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VOLUME AND TAPER RELATIONSHIPS FOR REDWOOD, DOUGLAS FIR, AND OTHER CONIFERS IN THE NORTH COAST OF CALIFORNIA

by

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I. Introduction

This report contains the results of a comprehensive analysis of mensurational relationships among major coniferous species in the North Coast Region of California. These species are redwoods, Douglas fir, and other whitewoods (lowland white fir, sitka spruce, and western hemlock). This latter group, hereafter referred to as whitewoods, was treated as a composite due to data limitations and the relatively minor importance these species have in commercial forest management in the region.

This analysis was performed on a large data set thought to be representative of the kinds of conifers typical to the crop components of young growth stands being managed in the region. In other words, old growth and severely suppressed trees and trees with broken or deformed tops or other abnormalities were purposely excluded from consideration. The volume component of this study is based on gross scale with no allowance for defect or breakage other than merchantable top specifications.

As a preliminary caution, it should be emphasized that the relationships presented in this report are intended to be representative of broad regional conditions. Local tests of reliability should be made before general usage.

Although most of this paper presumes that English units are being used, metric conversion factors are also given so that these results can be easily converted when the need arises.

II. Variable Definitions

The following is a list of variables and definitions that are used consistently throughout this report. They are presented here for quick reference and to alleviate the need of continuous repetition of variable definition.

DBH — Diameter outside bark 4.5 feet above the ground on the uphill side of the tree in inches.

dbh — Diameter inside bark 4.5 feet above the ground on the uphill side of the tree in inches.

D_i — Diameter outside bark in inches at a point "i" on the tree bole.

d_i — Diameter inside bark in inches at a point "i" on the tree bole.

h_i — Distance in feet from the ground to a point "i" on the tree bole.

b_r	bark ratio at breast height (4.5 feet) dbh = b_r(DBH)
GF	Girrards form class (GF = d_i/DBH X 100 where d_i is evaluated at 17.3 feet.)
DIA_i	General diameter term -- definition depends on the context.
H	General measure of tree height in feet.
H_t	Total tree height in feet.
H_m	Height to the merchantable top in feet.
H_l	Height to the merchantable top in units of 16.3 feet (log height).
S	Stump height in feet.
d_s	diameter inside bark at the stump.
D_s	diameter outside bark at the stump.
exp(X)	2.7128 raised to the power of X
ln(X)	Natural logarithm of X
$S_{y.x}$	Standard deviation of the residuals about the regression of "Y" on "X".

III. DATA SOURCES

The data used to develop the relationships presented in this report have been assimilated from four main sources.

A. U.C. Dendrometry

The University's Barr and Stroud optical dendrometer, model FP 15, was used to take measurements of bole height and outside bark stem diameters at selected points along tree stems.

Sampling was performed during the summer of 1975 on lands belonging to members of the Redwood Yield Research Cooperative. Tree selection was "semi-random". A loose criterion was adopted to select trees between 3-50 inches DBH over the range of conditions encountered on the properties sampled with the following restrictions:

a. Trees on the edges of road cuts were not measured unless the roads were recently constructed.

b. Trees were not selected in stands composed of residual old growth or in stands where there was evidence that the trees present developed as an understory of old-growth stands.

c. Trees were not selected if they were severely suppressed, had broken tops or possessed other abnormalities that would make them unlikely candidates as crop trees in managed young growth stands.

B. Palley Data

The majority of trees used by Palley (1959, 1961) for the previous redwood volume tables were retained after screening for this study. These trees were fall, buck, and scale (FBS) data. Measurements included DBH_o, total height, stump height and diameter, and inside and outside bark diameters on each 16-foot log.

C. USDA - 1900 Data

The United States Department of Agriculture carried out a comprehensive stem analysis project on young growth redwood sprouts around 1900. Sampling was performed in second growth stands in Del Norte, Humboldt, and northern Mendocino counties. The records of over 1000 trees are on file at the University. Approximately 200 dominant, intermediate, and codominant tree records were utilized in the present study.

D. Cooperator Data

Simpson Timber Company and Georgia Pacific Corporation of the Redwood Research Cooperative donated the FBS records of several hundred trees for use in this study.

Appendix B contains a breakdown of the numbers of trees by diameter and height classes for each species group. Also included are tables showing average form class by diameter and total height.

IV. SECONDARY RELATIONSHIPS

The basic set of measurements on each tree needed for volume and taper analysis consists of a sequential series of inside bark diameters and log lengths from a specified stump height to the tree tip. As the available data had been collected by a variety of field procedures, it was necessary to develop several estimators to make minor adjustments on the measurements of some trees so the entire data set would be in a compatible form.

A. Stump Diameter Estimators

In situations where the actual stump height was not coincident with nominal stump height used in this study, the following nonlinear model was used to estimate the stump diameter inside bark (d_s).

$$d_s = (1 - b_0X)(DIA_i)\exp(b_1(h_i - S)) \qquad (1)$$

where DIA_i is the measured diameter inside or outside bark at a height h_i. "X" is an indicator variable equal to "0" if DIA_i is inside bark and "1" if it is outside bark. Coefficient estimates and a statistical summary are shown in Table 1.

An approximately equal number of inside and outside bark measurements were used as observations. h_i ranged from .5 to 4.5 feet. Extrapolation outside these limits is not recommended. It should be noted that this model assumes bark ratios remain constant over short bole segments. As sufficient data were unavailable for other whitewoods, Douglas fir coefficients were used for this species group also.

Table 1

Coefficient estimates by species for the stump diameter model

Species	b_o	b_1	R^2	$S_{y.x}$	Sample Size
Douglas Fir	.097	.038	.95	1.76	403
Redwood	.153	.035	.97	1.48	591

B. Bark Ratio at Breast Height Estimators

Bark ratios (b_r) were estimated with the following model:

$$dbh = (b_r)(DBH) \qquad (2)$$

Estimates and a statistical summary are shown in Table 2.

Table 2

Bark ratio estimates and statistical summary

Species	b_r	R^2	Sample Size
Redwood	.85	.98	688
Douglas Fir	.91	.99	362
Whitewoods	.95	.99	160

C. Stump Height Estimators

In situations where stump height is unknown but stump diameter inside bark (d_s) and another diameter (DIA_i) at a known height (h_i) has been measured, solving equation (3) for "S" provides a logical form for a nonlinear stump height estimator.

$$S = c_1[\ln(d_s) - \ln(1-c_0X) - \ln(DIA_i)] + h_i \qquad (3)$$

All variable definitions in this model are the same as in equation 1. The coefficients (c_0,c_1) could be numerically derived from b_0 and b_1 in equation 1 if there was no statistical error. However, the coefficients, because of this error, were reestimated by nonlinear least squares and are shown in Table 3.

Table 3

Coefficient estimates and statistical summary for the stump height model

Species	c_o	c_1	R^2	$S_{y.x}$ (feet)	Sample Size
Redwood	.308	-16.88	.93	1.1	571
Douglas Fir	.206	-20.20	.91	1.3	403

D. Tip Estimators

In situations where the length of the tree stem from the last buck to the tree tip is not measured, it can be estimated with the models

$$TIP_i = b_0(d_i)^{b_1}(DBH)^{b_2} \qquad (4)$$

or

$$TIP_i = b_0(D_i)^{b_1}(DBH)^{b_2} \qquad (5)$$

where TIP_i is the length of the tree bole from the known diameter, d_i or D_i, to the tree top.

Tables 4 and 5 give coefficient estimates and a statistical summary. The sample basis used in developing these equations did not utilize top diameters in excess of 14 inches.

Table 4

Tip model -- diameter inside bark (d_i) coefficients and summary

Species	b_o	b_1	b_2	$S_{y.x}$ (ft)	R^2	Sample Size
Redwood	8.1	1.05	-.27	7.52	.80	601
Douglas Fir	7.39	1.03	-.24	4.25	.78	143

Table 5

Tip model -- diameter outside bark (D_i) coefficients and summary

Species	b_o	b_1	b_2	$S_{y.x}$	R^2	Sample Size
Redwood	6.7	1.08	-.26	6.98	.82	619
Douglas Fir	6.8	.99	-.19	3.94	.79	161

E. Bark Taper Estimators

Dendrometry measurements were converted to outside bark measurements at various heights on standing trees. To convert these measurements to diameters inside bark, a bark taper model was developed.

Douglas fir

There was not enough data available in the sample set to estimate coefficients in a bark taper model for Douglas fir. Consequently, the model developed by Johnson (1966) for Douglas fir in the Pacific Northwest was considered the next best alternative. This model is

$$d_i/D_i = .559 + .00006h_i + .203(D_i/DBH) - .1542(D_i/DBH)^2 + .3413\ (d_s/D_s) \quad (6)$$

This model was also used for other whitewoods.

Redwood

Three observations, each consisting of height from the ground (h_i), diameter inside bark (d_i) and outside bark (D_i), at randomly selected points on 172 redwood trees were used to develop a redwood bark taper model. The following model, fitted by nonlinear least squares, was found to give the best statistical fit as well as providing a logical and consistent functional form.

$$d_i/D_i = dbh/DBH + .38(1.-dbh/DBH)x\ (1. -exp(-.06(h_i - 4.5))) \quad (7)$$

Total Observations = 521

$R^2 = .12$

$Sy.x = .035$

Both coefficients and the overall model were statistically significant at the .01 level. The low precision is partly due to measurements being rounded to the nearest tenth inch and the form of the independent variable (d_i/D_i). Premultiplying both sides of the expression by D_i and refitting produced an R^2 value of .93 without any real increase in explanatory power.

V. Volume Equations

The volume equations developed for each species group in this study are of two general types:

Type I V = f(DBH,H)

Type II V = f(DBH,H,GF)

For each equation type and species group, twenty-four equations[17] were estimated by using combinations of the following items:

1. The specifications used here for the volume equations are those recommended by the Advisory Panel of the Redwood Yield Cooperative.

