	0	.2	.5	.2	0	18.9
6	5.7	6.3	9.8	7.4	0	.3	.7	.4	0	30.5
7	7.7	8.5	14.1	12.7	.7	.4	1.0	.7	0	45.7
8	9.9	10.9	19.3	19.8	2.0	.4	1.4	1.1	0	64.9
9	12.4	13.4	25.1	29.0	4.3	.5	1.8	1.7	0	88.3
10	14.9	16.2	31.7	40.3	8.0	.6	2.2	2.5	0	116.5
11	17.7	19.0	39.0	53.8	13.3	.6	2.6	3.6	0	149.5
12	20.5	22.0	46.9	69.3	20.7	.7	3.0	4.5	.3	187.9
13	23.5	25.1	55.3	86.8	30.6	.7	3.5	5.7	.6	231.8
14	26.6	28.3	64.2	106.2	43.4	.8	3.9	6.9	1.1	281.5
15	29.8	31.6	73.7	127.3	59.7	.8	4.4	8.4	1.8	337.4
16	33.1	35.0	83.6	150.1	79.8	.8	4.8	9.9	2.6	399.6
17	36.5	38.4	94.0	174.2	104.2	.8	5.2	11.6	3.6	468.5
18	39.9	41.9	104.7	199.7	133.3	.8	5.6	13.4	4.9	544.3
19	43.4	45.5	115.9	226.2	167.7	.8	6.0	15.4	6.3	627.2
20	47.0	49.1	127.4	253.7	207.8	.8	6.3	17.5	8.0	717.5
21	50.7	52.8	139.2	281.9	253.9	.7	6.6	19.6	10.0	815.5
22	54.4	56.5	151.4	310.7	306.5	.7	6.9	21.9	12.2	921.4
23	58.2	60.3	163.9	340.0	366.0	.7	7.2	24.3	14.8	1035.3
24	62.0	64.1	176.7	369.5	432.7	.7	7.4	26.8	17.6	1157.6
25	65.9	68.0	189.8	399.3	507.0	.6	7.6	29.4	20.8	1288.5

Table 8 — Live and dead crown weight of giant chinkapin by diameter at breast height and fuel class

D.b.h.	Live crown					Dead crown				Total crown weight
	Leaves	Branchwood diameter (inches)				Branchwood diameter (inches)				
		0-0.24	0.25-0.99	1-2.99	≥3	0-0.24	0.25-0.99	1-2.99	≥3	
Incnes	Ovendry pounds									
1	0.2	0.1	0.1	0	0	0	0.1	0	0	0.6
2	.9	.6	.7	0	0	.2	.3	0	0	2.7
3	1.9	1.3	1.8	.3	0	.5	.9	0	0	6.8
4	3.4	2.4	3.5	1.2	0	.9	1.7	.1	0	13.1
5	5.2	3.7	5.7	2.7	0	1.4	2.8	.3	0	21.8
6	7.4	5.2	8.5	5.0	0	1.9	4.0	.9	0	33.0
7	9.9	7.0	11.9	8.2	.1	2.5	5.5	1.7	0	46.8
8	12.8	9.0	15.9	12.2	.4	3.2	7.1	2.9	0	63.5
9	15.9	11.2	20.5	17.1	1.0	3.8	9.0	4.4	.2	83.0
10	19.3	13.6	25.7	23.1	1.7	4.5	10.9	6.2	.5	105.5
11	23.0	16.1	31.6	30.0	2.8	5.1	13.0	8.3	1.1	131.0
12	27.0	18.8	38.0	38.1	4.2	5.8	15.2	10.8	1.9	159.8
13	31.2	21.7	45.1	47.3	5.9	6.4	17.4	13.8	2.8	191.7
14	35.7	24.7	52.8	57.6	8.1	7.0	19.7	17.2	4.1	226.9
15	40.4	27.8	61.1	69.1	10.8	7.5	22.0	21.1	5.6	265.5
16	45.4	31.1	70.1	81.7	14.0	8.0	24.4	25.4	7.4	307.6
17	50.5	34.6	79.6	95.6	17.8	8.5	26.7	30.2	9.6	353.1
18	56.0	38.1	89.8	110.6	22.2	8.9	29.0	35.5	12.1	402.2
19	61.6	41.8	100.5	126.7	27.3	9.3	31.3	41.2	15.1	454.9
20	67.5	45.5	111.9	144.1	33.2	9.6	33.6	47.5	18.4	511.2
21	73.6	49.4	123.8	162.7	39.8	9.9	35.8	54.1	22.2	571.3
22	79.9	53.4	136.3	182.4	47.2	10.2	37.9	61.3	26.5	635.1
23	86.4	57.5	149.5	203.4	55.6	10.4	40.0	68.9	31.3	702.8
24	93.1	61.7	163.2	225.5	64.8	10.5	42.0	77.0	36.6	774.3
25	100.0	66.0	177.5	248.8	75.1	10.7	43.8	85.5	42.4	849.7

Table 9 — Live and dead crown weight of bigleaf maple by diameter at breast height and fuel class

D.b.h.	Live crown					Dead crown				Total crown weight
	Leaves	Branchwood diameter (inches)				Branchwood diameter (inches)				
		0-0.24	0.25-0.99	1-2.99	≥3	0-0.24	0.25-0.99	1-2.99	≥3	
Inches	Ovendry pounds									
1	0.2	0.1	0.7	0	0	0	0	0	0	1.0
2	.8	.3	3.0	0	0	0	.1	0	0	4.4
3	1.8	.7	6.6	.9	0	.1	.4	.1	0	10.6
4	2.9	1.1	10.9	3.7	0	.2	.7	.2	0	19.7
5	4.0	1.6	15.2	9.1	.2	.3	1.2	.4	0	32.0
6	5.0	2.0	19.3	15.7	2.5	.3	1.8	.8	0	47.5
7	5.9	2.3	22.8	24.3	6.6	.4	2.6	1.4	.1	66.5
8	6.7	2.6	25.8	34.5	13.0	.5	3.4	2.3	.1	88.9
9	7.4	2.9	28.2	46.1	21.8	.5	4.4	3.3	.2	114.8
10	8.0	3.1	30.2	58.6	33.6	.6	5.4	4.7	.3	144.4
11	8.5	3.2	31.8	71.8	48.4	.6	6.5	6.4	.4	177.7
12	9.0	3.4	33.1	85.4	66.6	.6	7.7	8.5	.5	214.8
13	9.4	3.5	34.2	99.2	88.3	.6	8.9	11.0	.7	255.7
14	9.7	3.6	35.0	113.1	113.6	.6	10.1	13.9	.9	300.6
15	10.0	3.7	35.7	127.0	142.7	.6	11.3	17.2	1.2	349.4
16	10.2	3.8	36.3	140.7	175.6	.6	12.5	21.0	1.6	402.2
17	10.5	3.9	36.8	154.2	212.3	.6	13.7	25.3	1.9	459.1
18	10.7	3.9	37.2	167.5	253.1	.6	14.9	30.0	2.4	520.1
19	10.9	4.0	37.5	180.4	297.8	.5	16.0	35.3	2.9	585.3
20	11.0	4.0	37.7	193.1	346.5	.5	17.1	41.2	3.5	654.6
21	11.2	4.1	38.0	205.5	399.2	.5	18.1	47.6	4.2	728.3
22	11.3	4.1	38.1	217.5	456.0	.4	19.1	54.6	4.9	806.2
23	11.4	4.1	38.3	229.3	516.9	.4	20.1	62.1	5.8	888.4
24	11.6	4.2	38.4	240.7	581.9	.4	20.9	70.2	6.7	975.0
25	11.7	4.2	38.5	251.8	651.0	.3	21.8	79.0	7.8	1065.0

Table 10 — Live and dead crown weight of Pacific madrone by diameter at breast height and fuel class

D.b.h.	Live crown					Dead crown				Total crown weight
	Leaves	Branchwood diameter (inches)				Branchwood diameter (inches)				
		0-0.24	0.25-0.99	1-2.99	≥3	0-0.24	0.25-0.99	1-2.99	≥3	
Inches	Ovendry pounds									
1	0.2	0.1	0.1	0	0	0.1	0	0	0	0.5
2	1.0	.6	.8	.2	0	.2	.2	0	0	3.0
3	2.2	1.2	2.8	.8	0	.4	.7	0	0	8.1
4	3.7	1.9	6.2	2.4	0	.7	1.4	.2	0	16.4
5	5.4	2.7	10.8	5.0	.9	1.0	2.3	.4	0	28.4
6	7.3	3.5	16.1	8.7	3.4	1.3	3.5	.8	0	44.5
7	9.2	4.3	21.7	14.1	7.8	1.6	4.9	1.4	0	65.1
8	11.3	5.2	27.3	21.2	14.6	2.0	6.5	2.2	0	90.4
9	13.4	6.0	32.6	30.0	24.6	2.3	8.4	3.2	.1	120.7
10	15.5	6.9	37.5	40.6	38.1	2.7	10.5	4.4	.3	156.5
11	17.8	7.7	41.7	52.7	55.6	3.0	12.8	5.9	.6	197.9
12	20.0	8.6	45.5	66.2	77.7	3.3	15.3	7.6	1.1	245.2
13	22.3	9.4	48.6	80.9	104.6	3.7	17.9	9.5	1.6	298.6
14	24.7	10.2	51.2	96.7	136.8	4.0	20.7	11.7	2.4	358.4
15	27.0	11.1	53.4	113.3	174.5	4.4	23.6	14.1	3.4	424.8
16	29.4	11.9	55.0	130.7	218.2	4.7	26.6	16.8	4.7	498.0
17	31.9	12.8	56.3	148.6	268.1	5.0	29.6	19.7	6.2	578.3
18	34.3	13.6	57.3	167.1	324.4	5.3	32.8	22.9	8.1	665.7
19	36.8	14.4	57.9	185.9	387.4	5.7	36.0	26.2	10.4	760.6
20	39.3	15.2	58.2	205.0	457.4	6.0	39.2	29.8	13.0	863.1
21	41.8	16.1	58.2	224.4	534.5	6.3	42.4	33.6	16.2	973.4
22	44.4	16.9	58.1	243.9	618.9	6.6	45.5	37.5	19.9	1091.6
23	46.9	17.7	57.7	263.6	710.8	6.9	48.7	41.6	24.1	1218.0
24	49.5	18.5	57.1	283.4	810.5	7.2	51.7	45.8	28.9	1352.8
25	52.1	19.4	56.4	303.3	918.1	7.6	54.7	50.2	34.3	1496.0

Table 11 — Live and dead crown weight of tanoak by diameter at breast height and fuel class

