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ABSTRACT

The computer program MULTI accepts basic field inventory data describing individual sample trees. It calculates gross board-foot and cubic-foot volume, grades or classifies for a number of specified primary products, adjusts gross volume for visual defect, and calculates standard error. Output tables indicate adjusted gross volume per acre, by grade and size class, for each product independently. An option allows allocation of volume between several products of a multiproduct combination following a specified order of preference.

MULTI was developed on a CDC 6400 computer system. It is written in FORTRAN Extended Language, and can use tape and/or disk storage. Although the program was developed for products and grading systems common to ponderosa pine (Pinus ponderosa Laws.), it is adaptable to other species, products, and grading systems.

Key Words: Multiproduct timber inventory, primary product evaluation (timber), forest surveys, product volume estimates, product volume adjustments, timber utilization.

Determining Timber Conversion Alternatives
Through Computer Analysis

by

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Timber Product Evaluation

To achieve the best physical and economic utilization of his timber resource, the manager of a diversified timber operation must be able to evaluate the potential of standing timber for a variety of primary products. He must also be able to estimate the effects of one utilization program upon resource availability or suitability for any other program or product mix. In the long run, the processor can try to establish the utilization program that makes best use of the available raw material. In the short run, however, he must generally choose between existing products and markets.

A method of evaluating standing timber for a variety of primary products has been described by Barger and Ffolliott (1970). Their system may be used with any valid sampling scheme, and involves observing and recording for each sample tree the basic physical characteristics that are quality criteria for most primary timber products. Occurrence and severity of defects form the basis for estimating the potential of the timber stand to produce a variety of products.

Equally as important as the inventory information itself is the ability of the manager to evaluate these inventory data for the entire array of potential timber products. Large volumes of data must be analyzed to determine suitability for individual products and combinations of products in the array of possible conversion alternatives (fig. 1). To make practical use of inventory data, the timber manager or processor must turn to automatic data processing and computer analysis. The computer program MULTI has been written as a guideline to show one possible way to implement such a system.

MULTI—A Program to Analyze Product Potential

MULTI was developed on a CDC 6400 computer system. It is written in FORTRAN Extended Language, and can use tape and/or disk storage.

The program accepts basic field inventory data describing individual trees. It then calculates gross volume, grades or classifies for a number of primary products, adjusts volume for visual defect, and calculates standard error.

Gross volume in cubic feet or board feet, or both, may be calculated for each half-log or 8-foot stem section, to minimum merchantable saw log diameter. Board-foot volume may also be determined for 16-foot saw logs. In addition, cubic volume may be calculated for the stem section from minimum saw log top to a 4.0-inch top diameter inside bark (d.i.b.).

Depending upon the needs of the user, the program can be used to grade or classify trees or sections of trees for all possible products, or for the individual products of greatest value in a specified order of preference.

Program Adaptability

A key objective in writing the computer program MULTI was to develop a system that could easily be changed to fit individual needs. Although the program was developed for products and grading systems common to ponderosa pine (*Pinus ponderosa* Laws.), it is adaptable to other species, products, and grading systems.

Input parameters needed to calculate tree and log volumes and estimate product volumes

Figure 1.--There are many primary product and product-combination conversion alternatives for any particular stand of timber. Illustrated are the primary timber products considered in program MULTI.

per acre are contained on program data cards and control cards. Individual products are evaluated and graded through a series of product evaluation subroutines. Different species or products can be accommodated by substituting appropriate input parameters and product evaluation subroutines. Changes in grading systems require only that the grading section of the affected subroutine be changed.

For The Non-Programmer— A Program Description

The following information will describe for the non-programmer what data are used and what is accomplished by the program.

Field Data Input

Field data recorded for each sample tree include:

1. Descriptive and size data, including
 - a. Species.
 - b. Diameter breast high (d.b.h.).
 - c. Total tree height in merchantable half logs.
 - d. Pole height for potential commercial poles.
2. Visual defect characteristics, including
 - a. Stem form defects—sweep, crook, fork, lean.
 - b. Stem scar defects—basal, lightning.
 - c. Knot or limbing characteristics in the first 32 feet.

How these data are measured and recorded is described in detail in appendix A.

Product, Grade, and Priority Specification

The program can accommodate the full range of primary products and product grades appropriate for a particular timber type or species. The program illustrated includes and is limited to five primary products from ponderosa pine: saw logs, stud logs, veneer logs,

commercial poles, and pulpwood. Within these products, the program will accommodate four saw-log grades, three stud-log grades, three veneer-log grades (plus an "unacceptable" category in veneer and stud logs), and 15 pole height classes.

Product priorities can be specified by means of a program control card. If each tree or section is to be graded and classified for as many products as it is suitable for, no priority selection is used. The output will reflect the total potential of the stand for each product as if the entire stand were being utilized for that product. More often, however, a descending order of product priority will be specified. A typical order might be (a) commercial poles; (b) saw logs grade 1, 2, 3; (c) veneer logs grade 1, 2, 3; (d) stud logs grade 1, 2, 3; (e) saw log grade 5; (f) pulpwood. In the program illustrated, pulpwood always assumes lowest priority. Each tree or section would then be graded for these products in order of preference stated, and placed only in the highest product class for which it qualifies. If desired, a series of different product priorities can be specified, to be considered one after another.

Volume Determination

Gross cubic-foot and board-foot volume of each sample tree is calculated from volume equations appropriate for the species. Board-foot volume is determined to minimum merchantable saw-log diameter in the tree, while cubic volume is determined to a 4-inch top diameter. Average volume distribution values are then used to allocate volume by log and half-log stem sections. Volume equations and volume distribution values used for southwestern ponderosa pine are shown in appendix A.

Volume suitable for log products is normally expressed in board feet, while volume of pulpwood is expressed in cubic feet. Either expression can be used with any product, however. For products normally considered by number or count, such as commercial poles, a piece count is maintained.

Product Grading and Volume Adjustment

Each sample tree is graded for the products specified by using a combination of recorded field data and program grading instructions. Grading instructions are based upon grading

or quality specifications for each product (appendix A), and utilize the measured stem defect characteristics that form these grading criteria.

Tree size or estimated stem section diameter is used to judge initial suitability for each primary product. Trees or stem sections of acceptable size are graded for the products specified. Gross volume graded is then adjusted for defects that either prohibit use of the stem or stem section for the product, or reduce merchantable volume.

Commercial poles. —All sample trees 9.0 through 20.9 inches in diameter, for which a pole height has been field recorded, are considered for commercial poles. The programed evaluation procedure for a potential commercial pole proceeds as follows:

1. Verify acceptable stem size limits—9.0 through 20.9 inches d.b.h.
2. Accept recorded pole height from input field data.
3. Divide pole height by 8 to find 8-foot stem sections or half-logs involved. All fractions of sections are rounded upward (pole height/8 + 0.9) to assure that all sections wholly or partially contained in the pole are included.
4. Scan defect data for included stem sections for inadmissible or limiting defects.
 - a. The stem is dropped from further consideration as a pole by the occurrence of
 - sweep (class 1 or class 2)
 - lightning scar
 - lean of 10° or more (class 2 or 3)
 - knots 4 inches or larger in diameter
 - major crook (class 2) or fork in any except the first or last stem section included in the pole height
 - indication of rot.
 - b. Reduce merchantable pole height by one class (5 feet) if recorded defects include
 - fire or basal scar
 - fork or major crook (class 2) in the first or last stem section included in the pole height.
5. Pole count is accumulated by tree diameter class and pole height class.

Pole height is normally recorded in the field only for stems that do not have inadmissible defect. Programed defect screening is consequently a "double check" on the entry made in the field. The pole height recorded in the field will usually be accepted as correct pole potential for the stem.

Saw logs.—All sample trees of sawtimber size (11.0-inch d.b.h. and larger in ponderosa pine) are evaluated for saw log potential. Saw log grades are determined for lower logs, to a maximum of two logs or 32 feet of merchantable height. Grades are arbitrarily assigned to logs above that height. Gross saw log volume for each log in the tree is adjusted for the presence of scaling defects. The programed evaluation proceeds as follows:

1. Verify acceptable stem size—11.0-inch d.b.h. or larger, plus merchantable height of two or more half-logs.
2. Determine gross board-foot volume of the tree, and volume by 16-foot saw logs (including a top half-log where present), as previously described.
3. Estimate the grade of each saw log in the tree. Procedures for estimating grade depend upon the position of the log in the tree and the tree species or grading system used. Ponderosa pine saw logs are graded as follows:
 - a. First 16-foot saw log:

Scan recorded knot data by 8-foot section and face, starting with stem section 1, face 1, and proceeding in turn to faces 2, 3, and 4. For each face, accumulate a "clear 4-foot panel" count of:

 - no knots = count two (2)
 - one knot = count one (1)
 - two or more knots = count zero (0)

Repeat for stem section 2, accumulating the panel count for the first two stem sections (totaling 16 feet of merchantable length). From the accumulated panel count, assign a log grade to the log as described in appendix A.
 - b. Second 16-foot saw log:

Grade the second full saw log in a tree by the same process. Add the clear panel count for stem section 3 to panel count for stem section 4, and assign a grade. Panel count for stem section 4 is limited to counting 2 for each clear face (coded 0), since knot numbers are not recorded. Where the third stem section is the last merchantable saw log volume in the tree (that is, merchantable tree height of three half-logs), the panel count for the one section is multiplied by two to determine grade.
 - c. Third log and above:

Assign lowest grade (grade 5) to all saw logs above 32 feet in the tree. (Alternatively, upper saw logs can be carried as ungraded volume, or can be assigned other grades based on available data.)
4. Adjust gross volume of each saw log for visual defect. Defects considered to reduce

usable volume, and average scale deductions applied, are:

Defect	Scaling deduction	
	16-foot log (percent)	8-foot (top) log (percent)
a. Lightning scar (class 1) in tree	25	25
b. Lightning scar (class 2) in tree	50	50
c. Sweep (class 2) in tree	20	20
d. Fire scar (class 2) in tree (reduce butt log scale only)	13	0
e. Crook (any class) in either section of log	25	50
f. Fork in either section of log	25	50
5. Accumulate both gross and adjusted saw log volumes, by tree diameter class and log grade.		

Veneer logs.—All 8-foot stem sections with an estimated diameter of 10 inches or more are potentially suitable for veneer. Veneer log quality evaluation is limited to the first three stem sections (24 feet), however, since knot data needed for grading are limited to these sections. Veneer log evaluation proceeds as follows:

1. Verify acceptable stem section diameter. In the absence of actual scaling diameters, stem sections in the first 24 feet considered to have scaling diameters of 10 inches or more are:

Tree d.b.h. class	Acceptable stem sections
12	1st section
14	1st, 2nd sections
16 or over	1st, 2nd, 3rd sections
2. Determine gross board-foot volume of the tree, and volume of acceptable 8-foot stem sections, as previously described. (Merchantable stem volume above 24 feet may also be calculated and carried as ungraded potential veneer log volume, if so desired.)
3. Estimate the grade of each potential veneer log in the tree. The grade of each 8-foot log (maximum of three logs) is estimated by scanning recorded knot type and size data for the four faces. Using size of largest dead and largest live knot, assign a grade as described in appendix A.

4. Adjust gross volume of each veneer log for visual defect. Defects considered to reduce usable volume, and average scale deductions applied, are:

Defect	Scaling deduction (percent)
a. Indication of rot in section (If by d.b.h. core, apply reduction to butt section only)	100
b. Crook (class 2) in section	100
c. Crook (class 1) in section	50
d. Fork in section	50
e. Lightning scar (class 2) in tree	50
f. Lightning scar (class 1) in tree	25
g. Fire scar (class 2) in tree (Apply reduction to butt section only)	25

Scan for occurrence of defects in the order shown. If total deduction reaches 100 percent, omit further scanning and apply 100 percent deduction.

5. Accumulate both gross and adjusted veneer log volumes by tree diameter class and log grade.

Stud logs.—Stud logs are typically processed through chipping headrig mills, or mills similarly equipped for the specialty manufacture of studs and dimension stock. The logs are often processed in 8-foot lengths, and are restricted in maximum diameter by the nature of the processing equipment. All 8-foot stem sections with an estimated scaling diameter of 17 inches or less are potentially suitable for stud logs. Stud log quality evaluation is limited to the first three stem sections (24 feet), however, because of the limitations in grading. Stud log evaluation proceeds as follows:

1. Verify acceptable stem section diameter. In the absence of actual scaling diameters, stem sections in the first 24 feet considered to have scaling diameters of 17 inches or less are:

Tree d.b.h. class	Acceptable stem sections
18 or under	1st, 2nd, 3rd sections
20	2nd, 3rd sections
22	3rd section
24 or over	None

2. Determine gross board-foot volume of the tree, and volume of acceptable 8-foot stem sections, as previously described.
3. Estimate the grade of each potential stud log in the tree. The grade of each 8-foot log (maximum of three logs) is estimated

by scanning recorded knot count and size data for the four faces. Using size of largest dead and largest live knot, and knot count, assign a grade to the stud log as described in appendix A.

4. Adjust gross volume of each stud log for visual defect. Defects considered to reduce usable volume, and average scale deductions applied, are:

Defect	Scaling deduction (percent)
a. Indication of rot in section (If by d.b.h. core, apply reduction to butt section only)	100
b. Crook (class 2) in section	100
c. Crook (class 1) in section	50
d. Fork in section	50
e. Lightning scar (class 2) in tree	50
f. Lightning scar (class 1) in tree	25
g. Fire scar (class 2) in tree (Apply reduction to butt section only)	25

Scan for occurrence of defects in the order shown. If total deduction reaches 100 percent, omit further scanning and apply 100 percent deduction.

5. Accumulate both gross and adjusted stud log volumes, by tree diameter class and log grade.

Pulpwood.—The cubic volume of all trees, to a 4-inch top diameter, is potentially suitable for pulpwood. Pulpwood is a low-value product, however, and is usually obtained from trees or stem sections not suitable for other primary products. Pulpwood evaluation is consequently limited to cubic volume not accepted for other products, including top volume from minimum saw log top to a 4-inch diameter, plus any tree diameter classes or stem sections specifically excluded from other products. Pulpwood evaluation includes:

1. Specify tree diameter classes or stem sections (if any) excluded from prior product consideration: smaller tree diameter classes for which knot data are not recorded, tops to 4-inch d.i.b.
2. Determine gross cubic-foot volume of tree or stem sections designated for pulp. For sample trees 11.0 inches d.b.h. or over which have been evaluated for log products, only top volume will be required.
3. Adjust gross volume of each tree or section for visual defect. Defects considered to

reduce usable volume, and average volume deductions applied, are:

Defect	Volume deduction (percent)
a. Lightning scar (any class) in tree (including top)	100
b. Fire scar (any class) in tree (Applies only as reduction in butt section volume when entire tree is allocated to pulp)	50

Scan for occurrence of defects in the order shown. If total deduction reaches 100 percent, omit further scanning and apply 100 percent deduction.

