SWYLD2: Yield Tables for Even-Aged and Two-Storied Stands of Southwestern Ponderosa Pine, Including Effects of Dwarf Mistletoe

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Abstract

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Presents a procedure for computation of yield tables for ponderosa pines in Arizona and New Mexico. Possible alternatives include: even-aged or two-storied stands, healthy or diseased stands, and managed or unmanaged stand densities. Stand conditions and severity of dwarf mistletoe infestation change with time and in response to intermediate cuttings. Supersedes SWYLD, published in 1972 as USDA For. Serv. Res. Pap. RM-87. A concise user's guide for program SWYLD2 is available as USDA For. Serv. Gen. Tech. Rep. RM-23, 1976.

Keywords: Stand yield tables, timber management, forest management, simulation, *Arceuthobium vaginatum*, *Pinus ponderosa*.

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Introduction

Computer program SWYLD (Myers and others 1972) was developed to compute yield tables for managed, even-aged stands of southwestern ponderosa pine (*Pinus ponderosa* Laws.). Users of SWYLD recognized a need for a capability of handling a wider range of situations. A few of the original relationships and analytic procedures have been modified and new ones have been added. Program SWYLD2, described in this paper, has been written to supersede SWYLD, published as a USDA Forest Service Research Paper RM-87.

Modifications and additions now provide the following features: (1) yield tables are computed for even-aged stands or for each story of two-storied stands; (2) equations predict the contribution of the overstory to dwarf mistletoe infection in the understory, if any; (3) height and diameter growth equations apply to a wide range of stand densities, and (4) an intermediate or regeneration cut is no longer required at the initial age printed in the yield table.

The material presented includes: (1) descriptions of the field measurements, (2) descriptions of the relationships obtained from the measurements, (3) a computer program that contains the relationships, and (4) an example of what the program can produce. Instructions for adapting the procedures and program to other species or forest regions are also given.

A published summary of instructions on preparation of yield tables for diseased stands, directed to personnel of pest detection and control programs, is mostly applicable to SWYLD2 (Hawksworth and Myers 1973). One important exception is that the new program is useful for two-storied stands as well as those that are even-aged. A second exception is that SWYLD2 accepts more than one way of expressing degree of dwarf mistletoe infestation.

SWYLD2 is written in standard FORTRAN IV and can be run on almost any computer that provides 50,000 octal memory locations. Yield tables can be produced at a cost of about 8 cents each, excluding cost of program compilation.

Uses of Yield Tables

Yield tables are essential guides for forest managers. They report probable wood yields that result from specified combinations of such factors as site quality, utilization standards, and frequency and intensity of thinning. They are, therefore, the basis for timber management planning. They also provide an important part of the information needed for determining the influence of timber treatments on other forest resources.

Two types of yield tables can be computed by program SWYLD2: (1) tables for managed stands, and (2) tables that describe the remainder of the rotation or life of existing stands. The term "managed," as used in this paper, means stand density is controlled throughout the life of the stand. The term "stand," following the usual definition, refers to an area of trees consistent in site quality, species, structure, density, and incidence of disease. Uniformity of site quality and stand characteristics must be such that site index and other area averages really describe the unit of forest simulated. Stand area, therefore, may range from a very few acres in rough terrain to a hundred or more acres where meaningful averages may be computed.

Managed Stands

Yield tables for managed stands are useful regardless of the current level of management. Well-managed forests can benefit from refinements in operations that are guided by comparisons of actual conditions with a good standard. Where conversion to managed stands is underway, yield tables provide goals toward which conversion can be directed.

Several factors influence the ways that yield tables should be produced and the types of data used to compute them. These factors include:

1. Yield tables for managed stands are needed even for regions and species where managed stands do not yet exist. Temporary plots must be used to obtain needed relationships.
2. No single yield table can be adopted as standard for a species or region. Applied forest management requires the use of various practices that can and will differ from one forest to another, and must appear as variables in yield table computations.
3. A manager should not be restricted to only one yield table per working group, or series of stands managed under the same silvicultural system. He must have the opportunity to examine the probable future results of current operations, to propose changes in the management of resources in his care, and to estimate the effects of these changes before money is spent on them.

The second and third items above relate to a disadvantage of normal and empirical yield tables. One table can report probable yields for only one combination of stand characteristics and management objectives. This is not an effective basis for comparing alternatives and making decisions. Since a group of yield tables can show various combinations of characteristics and objectives, a means of producing many yield tables at low cost can be useful to a forest manager. A computer program that will do this is described below and listed in appendix 1. Once the relationships between stand variables have been established, a manager can examine the probable outcomes of many possible variations in management. There is no need to delay decisions or to speculate on what may happen if a condition or procedure changes.

Existing Stands

Existing stands are mentioned separately from managed stands to emphasize that yield tables have uses besides those for setting management goals. In this case, the question is not the proper management for a specific combination of tree species, region, and objective. Rather, the problem is to select the proper procedure for changing a stand condition that actually exists to some desired condition. Change may be called for because stand density is too high, tree ages are greater than planned felling age, or disease problems prevent application of usual management practices.

As an example of the problems created by existing unsatisfactory stand conditions, consider a parasite or other disease on ponderosa pines. Management decisions must be made for each diseased stand. Possible alternative treatments are: (1) sanitation thinning, (2) removal of a diseased overstory to release a well-stocked understory, (3) no treatment, with the hope that the stand may eventually become merchantable, or (4) destruction and regeneration. Knowledge of stand structure and density will remove some alternatives from further consideration. For further selection, an estimate of potential yield with each alternative is necessary. This information can be provided by yield tables that describe not managed or goal conditions, but possible results from treating a situation that actually exists. The final alternative chosen must then also consider other forest resources, including scenic values.

Importance of Dwarf Mistletoe

Yield tables for healthy stands do not provide all the information needed for decisionmaking in the Southwest. For practical application, important and predictable causes of reduced growth and yield must be included in the computations. Dwarf mistletoe (*Arceuthobium vaginatum* subsp. *cryptopodum* (Engelm.) Hawksw. & Wiens) is so widespread and so reduces growth and yield that it is an important factor in management planning. Andrews and Daniels (1960) found this parasite on 36 percent of some 2,700 ponderosa pine plots located throughout Arizona and New Mexico. On the Lincoln National Forest and adjacent Mescalero Apache Reservation in southern New Mexico, more than 50 percent of the plots were infested (Hawksworth and Lusher 1956, Andrews and Daniels 1960).

Dwarf mistletoe is one of the four major causes of mortality in southwestern ponderosa pine (Pearson 1939, Myers and Martin 1963). Pearson (1938) found mortality in heavily infested, cutover stands to be about five times that in comparable lightly infested or healthy stands. On the Mescalero Apache Reservation, mortality in stands with dwarf mistletoe was nearly twice as high as in healthy stands (Hawksworth and Lusher 1956). The differences were most pronounced in cutover areas, where the mortality rate in infested stands was 3.3 times that in mistletoe-free stands.

Several studies have documented the adverse effects of dwarf mistletoe on the height and diameter growth of individual ponderosa pines (Korstian and Long 1922, Sperry 1934, Hawksworth 1961). Such studies do not, however, reveal the total stand loss due to dwarf mistletoe. They do not report mortality, but give information on surviving trees only.

A recent study compared growth rates and mortality in treated and untreated mistletoe-infested stands in Arizona (Lightle and Hawksworth 1973). Some of the information in SWYLD2 on the effects of dwarf mistletoe was obtained from the plots used for that study.

The publications cited above dealt primarily with the cumulative effects of dwarf mistletoe in unmanaged stands. They do not provide data that can be used directly for yield prediction in managed stands or for comparisons of alternatives. Many of the pine-mistletoe relationships needed for these purposes were reported in the publication describing program SWYLD (Myers and others 1972). Modifications of some of these and additional relationships are reported here for the first time.

The measure of dwarf mistletoe infestation used in SWYLD2 is the 6-class rating system developed by Hawksworth (1961). A rating is obtained for each tree (fig. 1). The individual ratings are then averaged to obtain the value for the entire stand that is used in the relationships of program SWYLD2.

Description of Program SWYLD2

Program SWYLD2 consists of a main program and eight subroutines. Operations performed by each routine are described below and identified by comment statements in the listing of the source program (appendix 1). Subsequent sections of this paper describe the relationships used to compute values of the dependent variables. Input variables and data deck structure are described in the section headed User-Supplied Information.

Main Program

The main program performs the following seven operations:

1. Reads two data cards containing the number of stands to be processed, the length of the projection period in years (10.0 for SWYLD2), and minimum commercial cuts in board and cubic feet.
2. Checks that the number of stands to be processed is not zero or blank. An error message is printed and the entire job terminates if this error is found.
3. Calls subroutine BEGIN at the beginning of processing of each stand to set values of many variables to zero and to read all data applicable to the stand being processed.

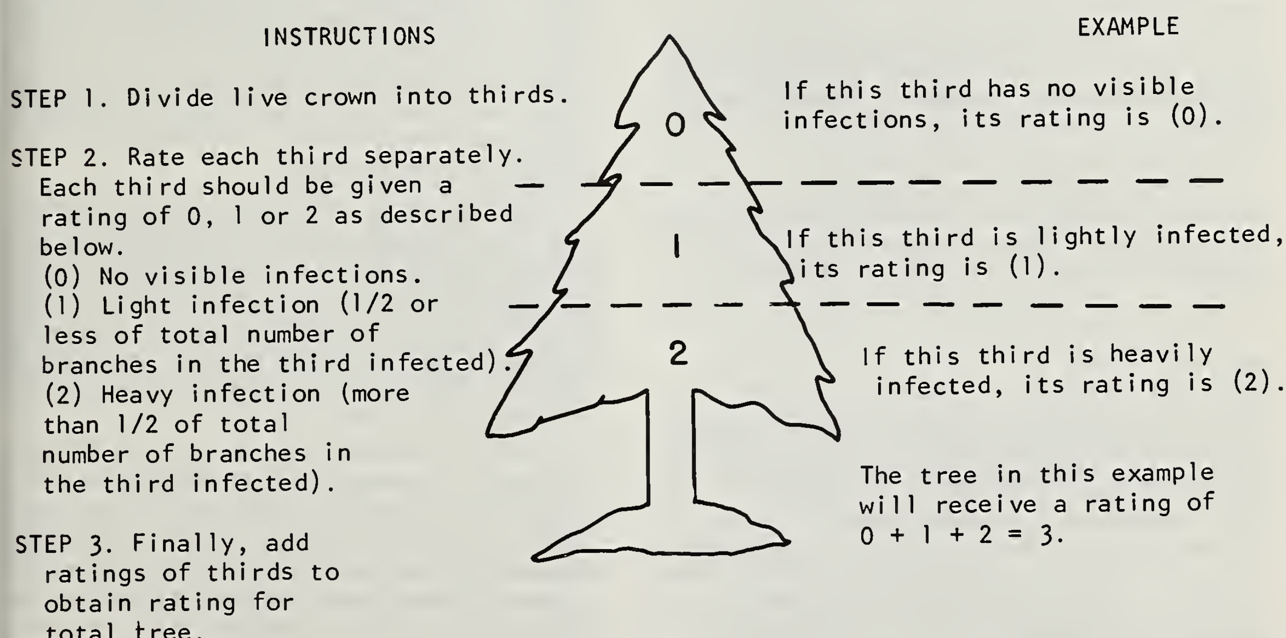

Figure 1.—Instructions for and example of the use of the 6-class mistletoe rating system (Hawksworth 1961).

4. Checks many variables of the data deck for unwanted zero or blank values. An error message is printed and processing terminates for any stand with such errors in the data cards. Understory variables are not checked because they must have zero or blank values for single-storied stands.

5. Calls subroutine FIRST to compute initial values of several stand characteristics and program controls.

6. Calls 2 subroutines (CUTS, PROJ) in sequence as many times as necessary to simulate the number of projection periods required to reach the final age desired for each yield table.

7. Calls subroutine TABLE after each stand is processed to print yield tables for the stand. One table is produced for single-storied stands. Separate tables are printed for the overstory and understory of two-storied stands.

Subroutine BEGIN

Subroutine BEGIN is called by the main program to initiate the processing of each set of stand data. Many variables are assigned initial values of zero to clear computer memory of data from previous computations, and to prevent processing of an understory in single-storied stands. Four cards (types 3, 4, 5, and 6) are read by BEGIN to describe stand conditions and the management controls to be used in computations. These stand and control variables are described in a subsequent section and in the listing of the Order and Contents of the Data Deck.

Values of 21 input variables are stored in an array named VAR. Some items in VAR are examined by the main program to locate errors, as already described. Others are used by other subroutines as a record of initial values.

The data deck for one job must contain one set of four cards (types 3, 4, 5, and 6) for each stand to be processed. The number of sets or stands is specified by a value read by the main program.

Subroutine FIRST

FIRST computes values of several variables that, with the input variables, describe the stand and the management decisions applicable to it. Where appropriate, separate values are computed for each story of two-storied stands. The final age to appear in the yield table and the initial basal area are computed. Initial dwarf mistletoe rating and average heights of dominant and codominant trees are also computed if these values have not been entered for the stand.

Subroutine SWVOL is called by FIRST to compute initial stand volume per acre in each of the units provided for in SWVOL. These volumes plus other computed values are then stored for later recall when the yield tables are printed.

Subroutine CUTS

CUTS executes the thinnings and regeneration cuts called for by the variables specifying management controls. CUTS also makes any necessary changes in the interval between cuts and in residual density of shelterwoods.

A scheduled thinning will be bypassed if any one of the three following conditions exists at the time the thinning should occur:

1. Comparison of current growing stock level with the growing stock goal indicates that the stand or story is already understocked in relation to the goal.

2. Current dwarf mistletoe rating exceeds the maximum value specified by the program user. This value will usually be 3.0 for the host-parasite combination of SWYLD2.

3. Noncommercial volumes would be cut and the appropriate control variable is given a value to deny this option.

Each partial cut executed is followed by computation of new values for each average stand d.b.h., average stand height, and dwarf mistletoe rating. Each new diameter and height is larger or smaller than the corresponding old value, depending on the type of cutting executed. Post-cutting basal areas, residual volumes, and volumes removed are also computed and stored for later printing in the yield tables.

In two-storied stands, CUTS executes thinnings and regeneration cuts separately for each story. The user may specify simultaneous cuttings in both the overstory and understory or a cutting in only one story. Growing stock level specified for a cut applies only to the basal area and average diameter of the story involved and not to the combined basal area of both stories.

The first thinning in diseased stands will be from above, as simulated by subroutine SWCUT2, unless the option of preventing thinning from above is exercised. Average diameters and heights will therefore be reduced. Subsequent thinnings in diseased stands will increase average d.b.h. and height, but by lesser amounts than in healthy stands, where the smaller trees make up a larger percentage of those removed. This effect, an alternative computation in SWCUT1, has been observed in subsequent thinnings of actual diseased stands.

Subroutine PROJ

Subroutine PROJ contains the relationships of SWYLD2 that describe growth and other changes over time. The routine consists of one long loop to process the values of each story of two-storied stands separately.

Values computed by PROJ during each projection period, if needed, are as follows: (1) nonzero dwarf mistletoe rating (DMR) that accounts for latent infestation after apparent elimination of the parasite by partial cutting, (2) initial DMR if infestation occurs after the simulation period begins, (3) value of DMR at the end of the period if an infestation exists and if neither of the previous situations apply, (4) actual growing stock level, (5) average d.b.h. and height at end of the period, and (6) mortality during the period. Computations of d.b.h., height, and mortality include the effects of dwarf mistletoe, if present. PROJ uses the combined basal area of both stories (SBAS) in calculations of growing stock level for each story, growth projections, and mortality calculations.

PROJ completes the operations of each projection period by calling SWVOL to compute volumes. These and other values are then stored for printing at the end of the simulation.

Subroutine TABLE

TABLE is called by the main program after each set of stand data is processed. In two-storied stands, yield tables for the overstory and understory are printed separately and labeled to identify the stand component described. Only one table, without a story designation, is printed for single-storied stands. Examples of the tables are given in appendix 2.