D.b.h.	Live crown					Dead crown				Total Crown weight
	Leaves	Branchwood diameter (inches)				Branchwood diameter (inches)				
		0-0.24	0.25-0.99	1-2.99	≥3	0-0.24	0.25-0.99	1-2.99	≥3	
Inches	Ovendry pounds									
1	0.3	0.2	0.2	0	0	0.1	0	0	0	0.8
2	1.3	.9	1.3	.1	0	.2	.2	0	0	3.9
3	2.9	1.9	3.3	.8	0	.3	.5	0	0	9.7
4	5.0	3.4	6.5	2.2	0	.4	1.0	0	0	18.5
5	7.7	5.2	10.7	4.8	0	.5	1.6	.1	0	30.7
6	10.9	7.5	16.1	8.7	0	.7	2.2	.3	0	46.3
7	14.5	10.0	22.5	14.2	0	.8	2.9	.7	0	65.6
8	18.5	13.0	30.0	21.5	0	1.0	3.6	1.2	0	88.7
9	23.0	16.2	38.5	30.7	0	1.1	4.3	1.9	0	115.8
10	27.9	19.8	48.1	42.2	0	1.2	5.0	2.7	.1	147.0
11	33.2	23.7	58.6	55.9	0	1.3	5.7	3.8	.1	182.4
12	38.8	28.0	70.1	72.1	0	1.5	6.3	5.1	.2	222.1
13	44.7	32.5	82.6	90.9	0	1.6	6.9	6.6	.3	266.2
14	51.1	37.4	95.9	112.5	0	1.7	7.5	8.4	.4	314.8
15	57.7	42.5	110.2	137.0	0	1.8	8.0	10.3	.5	368.0
16	64.7	48.0	125.2	164.5	0	2.0	8.5	12.5	.7	425.9
17	71.9	53.7	141.2	195.1	0	2.1	8.9	14.9	.8	488.6
18	79.5	59.8	157.9	229.0	0	2.2	9.2	17.5	1.0	556.1
19	87.4	66.1	175.5	266.2	0	2.3	9.5	20.3	1.3	628.6
20	95.6	72.7	193.8	306.8	0	2.4	9.8	23.4	1.6	706.0
21	104.0	79.5	212.9	351.0	0	2.6	10.0	26.6	1.9	788.5
22	112.7	86.7	232.8	398.8	0	2.7	10.1	30.1	2.2	876.1
23	121.7	94.1	253.3	450.4	0	2.8	10.2	33.7	2.6	968.9
24	131.0	101.8	274.6	505.8	0	3.0	10.3	37.6	3.0	1066.9
25	140.5	109.7	296.6	565.0	0	3.1	10.3	41.6	3.4	1170.3

Table 12 — Weight of bole tips of red alder by size class and top diameters outside bark of 4, 5, 6, and 8 inches

D.b.h.	Weight of tip <3 inches in d.o.b. between diameters of (inches):				Weight of tip >3 inches in d.o.b. to a top diameter of (inches):				Total weight of tip above a top diameter of (inches):			
	0-0.25	0.25-1	1-3	0-3	4	5	6	8	4	5	6	8
Inches	Ovendry pounds											
1	0	0.68	0.92	1.6	0	0	0	0	1.6	1.6	1.6	1.6
2	0	.40	8.69	9.1	0	0	0	0	9.1	9.1	9.1	9.1
3	0	.29	13.01	13.3	11.8	11.8	11.8	11.8	25.1	25.1	25.1	25.1
4	0	.23	10.43	10.7	18.2	40.8	40.8	40.8	28.9	51.4	51.4	51.4
5	0	.20	8.78	9.0	15.4	43.7	80.9	80.9	24.3	52.7	89.9	89.9
6	0	.17	7.63	7.8	13.3	38.0	78.4	133.9	21.2	45.8	86.2	141.8
7	0	.15	6.78	6.9	11.9	33.8	69.6	200.5	18.8	40.7	76.6	207.5
8	0	.14	6.12	6.3	10.7	30.5	62.8	181.0	17.0	36.7	69.1	187.2
9	0	.13	5.59	5.7	9.8	27.8	57.4	165.3	15.5	33.6	63.1	171.0
10	0	.12	5.15	5.3	9.0	25.7	52.9	152.4	14.3	30.9	58.2	157.7
11	0	.11	4.79	4.9	8.4	23.9	49.2	141.6	13.3	28.8	54.1	145.5
12	0	.10	4.48	4.6	7.8	22.3	46.0	132.5	12.4	26.9	50.6	137.1
13	0	.09	4.21	4.3	7.4	21.0	43.3	124.6	11.7	25.3	47.6	128.9
14	0	.09	3.98	4.1	7.0	19.8	40.9	117.7	11.0	23.9	44.9	121.7
15	0	.09	3.77	3.9	6.6	18.8	38.7	111.6	10.5	22.7	42.6	115.4
16	0	.08	3.59	3.7	6.3	17.9	36.9	106.2	9.9	21.6	40.5	109.9
17	0	.08	3.43	3.5	6.0	17.1	35.2	101.3	9.5	20.6	38.7	104.8
18	0	.07	3.28	3.4	5.7	16.3	33.7	97.0	9.1	19.7	37.0	100.3
19	0	.07	3.15	3.2	5.5	15.7	32.3	93.0	8.7	18.9	35.5	96.2
20	0	.07	3.02	3.1	5.3	15.1	31.1	89.4	8.4	18.2	34.1	92.5
21	0	.07	2.91	3.0	5.1	14.5	29.9	86.1	8.1	17.5	32.9	89.1
22	0	.06	2.81	2.9	4.9	14.0	28.9	83.1	7.8	16.9	31.7	86.0
23	0	.06	2.72	2.8	4.7	13.5	27.9	80.3	7.5	16.3	30.7	83.1
24	0	.06	2.63	2.7	4.6	13.1	27.0	77.7	7.3	15.8	29.7	80.4
25	0	.06	2.55	2.6	4.5	12.7	26.2	75.3	7.1	15.3	28.8	77.9

Table 13 — Weight of bole tips of giant chinkapin by size class and top diameters outside bark of 4, 5, 6, and 8 inches

D.b.h.	Weiyht of tip <3 inches in d.o.b. between diameters of (inches):				Weight of tip >3 inches in d.o.b. to a top diameter of (inches):				Total weight of tip above a top diameter of (inches):			
	0-0.25	0.25-1	1-3	0-3	4	5	6	8	4	5	6	8
Inches	Ovendry pounds											
1	0	0.47	0.80	1.3	0	0	0	0	1.3	1.3	1.3	1.3
2	0	.26	7.05	7.3	0	0	0	0	7.3	7.3	7.3	7.3
3	0	.18	9.66	9.8	10.5	10.5	10.5	10.5	20.3	20.3	20.3	20.3
4	0	.14	7.48	7.6	14.1	34.2	34.2	34.2	21.7	41.9	41.9	41.9
5	0	.ll	6.13	6.2	11.6	33.9	67.1	67.1	17.8	40.1	73.4	73.4
6	0	.10	5.21	5.3	9.8	28.8	61.0	110.8	15.1	34.1	66.3	116.1
7	0	.08	4.55	4.6	8.6	25.1	53.2	160.2	13.2	29.8	57.8	164.8
8	0	.07	4.04	4.1	7.6	22.3	47.2	142.3	11.7	26.4	51.3	146.4
9	0	.07	3.64	3.7	6.9	20.1	42.5	128.1	10.6	23.8	46.2	131.8
10	0	.06	3.31	3.4	6.2	18.3	38.7	116.7	9.6	21.7	42.1	120.0
11	0	.06	3.04	3.1	5.7	16.8	35.6	107.2	8.8	19.9	38.7	110.3
12	0	.05	2.82	2.9	5.3	15.6	32.9	99.2	8.2	18.4	35.8	102.1
13	0	.05	2.62	2.7	4.9	14.5	30.7	92.4	7.6	17.2	33.3	95.1
14	0	.05	2.45	2.5	4.6	13.6	28.7	86.5	7.1	16.1	31.2	89.0
15	0	.04	2.31	2.4	4.4	12.8	27.0	81.4	6.7	15.1	29.4	83.7
16	0	.04	2.18	2.2	4.1	12.1	25.5	76.8	6.3	14.3	27.7	79.0
17	0	.04	2.07	2.1	3.9	11.4	24.2	72.8	6.0	13.5	26.3	74.9
18	0	.04	1.96	2.0	3.7	10.9	23.0	69.2	5.7	12.9	25.0	71.2
19	0	.03	1.87	1.9	3.5	10.3	21.9	65.9	5.4	12.2	23.8	67.8
20	0	.03	1.79	1.8	3.4	9.9	20.9	63.0	5.2	11.7	22.7	64.8
21	0	.03	1.71	1.7	3.2	9.5	20.0	60.3	5.0	11.2	21.8	62.1
22	0	.03	1.64	1.7	3.1	9.1	19.2	57.9	4.8	10.8	20.9	59.6
23	0	.03	1.58	1.6	3.0	8.7	18.5	55.6	4.6	10.3	20.1	57.2
24	0	.03	1.52	1.5	2.9	8.4	17.8	53.6	4.4	10.0	19.3	55.1
25	0	.03	1.47	1.5	2.8	8.1	17.1	51.7	4.3	9.6	18.6	53.2

Table 14 — Weight of bole tips of bigleaf maple by size class and top diameters outside bark of 4, 5, 6, and 8 inches

D.b.n.	Weight of tip ≤3 inches in d.o.b. between diameters of (inches):				Weight of tip >3 inches in d.o.b. to a top diameter of (inches):				Total weight of tip above a top diameter of (inches):			
	0-0.25	0.25-1	1-3	0-3	4	5	6	8	4	5	6	8
Inches	Ovendry pounds											
1	0	0.92	1.28	2.2	0	0	0	0	2.2	2.2	2.2	2.2
2	0	.94	10.07	11.0	0	0	0	0	11.0	11.0	11.0	11.0
3	0	.95	12.01	13.0	12.5	15.1	15.1	15.1	25.5	28.1	28.1	28.1
4	0	.95	12.11	13.1	12.6	30.4	41.5	41.5	25.7	43.5	54.6	54.6
5	0	.96	12.19	13.2	12.7	30.6	53.9	78.1	25.9	43.7	67.1	91.2
6	0	.97	12.25	13.3	12.8	30.7	54.2	119.3	26.0	44.0	67.5	132.6
7	0	.97	12.30	13.3	12.8	30.9	54.5	119.9	26.2	44.2	67.8	133.2
8	0	.97	12.35	13.4	12.9	31.0	54.7	120.3	26.3	44.4	68.0	133.7
9	0	.98	12.39	13.4	12.9	31.1	54.9	120.8	26.4	44.5	68.3	134.2
10	0	.98	12.43	13.5	13.0	31.2	55.0	121.1	26.4	44.6	68.5	134.6
11	0	.98	12.47	13.5	13.0	31.3	55.2	121.5	26.5	44.8	68.7	135.0
12	0	.99	12.50	13.5	13.1	31.4	55.3	121.8	26.6	44.9	68.9	135.3
13	0	.99	12.53	13.6	13.1	31.4	55.5	122.1	26.6	45.0	69.0	135.6
14	0	.99	12.55	13.6	13.1	31.5	55.6	122.3	26.7	45.1	69.2	135.9
15	0	.99	12.58	13.6	13.1	31.6	55.7	122.6	26.7	45.2	69.3	136.2
16	0	.99	12.60	13.6	13.2	31.6	55.8	122.8	26.8	45.3	69.4	136.4
17	0	1.00	12.63	13.7	13.2	31.7	55.9	123.0	26.8	45.3	69.6	136.7
18	0	1.00	12.65	13.7	13.2	31.7	56.0	123.2	26.9	45.4	69.7	136.9
19	0	1.00	12.67	13.7	13.2	31.8	56.1	123.4	26.9	45.5	69.8	137.1
20	0	1.00	12.69	13.7	13.2	31.8	56.2	123.6	27.0	45.5	69.9	137.3
21	0	1.00	12.70	13.7	13.3	31.9	56.2	123.8	27.0	45.6	70.0	137.5
22	0	1.00	12.72	13.8	13.3	31.9	56.3	123.9	27.0	45.7	70.1	137.7
23	0	1.00	12.74	13.8	13.3	31.9	56.4	124.1	27.1	45.7	70.2	137.9
24	0	1.01	12.75	13.8	13.3	32.0	56.5	124.2	27.1	45.8	70.3	138.0
25	0	1.01	12.77	13.8	13.3	32.0	56.5	124.4	27.1	45.8	70.3	138.2