4. Accumulate both gross and adjusted pulpwood volumes, by tree diameter class.

Other products.—Potential for other primary conversion products can also be evaluated as other products become of interest. An analysis of suitability and quality can be made for any product for which the recorded stem characteristics are grading criteria. Potential for a specific product can also be reevaluated after a grade change or revision of grading rules.

Calculation of Errors of Estimate

The adjusted gross volume of each stem section or tree graded is converted to a volume-per-acre estimate by means of the expansion or conversion factors appropriate for the sample. For all products, adjusted gross volume or piece count per acre is then accumulated by product, grade, and tree diameter class, for each random sampling unit.

Volumes per acre for each random sampling unit provide the basis for calculating precision of estimate for each product. The program uses a simple algorithm to compute standard error of the mean for each product and grade, by tree diameter class. The algorithm is most useful for simple random sampling and subsampling with units of equal size. It can also be used for proportional stratified sampling. Subsampling systems with substantially unequal sample units may require weighting procedures.

Calculated error terms are ultimately printed out with the volume estimates to which they correspond.

Form of the Output

The program prints out the product analyses in a series of tables. Each table presents potential by tree diameter class for one product and one or more grades within the product (appendix B). Average gross or adjusted volume per acre and standard error are printed out for each grade within each diameter class, and for the accumulated grade totals. Errors for totals are generally sufficient for most purposes.

As an integral part of the program, a permanent unit record is also developed for each sample tree. The unit record consists of all descriptive variables recorded in the field, and variables computed in the course of product evaluations (appendix A). Thereafter, output information can be obtained from the unit records for sample trees, classified or grouped by any recorded variables desired. Examples might be (1) volume of grade 3 and better saw logs in blackjack trees (as opposed to old-growth trees); (2) volume of acceptable veneer logs in trees with grade 5 saw logs in lower sections; (3) volume of acceptable veneer logs in trees acceptable as commercial poles.

For the Programmer— Program Implementation

Program MULTI operates as an executive routine that provides for initial data card read-in, tree diameter class computation, initial tests of sample tree diameter against product size limit criteria, and preparation of a tape or disk file of tree records for further processing (fig. 2). Once the initial data have been tape or disk filed, MULTI is designed to make multiple passes through the data, executing options as specified on program control cards. MULTI calls on various subroutines to do the necessary grading, volume computations, and error calculations. An option is provided for writing a unit record tape file for each tree processed.

The program utilizes eight subroutines. Five are the product evaluation routines POLE, SAW, VENR, STUD, and PULP, with the names corresponding to the product being evaluated. The remaining three are VOLUM, which calculates board-foot and cubic-foot volumes of sample trees, CVOL, which converts sample volumes to volume per acre, and STDER, which calculates confidence limits around the means.

A complete printout of program MULTI, including all subroutines, is included as appendix B.

Program Data Cards

Program data cards type A, B, and C are read in at the beginning of the program. These cards provide the board-foot and cubic-foot volume distribution percentages needed to calculate volume by stem section (see appendix A).

Card type A includes a set of three cards containing cubic-foot volume distribution percentages for half-log (8-foot) stem sections, plus top to 4-inch d.i.b. The data are used to fill the array KCUV8(65). Card type B includes three cards containing board-foot volume distribution percentages, also by half-log (8-foot) stem section. The data are used to fill the array KBFV8(55). Card type C includes two cards containing board-foot volume distribution percentages for 16-foot saw logs. Data are used to fill the array KBFV16(29). In each case, volume distribution data are included for tree heights and log or half-log positions through 10 half-logs or five saw logs.

Complete program card data for southwest-ern ponderosa pine are shown in appendix A. The cards are coded as follows (format 26I3), with all values right-adjusted in the data fields:

Card type	Card number	Card columns	Percent value	Array element
A	A-1	1-3	65	L(1,1)
		4-6	35	L(1,T)
		7-9	50	L(2,1)
		etc.	etc.	etc.
		.	.	.
	A-2	73-75	10	L(6,5)
		76-78	8	L(6,6)
		1-3	3	L(6,T)
		4-6	26	L(7,1)
		7-9	18	L(7,2)
	A-3	etc.	etc.	etc.
		.	.	.
		73-75	8	L(9,7)
		76-78	6	L(9,8)
		1-3	4	L(9,9)
		4-6	2	L(9,T)

B	B-1	7-9	19	L(10,1)
		etc.	etc.	etc.
		.	.	.
		34-36	4	L(10,10)
		37-39	2	L(10,T)
	B-2	1-3	100	L(1,1)
		4-6	66	L(2,1)
		7-9	34	L(2,2)
		10-12	52	L(3,1)
		etc.	etc.	etc.
	B-3	73-75	13	L(7,4)
		76-78	10	L(7,5)
		1-3	7	L(7,6)
		4-6	6	L(7,7)
		7-9	25	L(8,1)
C	C-1	etc.	etc.	etc.
		73-75	9	L(10,6)
		76-78	7	L(10,7)
		1-3	6	L(10,8)
		4-6	4	L(10,9)
	C-2	7-9	4	L(10,10)
		1-3	100	L(1,1)
		4-6	75	L(1.5,1)
		7-9	25	L(1.5,1.5)
		10-12	64	L(2,1)
		etc.	etc.	etc.
		.	.	.
		73-75	35	L(5,1)
		76,78	27	L(5,2)
		1-3	20	L(5,3)
		4-6	13	L(5,4)
		7-9	5	L(5,5)

The volume distribution data, illustrated here for ponderosa pine, are input by means of cards to allow the user to select the set of distribution percentages that he wishes to use. If values for other species are desired, they can be substituted in the same manner. If additional values are required which exceed the dimensions of the arrays mentioned, array size should be increased and the source code modified or expanded in initial READ statements and in subroutine VOLUM. The data cards type A, B, and C are initial input only, and are not repeated for successive passes.

Figure 2.--Program MULTI mainline flow chart.

Program Control Cards

Program control and option parameters are read in on four control cards (card types 1 through 4) at the beginning of each problem and before each pass through the data. Program control cards are coded as follows, with all values right-adjusted in the data fields:

Card Type 1

Variable name	Card columns	Format	Description
PROB	1-80	8A10	Alphameric code to describe problem and user options.

Card Type 2

IN	1-5	I5	IN = 0, read tree data from cards. IN = 1, read tree data from tape.
NSAM	6-10	I5	Number of sample units. If "cluster" sampling is used, NSAM is number of clusters.
R	11-15	F5.3	If R is punched to any non-zero value, rot occurrence observed and recorded in a subsample of trees will be randomly extended to the entire sample. If rot occurrence data are available for all sample trees, R should be punched zero.
NPROD	16-20	I5	Number of products to be evaluated in each run. Maximum size of NPROD is 11, 1 pole grade, 4 saw log grades, 3 veneer grades, and 3 stud grades.
IP(I)	21-75	11I5	Sets the product priority order for product evaluation.
EXPFC	76-80	F5.0	EXPFC, when equal to some value other than zero, is a conversion factor to convert fixed-size plot sample values to per-acre basis. In plotless or point

Variable Card

name	columns	Format	Description
			sampling, computed conversion factors are used, and EXPFC = 0.

Format (2I5, F5.3, 12I5, F5.0)

Card Type 3

JON	1-5	I5	JON = 1, specifies product evaluation on priority basis, each stem section evaluated only for highest priority product for which it is suited, following specified order of preference per IP(I), card type 2. JON = 2, specifies primary product evaluation in which each stem section is evaluated for all products for which it is suited. JON = 3, specifies both evaluations to be made.
KPOLE	6-10	I5	Trees to be evaluated for poles, KPOLE = 1; otherwise KPOLE = 0.
KSAW	11-15	I5	Trees to be evaluated for saw logs, KSAW = 1; otherwise KSAW = 0.
KVENR	16-20	I5	Trees to be evaluated for veneer, KVENR = 1; otherwise KVENR = 0.
KSTUD	21-25	I5	Trees to be evaluated for stud logs, KSTUD = 1; otherwise KSTUD = 0.
KPULP	26-30	I5	Trees to be evaluated for pulpwood, KPULP = 1; otherwise KPULP = 0.
KOUT	31-35	I5	KOUT = 1, write on output unit record tape; KOUT = 0, skip this option. A unit record can be written only if JON = 2 or 3.
IBUG	36-40	I5	IBUG = 1, print out individual tree sta-

			tistics; IBUG = 0, skip this option. Use only for testing or debugging program as a large amount of output is generated.
KVOL	41-45	15	KVOL = 1, compute and output gross volume tables; KVOL = 2, compute and output adjusted gross volume tables, volumes adjusted for visual scaling defects.
BAFV	48-55	F8.4	BAF value of the prism or angle gage used in plotless sampling.

Format (9I5, 2X, F8.4)

Sample input for a production run might be:
3-1-1-1-1-1-1-0-1-25.0000

Card Type 4

POINT(I) 1-80	16F5.0	Specifies the number of sampling points in each sample unit (NSAM). If more than 16 sample units are used, continue on subsequent cards. If cluster sampling is not used, POINT (I) should equal 1 for all entries. Decimal point need not be punched.
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Product Priority Instructions

If products are to be evaluated on a priority basis, the desired order of priority must be specified by entries in the IP(I) fields, columns 21-75, of control card type 2. Entries refer to the specific subroutine being called:

- 1 Subroutine POLE
- 2 Subroutine SAW
- 3 Subroutine VENR
- 4 Subroutine STUD

If the desired priority is poles, followed by grades 1-3 saw logs, grades 1-3 veneer logs, grades 1-3 stud logs, and grade 5 saw logs, the IP(I) values would be coded as follows:

Variable	Column	Number	Product considered
NPROD	19-20	11	
IP(1)	25	1	Poles
IP(2)	30	2	Saw logs, grade 1

IP(3)	35	2	Saw logs, grade 2
IP(4)	40	2	Saw logs, grade 3
IP(5)	45	3	Veneer, grade 1
IP(6)	50	3	Veneer, grade 2
IP(7)	55	3	Veneer, grade 3
IP(8)	60	4	Studs, grade 1
IP(9)	65	4	Studs, grade 2
IP(10)	70	4	Studs, grade 3
IP(11)	75	2	Saw logs, grade 5

Computed Control Variables

A number of control variables are computed during the execution of the program. These variables are as follows:

KMAX	Equals the maximum diameter class in each data set.
KMIN	Equals the minimum diameter class in each data set.
IND(I) I=1, 10	Is an indicator which is set to one to indicate that a particular log or tree has been utilized for a priority product. If ITRHT is greater than 10, ITRHT=10.
KOUNT(I)	Equals the number of trees in each diameter class.
NBORE	Number of trees sampled for rot determination.
NROT	Number of sampled trees containing rot.
PROROT	Proportion of trees with rot as computed by NROT/NBORE. The program uses a random number generator to randomly extend the observed frequency of occurrence of rot to the entire sample. If rot occurrence data are available for all sample trees, the program provides an option (R=0) to bypass this procedure and use rot data directly. In either case, occurrence of rot should be coded 2 for proper program evaluation.

Tree Data Cards

Inventory data are recorded on punch cards, one card for each sample tree. The data included on the cards, and the coding and format required for the program, are described and illustrated in appendix A.

As many tree data cards as desired, within the limits of the disk or tape file, may be read in. Data may be entered in any order without regard to diameter class or sample number.

One blank card is used to signal the end of tree card input; two additional blank cards (read as type 1 and 2 control cards) will terminate the program after the desired computation and output is completed.

If additional runs or problems are to be executed on the filed data, repeat program control cards types 1, 2, and 3. Control card type 4 is not required for additional runs. As many sets of type 1, 2, and 3 control cards may be input as desired, with the last set being followed by two blank cards.

Subroutine POLE (PLHT2, POINT, TOTAL, ISAM, IMAX, PLHT1)

The arguments PLHT2, POINT, and TOTAL are dimensioned variables, the sizes set by the argument ISAM, which is equal to or greater than NSAM, the number of sample units used. The argument PLHT1 accumulates POLE counts by diameter class. The argument PLHT2 accumulates POLE counts by sample number and pole height class. In other product subroutines, each stem section is evaluated independently for the product being considered, and if JON = 1 accepted sections are withdrawn from consideration for subsequent products. In subroutine POLE, however, the use of a tree as a pole eliminates any consideration for other products and, conversely, use of any 8-foot section for another product eliminates the entire tree from being considered as a pole.

Subroutine SAW (VCNT, POINT, TOTAL, ISAM, IMAX)

The arguments VCNT, POINT, and TOTAL are dimensioned variables, the sizes set by ISAM and IMAX. ISAM must be equal to or greater than the total number of samples (NSAM), and IMAX must be equal to or greater than the largest diameter class in the data. The array VCNT is an accumulator for saw log volumes by diameter class and grade, POINT is a vector specifying the number of points (or subplots) in each sample, and TOTAL is an array for accumulation of volumes. This subroutine evaluates each sample tree between a minimum diameter class (KMIN) and maximum class (KMAX) that has at least one saw log (two 8-foot sections). Descriptive tree quality data are screened by 8-foot stem section, and a grade from the designated grading system is assigned each saw log. The grading system and method of evaluating grading criteria in ponderosa pine are described in appendix A.

If priorities are established (JON = 1), selection of either or both half-logs for a higher priority will eliminate the full log from saw log consideration. Log volumes can be computed and printed out in terms of either gross volume (KVOL = 1) or volume adjusted for visual scaling defect (KVOL = 2), as previously discussed. Information is printed out by diameter class and total, for one log grade at a time if JON = 1 or for all grades at once if JON = 2.

Subroutine VENR (VCNT, POINT, TOTAL, ISAM, IMAX)

Input arguments for this subroutine are the same as those described for SAW. This subroutine evaluates each sample tree meeting initial diameter class specifications; it screens by 8-foot stem section and assigns a grade from the designated grading system (appendix A). Since grades are based on recorded knot data, grading is limited to the first three 8-foot stem sections in each tree. Log volume can be adjusted for visual scaling defects (KVOL = 2) if desired. If priorities are established (JON = 1), printouts will include only the three acceptable grades. A "grade 4" (material unacceptable because of knot size) is accumulated, however, and under option JON = 2 will be printed out and listed in the tree unit record.

Subroutine STUD (VCNT, POINT, TOTAL, ISAM, IMAX)

The input arguments and operations of this subroutine are the same as those described for VENR. The same options and restrictions apply to grade evaluation (appendix A) and printouts for the product.

Subroutine PULP (PULPV, POINT, TOTAL, ISAM, IMAX)

The argument PULPV is a dimensioned variable of size ISAM. The other arguments are the same as in other subroutines. PULP accumulates cubic-foot volumes for all sample tree sections not accepted for other products, plus top volume from minimum saw log top to a 4-inch top diameter for each tree evaluated. All trees excluded because of d.b.h. less than 9 inches are also included in pulpwood totals. Pulpwood gross volumes can be adjusted for inadmissible visual defect (fire and lightning scar) as previously discussed, under the KVOL = 2 option.