Footnotes to each table report: (1) merchantability limits for cubic- and board-foot volumes, (2) type of initial thinning allowed, (3) minimum DMR that prevents intermediate cuts, (4) minimum volumes included in total yields, (5) controls on noncommercial thinnings, (6) initial status of dwarf mistletoe infestation if DMR is not read from data card type 5, and (7) skipping of scheduled intermediate cuts.

Subroutine SWVOL

Subroutine SWVOL is called by other subroutines after each growth projection and after each intermediate or regeneration cut. Total cubic volume per acre (TCF) of all trees, from groundline to tip, is computed with stand volume equations. Factors are then computed and used to convert total cubic volumes to merchantable cubic feet (FCTR) and to board feet (PROD). Utilization standards for these units are given in the comment statements of SWVOL and in footnotes to the yield tables.

Two or three equations each are used to compute TCF, FCTR, and PROD to avoid the need for complex forms. These relationships are not linear over the necessary ranges of the independent variables.

Conversions to other units or utilization standards may supplement or replace those already in SWVOL (appendix 1). Additional units might be square feet of veneer or wood weight in pounds (Myers 1960).

Subroutine SWCUT1

Subroutine SWCUT1 computes average stand d.b.h. after partial cuttings that emphasize, but are not restricted to, removal of the smaller trees. Average diameter and height after cutting, therefore, are larger than corresponding values before cutting. The percentage of trees retained is needed as an independent variable, but is itself an unknown. Successive percentages of trees are therefore tested until d.b.h. after cutting, number of trees retained, and residual basal area agree with the growing stock level selected by the program user.

Two major loops in the subroutine provide for the increasing and constant segments of each growing stock level curve (fig. 2). Limiting d.b.h. for selection of loops is 10.0 inches minus the average change expected with light partial cuttings in stands just under 10.0 inches d.b.h.

Computed increases in average d.b.h. of diseased stands are half the increases of similar, healthy stands, as occurs in actual dwarf mistletoe-infested stands, because more of the larger trees are removed than would otherwise be the case.

Subroutine SWCUT2

SWCUT2 computes the reduced average d.b.h. that results when thinning from above in dwarf mistletoe-infested stands. The computations,

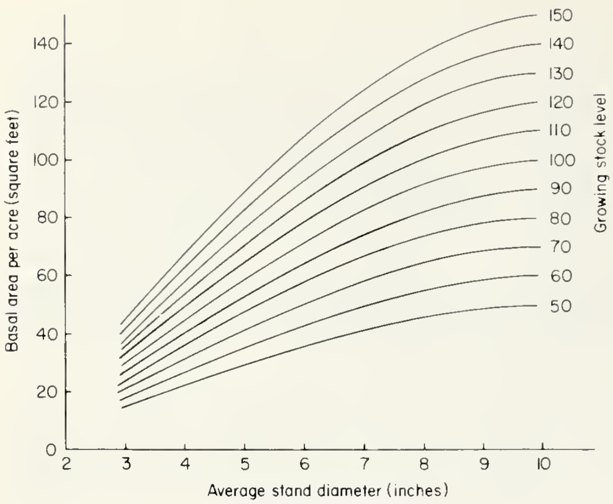

Figure 2.—Basal area after thinning in relation to average stand diameter for standard levels of growing stock.

which resemble SWCUT1, determine an estimated post-thinning d.b.h. and compare the equivalent basal area with the thinning level desired. Program SWYLD2 duplicates actual practice in diseased stands by restricting thinning from above to the initial entry. The program user also has the option of requiring that all thinnings be from below.

Program Relationships

Field and office procedures used to obtain the relationships described below were similar to those outlined previously for healthy (Myers 1971) and dwarf mistletoe-infested stands (Myers and others 1971, Myers and others 1972). Most relationships in SWYLD2 are the same as already reported (Myers and others 1972, Myers 1974). Additional information on spread of dwarf mistletoe from overstory to understory was obtained from temporary plots in Arizona and New Mexico.

Basal area and other per-acre values, average stand diameter, average height, and site index are used as dependent and independent variables to obtain the prediction equations used. The relationships shown in the program listing (appendix 1) contain only significant independent variables.

Variable and subroutine names are given in capital letters in this and the following sections. Names of subscripted variables included in text material usually are not accompanied by symbols for subscripts. Variables are defined in the listing of the Order and Contents of the Data Deck and in the program listing (appendix 1).

Program statements of species-specific relationships must be replaced to adapt SWYLD2 to other species or conditions. Suggested program modifications are given in the section headed Local Modification.

1. Stocking After Cutting

Stand density to be left after each partial cut in healthy stands, or in diseased stands thinned from below, is expressed as a relationship between d.b.h. and basal area (table 1). Tabular values, computed as SQFT in subroutine SWCUT1, represent one possible series of densities that could be used to guide successive thinnings.

In table 1, basal area increases with diameter until 10.0 inches diameter is reached, and remains constant thereafter. The designation "growing stock level 80" indicates that basal area is 80.0 ft^2 when diameter is 10.0 inches or larger, regardless of what basal area may be at lower average diameters.

Desired stand density will vary with the objectives of management, and a family of basal area–diameter relationships is needed (see fig. 2). Other growing stock levels are named the same way as level 80. For example, level 100 means that reserve basal area will be 100 ft^2 when d.b.h. is 10.0 inches or larger. Basal areas for any growing stock level are computed by multiplying the values for level 80 in table 1 by the ratio level/80. For example, basal areas for level 100 and diameters smaller than 10.0 inches are each 100/80 times the corresponding basal areas of table 1.

Desired levels are designated by assigning values to variables DSTY and THIN on data card type 4, as shown in the listing of Order and Contents of the Data Deck. Each assigned value is a growing stock level, the basal area to be left when d.b.h. after thinning is 10.0 inches or larger.

Equations for DBHP in subroutine SWCUT1 also describe the tabulated values. In this case, average diameters less than 10.0 inches are estimated when basal areas and the desired stocking level are known. Variables BREAK and BUST indicate points where the relationship of diameter to basal area has been broken into segments for convenience in regression analysis.

Three equations for GSLEVL in CUTS, SWCUT2, and PROJ are obtained from the values of table 1, adjusted for various growing stock levels. They compute the equivalent growing stock level when basal area and average diameter are known. The first equation of each set is a linear extrapolation to zero of the data in table 1.

Table 1.--Basal areas after partial cutting in relation to average stand diameter, growing stock level 80

Average stand d.b.h. after cutting (Inches)	Basal area per acre	Average stand d.b.h. after cutting (Inches)	Basal area per acre	Average stand d.b.h. after cutting (Inches)	Basal area per acre	Average stand d.b.h. after cutting (Inches)	Basal area per acre
	ft^2		ft^2		ft^2		ft^2
2.0	12.1	4.0	35.2	6.0	56.6	8.0	72.5
2.1	13.2	4.1	36.4	6.1	57.6	8.1	73.1
2.2	14.4	4.2	37.6	6.2	58.5	8.2	73.7
2.3	15.5	4.3	38.7	6.3	59.4	8.3	74.3
2.4	16.7	4.4	39.9	6.4	60.3	8.4	74.8
2.5	17.9	4.5	41.0	6.5	61.2	8.5	75.3
2.6	19.0	4.6	42.2	6.6	62.1	8.6	75.8
2.7	20.2	4.7	43.4	6.7	62.9	8.7	76.3
2.8	21.3	4.8	44.5	6.8	63.8	8.8	76.7
2.9	22.5	4.9	45.7	6.9	64.6	8.9	77.1
3.0	23.7	5.0	46.8	7.0	65.4	9.0	77.5
3.1	24.8	5.1	47.8	7.1	66.2	9.1	77.9
3.2	26.0	5.2	48.8	7.2	67.0	9.2	78.2
3.3	27.1	5.3	49.8	7.3	67.7	9.3	78.5
3.4	28.3	5.4	50.8	7.4	68.5	9.4	78.8
3.5	29.5	5.5	51.8	7.5	69.2	9.5	79.1
3.6	30.6	5.6	52.8	7.6	69.9	9.6	79.3
3.7	31.8	5.7	53.8	7.7	70.6	9.7	79.5
3.8	32.9	5.8	54.7	7.8	71.2	9.8	79.7
3.9	34.1	5.9	55.7	7.9	71.9	9.9	79.8
						10.0+	80.0

2. Diameter Increase from Growth

Equations that predict future average d.b.h. of healthy stands (DBHO) are obtained from plot data that include past and present average diameters and other stand measures. Separate equations estimate growth at stand densities: (1) somewhat less than or within the possible range of managed stands, and (2) greater than any goals of management.

Data from diseased plots provide the equation for the reduced diameter growth caused by dwarf mistletoe (DINC). Plot values at the beginning of the projection period and the DBHO equation for healthy stands give potential periodic growth. Actual growth and dwarf mistletoe ratings of the plots are then used to express actual growth as a percentage of the potential for various degrees of infestation.

Data for diameter growth equations may be obtained from either permanent or temporary plots. On permanent plots, measurements must be made at intervals equal to the projection period desired. Past diameters are obtainable from temporary plot data when present diameters, radial wood growth, and adjustment for bark growth are known.

Average stand diameter in SWYLD2 is the diameter of the tree of average basal area.

3. Diameter Change from Thinning

Two sets of equations are used to determine average diameters after partial cutting. Equations for DBHE in subroutine SWCUT1 estimate the increased averages after cuts that emphasize removal of the smaller trees. The computed increase in infested stands is half that in healthy stands, to account for the larger trees removed in dwarf mistletoe control. Equations for DBHE in subroutine SWCUT2 compute the smaller average diameters produced by thinning from above. The latter situation, with emphasis on removal of the larger trees, is the usual initial thinning in infested stands if the objective is reduction of dwarf mistletoe.

Equations for post-thinning diameters are derived from data obtained in a variety of stands marked for thinning. Thinnings simulated on a computer also provide data for the equations (Myers 1971).

4. Height Increase from Growth

Equations in subroutines FIRST and PROJ compute average heights of dominant and codominant trees in healthy stands. Equations for HTSO and TEMH apply to stands of basal area less than or within the range of possible management goals. The equation for HTNEW applies to stands of greater density. The equations for HTSO in FIRST are bypassed if actual initial heights are read in.

Two equations for reduction in height growth due to dwarf mistletoe are based on data from infested stands. The equation for HTPCT in FIRST computes any reduction during the period from stand origin to AGEO and is not used if initial heights are read in. The equation for PCT in PROJ provides the reduction for a single projection period. Procedures for measurement and regression analysis of field data parallel those for the diameter growth equations described above.

Stand ages used in the equations are averages of dominant and codominant trees. For a two-storied stand, age of the understory is obtained from trees judged to be potential dominants and codominants.

5. Height Change from Thinning

Two equations for ADDHT in subroutine CUTS compute the change in average height due to partial cutting. One equation determines the increase resulting from thinning primarily from below. The other estimates the decrease in average height that occurs when cutting from above with emphasis on removal of the larger trees. At each cutting, the current value of ADDHT is added algebraically to height before thinning to obtain average height after thinning. Computed values of ADDHT are small when thinning from below because average heights and their changes refer to dominant and codominant trees only.

6. Noncatastrophic Mortality

Equations to estimate mortality in healthy (OUT) and diseased (DIE) stands require values for several easily measured stand variables. Data for regression analyses came from permanent and temporary plots, with and without dwarf mistletoe. As used here, the term "noncatastrophic" refers to gradual losses from competition, endemic insect populations, and dwarf mistletoe. Effects of forest fires, insect epidemics, and other abrupt changes are not computed by these equations.

Reduction in numbers of trees is important in unthinned stands of ponderosa pine, but is minor and erratic in healthy, thinned stands. A prediction equation for mortality could not be computed for healthy thinned stands with an average d.b.h. of 10.0 inches or larger. Subroutine PROJ therefore computes mortality reductions only for mistletoe-free stands that average less than 10.0 inches d.b.h. Losses are computed for all infested stands with a DMR large enough to influence rate of mortality. In all computations, mortality is a percentage expressed as a decimal.

7. Dwarf Mistletoe Infestation

Several prediction equations compute initial dwarf mistletoe ratings (DMR) and subsequent annual or periodic increases. Data used to obtain these equations come from permanent and temporary plots. Three ways of reporting initial degree of infestation are provided. One alternative is to enter DMR as part of the input. Otherwise, stand age at time of initial infestation or the percentage of trees infected may be used.

Initial ratings are computed by subroutines FIRST or PROJ, if an initial DMR is not reported. The first equation for an initial rating computes DMR from the percentage of infected trees (PINF) in the story or even-aged stand. This requires that PINF be read in as a second alternative way of reporting the degree of infestation. Methods for determining PINF in southwestern ponderosa pine stands were described by Walters (1975). The other three computations of initial DMR are based on another alternative, use of the variable START. This is the average tree age when the story or even-aged stand is first infected. It is the mean age when infection began at various points throughout the story or stand. It is not the age when earliest infection occurred. Three equations involving TIME (derived from START) are needed, one for an overstory or single-storied stand, one for understories with less than 3,000 trees per acre, and another for understories of greater density.

A value of PINF is computed in CUTS, even when other alternative measures of degree of infestation have been provided. This value for PINF is then used to compute the buildup of infestation over a 20-year period after DMR has apparently been reduced to zero by partial cutting.

Values of DMR computed from START and TIME apply to infested stands that have never been partially cut. To simulate future growth in actual stands that have been partially cut, either DMR or PINF should be used to describe the infestation.

Four equations for YDM in subroutine PROJ provide the annual increase in dwarf mistletoe rating that is then used to obtain the new rating at the end of the projection period. The first equation for YDM applies to the increase in even-aged stands or to overstories. The third and fourth equations apply to understories and include the additional contribution of dwarf mistletoe seeds from the overstory. The second equation, YDM = 0.08, provides the constant increase in stands of 15 or less trees per acre. Spread of infection in such open stands is within-tree and not between trees.

The two equations for DMR in PROJ that use computed values of YDM contain no species-specific regression coefficients. The weights of 0.5 and 1.0 assigned the periodic increases may, however, be different for other combinations of host and parasite.

8. Decrease in DMR from Thinning

Two equations in CUTS compute the reduction in dwarf mistletoe rating produced by partial cutting. An initial cut in an infested stand will emphasize removal of the larger trees unless the option is overridden by a non-zero value of IOPT on data card type 4. The equation for DELDMR computes the reduction if the initial thinning is from above. The next statement in the subroutine applies to thinnings from below, and indicates that the reduction in DMR is ⅔ of that possible when thinning from above.

The equations were computed from data obtained by simulation of thinnings in actual stands.

Thinnings are not performed if the current DMR exceeds the value of DMLEV read in by data card type 4. A DMLEV value of 3.0 is usually appropriate for the host-parasite combination described here.

9. Stand Volume Equation

Volumes per acre in total cubic feet inside bark from groundline to tip (TCF) are computed from stand volume equations. Tree volume equations for southwestern ponderosa pine (Myers 1963) were used to obtain plot volumes for the regression analysis. Two statements for TCF appear in subroutine SWVOL because the relationship is not linear over the range of D^2H that can appear in yield tables.

Total cubic feet is the only volume computed directly by SWYLD2. Volumes in other units are obtained from total cubic volume and appropriate conversion factors, as explained below.

10. Volume Conversion Factors

Volumes in total cubic feet can be converted to merchantable cubic feet, board feet, square feet of veneer, weight per acre, or other units. Appropriate factors are used to make conversions. Subroutine SWVOL converts total cubic volumes to merchantable cubic feet (with FCTR) and to board feet Scribner Rule (with PROD). Footnotes to the yield tables give minimum limits for tree d.b.h. and top diameter.

Plot data used to compute total cubic feet also provide volumes in other units of interest (Myers 1963). The quantity of each unit per total cubic foot is determined separately for each plot. These ratios are then used to obtain equations for FCTR and PROD. Three equations for FCTR and two for PROD are included in SWVOL to simplify regression analysis.