Table 15 — Weight of bole tips of Pacific madrone by size class and top diameters outside bark of 4, 5, 6, and 8 inches

D.b.h.	Weight of tip <3 inches in d.o.b. between diameters of (inches):				Weight of tip >3 inches in d.o.b. to a top diameter of (inches):				Total weight of tip above a top diameter of (inches):			
	0-0.25	0.25-1	1-3	0-3	4	5	6	8	4	5	6	8
Inches	Ovendry pounds											
1	0.01	0.59	1.89	2.5	0	0	0	0	2.5	2.5	2.5	2.5
2	.01	.50	11.72	12.2	0	0	0	0	12.2	12.2	12.2	12.2
3	.01	.46	11.56	12.0	16.1	19.0	19.0	19.0	28.1	31.1	31.1	31.1
4	.01	.43	10.86	11.3	15.1	39.7	48.8	48.8	26.4	51.0	60.1	60.1
5	.01	.41	10.35	10.8	14.4	37.9	72.5	89.6	25.2	48.7	83.3	100.4
6	.01	.40	9.96	10.4	13.9	36.4	69.8	142.2	24.2	46.8	80.1	152.6
7	.01	.39	9.63	10.0	13.4	35.2	67.5	171.1	23.4	45.3	77.5	181.1
8	.01	.37	9.36	9.7	13.0	34.2	65.6	166.3	22.8	44.0	75.3	176.0
9	.01	.36	9.12	9.5	12.7	33.4	63.9	162.1	22.2	42.9	73.4	171.6
10	.01	.36	8.92	9.3	12.4	32.6	62.5	158.5	21.7	41.9	71.8	167.8
11	.01	.35	8.74	9.1	12.2	32.0	61.2	155.3	21.3	41.1	70.3	164.4
12	.01	.34	8.58	8.9	11.9	31.4	60.1	152.4	20.9	40.3	69.0	161.3
13	.01	.34	8.43	8.8	11.7	30.8	59.1	149.8	20.5	39.6	57.8	158.6
14	.01	.33	8.30	8.6	11.5	30.4	58.1	147.4	20.2	39.0	66.8	156.1
15	.01	.33	8.17	8.5	11.4	29.9	57.3	145.2	19.9	38.4	65.8	153.8
16	.01	.32	8.06	8.4	11.2	29.5	56.5	143.2	19.6	37.9	64.9	151.6
17	.01	.32	7.96	8.3	11.1	29.1	55.8	141.4	19.4	37.4	64.0	149.7
18	.01	.31	7.86	8.2	10.9	28.8	55.1	139.7	19.1	36.9	63.3	147.8
19	.01	.31	7.77	8.1	10.8	28.4	54.4	138.0	18.9	36.5	62.5	145.1
20	.01	.31	7.68	8.0	10.7	28.1	53.8	136.5	18.7	36.1	61.8	144.5
21	.01	.30	7.60	7.9	10.6	27.8	53.3	135.1	18.5	35.7	61.2	143.0
22	.01	.30	7.53	7.8	10.5	27.5	52.7	133.8	18.3	35.4	60.6	141.6
23	.01	.30	7.46	7.8	10.4	27.3	52.2	132.5	18.1	35.0	60.0	140.2
24	.01	.30	7.39	7.7	10.3	27.0	51.8	131.3	18.0	34.7	59.5	139.0
25	0	.29	7.32	7.6	10.2	26.8	51.3	130.1	17.8	34.4	58.9	137.8

Table 16 — Weight of bole tips of tanoak by size class and top diameters outside bark of 4, 5, 6, and 8 inches

D.b.h.	Weight of tip <3 inches in d.o.b. between diameters of (inches):				Weight of tip >3 inches in d.o.b. to a top diameter of (inches):				Total weight of tip above a top diameter of (inches):			
	0-0.25	0.25-1	1-3	0-3	4	5	6	8	4	5	6	8
Inches	Ovendry pounds											
1	0.01	0.54	1.41	2.0	0	0	0	0	2.0	2.0	2.0	2.0
2	.01	.50	10.54	11.0	0	0	0	0	11.0	11.0	11.0	11.0
3	.01	.48	13.23	13.7	16.7	16.7	16.7	16.7	30.5	30.5	30.5	30.5
4	.01	.47	12.84	13.3	18.6	49.2	49.2	49.2	31.9	62.5	62.5	62.5
5	.01	.46	12.55	13.0	18.2	48.4	93.9	96.3	31.2	61.4	106.9	109.3
6	.01	.45	12.32	12.8	17.8	47.5	92.2	159.6	30.6	60.3	104.9	172.4
7	.01	.44	12.13	12.6	17.6	46.8	90.7	235.0	30.1	59.4	103.3	247.6
8	.01	.43	11.97	12.4	17.3	46.2	89.5	231.8	29.7	58.6	101.9	244.2
9	.01	.43	11.82	12.3	17.1	45.6	88.4	229.0	29.4	57.9	100.7	241.3
10	.01	.42	11.70	12.1	16.9	45.1	87.5	226.6	29.1	57.2	99.6	238.7
11	.01	.42	11.58	12.0	16.8	44.7	86.6	224.4	28.8	56.7	98.6	236.4
12	.01	.42	11.48	11.9	16.6	44.3	85.9	222.4	28.5	56.2	97.8	234.3
13	.01	.41	11.39	11.8	16.5	43.9	85.2	220.6	28.3	55.7	97.0	232.4
14	.01	.41	11.30	11.7	16.4	43.6	84.5	218.9	28.1	55.3	95.3	230.7
15	.01	.41	11.22	11.6	16.2	43.3	83.9	217.4	27.9	54.9	95.6	229.0
16	.01	.40	11.15	11.6	16.1	43.0	83.4	216.0	27.7	54.6	94.9	227.5
17	.01	.40	11.08	11.5	16.0	42.7	82.9	214.6	27.5	54.2	94.4	226.1
18	.01	.40	11.02	11.4	16.0	42.5	82.4	213.4	27.4	53.9	93.8	224.8
19	.01	.40	10.96	11.4	15.9	42.3	81.9	212.2	27.2	53.6	93.3	223.6
20	.01	.40	10.90	11.3	15.8	42.0	81.5	211.1	27.1	53.3	92.8	222.4
21	.01	.39	10.84	11.2	15.7	41.8	81.1	210.1	26.9	53.1	92.4	221.3
22	.01	.39	10.79	11.2	15.6	41.6	80.7	209.1	26.8	52.8	91.9	220.3
23	.01	.39	10.74	11.1	15.6	41.4	80.4	208.1	26.7	52.6	91.5	219.3
24	.01	.39	10.70	11.1	15.5	41.3	80.0	207.2	26.6	52.4	91.1	218.3
25	.01	.39	10.65	11.0	15.4	41.1	79.7	206.4	26.5	52.1	90.7	217.4

Table 17 — Bole weight of red alder to top diameters outside bark and total bole weight, by diameter at breast height outside bark 1/

D.b.h.	Bole weight to a top diameter of (inches):				Total bole
	4	5	6	8	
Inches	Ovendry pounds				
1	0	0	0	0	1.6
2	0	0	0	0	9.1
3	0	0	0	0	25.1
4	22.6	0	0	0	51.4
5	65.5	37.1	0	0	89.9
6	120.6	95.9	55.6	0	141.8
7	189.6	167.7	131.8	.9	208.4
8	274.0	254.3	221.9	103.8	291.0
9	375.1	357.1	327.5	219.6	390.6
10	494.0	477.4	450.1	350.6	508.3
11	631.8	616.3	591.0	498.5	645.1
12	789.4	774.9	751.3	664.8	801.8
13	967.8	954.2	931.9	850.6	979.5
14	1167.8	1154.9	1133.9	1057.1	1178.8
15	1390.3	1378.1	1358.1	1285.3	1400.7
16	1636.0	1624.4	1605.4	1536.1	1646.0
17	1905.8	1894.7	1876.6	1810.5	1915.3
18	2200.4	2189.8	2172.5	2109.2	2209.5
19	2520.6	2510.4	2493.7	2433.0	2529.3
20	2866.9	2857.1	2841.2	2782.8	2875.3
21	3240.2	3230.8	3215.4	3159.2	3248.3
22	3641.1	3632.0	3617.2	3562.9	3648.9
23	4070.2	4061.5	4047.1	3994.7	4077.8
24	4528.3	4519.8	4505.9	4455.1	4535.5
25	5015.8	5007.5	4994.1	4944.9	5022.8

1/ Bole weight was calculated from ground level to given top diameter.

Table 18 — Bole weight of giant chinkapin to top diameters outside bark and total bole weight, by diameter at breast height outside bark 1/

D.b.h.	Bole weight to a top diameter of (inches):				Total bole
	4	5	6	8	
Inches	Ovendry pounds				
1	0	0	0	0	1.3
2	0	0	0	0	7.3
3	0	0	0	0	20.3
4	20.1	0	0	0	41.9
5	55.6	33.3	0	0	73.4
6	101.0	82.0	49.8	0	116.1
7	158.0	141.4	113.4	6.3	171.2
8	227.8	213.1	188.2	93.2	239.5
9	311.7	298.4	276.0	190.4	322.2
10	410.4	398.4	378.0	300.0	420.1
11	525.1	514.0	495.3	423.6	533.9
12	656.5	646.2	628.9	562.6	664.7
13	805.4	795.8	779.7	717.9	813.0
14	972.6	963.6	948.5	890.7	979.7
15	1158.8	1150.4	1136.1	1081.8	1165.5
16	1364.7	1356.8	1343.3	1292.0	1371.1
17	1591.1	1583.6	1570.8	1522.2	1597.1
18	1838.5	1831.3	1819.2	1773.0	1844.2
19	2107.6	2100.8	2089.2	2045.2	2113.0
20	2399.0	2392.5	2381.5	2339.4	2404.2
21	2713.4	2707.1	2696.6	2656.3	2718.3
22	3051.2	3045.2	3035.1	2996.4	3056.0
23	3413.2	3407.4	3397.7	3360.5	3417.8
24	3799.8	3794.2	3784.9	3749.1	3804.2
25	4211.6	4206.2	4197.2	4162.7	4215.8

1/ Bole weight was calculated from ground level to given top diameter.