1. Volume types - two volume definitions were used: Scribner board foot and cubic feet[2/].

2. Height - three definitions of height were used: total height (H_t), merchantable height (H_m) and log height (H_l).

3. Merchantable top - volumes were computed to four inside bark top diameter limits -- 8, 7, 6, and 5 inches.

A. Scaling Procedures

Volumes for each tree were computed from stump height to the merchantable top limit. As the actual measurements on each tree were not all at even log multiples, some means of interpolation was necessary. The best procedure was found to be fitting a system of several third order polynomials to the actual measurements on each tree (see Akima, 1970). The basic result of this process was to provide the numerical equivalent of a free-hand curve drawn through the stem profile conditioned to pass through every measured point. This equation system was then utilized to "buck" the trees into standard lengths and produce interpolated diameters.

B. Board foot scale

Board foot scale was based on a 1.0 foot stump height, a nominal log length of 16 feet, and a trim allowance of .3 feet. Board foot volumes of each log were computed by the following equation (Bruce and Schumacher, 1950)

$$BV = .79(DIA)^2 - 2DIA - 4$$

where DIA is the diameter inside bark at the small end of the log.

Based on general scaling practices in the region, the following procedure was used when the top log was not an even multiple of 16.3 feet. If the length was less than 8 feet, the piece was appended to the next lower log which was subsequently scaled as a "long" log. If it was between 8 and 16.3 feet, the piece was appended to the next lower log which was subsequently split in half and scaled as two "short" logs.

It should be noted that largely due to the viscissitudes of the Scribner log rule, reducing the top merchantability diameter frequently resulted in an overall decrease in the board foot scale for specific trees. While no formal

2. Volumes in cubic meters are obtained using the cubic foot equations and metric conversion factors. See section V.F on metric units.

analysis was performed, the general impression gained during data analysis was that a top diameter of 6 to 7 inches would produce the maximum overall board foot scale obtainable with the scaling procedures employed in this study.

An end result of this phenomena is that the volume equations developed in this report are not guaranteed to estimate more board foot volume as the merchantable top diameter decreases, particularly since this is not what happens in practice!

C. Cubic foot scale

The local taper equation developed for each tree was used to estimate inside bark diameters at one foot intervals from the stump to the merchantable top. Smalian's formula was applied to each one foot segment to compute volumes.

D. Functional Relationships and Statistical Procedures

The functional form of the volume equations fitted were

Type 1 $V = b_o(DBH)^{b_1}H^{b_2}$

Type 2 $V = b_o(DBH)^{b_1}H^{b_2}GF^{b_3}$

For each volume equation case, data were transformed by taking natural logarithms and parameters were subsequently estimated by linear least squares regression. The constant term (b_o) was exponentiated to convert the equation to the natural number scale. A synopsis and statistical summary for each fitted equation is displayed in Appendix A.

Experience has shown that fitting volume equations by the logarithmic procedure provides consistent and logical estimators as well as satisfying the usual assumptions of regression (see Wensel, 1973). The major objection is that a negative bias is introduced by this procedure and volume estimates should be multiplied by a correction factor to provide "theoretically" consistent estimates. This factor is equal to

$$\exp(.5MSE)$$

where MSE is the mean squared residual of the respective volume equation in logarithmic units (Baskerville, 1972). This factor (.2 to 2 percent) is usually much smaller than the statistical error (6 to 22 percent) of the volume equations, and for most purposes, can be ignored. These bias corrections are also shown in Appendix A.

E. Reliability and Adjustments to Local Conditions

The volume tables essentially give "average" volumes for trees of a given DBH and height. These volumes are subject to two sources of statistical error when used for an individual tree: (1) an error associated with estimating the "true" population volume relationship from samples. This source of error can be reduced by taking more samples. (2) An error associated with random deviations about the "true" population volume relationship. This source of error may be reduced by adding additional explanatory variables (e.g., form class).

As with all regional volume tables, there is a possibility that stands of trees in specific localities may depart from the general relationships shown in these tables. Also, where scaling practices differ from the ones used in this study an additional source of bias may be introduced. Hence, field checks should be made before local use.

The following procedures are suggested to check the accuracy of volume tables at the 95% probability level.

1. Specify the accuracy level desired for the estimate of tree volume, on the average, for the stand being sampled.

2. Determine from Table 6 the number of sample trees required. Sample sizes were computed with the aid of the well known sample size formula.

$$n = t^2(CV)^2/A^2$$

where:

n = number of sample trees

t = student's "t" value corresponding to the number of sample trees and the confidence level being used

CV = coefficient of variation expressed as a decimal

A = accuracy level expressed as a decimal

Table 6

Sample trees required for 95% confidence intervals of various levels of accuracy for tree volumes.

Accuracy (%)	Cubic Feet	Board Feet
10	9	16
8	14	25
6	25	44
4	56	100
2	225	400
Assumed Coefficient of Variation (%)	15	20

3. Once the sample size is chosen, trees should be selected for volume measurement that are representative of the trees for which volume estimates are desired. Each sample tree is measured for DBH, total height and volume. Volume can be obtained with a Relaskop, dendrometer, or by scaling felled trees. Volumes of sample trees should be determined by the same procedures used in actual scaling operations.

4. Compute the percent difference between the measured volumes and those estimated by the volume tables for each sample tree. Then compute the average percent difference for all sample trees.

5. If the absolute value of the average percent difference, $|\bar{P}|$, is less than the accuracy level, use the tables without adjustment.

6. If the $|\bar{P}|$ is greater than the accuracy level and there are no trends in the percent deviations over size classes, multiply estimated volumes by the factor

$$F = (1+\bar{P}/100)$$

7. Percent deviations sometimes show trends with estimated volume or DBH in which case regression adjustments may be utilized. For example, if the percentage volume deviation of the sample varies with DBH in a linear fashion, the following correction factor may be used:

$$F_{D_i} = [1+(\bar{P}+b(D_i-\bar{D}))/100]$$

where

F_{D_i} = correction factor for a tree of D_i inches

$\overline{D}$ = average DBH of volume sample trees

b = regression constant computed from the volume sample

$$= \frac{\Sigma P_j D_j - n\overline{PD}}{\Sigma D_i^2 - n\overline{D}^2}$$

n = number of sample trees

P_j = Percent deviation of the jth tree in the volume sample

D_j = DBH of the jth tree in the volume sample

If more refined estimates or different confidence levels are desired, coefficients of variation derived from Appendix A for each species-volume group can be utilized in conjunction with the familiar sample size formula.

8. As an example, suppose 8 percent accuracy levels were desired at the 95 percent probability level. A redwood cubic volume check yielded the following data:

Sample Tree No.	DBH (inches)	Total Height (feet)	Volumes from Tables (cubic feet)	Volumes Scaled (cubic feet)	Percent Difference (percent)
1	12	60	14	14.8	+5.7
2	12	70	16	17.1	+6.8
3	12	90	21	22.8	+4.8
4	18	90	46	49.4	+7.4
5	20	130	82	88.3	+7.5
6	22	110	84	91.7	+9.2
7	28	100	123	134.2	+9.1
8	28	130	160	175.5	+9.7
9	30	120	169	185.9	10.0
10	34	130	234	260.4	11.3
11	36	130	262	290.8	11.0
12	36	140	282	314.4	11.5
13	44	160	477	538.0	12.8
14	44	160	477	540.9	13.4
Averages	26.86				+9.3

In this example $\overline{P} = 9.3$ is greater than the 8 percent accuracy requirement and may be used to compute the correction factor

$$F = 1 + 9.3/100 = 1.093$$

There is also a trend in the percentage difference which increases with DBH. In this case, a regression correction factor that varies with DBH will be more precise. The regression coefficient "b" for the correction factor F_{D_i} is computed as

$$b = \frac{[(5.7)(12) + (6.8)(12) + \ldots (13.4)(44) - 14\,(9.3)(26.86)]}{[12^2 + 12^2 + \ldots 44^2 - 14(26.86)^2]}$$

$$= 0.227$$

The correction is then

$$F_{D_i} = 1 + (9.3 + .227\ (D_i - 26.8))/100]$$

$$= 1.093 + .00227(D_i - 26.8)$$

For a 44 inch tree, the volume estimate from the table would be adjusted upward by the factor

$$F_{44} = 1.093 + .00227(44 - 26.8)$$

$$= 1.132$$

Adjusted Volume = 1.132 x 477 = 540 cubic feet

F. Metric Units

Each of the equations presented in this report presumes that English units are being used. In the case where metric units are used for one or more of the measurements, the volume equations are altered as follows:

Measurement Units DBH	Height	Volume Desired	Conversion(C)
inches	feet	$(feet)^3$	none
inches	feet	$(meters)^3$	c_3
cm	meters	$(feet)^3$	$(c_1^{-b_1})(c_2^{-b_2})$
cm	meters	$(meters)^3$	$(c_1^{-b_1})(c_2^{-b_2})c_3$

where: c_1 = 2.54 inches/cm

c_2 = 0.3048 ft/meter

c_3 = 0.0283168 m^3/ft^3

b_1, b_2 = coefficients of the volume equation used.

These conversion factors can be used in several ways. First, if desired, measurements of D and H can be converted using the terms c_1 and c_2 respectively. Alternatively, the appropriate composite conversions, C, can be used to convert the final volume. Desired volume is obtained by multiplying the calculated volume from the volume equation times the appropriate conversion factor above.

VI. CONIFER TAPER MODELS

Taper models estimate diameter inside bark at various heights on tree boles when only DBH and some measure of tree height are observed. Taper models are used for two principle purposes.

1. Estimation of the dimensions of upper stem portions for defect adjustment in cruising.

2. Estimation of the log size mix potentially available from standing trees.

A. Model Criteria

Taper models are conventionally required to have several properties:

1. If total height is an access variable, the model should predict a diameter inside bark of 0 at the tree tip. Similarly, if merchantable height is used, the equation should predict the top merchantable inside bark diameter at the merchantable height.

2. Predictions of stump or breast high diameters should equal actual measurements at these points. While these values are not conventionally recorded in the field, the taper model should be structured so predicted inside bark diameters can be forced through logical values of these points if necessary.

3. Predictions derived from these equations should be always positive, always decrease with increases in bole height, and be relatively unbiased at various points on the tree bole.