Ratios are not computed for the smallest average stand diameters because the factors vary greatly in such stands. This variation has no important effect on yield table construction. Merchantable material will not be a part of thinnings until stand diameter is large enough for conversion factors to be reliable.

User-Supplied Information

Values of 38 variables that describe stand conditions or control program execution are read from data cards supplied by the program user. Twelve of these values must be zero or blank, if the data apply to an even-aged stand. Names, input formats, sequence for punching, and definitions of these variables are given in the tabulation headed Order and Contents of the Data Deck. Twenty variables that require management decisions or the collection of field data are described in detail in this section.

1. Initial Stand Measurements

Values for AGEO, DBHO, HTSO, and DENO on data card type 5 are obtained in one of two

Order and Contents of the Data Deck

Card type	Number of cards	Variable name	Columns	Format	Description of variable
1	1	NSTND	1-5	I5	Number of stand records to be processed in a single job.
		RINT	6-10	F5.0	Number of years for which growth and infection equations make one projection of growth or change. Value is 10.0 for the equations in appendix 1.
2	1	COMCU	1-5	F5.0	Minimum cut in merchantable cubic feet to be included in total yields. Must be at least 1.0.
		COMBF	6-10	F5.0	Minimum cut in board feet to be included in total yields. Must be at least 1.0.
3	1 per stand	NOTE(I)	1-80	16A5	Description of test conditions for the stand being processed.
4	1 per stand	ICUT	1-5	I5	Control to choose: no precommercial thinnings (0), initial precommercial thinning only (1), no restriction on precommercial thinnings (2).
		DMLEV	6-10	F5.1	Dwarf mistletoe rating above which no intermediate cutting will be done.
		DELAY(1)	11-15	F5.0	Number of years between initial age in yield table and tree age at first cut in the overstory.
		IOPT(1)	16-20	I5	Initial thinning in diseased overstory to be from above (0) or below (1).
		THIN(1)	21-25	F5.0	Growing stock level for initial thinning in a healthy overstory.
		DSTY(1)	26-30	F5.0	Growing stock level for intermediate cuts after the first in the overstory.
		JCYCL(1)	31-35	I5	Interval between intermediate cuts in the overstory.
		DELAY(2)	36-40	F5.0	Number of years between initial age in yield table and tree age at first cut in the understory.
		IOPT(2)	41-45	I5	Initial thinning in diseased understory to be from above (0) or below (1).
		THIN(2)	46-50	F5.0	Growing stock level for initial thinning in a healthy understory.
		DSTY(2)	51-55	F5.0	Growing stock level for intermediate cuts after the first in the understory.
		JCYCL(2)	56-60	I5	Interval between intermediate cuts in the understory.
5	1 per stand	STND	1-5	F5.0	Number of the stand.
		SITE	6-10	F5.0	Site index of the stand.
		AGEO(1)	11-15	F5.0	Age of overstory at first entry in the yield table.
		DBHO(1)	16-20	F5.1	Average d.b.h. of the overstory at age AGEO(1).
		HTSO(1)	21-25	F5.1	Average height of overstory dominants and codominants at age AGEO(1).
		DENO(1)	26-30	F5.0	Number of live trees per acre in the overstory at age AGEO(1).
		DMR(1)	31-35	F5.1	Average dwarf mistletoe rating of overstory at age AGEO(1).

		PINF(1)	36-40	F5.1	Percentage of overstory trees infected by dwarf mistletoe at age AGEO(1).
		START(1)	41-45	F5.0	Age of overstory when dwarf mistletoe infection begins. Enter number larger than largest REGN if infection will not occur during the rotation.
		AGEO(2)	46-50	F5.0	Age of understory at first entry in the yield table.
		DBHO(2)	51-55	F5.1	Average d.b.h. of the understory at age AGEO(2).
		HTSO(2)	56-60	F5.1	Average height of potential dominants and codominants in understory at age AGEO(2).
		DENO(2)	61-65	F5.0	Number of live trees per acre in the understory at age AGEO(2).
		DMR(2)	66-70	F5.1	Average dwarf mistletoe rating of understory at age AGEO(2).
		PINF(2)	71-75	F5.1	Percentage of understory trees infected by dwarf mistletoe at age AGEO(2).
		START(2)	76-80	F5.0	Age of understory when dwarf mistletoe infection begins. Enter number larger than largest REGN if infection will not occur during the rotation.
6	1 per stand	REGN(1)	1-5	F5.0	Stand age when first regeneration cut will occur. Must never be zero or blank. This is age for clearcutting if rest of card is zero or blank.
		VLLV(1)	6-10	F5.3	Percentage of DSTY to be left at age REGN(1). Will be zero with clearcutting. Enter as a decimal.
		REGN(2)	11-15	F5.0	Stand age at which second regeneration cut, if any, will occur. Age for removal of seed trees or second cut of shelterwood.
		VLLV(2)	16-20	F5.3	Percentage of basal area left after first regeneration cut to be left at age REGN(2). Will be zero except for 3-cut shelterwood. Enter as a decimal.
		REGN(3)	21-25	F5.0	Stand age at which third regeneration cut, if any, will occur. Final cut of 3-cut shelterwood.

ways, depending on the purpose of the computer run. These stand descriptors are printed on the first line of the yield table; thus they report initial conditions. Ways of obtaining the data are:

a. When the purpose is to estimate performance of a future or hypothetical managed stand: examine numerous young stands to determine the average d.b.h. and height attained at various ages for each site class and for each of several stand densities. The objective is to describe stand conditions at some selected age (AGEO) if regeneration and subsequent growth and mortality progress according to some goal set for the site class and density.

b. When the purpose is to estimate future performance of an actual stand: obtain age, average d.b.h., average dominant and codominant height, and number of trees per acre by usual stand inventory procedures.

AGEO is the average age of living dominant and codominant trees. For an understory, age of potential dominants and codominants is determined separately from age of the overstory. AGEO is the first age that will appear in the yield table for each stand and, unless a delay is called for, will be stand age at time of the first cutting computed by SWYLD2. AGEO for actual stands is age at time of inventory. In the case of hypothetical stands examined to establish management principles, AGEO should usually be age at time of first thinning.

DBHO is average d.b.h. of all live trees at age AGEO, regardless of crown class. For two-storied stands, DBHO is determined separately for each story. DBHO should be determined to the nearest 0.1 inch. Average d.b.h. is the diameter of the tree of average basal area.

HTSO is the average height of live dominant and codominant trees of an even-aged stand, or of a single story of a two-storied stand. As with AGEO, an understory value is obtained from trees judged to be potential dominants and codominants. HTSO may be omitted from data card type 5 if a hypothetical stand with a density below growing stock level 160 is being examined. Values for HTSO are computed if zero or blank fields appear on the data cards. For actual stands, measured heights should be used to account for the past effects on height growth of stand density and disease.

DENO is the number of live trees per acre in an even-aged stand or in each story of two-storied stands. All trees over 4.5 feet tall are counted, regardless of crown class. These are the same trees used to obtain DBHO.

2. Initial Dwarf Mistletoe Conditions

Three situations involving time of initial infestation can be examined for actual or hypothetical stories or stands. For each, a non-zero value of one variable is punched in data card 5 and the values of the other two disease variables are zero or blank. The situations are:

1. The story or stand is already infested at age AGEO, the first age in the yield table. Either the DMR or the percentage of trees infected is known.
2. Infestation begins at any time before or during the period simulated, and story or stand age at this time is known.
3. The story or stand remains healthy throughout the period simulated.

An infestation already present at age AGEO is described in either of two ways:

1. DMR—average dwarf mistletoe rating (see fig. 1) at age AGEO of all trees of an actual story or stand or a selected value assigned to a hypothetical stand. A nonzero value of DMR on the data card causes statements that compute initial DMR to be bypassed.
2. PINF—percentage of the live trees infected with dwarf mistletoe in an actual or hypothetical story or stand at age AGEO. DMR is later computed from PINF.

An infestation that begins at a known stand or story age, before or after AGEO, is described by the variable START. This is the average age of the dominant and codominant trees when the story or stand is first infected. Refer to item 7 of "Program Relationships" for a detailed definition of START. Preferably, START should be used only when simulating growth in hypothetical stands. DMR is computed from START only if both the DMR and PINF fields of data card type 5 are zero or blank.

All computations of DMR must be bypassed if the story or stand remains mistletoe-free throughout the period simulated. This is done by entering zero values for both DMR and PINF and a value for START greater than the largest value of the three REGN variables. For example, if with 2-cut shelterwood REGN(1) equals 110, REGN(2) equals 130, and REGN(3) equals 0, then START must have some value greater than 130.

3. Site Index

The site index value read in for each stand is based on mean height of dominant and codominant trees at a base age of 100 years. Tables and graphs published by Meyer (1938) provide the relationships used to determine each index.

Site index values used in growth computations for actual stands must be reliable indicators of relative productivity. Trees in dense stands or with any disease or deformity severe enough to reduce height growth do not furnish reliable information. In such cases, site index can be obtained from suitable nearby stands or from soil variables.

4. Intermediate Cuts

Seven variables on data card type 4 control the execution of intermediate cuts. Eleven fields are provided for them, since four variables require separate entries for each story of two-storied stands. The purpose of each variable is as follows:

1. ICUT—control of the number of noncommercial thinnings that will be simulated. An input value of zero causes all noncommercial thinnings to be bypassed. Assign ICUT a value of one if only the initial thinning can be noncommercial. An input value of two results in all scheduled thinnings being performed, regardless of how many may be noncommercial. Minimum volumes for commercial cuts are entered as COMBF and COMCU on data card type 2. Variables COMBF and COMCU must be assigned values of at least 1.0, regardless of the value of ICUT.

2. THIN—growing stock level for initial thinning in healthy stands. Levels are designated in the manner shown in figure 2. They will frequently be 80, 90, or 100 for southwestern ponderosa pine, but may range from 40 to 160.

3. DMLEV—maximum dwarf mistletoe rating above which intermediate cuttings will not be performed. A value of 3.0 will often be used for ponderosa pine. Experience indicates that thinnings cannot materially reduce effects of the infestation or improve stand growth when DMR exceeds 3.0.

4. JCYCL—interval between intermediate cuts, as punched on card type 4. JCYCL is later redefined in subroutine CUTS when an interval between regeneration cuts is needed. Values assigned to JCYCL must be a multiple of the projection period of the growth and mortality equations (RINT). For example, the equations of SWYLD2 project d.b.h. and other measures for 10-year periods, and RINT has a value of 10.0. The value of JCYCL on card type 4 can therefore be 10, 20, 30, etc. years.

5. DSTY—growing stock level for intermediate cuts after the first cut. Discussion of choice of level for THIN, above, also applies to DSTY. Levels assigned to THIN and DSTY may be equal.

6. DELAY—number of years between the first age reported in the yield table (AGEO) and age of the story or stand at time of the first simulated cutting. The value of DELAY must be a multiple of the value of RINT. The variable DELAY schedules the first cut but does not assure that it actually will be performed. Restriction on noncommercial thinning, basal area less than the growing stock goal, or a value of DMR larger than DMLEV will prevent or postpone thinning regardless of the value of DELAY. Initial cutting will take place at age AGEO if DELAY is assigned a value of zero and if other restrictions on cutting do not apply.

7. IOPT—control on whether or not the initial thinning in an infested stand will be from above. Thinning from above emphasizes, but is not restricted to, removal of the larger trees. Such cutting is usual practice in infested stands because the larger trees usually support the greater amounts of dwarf mistletoe. IOPT is assigned a value of zero if initial thinning is to be from above and a value greater than zero if the initial thinning is to be from below. Regardless of the value of IOPT, thinning will not be performed unless all restrictions on thinning are met.

5. Regeneration Cuts

Entries on data card type 6 determine the method of regeneration to be simulated, stand age when each cut will be performed, and the basal area to be left for seed trees or shelterwood. Stand ages at regeneration cuts must equal the sum of AGEO plus appropriate multiples of the value of RINT. Regardless of regeneration method, REGN(1) will never be assigned a value of zero on data card type 6.

For clearcutting, stand age at time of final cutting, or REGN(1), is the only entry needed on the card.

Seed tree cutting requires that values for REGN(1), VLLV(1), and REGN(2) be punched in card type 6. REGN(1) is the stand age at first regeneration cutting, and REGN(2) is stand age when the seed trees are removed. The interval between AGEO and REGN(1) and the interval between REGN(1) and REGN(2) must each be a multiple of RINT. VLLV(1) is the percentage of the growing stock goal, DSTY, to be left for seed trees. VLLV(1) is entered as a decimal.

Shelterwood cuttings are controlled in the same manner as seed tree cuts except that up to three regeneration cuts are possible. The restrictions on formats and intervals described above also apply here. Two-cut shelterwood requires that values be assigned to the same three variables used with the seed tree method, described above. For three-cut shelterwood, REGN(1) and REGN(2) are stand ages at the two removal cuts and REGN(3) is stand age at the final cut. VLLV(2) is the percentage of the shelterwood basal area left at age REGN(1) that will be retained at age REGN(2). For example, assume that DSTY is 100 square feet and that VLLV(1) and VLLV(2) are 0.5 and 0.4, respectively. Basal area of the shelterwood at age REGN(1) will be 50 square feet. Residual basal area at age REGN(2) will be 20 square feet.

Local Modifications

This section may be skipped by readers who are not modifying SWYLD2 for local use. If the adaptation is to apply to healthy, single-storied stands only, it will be more efficient to modify program PONYLD (Myers 1971) rather than SWYLD2.

Complete modification of SWYLD2 for other host–dwarf mistletoe combinations, regions, thinning specifications, and utilization standards requires replacement of 65 statements that compute values of 24 variables. The statements are described in the section headed "Program Relationships." The 65 replacements require that coefficients for 46 different relationships be computed. The difference of 19 is due to duplication among the 65 replaceable statements. The 46 different relationships include several cases where, for simplicity of regression analysis, a single variable is computed by two or three separate relationships.

The 65 replaceable statements described below do not include the IF statements needed to select one appropriate statement from among the two or three provided for some variables. The number of IF statements to be modified or removed will depend on the results of each regression analysis.

Statements to be replaced for complete modification are in six subroutines, as follows:

FIRST has seven replaceable statements: four for DMR, two for HTSO, and one for HTPCT.

CUTS has eight replaceable statements: three for GSLEVL, two for DELDMR, two for ADDHT, and one for PINF.

PROJ has 23 replaceable statements:

Variable	Statements	Variable	Statements
DMR	6	DIE	1
DENT	1	OUT	1
YDM	4	TEMH	2
GSLEVL	3	HTNEW	1
DBHO	2	PCT	1
DINC	1		

The first four statements for DMR contain the same coefficients as the four in subroutine FIRST. The last two statements for DMR have weighting factors of 0.5 and 1.0 that could vary by species. The IF statement using DENT, immediately following the statement labeled 20, contains a constant that may be species-specific. Three statements for YDM resemble three of the statements for DMR, but do not include the variable TIME. The other statement for YDM sets a constant value of 0.08 that may be species-specific. Statements for GSLEVL are the same in PROJ and CUTS. Two statements for TEMH have the same coefficients as the statements for HTSO in subroutine FIRST. The remaining seven replaceable statements in PROJ are not duplicated in PROJ or in other subroutines.

SWVOL has seven replaceable statements: two for TCF, three for FCTR, and two for PROD. None of them are duplicated elsewhere in the program.

SWCUT1 has 14 replaceable statements, none of which are duplicated elsewhere. Long statements for DBHE and PDBHE (log-log relationship for DBHE) each appear twice. Two short identical statements for DBHE just before the statements labeled 20 and 70, contain a constant 0.5 that may be species-specific. With other host–parasite combinations, thinning from below in diseased stands may not produce half the change in d.b.h. that thinning from below produces in healthy stands. The remaining eight replaceable statements are not duplicated in SWCUT1 or elsewhere. They include one statement each for BREAK and BUST, three statements for SQFT, and three statements for DBHP.