Table 19 — Bole weight of bigleaf maple to top diameters outside bark and total bole weight, by diameter at breast height outside bark 1/

D.b.h.	Bole weight to a top diameter of (inches):				Total bole
	4	5	6	8	
Incnes	Ovendry Dounds				
1	0	0	0	0	2.2
2	0	0	0	0	11.0
3	2.6	0	0	0	28.1
4	28.8	11.1	0	0	54.6
5	65.3	47.5	24.1	0	91.2
6	112.9	94.9	71.4	6.3	138.9
7	172.0	154.0	130.4	65.0	198.2
8	243.3	225.2	201.6	135.9	269.6
9	327.3	309.2	285.4	219.5	353.7
10	424.5	406.3	382.4	316.3	450.9
11	535.2	516.9	493.0	426.8	561.7
12	659.9	641.6	617.6	551.2	686.5
13	798.9	780.6	756.5	689.9	825.5
14	952.6	934.2	910.2	843.4	979.3
15	1121.4	1103.0	1078.8	1011.9	1148.1
16	1305.5	1287.0	1262.8	1195.8	1332.3
17	1505.2	1486.7	1462.5	1395.4	1532.1
18	1720.9	1702.4	1678.2	1610.9	1747.8
19	1952.9	1934.3	1910.0	1842.7	1979.8
20	2201.3	2182.7	2158.4	2091.0	2228.3
21	2466.5	2447.9	2423.5	2356.0	2493.5
22	2748.7	2730.1	2705.7	2638.1	2775.8
23	3048.2	3029.5	3005.1	2937.4	3075.2
24	3365.1	3346.4	3322.0	3254.2	3392.2
25	3699.8	3681.1	3656.6	3588.7	3726.9

1/ Bole weiyht was calculated from ground level to given top diameter.

Table 20 — Bole weight of Pacific madrone to top diameters outside bark and total bole weight, by diameter at breast height outside bark 1/

D.b.h.	Bole weight to a top diameter of (inches):				Total bole
	4	5	6	8	
Incnes	Ovendry pounds				
1	0	0	0	0	2.5
2	0	0	0	0	12.2
3	2.9	0	0	0	31.1
4	33.7	9.1	0	0	60.1
5	75.2	51.7	17.1	0	100.4
6	128.4	105.8	72.5	0	152.6
7	194.0	172.2	139.9	36.3	217.4
8	272.7	251.5	220.2	119.5	295.5
9	365.1	344.4	313.8	215.7	387.3
10	471.6	451.4	421.5	325.5	493.3
11	592.8	573.0	543.7	449.7	614.0
12	729.0	709.6	680.8	588.5	749.9
13	880.7	861.6	833.4	742.6	901.2
14	1048.3	1029.4	1001.7	912.4	1068.4
15	1232.0	1213.5	1186.1	1098.1	1251.9
16	1432.3	1414.1	1387.1	1300.3	1451.9
17	1649.5	1631.5	1604.8	1519.2	1668.9
18	1883.9	1866.1	1839.8	1755.2	1903.0
19	2135.7	2118.1	2092.1	2008.5	2154.6
20	2405.4	2387.9	2362.2	2279.5	2424.1
21	2693.0	2675.8	2650.3	2568.5	2711.5
22	2999.0	2981.9	2956.7	2875.7	3017.3
23	3323.5	3306.6	3281.6	3201.4	3341.6
24	3666.8	3650.1	3625.3	3545.8	3684.8
25	4029.2	4012.6	3988.1	3909.3	4047.0

1/ Bole weight was calculated from ground level to given top diameter.

Table 21 — Bole weight of tanoak to top diameters outside bark and total bole weight, by diameter at breast height outside bark 1/

D.b.h.	Bole weight to a top diameter of (inches):				Total bole
	4	5	6	a	
Inches	Ovendry pounds				
1	0	0	0	0	2.0
2	0	0	0	0	11.0
3	0	0	0	0	30.5
4	30.6	0	0	0	62.5
5	78.1	47.8	2.4	0	109.3
6	141.8	112.1	67.5	0	172.4
7	223.4	194.1	150.2	5.9	253.5
8	324.3	295.4	252.1	109.8	354.0
9	445.9	417.4	374.6	234.0	475.3
10	589.5	561.3	518.9	379.8	618.5
11	756.3	728.4	686.4	548.6	785.1
12	947.4	919.7	878.1	741.6	975.9
13	1163.9	1136.5	1095.2	959.8	1192.2
14	1406.9	1379.6	1338.7	1204.3	1435.0
15	1677.3	1650.3	1609.6	1476.2	1705.2
16	1976.2	1949.3	1909.0	1776.4	2003.9
17	2304.5	2277.8	2237.6	2105.9	2332.0
18	2663.0	2636.4	2596.5	2465.5	2690.4
19	3052.7	3026.3	2986.6	2856.3	3079.9
20	3474.4	3448.1	3408.7	3279.0	3501.5
21	3928.9	3902.8	3863.5	3734.6	3955.9
22	4417.2	4391.2	4352.1	4223.7	4444.0
23	4939.9	4914.0	4875.1	4747.3	4966.6
24	5497.8	5472.0	5433.3	5306.0	5524.4
25	6091.7	6066.0	6027.5	5900.8	6118.2

1/ Bole weight was calculated from ground level to given top diameter.

Table 22 — Total weight of residue for red alder with top bole diameters outside bark, by diameter at breast height outside bark 1/

D.b.h	Residue weight <3 inches in diameter	Residue weight ≥3 inches in diameter above a top diameter of (inches):			
		4	5	6	8
Inches	Ovendry pounds				
1	1.9	0	0	0	0
2	10.8	0	0	0	0
3	18.3	11.8	11.8	11.8	11.8
4	21.2	18.2	40.8	40.8	40.8
5	27.9	15.4	43.7	80.9	80.9
6	38.3	13.3	38.0	78.4	133.9
7	52.0	12.5	34.4	70.3	201.2
8	69.1	12.7	32.5	64.9	183.0
9	89.7	14.1	32.2	61.7	169.6
10	113.7	17.0	33.7	60.9	160.4
11	141.2	21.7	37.1	62.5	154.9
12	171.5	28.8	43.2	66.9	153.4
13	204.9	38.6	52.2	74.5	155.8
14	241.0	51.5	64.4	85.4	162.2
15	279.8	68.0	80.2	100.2	173.0
16	320.9	88.7	100.3	119.2	188.6
17	364.2	113.8	124.9	143.0	209.2
18	409.4	144.0	154.6	171.9	285.1
19	456.4	179.6	189.7	206.4	
20	504.8	221.1	230.9	246.9	305.2
21	554.6	269.0	278.4	293.8	350.0
22	605.5	323.6	332.7	347.6	401.8
23	657.3	385.5	394.3	408.6	461.1
24	710.0	454.9	463.4	477.3	528.1
25	763.2	532.3	540.5	554.0	603.2

1/ Residue includes all leaves, live and dead branchwood, and that part of the bole above a specific top diameter.

Table 23 — Total weight of residue for giant chinkapin with top bole diameters outside bark, by diameter at breast height outside bark 1/

D.b.h	Residue weiyht <3 inches in diameter	Residue weight >3 inches in diameter above a top diameter of (inches):			
		4	5	6	8
Inches	Ovendry pounds				
1	1.8	0	0	0	0
2	10.0	0	0	0	0
3	16.6	10.5	10.5	10.5	10.5
4	20.7	14.1	34.2	34.2	34.2
5	28.0	11.6	33.9	67.1	67.1
6	38.3	9.8	28.8	61.0	110.8
7	51.4	8.7	25.2	53.3	160.3
8	67.1	8.0	22.7	47.7	142.7
9	85.6	8.0	21.2	43.6	129.2
10	106.6	8.5	20.6	41.0	118.9
11	130.2	9.6	20.7	39.5	111.1
12	156.6	11.3	21.6	39.0	105.2
13	185.6	13.7	23.3	39.5	101.2
14	217.2	16.8	25.8	40.9	98.7
15	251.5	20.8	29.2	43.4	97.8
16	288.3	25.6	33.5	46.9	98.3
17	327.8	31.3	38.8	51.6	100.2
18	369.8	38.0	45.2	57.3	103.5
19	414.4	45.9	52.7	64.3	108.3
20	461.5	54.9	61.4	72.5	114.6
21	511.1	65.2	71.4	82.0	122.3
22	563.1	76.8	82.8	92.9	131.6
23	617.6	89.8	95.5	105.3	142.5
24	674.5	104.3	109.8	119.2	155.0
25	733.7	120.3	125.6	134.7	169.2

1/ Residue includes all leaves, live and dead branchwood, and that part of the bole above a specific top diameter.

Table 24 — Total weight of residue for bigleaf maple with top bole diameters outside bark, by diameter at breast height outside bark 1/

D.b.h	Residue weight <3 inches in diameter	Residue weight ≥3 inches in diameter above a top diameter of (inches):			
		4	5	6	8
Inches	Ovendry pounds				
1	3.2	0	0	0	0
2	15.4	0	0	0	0
3	23.5	12.5	15.1	15.1	15.1
4	32.8	12.6	30.4	41.5	41.5
5	44.9	13.0	30.8	54.2	78.3
6	58.2	15.4	33.3	56.8	121.9
7	73.1	19.6	37.6	61.2	126.6
8	89.1	26.0	44.1	67.8	133.4
9	106.2	34.9	53.1	76.9	142.8
10	124.0	46.8	65.0	88.9	155.0
11	142.4	61.8	80.1	104.0	170.3
12	161.2	80.2	98.5	122.5	188.9
13	180.3	102.1	120.5	144.5	211.1
14	199.6	127.7	146.1	170.2	236.9
15	219.1	157.0	175.5	199.6	266.5
16	238.7	190.3	208.7	232.9	299.9
17	258.5	227.5	245.9	270.2	337.3
18	278.3	268.6	287.2	311.4	378.7
19	298.3	313.9	332.4	356.7	424.1
20	318.4	363.2	381.8	406.1	473.5
21	338.6	416.6	435.2	459.6	527.1
22	359.0	474.2	492.9	517.3	584.9
23	379.5	536.0	554.6	579.1	646.8
24	400.2	601.9	620.6	645.1	712.9
25	421.1	672.1	690.8	715.3	783.1

1/ Residue includes all leaves, live and dead branchwood, and that part of the bole above a specific top diameter.

Table 25 — Total weight of residue for Pacific madrone with top bole diameters outside bark, by diameter at breast height outside bark 1/

D.b.h	Residue weight <3 inches in diameter	Residue weight ≥3 inches in diameter above a top diameter of (inches):			
		4	5	6	8
Inches	Ovendry pounds				
1	3.0	0	0	0	0
2	15.2	0	0	0	0
3	20.1	16.1	19.0	19.0	19.0
4	27.7	15.1	39.7	48.8	48.8
5	38.3	15.3	38.8	73.5	90.5
6	51.5	17.2	39.8	73.1	145.6
7	67.3	21.2	43.0	75.2	178.9
8	85.4	27.7	48.9	80.2	180.9
9	105.5	37.4	58.1	88.7	186.8
10	127.4	50.8	71.1	100.9	196.9
11	150.7	68.4	88.2	117.5	211.5
12	175.4	90.7	110.1	138.8	231.1
13	201.2	118.0	137.1	165.3	256.0
14	227.9	150.7	169.5	197.3	286.6
15	255.4	189.3	207.9	235.2	323.2
16	283.5	234.1	252.4	279.4	366.1
17	312.2	285.4	303.4	330.1	415.7
18	341.4	343.5	361.3	387.6	472.2
19	370.9	408.6	426.2	452.2	535.8
20	400.7	481.1	498.5	524.3	607.0
21	430.6	561.2	578.5	603.9	685.8
22	460.7	649.2	666.3	691.5	772.5
23	490.9	745.3	762.2	787.1	867.4
24	521.1	849.7	866.4	891.2	970.7
25	551.2	962.6	979.2	1003.7	1082.5

1/ Residue includes all leaves, live and dead branchwood, and that part of the bole above a specific top diameter.