B. Model Development

Experimentation with several possible functional forms led to the following model which is based on the modified inverse of a general sigmoidal equation. This model was found to satisfy the previous criteria and has the general form:

$$d_i = c_o D - Df_1 \ln[1-R^{c_1}(1-\exp(c_o/f_1 - d_m/(Df_1)))]$$

Where:

d_i = d.i.b. in inches at a point "i" on the tree bole

D = DBH

h_i = height in feet from ground to a point i on the tree bole

H = general measure of tree height in feet

$R = (h_i-1.)/(H-1.)$

d_m = merchantable top diameter inside bark corresponding to the point where $h_i = H$

$f_1 = c_2 + c_3D + c_4H$

c_i = parameters estimated by regression methods.

This model is conditioned so that the predicted diameter inside bark will equal 0 when $h_i = H$. If H is total height, d_m is 0, and the predicted diameter will be 0 at the tree tip. Similarly, if H is the height to a merchantable top of say 5.0 inches, d_m is 5.0 inches and the prediction will be conditioned to predict 5.0 inches d.i.b. when h_i = H.

Six taper equations were developed with H being defined as height from the ground to an 8,5, and 0 inch (tree tip)

top d.i.b. for redwood and Douglas fir. The models were fitted by nonlinear least squares. Two to three sample points on suitable trees used in the previously described volume analysis were randomly chosen for equation fitting. Coefficient estimates and a statistical summary are shown in Table 7.

C. Model Interpretation and Discussion

The coefficient c_0 is interpreted as the ratio of d.i.b. at a 1.0 foot stump to DBH. The fitted coefficients were almost numerically equal to simple ratio estimators based on the same data set so constraining the model was not considered necessary. The term f_1 for the taper models were chosen after considerable experimentation in attempts to account for general differences in taper between trees in different diameter and height classes. Table 8 gives average bias (average difference between actual and predicted values) by relative height for all six taper equations. In general, these biases are small and quite acceptable for the general level of precision usually required in estimating upper bole diameters.

Table 7

Taper Model Coefficients and Statistical Summary

	REDWOOD			DOUGLAS FIR		
	Merchantable Tops					
	0.0"	5.0"	8.0"	0.0"	5.0"	8.0"
c_0	.955	.956	.955	1.008	1.016	1.024
c_1	.387	.346	.326	.415	.320	.276
c_2	-.362	-.247	-.211	-.275	-.169	-.142
c_3	-.00581	-.00666	-.00542	-.00770	-.00539	-.00364
c_4	.00122	.00116	.000847	.000640	.000178	.000108
R^2	.902	.962	.967	.974	.978	.975
$S_{y.x}$	1.28"	1.19"	1.14"	.97"	.81"	.82"
Sample Size	1238	1217	1164	671	631	574

Table 8

Bias of conifer taper equations at various point on the sample tree boles.

	REDWOOD			DOUGLAS FIR		
	Equation top diameter			Equation top diameter		
	0.0	5.0	8.0	0.0	5.0	8.0
	Bias in Inches					
Stump	.13	.01	-.03	.22	.10	.03
DBH	-.16	.01	.09	-.15	.03	.05
$h_{.17}$	-.22	-.20	-.22	-.20	-.10	-.10
$h_{.33}$	.30	.17	.03	.25	.07	.10
$h_{.5}$	.30	-.04	.07	.35	.17	.05
$h_{.67}$	-.06	-.03	.08	.11	-.14	-.00
$h_{.85}$	-.34	.06	.26	-.54	-.04	.00
top	0.0	0.0	0.0	0.0	0.0	0.0

$h_{.xx}$ refers to a bole height equal to xx% of total height.

Positive table values indicate predictions are low.

VII. VOLUME EQUATION VERSUS TAPER BASED VOLUME ESTIMATES

The coefficients in Appendix A can be used to estimate gross volume directly in standing trees. The taper equations can also be used to obtain indirect estimates of gross volume. Essentially, the taper equation is used to estimate inside bark diameters at the places on the tree bole where it is to be "bucked" into lengths. These lengths are then scaled using predicted inside bark diameters, and summed to estimate total volume. Mathematical integration of the taper function is impossible so this numerical technique is required.

It should be emphasized that the taper equations were developed to predict inside bark bole diameters, not tree

volume. Hence, their adequacy in volume estimation cannot be judged by conventional statistics. Regardless, the following ad hoc comparisons were made.

A. Comparisons

Diameters, total heights and scaled cubic volumes to a five inch top of the trees used in the taper analysis were utilized for comparative purposes. The coefficients from the appropriate total height-DBH cubic volume equation were used to directly predict volumes to a five inch top for these trees. The "total height" taper equations (H is defined as total height) have the greatest standard deviations and range in bias. Consequently, they were used for comparative purposes as a measure of the worst that could be done using taper equations to obtain volume estimates. These taper equations were used to predict inside bark diameters at one foot intervals on each tree from the stump to a five inch top. Smalian's formula was then used to compute volume of each segment which were then summed to give an indirect estimate of cubic volume. The following statistics were then computed for both redwood and Douglas fir;

1. Aggregate percentage difference

2. Average percentage difference

3. Root mean square percent deviation (RMSPD) computed as

$$RMSPD = (\Sigma((\hat{y}_i - y_i)/y_i)^2/n)^{\frac{1}{2}}$$

where

$\hat{y}_i$ = volume estimated by volume equation or taper equation for the ith sample tree

y_i = actual scaled volume of the ith sample tree

n = number of sample trees

These values are shown in Table 9 and are essentially a measure of how close predicted volumes are to actual scaled tree volumes used in the basic analysis. As indicators of lack of bias, average and aggregate percent differences should be close to zero. The RMSPD value is essentially an approximation to the standard deviation expressed as a percent. Comparisons of these values for the taper equation with those of the volume equation provides a measure of relative efficiency. Judging from table 9, there appears to be no bias in volume prediction from the taper equations

and RMSPD values are almost identical.

Table 9

Comparative statistics for judging differences between volume equation and taper equation based volume estimates.

	Redwood			Douglas fir		
	Average difference	Aggregate difference	RMSPD	Average difference	Aggregate difference	RMSPD
	---per cent---					
Volume equation	-.8	.8	15.3	.1	-1.2	11.5
Taper equation	-.2	1.9	15.1	.2	1.1	11.2

Positive percent differences indicate that the estimators are low compared to actual volumes.

To provide a measure of relative compatability between volume equations and taper-based volume estimates, ratios of estimates produced by both methods are shown for diameter and height classes of trees used in the taper analysis in tables 10 and 11. Except at the "edges" of the data set, there is remarkable agreement between the estimators considering no attempt was made to condition the taper equations.

B. Evaluation

In the course of this taper analysis several items were noted which are possible areas for refinement.

1. The taper equations are, overall, slightly low, judging by the aggregate difference. This is probably due to estimating d.i.b. rather than d.i.b. squared, which is proportional to volume. It is well known that the squared average of a sample is less than the average squared value unless all of the diameters are the same.

2. The rather simple expression of the term f_1 in the equation may not be totally adequate for describing taper differences between trees of different DBH and height.

3. The increases with height in the ratios of volume equations to taper based estimates is largely due to the data set being used. No significant trends indicating a lack of fit were detected in a comparison of both volume equations and taper estimates with actual scaled volumes. For Douglas fir, the difference is more pronounced and apparently due to a small and somewhat lopsided distribution of the sample trees.

We encourage the cooperators to review these taper equations prior to final publication.

In summary, volume equations produce simple and efficient estimates of gross tree volume. However, taper equations can be used to produce similar estimates although they are somewhat cumbersome. Taper equations are necessary when volumes by logs in individual trees are desired.

VIII. VOLUME TABLES

While the volume equations presented here are very useful for incorporation into inventory analysis programs, many foresters will want some of these volume equations turned into table form. The combinations of species groups (3), equation types (2), measurement units (3), and top diameters (4), would require 72 individual volume tables. When one considers the possible range of form classes of interest, the number of possible tables is even more formidable. Since any individual would only be interested in a few of these tables, no attempt is being made to publish all of these tables.

However, in Appendix C, 5.0 inch merchantable top board foot, cubic foot and cubic meter tables are given for each of the two species, Redwood and Douglas fir, by DBH and total height. A listing of the computer program used to produce these tables is available from the authors.

TABLE 10. Redwood -- Ratios of volume equation to taper based estimates of cubic volume from a 1.0 foot stump to a 5.0 inch top for DBH and Height classes of trees used in taper analysis.

DBH	TOTAL HEIGHT (FEET)																			
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
10				1.09																
12				1.02	1.05	1.07	1.08	1.12	1.06	1.07										
14				.97	1.01	1.01	1.03	1.03	1.03	1.03	1.02									
16					.96	.97	.99	1.01	1.01	1.01	1.01	1.00	1.00							
18							.98	.99	1.00	1.00	1.00	1.00	.99							
20							.97	.98	.99	1.00	1.00	1.00	.99	.98	.98					
22								.98	.99	.99	1.00	1.00	.99	.99	.97	.96	.94			
24						.94		.97	.99	.99	1.00	1.00	1.00	.99	.98	.97				
26							.96	.97	.99	.99	1.00	1.00	1.00	1.00	.99	.98	.97			
28								.98	.99	1.00	1.00	1.01	1.01	1.00	1.00	.99	.98	.97		
30										1.00	1.01	1.01	1.01	1.01	1.00	1.00	.99	.98	.97	
32										1.01	1.01	1.02	1.02	1.02	1.01	1.01	1.00	.99		
34									1.00	1.01	1.02	1.02	1.03	1.02	1.02	1.01	1.01			
36									1.00		1.02	1.03	1.03	1.03	1.03	1.02	1.02		1.01	
38														1.04	1.04	1.03		1.02	1.01	1.00
40													1.05					1.03	1.03	1.01
42																	1.05	1.04	1.04	1.01
44													1.06			1.06	1.06			1.04
46																1.07	1.06	1.06		1.05
48																1.08	1.07			
50																1.08				1.06
52																	1.10			
54																				
56																				
58																				
60																				

TABLE 11. Douglas fir -- Ratios of volume equation to taper based estimates of cubic volume from a 1.0 foot stump to a 5.0 inch top for DBH and Height classes of trees used in taper analysis.