SWCUT2 has six replaceable statements, four of which are duplicated elsewhere. The three equations for GSLEVL have the same coefficients as those in CUTS and PROJ. The equation for DBHE just before the statement labeled 30 also appears in SWCUT1. The two long statements for DBHE (one as PDBHE for a log-log relationship) compute the reduced d.b.h. after thinning from above, and do not appear elsewhere.

Seventeen statements relating to stocking need not be replaced if the method of expressing stocking levels shown in table 1 and figure 2 is retained. These 17 include nine statements for GSLEVL in CUTS, SWCUT2, and PROJ. Other retainable statements are in SWCUT1: three for DBHP, one each for BREAK and BUST, and three for SQFT.

Several statements in subroutine TABLE that write table headings and footnotes must be modified to conform to changes in species, units of measure, or utilization standards.

A Sample Problem

The problem described below demonstrates most of the computations made by SWYLD2 and the printed results obtained. It illustrates some of the questions that may be asked and the information that will be provided. For brevity, only three of the many possible stand conditions are examined. The example also serves as a test problem for use in adapting the source program to locally available computing facilities.

Assume a forest composed of even-aged and two-storied stands of ponderosa pine with differing degrees of infestation by dwarf mistletoe. Some of the many questions the manager of such a forest would have and their relation to management include:

1. What growth can be expected in a hypothetical even-aged stand, without dwarf mistletoe, that is to be managed according to a selected set of management controls? Initially, many yield tables would be produced to examine the effect of variations in length of cutting cycle and other controls on yields and on the number of precommercial thinnings required.

2. How would this performance be affected by a dwarf mistletoe infestation that started when the stand was 10 years old? Tables of this type provide information on impacts of the disease, free of the accidents of past history of actual stands.

3. What yields can be expected from an existing two-storied stand infested with dwarf mistletoe if the overstory is removed now? This and the next question relate to determination of the best way of converting an undesirable stand condition to something better.

4. What would be the effect on yield if question 3 were modified to delay overstory removal for 20 years?

For purposes of this example, assume that the values of several management controls have been standardized for the working circle. Cutting cycle length is 20 years. Initial thinnings in young stands reduce density to growing stock level 120. Other intermediate cuts are to growing stock level 90. Only the first thinning may be noncommercial. Minimum commercial volumes per acre are 320 cubic feet to a 4-inch top and 1,500 board feet. Regeneration is by two-cut shelterwood with a removal cut at stand age 110 and the final cut at age 130. The manager expects that his procedure for regeneration cuts will result in a new stand with 950 trees per acre at age 30. This new crop will average 4.8 inches in diameter on areas of site index 70.

The data deck consists of the 18 cards shown in figure 3. The first two cards shown are the type 1 and type 2 cards, respectively, read by the main program. The next four cards are the type 3, 4, 5, and 6 cards used to answer the first of the questions listed above. The remaining 12 cards are the type 3, 4, 5, and 6 cards for the other three questions.

Yield tables produced by SWYLD2 to answer the four questions given, and with the data deck described above, are reproduced in appendix 2.

Yield tables can be used in many ways to assist in decisionmaking. For many purposes, yields of healthy stands will be desired so that

```
                                  COLUMN NUMBERS

                   1         2         3         4         5         6         7         8
          12345678901234567890123456789012345678901234567890123456789012345678901234567890

CARD TYPE

  1              4    10

  2            320  1500

  3       HYPOTHETICAL HEALTHY EVEN-AGED STAND. BEGIN TABLE AT AGE 30.
  4              1    30     0     0   120    90    20     0     0     0     0     0
  5              1    70    30    48     0   950     0     0   999     0     0     0     0     0     0     0
  6            110   500   130     0     0

  3       HYPOTHETICAL EVEN-AGED STAND. INFESTATION STARTS AT AGE 10.
  4              1    30     0     0   120    90    20     0     0     0     0     0
  5              2    70    30    48     0   950     0     0    10     0     0     0     0     0     0     0
  6            110   500   130     0     0

  3       TWO-STORIED INFESTED STAND WITH IMMEDIATE OVERSTORY REMOVAL.
  4              1    30     0     0   120    90    20     0     0   120    90    20
  5              3    70   150   161   750    20    48     0     0    30    41   210   600    10     0     0
  6            110   500   130     0     0

  3       TWO-STORIED INFESTED STAND. OVERSTORY REMOVAL DELAYED 20 YEARS.
  4              1    30    20     0   120    90    20    20     0   120    90    20
  5              4    70   150   161   750    20    48     0     0    30    41   210   600    10     0     0
  6            110   500   130     0     0
```

Figure 3.—Data deck for sample problem.

long-range goals can be determined. Yields, number of noncommercial cuts, number of scheduled cuts that cannot be made, and size of the average tree are some of the values produced. Money yields and rates earned can be computed if necessary data on costs and stumpage values are available. Stand ages at culmination of mean annual increment, and rates earned can help the manager determine suitable rotations for his working groups.

With a disease as important as dwarf mistletoe, it is also necessary to project the growth of diseased stands. Two important types of information can be obtained from yield tables that include disease effects. A comparison of projected yields of healthy and diseased stands indicates the impact of the disease on the timber resource. Yield tables for actual diseased stands indicate the types of treatment that may be practical, and give an estimate of the expected benefits.

Literature Cited

Andrews, Stuart R., and John P. Daniels.
1960. A survey of dwarfmistletoes in Arizona and New Mexico. U.S. Dep. Agric. For. Serv., Rocky Mt. For. and Range Exp. Stn., Stn. Pap. 49, 17 p. Fort Collins, Colo.

Hawksworth, Frank G.
1961. Dwarfmistletoe of ponderosa pine in the Southwest. U.S. Dep. Agric., Tech. Bull. 1246, 112 p.

Hawksworth, Frank G., and Arthur A. Lusher.
1956. Dwarfmistletoe survey and control on the Mescalero-Apache Reservation, New Mexico. J. For. 54(6):384-390.

Hawksworth, Frank G., and Clifford A. Myers.
1973. Procedures for using yield simulation programs for dwarf mistletoe-infested lodgepole and ponderosa pine stands. USDA For. Serv. Res. Note RM-237, 4 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Korstian, Clarence F., and W. H. Long.
1922. The western yellow pine mistletoe: effects on growth and suggestions for control. U.S. Dep. Agric. Bull. 1112, 35 p.

Lightle, Paul C., and Frank G. Hawksworth.
1973. Control of dwarf mistletoe in a heavily used ponderosa pine recreation forest: Grand Canyon, Arizona. USDA For. Serv. Res. Pap. RM-106, 22 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Meyer, Walter H.
1938. Yield of even-aged stands of ponderosa pine. U.S. Dep. Agric., Tech. Bull. 630, 59 p.

Myers, Clifford A.
1960. Estimating oven-dry weight of pulpwood in standing ponderosa pines. J. For. 58(11): 889-891.

Myers, Clifford A.
1963. Volume, taper, and related tables for southwestern ponderosa pine. U.S. For. Serv. Res. Pap. RM-2, 24 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Myers, Clifford A.
1971. Field and computer procedures for managed-stand yield tables. USDA For. Serv. Res. Pap. RM-79, 24 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Myers, Clifford A.
1974. Computerized preparation of timber management plans: TEVAP2. USDA For. Serv. Res. Pap. RM-115, 72 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Myers, Clifford A., Frank G. Hawksworth, and Paul C. Lightle.
1972. Simulating yields of southwestern ponderosa pine stands, including effects of dwarf mistletoe. USDA For. Serv. Res. Pap. RM-87, 16 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Myers, Clifford A., Frank G. Hawksworth, and James L. Stewart.
1971. Simulating yields in managed, dwarf mistletoe-infested lodgepole pine stands. USDA For. Serv. Res. Pap. RM-72, 15 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Myers, Clifford A., and Edward C. Martin.
1963. Mortality of southwestern ponderosa pine sawtimber after second partial harvest. J. For. 61(2):128-130.

Pearson, G. A.
1938. Lighter cuts and larger yields in ponderosa pine. J. For. 36(8):779-789.

Pearson, G. A.
1939. Mortality in cutover stands of ponderosa pine. J. For. 37(5):383-387.

Sperry, O. E.
1934. The rate of growth of the ponderosa pine in Estes Park, Colorado. Torrey Bot. Club Bull. 61:19-34.

Walters, James W.
1975. Evaluation of a dwarf mistletoe survey procedure. USDA For. Serv., For. Insect and Dis. Manage. Rep. R-3, 75-23, 7 p. Southwest. Reg., Albuquerque, N.M.

APPENDIX 1
Listing of Program SWYLD2

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      PROGRAM SWYLO2
     1(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
C
C TO COMPUTE ANO PRINT YIELO TABLES FOR EVEN-AGEO ANO TWO-STORIEO STANOS
C OF SOUTHWESTERN PONOEROSA PINE WITH OR WITHOUT OWARF MISTLETOE.
C
C OEFINITIONS OF VARIABLES.
C     SUBSCRIPTS -
C     I = 1 FOR OVERSTORY, I = 2 FOR UNOERSTORY.
C     J = 1, 2, OR 3 TO NUMBER REGENERATION GUT.
C     K = AGE CLASS AT TIME OF OPERATION.
C
C     AOOHT(I) = INCREASE OR OECREASE IN AVERAGE STAND HEIGHT FROM
C          PARTIAL GUTTING.
C     AGEO(I) = INITIAL ANO SUBSEQUENT AGES IN YIELO TABLE.
C     BASO(I) = BASAL AREA PER ACRE BEFORE PARTIAL CUTTING.
C     BAST(I) = BASAL AREA PER ACRE AFTER PARITAL CUTTING.
C     BREAK = POINT WHERE GROWING STOGK RELATIONSHIP OF OIAMETER ON
C          BASAL AREA IS BROKEN INTO SEGMENTS.
C     BUST = POINT WHERE GROWING STOGK RELATIONSHIP OF OIAMETER ON
C          BASAL AREA IS BROKEN INTO SEGMENTS.
C     CBAS(I,K) = BASAL AREA REMOVED.
C     CBF(I,K) = M BO. FT. REMOVEO.
C     COEN(I,K) = NUMBER OF TREES REMOVEO.
C     CHNG = PERIOOIC INCREASE IN AVERAGE OOM ANO COOOM HEIGHT.
C     CMCF(I,K) = MERCH. CU. FT. REMOVEO.
C     GOMBF = MINIMUM COMMERCIAL CUT, BOARO FEET.
C     COMCU = MINIMUM COMMERCIAL CUT, CU. FT.
C     CTOT(I,K) = TOTAL GU. FT. REMOVEO.
C     OBHE = TEMPORARY VARIABLE FOR AVERAGE STANO O.B.H. AFTER PARTIAL
C          CUTTING.
C     OBHO(I) = AVERAGE STANO O.B.H. BEFORE PARTIAL CUTTING.
C     OBHP = AVERAGE O.B.H. FROM GROWING STOCK LEVEL CURVES.
C     OBHT(I) = AVERAGE STANO O.B.H. AFTER PARTIAL GUTTING.
C     OELAY(I) = NUMBER OF YEARS BETWEEN INITIAL AGE ANO FIRST PARTIAL
C          CUTTING, IF FIRST PARTIAL CUTTING IS NOT OONE AT ONCE.
C     OELOMR = CHANGE IN O.M.R. DUE TO PARTIAL CUTTING.
C     OENO(I) = TREES PER ACRE BEFORE PARTIAL GUTTING.
C     OENT(I) = TREES PER AGRE AFTER PARTIAL CUTTING.
C     OIE = TREES LOST IN OISEASEO STANOS IN RINT YEARS, IN PERCENT.
C     OINC = PERIOOIC INCREASE IN AVERAGE O.B.H. IN STANOS WITH O.M.R.
C          GREATER THAN 3.5.
C     OLEV(I) = GROWING STOCK LEVEL FOR INTERMEOIATE CUTS AFTER THE
C          FIRST ANO FOR REGENERATION CUTS BY SEEO TREE OR SHELTERWOOO.
C     OMLEV = O.M.R. ABOVE WHICH NO INTERMEOIATE CUTTING WILL BE OONE.
C     OMR(I) = OWARF MISTLETOE INFECTION RATING.
C     OMRT(I) = MAXIMUM INFECTION EXPECTEO IN STANOS AFTER PARTIAL
C          CUTTING.
C     OSTY(I) = GROWING STOCK LEVEL FOR INTERMEOIATE CUTS AFTER THE
C          FIRST.
C     FCTR = FACTOR TO CONVERT TOTAL CU. FT. TO MERCH. CU. FT.
C     GSLEVL = CURRENT ACTUAL GROWING STOCK LEVEL.
C     HTNEW = ESTIMATEO AVERAGE TREE HEIGHT IN STANOS WITH GROWING STOCK
C          LEVEL GREATER THAN 160.
C     HTPCT = PERCENTAGE OF POTENTIAL HEIGHT GROWTH ACTUALLY ATTAINEO
C          BY INFESTEO STANOS.
C     HTSO(I) = AVERAGE TREE HEIGHT BEFORE PARTIAL CUTTING.
C     HTST(I) = AVERAGE TREE HEIGHT AFTER PARTIAL CUTTING.
C     ICUT = FLAG WITH INPUT VALUE OEFINEO BELOW TO CONTROL THINNINGS.
C          0 - NO NONCOMMERCIAL THINNINGS ALLOWEO.
C          1 - PRECOMMERCIAL INITIAL THINNING ALLOWED. NONCOMMERCIAL
C               SUBSEQUENT THINNINGS NOT ALLOWEO.
C          2 - ALL THINNINGS HAY BE NONCOMHERCIAL.
C     IK(I) = NUMBER OF GROWTH PROJECTION PERIOOS IN JCYCL(I).
C     IOPT(I) = FLAG TO ALLOW (0) OR PREVENT (1) INITIAL THINNING FROM
C          ABOVE IN STANOS WITH OWARF MISTLETOE.
C     IREGN(I) = FLAG WITH A VALUE OF ONE IF A REGENERATION CUT IS BEING
C          PERFORMEO.
C     ISANS(I) = FLAG WITH A VALUE EQUAL TO THE NUMBER OF GROWTH
C          PROJECTIONS SINCE A CUT WHICH REOUCES O.H.R. TO ZERO IN
C          INFESTEO STANOS.
C     JCYCL(I) = INTERVAL BETWEEN INTERHEOIATE OR REGENERATION CUTS.
C     KOEL(I) = NUMBER OF PROJECTION PERIOOS BEFORE INITIAL PARTIAL
C          CUTTING IS PERFORMEO.
C     KOL = COUNTER TO CONTROL STORAGE IN ARRAYS PRINTEO IN YIELO TABLES
C     KOUNT(I) = NUMBER OF GROWTH PROJECTIONS SINCE LAST CUT.
C     KPER = NUMBER OF PROJECTION PERIOOS FROM INITIAL AGE TO CURRENT
C          AGE.
C     KSTEP(I) = INOICATOR WITH VALUE OF ONE IF CURRENT PARTIAL CUTTING
C          IS FROM BELOW ANO TWO IF CURRENT PARTIAL CUTTING IS FROM
C          ABOVE.
C     KTR(I) = INOICATOR WITH VALUE GREATER THAN ZERO IF A SCHEOULEO
C          THINNING HAS BEEN SKIPPEO BECAUSE O.M.R. IS GREATER THAN
C          OMLEV, STANO IS ALREAOY AT OR BELOW SPECIFIEO STOCKING, OR
C          THINNING OIO NOT MEET IMPOSEO HERCHANTABILITY STANOAROS.
C     NOTE(L) = OESCRIPTION OF TEST CONOITIONS FOR STANO OUTPUT.
C     NSTNO = NUMBER OF STANOS BEING PROCESSEO BY RUN.
C     OUT = PERCENTAGE HORTALITY IN HEALTHY STANOS.
C     PCT = PERCENTAGE OF POTENTIAL PERIOOIC HEIGHT GROWTH ACTUALLY
C          ATTAINEO BY INFESTEO STANOS.
C     PINF(I) = PERCENTAGE OF TREES INFECTEO WITH OWARF MISTLETOE.
C     PRET = PERCENTAGE OF TREES RETAINEO AFTER PARTIAL CUTTING.
C     PROO = FACTOR TO CONVERT TOTAL CU. FT. TO BO. FT.
C     REGN(J) = STANO AGE WHEN REGENERATION CUT J OCCURS.
C     REST(I) = GROWING STOCK LEVEL FOR CURRENT INTERMEOIATE CUT.
C     RINT = NUHBER OF YEARS FOR WHICH A SINGLE PROJECTION IS MAOE.
C     ROTA = FINAL AGE IN YIELO TABLE.
C     ROTAOS = AGE OF OVERSTORY AT TIME OF FINAL REMOVAL IF OVERSTORY IS
C          TO BE RETAINEO PAST LARGEST REGN(J).
C     SBAS = TOTAL BASAL AREA OF STANO, INCLUOING BOTH STORIES.
C     SBO(I) = SUM OF BOARO FEET FROM ALL GUTS WITH YIELO OF COMBF OR
C          LARGER.
C     SITE = SITE INOEX.
C     SHC(I) = SUM OF MERCH. CU. FT. FROM ALL CUTS WITH YIELO OF COMCU
C          OR LARGER.
C     SQFT = BASAL AREA AS A FUNCTION OF AVERAGE O.B.H. FOR GROWING
C          STOCK LEVEL 80.
C     START(I) = AGE OF STORY AT TIME OF INITIAL INFECTION.
C     STF(I) = SUM OF TOTAL CU. FT. FROH ALL GUTS.
C     STNO = STANO IOENTIFICATION NUMBER.
C     TAGE(I,K) = STANO AGE AFTER GUTTING.
C     TBAS(I,K) = BASAL AREA AFTER CUTTING.
C     TBF(I,K) = M BO. FT. AFTER CUTTING.
C     TCF = TEMPORARY VARIABLE FOR TOTAL CU. FT.
C     TOEN(I,K) = NUMBER OF TREES AFTER CUTTING.
C     TOM(I,K) = AVERAGE O.B.M. AFTER CUTTING.
C     TOMR(I,K) = OWARF MISTLETOE INFEGTION RATING AFTER CUTTING.
C     TEMM(L) = TEMPRORAY VARIABLES USEO IN COMPUTATION OF PERIOOIC
C          HEIGHT GROWTH.
C     THIN(I) = GROWING STOCK LEVEL FOR INITIAL THINNING, HEALTHY
C          STANOS.
C     THT(I,K) = AVERAGE HEIGHT AFTER GUTTING.
C     TIME = NUMBER OF YEARS STANO INFESTEO BY OWARF MISTLETOE.
C     THCF(I,K) = MERGH. CU. FT. AFTER CUTTING.
C     TTOT(I,K) = TOTAL CU. FT. AFTER CUTTING.
C     UAGE(I,K) = STANO AGE BEFORE GUTTING.
C     UBAS(I,K) = BASAL AREA BEFORE CUTTING.
C     UBF(I,K) = M BO. FT. BEFORE CUTTING.
C     UOEN(I,K) = NUMBER OF TREES BEFORE CUTTING.
C     UOM(I,K) = AVERAGE O.B.H. BEFORE CUTTING.
C     UOMR(I,K) = OWARF MISTLETOE INFECTION RATING BEFORE CUTTING.
C     UHT(I,K) = AVERAGE HEIGHT BEFORE CUTTING.
C     UMGF(I,K) = MERGH. GU. FT. BEFORE GUTTING.
C     UTOT(I,K) = TOTAL CU. FT. BEFORE GUTTING.
C     VLLV(J) = PERGENT OF PREVIOUS OLEV(I) TO BE LEFT AT REGN(J),
C          ENTEREO AS A OEGIMAL.
C     YOM = ANNUAL INCREASE IN OMR IN INFESTEO STANOS.
C
      COMMON /BLKA/BA,OBM,OEN,HT,BOF,CFM,TCF
C
      COMMON /BLKB/BAST(2),OBHO(2),OBHT(2),OENO(2),OENT(2),OMR(2),PRET,
     1REST(2),ITH,MOL,OMLEV,IREGN(2),PINF(2),ISANS(2)
C
      COMMON /BLKC/OSTY(2),KTR(2),STNO,SBO(2),SITE,SHC(2),STF(2),
     1THIN(2),VAR(22),COMBF,COMCU,START(2),NOTE(16),ICUT
C
      COMMON /BLKO/CBAS(2,20),TBAS(2,20),UBAS(2,20),CBF(2,20),TBF(2,20),
     1UBF(2,20),COEN(2,20),TOEN(2,20),UOEN(2,20),CMCF(2,20),THCF(2,20),U
     2MCF(2,20),CTOT(2,20),TTOT(2,20),UTOT(2,20),TAGE(2,20),UAGE(2,20),T
     3OM(2,20),UOM(2,20),THT(2,20),JHT(2,20),UOMR(2,20),TOMR(2,20)
C
      COMMON /BLKE/AOOHT(2),AGEO(2),BASO(2),OELAY(2),OLEV(2),OHRT(2),
     1HTSO(2),HTST(2),IOPT(2),JCYCL(2),JOEN(2),KOL,KSTEP(2),REGN(3),
     2RINT,ROTA,TEMM(2),TIHE,VLLV(2),ROTAOS
C
      COMMON /BLKF/IK(2),KOUNT(2),SBAS,KPER,KOEL(2)
C
      NSTNO = 0
      OO 10 J=16,18
      VAR(J) = 0.0
   10 CONTINUE
C
C REAO NUMBER OF STANOS TO BE PROCESSEO ANO PROJECTION LENGTH FROH CARO
C TYPE ONE.
C
      REAO (5,20) NSTNO,RINT
   20 FORMAT (I5,F5.0)
      IF(NSTNO .LE. 0) GO TO 120
      VAR(16) = RINT
C
C REAO MINIMUM COMHERCIAL CUTS FROM CARO TYPE TWO.
C
      REAO (5,30) COMCU,COHBF
   30 FORMAT (2F5.0)
      VAR(17) = COMBF
      VAR(18) = COMCU
C