Table 26 — Total weight of residue for tanoak with top bole diameters outside bark, by diameter at breast height outside bark 1/

D.b.h	Residue weiyht <3 inches in diameter	Residue weight >3 inches in diameter above a top diameter of (inches):			
		4	5	6	8
Inches	Ovendry pounds				
1	2.8	0	0	0	0
2	14.9	0	0	0	0
3	23.4	16.7	16.7	16.7	16.7
4	31.8	18.6	49.2	49.2	49.2
5	43.7	18.2	48.4	93.9	96.3
6	59.1	17.8	47.5	92.2	159.6
7	78.2	17.6	46.8	90.7	235.0
8	101.1	17.3	46.2	89.5	231.8
9	128.1	17.1	45.6	88.5	229.1
10	159.1	17.0	45.2	87.6	226.7
11	194.3	16.9	44.8	86.8	224.5
12	233.8	16.8	44.5	86.1	222.6
13	277.7	16.8	44.2	85.4	220.9
14	326.2	16.7	44.0	84.9	219.3
15	379.2	16.8	43.8	84.4	217.9
16	436.8	16.8	43.7	84.0	216.6
17	499.3	16.9	43.6	83.7	215.5
18	566.5	17.0	43.5	83.4	214.4
19	638.6	17.1	43.5	83.2	213.5
20	715.7	17.3	43.6	83.1	212.7
21	797.9	17.6	43.7	83.0	211.9
22	885.1	17.8	43.8	82.9	211.3
23	977.5	18.1	44.0	82.9	210.7
24	1075.0	18.5	44.3	83.0	210.2
25	1177.9	18.9	44.5	83.1	209.8

1/ Residue includes all leaves, live and dead branchwood, and that part of the bole above a specific top diameter.

Table 27 — Total weight of red alder, giant chinkapiw, bigleaf maple, Pacific madrone, and tanoak trees by diameter at breast height outside bark 1/

D.b.h.	Red alder	Giant chinkapin	Bigleaf maple	Pacific madrone	Tanoak
Inches	----------	Ovendry pounds	----------		
1	1.9	1.8	3.2	3.0	2.8
2	10.8	10.0	15.4	15.2	14.9
3	30.0	27.1	38.7	39.2	40.1
4	62.0	54.9	74.3	76.6	81.1
5	108.8	95.2	123.2	128.8	139.9
6	172.2	149.1	186.4	197.1	218.7
7	254.1	218.0	264.6	282.5	319.1
8	355.8	303.0	358.5	385.8	442.7
3	479.0	405.2	468.5	508.0	591.1
10	624.8	525.5	595.3	649.8	765.6
11	794.6	665.0	739.4	811.9	967.4
12	989.7	824.4	901.3	995.0	1198.0
13	1211.2	1004.7	1081.3	1199.8	1458.4
14	1460.3	1206.6	1279.9	1426.9	1749.8
15	1738.1	1431.0	1497.5	1676.7	2073.2
16	2045.6	1678.6	1734.5	1950.0	2429.8
17	2383.8	1950.2	1991.2	2247.1	2820.6
18	2753.8	2246.4	2267.9	2568.7	3246.5
19	3156.5	2567.9	2565.1	2915.3	3708.5
20	3592.8	2915.4	2882.9	3287.1	4207.4
21	4063.8	3289.6	322108	3684.9	4744.4
22	4570.3	3691.1	3581.9	4108.9	5320.1
23	5113.1	4120.6	3963.6	4559.7	5935.4
24	5693.1	4578.5	4367.2	5037.6	6591.3
25	6311.3	5065.6	4792.9	5543.0	7288.5

1/ Tree weight includes leaves, live and dead branchwood, entire bole from ground to tip, and bark.

Example

To illustrate how to use these tables to estimate weights of potential residue, consider a clearcut of Pacific madrone and tanoak. **All** boles with d.b.h. of 10 inches and larger will be cut at a top diameter of 4 inches and removed from the site. **All** other trees will be felled and left. The number of trees per acre by species and d.b.h. for this example are shown in table 28. The total weight of aboveground biomass, residue, and 1,000-hour timelag fuels can be calculated from weights in tables 25, 26, and 27.

For example, to calculate the total weight of all Pacific madrone with d.b.h. of 10 inches, multiply the total weight per tree (table 27) by the number of trees (table 28):

649.8 lb × 30 trees per acre = 19,494 lb or 9.7 tons per acre.

The total residue from these trees will be that part of the bole less than 4 inches in diameter and all of the crown. Total residue can be determined from table 25 as the weight of residue less than 3 inches in d.o.b. (127.4 lb) plus the weight of crown and tip 3 to 4 inches in d.o.b. (50.8 lb):

Residue weight (127.4 + 50.8) lb per tree × 30 trees per acre
= 5,346 lb or 2.7 tons per acre.

The 1,000-hour timelag fuels for these 10-inch trees will include all of the crown greater than 3 inches in d.o.b. and that part of the tip that is 3 to 4 inches in d.o.b. because all bolewood greater than 4 inches in diameter will be harvested:.

1,000-hour fuel weight (table 25) 50.8 lb × 30 trees per acre
= 1,527 lb or 0.76 ton per acre.

For trees less than 10 inches in d.b.h., 1,000-hour timelag fuels will include components of crown and bole that are 3 to 8 inches in d.o.b.

The total residue for the stand will include the residue from all trees greater than 10 inches in d.b.h. and the total weight of all trees less than 10 inches in d.b.h. because they will not be harvested.

Now suppose that all material less than 4 inches and greater than 1 inch in d.o.b. are to be chipped for fuel. The total weight of the material available for chips will include all crown and tip between 3 and 4 inches in d.o.b. (table 25) and all live crown, dead crown, and tip between 1 and 3 inches in d.o.b. (tables 10 and 15). For the 10-inch-d.b.h. Pacific madrone:

Crown and tip 3-4 inches in d.o.b. (table 25)	50.8 lb
Live crown 1-3 inches in d.o.b. (table 10)	40.6 lb
Dead crown 1-3 inches in d.o.b. (table 10)	4.4 lb
Tip 1-3 inches in d.o.b. (table 15)	8.9 lb
Total weight per tree	104.7 lb

Total weight = 104.7 lb × 30 trees per acre = 3,141 lb or 1.6 tons per acre.

The weight of chippable material for the stand is listed in table 29.

Table 28 — Deriving weight of Pacific madrone and tanoak trees on a sample acre

D.b.h.	Trees per acre	Total tree weight	Total residue weight	1,000-h fuel weight (residue 3 to 6 inches in diameter)
Inches	Number	Ovendry tons per acre		
		PACIFIC MADRONE		
2	200	1.5	1.5	0
4	300	11.5	11.5	7.3
6	250	24.6	24.6	9.1
9	50	12.7	12.7	2.2
10	30	9.7	2.7	.8
14	10	7.1	1.9	.8
Total		67.1	54.9	20.2
		TANOAK		
2	100	0.7	0.7	0
4	50	2.0	2.0	1.2
6	100	10.9	10.9	4.6
9	25	7.4	7.4	1.1
10	15	5.7	1.3	.1
14	5	4.4	.9	.04
Total		31.2	23.2	7.0
All trees		98.3	78.1	27.2

Table 29 — Chippable material from Pacific madrone and tanoak trees on a sample acre

D.b.h.	Trees per acre	Total residue weight	Total weight of residue 1 to 4 inches in diameter
Inches	Number	-------- Ovendry tons per acre -------	
		PACIFIC MADRONE	
2	200	1.5	1.2
4	300	11.5	4.3
6	250	24.6	4.6
9	50	12.7	2.0
10	30	2.7	1.6
14	10	1.9	1.3
Total		54.9	15.0
		TANOAK	
2	100	.7	.5
4	50	2.0	.8
6	100	10.9	2.0
9	25	7.4	.8
10	15	1.3	.6
14	5	.9	.4
Total		23.2	5.1
All trees		78.1	20.1