DBH	TOTAL HEIGHT (FEET)																			
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
10							.99													
12					.86	.95		.99		1.04	1.06									
14							.91	.95	.99	1.02	1.03	1.05	1.08							
16								.92	.94	.97	1.00	1.01	1.03	1.06						
18									.90		.97	1.00	1.01	1.04	1.05					
20										.93	.96	.98	1.00	1.02	1.03	1.04		1.07		
22										.92	.95	.97	.99	1.01	1.02	1.04				
24										.90	.93	.96	.98	1.00	1.02	1.04	1.05	1.06		
26											.93	.95	.97	.99	1.01		1.04	1.06		
28									.87			.94		.98			1.04	1.05		
30													.97		1.00	1.02		1.06		
32															1.00	1.02	1.04	1.04	1.06	
34															.99	1.01	1.02	1.05		1.09
36															1.00			1.04	1.06	1.08
38																	1.03		1.06	
40																		1.04		
42																				
44																		1.04		
46																				
48																				
50																				1.07
52																				
54																				
56																				
58																				
60																				

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Appendix A

CONIFER TREE VOLUME EQUATIONS

This appendix contains tables of statistical summaries and coefficient estimates of conifer tree volume equations. Each table has six equation summaries: three board foot and three cubic foot each accessed by total height, merchantable height, or height in 16.3 foot logs. Stump height is assumed to be one foot and board foot volumes are based on Scribner scale with a nominal scaling length of 16 feet with a .3 foot trim allowance. Top diameters vary with each table. Table A1 provides a quick reference guide to table specifications.

(1) Types of Equations

Equations are of two types:

a) D-H. Diameter-height equations
b) D-H-GF. Diameter-height-form class equations

The form of diameter height equations is indicated in Fortran notation as:

```
V = BO(D**B1)(H**B2)
```

which in regular mathematical notation is

$$V = b_o D^{b_1} H^{b_2}$$

Similarly, the form class equations are in Fortran notation

```
V = BO(D**B1)(H**B2)(GF**B3)
```

which in standard notation is equivalent to

$$V = b_o D^{b_1} H^{b_2} GF^{b_3}$$

(2) Exponential Notation

The coefficient estimates are given to 4 significant digits in exponential notation. As examples:

$$.5639E-03 = .5639 \times 10^{-3} = .0005639$$

$$.5639E+02 = .5639 \times 10^{2} = 56.39$$

(3) Standard Deviations

a) Logarithmic (LN UNITS) - Standard deviations of residuals are reported in natural logarithmic (base 'e') units.

b) Normal Units (PERCENT) - Standard deviations are also reported as a percentage of predicted volumes. This value is also the coefficient of variation.

(4) Adjustment for Logarithmic Bias (LN BIAS)

This value is a multiplicative adjustment, usually negligable, that can be used to correct the volume equations for any inherent bias resulting from the logarithmic transformations in the equation fitting process.

(5) Percent Average Deviation (AVE DEV PERCENT)

This value is the average percent deviation of actual versus predicted values of the sample used in fitting the respective equation.

(6) Percent Aggregate Difference (AGG DIFF PERCENT)

This value is the percent difference of the total actual volume of sample trees versus predicted. Negative values indicate the equations are low, positive values indicate the equations are high.

TABLE A1

Quick Reference Guide to Conifer Volume Equations

Table No.	Species	Volume to Top d.i.b. (inches)	Equation Type
1	Redwood	8	D-H
2	Redwood	8	D-H-GF
3	Redwood	7	D-H
4	Redwood	7	D-H-GF
5	Redwood	6	D-H
6	Redwood	6	D-H-GF
7	Redwood	5	D-H
8	Redwood	5	D-H-GF
9	Douglas Fir	8	D-H
10	Douglas Fir	8	D-H-GF
11	Douglas Fir	7	D-H
12	Douglas Fir	7	D-H-GF
13	Douglas Fir	6	D-H
14	Douglas Fir	6	D-H-GF
15	Douglas Fir	5	D-H
16	Douglas Fir	5	D-H-GF
17	Whitewoods	8	D-H
18	Whitewoods	8	D-H-GF
19	Whitewoods	7	D-H
20	Whitewoods	7	D-H-GF
21	Whitewoods	6	D-H
22	Whitewoods	6	D-H-GF
23	Whitewoods	5	D-H
24	Whitewoods	5	D-H-GF

TABLE 1 GROSS VOLUME TABLES FOR REDWOOD

TYPE=D-H

SAMPLE SIZE= 847

1.0 FOOT STUMP TO 8.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)

WHERE

D=DIAMETER OUTSIDE BARK AT 4.5 FEET

H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.205	22.73	.956	1.021	16.010	.646	1.4702E-03	2.2120E+01	1.1527E+01
H=MERCH HEIGHT	.158	16.20	.977	1.011	11.895	3.258	1.1741E-01	1.1487E+01	1.1297E+01
H=LOG HEIGHT							1.6505E+00	1.1487E+01	1.1297E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.170	18.48	.963	1.014	13.200	.383	1.4241E-03	1.1935E+01	1.1044E+01
H=MERCH HEIGHT	.122	12.92	.981	1.007	9.125	2.188	1.8100E-02	1.1457E+01	1.1092E+01
H=LOG HEIGHT							1.1572E+00	1.1485E+01	1.1069E+01

TABLE 2 GROSS VOLUME TABLES FOR REDWOOD

TYPE=D H-GF
SAMPLE SIZE= 847

1.0 FOOT STUMP TO 8.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)(GF**B3)
WHERE
D=DIAMETER OUTSIDE BARK AT 4.5 FEET
H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW
GF=GIRARD'S FORM CLASS (SEE TEXT)

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.122	12.94	.985	1.007	9.417	-1.420	.1836E-06	.2208E+01	.1151E+01	.2182E+01
H=MERCH HEIGHT	.070	7.24	.995	1.002	5.309	1.133	.1070E-04	.1773E+01	.9882E+00	.1823E+01
H=LOG HEIGHT							.1688E-03	.1773E+01	.9882E+00	.1823E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.165	11.02	.986	1.005	7.869	-1.012	.7342E-05	.2083E+01	.9452E+00	.1768E+01
H=MERCH HEIGHT	.059	6.07	.996	1.002	4.194	.750	.2189E-04	.1714E+01	.8221E+00	.1458E+01
H=LOG HEIGHT							.2139E-03	.1714E+01	.8221E+00	.1458E+01

TABLE 3 GROSS VOLUME TABLES FOR REDWOOD

1.0 FOOT STUMP TO 7.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)

WHERE

D=DIAMETER OUTSIDE BARK AT 4.5 FEET

H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.284	22.61	.962	1.021	15.825	.261	.4900E-03	.2002E+01	.1632E+01
H=MERCH HEIGHT	.154	16.69	.978	1.012	12.864	2.998	.1033E-01	.1560E+01	.1345E+01
H=LOG HEIGHT							.4407E+00	.1560E+01	.1345E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.162	17.61	.968	1.013	12.617	.549	.5501E-02	.1672E+01	.1572E+01
H=MERCH HEIGHT	.126	13.48	.981	1.008	9.875	2.340	.6951E-02	.1528E+01	.1063E+01
H=LOG HEIGHT							.1224E+00	.1528E+01	.1063E+01

TABLE 4 GROSS VOLUME TABLES FOR REDWOOD

TYPE=D-H-GF
SAMPLE SIZE = 963

1.0 FOOT STUMP TO 7.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)(GF**B3)
WHERE
D=DIAMETER OUTSIDE BARK AT 4.5 FEET
H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--
GF=GIRARD'S FORM CLASS (SEE TEXT)

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.122	13.03	.986	1.008	9.288	-1.682	.2030E-06	.2190E+01	.1176E+01	.2146E+01
H=MERCH HEIGHT	.073	7.60	.995	1.003	5.558	.857	.6825E-05	.1827E+01	.1022E+01	.1839E+01
H=LOG HEIGHT							.1183E-03	.1827E+01	.1022E+01	.1839E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.097	10.22	.989	1.005	7.345	-.704	.1233E-05	.2021E+01	.9360E+00	.1710E+01
H=MERCH HEIGHT	.064	6.57	.995	1.002	4.584	.919	.1926E-04	.1743E+01	.8035E+00	.1479E+01
H=LOG HEIGHT							.1787E-03	.1743E+01	.8035E+00	.1479E+01

TABLE 5 GROSS VOLUME TABLES FOR REDWOOD TYPE=D-H

1.0 FOOT STUMP TO 6.0 INCHES TOP D.I.B. SAMPLE SIZE: [illegible]

EQUATION: V = B0(D**B1)(H**B2)

WHERE

D=DIAMETER OUTSIDE BARK AT 4.5 FEET

H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.201	22.31	.969	1.020	15.718	-.333	1.3570E-03	1.2012E+01	1.1664E+01
H=MERCH HEIGHT	.161	17.53	.980	1.013	12.688	2.878	1.6162E-02	1.1641E+01	1.1385E+01
H=LOG HEIGHT							1.2940E+00	1.1641E+01	1.1385E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.155	16.01	.975	1.012	12.146	.598	1.6605E-03	1.1833E+01	1.1290E+01
H=MERCH HEIGHT	.130	13.93	.982	1.009	10.171	2.580	1.6088E-02	1.1560E+01	1.1060E+01
H=LOG HEIGHT							1.1150E+00	1.1560E+01	1.1060E+01

TABLE 6 GROSS VOLUME TABLES FOR REDWOOD

TYPE=D-H-GF
SAMPLE SIZE= 884

1.0 FOOT STUMP TO 6.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)(GF**B3)
WHERE
D=DIAMETER OUTSIDE BARK AT 4.5 FEET
H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW -
GF=GIRARD'S FORM CLASS (SEE TEXT)

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.123	13.04	.989	1.000	9.279	-2.214	1.1986E-06	.2203E+01	1.2048E+01	.7110E+01
H=MERCH HEIGHT	.080	8.37	.995	1.003	6.091	.574	1.3823E-05	1.1897E+01	1.1049E+01	1.1000E+01
H=LOG HEIGHT							1.7144E-04	1.1897E+01	1.1049E+01	1.1000E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.092	9.63	.991	1.004	6.955	-.561	1.1856E-05	1.1983E+01	1.9291E+01	1.1654E+01
H=MERCH HEIGHT	.067	6.96	.995	1.002	4.893	1.101	1.1679E-04	1.1764E+01	1.7918E+01	1.1500E+01
H=LOG HEIGHT							1.1509E-03	1.1764E+01	1.7918E+01	1.1500E+01