Subroutine VOLUM (KCUV8, KBFV8, KBFV16, BAFV)

This subroutine calculates total merchantable board-foot and cubic-foot volume in each sample tree. Board-foot volume is calculated to minimum saw-log diameter and cubic-foot volume is calculated to a 4-inch top diameter. Volumes are allocated by log and half-log stem sections, by means of average volume distribution values. Tree volume equations and volume distribution percentages used for ponderosa pine are described in appendix A. The arguments KCUV8, KBFV8, and KBFV16 are dimensioned variables (volume distribution percentage values) read in by the program data cards.

If plotless or point sampling has been used, the subroutine also calculates expansion factors to convert sample values to per-acre values. An expansion factor is calculated for each sample tree, from the equation

$$EF = \frac{BAFV}{0.005454D^2}$$

where BAFV is input on control card type 3 and D^2 is tree d.b.h. squared.

Subroutine CVOL (VBL, EXPFC, EF)

This is a function subroutine used to convert product count or volume per tree or stem section to count or volume per acre, when plotless sampling has been used. Argument VBL is a dummy argument used to pass the sample value to be converted to the function CVOL. Argument EF is the point sample per-acre expansion factor calculated by subroutine VOLUM.

EXPFC (also called PRISM in some subroutines) is a factor to convert fixed-size plot sample values to per-acre values. $EXPFC = 0$ when plotless sampling is used.

Subroutine STDER (NSAM, Y, S, AMTRX, POINT)

This subroutine uses a simple algorithm to compute standard error of the mean for each product and grade, as indicated earlier. Calculated error terms are printed out with the volume estimates for the product. Arguments for the subroutine are:

Input

NSAM Number of sample units
AMTRX Data vector of size NSAM
POINT Vector of size NSAM giving number of points or subplots per sample.

Return

Y Mean of vector AMTRX
S Standard error of vector AMTRX.

Unit Record Output

A permanent unit record, containing descriptive variables and a number of computed variables, is developed for each sample tree. The variables included in the record are described in appendix A. Unit record output is generated when program control card type 3 specifies $JON = 2$ or 3 and $KOUT = 1$. The record is written on external device logical file 4 (tape or disk storage) by a `WRITE(4) LIST` statement, and consists of strings of binary word values in the form in which they appear in storage. Each tree record consists of 105 binary words. An end-of-file is written after the last tree processed; a message is then printed that gives the number of records in the output file, plus a printout of the last tree record processed for check purposes.

It is assumed that the unit record output file would normally be used as input on the CDC 6400 system for further processing by the IOCS input-output routines. If this is not the case, it would be advisable to write the unit record output with a `WRITE(4,FMT) LIST` statement in the BCD mode. BCD tapes written with this statement can normally be read on a different computer, often with the normal FORTRAN input-output routines.

Program Operation and Limitations

Program MULTI is written in the FORTRAN Extended Language Version 1.0, an extension of the USASI FORTRAN language, for the Control Data 6400 computer system. Operation of the program requires a central processor, a card reader, output line printer (assigned logical file 3) and two external tape or disk storage devices (assigned logical files 1 and 4).

The program contains error messages which provide information to help the user correct the input data. There are no recovery points in the program. When an abort or execution failure occurs, all volume accumulations to time of failure are lost and the program must be restarted from the beginning.

Maximum diameter class and sample size are set in the data statement, DATA IMAX, ISAM/40.4/. Dimensioned variables SAWV, VENRV, STUDV, PULPV, VCNT, PLHT2, TOTAL, and POINT contain as their first sub-

script the maximum sample size allowed. Because all of these variables except VCNT are intermeshed with an EQUIVALENCE statement, their first dimensions must be the same and should equal ISAM. The last dimension of SAWV, VENRV, and VCNT must equal IMAX. Any change in ISAM and/or IMAX requires a program coding change in all the variables mentioned. Other dimensioned variables do not require changes due to changes in sample number or maximum diameter class.

A test version of program MULTI, with maximum sample size = 130 and maximum diameter class = 34, required a field length of 105,700₈ or core storage of 36₁₀ K to load the program. A CDC 6400 computer system with 140,000₈ or 50₁₀ K available can possibly accommodate maximum variable combinations to sample size = 150 and diameter class = 40. Larger combinations may require overlay subroutines.

Loading procedure

The order for loading the program is:

1. Computer center control cards.
2. MULTI-Main and all subroutines.
3. Program data cards, types A, B, and C (a set of eight cards)
4. Program control cards, types 1, 2, 3, and 4.
5. Individual tree data cards.
6. Blank card to signal end of tree data.
7. Two additional blank cards if run is to terminate after first pass, or
Repeat program control cards, types 1, 2, and

- 3 as many times as desired, one set for each pass.
8. Two blank cards to terminate job, final pass.

Literature Cited

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APPENDIX A

Field Inventory Data

Field inventory methods are described in Barger and Ffolliott (1970). Field inventory data described here are those taken in inventorying ponderosa pine. For other species or primary products, some modification of the data recorded may be desirable. For the evaluation program MULTI, one data card is punched for each sample tree, following the coding and format described:

Variable name	Card columns	Format	Description
—	1-2	2X	Blank or identification data.
ISTR	3-4	I2	Sample number, range 01 to 99.
IDMY	5-11	I7	Dummy variable, can be used for ID data.
DBH	12-16	F5.2	Tree d.b.h., punch decimal point, XX.XX.
IPLHT	18-19	I2	Pole height, recorded as maximum 5-foot height class obtainable (25', 30', 35', etc.).
ISWP	21	I1	Sweep entered as 1 (minor) or 2 (major).
IPCR	22	I1	Number of half-log in which crook occurs.
ICRK	23	I1	Crook entered as 1 (minor) or 2 (major).
IPFK	24	I1	Number of half-log in which fork occurs.
IFRK	25	I1	Coded as 1 if fork exists.
IFS	26	I1	Fire scar entered as 1 (minor) or 2 (major).
ILS	27	I1	Lightning scar entered as 1 (minor) or 2 (major).
KNOT (1,1,1)	29	I1	Number of knots in face 1, section 1.
KNOT (1,1,2)	30	I1	Size of largest live knot to nearest inch, face 1, section 1.
KNOT (1,1,3)	31	I1	Size of largest dead knot to nearest inch, face 1, section 1.
KNOT (1,2,N)	32-34	3I1	Repeat for face 2, section 1, N=1,2,3.
KNOT (1,3,N)	35-37	3I1	Repeat for face 3, section 1, N=1,2,3.
KNOT (1,4,N)	38-40	3I1	Repeat for face 4, section 1, N=1,2,3.
KNOT (2,M,N)	43-54	12I1	Same knot data recorded by 8-foot section and face for second section (or to minimum merchantable top diameter).
			For the fourth 8-foot section (24' - 32'), only presence or absence of clear 8-foot faces is entered as:
	I24P		Face 1: 0 if clear, 1 if knots occur.
	I24P(1) 71	I1	Face 2: 0 if clear, 1 if knots occur.
	I24P(2) 72	I1	Face 3: 0 if clear, 1 if knots occur.
	I24P(3) 73	I1	Face 4: 0 if clear, 1 if knots occur.
	I24P(4) 74	I1	Tree height, recorded as total half-logs or 8-foot sections to the minimum saw log top diameter. If tree height is recorded in total feet or in 16-foot sections, a conversion to half-log height is required.
LEAN	76-77	I2	Lean, recorded by 5 degree classes (nearest class) as: 0 - Less than 3 degrees

Variable name	Card columns	Format	Description
			1 - 5 degrees
			2 - 10 degrees
			3 - 15 degrees or more
IROT	80	I1	Rot, as observed in subsample by means of increment cores or other indicators, recorded as:
			0 - not sampled
			1 - sampled, no rot
			2 - sampled, rot

Card format (2X12, I7, F5.2, 1x12, 1x7I1, 1x12I1, 2x12I1, 2x12I1, 2x4I1, 1x12, 1x2I1)

Sample Tree Volume Determination

Cubic-foot Volume Determination

Determine tree height in half-logs (8-foot sections) to minimum merchantable saw log diameter. If only total tree height has been

recorded, estimate half-log height from total height (Van Deusen 1967).

Calculate total merchantable cubic-foot volume of sample tree to 4.0-inch top, by equation. For tree height in 16-foot logs to nearest half-log (H) and d.b.h. outside bark (D), equations for southwestern ponderosa pine are (Myers 1963):

- (1) Tree d.b.h. under 19.0 —

$D^2 H$ 800 or less:

$$V = 0.046000 D^2 H + 6.800000$$

$D^2 H$ over 800 :

$$V = 0.044204 D^2 H + 8.266000$$

- (2) Tree d.b.h. over 19.0 —

$D^2 H$ 1,000 or less :

$$V = 0.050666 D^2 H + 5.866800$$

$D^2 H$ over 1,000 :

$$V = 0.045736 D^2 H + 10.857212$$

Nineteen inches is the assumed breaking point between blackjack and old-growth trees.

Determine volume distribution among stem sections of the tree. Apply percentages to total tree volume to estimate volume of sections. Average cubic volume distribution in southwestern ponderosa pine of specified half-log height is:

Tree height half-logs	Half-log position in tree										Top to 4.0-inches d.i.b.
	1	2	3	4	5	6	7	8	9	10	
Number	- - - Percent of total cubic-foot tree volume - - -										
1	65										35
2	50	31									19
3	43	29	17								11
4	38	27	17	11							7
5	32	24	17	13	9						5
6	28	21	16	14	10	8					3
7	26	18	15	13	10	9	6				3
8	24	16	14	12	10	9	7	5			3
9	22	15	13	12	10	8	8	6	4		2
10	19	15	12	11	10	8	8	6	5	4	2

Board-foot volume determination

Determine tree height in half-logs (8-foot stem sections) to minimum merchantable saw-log diameter. If only total tree height has been recorded, estimate half-log height from total height.

Calculate total merchantable board-foot volume of sample tree to minimum merchantable top diameter (variable), by equation. For tree height in 16-foot logs to nearest half-log (H) and d.b.h. outside bark (D), Scribner rule equa-

tions for southwestern ponderosa pine are (Myers 1963):

- (1) Tree d.b.h. under 19.0—

$D^2 H$ 800 or less:

$$V = 0.224793 D^2 H + 8.165600$$

$D^2 H$ over 800:

$$V = 0.300081 D^2 H - 52.090112$$

- (2) Tree d.b.h. 19.0 or over —

$D^2 H$ 1,130 or less:

$$V = 0.275784 D^2 H - 5.091250$$

$D^2 H$ over 1,130:

$$V = 0.326427 D^2 H - 62.962331$$

Nineteen inches is the assumed breaking point between blackjack and old-growth trees.

Determine volume distribution among stem sections of the tree. Average board-foot volume distribution in southwestern ponderosa pine of specified log height is indicated below. For saw logs, normally expressed in terms of

16-foot logs and half-logs, refer to the first tabulation. For veneer and stud logs or other log products utilized in 8-foot lengths, refer to the second tabulation. Apply percentages to total tree volume to estimate volume of individual logs or sections.

Tree height in		16-foot saw log position in tree								
Logs	Half-logs	1	1.5	2	2.5	3	3.5	4	4.5	5
<u>Number</u>		<u>- Percent of total board-foot tree volume -</u>								
1	2	100								
1.5	3	75	25							
2	4	64	--	36						
2.5	5	58	--	32	10					
3	6	49	--	33	--	18				
3.5	7	41	--	32	--	19	8			
4	8	44	--	31	--	17	--	8		
4.5	9	39	--	29	--	19	--	10	3	
5	10	35	--	27	--	20	--	13	--	5

Tree height, half-logs		8-foot half-log position in tree									
		1	2	3	4	5	6	7	8	9	10
Number		Percent of total board-foot tree volume									
1	2	100									
2	3	66	34								
3	4	52	32	16							
4	5	43	30	18	9						
5	6	36	26	18	12	8					
6	7	31	23	18	14	9	5				
7	8	28	20	16	13	10	7	6			
8	9	25	18	15	13	10	9	6	4		
9	10	23	16	14	12	10	9	7	5	4	
10		21	15	13	11	10	9	7	6	4	4

Product Specifications and Grades

Ponderosa Pine Commercial Poles

All trees 9.0 through 20.9 inches in diameter and of acceptable pole form are considered potential poles. Grading specifications for commercial poles were adapted from those of the American Standards Association (1963).

Inadmissible defects in commercial poles include

- sweep (deviation greater than 1/3 d.b.h.)
- major crook (deviation greater than 1/2 pole diameter at crook)
- knots larger than 4 inches in diameter (dead or green)

—knot whorls or clusters aggregating more than 8 inches of knot diameter within 1 linear foot

—fork

—heart rot

—lightning scar

—fire scar

—compression wood (considered present in stems leaning 10° or more)

For trees meeting minimum merchantable specifications, stem length to the first limiting defect, such as length to first inadmissible knot, is field recorded. Such defects as fork, crook, and fire scar, if located near the butt or top of the stem, may not eliminate the pole but require a reduction of acceptable pole length.

Programed grading procedures scan defect data for stem sections included in pole height, and either verify or change recorded pole height as necessary.

Ponderosa Pine Saw Logs

All trees 11.0 inches d.b.h. and larger are considered sawtimber trees, and logs 8.0 inches

and larger in scaling diameter are evaluated as saw logs.

All grading specifications apply to 16-foot log lengths. The same specifications apply to shorter logs, in proportion to their length.

All logs meeting the minimum merchantability standards are graded by the improved grading system for ponderosa pine logs (Gaines 1962).

Abbreviated grading specifications are as follows:

Grade	<u>Defects Permitted</u>	
	<u>Primary (log knots)</u>	<u>Secondary (scar, etc.)</u>
1	One log knot not over $\frac{1}{2}$ inch in diameter.	Confined to three 4-foot panels or less.
2	Confined to four 4-foot panels or less.	Secondary plus primary confined to six 4-foot panels.
3	Six 4-foot panels free of all grading defects.	
4	(Logs of the type described by grade 4 of this system do not generally occur in southwestern ponderosa pine; consequently, the grade is omitted from consideration.)	
5	All other logs with net scale of one-third or more of gross scale.	

Programed grading instructions estimate the number of clear 4-foot panels in each log, based on recorded knot data. Accumulated panel count is used to assign a log grade to the log, as follows:

Clear panels, 1/4 circumference x 4 feet	Log grade
15-16	1
12-14	2
5-11	3
Less than 5	5

Ponderosa Pine Veneer Logs

Logs 10.0 inches and larger in scaling diameter are considered potential veneer logs.