Appendix 2. Summary Tables of Data Used in Developing Equations in Tables 1 to 6

Table 30 — Data from red alder sampled

D.b.h.	Tree height	Age	Crown length	Crown width	Diameter of bole at base of crown	Dead crown weight: Branchwood diameter (inches) 0-0.24	0.25-0.99	1-2.99	3+	Total dead	Live crown weight: Foliage	Branchwood diameter (inches) 0-0.24	0.25-0.99	1-2.99	3+	Total live	Bole volume
Inches	Feet	Years	Feet	Feet	Inches	Pounds											Cubic feet
1.0	15.1	6	6.9	5.1	0.8	0	0	0	0	0.1	0.2	0.3	0.2	0	0	0.7	0.1
1.1	17.1	5	6.6	6.7	.7	0	0	0	0	0	.2	.2	.1	0	0	.5	.1
1.3	15.8	9	9.2	5.1	1.0	0	0	0	0	0	.3	.4	.4	0	0	1.1	.1
2.2	42.6	9	27.4	10.7	1.6	.1	.1	0	0	.2	.7	.8	1.0	0	0	2.4	.5
2.4	24.8	6	18.2	10.7	2.3	.1	0	0	0	.2	1.7	2.0	2.5	0	0	6.2	.5
2.4	28.5	12	11.3	6.7	1.6	.1	0	0	0	.1	.4	.5	.6	0	0	1.5	.6
2.5	22.3	14	9.2	5.2	1.5	.1	.7	0	0	.9	.6	.7	.9	0	0	2.1	.3
2.9	24.7	18	11.1	8.0	1.8	.1	.4	0	0	.5	1.4	1.6	2.2	0	0	5.1	.6
3.3	27.9	17	14.1	11.5	2.3	.1	0	0	0	.1	1.6	1.8	2.5	0	0	5.9	.8
3.5	45.1	14	8.9	5.9	1.0	.1	.7	0	0	.8	.3	.3	.3	0	0	.8	1.4
3.5	57.5	12	11.2	8.1	1.5	.1	0	0	0	.1	1.3	1.5	1.5	0	0	4.4	1.8
4.2	43.6	10	18.5	11.4	2.6	.7	2.4	0	0	3.1	2.3	2.6	4.0	2.0	0	10.9	2.0
4.5	44.6	19	19.2	9.7	3.0	.2	.1	0	0	.3	2.4	2.7	3.9	0	0	9.0	2.6
4.7	36.6	22	16.6	10.3	3.3	.1	.3	.2	0	.6	3.1	3.4	5.6	6.1	0	18.2	2.3
4.8	30.9	7	30.9	15.3	6.9	.2	.3	0	0	.5	7.0	7.7	12.4	9.5	0	36.5	1.7
5.0	46.0	11	27.6	15.7	3.8	.2	.7	0	0	.9	3.8	4.2	6.5	3.3	0	17.8	3.1
5.8	43.7	27	21.9	11.8	3.8	.3	.3	0	0	.6	3.7	4.1	5.9	.7	0	14.4	3.5
6.4	80.4	22	37.2	15.6	4.7	.3	5.4	.6	0	6.3	5.1	5.6	9.0	9.7	0	29.3	7.7
6.5	72.1	34	22.9	8.6	3.8	0	0	0	0	0	3.0	3.3	5.6	6.2	0	18.0	7.4
6.8	73.4	22	8.0	11.5	2.5	.1	1.8	1.3	0	3.3	1.4	1.5	2.5	2.7	0	8.1	8.8
7.1	52.9	17	27.4	16.4	4.7	.4	1.7	0	0	2.1	6.6	7.2	12.4	13.9	0	40.0	6.5
7.7	64.0	28	29.9	20.8	4.9	0	0	0	0	0	5.1	5.5	9.5	12.6	0	32.8	10.6
8.1	52.4	16	34.5	21.8	6.5	.8	2.5	0	0	3.3	9.0	9.8	17.0	20.0	0	55.9	8.0
8.6	45.4	33	28.2	16.4	7.3	.8	5.2	3.1	2.3	11.4	9.2	10.0	18.9	28.0	0	66.2	7.8
9.2	72.3	59	33.2	13.1	7.2	.3	1.3	0	0	1.6	11.1	11.9	24.8	41.9	3.5	93.1	14.5
9.5	87.7	40	37.1	18.9	6.2	.2	1.2	1.3	0	2.7	7.8	8.6	14.4	17.4	0	48.2	18.1
9.7	66.1	36	45.7	23.0	7.5	.7	2.8	.1	0	3.7	11.3	12.3	22.9	34.6	0	81.1	12.5
10.2	95.0	52	35.6	16.2	6.5	.2	.1	0	0	.3	8.4	9.1	18.7	31.2	8.9	76.3	26.4
10.3	73.7	31	52.2	21.1	7.2	.6	54.3	12.7	0	67.6	15.0	16.1	34.3	57.2	26.7	149.4	18.4
11.5	91.7	50	60.7	14.7	6.7	.9	3.4	50.4	.6	55.4	10.6	11.4	23.6	39.1	0	84.8	45.1
11.6	80.9	45	47.1	28.1	8.9	.2	.1	2.2	0	2.4	14.1	15.0	33.9	59.4	31.9	154.4	26.6
11.7	70.4	30	36.4	24.6	8.6	.8	13.1	23.0	0	36.9	21.4	23.0	46.8	81.2	3.5	175.9	22.6
12.1	65.9	53	36.2	25.5	9.8	2.1	3.6	3.9	0	9.5	20.5	21.9	47.0	80.2	4.0	173.6	24.4
12.3	88.3	28	40.8	25.4	8.6	0.2	5.3	15.5	0	21.0	15.8	17.1	32.8	52.0	0	117.7	34.4
12.6	88.5	89	47.8	22.2	9.2	.4	2.3	9.8	0	12.6	14.6	15.5	34.6	61.9	21.5	148.1	40.5
12.6	65.3	22	44.7	31.5	11.3	2.8	13.6	33.3	0	49.7	27.3	29.0	64.3	117.0	14.1	251.7	19.7
12.7	86.0	38	30.8	22.8	8.0	.3	3.9	26.6	0	30.8	19.2	20.7	42.4	72.7	14.3	169.3	33.0
13.3	75.8	30	32.0	28.7	8.8	1.2	24.5	28.4	0	54.1	21.1	22.7	44.6	75.3	0	163.6	29.3
13.7	85.2	35	55.2	30.1	10.7	.2	4.3	12.3	0	16.8	23.4	25.1	52.0	89.4	3.0	192.8	34.9
14.2	74.6	52	40.5	24.6	10.5	1.1	4.9	18.0	1.9	25.8	26.5	28.2	63.4	106.3	53.2	277.7	33.1
14.5	84.7	95	29.6	23.8	7.8	2.9	6.2	8.3	0	17.4	13.6	14.4	33.9	58.2	51.2	171.5	35.5
15.1	91.0	46	62.8	24.0	12.5	.5	1.9	.5	0	2.9	21.0	22.0	56.1	103.8	111.9	314.8	58.4
16.3	95.6	61	42.5	37.8	11.9	2.5	3.7	11.2	0	17.3	29.1	30.8	74.0	135.5	118.8	388.2	95.6
16.6	95.5	46	70.9	39.9	14.6	.5	5.8	23.4	1.6	31.3	42.6	44.4	119.2	224.3	370.9	801.4	61.8
17.0	96.3	45	55.7	32.3	12.9	1.2	14.2	55.4	0	70.8	45.2	47.9	108.7	195.6	43.4	440.9	63.1
18.0	77.7	40	49.4	32.5	14.2	.6	7.9	30.3	0	38.8	51.9	54.7	132.3	243.5	143.3	625.8	58.6
18.7	95.0	52	43.9	28.8	10.7	2.1	4.0	36.2	7.7	50.0	26.3	27.9	63.2	112.3	46.1	275.8	99.8
19.7	82.0	35	41.3	36.2	12.8	1.4	21.1	108.9	10.5	141.9	63.4	66.8	162.1	301.1	136.4	729.8	73.8
20.2	95.3	56	36.1	29.7	13.5	.2	.3	0	0	.5	31.2	32.9	78.8	143.9	74.8	361.5	110.4
21.9	103.1	69	41.9	47.8	15.9	.9	6.9	7.6	0	15.4	64.4	67.1	181.4	346.7	447.8	1107.3	132.7
22.1	83.8	48	41.7	35.4	15.1	1.0	9.4	76.7	18.2	105.3	68.2	71.5	180.7	340.6	216.2	877.2	78.4
24.1	110.5	80	40.0	29.5	13.7	4.5	5.3	13.3	55.7	78.7	56.1	58.8	150.7	283.4	358.2	807.2	155.3
24.8	72.1	46	55.3	49.0	23.9	2.4	24.6	9.9	54.8	91.7	144.2	149.7	410.3	792.2	982.0	2478.4	97.7

Table 31 — Data from giant chinkapin sampled

D.b.h.	Tree height	Age	Crown length	Crown width	Diameter of bole at base of crown	Dead crown weight: Branchwood diameter (inches) 0-0.24	0.25-0.99	1-2.99	3+	Total dead	Live crown weight: Foliage	Branchwood diameter (inches) 0-0.24	0.25-0.99	1-2.99	3+	Total live	Bole volume
Inches	Feet	Years	Feet	Feet	Inches	Pounds											Cubic feet
1.3	11.5	20	7.2	3.9	1.5	0	0	0	0	0	.8	.5	.5	0	0	1.8	0.1
1.4	11.2	53	4.2	5.9	.9	.2	.4	0	0	.6	.6	.4	.6	0	0	1.7	.1
1.6	14.9	32	8.7	6.9	1.3	.1	0	0	0	.1	.8	.5	.6	0	0	1.9	.1
2.0	17.5	18	12.9	7.4	2.0	.3	.4	0	0	.7	.7	.4	.6	0	0	1.7	.2
2.9	25.9	60	6.4	5.8	1.1	1.3	3.4	0	0	4.8	1.0	.7	.9	0	0	2.5	.7
3.0	21.4	30	9.2	6.8	1.7	.3	.6	0	0	.8	.6	.4	.4	0	0	1.3	.5
3.7	37.9	45	23.1	7.0	3.0	1.3	2.7	0	0	4.0	2.6	1.8	2.7	0	0	7.1	1.2
4.2	25.0	75	13.8	6.8	3.3	.5	1.0	0	0	1.6	4.1	2.8	4.7	1.6	0	13.3	1.2
5.0	26.9	63	13.1	9.4	4.1	3.0	8.0	.9	0	11.9	5.6	3.9	6.7	4.2	0	20.3	2.1
5.1	35.9	74	22.4	7.9	3.7	.9	1.1	0	0	2.1	4.4	3.0	4.3	0	0	11.7	2.1
5.6	43.9	64	20.5	8.3	4.0	1.7	5.8	.8	0	8.3	6.2	4.3	7.4	3.9	0	21.8	3.2
6.2	52.4	91	25.5	12.3	4.8	.7	3.7	.1	0	4.6	5.1	3.5	6.1	2.9	0	17.6	5.2
6.8	53.4	49	50.0	10.6	4.4	4.0	10.9	2.3	0	17.2	9.5	6.6	11.5	6.0	0	33.6	5.8
6.9	45.1	63	29.6	9.4	5.9	4.6	12.4	1.1	0	18.0	8.6	6.1	10.9	8.1	0	33.7	4.9
7.6	52.7	75	20.0	13.7	4.5	4.6	12.6	0	0	17.2	8.6	6.0	10.6	6.5	0	31.8	6.8
7.7	39.2	71	13.1	10.8	4.0	5.6	18.5	3.5	0	27.6	7.1	5.0	8.6	4.8	0	25.5	5.4
8.2	55.0	68	29.5	12.2	6.0	4.0	16.3	0	0	20.4	13.3	9.5	17.9	17.6	0	58.3	8.7
8.7	46.6	55	27.6	11.5	6.9	13.4	8.2	6.2	0	27.8	17.8	12.7	23.6	19.7	0	73.9	8.2
9.2	64.5	56	32.0	13.9	6.8	5.6	7.6	15.9	0	29.1	18.3	13.0	24.4	21.5	0	77.3	14.7
9.7	51.6	83	28.7	11.8	6.9	.9	6.4	6.5	0	13.8	12.6	9.1	17.8	18.2	0	57.8	13.0
10.2	57.0	102	37.7	14.3	8.5	4.2	8.6	7.8	0	20.6	21.3	15.4	30.7	33.3	0	100.8	16.5
11.2	54.0	89	24.5	14.8	7.2	6.4	15.1	11.5	0	33.0	15.4	11.0	20.7	19.6	0	66.7	16.5
11.6	52.6	109	30.0	13.8	8.3	2.8	6.8	4.1	0	13.7	22.9	16.6	34.0	40.0	15.9	129.3	21.6
12.6	73.4	123	37.6	14.0	8.5	3.0	21.9	3.0	0	27.9	25.9	18.7	36.8	37.0	0	118.3	31.6
14.4	59.2	75	39.6	19.3	11.7	9.0	17.2	10.4	0	36.6	41.9	30.8	64.6	78.6	11.4	227.3	33.9
14.6	72.7	195	37.0	17.8	9.0	3.6	11.5	19.6	0	34.7	23.1	17.3	39.2	54.4	14.4	148.5	33.4
18.0	66.7	150	24.3	21.2	9.9	14.2	16.8	34.2	25.7	90.9	54.9	41.0	91.9	127.3	37.5	352.6	57.9
19.9	80.2	179	31.0	19.5	10.8	5.2	16.9	41.0	0	63.1	54.1	39.8	85.0	106.7	12.5	298.0	72.6
22.0	67.6	98	38.7	21.1	14.5	15.4	36.4	58.4	109.4	219.6	44.6	33.0	72.1	94.0	19.8	263.5	65.9
23.6	86.6	185	52.3	23.6	18.2	6.5	30.3	35.7	0	72.5	127.2	95.8	221.2	320.6	99.1	863.8	98.0