TABLE 7 GROSS VOLUME TABLES FOR PERUNDOS TYPE=P-H

SAMPLE SIZE= 900

1.0 FOOT STUMP TO 5.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)

WHERE

D=DIAMETER OUTSIDE BARK AT 4.5 FEET

H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

BOARD FOOT VOLUMES—STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN DIAS	AVE DEV (PERCENT)	AVG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.216	24.10	.971	1.024	16.000	-2.099	.1675E-03	.2076E+01	.1775E+01
H=MERCH HEIGHT	.170	18.45	.962	1.015	13.343	1.257	.2909E-02	.1694E+01	.1540E+01
H=LOG HEIGHT							.1225E+00	.1694E+01	.1540E+01

CUBIC FOOT VOLUMES—STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN DIAS	AVE DEV (PERCENT)	AVG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.149	16.00	.979	1.014	11.789	.835	.2902E-03	.1792E+01	.1279E+01
H=MERCH HEIGHT	.132	14.16	.984	1.009	10.827	2.683	.5005E-02	.1596E+01	.1068E+01
H=LOG HEIGHT							.9670E-01	.1596E+01	.1068E+01

TABLE 8 GROSS VOLUME TABLES FOR REDWOOD

TYPE=D-H-G
SAMPLE SIZE= 980

1.0 FOOT STUMP TO 5.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)(GF**B3)
WHERE
D=DIAMETER OUTSIDE BARK AT 4.5 FEET
H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW
GF=GIRARD'S FORM CLASS (SEE TEXT)

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.136	14.62	.989	1.009	10.218	-3.759	.8725E-07	1.2221E+01	1.1985E+01	1.2197E+01
H=MERCH HEIGHT	.092	9.67	.995	1.004	6.914	-.849	.1563E-05	1.1942E+01	1.1170E+01	1.1912E+01
H=LOG HEIGHT							.4095E-04	1.1942E+01	1.1170E+01	1.1912E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.084	8.72	.993	1.003	6.432	-.060	.2731E-05	1.1937E+01	1.0998E+01	1.1023E+01
H=MERCH HEIGHT	.072	7.46	.995	1.003	5.320	1.368	.1679E-04	1.1789E+01	1.0751E+01	1.1[illegible]E+01
H=LOG HEIGHT							.1440E-03	1.1789E+01	1.0751E+01	1.1[illegible]E+01

TABLE 3 GROSS VOLUME TABLES FOR DOUGLAS FIR TYPE-D-H

1.0 FOOT STUMP TO 6.0 INCHES TOP D.I.B. (WORKS 5-1) 220

EQUATION: V = B0(D**B1)(H**B2)
WHERE
D=DIAMETER OUTSIDE BARK AT 4.5 FEET
H=HEIGHT IN FEET OF NUMBER OF LOGS--SEE BELOW--

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN DIAG	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.154	16.79	.967	1.012	11.491	-1.153	1.1067E-02	1.1753E+01	1.1506E+01
H=TERCH HEIGHT	.108	11.47	.984	1.006	8.243	1.236	1.2058E-01	1.1525E+01	1.1171E+01
H=LOG HEIGHT							1.2903E+00	1.1529E+01	1.1177E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN DIAG	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.131	14.05	.971	1.009	9.818	-.836	1.7104E-03	1.1703E+01	1.1379E+01
H=TERCH HEIGHT	.091	9.48	.986	1.004	6.375	.915	1.1212E-01	1.1475E+01	1.1011E+01
H=LOG HEIGHT							1.2810E+00	1.1475E+01	1.1011E+01

TABLE 10 GROSS VOLUME TABLES FOR DOUGLAS FIR

TYPE=D-H-GF

SAMPLE SIZE= 720

1.0 FOOT STUMP TO 8.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)(GF**B3)

WHERE

D=DIAMETER OUTSIDE BARK AT 4.5 FEET

H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

GF=GIRARD'S FORM CLASS (SEE TEXT)

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.105	11.16	.985	1.006	7.821	-1.615	1.2884E-06	1.2888E+01	1.1260E+01	1.2040E+01
H=MERCH HEIGHT	.062	6.38	.995	1.002	4.624	.581	1.2101E-04	1.1820E+01	1.9651E+00	1.1662E+01
H=LOG HEIGHT							1.3108E-03	1.1820E+01	1.9651E+00	1.1662E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.089	9.34	.987	1.004	6.290	-1.161	1.6164E-06	1.1957E+01	1.1030E+01	1.1755E+01
H=MERCH HEIGHT	.049	5.05	.996	1.001	3.563	.456	1.2464E-04	1.1725E+01	1.0292E+00	1.1422E+01
H=LOG HEIGHT							1.2455E-03	1.1725E+01	1.0292E+00	1.1422E+01

TABLE 11 GROSS VOLUME TABLES FOR DOUGLAS FIR TYPE=D-H

SAMPLE SIZE= 221

1.0 FOOT STUMP TO 7.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)

WHERE

D=DIAMETER OUTSIDE BARK AT 4.5 FEET

H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.153	16.55	.968	1.012	11.509	-1.304	.1028E-02	.1772E+01	.1631E+01
H=MERCH HEIGHT	.114	12.88	.983	1.007	8.743	.934	.1813E-01	.1577E+01	.1237E+01
H=LOG HEIGHT							.5730E+00	.1577E+01	.1237E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.122	12.94	.975	1.007	9.153	-.551	.1022E-02	.1664E+01	.1633E+01
H=MERCH HEIGHT	.094	9.84	.985	1.004	7.162	.960	.1089E-01	.1515E+01	.9997E+00
H=LOG HEIGHT							.1741E+00	.1515E+01	.9997E+00

TABLE 12 GROSS VOLUME TABLES FOR DOUGLAS FIR TYPE-D-H-GF

SAMPLE SIZE= [illegible]

1.0 FOOT STUMP TO 7.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)(GF**B3)

WHERE

D=DIAMETER OUTSIDE BARK AT 4.5 FEET

H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

GF=GIRARD'S FORM CLASS (SEE TEXT)

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.102	10.76	.986	1.005	7.414	-1.732	1.2493E-06	1.2068E+01	1.1277E+01	1.2076E+01
H=MERCH HEIGHT	.063	6.48	.995	1.002	4.835	.289	1.8869E-05	1.1868E+01	1.1006E+01	1.1770E+01
H=LOG HEIGHT							1.1471E-03	1.1868E+01	1.1006E+01	1.1770E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.079	8.26	.989	1.003	5.629	-.810	1.1216E-05	1.1994E+01	1.1047E+01	1.1688E+01
H=MERCH HEIGHT	.052	5.35	.995	1.001	3.855	.529	1.2111E-04	1.1754E+01	1.8104E+00	1.1450E+01
H=LOG HEIGHT							1.1997E-03	1.1754E+01	1.8104E+00	1.1450E+01

TABLE 43 GROSS VOLUME TABLES FOR DOUGLAS FIR TYPE=D-H

1.0 FOOT STUMP TO 6.0 INCHES TOP D.I.B. SAMPLE SIZE= 224

EQUATION: V = B0(D**B1)(H**B2)
WHERE
D=DIAMETER OUTSIDE BARK AT 4.5 FEET
H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.164	17.80	.971	1.014	12.411	-2.414	.4968E-03	.1725E+01	.1009E+01
H=MERCH HEIGHT	.124	13.19	.983	1.008	9.413	.419	.9228E-02	.1585E+01	.1363E+01
H=LOG HEIGHT							.4144E+00	.1585E+01	.1363E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.117	12.36	.980	1.007	8.979	-.703	.9947E-03	.1625E+01	.1366E+01
H=MERCH HEIGHT	.095	10.01	.986	1.005	7.350	.969	.9413E-02	.1540E+01	.1006E+01
H=LOG HEIGHT							.1533E+00	.1540E+01	.1006E+01

TABLE 14 GROSS VOLUME TABLES FOR DOUGLAS FIR TYPE=D-H-G

SAMPLE SIZE= 224

1.0 FOOT STUMP TO 6.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)(GF**B3)

WHERE

D=DIAMETER OUTSIDE BARK AT 4.5 FEET

H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

GF=GIRARD'S FORM CLASS (SEE TEXT)

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.107	11.24	.988	1.006	8.889	-2.539	.7919E-07	1.2051E+01	1.1300E+01	1.2235E+01
H=MERCH HEIGHT	.071	7.39	.994	1.003	5.432	-.099	.3426E-05	1.1893E+01	1.1084E+01	1.1374E+01
H=LOG HEIGHT							.7065E-04	1.1892E+01	1.1084E+01	1.1374E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.072	7.42	.992	1.003	5.302	-.725	.1551E-05	1.1866E+01	1.1049E+01	1.1452E+01
H=MERCH HEIGHT	.056	5.76	.995	1.002	4.198	.672	.2281E-04	1.1775E+01	1.0938E+01	1.1328E+01
H=LOG HEIGHT							.2061E-03	1.1775E+01	1.0938E+01	1.1328E+01

TABLE 15 GROSS VOLUME TABLES FOR DOUGLAS FIR TYPE=D-H

1.0 FOOT STUMP TO 5.0 INCHES TOP D.I.B. SAMPLE SIZE 271

EQUATION: V = B0(D**B1)(H**B2)

WHERE

D=DIAMETER OUTSIDE BARK AT 4.5 FEET

H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.197	21.76	.974	1.020	14.773	-5.243	.1584E-03	.1732E+01	.2037E+01
H=MERCH HEIGHT	.130	13.91	.988	1.009	10.069	-.758	.3960E-02	.1602E+01	.1518E+01
H=LOG HEIGHT							.2737E+00	.1602E+01	.1518E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.119	12.61	.985	1.007	9.031	-1.141	.7938E-03	.1590E+01	.1436E+01
H=MERCH HEIGHT	.098	10.26	.990	1.005	7.426	1.850	.8295E-02	.1556E+01	.1015E+01
H=LOG HEIGHT							.1383E+00	.1556E+01	.1015E+01

TABLE 16 GROSS VOLUME TABLES FOR DOUGLAS FIR TYPE=D H-GF

1.0 FOOT STUMP TO 5.0 INCHES TOP D.I.B. SAMPLE SIZE= 231

EQUATION: V = B0(D**B1)(H**B2)(GF**B3)