All grading specifications apply to 8-foot log lengths.

Logs that meet the minimum merchantability requirements for veneer logs are graded according to the following arbitrary grading rules for ponderosa pine veneer logs, written for use in multiproduct inventory analysis.

GRADE I Veneer logs from which a high proportion of grade A and B

veneer can probably be recovered.

Grade Specifications

Dead knots - none allowed.
Green knots - allowed up to 2 inches in diameter.

GRADE II Veneer logs from which a high proportion of grade C veneer can probably be recovered.

Grade Specifications

Dead knots - allowed up to 2 inches in diameter.
Green knots - allowed up to 2 inches in diameter.

GRADE III Veneer logs from which a high proportion of grade D veneer can probably be recovered.

Grade Specifications

Dead knots - allowed up to 3 inches in diameter.
Green knots - allowed without size limit.

UNACCEPTABLE Logs identified as "grade 4" for computer programing and output purposes.

Dead knots - 4 inches or more in diameter.

Ponderosa Pine Stud Logs

Logs 6.0 through 16.9 inches in scaling diameter are considered potential stud logs.

All grading specifications apply to 8-foot log lengths.

Logs that meet basic size requirements for stud logs are graded according to the following arbitrary grading rules for ponderosa pine stud logs, written for use in multiproduct inventory analysis.

GRADE I Stud logs from which a high proportion of SELECT and CONSTRUCTION grade studs can probably be recovered.

Grade Specifications

Dead knots - allowed to 1 inch in diameter.

Green knots - allowed to 2 inches in diameter.

Total number of knots - cannot exceed 16.

GRADE II Stud logs from which a high proportion of STANDARD grade studs can probably be recovered.

Grade Specifications

Dead knots - allowed to 2 inches in diameter.

Green knots - allowed to 2 inches in diameter.

Total number of knots - cannot exceed 32.

GRADE III Stud logs from which a high proportion of UTILITY and ECONOMY grade studs can probably be recovered.

Grade Specifications

Dead knots - allowed to 2 inches in diameter.

Green knots - allowed to 3 inches in diameter.

Total number of knots - unlimited.

UNACCEPTABLE Logs identified as "grade 4" for computer programming and output purposes.

Dead knots - 3 inches or more in diameter.

Green knots - 4 inches or more in diameter.

Sample Tree Unit Record

The unit record for each sample tree includes the following descriptive and computed variables applicable to the tree, printed in the following order:

Tree diameter class (K)
Sample number (ISTR)

Sample identification data (IDMY)

Tree d.b.h. (DBH)

Commercial pole merchantable height (IPLHT)

Defect occurrence:

Sweep (Class 1, 2: ISWP)

Crook (Location and Class 1, 2: IPCR, ICRK)

Fork (Location and occurrence: IPFK, IFRK)

Fire scar (Class 1, 2: IFS)

Lightning scar (Class 1, 2: ILS)

Knot data:

Count, size, first stem section KNOT (N,L,D)

Count, size, second stem section KNOT (N,L,D)

Count, size, third stem section KNOT (N,L,D)

Clear face count, fourth stem section I24P(N)

Half-log merchantable tree height (ITRHT)

Lean (Class 1, 2, 3: LEAN)

Indication of internal rot (IROT)

Pole selector indicator (0 = No, 1 = Yes) (KP)

Total tree cubic-foot volume to 4-inch top (TCFV)

Total tree board-foot volume to saw log top (TBFV)

Vol./Acre expansion factor used for tree (EF)

Volume of saw logs (board feet), by log position and grade

BFSW(1,1), grade 1, log position 1

BFSW(2,2), grade 1, log position 2

BFSW(1,3), grade 1, log position 3

BFSW(1,4), grade 1, log position 4

BFSW(1,5), grade 1, log position 5

Repeat for saw log grades 2, 3, 4 (grade 4 = 5)

Volume of veneer logs (board feet), by log position and grade

BFVN(1,1), grade 1, log position 1

BFVN(1,2), grade 1, log position 2

BFVN(1,3), grade 1, log position 3

Repeat for veneer log grades 2, 3, 4 (grade 4 = unacceptable)

Volume of stud logs (board feet), by log position and grade

BFST(1,1), grade 1, log position 1

BFST(1,2), grade 1, log position 2

BFST(1,3), grade 1, log position 3

Repeat for stud log grades 2, 3, 4 (grade 4 = unacceptable)