C EXECUTE PROGRAM ONCE FOR EACH STANO.
C
      OO 110 KAN=1,NSTNO
      CALL BEGIN
C
C CHECK FOR UNWANTEO ZEROS OR BLANKS IN OATA.
C
      OO 40 I=1,7,2
      IF(VAR(I) .LE. 0.0) GO TO 90
   40 CONTINUE
      OO 50 I=13,19
      IF(VAR(I) .LE. 0.0) GO TO 90
   50 CONTINUE
C
C COMPUTE VALUES FOR FIRST ENTRIES IN YIELO TABLES.
C
      CALL FIRST
      SBAS = BASO(1) + BASO(2)
C
C ENTER LOOP FOR REMAINING COMPUTATIONS FOR A STANO.
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C
      LIM = (ROTA - AGEO(1)) / RINT + 1.5
      IF(JOEN(2) .GT. 0) LIM = (ROTA - AGEO(2)) / RINT + 1.5
      00 70 K=1,LIM
      KPER = K
      CALL CUTS
      SBAS = BAST(1) + BAST(2)
      CALL PROJ
      SBAS = BASO(1) + BASO(2)
   70 CONTINUE
C
C WRITE YIELD TABLES FOR A STANO.
C
      00 80 I=1,2
      IF(AGEO(I) .LE. 0.0) GO TO 80
      MOL = I
      CALL TABLE
   80 CONTINUE
      GO TO 110
C
C PROGRAM CONTROL GOES HERE IF ANY UNWANTEO ZEROS OR BLANKS ARE FOUNO
C IN OATA.
C
   90 WRITE (6,100) STNO
  100 FORMAT (1H1,///,10X,73HEXECUTION STOPPEO BECAUSE OF NEGATIVE OR ZE
     1RO ITEM ON OATA CAROS OF STANO,F4.0)
  110 CONTINUE
      GO TO 140
  120 WRITE (6,130)
  130 FORMAT (1H1,////,30X,52HEXECUTION STOPPEO BECAUSE OF ILLEGAL VALUE
     1 OF NSTNO.)
  140 STOP
      ENO
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      SUBROUTINE BEGIN
C
C TO INITIALIZE STANO VARIABLES ANO REAO IN STAND OATA.
C
      COMMON /BLKB/BAST(2),OBHO(2),OBHT(2),OENO(2),DENT(2),UMR(2),PRET,
     1REST(2),ITM,MOL,OMLEV,IREGN(2),PINF(2),ISANS(2)
C
      COMMON /BLKC/OSTY(2),KTR(2),STNO,SBO(2),SITE,SMC(2),STF(2),
     1THIN(2),VAR(22),COMBF,COMCU,START(2),NOTE(16),ICUT
C
      COMMON /BLKO/CBAS(2,20),TBAS(2,20),UBAS(2,20),CBF(2,20),TBF(2,20),
     1UBF(2,20),COEN(2,20),TOEN(2,20),UOEN(2,20),CMCF(2,20),TMCF(2,20),U
     2MCF(2,20),CTOT(2,20),TTOT(2,20),UTOT(2,20),TAGE(2,20),UAGE(2,20),T
     3OM(2,20),UOM(2,20),THT(2,20),UHT(2,20),UOMR(2,20),TOMR(2,20)
C
      COMMON /BLKE/AOOHT(2),AGEO(2),BASO(2),OELAY(2),OLEV(2),OMRT(2),
     1HTSO(2),HTST(2),IOPT(2),JCYCL(2),JOEN(2),KOL,KSTEP(2),REGN(3),
     2RINT,ROTA,TEMH(2),TIME,VLLV(2),ROTAOS
C
      COMMON /BLKF/IK(2),KOUNT(2),SBAS,KPER,KOEL(2)
C
      00 10 J=1,15
      VAR(J) = 0.0
   10 CONTINUE
      00 20 I=1,2
      AOOHT(I) = 0.0
      AGEO(I) = 0.0
      BASO(I) = 0.0
      BAST(I) = 0.0
      OBHO(I) = 0.0
      OBHT(I) = 0.0
      OELAY(I) = 0.0
      OENO(I) = 0.0
      OENT(I) = 0.0
      OLEV(I) = 0.0
      OMR(I) = 0.0
      OMRT(I) = 0.0
      OSTY(I) = 0.0
      HTSO(I) = 0.0
      HTST(I) = 0.0
      IOPT(I) = 0
      IREGN(I) = 0
      ISANS(I) = 1000
      JCYCL(I) = 0
      JOEN(I) = 0
      KOUNT(I) = 1000
      KSTEP(I) = 1
      KTR(I) = 0
      PINF(I) = 0.0
      REST(I) = 0.0
      SBO(I) = 0.0
      SMC(I) = 0.0
      START(I) = 0.0
      STF(I) = 0.0
      THIN(I) = 0.0
      VLLV(I) = 0.0
   20 CONTINUE
      00 30 I=1,3
      REGN(I) = 0.0
   30 CONTINUE
      00 40 I=1,2
      00 40 J=1,20
      CBAS(I,J) = 0.0
      CBF(I,J) = 0.0
      COEN(I,J) = 0.0
      CMCF(I,J) = 0.0
      CTOT(I,J) = 0.0
      TAGE(I,J) = 0.0
      TBAS(I,J) = 0.0
      TBF(I,J) = 0.0
      TOEN(I,J) = 0.0
      TOM(I,J) = 0.0
      TOMR(I,J) = 0.0
      THT(I,J) = 0.0
      TMCF(I,J) = 0.0
      TTOT(I,J) = 0.0
      UAGE(I,J) = 0.0
      UBAS(I,J) = 0.0
      UBF(I,J) = 0.0
      UOEN(I,J) = 0.0
      UOM(I,J) = 0.0
      UOMR(I,J) = 0.0
      UHT(I,J) = 0.0
      UMCF(I,J) = 0.0
      UTOT(I,J) = 0.0
   40 CONTINUE
      OMLEV = 0.0
      ICUT = 0
      STNO = 0.0
      TIME = 0.0
C
C REAO TEST DESCRIPTION FROM CARO TYPE THREE.
C
      REAO (5,50) (NOTE(I),I=1,16)
   50 FORMAT (16A5)
C
C REAO INTERMEOIATE CUT INSTRUCTIONS FROM CARO TYPE FOUR.
C
      REAO (5,60) ICUT,OMLEV,OELAY(1),IOPT(1),THIN(1),OSTY(1),JCYCL(1),
     1OELAY(2),IOPT(2),THIN(2),OSTY(2),JCYCL(2)
   60 FORMAT (I5,F5.1,2(F5.0,I5,2F5.0,I5))
      ICUT = ICUT + 1
C
C STORE INITIAL VALUES FOR ERROR CHECKS ANO LATER USE.
C
      VAR(7) = JCYCL(1)
      IF(JCYCL(2) .LE. 0) JCYCL(2) = JCYCL(1)
      VAR(8) = JCYCL(2)
      VAR(14) = THIN(1)
      IF(THIN(2) .LE. 0.0) THIN(2) = THIN(1)
      VAR(15) = OSTY(1)
      IF(OSTY(2) .LE. 0.0) OSTY(2) = OSTY(1)
C
C REAO INITIAL STAND VALUES FROM CARO TYPE FIVE.
C
      REAO (5,70) STNO,SITE,AGEO(1),OBHO(1),HTSO(1),OENO(1),OMR(1),
     1PINF(1),START(1),AGEO(2),OBHO(2),HTSO(2),OENO(2),OMR(2),PINF(2),
     2START(2)
   70 FORMAT (2F5.0,2(F5.0,2F5.1,F5.0,2F5.1,F5.0))
C
C STORE INITIAL VALUES FOR ERROR CHECKS AND LATER USE.
C
      VAR(1) = AGEO(1)
      VAR(2) = AGEO(2)
      VAR(3) = OBHO(1)
      VAR(4) = OBHO(2)
      VAR(5) = OENO(1)
      VAR(6) = OENO(2)
      VAR(9) = START(1)
      VAR(10) = START(2)
      VAR(11) = OMR(1)
      VAR(12) = OMR(2)
      VAR(13) = SITE
      VAR(21) = PINF(1)
      VAR(22) = PINF(2)
      JOEN(1) = OENO(1) + 0.5
      JOEN(2) = OENO(2) + 0.5
C
C REAO REGENERATION CUT INSTRUCTIONS FROM CARO TYPE SIX.
C
      REAO (5,80) REGN(1),VLLV(1),REGN(2),VLLV(2),REGN(3)
   80 FORMAT (F5.0,F5.3,F5.0,F5.3,F5.0)
      VAR(19) = REGN(1)
      RETURN
      ENO
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      SUBROUTINE FIRST
C
C TO COMPUTE VALUES FOR FIRST ENTRIES IN YIELO TABLES.
C
      COMMON /BLKA/DA,OBH,OEN,HT,BOF,CFM,TCF
C
      COMMON /BLKB/BAST(2),OBHO(2),OBHT(2),OENO(2),DENT(2),OMR(2),PRET,
     1REST(2),ITM,MOL,OMLEV,IREGN(2),PINF(2),ISANS(2)
C
      COMMON /BLKC/OSTY(2),KTR(2),STNO,SBO(2),SITE,SMC(2),STF(2),
     1THIN(2),VAR(22),COMOF,COMCU,START(2),NOTE(16),ICUT
C
      COMMON /BLKO/CBAS(2,20),TBAS(2,20),UBAS(2,20),CBF(2,20),TBF(2,20),
     1UBF(2,20),COEN(2,20),TOEN(2,20),UOEN(2,20),CMCF(2,20),TMCF(2,20),U
     2MCF(2,20),CTOT(2,20),TTOT(2,20),UTOT(2,20),TAGE(2,20),UAGE(2,20),T
     3OM(2,20),UOM(2,20),THT(2,20),UHT(2,20),UOMR(2,20),TOMR(2,20)
C
      COMMON /BLKE/AOOHT(2),AGED(2),BASO(2),OELAY(2),OLEV(2),OMRT(2),
     1HTSO(2),HTST(2),IOPT(2),JCYCL(2),JOEN(2),KOL,KSTEP(2),REGN(3),
     2RINT,ROTA,TEMH(2),TIME,VLLV(2),ROTAOS
C
      COMMON /BLKF/IK(2),KOUNT(2),SBAS,KPER,KOEL(2)
C
      KOL = 1
      IRINT = RINT
C
C IOENTIFY FINAL AGE IN YIELO TABLE.
C
      00 10 NA=1,3
      L = 4 - NA
      IF(REGN(L) .GT. 0.0) GO TO 20
   10 CONTINUE
   20 ROTA = REGN(L)
      VAR(20) = ROTA
      ROTAOS = AGEO(1) + OELAY(1)
      IF(ROTAOS .LT. ROTA) ROTAOS = ROTA
C
C COMPUTE VALUES OF STANO CHARACTERISTICS, ONE STORY AT A TIME.
C
      00 140 I=1,2
      IF(JOEN(I) .EO. 0) GO TO 140
C
C COMPUTE INITIAL O.M.R. IF ONLY INFECTION TIME OR INITIAL PERCENT
C INFECTED REPORTEO.
C
      IF(OMR(I) .GT. 0.0) GO TO 70
      IF(PINF(I) .LE. 0.0) GO TO 40
      OMR(I) = 10.0 ** (-0.94652 + 0.01651 * PINF(I))
      GO TO 70
   40 TIME = AGEO(I) - START(I)
      IF(TIME .LE. 0.0) GO TO 100
      IF(I .EQ. 2) GO TO 60
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      OMR(1) = 0.120055 * TIME - 0.961031 * TIME / OENO(1) - 0.003420 *
     1 TIME * SITE
      GO TO 70
   60 IF(DENO(2) .GT. 3000.0) GO TO 65
      OMR(2) = 0.087923 * TIME - 0.000018 * TIME * OENO(2) + 0.000051 *
     1 TIME * OMR(1) * OMR(1) * OENO(1)
      GO TO 70
   65 OMR(2) = 0.0441757 * TIME - 0.0000034 * TIME * DENO(2) +
     1 0.000051 * TIME * OMR(1) * OMR(1) * OENO(1)
   70 IF(OMR(I) .LT. 0.0) OMR(I) = 0.0
      IF(OMR(I) .GT. 6.0) OMR(I) = 6.0
      IF(OMR(I) .GI. 0.0) START(I) = 10000.0
C
C COMPUTE INITIAL AVERAGE HEIGHT IF NOT REPORTEO.
C
  100 IF(HISO(I) .GI. 0.0) GO TO 130
      IF(AGEO(I) .GT. 55.0) GO TO 110
      HTSO(I) = 0.01441 * AGEO(I) * SITE - 0.12162 * AGEO(I) - 1.50953
      GO TO 120
  110 HTSO(I) = 0.59947 - 61.5019 / AGEO(I) + 0.80522 * ALOG10(SITE) +
     1 20.52528 * ALOG10(SITE) / AGEO(I)
      HTSO(I) = 10.0 ** HTSO(I)
  120 HTPCT = 1.073 - 0.0367 * OMR(I)
      IF(HTPCT .GT. 1.0) HTPCT = 1.0
      HISO(I) = HTSO(I) * HTPCT
C
C COMPUTE INITIAL BASAL AREA AND VOLUMES.
C
  130 BASO(I) = DENO(I) * 0.0054542 * OBHO(I) * OBHO(I)
      BA = BASO(I)
      DBH = OBHO(I)
      OEN = OENO(I)
      HT = HTSO(I)
      CALL SWVOL
C
C STORE VALUES FOR PRINTING.
C
      UAGE(I,KOL) = AGEO(I) + 0.5
      MAX = OMR(I) * 10.0 + 0.5
      UOMR(I,KOL) = MAX
      UOMR(I,KOL) = UOMR(I,KOL) * 0.1
      UOEN(I,KOL) = OENO(I)
      MAX = BASO(I) + 0.5
      UBAS(I,KOL) = MAX
      UOM(I,KOL) = OBHO(I)
      MAX = HISO(I) + 0.5
      UMI(I,KOL) = MAX
      MAX = (TCF * 0.1) + 0.5
      UTOT(I,KOL) = MAX * 10
      MAX = (CFM * 0.1) + 0.5
      UMCF(I,KOL) = MAX * 10
      MAX = (BOF * 0.01) + 0.5
      UBF(I,KOL) = MAX * 100
C
C COMPUTE VALUES OF NEEOEO CONTROL VARIABLES.
C
      IK(I) = JCYCL(I) / IRINT
      ITEM = (REGN(1) - AGEO(I)) / RINT + 0.5
      IF(IK(I) .GT. ITEM) IK(I) = ITEM
      KOEL(I) = OELAY(I) / RINT + 0.5
      REST(I) = THIN(I)
      OLEV(I) = OSTY(I)
  140 CONTINUE
      RETURN
      END