WHERE

D=DIAMETER OUTSIDE BARK AT 4.5 FEET

H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

GF=GIRARD'S FORM CLASS (SEE TEXT)

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.124	13.19	.990	1.008	9.440	-4.034	.1302E-07	.2126E+01	.1393E+01	.2562E+01
H=MERCH HEIGHT	.076	7.89	.996	1.003	5.978	-.784	.1826E-05	.1939E+01	.1148E+01	.1904E+01
H-LOG HEIGHT							.4503E-04	.1939E+01	.1148E+01	.1904E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.067	6.93	.995	1.002	5.103	-.402	.1988E-05	.1843E+01	.1053E+01	.1642E+01
H=MERCH HEIGHT	.063	6.51	.996	1.002	4.774	1.052	.3712E-04	.1794E+01	.7548E+00	.1341E+01
H=LOG HEIGHT							.3010E-03	.1794E+01	.7548E+00	.1341E+01

TABLE 17 GROSS VOLUME TABLES FOR WHITEWOODS

TYPE=D-H
SAMPLE SIZE= 68

1.0 FOOT STUMP TO 8.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)
WHERE
D=DIAMETER OUTSIDE BARK AT 4.5 FEET
H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.188	20.65	.971	1.018	14.592	-.637	1.1061E-03	1.1754E+01	1.2113E+01
H=MERCH HEIGHT	.123	13.14	.988	1.008	9.743	1.746	1.2190E-01	1.1476E+01	1.1283E+01
H=LOG HEIGHT							1.7860E+00	1.1476E+01	1.1283E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.174	19.03	.969	1.015	13.038	-.514	1.1273E-03	1.1702E+01	1.1736E+01
H=MERCH HEIGHT	.107	11.28	.988	1.006	8.610	1.130	1.1001E-01	1.1440E+01	1.1081E+01
H=LOG HEIGHT							1.2006E+00	1.1440E+01	1.1081E+01

TABLE 10 GROSS VOLUME TABLES FOR WHITEWOODS TYPE=D-H-GF

SAMPLE SIZE= 68

1.0 FOOT STUMP TO 8.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)(GF**B3)

WHERE

D=DIAMETER OUTSIDE BARK AT 4.5 FEET

H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

GF=GIRARD'S FORM CLASS (SEE TEXT)

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.116	12.35	.989	1.007	9.553	-.905	1.9473E-08	.2052E+01	1.1523E+01	.2563E+01
H=MERCH HEIGHT	.085	8.82	.994	1.004	6.530	1.284	1.1465E-04	1.1760E+01	1.1017E+01	1.1736E+01
H=LOG HEIGHT							1.2501E-03	1.1760E+01	1.1017E+01	1.1736E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.115	12.21	.987	1.007	8.709	-.721	1.3196E-07	.1967E+01	1.1212E+01	1.2279E+01
H=MERCH HEIGHT	.074	7.64	.995	1.003	5.693	.802	1.1849E-04	.1684E+01	1.8521E+00	1.1495E+01
H=LOG HEIGHT							1.1964E-03	1.1684E+01	1.8521E+00	1.1495E+01

TABLE 19 GROSS VOLUME TABLES FOR WHITEWOODS TYPE=D-H

SAMPLE SIZE= 71

1.0 FOOT STUMP TO 7.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)

WHERE

D=DIAMETER OUTSIDE BARK AT 4.5 FEET

H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.186	20.41	.978	1.017	14.341	-.211	.1479E-03	.1759E+01	.2041E+01
H=MERCH HEIGHT	.140	15.00	.988	1.010	11.095	1.991	.1269E-01	.1522E+01	.1354E+01
H=LOG HEIGHT							.5560E+00	.1522E+01	.1354E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.154	16.61	.990	1.012	11.813	.070	.2973E-03	.1683E+01	.1584E+01
H=MERCH HEIGHT	.114	12.12	.989	1.007	9.146	1.496	.9043E-02	.1489E+01	.1059E+01
H=LOG HEIGHT							.1705E+00	.1489E+01	.1059E+01

TABLE 20 GROSS VOLUME TABLES FOR WHITEWOODS TYPE=D-H-GF

SAMPLE SIZE= 71

1.0 FOOT STUMP TO 7.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)(GF**B3)

WHERE

D=DIAMETER OUTSIDE BARK AT 4.5 FEET

H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

GF=GIRARD'S FORM CLASS (SEE TEXT)

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.126	13.39	.990	1.008	9.521	-.481	.2891E-07	.2067E+01	.1457E+01	.2371E+01
H=MERCH HEIGHT	.093	9.71	.995	1.004	7.168	1.345	.4562E-05	.1831E+01	.1038E+01	.1901E+01
H=LOG HEIGHT							.8602E-04	.1831E+01	.1038E+01	.1901E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.114	12.05	.989	1.006	8.213	-.048	.4445E-06	.1917E+01	.1141E+01	.1797E+01
H=MERCH HEIGHT	.085	9.02	.994	1.004	6.579	1.138	.2892E-04	.1714E+01	.8280E+00	.1389E+01
H=LOG HEIGHT							.2872E-03	.1714E+01	.8280E+00	.1389E+01

TABLE 21 GROSS VOLUME TABLES FOR WHITEWOODS TYPE=D-H

1.0 FOOT STUMP TO 6.0 INCHES TOP D.I.B. SAMPLE SIZE= 73

EQUATION: V = B0(D**B1)(H**B2)

WHERE

D=DIAMETER OUTSIDE BARK AT 4.5 FEET

H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.185	20.30	.982	1.017	14.634	-1.169	1.9457E-04	1.1767E+01	1.2128E+01
H=MERCH HEIGHT	.150	16.23	.988	1.011	11.806	2.816	1.6646E-02	1.1511E+01	1.1488E+01
H=LOG HEIGHT							1.4231E+00	1.1511E+01	1.1488E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.152	16.47	.983	1.012	11.551	-.128	1.3902E-07	1.1709E+01	1.1502E+01
H=MERCH HEIGHT	.116	12.35	.990	1.007	9.316	1.746	1.7863E-02	1.1500E+01	1.1074E+01
H=LOG HEIGHT							1.1546E+00	1.1500E+01	1.1074E+01

TABLE 22 GROSS VOLUME TABLES FOR WHITEWOODS

TYPE-D-H-GF
SAMPLE SIZE= 73

1.0 FOOT STUMP TO 6.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)(GF**B3)
WHERE
D=DIAMETER OUTSIDE BARK AT 4.5 FEET
H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--
GF=GIRARD'S FORM CLASS (SEE TEXT)

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.122	12.94	.992	1.007	8.925	-1.645	.1588E-07	.2071E+01	.1571E+01	.2380E+01
H=MERCH HEIGHT	.096	10.07	.995	1.005	7.538	.974	.1472E-07	.1635E+01	.1146E+01	.2043E+01
H=LOG HEIGHT							.3622E-04	.1835E+01	.1148E+01	.2043E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.113	11.97	.991	1.006	8.806	-.367	.6777E-06	.1931E+01	.1094E+01	.1746E+01
H=MERCH HEIGHT	.094	8.81	.995	1.004	6.548	1.188	.2267E-04	.1725E+01	.8375E+00	.1420E+01
H=LOG HEIGHT							.2312E-03	.1725E+01	.8375E+00	.1420E+01

TABLE 23 GROSS VOLUME TABLES FOR WHITEWOODS TYPE-D-H

1.0 FOOT STUMP TO 5.0 INCHES TOP D.I.B. SAMPLE SIZE- 76

EQUATION: V = B0(D**B1)(H**B2)

WHERE

D=DIAMETER OUTSIDE BARK AT 4.5 FEET

H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.217	24.23	.980	1.024	17.212	-2.071	.5157E-04	1.1864E+01	1.2070E+01
H=MERCH HEIGHT	.173	18.94	.987	1.015	13.476	1.102	.3088E-02	1.1594E+01	1.1580E+01
H=LOG HEIGHT							1.2540E+00	1.1594E+01	1.1580E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2
H=TOTAL HEIGHT	.136	14.59	.989	1.009	10.685	.436	.5621E-03	1.1648E+01	1.1473E+01
H=MERCH HEIGHT	.128	13.69	.989	1.008	10.058	2.188	.7219E-02	1.1582E+01	1.1082E+01
H=LOG HEIGHT							1.1458E+00	1.1582E+01	1.1082E+01

TABLE 24 GROSS VOLUME TABLES FOR WHITEWOODS TYPE=D-H-GF

SAMPLE SIZE= 76

1.8 FOOT STUMP TO 5.0 INCHES TOP D.I.B.

EQUATION: V = B0(D**B1)(H**B2)(GF**B3)

WHERE

D=DIAMETER OUTSIDE BARK AT 4.5 FEET

H=HEIGHT IN FEET OR NUMBER OF LOGS--SEE BELOW--

GF=GIRARD'S FORM CLASS (SEE TEXT)

BOARD FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.157	16.90	.990	1.012	11.795	-2.558	.1536E-07	.2232E+01	.1407E+01	.2450E+01
H=MERCH HEIGHT	.118	12.57	.994	1.007	8.793	-.022	.6724E-06	.1971E+01	.1158E+01	.2100E+01
H=LOG HEIGHT							.1702E-04	.1971E+01	.1158E+01	.2100E+01

CUBIC FOOT VOLUMES--STATISTICAL SUMMARY

	STANDARD DEVIATION (LN UNITS)	STANDARD DEVIATION (PERCENT)	R**2	LN BIAS	AVE DEV (PERCENT)	AGG DIFF (PERCENT)	B0	B1	B2	B3
H=TOTAL HEIGHT	.100	10.54	.994	1.005	7.554	.281	.2690E-05	.1874E+01	.1066E+01	.1506E+01
H=MERCH HEIGHT	.096	10.11	.994	1.005	7.536	1.608	.2515E-04	.1755E+01	.7986E+00	.1410E+01
H=LOG HEIGHT							.2303E-03	.1755E+01	.7986E+00	.1410E+01