Table 32 — Data from bigleaf maple sampled

D.b.h.	Tree heiyht	Age	Crown length	Crown width	Diameter of bole at base of crown	Dead crown weight: Branchwood diameter (inches) D-0.24	0.25-0.99	1-2.99	3+	Total dead	Live crown weight: Foliage	Branchwood diameter (inches) 0-0.24	0.25-0.99	1-2.99	3+	Total live	Bole volume
Inches	Feet	Years	Feet	Feet	Inches	Pounds											Cubic feet
1.6	18.1	12	14.4	9.7	1.6	0.1	0	0	0	0.1	0.7	0.3	2.6	0	0	3.6	.2
4.0	39.7	31	53.8	16.4	3.0	.5	.5	0	0	1.0	1.7	.7	6.8	.7	0	9.9	1.5
5.2	52.0	31	30.4	18.9	2.8	.2	1.5	1.0	0	2.7	2.5	1.0	9.9	12.7	4.1	30.3	3.5
5.2	58.8	18	26.8	10.9	2.7	.1	3.6	2.7	0	6.4	1.7	.7	6.7	7.0	0	16.1	3.5
5.7	65.9	45	39.3	23.5	4.0	.2	.8	0	0	1.0	2.5	1.0	9.6	2.5	0	15.6	4.6
6.2	58.5	29	37.6	15.3	4.0	.4	3.2	1.3	0	4.9	2.2	.9	8.7	7.8	0	19.6	3.8
6.3	51.9	29	34.1	21.1	4.8	.2	.8	0	0	1.0	4.3	1.7	16.8	15.3	0	38.2	5.0
7.0	75.2	30	55.5	26.2	5.4	.1	1.7	1.4	0	3.2	5.0	2.0	20.1	18.2	0	45.4	7.3
8.4	76.0	32	50.2	12.5	6.7	.3	1.9	1.4	0	3.6	3.5	1.4	13.5	24.3	17.5	60.1	10.0
9.4	48.9	31	31.2	29.8	7.5	.8	7.0	7.7	0	15.5	10.0	3.8	38.4	94.8	76.4	223.4	9.7
11.7	69.8	45	33.2	21.2	6.3	.5	7.1	5.3	0	12.9	6.7	2.6	25.2	52.0	26.7	113.2	18.3
12.0	55.8	37	34.1	29.7	9.8	1.5	18.9	27.2	14.6	62.2	12.6	4.8	47.2	134.9	185.8	385.2	15.2
13.0	63.4	37	37.6	25.5	10.5	1.5	11.5	32.1	0	45.1	9.6	3.7	36.5	84.8	57.9	192.4	20.6
14.6	96.0	64	68.4	24.6	11.7	.6	10.4	20.8	0	31.8	9.3	3.6	35.2	88.3	81.9	218.3	45.1
15.6	79.3	38	66.5	33.0	11.5	1.3	28.5	31.7	2.6	64.0	17.6	6.6	65.8	220.6	366.3	676.9	23.4
17.3	107.5	114	51.7	28.1	9.8	.3	3.9	4.3	0	8.4	12.2	4.6	46.2	135.9	194.4	393.3	53.7

Table 33 — Data from Pacific madrone sampled

D.b.h.	Tree height	Age	Crown length	Crown width	Diameter of bole at base of crown	Dead crown weight: Branchwood diameter (inches) 0-0.24	0.25-0.99	1-2.99	3+	Total dead	Live crown weight: Foliage	Branchwood diameter (inches) 0-0.24	0.25-0.99	1-2.99	3+	Total live	Bole volume
Inches	Feet	Years	Feet	Feet	Inches	Pounds											Cubic feet
1.2	11.4	32	5.9	3.8	1.3	0.1	0.1	0	0	0.2	2.7	1.8	3.4	0	0	7.8	0.1
1.3	19.7	31	6.9	2.8	0.9	.1	0	0	0	.1	0.3	0.2	0	0	0	0.5	.3
2.1	23.0	48	13.3	5.6	2.0	.3	.7	0	0	1.0	.8	.5	1.4	.7	0	3.5	.5
2.7	22.9	103	9.3	4.6	1.9	.5	.5	0	0	1.0	1.1	.7	1.8	1.2	0	4.7	.7
2.7	22.1	71	13.9	5.1	2.3	.3	.9	0	0	1.2	1.6	1.0	1.9	0	0	4.5	.5
3.1	17.8	38	6.2	3.4	1.6	.2	.3	0	0	.5	.4	.3	0.3	0	0	.9	.4
4.2	25.2	66	12.0	11.5	3.4	0.8	4.9	0	0	5.7	2.7	1.6	5.7	5.6	0	15.5	1.6
4.2	24.4	51	16.2	7.7	3.4	.3	.6	0	0	.9	3.6	2.2	6.7	5.7	0	18.3	1.2
4.4	24.8	69	15.3	7.7	3.8	1.2	3.2	.4	0	4.8	4.2	2.6	7.6	5.8	0	20.1	1.8
5.2	26.9	107	15.9	8.4	4.0	1.0	3.1	.4	0	4.4	4.2	2.6	7.6	5.8	0	20.3	2.0
5.4	32.0	76	24.6	6.0	5.0	.4	.7	0	0	1.1	7.1	4.4	13.2	3.4	0	28.1	7.8
5.8	29.5	173	22.6	5.9	5.3	.7	.8	0	0	1.5	6.9	4.3	12.9	5.5	0	29.7	2.7
6.2	41.0	63	22.1	8.9	4.3	1.8	4.4	.2	0	6.4	5.9	3.6	11.2	5.4	0	26.1	4.0
7.2	55.0	80	41.2	11.2	6.2	1.0	5.7	4.5	0	11.1	11.0	6.4	25.2	32.1	7.0	81.7	7.2
7.4	57.3	69	18.6	8.2	3.7	.1	.7	4.2	0	4.9	2.3	1.3	4.7	4.4	0	12.7	6.4
7.8	36.9	102	20.8	12.1	4.6	2.1	5.8	0	0	7.9	8.9	4.9	24.5	37.6	69.8	145.6	4.6
8.3	59.2	191	30.0	11.5	5.9	4.9	10.1	3.4	0	18.4	13.6	8.0	29.3	33.8	0	84.7	10.2
9.0	34.9	95	27.7	10.5	7.5	1.5	2.5	1.0	0	4.9	7.2	4.1	17.3	23.5	18.8	70.9	6.9
9.2	35.9	175	13.2	13.6	5.0	3.0	16.3	4.9	0	24.2	13.1	7.3	34.3	52.0	68.2	175.0	8.0
10.3	33.9	81	16.0	14.2	7.6	2.5	22.4	9.2	0	34.0	12.5	6.9	33.3	54.4	53.9	161.0	10.8
10.7	64.4	193	40.1	13.1	7.0	8.7	35.4	13.5	0	57.6	20.2	11.1	55.8	85.8	138.1	314.0	15.3
11.8	35.7	167	7.1	14.8	7.6	7.4	33.1	21.4	0	61.8	9.9	5.2	30.2	48.7	125.6	219.5	19.5
12.6	67.2	129	39.6	13.5	8.1	2.3	27.0	24.8	14.3	68.5	15.6	8.5	43.2	68.0	112.7	248.0	24.3
14.4	73.3	128	49.0	13.0	11.7	9.9	34.9	6.6	0	51.4	18.2	10.0	50.4	77.1	135.0	290.7	33.5
16.1	49.9	76	32.5	15.4	13.0	8.2	33.2	33.2	0	74.6	21.2	11.2	63.8	108.4	198.4	403.1	27.3
16.4	69.5	145	52.1	15.6	14.2	6.4	44.1	27.0	0	77.6	27.9	14.6	86.6	139.9	342.3	611.4	35.4
17.2	86.2	132	47.6	18.4	13.0	.5	22.3	16.8	11.2	50.8	26.7	13.5	90.8	151.6	459.0	741.8	50.9
19.3	70.1	208	47.9	18.2	16.6	2.4	23.2	12.0	0	37.5	33.5	16.8	117.7	194.3	622.6	985.0	60.1
20.4	78.4	174	39.0	20.7	9.0	1.0	46.3	49.0	59.8	156.1	46.7	23.6	165.1	258.1	838.6	1332.1	49.6
20.6	68.4	200	40.8	16.9	14.5	11.2	45.8	15.7	0	72.8	37.0	19.0	120.6	207.6	510.9	895.2	65.3
25.0	95.0	200	40.8	21.0	13.3	2.3	15.7	26.8	14.1	58.9	56.6	29.5	179.9	295.7	690.3	1252.1	117.9

Table 34 — Data from tanoak sampled

D.b.h.	Tree height	Age	Crown length	Crown width	Diameter of bole at base of crown	Dead crown weight: Branchwood diameter (inches) 0-0.24	0.25-0.99	1-2.99	3+	Total dead	Live crown weight: Foliage	Branchwood diameter (inches) 0-0.24	0.25-0.99	1-2.99	3+	Total live	Bole volume
Inches	Feet	Years	Feet	Feet	Inches	Pounds											Cubic feet
1.3	11.7	18	6.7	5.6	1.1	0.1	0.1	0	0	0.2	0.7	0.5	0.8	0	0	2.0	0.1
1.6	16.4	15	5.0	3.0	0.8	.1	.1	0	0	.2	.4	.3	.3	0	0	1.0	.1
2.0	23.4	24	10.8	6.7	1.5	.4	.7	0	0	1.1	1.7	1.3	1.3	0	0	4.3	.4
3.0	17.2	62	9.8	8.9	2.6	.7	1.4	0	0	2.1	2.9	2.5	5.4	4.2	0	15.0	.5
3.2	22.8	65	14.3	9.2	2.5	.1	.4	0	0	.5	3.4	2.8	5.6	3.9	0	15.8	.5
3.7	22.5	32	14.6	6.2	3.0	.4	.6	0	0	1.0	5.8	4.8	8.8	2.8	0	22.2	.7
3.8	28.5	29	18.2	6.1	3.2	.3	.6	0	0	.9	3.7	3.0	4.8	0.8	0	12.3	1.0
4.0	48.3	31	11.2	2.5	1.9	.1	1.5	.6	0	2.2	1.3	1.1	2.0	1.5	0	5.8	1.7
4.8	47.3	46	28.3	2.6	3.5	.1	.3	0	0	.4	3.4	2.8	5.2	3.5	0	14.9	2.8
5.1	43.0	47	22.5	3.0	3.8	.4	.3	0	0	.7	3.5	2.9	4.9	4.2	0	15.4	3.0
5.3	40.8	42	26.1	7.9	4.1	.5	2.2	.3	0	3.0	7.0	5.8	10.9	.7	0	24.4	2.7
6.0	34.0	59	21.7	11.0	4.6	0.5	1.0	0	0	1.5	9.3	8.0	17.3	15.6	0	50.1	4.7
6.0	63.4	43	42.4	6.0	4.6	0	.9	0	0	.9	9.2	7.9	17.5	14.8	0	49.5	2.8
6.8	41.9	65	27.8	12.1	5.8	.6	2.4	0	0	3.0	12.9	11.4	29.2	34.7	0	88.2	4.1
8.0	36.8	55	23.1	17.6	6.9	4.2	18.2	13.2	0	35.6	21.4	19.5	56.5	72.7	0	170.1	5.4
8.0	74.5	81	31.2	8.5	4.3	.4	5.7	.7	0	6.8	12.6	10.6	20.8	8.0	0	52.0	8.1
8.0	56.2	59	32.1	8.8	5.7	1.2	3.8	1.9	0	6.9	14.2	12.1	25.0	17.1	0	68.4	7.6
8.6	52.9	62	33.2	19.7	6.9	1.6	7.6	2.8	0	12.0	16.6	14.6	35.8	38.1	0	105.1	8.6
9.4	61.0	65	40.6	14.4	7.3	2.9	15.1	15.3	0	33.3	28.5	25.2	64.3	77.8	0	195.8	11.0
9.8	53.7	57	30.1	10.0	6.6	.5	3.8	1.4	0	5.7	18.9	16.4	37.6	37.1	0	109.9	10.0
10.5	54.4	63	42.9	11.8	8.9	3.0	3.3	0	0	6.2	34.1	29.7	70.2	69.6	0	203.5	11.6
11.0	66.2	120	34.9	14.9	6.9	.4	1.5	0.6	0	2.5	24.6	22.0	58.4	74.3	0	179.5	15.3
11.8	59.9	83	38.6	14.9	8.6	2.1	16.3	7.6	0	26.1	30.4	27.4	75.5	96.4	0	229.7	12.5
13.2	52.1	61	42.5	20.0	12.9	.5	8.4	8.7	0	17.6	55.2	50.1	142.1	181.4	0	428.8	19.4
13.9	93.1	58	74.6	15.9	11.9	1.4	3.6	2.2	0	7.3	61.0	54.4	143.7	173.1	0	432.2	34.7
14.9	82.6	75	64.1	21.7	12.3	4.6	20.2	45.8	0	70.6	58.5	52.3	140.5	169.7	0	421.0	33.0
17.0	70.4	97	41.2	1208	12.0	1.6	9.1	12.1	0	22.8	60.1	55.3	165.6	226.4	0	507.4	37.2
19.6	89.8	200	43.2	22.6	10.0	.6	6.4	19.9	6.5	33.4	60.9	56.5	177.6	227.2	0	522.2	58.0
20.7	72.2	137	56.4	20.8	17.0	4.0	35.4	120.6	18.5	178.4	85.2	79.9	259.8	348.3	0	773.2	46.2
22.3	136.4	153	81.3	13.1	14.9	1.0	3.6	12.1	0	16.8	57.2	52.3	153.3	200.3	0	463.1	147.5
25.3	112.6	200	57.8	22.6	14.8	3.1	18.6	39.4	0	61.0	82.6	76.5	235.1	317.1	0	711.2	164.4