      SUBROUTINE CUTS
C
C TO CONTROL EXECUTION OF INTERMEOIATE ANO REGENERATION CUTS.
C
      COMMON /BLKA/BA,OBM,OEN,HT,BOF,CFM,TCF
C
      COMMON /BLKB/BAST(2),OBHO(2),OBHT(2),OENO(2),OENT(2),OMR(2),PRET,
     1REST(2),ITM,MOL,OMLEV,IREGN(2),PINF(2),ISANS(2)
C
      COMMON /BLKC/OSTY(2),KTR(2),STNO,SBO(2),SITE,SMC(2),STF(2),
     1THIN(2),VAR(22),COMBF,COMCU,START(2),NOTE(16),ICUT
C
      COMMON /BLKO/CBAS(2,20),IBAS(2,20),UBAS(2,20),CBF(2,20),TBF(2,20),
     1UBF(2,20),COEN(2,20),TOEN(2,20),UOEN(2,20),CMCF(2,20),TMCF(2,20),U
     2MCF(2,20),CTOT(2,20),TIOI(2,20),UTOT(2,20),TAGE(2,20),UAGE(2,20),T
     3OM(2,20),UOM(2,20),THT(2,20),UHT(2,20),UOMR(2,20),TOMR(2,20)
C
      COMMON /BLKE/AOOHT(2),AGEO(2),BASO(2),OELAY(2),OLEV(2),OMRT(2),
     1MTSO(2),HIST(2),IOPT(2),JCYCL(2),JOEN(2),KOL,KSTEP(2),REGN(3),
     2RINT,ROTA,TEMH(2),TIME,VLLV(2),ROTAOS
C
      COMMON /BLKF/IK(2),KOUNT(2),SBAS,KPER,KOEL(2)
C
      IRINT = RINT + 0.5
C
C COMPUTE VALUES OF STANO CHARACTERISTICS, ONE STORY AT A TIME.
C
      OO 230 I=1,2
      IF(JOEN(I) .EQ. 0) GO TO 230
      IF(I .EQ. 1 .ANO. AGEO(1) .GE. ROTAOS) GO TO 210
      IF(I .EQ. 2 .ANO. AGEO(2) .GE. ROTA) GO TO 210
      BASI(I) = BASO(I)
      OBMI(I) = OBMO(I)
      OENT(I) = OENO(I)
      OMRT(I) = OMR(I)
      MTSI(I) = MTSO(I)
      IF(KPER .LE. KOEL(I)) GO TO 230
      IF(KOUNT(I) .LT. IK(I)) GO IO 230
C
C REOEFINE INTERVAL TO FIRST REGENERATION CUT IF LESS THAN CURRENT
C CUTTING CYCLE.
C
      ITEM = (REGN(1) - AGEO(I)) / RINT + 0.5
      IF(IREGN(I) .EQ. 0 .ANO. IK(I) .GT. ITEM) IK(I) = ITEM
      IREGN(I) = 0
      ITM = I
      KOUNI(I) = 0
      TAGE(I,KOL) = AGEO(I) + 0.5
C
C CHANGE CUTTING STANOAROS IF A REGENERATION CUT IS OUE.
C
      IF(AGEO(I) .LI. REGN(1)) GO TO 20
      OO 10 L=1,2
      IF(AGEO(I) .NE. REGN(L)) GO IO 10
      OLEV(I) = OLEV(I) * VLLV(L)
      REST(I) = OLEV(I)
      JCYCL(I) = REGN(L+1) - REGN(L) + 0.5
      IK(I) = JCYCL(I) / IRINT
      IREGM(I) = 1
      GO TO 20
   10 CONTINUE
C
C COMPUTE CURRENT GROWIMG STOCK LEVEL TO OETERMINE IF STORY IS ALREAOY
C AT OR BELOW OESIREO STOCKIMG LEVEL.
C
   20 IF(OBMO(I) .GT. 2.0) GO IO 22
      GSLEVL = 80.0 * BASO(I) / (6.03633 * OOHO(I))
      GO TO 40
   22 IF(OBMO(I) .GE. 5.0) GO TO 25
      GSLEVL = 80.0 * BASO(I) / (11.58495 * OBMO(I) - 11.09724)
      GO TO 40
   25 IF(OBMO(I) .GT. 10.0) GO TO 30
      TEM = OBHO(I) * OBHO(I)
      GSLEVL = 80.0 * BASO(I) / (7.76226 * OBMO(I) + 0.85289 * TEM -
     1 0.07952 * TEM * OBMO(I) - 3.45624)
      GO IO 40
   30 GSLEVL = BASO(I)
C
C CHANGE O.B.H. ANO O.M.R. BY PARTIAL CUTTING.
C
   40 IF(OMR(I) .LE. 0.0) GO TO 70
      IF(IREGN(I) .EQ. 1) GO TO 70
      IF(OMR(I) .GI. OMLEV) GO TO 180
      IF(IOPT(I) .GT. 0) GO TO 70
      IF(KPER .GT. (KOEL(I) + 1)) GO TO 70
C
C COMPUTE INITIAL THINNING LEVEL IF THINNING FROM ABOVE. EXECUTE
C THINNING FROM ABOVE.
C
   50 IF(TMIN(I) .LE. 60.0) GO TO 60
      REST(I) = THIM(I) - (OMR(I) * (TMIN(I) - 60.0) / 3.0)
      IF(OMR(I) .GT. 3.0) REST(I) = 60.0
   60 IF(GSLEVL .LE. REST(I)) GO TO 180
      CALL SWCUT2
      KSTEP(I) = 2
      GO TO 90
C
C EXECUTE PARTIAL CUTTING FROM BELOW.
C
   70 IF(GSLEVL .LE. REST(I)) GO TO 180
      CALL SWCUT1
      IF(PREI .GE. 100.0) GO TO 180
      KSTEP(I) = 1
   90 IF(BAST(I) .GE. BASO(I)) GO TO 180
C
C COMPUTE O.M.R. AFTER PARTIAL CUTTING.
C
      OMRT(I) = OMR(I)
      IF(OMR(I) .LE. 0.0) GO TO 110
      OELOMR = 2.92759 + 0.06144 * OMR(I) * OMR(I) - 0.25988 *
     1 SQRT(PRET) - 0.00882 * OHR(I) * OMR(I) * SQRT(PRET)
      IF(KSTEP(I) .EQ. 1) OELOMR = OELOMR * 0.66667
      IF(OELOMR .LT. 0.0) OELOMR = 0.0
      OMRT(I) = OMR(I) - OELOMR
      IF(OMRT(I) .LT. 0.0) OMRT(I) = 0.0
      IF(OMRT(I) .GT. 6.0) OMRT(I) = 6.0
C
C COMPUTE MEIGHI, OASAL AREA, OENSITY, ANO VOLUMES AFTER PARTIAL CUTTING
C
  110 KS = KSTEP(I)
      GO TO (120,130), KS
  120 AOOHT(I) = 7.64833 - 3.82286 * ALOG10(PRET)
      GO TO 140
  130 AOOMT(I) = 2.43837 * ALOG10(PRET) + 1.64026 * ALOG10(BAST(I))
     1 - 8.47960
  140 MTST(I) = HTSO(I) + AOOHT(I)
      JOENT = BAST(I) / (0.0054542 * OBHT(I) * OBHT(I)) + 0.5
      OENT(I) = JOENT
      BAST(I) = 0.0054542 * OBHT(I) * OBHT(I) * OENT(I)
      BA = BAST(I)
      OBM = OBHT(I)
      OEN = OENT(I)
      HT = MTSI(I)
      CALL SWVOL
C
C CHECK TO SEE IF INTERMEOIATE CUT SATISFIES COMMERCIAL CRITERIA, IF
C ANY.  OO NOT CUT IF COMMERCIAL CRITERIA NOT SATISFIEO.
C STORE VALUES FOR PRINTING.
C
      MAX = CFM * 0.1 + 0.5
      TMCF(I,KOL) = MAX * 10
      IF(TMCF(I,KOL) .GT. UMCF(I,KOL)) UMCF(I,KOL) = TMCF(I,KOL)
      CMCF(I,KOL) = UMCF(I,KOL) - TMCF(I,KOL)
      MAX = BOF * 0.01 + 0.5
      TBF(I,KOL) = MAX * 100
      IF(TBF(I,KOL) .GT. UBF(I,KOL)) UBF(I,KOL) = TBF(I,KOL)
      CBF(I,KOL) = UBF(I,KOL) - TBF(I,KOL)
      IF(IREGN(I) .EQ. 1) GO TO 190
      GO IO (170,160,190). ICUT
  160 IF(KPER .EO. (KOEL(I) + 1)) GO TO 190
  170 IF(CBF(I,KOL) .GE. COMBF) GO TO 190
      IF(CMCF(I,KOL) .GE. COMCU) GO TO 190
  180 BAST(I) = BASO(I)
      OBHT(I) = OBHO(I)
      OENT(I) = OENO(I)
      OMRT(I) = OMR(I)
      HTST(I) = MTSO(I)
      KTR(I) = 1
      TBAS(I,KOL) = UBAS(I,KOL)
      TBF(I,KOL) = UBF(I,KOL)
      TOEM(I,KOL) = UOEN(I,KOL)
      TOM(I,KOL) = UOM(I,KOL)
      TOMR(I,KOL) = UOMR(I,KOL)
      THT(I,KOL) = UMT(I,KOL)
      TMCF(I,KOL) = UMCF(I,KOL)
      TTOT(I,KOL) = UTOT(I,KOL)
      CBAS(I,KOL) = 0.0
      CBF(I,KOL) = 0.0
      COEN(I,KOL) = 0.0
      CMCF(I,KOL) = 0.0
      CTOT(I,KOL) = 0.0
      GO TO 230
  190 TOEM(I,KOL) = OENT(I)
      MAX = OHRT(I) * 10.0 + 0.5
      TOMR(I,KOL) = MAX
      TOMR(I,KOL) = TOMR(I,KOL) * 0.1
      MAX = MTST(I) + 0.5
```