Appendix B

Distributions of Sample Trees

I. Numbers by height and diameter class by species

II. Average form class by height and diameter class by species.

TABLE B1. NUMBERS OF SAMPLE TREES BY TOTAL HEIGHT AND DBH FOR REDWOOD

DBH	TOTAL HEIGHT (FEET)																			
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
10				18	9	14	2	1												
12				1	7	12	4	1	1	1										
14				1	2	9	14	9	7	5	2									
16					4	6	10	13	11	7	13	3	2							
18							7	14	12	16	16	12	2							
20							6	11	9	21	18	18	9	2	1					
22								6	12	14	27	14	21	10	4	1	1			
24						1		4	4	14	33	26	18	10	2	3				
26							2	5	5	14	28	13	23	14	3	4	2			
28								4	4	16	22	27	15	18	4	2	1	2		
30								.	2	1	18	19	24	13	12	6	3	2	1	
32							1		1	5	8	17	21	12	8	8	3	1		
34									1	3	6	15	13	9	9	5	7			
36								1	3		4	5	7	4	9	3	2		2	
38										1	1	2	4	5	5	2	1	1	1	1
40												1	3		2	2		2	2	1
42													1	2	1	3	3	3	2	2
44													1		2	1	4			1
46											1		1	1	1	2	1	1		2
48														1		2	1			
50												1				1				1
52																	1			
54													1				1			
56														1		1				
58																				
60																1				

TABLE 12. AVERAGE FORM CLASS BY DBH AND HEIGHT CLASS FOR REDWOOD

DBH	TOTAL HEIGHT (FEET)																			
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
10				61	70	71	70	75												
12				53	67	68	72	75	70	92										
14				51	71	69	70	73	72	74	80									
16					61	65	69	72	75	77	74	79	80							
18							72	68	75	73	73	75	76							
20							69	70	70	71	74	75	77	80	81					
22								70	70	73	74	73	75	75	84	79	85			
24						61		65	74	70	73	74	74	78	81	81				
26							68	72	71	72	72	72	74	76	81	80	82			
28								67	73	70	72	75	72	77	74	81	85	87		
30									72	76	72	72	75	76	78	75	73	90	76	
32							82		70	69	70	73	72	77	77	77	79	84		
34									73	72	73	71	72	75	76	75	76			
36								71	68		71	76	73	78	75	79	79		79	
38										74	68	71	74	74	71	74	85	79	70	76
40												73	74		74	81		76	83	74
42													76	66	70	72	74	79	82	84
44													49		74	82	72			77
46											62		71	67	74	74	83	73		78
48														72		76	82			
50												59				75				74
52																	86			
54													60				70			
56														66		68				
58																				
60																68				

TABLE B3. NUMBERS OF SAMPLE TREES BY TOTAL HEIGHT AND DBH FOR DOUGLAS FIR

DBH	TOTAL HEIGHT (FEET)																			
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
10				5	4	4	3	2												
12					1	1		1		2	2									
14							1	3	2	7	4	5	2							
16								1	1	3	4	9	4	2						
18									3		4	9	13	5	1					
20									1	3	5	12	16	11	8	1		1		
22										1	6	8	9	12	4	3				
24										4	6	7	6	12	4	1	2	1		
26											1	8	4	5	9	2	2	1		
28									2		2	3	2	4	3	2	3	1		
30										1		1	2	3	6	1		1		
32											2	1	4		3	4	3		2	
34												1		1	3	1	2	1		1
36														1	2	1	1	1	1	2
38													2				1		1	
40																1		4		
42																2	1	1		
44																	1	2		
46																		1		
48																			2	
50																				1
52																				
54																				
56																				
58																				
60																				

TABLE 84. AVERAGE FORM CLASS BY DBH AND HEIGHT CLASS FOR DOUGLAS FIR

DBH	TOTAL HEIGHT (FEET)																			
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
10				66	69	80	82	84												
12					66	74		79		90	93									
14							80	84	83	79	80	85	88							
16								71	85	77	85	82	86	85						
18									81		80	81	83	84	85					
20									77	81	77	84	82	81	83	90		83		
22										76	82	79	82	82	81	81				
24										69	78	74	83	79	81	74	81	76		
26											80	78	80	80	83	78	87	76		
28									77		78	79	81	83	76	80	79	78		
30										76		73	80	80	79	86		80		
32											72	74	73		79	79	83	82	81	
34												65		81	80	76	71	81		91
36														80	77	78	79	74	89	84
38													65				77		84	
40																81		81		
42																81	83	81		
44																	75	72		
46																		81		
48																			84	
50																				78
52																				
54																				
56																				
58																				
60																				

TABLE B5. NUMBERS OF SAMPLE TREES BY TOTAL HEIGHT AND DBH FOR WHITEWOODS

DBH	TOTAL HEIGHT (FEET)																			
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
10				1	3	2	2													
12				1	1		2			1										
14								1		1	1									
16						1	1		1	1		2	1	1						
18								1		2		1								
20										1	1	1								
22										1	1	1		3	1					
24											3		4				1			
26											1	1	1	2			1			
28												1	2	.		3				
30											1	1		.	1					
32															1		1	1		
34														2	2					
36																1				
38																				
40														1						
42													1			1				
44																				
46																				
48																				
50																				
52																				
54																				
56																				
58																				
60																				

TABLE 86. AVERAGE FORM CLASS BY DBH AND HEIGHT CLASS FOR WHITEWOODS

DBH	TOTAL HEIGHT (FEET)																			
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
10				60	75	80	83													
12				63	68		69			86										
14								75		83	81									
16						77	72		71	75		85	85	83						
18								75		79		83								
20										80	83	81								
22										80	80	84		81	87					
24											78		81				89			
26											77	82	80	83			74			
28												87	82	79		83				
30											82	79		73	77					
32															84		84	69		
34														75	78					
36																78				
38																				
40														68						
42													79			83				
44																				
46																				
48																				
50																				
52																				
54																				
56																				
58																				
60																				

Appendix C

Tree Volume Tables

TABLE C1 REDWOOD

GROSS CUBIC FOOT VOLUME TABLE
VOLUME FROM 1. FOOT STUMP TO 5. INCH TOP (INSIDE BARK)

DBH (INCHES)	TOTAL HEIGHT(FEET) 20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
10	2	4	6	7	9	11	13	16	18	20	23	25	28	30	33	35	38	41	44
12	3	5	8	10	13	16	19	22	25	28	31	35	38	42	45	49	53	57	60
14	4	7	10	13	17	21	25	29	33	37	41	46	50	55	60	65	70	75	80
16	5	9	13	17	22	26	31	36	42	47	53	58	64	70	76	82	88	95	101
18	7	11	16	21	27	33	39	45	51	58	65	72	79	86	94	102	109	117	125
20	8	13	19	26	32	39	47	54	62	70	78	87	96	104	113	123	132	141	151
22	9	16	23	30	38	47	55	64	74	83	93	103	113	124	135	145	156	168	179
24	11	18	27	35	45	54	65	75	86	97	109	121	133	145	157	170	183	196	209
26	13	21	31	41	52	63	75	87	99	112	126	139	153	167	182	196	211	226	242
28	14	24	35	47	59	72	85	99	113	128	143	159	175	191	207	224	241	258	276
30	16	27	40	53	67	81	96	112	128	145	162	180	198	216	235	254	273	292	312
32	18	31	45	59	75	91	108	126	144	163	182	202	222	242	263	285	306	328	351
34	20	34	50	66	83	102	121	140	161	182	203	225	247	270	294	317	341	366	391
36	23	38	55	73	92	113	134	156	178	201	225	249	274	299	325	352	378	405	433
38	25	42	61	81	102	124	147	171	196	222	248	275	302	330	358	387	417	447	477
40	27	46	66	88	112	136	162	188	215	243	272	301	331	362	393	425	457	490	523
42	30	50	72	97	122	149	176	205	235	265	296	328	361	395	429	463	499	534	571
44	32	54	79	105	133	161	192	223	255	288	322	357	393	429	466	504	542	581	620
46	35	59	85	114	144	175	208	241	276	312	349	387	425	465	505	545	587	629	672
48	38	64	92	123	155	189	224	260	298	337	377	417	459	501	545	589	633	679	725
50	41	69	99	132	167	203	241	280	321	362	405	449	494	539	586	633	681	730	780

TABLE C2 REDWOOD

GROSS BOARD FOOT VOLUME TABLE

VOLUME FROM 1. FOOT STUMP TO 4. INCH TOP (INSIDE BARK)

DBH (INCHES)	TOTAL HEIGHT(FEET) 20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
10	4	9	15	22	30	40	51	63	76	90	105	121	138	156	175	195	216	238	261
12	6	13	21	32	44	58	73	91	109	130	151	175	200	226	252	282	313	345	378
14	8	17	29	43	60	79	100	124	149	177	207	239	273	308	346	386	427	471	516
16	11	23	38	57	78	103	131	162	196	232	271	313	357	404	454	506	560	617	676
18	14	29	49	72	100	131	167	206	249	295	344	397	454	513	576	641	711	783	857
20	17	36	60	88	125	163	206	255	308	365	426	492	562	635	714	796	883	973	1065
22	21	43	72	108	150	197	250	309	373	443	517	597	681	771	865	963	1066	1172	1280
24	25	52	86	129	179	235	299	369	445	528	617	712	813	919	1032	1150	1274	1403	1538
26	29	61	102	151	210	277	351	434	523	621	725	837	956	1081	1214	1352	1497	1648	1801
28	34	71	119	176	243	321	408	504	608	721	843	973	1111	1256	1410	1572	1741	1918	2102
30	39	81	136	202	280	370	469	579	698	830	969	1119	1277	1445	1622	1808	2002	2205	2412
32	45	93	155	231	320	421	534	660	797	945	1105	1276	1456	1647	1848	2060	2282	2514	2756
34	51	105	175	261	361	476	605	747	901	1069	1249	1441	1646	1862	2090	2328	2580	2842	3113
36	57	117	196	293	405	535	679	838	1012	1200	1402	1618	1848	2091	2346	2615	2897	3191	3496
38	63	131	219	327	453	597	758	935	1129	1339	1565	1806	2062	2333	2618	2918	3232	3560	3902
40	70	145	244	363	502	662	841	1038	1253	1486	1736	2003	2287	2588	2905	3237	3586	3950	4329
42	78	160	270	400	553	731	928	1145	1383	1640	1917	2213	2526	2857	3206	3574	3959	4361	4780
44	85	175	295	436	603	795	1009	1245	1503	1782	2083	2403	2743	3103	3483	3883	4301	4738	5194
46	92	191	321	474	655	863	1095	1351	1631	1933	2259	2607	2976	3366	3777	4209	4661	5134	5626
48	100	210	352	521	720	948	1203	1484	1792	2124	2482	2864	3270	3698	4149	4624	5122	5642	6184
50	111	228	382	570	790	1040	1321	1631	1969	2335	2729	3149	3595	4067	4565	5088	5636	6209	6806