Volume of pulpwood (cubic feet); top piece and other sections

CFPL(1), in top, saw log to 4-inch top

CFPL(2), all sections not acceptable for other products

APPENDIX B

```

PROGRAM MULTI
1 INPUT, OUTPUT, TAPE5=INPUT, TAPE3=OUTPUT, TAPE1, TAPE4)
C-----COMPUTER PROGRAM TO CONVERT MULTIPRODUCT INVENTORY DATA TO YIELD
C-----BY PRODUCT
C-----BY
C-----JACK O. HEIOT AND DONALD A. JAMESON
C-----ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION
C-----PROGRAM CONTROL CAROS
C-----
C-----DATA CARO(S) TYPE A
C-----
C-----A SET OF THREE CAROS TO INPUT THE PERCENT OF TOTAL CUBIC FOOT VOL.
C-----BY 8-FT. STEM SECTIONS. SEE PROG. DESCRIPTION FOR ORDER AND FORMAT
C-----
C-----DATA CARO(S) TYPE B
C-----
C-----A SET OF THREE CAROS TO INPUT THE PERCENT OF TOTAL BOARD FOOT VOL.
C-----BY 8-FT. STEM SECTIONS. SEE PROG. DESCRIPTION FOR ORDER AND FORMAT
C-----
C-----DATA CARO(S) TYPE C
C-----
C-----A SET OF TWO CAROS TO INPUT THE PERCENT OF TOTAL BOARD FOOT VOL.
C-----BY 16-FT. STEM SECTIONS(SAWLOGS). SEE PROG. DESCRIPTION FOR ORDER
C-----AND FORMAT
C-----CONTROL CARO TYPE 1
C-----
C-----PROB(1)=PROBLEM IDENTIFIER
C-----
C-----CONTROL CARO TYPE 2
C-----
C-----IN=0 INDICATES TREE DATA TO BE INPUT FROM CAROS
C-----IN=1 INDICATES TREE DATA TO BE EVALUATED
C-----NSAM=NUMBER OF SAMPLE UNITS IF CLUSTER SAMPLING IS USED, NSAM IS
C-----THE NUMBER OF CLUSTERS.
C-----FOR PROPORTIONAL ROT REDUCTION, R=NON-ZERO
C-----NPROD=NUMBER OF PRODUCTS TO BE EVALUATED
C-----IP(1)=PRODUCT PRIORITY
C-----IF USING PRIMARY PRODUCT SELECTION CRITERIA IP(1) SPECIFIES ORDER
C-----OF PRODUCT PRIORITIES
C-----FOR PLOTLESS CRUISING, EXPC=0, FOR FIXED PLOT SIZE CRUISING,
C-----EXPC=1 IS A CONVERSION FACTOR TO ADJUST RESULTS BASED ON PLOT SIZE
C-----
C-----CONTROL CARO TYPE 3
C-----
C-----JON=1 INDICATES PRIMARY PRODUCT SELECTION CRITERIA
C-----JON=2 INDICATES SAMPLE WILL BE EVALUATED FOR ALL PRODUCTS
C-----JON=3 GIVES BOTH TYPES OF EVALUATION
C-----FOR POLE STUDY, KPOLE=1, TO OMIT KPOLE=0
C-----FOR SAWLOG STUDY KSAW=1, TO OMIT KSAW=0
C-----FOR VENER STUDY, KVENR=1, TO OMIT KVENR=0
C-----FOR STUD LOG STUDY, KSTUO=1, TO OMIT KSTUO=0
C-----FOR PULP STUDY KPULP=1, TO OMIT KSTUO=0
C-----FOR UNIT RECORD OUTPUT TAPE, JON=2OR3, KOUT=1, TO OMIT KOUT=0
C-----FOR INDIVIDUAL TREE COMPUTATIONS IBUG=1, TO OMIT IBUG=0
C-----FOR GROSS VOL OUTPUT KVOL=1, FOR ADJUSTED GROSS VOL OUTPUT KVOL=2
C-----UNIT RECORD OUTPUT IS ACCUMULATED ONLY FOR GROSS VOL, KVOL=1.
C-----BAFV=BASEL AREA FACTOR VALUE OF THE PRISM OR ANGLE GAUGE USED IN
C-----PLOTLESS CRUISING
C-----
C-----CONTROL CARO TYPE 4
C-----
C-----THIS CARO WILL BE READ ONLY ON INITIAL PASS THROUGH DATA
C-----POINT(1) = NUMBER OF PLOTS PER CLUSTER
C-----USE ADDITIONAL CAROS IF NEEDED
C-----IF CLUSTER SAMPLING IS NOT USED, POINT(1)=1 FOR ALL ENTRIES
C-----
C-----COMPUTED CONTROL VARIABLES
C-----
C-----KMAX=MAXIMUM DIAMETER CLASS IN DATA
C-----KMIN=MINIMUM DIAMETER CLASS IN DATA
C-----IND(1)=PRIOR USE INDICATOR
C-----KOUNT(1)=NUMBER OF TREES PER DIAMETER CLASS
C-----NBORE= NUMBER OF TREES BORED
C-----NROT = NUMBER OF BORED TREES WITH ROT
C-----
C-----INDIVIDUAL TREE DATA CAROS
C-----
C-----THESE CAROS WILL NOT BE READ IF IN.NE.O
C-----I$TR=SAMPLE NUMBER
C-----IOMY=OUMMY VARIABLE, CAN BE USED FOR TREE IO INFORMATION
C-----OBH=DIAMETER BREAST HIGH
C-----PLHT=POLE HEIGHT
C-----ISWP=SWEEP CLASS
C-----IPCR=CROOK LOCATION
C-----ICRK=CROOK LOCATION
C-----IPFK=FORK LOCATION
C-----IFRK=FORK CLASS
C-----IFS=FIRES SCAR
C-----ILS=LIGHTNING SCAR
C-----KNOT(L,M)=KNOT NUMBER AND SIZE
C-----I24P(1)=CLEAR FACE CLASSES
C-----ITRHT=TREE HEIGHT IN HALF LOGS
C-----LEAN=LEAN CLASS
C-----IROT=ROT CLASS
C-----END TREE DATA CARO INPUT WITH ONE BLANK CARO
C-----
C-----INDICATORS INTERNAL IN THE PROGRAM
C-----VARIABLE DIMENSIONS OF ALL DIMENSIONED VARIABLES ARE SHOWN IN
C-----DATA STATEMENT, SEE SUBROUTINE DIMENSIONS FOR GUIDE
C-----NO CHANGES ARE REQUIRED IN SUBR. AS VARIABLE DIMENSIONS ARE USED
C-----IN SAM EQUAL TO OR GREATER THAN NSAM
C-----IN MAX EQUAL TO OR GREATER THAN KMAX
C-----FOR UNIT RECORD OUTPUT, REQUEST TAPE4 FOR OUTPUT. HAS EOF MARK END
C-----
DIMENSION SAWV(4,4,40), VENV(4,4,40), STUO(4,4,9), PLHT(1,1,5,20),
1 PLHT(2,4,15), TOTAL(4,4), POINT(4,1), PULPV(4), KCUV(65), KBFV(55),
2 KDFV(16,29)
C
COMMON KNOT(3,4,3), I24P(4,4), IP(1,1), INO(10), KOUNT(SO), Y(15), S(15),
1 PROB(8), PCUV(11), PBFV(10), PBFV(16,5), BFW(4,5), BFW(4,3),
2 BFW(14,3), CFPL(2), NPROD, KMIN, KMAX, NSAM, K, ISTR, OBH, IPLHT, ISWP,
3 IPCR, ICRK, IPFK, IFRK, IFS, ILS, ITRHT, LEAN, IROT, NSAW, NVENR, NSTUO, JON,
4 LAST, TCFV, TBV, IBUG, ICARO, PRISM, KP, IOMY, KVOL, EF
C
EQUIVALENCE (SAWV(1,1,1), PLHT(2,1,1)), (SAWV(1,1,5), TOTAL(1,1,1)),
1 (SAWV(1,1,6), PULPV(1,1)), (SAWV(1,1,7), POINT(1,1)), (SAWV(1,1,9), VENV(
2 1,1,10))
C
DATA IMAX, ISAM/40,4/
KPASS=0
NHEC=0
KP=0
EF=0.0
DO 100 I=1,4

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20 NSAW=NSAW+1
CALL SAW (SAWV,POINT,TOTAL,ISAM,IMAX)
GO TO 23
21 NVENR=NVENR+1
CALL VENR (VENRV,POINT,TOTAL,ISAM,IMAX)
GO TO 23
22 NSTUD=NSTUD+1
CALL STUD (STUDV,POINT,TOTAL,ISAM,IMAX)
23 CONTINUE
CALL PULP (PULPV,POINT,TOTAL,ISAM,IMAX)
LAST=2
24 CONTINUE
25 CONTINUE
C-----
C-----BEGIN ALL PRODUCT ROUTINES
C-----
IF (JONREF.NE.3) GO TO 999
26 JON=2
HEWIND 1
ICARO=0
IF (IRUG.EQ.1) WRITE (3,40) PROROT
LAST=1
C-----
C-----READ AND EVALUATE DATA FOR SELECTED PRODUCTS
C-----
DO 38 KX=KMIN,KMAX,2
LIM=KOUNT(K)
IF (LIM.EQ.0) GO TO 3R
DO 37 J=1,LIM
DO 27 I=1,10
27 INDI=0
READ(1,K,1) ISTAT, IOMY, OBH, IPLHT, ISWP, IPCR, ICRK, IPFK, IFRK, IFS, ILS, ((
IKNOT(L,M,N),M=1,3),M=1,4),L=1,3), (I24P(1),I=1,4), ITRHT, LEAN, IROT
IF (ITRHT.LF.0) WRITE(3,471) ITRHT, IOMY
IF (ITRHT.LE.0) GO TO 37
CALL VOLUM (KCUVB,KBFVB,KBFV6,BAFV)
C-----
C-----IF RANDOM NUMBER GENERATOR (RANF(1)) IS NOT USED TO DETERMINE SUB-
C-----SAMPLE FOR ROT REDUCTION, INSERT A GO TO 30 BRANCH CARD HERE. R=0
C-----
C
GO TO 30
IF (RANF(1).LT.PROROT) 28,29
28 IROT=2
GO TO 30
29 IROT=0
30 IF (IRUG.EQ.0) GO TO 32
ICARO=ICARO+1
WRITE(3,49) ICARO, ISTAT, POINT(ISTRT), EF,K,OBH, IPLHT, ITRHT, ISWP,
LEAN, ICRK, IPCR, IFRK, IPFK, IFS, ILS, IROT, (I24P(1),M=1,4)
DO 31 M=1,4
DO 31 M=1,4
31 WRITE (3,51) L,M,(KNOT(L,M,N),N=1,3)
32 IF (IKX.EQ.KMAX) AND (IJEQ.LIM) LAST=3
IF (KPOL.EQ.0) GO TO 33
CALL POLE (PLHT2,POINT,TOTAL,ISAM,IMAX,PLHT1)
33 IF (KSAM.EQ.0) GO TO 34
NSAM=0
CALL SAW (SAWV,POINT,TOTAL,ISAM,IMAX)
34 IF (KVENR.EQ.0) GO TO 35
NVENR=0
CALL VENR (VENRV,POINT,TOTAL,ISAM,IMAX)
35 IF (KSTUD.EQ.0) GO TO 36
NSTUD=0
CALL STUD (STUDV,POINT,TOTAL,ISAM,IMAX)
36 IF (KPULP.EQ.0) GO TO 60
CALL PULP (PULPV,POINT,TOTAL,ISAM,IMAX)
60 IF (KROT.EQ.0) GO TO 62
IF (KROT.EQ.1) IPLHT=IPLHT+5
WRITE(4) K, ISTAT, IOMY, OBH, IPLHT, ISWP, IPCR, ICRK, IPFK, IFRK, IFS, ILS,
((IKNOT(L,M,N),M=1,3),M=1,4),L=1,3), (I24P(1),I=1,4), ITRHT, LEAN,
IROT, KP, TCFV, TBFV, EF, ((RFSW(1,L),L=1,5),I=1,4), ((RFSV(1,L),L=1,3),
I=1,4), ((RFS(1,L),L=1,3),I=1,4), ((CFPL(1),I=1,2)
NREC=NREC + 1
62 LAST=2
37 CONTINUE
38 CONTINUE
ENDFILE 4
HEWIND 4
IF (KOUT.EQ.0) GO TO 999
WRITE(3,53) NREC
WRITE(3,54) K, ISTAT, IOMY, OBH, IPLHT, ISWP, IPCR, ICRK, IPFK, IFRK, IFS,
ILS, ((IKNOT(L,M,N),M=1,3),M=1,4),L=1,3), (I24P(1),I=1,4), ITRHT, LEAN,
IROT, KP, TCFV, TBFV, EF, ((RFSW(1,L),L=1,5),I=1,4), ((RFSV(1,L),L=1,3),
I=1,4), ((RFS(1,L),L=1,3),I=1,4), ((CFPL(1),I=1,2)
GO TO 999
39 CALL EXIT
C-----
40 FORMAT (3A10)
41 FORMAT (1H0= SAMPLE SIZE*16,2X* LARGER THAN ALLOWABLE, SEE DATA STATE
MENT)
42 FORMAT (2I5,F5.3,12I5,F5.0)
43 FORMAT (9I5,2X,F9.4)
44 FORMAT (16F5.0)
45 FORMAT (2X12,I7,F5.2,1,12,1X11,I1211,2X1211,2X1211,2X411,1X12,
11X1211)
46 FORMAT (1H0=DIAMETER*F6.2,2X* EXCEEDS MAXIMUM ALLOWABLE, DATA FROM
THIS TREE NOT USED)
47 FORMAT (1H *SAMPLE NUMBER*16,2X* EXCEEDS MAXIMUM ALLOWABLE, DATA FR
OM THESE SAMPLES NOT USED)
48 FORMAT (1H *TREE HEIGHT*14,2X* EXCEEDS MINIMUM OR MAXIMUM FOR VOL CA
LCULATION, DATA FOR TREE 1H10,* NOT USED)
49 FORMAT (1H1,130(==)/1H0= TREE STATISTICS PIECE BY PIECE*F20.5,3X*0
IF BUTT LUGS DISCARDED BASED ON ROT SAMPLE*F1H0,130(==))
50 FORMAT (1H,130(==)/1H *SAMPLE NUMBER*16,* SAMPLE NUMBER*15,* SUB
PLOTS IN THIS CLUSTER*F5.0,* VOLUME/ACRE EXPANSION FACTOR*F9.4,* TREE
2 SIZE DIAMETER CLASS*1,* DIAMETER*F6.2,* POLE HEIGHT*13,* L
3 TREE HEIGHT*13/* EFFECTS SWEEP*12,* LEAN*12,* CROOK*12,* CROO
4 LOCATION*12,* FORK*12,* FORK LOCATION*12,* FIRE SCAR*12,* LT
SGHTNING SCAR*12,* ROT*12/* CLEAR FACES IN FOURTH PIECE*F412,* KNO
6TS PIECE FACC TOTAL LIVE OEOA)
50 FORMAT (1H *H10,412)
51 FORMAT (1H *H10,412)
52 FORMAT (1H0= END-OF-RUN TOTAL RECORDS OUTPUT ON TAPE 4 UNDER OPTI
MUM 2 *15,* LAST RECORD PROCESSED WAS=)
54 FORMAT (1H1,13,14,19,F6.2,13,1X1212,1X1212,1X1212,1X1212,1X412,13,
1212,1X12,1X12,2F6.2,F9.4,1H0,2X,20F6.2,1H0,2X,20F6.2,1H0,2X,6F6.2)
END
SUBROUTINE POLE (PLHT2,POINT,TOTAL,ISAM,IMAX,PLHT1)
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POL 9560
POL 9570
POL 9580
POL 9590
POL 9600
POL 9610
POL 9620
POL 9630
POL 9640
POL 9650
POL 9660
POL 9670
POL 9680
POL 9690
POL 9700
POL 9710
POL 9720
POL 9730
POL 9740
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POL 9890
POL 9900
POL 9910
POL 9920
POL 9930
POL 9940
POL 9950
POL 9960
POL 9970
POL 9980
POL 9990

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C TEST FOR TWO OR MORE HALF LOGS IN TREE
C
5 IF (ITRHT-2)200,6,6
6 LOG=1
  LPC1=1
  LPC2=2
  IF (ITRHT.GT.2) GO TO 8
  KHT=0
  GO TO 10
8 KHT=1
10 GO TO (12,14,12),JON
12 IF (IN0(LPC1)+IN0(LPC2)-1)14,47,47
C
C GRADE FIRST LOG (2 SECTIONS)
C
14 NP=0
  00 22 L=1,2
  NO=0
  NI=0
  00 20 M=1,4
  IF (KNOT(L,M,1)-1)16,18,20
16 NO=NO + 2
  GO TO 20
18 NI=NI + 1
20 CONTINUE
22 CONTINUE
  NP=NP+NO+NI
  IF (NP)26,26,24
24 GO TO (26,26,26,26,28,28,28,28,28,28,28,30,30,30,32,32),NP
C
C IGR=4 DENOTES LOG GRADE 5
C
26 IGR=4
  IRG=5
  GO TO 34
28 IGR=3
  IRG=3
  GO TO 34
30 IGR=2
  IRG=2
  GO TO 34
32 IGR=1
  IRG=1
34 GO TO (36,40,36),JON
36 IF (NSAW-IGR)47,38,47
38 IN0(LPC1)=1
  IN0(LPC2)=1
40 IF (KVOL-1) 903,903,900
C
C ADJUST GROSS LOG VOL FOR VISUAL DEFECTS FOR 16FT LOG
C
900 PCNT=0.0
  IF (ILS.EQ.1) PCNT=PCNT + .25
  IF (ILS.EQ.2) PCNT=PCNT + .50
  IF (ISWP.EQ.2) PCNT=PCNT + .20
  IF (IFS.EQ.2.AND.LPC1.EQ.1) PCNT=PCNT + .13
  IF (IFRK.GT.0.AND.IPCR.EQ.LPC1.OR.IPCR.EQ.LPC2) PCNT=PCNT + .25
  IF (IFRK.GT.0.AND.IPKF.EQ.LPC1.OR.IPKF.EQ.LPC2) PCNT=PCNT + .25
C
C A00 INTO REGISTERS
C
41 IF (PCNT-1.) 42,44,44
42 VLM=PBFEV16(LOG)-(PBFEV16(LOG)*PCNT)
43 VLM=CVOL(VLM,PRISM,EF)
  GO TO 46
44 VLM=0.0
  IF (LPC1.EQ.LPC2) GO TO 45
  IN0(LPC1)=0
  IN0(LPC2)=0
  GO TO 46
45 IN0(LPC1)=0
46 VCNT(I1STR,I1GR,K)=VCNT(I1STR,I1GR,K) + VLM
  IF (I1BUE.EQ.1.AND.LAST.NE.3) GO TO 904
  GO TO 47
C
C NO GROSS LOG VOL ADJUSTMENT FOR VISUAL DEFECTS 16FT LOG
C
903 VLM=PBFEV16(LOG)
  BFW=I1GR,LOG=8FWSW(IGR,LOG) + VLM
  GO TO 43
C
904 GO TO (906,908),KVOL
908 WRITE(3,57) ICARO,LOG,IRG,VLM,K,PCNT
571 FORMAT(1H *TREE NUMBER*16,2X *LOG*13,2X*ACCEPTED AS SAWLOG GRADE*
  113,2X*WIDTH ADJUSTED WT VOL OF*F10.3,2X*DIAMETER CLASS*13,2X*PRV *
  2F5.2)
  GO TO 47
906 WRITE(3,570) ICARO,LOG,IRG,VLM,K
570 FORMAT(1H *TREE NUMBER*16,2X *LOG*13,2X*ACCEPTED AS SAWLOG GRADE*
  113,2X*WIDTH WEIGHTED VOLUME OF*F10.3,2X*DIAMETER CLASS*13)
C
C TEST FOR SECOND LOG
C
47 CONTINUE
  GO TO (48,48,98,98,118,118,126,126,200,200),LPC2
48 IF (KHT)200,200,50
50 IF (ITRHT-4)52,82,82
C
C ITRHT=3 NEXT SECTION IS HALF LOG (8FT)
C
52 LOG=2
  LPC1=3
  LPC2=3
  KHT=0
  GO TO (54,56,54),JON