```
      THT(I,KOL) = MAX
      MAX = BAST(I) + 0.5
      TBAS(I,KOL) = MAX
      MAX = TCF * 0.1 + 0.5
      TTOT(I,KOL) = MAX * 10
      TOM(I,KOL) = OBMT(I)
      GOEN(I,KOL) = UOEN(I,KOL) - TOEN(I,KOL)
      GBAS(I,KOL) = UBAS(I,KOL) - TBAS(I,KOL)
      CTOT(I,KOL) = UTOT(I,KOL) - TTOT(I,KOL)
      IF(OMP(I) .LE. 0.0) GO TO 195
C
C COMPUTE PERCENTAGE OF TREES INFECTED BEFORE THE PARTIAL CUT.
C
      PINF(I) = 57.33010 + 60.56935 * ALOG10(OMR(I))
      IF(PINF(I) .LT. 0.0) PINF(I) = 0.0
      IF(PINF(I) .GT. 100.0) PINF(I) = 100.0
      IF(OMRT(I) .LE. 0.0) ISANS(I) = 0
C
C ADD PERIODIC CUTS TO TOTAL YIELDS.
C
  195 STF(I) = STF(I) + GTOT(I,KOL)
      IF(CMCF(I,KOL) .LT. COMCU) GO TO 200
      SMC(I) = SMG(I) + CMCF(I,KOL)
  200 IF(CBF(I,KOL) .LT. COMBF) GO TO 230
      SBO(I) = SBO(I) + GBF(I,KOL)
      GO TO 230
C
C REMOVE STORY I IF STORY HAS REACHED ROTATION AGE.
C
  210 BAST(I) = 0.0
      OBHT(I) = 0.0
      OENT(I) = 0.0
      OMRT(I) = 0.0
      HTST(I) = 0.0
      BASO(I) = 0.0
      OOHO(I) = 0.0
      OENO(I) = 0.0
      OMR(I) = 0.0
      HTSO(I) = 0.0
      JOEN(I) = 0
C
C ADD FINAL CUTS TO TOTAL YIELDS.
C
      STF(I) = STF(I) + UTOT(I,KOL)
      IF(UMCF(I,KOL) .LT. COMCU) GO TO 220
      SMC(I) = SMG(I) + UMCF(I,KOL)
  220 IF(UBF(I,KOL) .LT. COMBF) GO TO 230
      S9O(I) = SBO(I) + UBF(I,KOL)
  230 CONTINUE
      RETURN
      END
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      SUBROUTINE PROJ
C
C TO MAKE PERIODIC GROWTH PROJECTIONS.
C
      COMMON /BLKA/BA,OBH,OEN,HT,BOF,CFM,TCF
C
      COMMON /BLKB/BAST(2),OBHO(2),OBHT(2),OENO(2),OENT(2),OMR(2),PRET,
     1REST(2),ITM,MOL,OMLEV,IREGN(2),PINF(2),ISANS(2)
C
      COMMON /BLKC/OSTY(2),KTR(2),STNO,SBO(2),SITE,SMC(2),STF(2),
     1THIN(2),VAR(22),COMBF,COMCU,START(2),NOTE(16),IOUT
C
      COMMON /BLKO/CBAS(2,20),TBAS(2,20),UBAS(2,20),CBF(2,20),TBF(2,20),
     1UBF(2,20),GOEN(2,20),TOEN(2,20),UOEN(2,20),CMCF(2,20),TMCF(2,20),U
     2MCF(2,20),GTOT(2,20),TTOT(2,20),UTOT(2,20),TAGE(2,20),UAGE(2,20),T
     3OM(2,20),UOM(2,20),THT(2,20),JHT(2,20),UOMR(2,20),TOMR(2,20)
C
      COMMON /BLKE/AOOHT(2),AGEO(2),OASO(2),OELAY(2),OLEV(2),OMRT(2),
     1HTSO(2),HTST(2),IOPT(2),JCYCL(2),JOEN(2),KOL,KSTEP(2),REGN(3),
     2RINT,ROTA,TEMH(2),TIME,VLLV(2),ROTAOS
C
      COMMON /BLKF/IK(2),KOUNT(2),SBAS,KPER,KOEL(2)
C
      KOL = KOL + 1
C
C COMPUTE VALUES OF STAND CHARACTERISTICS, ONE STORY AT A TIME.
C
      OO 220 I=1,2
      IF(JOEN(I) .EQ. 0) CO TO 220
      AGEO(I) = AGEO(I) + RINT
      KOUNT(I) = KOUNT(I) + 1
C
C COMPUTE CURRENT OWARF MISTLETOE RATING.
C
      ISANS(I) = ISANS(I) + 1
      IF(ISANS(I) .CT. 2) GO TO 5
      FP = ISANS(I)
      FP = 0.025 * FP * RINT
      OMR(I) = 10.0 ** (-0.94652 + 0.01651 * (PINF(I) * FP))
      CO TO 60
    5 IF(OMRT(I) .CT. 0.0) CO TO 20
      OMR(I) = 0.0
      TIME = AGEO(I) - START(I)
      IF(TIME .LE. 0.0) GO TO 70
      IF(I .EQ. 2 .ANO. JOEN(1) .GT. 0) GO TO 10
      OMR(I) = 0.120055 * TIME - 0.961031 * TIME / OENT(I) - 0.000420 *
     1 TIME * SITE
      CO TO 60
   10 IF(OENT(2) .GT. 3000.0) GO TO 15
      OMR(2) = 0.087923 * TIME - 0.000018 * TIME * OENT(2) + 0.000051 *
     1 TIME * OMRT(1) * OMRT(1) * OENT(1)
      GO TO 60
   15 OMR(2) = 0.0441757 * TIME - 0.0000034 * TIME * OENT(2) +
     1 0.000051 * TIME * OMRT(1) * OMRT(1) * OENT(1)
      GO TO 60
   20 IF(I .EO. 2 .ANO. JOEN(1) .GT. 0) GO TO 30
      IF(OENT(I) .LE. 15.0) GO TO 25
      YOM = 0.120055 - 0.961031 / OENT(I) - 0.000420 * SITE
      GO TO 40
      25 YOM = 0.08
         GO TO 40
      30 IF(OENT(2) .GT. 3000.0) GO TO 35
         YOM = 0.087923 - 0.000018 * OENT(2) + 0.000051 * OMRT(1) * OMRT(1)
        1 * OENT(1)
      GO TO 40
   35 YOM = 0.0441757 - 0.0000034 * OENT(2) + 0.000051 * OMRT(1) *
     1 OMRT(1) * OENT(1)
   40 IF(OMRT(I) .GT. 1.0 .ANO. OMRT(I) .LT. 4.5) GO TO 50
      IF(I .EQ. 2 .ANO. OENT(2) .GT. 3000.0) GO TO 50
      OMR(I) = OMRT(I) + 0.5 * YOM * RINT
      GO TO 60
   50 OMR(I) = OMRT(I) + YOM * RINT
   60 IF(OMR(I) .LT. OMRT(I)) OMR(I) = OMRT(I)
      IF(OMR(I) .LT. 0.0) OMR(I) = 0.0
      IF(OMR(I) .GT. 6.0) OMR(I) = 6.0
      IF(OMR(I) .GT. 0.0) START(I) = 10000.0
C
C COMPUTE CURRENT ACTUAL GROWING STOCK LEVEL.
C
   70 IF(OBMT(I) .GT. 2.0) GO TO 72
      GSLEVL = 80.0 * SBAS / (6.03533 * OBHT(I))
      GO TO 90
   72 IF(OBHT(I) .GE. 5.0) CO TO 75
      CSLEVL = 80.0 * SOAS / (11.58495 * OBHT(I) - 11.09724)
      CO TO 90
   75 IF(OOHT(I) .GT. 10.0) CO TO 80
      TEM = OBHT(I) * OBHT(I)
      CSLEVL = 80.0 * SBAS / (7.70226 * OBHT(I) + 0.35289 * TEM - 0.0735
     12 * TEM * OBHT(I) - 3.45624)
      CO TO 90
   80 GSLEVL = SBAS
C
C COMPUTE NEW O.B.H. AT END OF GROWTH PROJECTION PERIOD.
C
   90 IF(GSLEVL .GT, 160.0) GO TO 100
      OBHO(I) = 1.0097 * OBHT(I) + 0.0096 * SITE - 1.5766 * ALOG10(SBAS)
     1 + 3.3021
      GO TO 110
  100 OBHO(I) = 0.88511 * OBMT(I) + 1.29735 * ALOG10(HTST(I)) + 0.00119
     1 * OBHT(I) * SITE + 62.37174 / SBAS - 1.56975
  110 IF(OMRT(I) ,LE. 3.5) GO TO 120
      OINC = (OBHO(I) - OBHT(I)) * (1.197 - 0.056 * OMRT(I))
      OBHO(I) = OBHT(I) + OING
  120 IOBHO = OBHO(I) * 10.0 + 0.5
      OBHO(I) = IOOHO
      OBHO(I) = OBHO(I) * 0.1
C
C COMPUTE CURRENT NUMBER OF TREES PER ACRE AND BASAL AREA.
C
      OIE = 0.0
      IF(OMRT(I) .LT. 1.0) CO TO 130
      IF(OENT(I) .LT. 30.0 .ANO. OMRT(I) .LT. 4.0) GO TO 130
      OIE = 20.66469 + 4.42271 * OMRT(I) - 0.36374 * SITE + 3.87613 *
     1 ALOG10(OENT(I))
      OIE = OIE * 0.01
      IF(OIE .LT. 0.0) OIE = 0.0
  130 OUT = 0.0
      IF(OBHT(I) .GE. 10.0) CO TO 140
      OUT = 0.00247 + 0.00124 * OBHT(I) + 0.00028 * OBHT(I) * OBHT(I) +
     1 0.00000521 * SBAS * SBAS - 0.0000905 * OBMT(I) * SBAS
      IF(OUT .LT. 0.0) OUT = 0.0
  140 IF(OIE .LT. OUT) OIE = OUT
      JOENO = OENT(I) * (1.0 - OIE) + 0.5
      OENO(I) = JOENO
      BASO(I) = OENO(I) * 0.0054542 * OBHO(I) * OBHO(I)
C
C COMPUTE CURRENT AVERAGE HEIGHT.
C
      IF(GSLEVL .GT. 160.0) GO TO 200
      OO 190 J=1,2
      LUB = J
      GO TO (150,160), LUB
  150 YARS = ACEO(I)
      GO TO 170
  160 YARS = AGEO(I) - RINT
  170 IF(YARS .GT. 55,0) GO TO 180
      TEMH(J) = 0.01441 * YARS * SITE - 0.12162 * YARS - 1.50953
      CO TO 190
  180 TEMH(J) = 0.59947 - 61.5019 / YARS + 0.80522 * ALOG10(SITE) +
     1 20.52528 * ALOG10(SITE) / YARS
      TEMH(J) = 10.0 ** TEMH(J)
  190 CONTINUE
      CHNG = TEMH(1) - TEMM(2)
      GO TO 210
  200 HTNEW = 15.43021 + 1.107 * HTST(I) - 0.08637 * AGEO(I) - 304.12172
     1 / SITE - 0.0002447 * SITE * SBAS
      CHNC = HTNEW - HTST(I)
  210 PCT = 1.0 - 0.0002 * OMRT(I) * OMRT(I) * OMRT(I)
      HTSO(I) = HTST(I) + CHNG * PCT
C
C COMPUTE TOTAL CU. FT. AND CONVERT TO OTHER UNITS.
C
      BA = BASO(I)
      OBH = OBHO(I)
      OEN = OENO(I)
      HT = HTSO(I)
      CALL SWVOL
C
C STORE VALUES FOR PRINTING.
C
      UAGE(I,KOL) = AGEO(I) + 0.5
      MAX = OMR(I) * 10.0 + 0.5
      UOHR(I,KOL) = MAX
      UOMR(I,KOL) = UOMR(I,KOL) * 0.1
      UOEN(I,KOL) = OENO(I)
      MAX = BASO(I) + 0.5
      UBAS(I,KOL) = MAX
      UOM(I,KOL) = OBHO(I)
      MAX = MTSO(I) + 0.5
      UHT(I,KOL) = MAX
      MAX = TCF * 0.1 + 0.5
      UTOT(I,KOL) = MAX * 10
      MAX = CFM * 0.1 + 0.5
      UMCF(I,KOL) = MAX * 10
      MAX = BOF * 0.01 + 0.5
      UOF(I,KOL) = MAX * 100
      IF(KPER .GT. KOEL(I)) REST(I) = OLEV(I)
  220 CONTINUE
      RETURN
      END
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      SUBROUTINE TABLE
C
C TO PRINT YIELO TABLES ANO TABLE FOOTNOTES.
C
      CONNON /BLKB/BAST(2),DBHO(2),OBHT(2),DENO(2),OENT(2),OHR(2),PRET,
     1REST(2),ITH,HOL,ONLEV,IREGN(2),PINF(2),ISANS(2)
C
      CONHON /BLKC/OSTY(2),KTR(2),STNO,SBO(2),SITE,SMC(2),STF(2),
     1THIN(2),VAR(22),COMBF,CONCU,START(2),NOTE(16),ICUT
C
      COMNON /BLKD/CBAS(2,20),TBAS(2,20),UBAS(2,20),CBF(2,20),TBF(2,20),
     1UBF(2,20),CDEN(2,20),TOEN(2,20),UDEN(2,20),CNCF(2,20),TMCF(2,20),U
     2MCF(2,20),CTOT(2,20),TTOT(2,20),UTOT(2,20),TAGE(2,20),UAGE(2,20),T
     3ON(2,20),UOM(2,20),THT(2,20),JHT(2,20),UOMR(2,20),TOMR(2,20)
C
      COHNON /BLKE/AODHT(2),AGEO(2),BASO(2),OELAY(2),DLEV(2),OMRT(2).
     1HTSO(2),NTST(2),IOPT(2),JCYCL(2),JDEN(2),KOL,KSTEP(2),REGN(3),
     2RINT,ROTA,TEMH(2),TIME,VLLV(2),ROTAOS
C
      JSITE = SITE
      I = MOL
C
C PRINT HEADINGS FOR YIELO TABLE.
C
      IF(I .EQ. 2) GO TO 30
      IF(UOEN(2,1) .GT. 0.0) GO TO 10
      WRITE (6,5) STNO
    5 FORNAT (1H1,//,32X,60HYIELOS PER ACRE OF SOUTNWESTERN PONOEROSA PI
     1NE, STAND NUNBER,F7.0)
      GO TO 20
   10 WRITE (6,15) STND
   15 FORHAT (1H1,//,26X,60HYIELDS PER ACRE OF SOUTHWESTERN PONDEROSA PI
     1NE, STAND NUHBER,F7.0,12H, OVERSTORY.)
   20 WRITE (6,25) JSITE,THIN(1),DSTY(1)
   25 FORMAT (1H0,58X,10HSITE INOEX,I4/1H ,38X,29HTNINNING INTENSITY-- I
     1NITIAL-,F6.0,12H SUBSEQUENT-,F6.0)
      GO TO 50
   30 WRITE (6,40) STND
   40 FORNAT (1N1,//,26X,60HYIELOS PER ACRE OF SOUTHWESTERN PONDEROSA PI
     1NE, STANO NUNBER,F7.0,13N. UNDERSTORY.)
      WRITE (6,25) JSITE,THIN(2),DSTY(2)
   50 WRITE (6,60) (NOTE(J),J=1,16)
   60 FORHAT (1H0.25X,16A5)
      WRITE (6,70)
   70 FORMAT (1ND,21X,41HCHARACTERISTICS BEFORE ANO AFTER THINNING,30X,2
     16HPERIODIC INTERHEDIATE CUTS)
      WRITE (6,80)
   80 FORMAT (1ND,4X,5HSTANO,15X,5HBASAL,3X,7HAVERAGE,2X,7HAVERAGE,3X,5H
     1TOTAL,3X,9HNERCHANT-,3X,9HSAWTINBER,9X,5HBASAL,4X,5HTOTAL,3X,9HMER
     2CHANT-,3X,9HSAWTIMBER)
      WRITE (6,90)
   90 FORMAT  (1N ,5X,3HAGE,9X,5HTREES,3X,4NAREA,4X,6HD.B.H.,3X,6HHEIGHT
     1,2X,6HVOLUHE,2X,11HABLE VOLUME,4X,6HVOLUME,3X,5HTREES,3X,4HAREA,3X
     2,6HVOLUME,2X,11HABLE VOLUME,4X,6HVOLUME)
      WRITE (6,100)
  100 FORNAT (1H ,3X,7N(YEARS),2X,3HONR,3X,3HNO.,3X,5HSQ.FT.,4X,3HIN.,6X
     1,3HFT.,4X,6HCU.FT.,5X,6HCU.FT.,6X,6NBO.FT.,4X,3HNO.,3X,6HSQ.FT.,2X
     2,6HCU.FT.,5X,6HCU.FT.,6X,6HBO.FT.)
C
C PRINT TABLE ENTRIES OF STAND CHARACTERISTICS.
C
      DO 150 N=1,20
      JAGEO = UAGE(I,N)
      IF(JAGEO .EO. 0) GO TO 120
      JDENO = UOEN(I,N)
      JBASO = UBAS(I,N)
      OIAN = UON(I,N)
      JHTSO = UHT(I,N)
      JTOTO = UTOT(I,N)
      JCFMO = UNCF(I,N)
      JBOFO = UBF(I,N)
      WONR = UOMR(I,N)
      WRITE (6,110) JAGEO,WOMR,JOENO,JBASO,OIAM,JHTSO,JTOTO.JCFNO,JBOFO
  110 FORHAT (1H0,4X,I4,2X,F5.1.2X,I5,2X,I4,5X,F5.1,5X,I3,4X,I5,6X,I5,6X
     1,I6)
  120 JAGEO = TAGE(I,N)
      IF(JAGEO .ED. 0) GO TO 150
      JOENT = TOEN(I,N)
      JBAST = TBAS(I,N)
      OMTR = TOM(I.N)
      JNTST = TNT(I,N)
      JTOTT = TTOT(I,N)
      JCFMT = TNCF(I,N)
      JBOFT = TBF(I,N)
      JOENC = COEN(I,N)
      JBASC = CBAS(I,N)
      JTOTC = CTOT(I,N)
      JCFNC = CNCF(I,N)
      JBOFC = CBF(I,N)
      WONRT = TONR(I,N)
      WRITE (6,130) JAGEO,WONRT,JOENT,JBAST,OMTR,JNTST,JTOTT,JCFMT,JBOFT
     1,JOENC,JBASC,JTOTC,JCFMC,JBOFC
  130 FORNAT (1H ,4X,I4.2X,F5.1,2X,I5,2X,I4,5X,F5.1,5X,I3,4X,I5,6X,I5,6X
     1,I6,4X,I5,3X,I3,5X,I4,6X,I4,8X,I5)
  150 CONTINUE
      JSTF = STF(I)
      JSNC = SMC(I)
      JSBO = SBO(I)
      WRITE (6,160) JSTF,JSNC,JSBO
  160 FORNAT (1H0,/,67X,12NTOTAL YIELOS,19X,I5,5X,I5,7X,I6)
C
C PRINT APPROPRIATE FOOTNOTES FOR TABLE.
C
      WRITE (6,170)
  170 FORNAT (1H0,//,11X,68HNERCH. CU. FT. - TREES 6.0 INCHES O.B.H. ANO
     1 LARGER TO 4.0-INCH TOP.)
      WRITE (6,180)
  180 FORNAT (1H ,10X,68HBO. FT. - TREES 10.0 INCHES D.B.H. ANO LARGER T
     10 VARIABLE TOP LINIT.)
      IF(IOPT(I) .GT. 0) GO TO 200
      WRITE (6,190)
  190 FORNAT (1H ,10X,67HINITIAL THINNING FROM ABOVE ALLOWEO IN STANDS W
     1ITH OWARF NISTLETOE.)
      GO TO 220
  200 WRITE (6,210)
  210 FORNAT (1H ,10X,36HINITIAL THINNING HUST BE FROM BELOW.)
  220 WRITE (6,230) ONLEV
  230 FORMAT (1H ,10X,76HOWARF MISTLETOE RATING ABOVE WHICH PERIOOIC THI
     1NNINGS WILL NOT BE EXECUTEO -,F4.1,1N.)
      WRITE (6,240) CONCU,COMBF
  240 FORMAT (1H ,10X,44HNININUN CUTS FOR INCLUSION IN TOTAL YIELOS--,F6
     1.0,15N CUBIC FEET ANO,F7.0,12H BOARD FEET.)
      GO TO (250,270,290), ICUT
  250 WRITE (6,260)
  260 FORMAT (1H ,10X,35HNO NONCOMNERCIAL THINNINGS ALLOWEO.)
      GO TO 310
  270 WRITE (6,280)
  280 FORNAT (1H ,10X,87HPRECONMERCIAL INITIAL THINNING ALLOWED. NONCONM
     1ERCIAL SUBSEDUENT THINNINGS NOT ALLOWED.)
      GO TO 310
  290 WRITE (6.300)
  300 FORNAT (1H ,10X,35HALL TNINNINGS NAY BE NONCONMERCIAL.)
  310 II = I + 8
      IF(VAR(II) .GT. 0.0 .ANO. VAR(II) .LT. VAR(20)) GO TO 330
      II = I + 20
      IF(VAR(II) .LE. 0.0) GO TO 370
      WRITE (6,320) VAR(I),VAR(II)
  320 FORNAT (1H ,10X,14HAT INITIAL AGE,F5.0,1N,,F5.0,57H PERCENT OF THE
     1 TREES WERE INFECTED WITH DWARF NISTLETOE.)
      GO TO 370
  330 WRITE (6,340) VAR(II)
  340 FORMAT (1H ,10X,40HDWARF MISTLETOE INFECTION STARTED AT AGE,F5.0)
  370 IF(KTR(I) .EO. 0) GO TO 390
      WRITE (6,380)
  380 FORMAT (1H ,10X,52HNOTE THAT NOT ALL SCHEOULED THINNINGS WERE POSS
     1IBLE.)
  390 RETURN
      END
```