Appendix 3. Equations for Estimating Crown Weight and Bole Volume (Metric Units)

Table 35 — Regression equations for estimating ovendry weight of live crown for red alder, giant chinkapin, bigleaf maple, Pacific madrone, and tanoak

$$\ln(w) = A + B \ln(d)$$

Species	A	B	n	r^2	s^2
Red alder	-4.5648	2.6232	53	0.94	0.3202
Giant chinkapin	-3.7097	2.2699	30	.94	.2154
Bigleaf maple	-2.8534	2.1505	16	.93	.1495
Pacific madrone	-3.8941	2.4839	31	.89	.5410
Tanoak	-3.2304	2.2774	31	.94	.2081

Note: w = ovendry weight of live crown (kg), d=diameter at breast height (cm), s^2 = mean square error of the residuals.

Table 36 — Regression equations for estimating dead branchwood weight of red alder, giant chinkapin, bigleaf maple, Pacific madrone, and tanoak

$$\ln(dw) = A + B \ln(d)$$

Species	A	B	n	r^2	s^2
Red alder	-7.6156	2.6243	53	0.63	2.7976
Giant chinkapin	-5.1476	2.3038	30	.88	.4917
Bigleaf maple	-6.4918	2.5033	16	.78	.7131
Pacific madrone	-503224	2.2936	31	.88	.4932
Tanoak	-5.1792	2.0374	31	.75	.8375

Note: dw = ovendry weiyht of dead branchwood weiyht (kg), d=diameter at breast height (cm), s^2 = mean square error of the residuals.

Table 37 — Regression equations for estimating cumulative fractions (f(i)) of live crown component weights for red alder, giant chinkapin, bigleaf maple, Pacific madrone, and tanoak

$$f(i)=1/(A + B\ (d)^{C})$$

Fraction	A	B	C	n	s^2	Condition
			RED ALDER			
f(1)	2.7638	0.0620	1.3364	53	0.0006	None
f(2)	1.2860	.0288	1.3525	53	.0026	None
f(3)	.8847	.0131	1.3021	53	.0057	If d < 5.3 f(3)=1
f(4)	.9550	.0002	1.9736	41	.0077	If d < 15.6 f(4)=1
			GIANT CHINKAPIN			
f(1)	1.6048	.2979	.6828	30	.0008	None
f(2)	1.0700	.1239	.7637	30	.0020	None
f(3)	.7312	.0965	.6118	30	.0034	If d < 5.3 f(3)= 1
f(4)	.9669	.0012	1.1786	22	.0010	If d < 16.7 f(4)= 1
			BIGLEAF MAPLE			
f(1)	4.6762	.0163	2.0390	16	.0005	None
f(2)	3.3212	.0115	2.0496	16	.0009	None
f(3)	.9341	.0021	2.1627	16	.0137	If d < 4.9 f(3)=1
f(4)	.8625	.0019	1.7070	15	.0092	If d < 12.3 f(4)=1
			PACIFIC MADRONE			
f(1)	1.6013	.1060	1.3090	31	.0045	None
f(2)	1.0357	.0639	1.3567	31	.0115	None
f(3)	1.0281	.0011	2.1850	30	.0118	None
f(4)	.8778	.0025	1.6394	27	.0132	If d < 10.7 f(4)=1
			TANOAK			
f(1)	1.7936	.3031	.7239	31	.0013	None
f(2)	.9940	.2303	.6520	31	.0034	None
f(3)	.8759	.0446	.7843	31	.0061	If d < 3.7 f(3)=1
f(4)						f(4)=1.0 for all d

Note:
f(i) = cumulative fraction for the i^{th} component,
f(1) = fraction of leaf weight,
f(2) = f(1) + (fraction of 0 to 0.62 cm in diameter live branchwood);
f(3) = f(1) + (fraction of 0 to 2.53 cm in diameter live branchwood);
f(4) = f(1) + (fraction of 0 to 7.61 cm in diameter live branchwood);
d = diameter at breast height (cm); and
s^2 = mean square error of residuals.

Table 38 — Regression equations for estimating cumulative fractions (df(i)) of dead crown components for red alder, giant chinkapin, bigleaf maple, Pacific madrone, and tanoak

Fraction	n	r^2	s^2	Conditions
RED ALDER				
$\ln(df(1)) = -0.6880 - 0.0603(d)$	52	0.43	1.3243	None
$\ln(df(2)) = 0.02134 - 0.0342(d)$	48	.47	.3574	If $d < 6.2$ $df(2) = 1$
$\ln(df(3)) = 0.3473 - 0.0124(d)$	30	.34	.0512	If $d < 28.0$ $df(3) = 1$
GIANT CHINKAPIN				
$\ln(df(1)) = -0.7695 - 0.0326(d)$	30	.60	.1737	None
$\ln(df(2)) = 0.2022 - 0.0222(d)$	29	.72	.0469	If $d < 9.1$ $df(2) = 1$
$\ln(df(3)) = 0.1352 - 0.0063(d)$	19	.28	.0226	If $d < 21.5$ $df(3) = 1$
BIGLEAF MAPLE				
$\ln(df(1)) = -1.0444 - 0.0745(d)$	16	.51	.7589	None
$\ln(df(2)) = 0.0553 - 0.0260(d)$	15	.53	.0767	If $d < 2.1$ $df(2) = 1$
$\ln(df(3)) = 0.0083 - 0.0013(d)$	12	.03	.0064	If $d < 6.4$ $df(3) = 1$
PACIFIC MADRONE				
$df(1) = 0.3707 + 0.5714(d)^{0.25} - 0.4655(\ln(d))$	31	.56	.0187	If $d < 0.9$ $df(1) = 1$
$df(2) = 1.2671 - 0.1058(d)^{0.5}$	30	.49	.0321	If $d < 6.4$ $df(2) = 1$
$df(3) = \exp(0.0281 - 7.306 \times 10^{-5}(d)^2)$	20	.34	.0127	If $d < 19.7$ $df(3) = 1$
TANOAK				
$df(1) = -0.2985 + 0.6087(d)^{0.25} - 0.4730(\ln(d))$	31	.54	.0156	If $d < 0.8$ $df(1) = 1$
$df(2) = \exp(-2.810 + 3.469(d)^{0.25} - 1.061(d)^{0.5})$	31	.81	.0464	If $d < 10.3$ $df(2) = 1$
$df(3) = 1.027 - 0.001354(d)$	18	.16	.0023	If $d < 20.0$ $df(3) = 1$

Note:
df(i) = cumulative fraction for the i^{th} component;
df(1) = fraction of 0 to 0.62 cm in diameter dead branchwood;
df(2) = fraction of 0 to 2.53 cm in diameter dead branchwood;
df(3) = fraction of 0 to 7.61 cm in diameter dead branchwood;
d = diameter at breast height (cm); and
s^2 = mean square error of residuals.

Table 39 — Regression equations for estimating total bole volume inside bark for red alder, giant chinkapin, bigleaf maple, Pacific madrone, and tanoak

$$\ln(v) = A + B \ln(d)$$

Species	A	B	n	r^2	s^2
Red alder	-8.8272	2.4999	53	0.98	0.0708
Giant chinkapin	-9.1304	2.5169	30	.99	.0310
Bigleaf maple	-8.4397	2.3050	16	.97	.5530
Pacific madrone	-8.5385	2.2969	31	.97	.1036
Tanoak	-9.1707	2.5010	31	.98	.0738

Note:
v = total bole volume (m^3);
d = diameter at breast height (cm); and
s^2 = mean square error of residuals.

Table 40 — Regression equations for estimating the ratio of bole volume below a specified top diameter for red alder, giant chinkapin, bigleaf maple, Pacific madrone, and tanoak

$$R=1+(A(t^B)(d^C))$$

Species	A	B	C	n	s^2
Red alder	-0.3565	3.465	-3.269	258	0.000828
Giant chinkapin	-.3002	3.642	-3.406	133	.000744
Bigleaf maple	-.3993	2.348	-2.276	74	.002014
Pacific madrone	-.1588	2.951	-2.512	127	.001032
Tanoak	-.1861	3.038	-2.603	137	.001407

Note:
R = the fraction of bole volume below a specified top diameter;
t = specified top diameter (cm);
d = diameter at breast height (cm); and
s^2 = mean square error of residuals.

Snell, J.A. Kendall; Little, Susan N. Predicting crown weight and bole volume of five western hardwoods. Gen. Tech,. Rep. PNW-151. Portland, OR: Forest Service, Pacific Northwest Forest and Range Experiment Station; 1983. 37 p.

Regression equations are presented for estimating biomass of five western hardwoods: red alder ***(Alnus rubra*** Bong.), giant chinkapin ***(Castanopsis chrysophylla*** (Dougl.) A. DC.), bigleaf maple ***(Acer macrophyllum*** Pursh), Pacific madrone ***(Arbutus rnenziesii*** Pursh), and tanoak ***(Lithocarpus densiflorus*** (Hook. & Arn.) Rehd.). Estimators are given for total crown biomass, cumulative proportions for separating crown weight into foliage and four timelag fuel diameter classes, bark weight, and bole volume (inside bark) to any specified top diameter. With one exception, the equations use diameter at breast height as the only independent variable.

Keywords: Crown weights, volume (log), volume determination methods, hardwoods, biomass.

The Forest Service of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.

Pacific Northwest Forest and Range
Experiment Station
809 N.E. Sixth Avenue
P.O. Box 3890
Portland, Oregon 97208

GPO 997-501