54 IF (IN0(LPC1))56,56,47
C
C GRADE A HALF LOG SECTION (8FT)
C
56 NO=0
  NI=0
  00 62 M=1,4
  IF (KNOT(3,M,1)-1)58,60,62
58 NO=NO + 2
  GO TO 62
60 NI=NI + 1
62 CONTINUE
  NP=NP+NI
  NP=NP+2
  IF (NP)66,66,64
64 GO TO (66,66,66,66,68,68,68,68,68,68,68,70,70,70,72,72),NP
C
C IGR=4 DENOTES GRADE 5
C
66 IGR=4
  IRG=5
  GO TO 74

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GO TO 924
922 WRITE(3,598) NSWW
924 WRITE(3,600)
212 DO 214 I=1,NSAM
   ON 214 J=1,4
214 TOTAL(I,J)=0.0
   DO 226 KK=KMN,KMAX,2
   ON 216 J=1,4
216 CALL STOR (NSAM,Y(I),S(I),VCNT(I,J,KK),POINT)
218 WRITE(3,610) KK,(Y(I),I=1,4)
C
C SINGLE PRODUCT OUTPUT
C
   WRITE(3,620) (S(I),I=1,4)
   GO TO 222
C
C PRODUCT PRIORITY OUTPUT
C
220 WRITE(3,630) KK,Y(NSAM)
   WRITE(3,640) S(NSAM)
222 DO 224 J=1,4
   ON 224 I=1,NSAM
224 TOTAL(I,J)=TOTAL(I,J)+VCNT(I,J,KK)
226 CONTINUE
   DO 228 J=1,4
228 CALL STOR (NSAM,Y(J),S(J),TOTAL(I,J),POINT)
230 WRITE(3,650) (Y(I),I=1,4)
   WRITE(3,660) (S(I),I=1,4)
   GO TO 500
232 WRITE(3,670) Y(NSAM)
   WRITE(3,680) S(NSAM)
500 RETURN
C
580 FORMAT (1H1,8A10)
586 FORMAT(1H0,130(==)/1H0*SAWLOGS CONSIDERED AS SINGLE PRODUCT GRO
   155 VOLUME NOT ADJUSTED FOR VISUAL DEFECTS*)
588 FORMAT(1H0,130(==)/1H0*SAWLOGS CONSIDERED AS SINGLE PRODUCT GRO
   155 VOLUME ADJUSTED FOR VISUAL DEFECTS*)
590 FORMAT(1H0,130(==)/1H0*DIAMETER*32X*BOARD FOOT VOLUMES PER ACRE B
   1Y GRADE*/1H0* CLASS*25X*17X*2*17X*3*17X*5*/1H0,130(==))
596 FORMAT(1H0,130(==)/1H0*GRADE*13,* SAWLOG VOLUMES BASED ON PRODUCT
   1Y CRITERIA GROSS VOLUME NOT ADJUSTED FOR VISUAL DEFECTS*)
598 FORMAT(1H0,130(==)/1H0*GRADE*13,* SAWLOG VOLUMES BASED ON PRODUCT
   1Y CRITERIA GROSS VOLUME ADJUSTED FOR VISUAL DEFECTS*)
600 FORMAT(1H0,130(==)/1H0*DIAMETER*17X*BOARD FOOT VOLUMES PER ACRE *
   1YH * CLASS*/1H0,130(==))
610 FORMAT (1H0,14,6X,*MEAN*F20.2,3(F18.2))
620 FORMAT (1H ,10X*STO ERR*F17.2,3(F18.2))
630 FORMAT (1H0,14,24X*MEAN*F20.2)
640 FORMAT (1H ,28X*STO ERR*F17.2)
650 FORMAT (1H0,130(==)/1H0*TOTAL MEAN*3X,F20.2,3(F18.2))
660 FORMAT (1H0*STO ERR MEAN*2X,F20.2,3(F18.2)/1H0,130(==))
670 FORMAT (1H0,130(==)/1H0*TOTAL*23X*MEAN*F20.2)
680 FORMAT (1H0,28X*STO ERR*F17.2/1H0,130(==))
   END
SUBROUTINE VENTR (VCNT,POINT,TOTAL,ISAM,IMAX)
C-----
C-----GRADES FOR VENEER POTENTIAL USING A THREE GRADE SYSTEM
C-----ACCUMULATES VENEER VOLUMES
C-----
   DIMENSION VCNT(15AM,4,IMAX),POINT(15AH),TOTAL(15AM,4)
C
   COMMON KNOT(3,4,3),I24P(4),IP(11),INO(10),KOUNT(50),Y(15),S(15),
   1PROB(8),PCUV(8),PFCV(8),PFCV(8),PFCV(8),PFCV(8),PFCV(8),PFCV(8),
   28FST(4,3),CFPL(2),NPROD,KMN,KMAX,NSAM,K,ISTRT,OBH,IPMT,ISWP,
   3IPCR,ICRK,IPFK,IFRK,IFS,ILS,ITRHT,LEAN,IROT,NSAM,NVENR,NSTUD,JON,
   4LAST,TCFV,TBFV,IRUG,ICARO,PRISM,KP,10MY,KVOL,EF
C-----
   GO TO (1,3,3), LAST
   1 KMN=10
   IF (KMN.GT.10) KMN=KMIN
   DO 2 KK=KMN,KMAX,2
   ON 2 J=1,4
   ON 2 I=1,NSAM
2 VCNT(I,J,KK)=0.0
3 IF (K.LE.10) GO TO 21
   IF (K-14) 4,5,6
4 LIM=1
   GO TO 7
5 LIM=2
   GO TO 7
6 LIM=3
7 LIM=AMINO(LIM,ITRHT)
   IF (VENEER-18,8,10)
8 DO 9 I=1,4
   ON 9 J=1,3
9 OFVN(I,J)=0.0
10 DO 20 L=1,LIM
   GO TO (50,52),JON
50 IF (INO(L))52,52,20
C-----
C-----GRAING SECTION
52 IGR=1
   DO 54 M=1,4
   IF (KNOT(L,M,3).GT.0.OR.KNOT(L,M,2).GT.2) IGR=AMAXO(IGR,2)
   IF (KNOT(L,M,3).GT.2.OR.KNOT(L,M,2).GT.2) IGR=AMAXO(IGR,3)
   IF (KNOT(L,M,3).GT.3) IGR=4
   IF (KNOT(L,M,3).GT.3) GO TO 55
54 CONTINUE
   IF (K.LT.16) IGR=AMAXO(IGR,2)
55 CONTINUE
   GO TO (56,60),JON
56 IF (VENEER-IGR)20,58,20
58 INOI=1
60 IF (VOL-1)102,102,100
C-----
C-----ADJUST GROSS LOG VOL FOR VISUAL DEFECTS
100 PCNT=0.0
   IF (IROT.GT.1.AND.L.EQ.1) PCNT=PCNT + 1.0
   IF (ICRK.GE.2.AND.L.EQ.1) PCNT=PCNT + 1.0
   IF (ICRK.GE.1.AND.L.EQ.1) PCNT=PCNT + .5
   IF (IFRK.GE.2.AND.L.EQ.1) PCNT=PCNT + .5
   IF (IFS.GE.2) PCNT=PCNT + .5
   IF (ILS.GE.2) PCNT=PCNT + .25
   IF (IFS.GE.2.AND.L.FO.1) PCNT=PCNT + .25
C-----
C-----ADD INTO REGISTERS
   IF (PCNT-1,70,72,72)
70 VLM=(PFCV(L)-(PFCV(L)*PCNT))
71 VLM=CVOL(VLM,PRISM,EF)
   GO TO 74
   SAW2830
   SAW2840
   SAW2850
   SAW2860
   SAW2870
   SAW2880
   SAW2890
   SAW2900
   SAW2910
   SAW2920
   SAW2930
   SAW2940
   SAW2950
   SAW2960
   SAW2970
   SAW2980
   SAW2990
   SAW3000
   SAW3010
   SAW3020
   SAW3030
   SAW3040
   SAW3050
   SAW3060
   SAW3070
   SAW3080
   SAW3090
   SAW3100
   SAW3110
   SAW3120
   SAW3130
   SAW3140
   SAW3150
   SAW3160
   SAW3170
   SAW3180
   SAW3190
   SAW3200
   SAW3210
   SAW3220
   SAW3230
   SAW3240
   SAW3250
   SAW3260
   SAW3270
   SAW3280
   SAW3290
   SAW3300
   SAW3310
   SAW3320
   SAW3330
   SAW3340
   SAW3350
   SAW3360
   SAW3370
   SAW3380
   SAW3390
   VEN 10
   VEN 20
   VEN 30
   VEN 40
   VEN 50
   VEN 60
   VEN 70
   VEN 80
   VEN 90
   VEN 100
   VEN 110
   VEN 120
   VFN 130
   VEN 140
   VEN 150
   VEN 160
   VEN 170
   VEN 180
   VEN 190
   VEN 200
   VEN 210
   VEN 220
   VEN 230
   VEN 240
   VFN 250
   VEN 260
   VEN 270
   VEN 280
   VEN 290
   VEN 300
   VEN 310
   VEN 320
   VEN 330
   VEN 340
   VEN 350
   VEN 360
   VEN 370
   VEN 380
   VEN 390
   VEN 400
   VEN 410
   VEN 420
   VEN 430
   VEN 440
   VEN 450
   VEN 460
   VEN 470
   VEN 480
   VFN 490
   VEN 500
   VEN 510
   VEN 520
   VEN 530
   VEN 540
   VEN 550
   VEN 560
   VEN 570
   VEN 580
   VEN 590
   VEN 600
   VEN 610
   VEN 620
   VEN 630
   VEN 640
   VEN 650
   VEN 660
   VEN 670
   VEN 680
   VFN 690
   VEN 700
   VFN 710
   72 VLM=0.0
   INOI=0
74 VCNT(ISTRT,IGR,K)=VCNT(ISTRT,IGR,K) + VLM
   IF (BUG.EQ.1.AND.LAST.NE.3) GO TO 104
   GO TO 20
C
C NO GROSS LOG VOL ADJUSTMENT FOR VISUAL DEFECTS
C
C 102 IF (IROT.GT.1.AND.L.EQ.1) GO TO 99
C 102 IF (ICRK.GT.1.AND.L.EQ.1) GO TO 99
C 102 IF (IFRK.GT.1.AND.L.EQ.1) GO TO 99
C 102 IF (IFS.GT.1) GO TO 99
C 102 IF (IFS.GE.2.AND.L.EQ.1) GO TO 99
102 VLM=PFCV(L)
   RFVN(IGR,L)=RFVN(IGR,L) + VLM
   GO TO 71
C
C SET INO SELECTOR OFF PIECE FAILED VISUAL DEFECTS TEST
C
C INOI=0
C GO TO 70
C
104 GO TO (108,106),KVOL
106 WRITE(3,361) ICARO,L,IGR,VLM,K,PCNT
   GO TO 20
108 WRITE(3,36) ICARO,L,IGR,VLM,K
20 CONTINUE
21 IF (LAST.NE.3) GO TO 35
   WRITE (3,37) (PROB(I),I=1,8)
   GO TO (23,22), JON
C-----
C-----SINGLE PRODUCT HEADING
22 GO TO (110,112),KVOL
110 WRITE(3,376)
   GO TO 114
112 WRITE(3,378)
114 WRITE(3,39)
   GO TO 24
C-----
C-----PRODUCT PRIORITY HEADING
23 GO TO (116,118),KVOL
116 WRITE(3,386) NVENR
   GO TO 120
118 WRITE(3,388) NVENR
120 WRITE(3,39)
24 DO 25 J=1,4
   ON 25 I=1,NSAM
25 TOTAL(I,J)=0.0
   DO 31 KK=KMN,KMAX,2
   ON 26 J=1,4
26 CALL STOR (NSAM,Y(I),S(I),VCNT(I,J,KK),POINT)
   GO TO (28,27), JON
C-----
C-----SINGLE PRODUCT OUTPUT
27 WRITE (3,40) KK,(Y(I),I=1,4)
   WRITE (3,41) (S(I),I=1,4)
   GO TO 29
C-----
C-----PRODUCT PRIORITY OUTPUT
28 WRITE (3,42) KK,(Y(NVENR)
   WRITE (3,43) S(NVENR)
29 DO 30 J=1,4
   ON 30 I=1,NSAM
30 TOTAL(I,J)=TOTAL(I,J)+VCNT(I,J,KK)
31 CONTINUE
   DO 32 J=1,4
32 CALL STOR (NSAM,Y(I),S(I),TOTAL(I,J),POINT)
   GO TO (34,33), JON
33 WRITE (3,44) (Y(I),I=1,4)
   WRITE (3,45) (S(I),I=1,4)
   GO TO 35
34 WRITE (3,46) Y(NVENR)
   WRITE (3,47) S(NVENR)
35 RETURN
C-----
36 FORMAT (1H *TREE NUMBER*16,2X*PIECE*13,2X*ACCEPTED AS VENEER GRADE
   1*13,2X*WITH WEIGHTED VOLUME OF*F10.3,2X*DIAMETER CLASS*13,2X*PRV
   361 FORMAT (1H *TREE NUMBER*16,2X*PIECE*13,2X*ACCEPTED AS VENEER GRADE
   1*13,2X*WITH ADJUSTED WT VOL OF*F10.3,2X*DIAMETER CLASS*13,2X*PRV
   2F5.2)
37 FORMAT (1H1,8A10)
376 FORMAT(1H0,130(==)/1H0*VENEER CONSIDERED AS A SINGLE PRODUCT GRO
   155 VOLUME NOT ADJUSTED FOR VISUAL DEFECTS*)
378 FORMAT(1H0,130(==)/1H0*VENEER CONSIDERED AS A SINGLE PRODUCT GRO
   155 VOLUME ADJUSTED FOR VISUAL DEFECTS*)
38 FORMAT(1H0,130(==)/1H0*DIAMETER*23X*BOARD FOOT VOLUMES PER ACRE B
   1Y GRADE*/1H0* CLASS*25X*17X*2*17X*3*17X*5*/1H0,130(==))
386 FORMAT(1H0,130(==)/1H0*GRADE*13,* VENEER BASED ON PRODUCT PRIORIT
   1Y CRITERIA GROSS VOLUME NOT ADJUSTED FOR VISUAL DEFECTS*)
388 FORMAT(1H0,130(==)/1H0*GRADE*13,* VENEER BASED ON PRODUCT PRIORIT
   1Y CRITERIA GROSS VOLUME ADJUSTED FOR VISUAL DEFECTS*)
39 FORMAT(1H0,130(==)/1H0*DIAMETER*17X*BOARD FOOT VOLUMES PER ACRE *
   1YH * CLASS*/1H0,130(==))
40 FORMAT (1H0,14,6X,*MEAN*F20.2,3(F18.2))
41 FORMAT (1H ,10X*STO ERR*F17.2,3(F18.2))
42 FORMAT (1H0,14,24X*MEAN*F20.2)
43 FORMAT (1H ,28X*STO ERR*F17.2)
44 FORAT (1H0,130(==)/1H0,*TOTAL MEAN*3X,F20.2,3(F18.2))
45 FORMAT (1H0*STO ERR MEAN*2X,F20.2,3(F18.2)/1H0,130(==))
46 FORMAT (1H0,130(==)/1H0*TOTAL*23X*MEAN*F20.2)
47 FORAT (1H0,28X*STO ERR*F17.2/1H0,130(==))
   END
SUBROUTINE STUD (VCNT,POINT,TOTAL,ISAM,IMAX)
C-----
C-----GRADES FOR STUO POTENTIAL USING A THREE GRADE SYSTEM
C-----ACCUMULATES STUO VOLUMES
C-----
   DIMENSION VCNT(15AM,4,9),POINT(15AM),TOTAL(15AM,4)
C
   COMMON KNOT(3,4,3),I24P(4),IP(11),INO(10),KOUNT(50),Y(15),S(15),
   1PROB(8),PCUV(8),PFCV(8),PFCV(8),PFCV(8),PFCV(8),PFCV(8),PFCV(8),
   28FST(4,3),CFPL(2),NPROD,KMN,KMAX,NSAM,K,ISTRT,OBH,IPMT,ISWP,
   3IPCR,ICRK,IPFK,IFRK,IFS,ILS,ITRHT,LEAN,IROT,NSAM,NVENR,NSTUD,JON,
   4LAST,TCFV,TBFV,IRUG,ICARO,PRISM,KP,10MY,KVOL,EF
C-----
   GO TO (1,3,3), LAST
   1 KMN=10
   IF (KMN.GT.10) KMN=KMIN
   DO 2 KK=KMN,KMAX,2
   ON 2 J=1,4
   ON 2 I=1,NSAM
2 VCNT(I,J,KK)=0.0
3 IF (KMN.GT.10) KMN=KMIN
   DO 4 KK=KMN,KMAX,2
   ON 4 J=1,4
   ON 4 I=1,NSAM
4 VCNT(I,J,KK)=0.0
5 IF (KMN.GT.10) KMN=KMIN
   DO 6 KK=KMN,KMAX,2
   ON 6 J=1,4
   ON 6 I=1,NSAM
6 VCNT(I,J,KK)=0.0
7 IF (KMN.GT.10) KMN=KMIN
   DO 8 KK=KMN,KMAX,2
   ON 8 J=1,4
   ON 8 I=1,NSAM
8 VCNT(I,J,KK)=0.0
9 IF (KMN.GT.10) KMN=KMIN
   DO 10 KK=KMN,KMAX,2
   ON 10 J=1,4
   ON 10 I=1,NSAM
10 VCNT(I,J,KK)=0.0
11 IF (KMN.GT.10) KMN=KMIN
   DO 12 KK=KMN,KMAX,2
   ON 12 J=1,4
   ON 12 I=1,NSAM
12 VCNT(I,J,KK)=0.0
13 IF (KMN.GT.10) KMN=KMIN
   DO 14 KK=KMN,KMAX,2
   ON 14 J=1,4
   ON 14 I=1,NSAM
14 VCNT(I,J,KK)=0.0
15 IF (KMN.GT.10) KMN=KMIN
   DO 16 KK=KMN,KMAX,2
   ON 16 J=1,4
   ON 16 I=1,NSAM
16 VCNT(I,J,KK)=0.0
17 IF (KMN.GT.10) KMN=KMIN
   DO 18 KK=KMN,KMAX,2
   ON 18 J=1,4
   ON 18 I=1,NSAM
18 VCNT(I,J,KK)=0.0
19 IF (KMN.GT.10) KMN=KMIN
   DO 20 KK=KMN,KMAX,2
   ON 20 J=1,4
   ON 20 I=1,NSAM
20 VCNT(I,J,KK)=0.0
21 IF (KMN.GT.10) KMN=KMIN
   DO 22 KK=KMN,KMAX,2
   ON 22 J=1,4
   ON 22 I=1,NSAM
22 VCNT(I,J,KK)=0.0
23 IF (KMN.GT.10) KMN=KMIN
   DO 24 KK=KMN,KMAX,2
   ON 24 J=1,4
   ON 24 I=1,NSAM
24 VCNT(I,J,KK)=0.0
25 IF (KMN.GT.10) KMN=KMIN
   DO 26 KK=KMN,KMAX,2
   ON 26 J=1,4
   ON 26 I=1,NSAM
26 VCNT(I,J,KK)=0.0
27 IF (KMN.GT.10) KMN=KMIN
   DO 28 KK=KMN,KMAX,2
   ON 28 J=1,4
   ON 28 I=1,NSAM
28 VCNT(I,J,KK)=0.0
29 IF (KMN.GT.10) KMN=KMIN
   DO 30 KK=KMN,KMAX,2
   ON 30 J=1,4
   ON 30 I=1,NSAM
30 VCNT(I,J,KK)=0.0
31 IF (KMN.GT.10) KMN=KMIN
   DO 32 KK=KMN,KMAX,2
   ON 32 J=1,4
   ON 32 I=1,NSAM
32 VCNT(I,J,KK)=0.0
33 IF (KMN.GT.10) KMN=KMIN
   DO 34 KK=KMN,KMAX,2
   ON 34 J=1,4
   ON 34 I=1,NSAM
34 VCNT(I,J,KK)=0.0
35 IF (KMN.GT.10) KMN=KMIN
   DO 36 KK=KMN,KMAX,2
   ON 36 J=1,4
   ON 36 I=1,NSAM
36 VCNT(I,J,KK)=0.0
37 IF (KMN.GT.10) KMN=KMIN
   DO 38 KK=KMN,KMAX,2
   ON 38 J=1,4
   ON 38 I=1,NSAM
38 VCNT(I,J,KK)=0.0
39 IF (KMN.GT.10) KMN=KMIN
   DO 40 KK=KMN,KMAX,2
   ON 40 J=1,4
   ON 40 I=1,NSAM
40 VCNT(I,J,KK)=0.0
41 IF (KMN.GT.10) KMN=KMIN
   DO 42 KK=KMN,KMAX,2
   ON 42 J=1,4
   ON 42 I=1,NSAM
42 VCNT(I,J,KK)=0.0
43 IF (KMN.GT.10) KMN=KMIN
   DO 44 KK=KMN,KMAX,2
   ON 44 J=1,4
   ON 44 I=1,NSAM
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   ON 208 J=1,4
   ON 208 I=1,NSAM
208 VCNT(I,J,KK)=0.0
209 IF (KMN.GT.10) KMN=KMIN
   DO 210 KK=
```