TABLE C3 REDWOOD

METRIC VOLUME TABLE
VOLUME FROM 1. FOOT STUMP TO 5. INCH TOP (INSIDE BARK)

DBH (INCHES)	TOTAL HEIGHT(FEET) 20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
	-VOLUME IN TENS OF CUBIC METERS-																		
10	1	1	2	2	3	3	4	4	5	6	6	7	8	9	9	10	11	12	13
12	1	2	2	3	4	4	5	6	7	8	9	10	11	12	13	14	15	16	17
14	1	2	3	4	5	6	7	8	9	10	12	13	14	16	17	18	20	21	23
16	1	3	4	5	6	7	9	10	12	13	15	17	18	20	22	23	25	27	29
18	2	3	4	6	8	9	11	13	15	16	18	20	22	24	27	29	31	33	35
20	2	4	5	7	9	11	13	15	18	20	22	25	27	30	32	35	37	40	43
22	3	4	6	9	11	13	16	18	21	24	26	29	32	35	38	41	44	48	51
24	3	5	8	10	13	15	18	21	24	28	31	34	38	41	45	48	52	56	59
26	4	6	9	12	15	18	21	25	28	32	36	39	43	47	51	56	60	64	68
28	4	7	10	13	17	20	24	28	32	36	41	45	49	54	59	63	68	73	78
30	5	8	11	15	19	23	27	32	36	41	46	51	56	61	66	72	77	83	88
32	5	9	13	17	21	26	31	36	41	46	52	57	63	69	75	81	87	93	99
34	6	10	14	19	24	29	34	40	46	51	58	64	70	77	83	90	97	104	111
36	6	11	16	21	26	32	38	44	50	57	64	71	78	85	92	100	107	115	123
38	7	12	17	23	29	35	42	49	56	63	70	78	86	93	102	110	118	127	135
40	8	13	19	25	32	39	46	53	61	69	77	85	94	102	111	120	129	139	148
42	8	14	21	27	35	42	50	58	66	75	84	93	102	112	121	131	141	151	162
44	9	15	22	30	38	46	54	63	72	82	91	101	111	122	132	143	154	165	176
46	10	17	24	32	41	50	59	68	78	88	99	110	120	132	143	155	166	178	190
48	11	18	26	35	44	53	63	74	84	95	107	118	130	142	154	167	179	192	205
50	12	19	28	37	47	58	68	79	91	103	115	127	140	153	166	179	193	207	221

TABLE C4 DOUGLAS FIR

GROSS CUBIC FOOT VOLUME TABLE
STUMPAGE PRICE: 1 FOOT STUMP TO 5. INCH TOP (BASIC BASE)

DBH (INCHES)	TOTAL HEIGHT (FEET) 20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
10	2	4	6	9	11	14	17	20	23	26	30	34	37	41	45	49	54	58	62
12	3	5	8	11	15	18	22	26	31	35	40	45	50	55	60	66	71	77	83
14	4	7	11	15	19	24	29	34	39	45	51	57	64	70	77	84	91	99	106
16	5	9	13	18	23	29	35	42	49	56	63	71	79	87	96	104	113	122	131
18	6	10	16	22	28	35	43	50	59	67	76	85	95	105	115	125	136	147	158
20	7	12	18	26	33	41	50	60	69	79	90	101	112	124	136	149	161	174	187
22	8	14	22	30	39	48	58	69	81	93	105	117	131	144	158	171	187	203	219
24	9	16	25	34	44	55	67	80	93	106	120	135	150	166	182	198	215	233	250
26	10	19	28	39	50	63	76	90	105	121	137	153	170	188	206	225	244	264	284
28	12	21	32	44	57	71	86	102	118	136	154	172	192	212	232	253	275	297	320
30	13	23	35	49	63	79	96	113	132	151	171	192	214	236	259	283	306	332	357
32	14	26	39	54	70	88	106	126	146	168	190	213	237	262	287	313	340	368	396
34	16	29	43	60	77	96	117	139	161	185	209	235	261	289	316	345	375	405	436
36	17	31	47	65	85	106	128	152	176	202	229	257	286	316	346	379	410	444	477
38	19	34	52	71	92	115	139	165	192	220	250	280	312	344	377	412	447	483	519
40	21	37	56	77	100	125	151	179	208	239	271	304	338	373	409	447	485	524	564
42	22	40	60	82	108	135	164	194	225	258	293	328	365	403	441	482	524	566	610
44	24	43	65	90	117	145	176	209	243	278	315	354	393	434	475	520	564	610	656
46	26	46	70	96	125	156	189	224	261	299	339	380	422	466	511	558	606	654	705
48	28	49	75	103	134	167	202	239	279	319	362	406	452	499	547	597	649	700	754
50	29	53	80	110	143	179	216	256	297	341	386	433	482	532	584	637	691	747	804

TABLE C5 DOUGLAS FIR

GROSS BOARD FOOT VOLUME TABLE
VOLUME FROM 1. FOOT STUMP TO 5. INCH TOP (INSIDE BARK)

DBH (INCHES)	TOTAL HEIGHT(FEET) 20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
10	4	9	16	25	36	49	64	82	101	123	147	172	201	231	263	298	335	374	415
12	5	12	21	34	49	67	88	112	139	168	201	237	275	317	361	409	459	512	567
14	7	16	28	44	64	88	115	146	181	220	262	309	359	413	472	534	599	669	743
16	9	20	35	56	81	110	145	184	228	277	331	389	453	521	594	672	755	843	934
18	11	24	43	68	99	135	178	226	280	340	406	477	555	639	729	825	926	1034	1148
20	13	29	52	82	119	162	213	271	336	408	487	573	666	767	875	990	1112	1241	1378
22	15	34	61	97	140	192	251	320	396	481	574	676	786	905	1032	1167	1311	1464	1625
24	17	40	71	112	163	223	292	372	460	559	668	786	914	1052	1199	1357	1525	1702	1890
26	20	46	82	129	187	256	336	427	529	642	767	903	1050	1208	1378	1559	1751	1955	2171
28	23	52	93	147	212	291	382	485	601	730	872	1026	1193	1374	1566	1772	1991	2223	2468
30	26	58	106	165	239	328	430	547	678	823	982	1156	1345	1548	1765	1997	2244	2505	2781
32	29	65	117	185	269	366	481	611	758	920	1097	1293	1504	1731	1974	2234	2509	2802	3110
34	32	72	130	205	297	407	534	679	842	1022	1220	1436	1670	1923	2193	2481	2787	3112	3454
36	35	80	144	226	328	449	590	750	929	1128	1347	1586	1844	2123	2421	2739	3077	3436	3814
38	38	88	158	249	361	494	648	823	1021	1239	1480	1742	2025	2331	2658	3008	3379	3773	4188
40	42	96	173	272	394	539	708	900	1115	1354	1617	1903	2214	2548	2905	3287	3693	4123	4577
42	46	104	188	296	429	587	770	979	1214	1474	1760	2071	2409	2772	3162	3577	4019	4487	4981
44	50	113	203	321	465	636	835	1061	1316	1597	1907	2245	2611	3005	3427	3877	4356	4864	5399
46	54	122	220	346	502	687	902	1146	1421	1725	2060	2425	2820	3245	3701	4186	4705	5253	5831
48	58	132	237	373	540	740	971	1234	1530	1857	2217	2610	3035	3494	3984	4508	5065	5654	6277
50	62	141	254	400	580	794	1042	1325	1642	1993	2380	2801	3258	3749	4276	4838	5436	6069	6737

TABLE 66 DOUGLAS FIR

METRIC VOLUME TABLE
VOLUME FROM 1. FOOT STUMP TO 5. INCH TOP (INSIDE BARK)

BOLE (INCHES)	TOTAL HEIGHT(FEET) 20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
	-VOLUME IN TENS OF CUBIC METERS-																		
10	1	1	2	2	3	4	5	6	7	7	8	9	11	12	13	14	15	16	18
12	1	2	2	3	4	5	6	7	9	10	11	13	14	16	17	19	20	22	24
14	1	2	3	4	5	7	8	10	11	13	14	16	18	20	22	24	26	28	30
16	1	2	4	5	7	8	10	12	14	16	18	20	22	25	27	29	32	35	37
18	2	3	4	6	8	10	12	14	17	19	22	24	27	30	33	36	39	42	45
20	2	3	5	7	9	12	14	17	20	22	25	29	32	35	39	42	46	49	53
22	2	4	6	8	11	14	17	20	23	26	30	33	37	41	45	49	53	57	62
24	3	5	7	10	13	16	19	23	26	30	34	39	42	47	51	56	61	66	71
26	3	5	8	11	14	18	22	26	30	34	39	43	48	53	58	64	69	75	81
28	3	6	9	12	16	20	24	29	33	38	43	49	54	60	66	72	78	84	91
30	4	7	10	14	18	22	27	32	37	43	49	54	61	67	73	80	87	94	101
32	4	7	11	15	20	25	30	36	41	47	54	60	67	74	81	89	96	104	112
34	5	8	12	17	22	27	33	39	46	52	59	66	74	82	90	98	106	115	123
36	5	9	13	18	24	30	36	43	50	57	65	73	81	89	98	107	116	125	135
38	5	10	15	20	26	33	39	47	54	62	71	79	88	97	107	117	127	137	147
40	6	10	16	22	28	35	43	51	59	68	77	86	96	106	116	126	137	148	160
42	6	11	17	24	31	38	46	55	64	73	83	93	103	114	125	137	148	160	173
44	7	12	18	25	33	41	50	59	69	79	89	100	111	123	135	147	160	173	186
46	7	13	20	27	35	44	54	63	74	85	96	107	120	132	145	158	171	185	199
48	8	14	21	29	38	47	57	68	79	90	102	115	129	141	155	169	183	198	213
50	8	15	23	31	41	50	61	72	84	97	109	123	136	151	165	180	196	212	228