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      KMN=(KMN-4)/2
      KMX=(KMX-4)/2
3    IF (K.LT.6) GO TO 22
      KK=(K-4)/2
      IF (K=22) 5,4,22
4    LIM=3
      GO TO 12
5    IF (K=20) 7,6,6
6    LIM=2
      GO TO 12
7    LIM=1
8    LHT=AMINO(ITRHT,3)
      IF (LIM,GT,LHT) GO TO 22
      IF (NSTUD-1)8,8,10
9    DO 9 I=1,4
      DO 9 J=1,3
10   8FST(I,J)=0.0
10   DO 21 L=LIM,LHT
      GO TO (50,52),JON
50   IF (INO(I))52,52,21
52   NI=0
C-----
C-----GRAING SECTION
C-----
      IGR=1
      DO 54 M=1,4
      NI=N1+KNOT(L,M,1)
      IF (KNOT(L,M,3).GT.1.OR.KNOT(L,M,2).GT.2) IGR=AMAXO(IGR,2)
      IF (KNOT(L,M,3).GT.2.OR.KNOT(L,M,2).GT.2) IGR=AMAXO(IGR,3)
      IF (KNOT(L,M,3).GT.2.OR.KNOT(L,M,2).GT.3) IGR=4
      IF (KNOT(L,M,3).GT.2.OR.KNOT(L,M,2).GT.3) GO TO 55
54   CONTINUE
      IF (N1,GT,16) IGR=AMAXO(IGR,2)
      IF (N1,GT,32) IGR=AMAXO(IGR,3)
55   CONTINUE
      GO TO (56,60),JON
56   IF (NSTUD-IGR)21,58,21
58   INO(L)=1
      GO IF (VOL-1)102,102,100
C-----
C-----ADJUST GROSS LOG VOL FOR VISUAL DEFECTS
C-----
100  PCNT=0.0
      IF (IROT,GT,1.AND,L.EQ,1) PCNT=PCNT + 1.0
      IF (ICRK)64,64,2
62   IF (ICRK,GE,2.AND,L.EQ,IPCR) PCNT=PCNT + 1.0
      IF (ICRK,EQ,1.AND,L.EQ,IPCR) PCNT=PCNT + .5
64   IF (IFRK,GT,0.AND,L.EQ,IPFK) PCNT=PCNT + .5
      IF (ILS)68,68,66
66   IF (ILS,GT,2) PCNT=PCNT + .5
      IF (ILS,EQ,1) PCNT=PCNT + .25
68   IF (IFS,GE,2.AND,L.FQ,1) PCNT=PCNT + .25
C-----
C-----ADD INTO REGISTERS
C-----
      IF (PCNT-1,70,72,72)
70   VLM=(PBFV8(L)-(PBFV8(L)*PCNT))
71   VLM=CVOL(VLM,PRISM,EF)
72   GO TO 74
72   VLM=0.0
      INO(L)=0
74   VCNT(I,ISTRT,IGR,KK)=VCNT(ISTRT,IGR,KK) + VLM
      IF (IBUG,EQ,1.AND,LAST,NE,3) GO TO 104
      GO TO 21
C-----
C-----NO GROSS LOG VOL ADJUSTMENT FOR VISUAL DEFECTS
C-----
C102 IF (IROT,GT,1.AND,L.EQ,1) GO TO 99
C103 IF (ICRK,GT,1.AND,L.EQ,IPCR) GO TO 99
C104 IF (IFRK,GT,0.AND,L.EQ,IPFK) GO TO 99
C105 IF (ILS,GT,0) GO TO 99
C106 IF (IFS,GE,2.AND,L.FQ,1) GO TO 99
102  VLM=PBFV8(L)
      BFST(IGR,L)=BFST(IGR,L) + VLM
      GO TO 71
C-----
C-----SET I'NO SELECTOR OFF PIECE FAILED VISUAL DEFECTS TEST
C-----
99   INO(L)=0
      GO TO 21
C-----
104  GO TO (108,106),KVOL
106  WRITE(3,371) ICARO,L,IGR,VLM,K,PCNT
      GO TO 21
108  WRITE(3,37) ICARO,L,IGR,VLM,K
21   CONTINUE
22   IF (LAST,NE,3) GO TO 36
      WRITE (3,38) (PROB(I),I=1,8)
      GO TO (24,23), JON
C-----
C-----SINGLE PRODUCT HEADING
C-----
23   GO TO (110,112),KVOL
110  WRITE(3,386)
      GO TO 114
112  WRITE(3,388)
114  WRITE(3,39)
      GO TO 25
C-----
C-----PRODUCT PRIORITY HEADING
C-----
24   GO TO (116,118),KVOL
116  WRITE(3,376) NSTUD
      GO TO 120
118  WRITE(3,398) NSTUD
120  WRITE(3,40)
25   DO 26 J=1,4
      DO 26 I=1,NSAM
26   TOTAL(I,J)=0.0
      DO 32 KK=KMX,KMX
      KK=KK+24
      DO 27 J=1,4
27   CALL STOR (NSAM,Y(J),S(J),VCNT(I,J,KK),POINT)
      GO TO (29,28), JON
C-----
C-----SINGLE PRODUCT OUTPUT
C-----
28   WRITE (3,41) KX,(Y(I),I=1,4)
      WRITE (3,42) (S(I),I=1,4)
      GO TO 30
C-----
C-----PRODUCT PRIORITY OUTPUT
C-----
29   WRITE (3,43) KX,Y(NSTUD)
      WRITE (3,44) S(NSTUD)
      DO 31 J=1,4
      DO 31 I=1,NSAM
31   TOTAL(I,J)=TOTAL(I,J)+VCNT(I,J,KK)
      STU 230
      STU 240
      STU 250
      STU 260
      STU 270
      STU 280
      STU 290
      STU 300
      STU 310
      STU 320
      STU 330
      STU 340
      STU 350
      STU 360
      STU 370
      STU 380
      STU 390
      STU 400
      STU 410
      STU 420
      STU 430
      STU 440
      STU 450
      STU 460
      STU 470
      STU 480
      STU 490
      STU 500
      STU 510
      STU 520
      STU 530
      STU 540
      STU 550
      STU 560
      STU 570
      STU 580
      STU 590
      STU 600
      STU 610
      STU 620
      STU 630
      STU 640
      STU 650
      STU 660
      STU 670
      STU 680
      STU 690
      STU 700
      STU 710
      STU 720
      STU 730
      STU 740
      STU 750
      STU 760
      STU 770
      STU 780
      STU 790
      STU 800
      STU 810
      STU 820
      STU 830
      STU 840
      STU 850
      STU 860
      STU 870
      STU 880
      STU 890
      STU 900
      STU 910
      STU 920
      STU 930
      STU 940
      STU 950
      STU 960
      STU 970
      STU 980
      STU 990
      STU1000
      STU1010
      STU1020
      STU1030
      STU1040
      STU1050
      STU1060
      STU1070
      STU1080
      STU1090
      STU1100
      STU1110
      STU1120
      STU1130
      STU1140
      STU1150
      STU1160
      STU1170
      STU1180
      STU1190
      STU1200
      STU1210
      STU1220
      STU1230
      STU1240
      STU1250
      STU1260
      STU1270
      STU1280
      STU1290
      STU1300
      STU1310
      STU1320
      STU1330
      STU1340
      STU1350
      STU1360
      STU1370
      STU1380
      STU1390
      STU1400
      STU1410
      STU1420
      STU1430
      STU1440
      STU1450
      STU1460
      STU1470
      STU1480
      STU1490
      STU1500
32  CONTINUE
      DO 33 J=1,4
33  CALL STOR (NSAM,Y(J),S(J),TOTAL(I,J),POINT)
      GO TO (35,34), JON
34  WRITE (3,45) (Y(I),I=1,4)
      WRITE (3,46) (S(I),I=1,4)
      GO TO 36
35  WRITE (3,47) Y(NSTUD)
      WRITE (3,48) S(NSTUD)
36  RETURN
C-----
37  FORMAT (1H *TREE NUMBER=I6,2X*PIECE#I3,2X*ACCEPTED AS STUO GRADE
1*13,2X*WITH WEIGHTED VOLUME OF#I0,3,2X*DIAMETER CLASS#I3)
371 FORMAT(1H *TREE NUMBER=I6,2X*PIECE#I3,2X*ACCEPTED AS STUO GRADE#
113,2X*WITH ADJUSTED WT VOL OF#F10,3,2X*DIAMETER CLASS#I3,2X*PRV ==
2F5,2)
38  FORMAT (1H1,8A10)
386 FORMAT(IH0,I30(==)/IH0*STUOS CONSIDERED AS SINGLE PRODUCT GROSS
1VOLUME NOT ADJUSTED FOR VISUAL DEFECTS*)
388 FORMAT(IH0,I30(==)/IH0*STUOS CONSIDERED AS SINGLE PRODUCT GROSS
1VOLUME ADJUSTED FOR VISUAL DEFECTS*)
39  FORMAT(IH0,I30(==)/IH0*DIAMETER#23X*BOARD FOOT VOLUMES PER ACRE B
1Y GRADE#I1H0* CLASS#25X#1*17X#2*17X#3*17X#4*/IH0,I30(==*))
396 FORMAT(IH0,I30(==)/IH0*GRADE#I3,* STUOS BASED ON PRODUCT PRIORITY
1 CRITERIA GROSS VOLUME NOT ADJUSTED FOR VISUAL DEFECTS*)
398 FORMAT(IH0,I30(==)/IH0*GRADE#I3,* STUOS BASED ON PRODUCT PRIORITY
1 CRITERIA GROSS VOLUME ADJUSTED FOR VISUAL DEFECTS*)
40  FORMAT(IH0,I30(==)/IH0*DIAMETER#17X*BOARD FOOT VOLUME PER ACRE *
1IH * CLASS#I1H0,I30(==*))
41  FORMAT (1H0,I4,6X*MEAN#F20,2,3(F18,2))
42  FORMAT (1H -10X*STO ERP#F17,2,3(F18,2))
43  FORMAT (1H0,I4,24X*MEAN#F20,2)
44  FORMAT (1H -28X*STO ERR#F17,2)
45  FORMAT (1H0,I30(==)/IH0*TOTAL*2X*MEAN#3X,F20,2,3(F18,2))
46  FORMAT (1H0*STO ERR MEAN#2X,F20,2,3(F18,2)/IH0,I30(==*))
47  FORMAT (1H0,I30(==)/IH0*TOTAL*23X*MEAN#F20,2)
48  FORMAT (1H0,28X*STO ERR#F17,2/IH0,I30(==*))
      ENO
      SUBROUTINE PULP (PULPV,POINT,TOTAL,ISAM,IMAX)
      PUL 10
      PUL 20
      PUL 30
      PUL 40
      PUL 50
      PUL 60
      PUL 70
      PUL 80
      PUL 90
      PUL 100
      PUL 110
      PUL 120
      PUL 130
      PUL 140
      PUL 150
      PUL 160
      PUL 170
      PUL 180
      PUL 190
      PUL 200
      PUL 210
      PUL 220
      PUL 230
      PUL 240
      PUL 250
      PUL 260
      PUL 270
      PUL 280
      PUL 290
      PUL 300
      PUL 310
      PUL 320
      PUL 330
      PUL 340
      PUL 350
      PUL 360
      PUL 370
      PUL 380
      PUL 390
      PUL 400
      PUL 410
      PUL 420
      PUL 430
      PUL 440
      PUL 450
      PUL 460
      PUL 470
      PUL 480
      PUL 490
      PUL 500
      PUL 510
      PUL 520
      PUL 530
      PUL 540
      PUL 550
      PUL 560
      PUL 570
      PUL 580
      PUL 590
      PUL 600
      PUL 610
      PUL 620
      PUL 630
      PUL 640
      PUL 650
      PUL 660
      PUL 670
      PUL 680
      PUL 690
      PUL 700
      PUL 710
      PUL 720
      PUL 730
      PUL 740
      PUL 750
      PUL 760
      PUL 770
      PUL 780
      PUL 790
      PUL 800
      PUL 810
      PUL 820
      PUL 830
      PUL 840
      PUL 850
      PUL 860
      PUL 870
      PUL 880
      PUL 890
      PUL 900
      PUL 910
      PUL 920
      PUL 930
      PUL 940
      PUL 950
      PUL 960
      PUL 970
      PUL 980
      PUL 990
      PUL1000
      COMMON KNOT(3,4,3),I24P(4),IP(11),INO(10),KOUNT(50),Y(15),S(15),
      IPROB(8),PCUVB(11),PBFV(10),PBFV(8),DFSH(4,5),BFVN(4,3),
      2BFST(4,3),CFPL(2),PROB,KMN,KMX,NSAM,K,ISTRT,OBH,IPLHT,ISWP,
      3IPCR,ICRK,IPFK,IFRK,IFS,ILS,ITRHT,LEAN,IROT,NSAM,NVENR,NSTUD,JON,
      4LAST,TCFV,TBFV,IBUG,ICARO,PRISM,KP,IONY,KVOL,EF
C-----
      GO TO (1,20,20),LAST
1    DO 15 I=1,NSAM
15   PULPV(I)=0.0
20   NT=0
      KTOP=ITRHT + 1
      DO 25 I=1,2
25   CFPL(I)=0.0
      DO 30 J=1,ITRHT
30   NT=NT + INO(I)
      IF (NT)35,35,85
C-----
C-----TREE EXCLUDED FROM PRIOR PRODUCT CONSIDERATION
C-----MAKE GROSS VOLUME ADJUSTMENTS FOR VISUAL DEFECTS
C-----
35   IF (KVOL-1)60,60,37
37   DO 50 I=1,ITRHT
      PCNT=0.0
      IF (ILS)42,42,40
40   PCNT=PCNT + 1.0
42   IF (IFS,GT,0.AND,L.EQ,1) PCNT=PCNT + .5
      IF (PCNT-1,44,46,46)
44   VLM=(PCUVB(I)-(PCUVB(I)*PCNT))
      GO TO 48
46   VLM=0.0
48   VLM=CVOL(VLM,PRISM,EF)
      PULPV(ISTRT)=PULPV(ISTRT) + VLM
      IF (IBUG,EQ,1.AND,LAST,NE,3) WRITE(3,101) ICARO,I,VLM,K,PCNT
50   CONTINUE
C-----
C-----DO TOP PIECE FOR ADJUSTED GROSS VOLUME
C-----
51   IF (ILS)52,52,54
52   VLM=PCUVB(KTOP)
      PCNT=0.0
      GO TO 56
54   VLM=0.0
      PCNT=1.0
56   VLM=CVOL(VLM,PRISM,EF)
      PULPV(ISTRT)=PULPV(ISTRT) + VLM
      IF (IBUG,EQ,1.AND,LAST,NE,3) WRITE(3,103) ICARO,VLM,K,PCNT
58   IF (LAST,NE,3) GO TO 900
C-----
C-----DO TREE FOR GROSS VOLUMES--NO ADJUSTMENT FOR VISUAL DEFECTS
C-----
60   DO 62 I=1,ITRHT
      VLM=PCUVB(I)
      CFPL(2)=CFPL(2) + VLM
      VLM=CVOL(VLM,PRISM,EF)
      PULPV(ISTRT)=PULPV(ISTRT) + VLM
      IF (IBUG,EQ,1.AND,LAST,NE,3) WRITE(3,101) ICARO,I,VLM,K,PCNT
62   CONTINUE
C-----
C-----DO TOP PIECE FOR GROSS VOLUME--NO ADJUSTMENT FOR VISUAL DEFECTS
C-----
64   VLM=PCUVB(KTOP)
      CFPL(1)=CFPL(1) + VLM
      VLM=CVOL(VLM,PRISM,EF)
      PULPV(ISTRT)=PULPV(ISTRT) + VLM
      IF (IBUG,EQ,1.AND,LAST,NE,3) WRITE(3,9) ICARO,VLM,K
      GO TO 58
C-----
C-----STEM SECTIONS EXCLUDED FROM PRIOR PRODUCT CONSIDERATION PLUS TOP
C-----MAKE GROSS VOLUME ADJUSTMENTS FOR VISUAL DEFECTS
C-----
85   IF (KVOL-1)98,98,87
87   DO 96 I=1,ITRHT
      IF (INO(I),EQ,1) GO TO 96
      IF (ILS)90,90,92
90   VLM=PCUVB(I)
      PCNT=0.0
      GO TO 94
92   VLM=0.0
      PCNT=1.0
94   VLM=CVOL(VLM,PRISM,EF)
      PULPV(ISTRT)=PULPV(ISTRT) + VLM
      IF (IBUG,EQ,1.AND,LAST,NE,3) WRITE(3,101) ICARO,I,VLM,K,PCNT
96   CONTINUE

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GO TO 51
C-----DD STEM FOR GROSS VOLUMES--NO ADJUSTMENT FOR VISUAL DEFECTS
C
98 00 100 I=1, ITRHT
   IF(I=1, EQ, 1) GO TO 100
   VLM=PCUV8(I)
   CFPL(2)=CFPL(2) + VLM
   VLM=VOL(VLM, PRISM, EF)
   PULPV(I, ITRHT)=PULPV(I, ITRHT) + VLM
   IF(18UG, EQ, 1, AND, LAST, NE, 3) WRITE(3, 10) ICARO, I, VLM, X
100 CONTINUE
   GO TO 64
110 WRITE(3, 11) (PROB(1), I=1, 8)
   GO TO (6, 5), JDN
C-----
C-----ALL PRODUCTS HFAOING
C-----
5 GO TO (102, 104), KVOL
102 WRITE(3, 12)
   GO TO 7
104 WRITE(3, 121)
   GO TO 7
C
6 GO TO (106, 108), KVOL
106 WRITE(3, 13)
   GO TO 7
108 WRITE(3, 131)
C
7 00 8 I=1, NSAM
8 TOTAL(I, 1)=0.0
   CALL STORER (NSAM, Y(1), S(1), PULPV(1), POINT)
   WRITE (3, 14) Y(1), S(1)
900 RETURN
C-----
9 FORMAT(1H *TREE NUMBER*16, 2X*TOP PIECE*, 1X*ACCEPTED AS PULP*13X*W
1TH WEIGHTED VOLUME OF*F10, 3, 2X*DIAMETER CLASS*13)
10 FORMAT (1H *TREE NUMBER*16, 2X*PIECE*13, 2X*ACCEPTED AS PULP*13X*W
1TH WEIGHTED VOLUME OF*F10, 3, 2X*DIAMETER CLASS*13)
101 FORMAT(1H *TREE NUMBER*16, 2X*PIECE*13, 2X*ACCEPTED AS PULP*13X*W
1TH ADJUSTED WT VOL OF*F10, 3, 2X*DIAMETER CLASS*13, 2X*PRV *F5, 2)
103 FORMAT(1H *TREE NUMBER*16, 2X*TOP PIECE*, 1X*ACCEPTED AS PULP*13X*W
1TH ADJUSTED WT VOL OF*F10, 3, 2X*DIAMETER CLASS*13, 2X*PRV *F5, 2)
11 FORMAT (1H, 8A10)
12 FORMAT(1H, 130(==)/1H*PULP CONSIDERED AS SINGLE PRODUCT GROSS V
10LUME NOT ADJUSTED FOR VISUAL DEFECTS*/1H, 130(==))
121 FORMAT(1H, 130(==)/1H*PULP CONSIDERED AS SINGLE PRODUCT GROSS V
10LUME ADJUSTED FOR VISUAL DEFECTS*/1H, 130(==))
13 FORMAT(1H, 130(==)/1H*PULP CONSIDERED AS RESIDUAL PRODUCT ONLY
1GROSS VOLUME NOT ADJUSTED FOR VISUAL DEFECTS*/1H, 130(==))
131 FORMAT(1H, 130(==)/1H*PULP CONSIDERED AS RESIDUAL PRODUCT ONLY
1GROSS VOLUME ADJUSTED FOR VISUAL DEFECTS*/1H, 130(==))
14 FORMAT (1H *TOTAL PULP VOLUME IN CUBIC FEET*F18, 2/1H*STANDARD ERR
1OR*F35, 2/1H, 130(==))
SUBROUTINE VOLUM (KCUV8, KBFV8, KBFV16, 8AFV)
C THIS ROUTINE CALCULATES GROSS CUFT AND BRFT TREE VOL USING HGT IN 16FT
C LOGS AND DBH AND ALSO CALCULATES A VOL./ACRE EXPANSION FACTOR FOR EACH
C SAMPLE TREE USING DBH AND THE INPUT 8AF VALUE OF THE ANGLE GAUGE USED.
C THE CALCULATED GROSS VOLUMES ARE ALLOCATED AMONG STEM SECTIONS OF THE
C TREE BY SELECTED PERCENTAGE TABLES.
C
DIMENSION KCUV8(165), KBFV8(55), KBFV16(29)
COMMON KNOT(3, 4, 3), L24P(4), IP(11), IND(10), KOUNT(50), Y(15), S(15),
1PROB(8), PCUV8(11), PBFV(10), PBFV16(5), RFSW(4, 5), RFW(4, 3),
2BFS(16, 3), CFPL(2), NPROD, KMIN, KMAX, NSAM, K, ISTRT, DBH, IPLHT, ISWP,
3IPCR, ICRK, IPFK, IFRK, IFS, ILS, ITRHT, LEAN, IROT, NSAM, NVENR, NSTUO, JON,
4LAST, TCFV, TBFV, 18UG, ICARD, PRISM, KP, LOHY, KVOL, EF
C
A=0.0
EF=0.0
DO 5 N=1, 11
5 PCUV8(N)=0.0
DO 10 N=1, 10
10 PBFV8(N)=0.0
DO 15 N=1, 5
15 PBFV16(N)=0.0
C
C ASSUME BRKNG POINT OF 19.0 INCH DBH FOR BLACKJACK AND OLD GROWTH TREES
C TOT TREE VOL EQUATIONS FROM MYERS, C.A., USFS RES. PAPER RM-2, 1963.
C CONVERT HALF-LOG HT(I, ITRHT) TO LOG HT(16FT SECTIONS)
C
HT16=FLOAT(ITRHT)/2.
OSOR=OBH**2
IF (PRISM) 13, 13, 14
13 OLVSOR=0.005454
EF=8AFV/OLV
GO TO 16
C
14 EF=PRISM
16 A=OSQR*HT16
IF (OBH=19.0) 17, 17, 1R

```


MULTIPRODUCT INVENTORY PROGRAM TEST DATA SAMPLE OUTPUT

=====

POLES CONSIDERED AS SINGLE PRODUCT

DIAMETER		POLES PER ACRE BY HEIGHT CLASS													
CLASS		10	15	20	25	30	35	40	45	50	55	60	65	70	75
12		0.00	0.00	0.00	.58	.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14		0.00	0.00	0.00	.52	.47	.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
=====															
HEIGHT CLASS SUM		0.00	0.00	0.00	1.09	1.08	.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STD ERR MEAN		0.00	0.00	0.00	.55	1.08	.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

=====

MULTIPRODUCT INVENTORY PROGRAM TEST DATA SAMPLE OUTPUT

=====

SAWLOGS CONSIDERED AS SINGLE PRODUCT GROSS VOLUME NOT ADJUSTED FOR VISUAL DEFECTS

DIAMETER		BOARD FOOT VOLUMES PER ACRE BY GRADE			
CLASS		1	2	3	5
12	MEAN	0.00	0.00	0.00	292.60
	STD ERR	0.00	0.00	0.00	40.11
14	MEAN	0.00	0.00	0.00	300.44
	STD ERR	0.00	0.00	0.00	73.05
16	MEAN	0.00	0.00	0.00	53.38
	STD ERR	0.00	0.00	0.00	53.38
18	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
20	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
22	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
24	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
26	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
28	MEAN	0.00	0.00	0.00	80.42
	STD ERR	0.00	0.00	0.00	80.42
30	MEAN	0.00	0.00	60.08	102.95
	STD ERR	0.00	0.00	60.08	93.11
32	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
34	MEAN	0.00	0.00	49.58	63.10
	STD ERR	0.00	0.00	49.58	63.10
=====					
TOTAL MEAN		0.00	0.00	109.66	892.89
STD ERR MEAN		0.00	0.00	109.66	67.47

=====

MULTIPRODUCT INVENTORY PROGRAM TEST DATA SAMPLE OUTPUT

=====

PULP CONSIDERED AS SINGLE PRODUCT GROSS VOLUME NOT ADJUSTED FOR VISUAL DEFECTS

=====

TOTAL PULP VOLUME IN CUBIC FEET 234.43

STANDARD ERROR 13.63

=====

MULTIPRODUCT INVENTORY PROGRAM TEST DATA SAMPLE OUTPUT

=====

VENEER CONSIDERED AS A SINGLE PRODUCT GROSS VOLUME NOT ADJUSTED FOR VISUAL DEFECTS

=====

DIAMETER		BOARD FOOT VOLUMES PER ACRE BY GRADE			
CLASS		1	2	3	4
12	MEAN	0.00	74.11	73.61	0.00
	STD ERR	0.00	37.07	18.20	0.00
14	MEAN	0.00	94.52	121.03	0.00
	STD ERR	0.00	31.46	58.31	0.00
16	MEAN	0.00	0.00	42.70	0.00
	STD ERR	0.00	0.00	42.70	0.00
18	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
20	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
22	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
24	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
26	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
28	MEAN	0.00	43.43	14.48	0.00
	STD ERR	0.00	43.43	14.48	0.00
30	MEAN	0.00	103.00	0.00	12.02
	STD ERR	0.00	54.40	0.00	12.02
32	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
34	MEAN	0.00	65.36	0.00	0.00
	STD ERR	0.00	65.36	0.00	0.00
TOTAL MEAN		0.00	380.42	251.82	12.02
STD ERR MEAN		0.00	165.55	113.56	12.02

=====

MULTIPRODUCT INVENTORY PROGRAM TEST DATA SAMPLE OUTPUT

=====

STUOS CONSIDERED AS SINGLE PRODUCT GROSS VOLUME NOT ADJUSTED FOR VISUAL DEFECTS

=====

DIAMETER		BOARD FOOT VOLUMES PER ACRE BY GRADE			
CLASS		1	2	3	4
12	MEAN	42.06	115.54	32.93	93.98
	STD ERR	42.06	63.70	32.93	8.76
14	MEAN	9.78	76.67	17.85	159.55
	STD ERR	9.78	45.17	17.85	75.95
16	MEAN	0.00	0.00	0.00	42.70
	STD ERR	0.00	0.00	0.00	42.70
18	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
20	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
22	MEAN	0.00	0.00	0.00	0.00
	STD ERR	0.00	0.00	0.00	0.00
TOTAL MEAN		51.83	192.21	50.78	296.23
STD ERR MEAN		38.12	108.25	50.78	111.14

=====

Heidt, Jack D., Donald A. Jameson, Roland L. Barger, and Bernard J. Erickson.

1971. Determining timber conversion alternatives through computer analysis. USDA Forest Serv. Res. Pap. RM-74, 27 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado 80521.

The computer program MULTI accepts basic field inventory data describing individual sample trees. It calculates gross board-foot and cubic-foot volume, grades or classifies for a number of specified primary products, adjusts gross volume for visual defect, and calculates standard error. Output tables indicate adjusted gross volume per acre, by grade and size class, for each product independently. An option allows allocation of volume between several products of a multiproduct combination following a specified order of preference.

MULTI was developed on a CDC 6400 computer system. It is written in FORTRAN Extended Language, and can use tape and/or disk storage. Although the program was developed for products and grading systems common to ponderosa pine (Pinus ponderosa Laws.), it is adaptable to other species, products, and grading systems.

Key Words: Multiproduct timber inventory, primary product evaluation (timber), forest surveys, product volume estimates, product volume adjustments, timber utilization.

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