```
      SUBROUTINE SWVOL
C
C TO CONPUTE TOTAL CU. FT. AND CONVERT TO NERCN. CU. FT. AND BO. FT.
C
      CONNON /BLKA/BA,OBH,OEN,HT,OOF,CFM,TCF
C
      FCTR = 0.0
      PROD = 0.0
C
C COMPUTE TOTAL CU. FT.
C
      D2H = DBH * DBH * HT
      IF(O2H .GT. 5000.0) GO TO 10
      TCF = (0.53313 + 0.00033 * BA + 0.00179 * D2H) * OEN
      GO TO 20
   10 TCF = (0.00237 * BA + 0.00211 * D2H - 1.09356) * OEN
C
C OBTAIN CONVERSION FACTOR FOR NERCH. CU. FT. - VOLUMES TO 4.0-INCH TOP
C IN TREES 6.0 INCHES O.B.H. AND LARGER.
C
   20 IF(OBH .LT. 5.0) GO TO 70
      IF(OBH .GT. 6.5) GO TO 30
      FCTR = 0.25222 * DBH - 1.01119
      GO TO 50
   30 IF(DBH .GT. 10.0) GO TO 40
      FCTR = 3.02485 - 0.09957 * DBH - 11.35814 / DBH
      GO TO 50
   40 FCTR = 1.03936 - 1.41034 / DBH
C
C OBTAIN CONVERSION FACTOR FOR BO. FT. - VOLUHES TO VARIABLE TOP IN
C TREES 10.0 INCHES O.B.H. AND LARGER.
C
   50 IF(OBH .LT. 8.0) GO TO 70
      IF(OBH .GT. 11.5) GO TO 60
      PROO = 0.0028 * BA + 0.04355 * OBH * OBN - 2.78326
      GO TO 70
   60 PROO = 0.83943 + 0.20531 * OBH
C
C CONVERT TOTAL CU. FT. TO MERCH. CU. FT. ANO BO. FT.
C
   70 BOF = TCF * PROO
      CFM = TCF * FCTR
      RETURN
      ENO
```

```
      SUBROUTINE SWCUT1
C
C TO ESTINATE CHANGE IN AVERAGE D.B.H. OUE TO PARTIAL CUTTING
C SOUTNWESTERN PONOEROSA PINE FRON BELOW.
C
      COMNON /OLKB/BAST(2),OBHO(2),OBNT(2),OENO(2),OENT(2),ONR(2),PRET,
     1REST(2),ITN,MOL,OMLEV,IREGN(2),PINF(2),ISANS(2)
C
      I = ITN
      IF(OBHO(I) .LT. 9.5) GO TO 50
C
C COMPUTE O.B.H. IF OBNO IS LARGE ENOUGH FOR BASAL AREA TO REMAIN
C CONSTANT.
C
      PRET = 100.0
      DO 40 KJ=1,100
      IF(PRET .LT. 50.0 .OR. DBNO(I) .LT. 3.0) GO TO 10
      OBHE = 0.73365 + 1.02008 * OBHO(I) - 0.01107 * (PRET - 50.0) -
     1 0.00014 * (PRET - 50.0) * (PRET - 50.0)
      GO TO 15
   10 POBNE = 0.49401 + 0.71890 * ALOG10(OBHO(I)) - 0.22530 *
     1 ALOG10(PRET) + 0.12616 * ALOG10(OBNO(I)) * ALOG10(PRET)
      DBHE = 10.0 ** POBHE
   15 IF(IREGN(I) .EQ. 1) GO TO 20
      IF(ONR(I) .LE. 0.0) GO TO 20
      TEM = DBHE - DBHO(I)
      OBHE = OBHO(I) + TEN * 0.5
   20 IOBHE = OBNE  * 10.0 + 0.5
      OBHE = IOBHE
      OBHE = OOHE * 0.1
      OENE = OENO(I) * PRET * 0.01
      NOENE = OENE + 0.5
      OENE = NOENE
      BASE = 0.0054542 * OBHE * DBHE * OENE
      NBASE = BASE * 10.0 + 0.5
      BASE = NBASE
      BASE = BASE * 0.1
      TNPY = 0.0054542 * OBHE * DBHE
```

```
      TEN = BASE - REST(I)
      IF(KJ .EQ. 1 .AND. TEM .LT. 0.0) GO TO 190
      IF(TEN .LE. TNPY) GO TO 140
      IF(TEN .LT. 4.0) GO TO 30
      PRET = PRET - 1.0
      GO TO 40
   30 PRET = PRET - 0.3
   40 CONTINUE
      GO TO 140
C
C COMPUTE D.B.H. IF BASAL AREA INCREASES WITH D.B.H.
C
   50 PRET = 40.0
      IF(DBHD(I) .GT. 7.0) PRET = 70.0
      DO 130 J=1,100
      IF(PRET .GE. 50.0 .AND. DBHO(I) .GT. 2.9) GO TO 60
      PDBHE = 0.49401 + 0.71890 * ALOG10(DBHD(I)) - 0.22530 *
     1 ALOG10(PRET) + 0.12616 * ALOG10(DBHO(I)) * ALOG10(PRET)
      DBHE = 10.0 ** PDBHE
      GO TO 65
   60 DBNE = 0.73365 + 1.02008 * DBHO(I) - 0.01107 * (PRET - 50.0) -
     1 0.00014 * (PRET - 50.0) * (PRET - 50.0)
   65 IF(IREGN(I) .EQ. 1) GO TO 70
      IF(DMR(I) .LE. 0.0) GO TO 70
      TEN = DBNE - DBHO(I)
      DBNE = DBHD(I) + TEM * 0.5
   70 IDBHE = OBHE * 10.0 + 0.5
      DBHE = IDBHE
      DBHE = DBHE * 0.1
      DENE = OEND(I) * PRET * 0.01
      NDENE = DENE + 0.5
      DENE = NDENE
      BASE = 0.0054542 * DBNE * OBHE * DENE
      NBASE = BASE * 10.0 * 0.5
      BASE = NBASE
      BASE = BASE * 0.1
      BREAK = 49.9 * REST(I) / 80.0
      IF(BASE .GT. BREAK) GO TO 80
      DBHP = (80.0 / REST(I)) * 0.08682 * BASE + 0.94636
      GO TO 100
   80 BUST = 66.2 * REST(I) / 80.0
      IF(BASE .GT. BUST) GO TO 90
      DBNP = (80.0 / REST(I)) * 0.10938 * BASE - 0.17808
      GO TO 100
   90 TNPY = BASE * 80.0 / REST(I)
      TEM = TNPY * THPY
      DBHP = 19.04740 * THPY - 0.26673 * TEM + 0.0012539 * TEN * TNPY
     1 - 448.76833
      IF(TNPY .GT. 80.0) DBHP = DBHD(I) + 0.8
  100 IDBHP = DBHP * 10.0 + 0.5
      DBHP = IDBHP
      DBHP = DBHP * 0.1
      IF(DBHP - DBHE) 110,140,120
  110 PRET = PRET * 1.02
      IF(PRET .GT. 100.0) GO TO 190
      GO TO 130
  120 PRET = PRET * 0.98
  130 CONTINUE
  140 OBNT(I) = DBHE
C
C CONPUTE POST-CUTTING BASAL AREA.
C
      IF(OBHT(I) .GT. 2.0) GO TO 145
      SQFT = 6.03633 * DBHT(I)
      GO TO 160
  145 IF(DBHT(I) .GT. 5.0) GO TO 150
      SQFT = 11.58495 * DBHT(I) - 11.09724
      GO TO 160
  150 IF(OBHT(I) .GE. 10.0) GO TO 170
      TEM = DBHT(I) * DBHT(I)
      SQFT = 7.76226 * DBHT(I) + 0.85289 * TEM - 0.07952 * TEM * DBHT(I)
     1 - 3.45624
  160 BAST(I) = (REST(I) / 80.0) * SQFT
      GO TO 180
  170 BAST(I) = REST(I)
  180 RETURN
  190 PRET = 100.0
      RETURN
      END
```

```
      SUBROUTINE SWCUT2
C
C TO ESTIMATE CHANGE IN AVERAGE D.B.H. DUE TO THINNING SOUTHWESTERN
C PONDEROSA PINE FROM ABOVE.
C
      COMMON /BLKB/BAST(2),DBHD(2),DBHT(2),DENO(2),DENT(2),DMR(2),PRET,
     1REST(2),ITN,NOL,DMLEV,IREGN(2),PINF(2),ISANS(2)
C
      I = ITN
C
C DETERNINE PRET AND D.B.H. AFTER CUTTING BY AN ITERATIVE PROCESS.
C
      ITER = 0
      PRETP = 100.0
      PRET = 50.0
    5 ITER = ITER + 1
      IF(PRET .LT. 50.0 .OR. DBHO(I) .LT. 4.0) GO TO 10
      DBHE = 0.98543 * DBHO(I) + 0.00807 * (PRET - 50.0) + 0.00025 *
     1 (PRET - 50.0) * (PRET - 50.0) - 0.91172
      GO TO 20
   10 PDBHE = 0.51618 * ALOG10(PRET) + 1.69219 * ALOG10(OBHD(I))
     1 - 0.34768 * ALOG10(PRET) * ALOG10(DBHD(I)) - 1.03421
      OBNE = 10.0 ** PDBHE
   20 IF(DNR(I) .LE. 0.0) GO TO 30
      TEM = DBHE - DBHO(I)
      DBHE = DBHD(I) + TEM * 0.5
   30 DENE = DEND(I) * PRET * 0.01
      TREBA = 0.0054542 * DBHE * DBHE
      BASE = TREBA * DENE
      IF(DBHE .GT. 2.0) GO TO 35
      GSLEVL = 80.0 * BASE / (6.03633 * DBHE)
      GO TO 60
   35 IF(DBHE .GT. 4.92687) GO TO 40
      GSLEVL = 80.0 * BASE / (11.58495 * DBHE - 11.09724)
      GO TO 60
   40 IF(DBHE .GT. 10.07636) GO TO 50
      TEN = DBHE * DBHE
      GSLEVL = 80.0 * BASE / (7.76226 * OBHE + 0.85289 * TEN - 0.07952
     1 * TEM * DBHE - 3.45624)
      GO TO 60
   50 GSLEVL = BASE
   60 TEM = GSLEVL - REST(I)
      TENA = ABS(TEN)
      IF(TENA .LT. TREBA .OR. TEMA .LT. 0.01) GO TO 80
      IF(ITER .GE. 100) GO TO 80
      DIFF = ABS(PRETP - PRET) * 0.5
      PRETP = PRET
      IF(TEM .GT. 0.0) GO TO 70
      PRET = PRET + OIFF
      GO TO 5
   70 PRET = PRET - DIFF
      GO TO 5
C
C SET POST-CUTTING VALUES.
C
   80 IDBHE = DDHE * 10.0 + 0.5
      DBHE = IDBHE
      DBHT(I) = DBHE * 0.1
      IDENE = DENE + 0.5
      OENT(I) = IDENE
      BAST(I) = 0.0054542 * OBHT(I) * DBHT(I) * DENT(I)
      RETURN
      END
```

APPENDIX 2
Output of Sample Problem

YIELDS PER ACRE OF SOUTHWESTERN PONDEROSA PINE, STAND NUMBER 1.

SITE INDEX 70
THINNING INTENSITY-- INITIAL- 120. SUBSEQUENT- 90.

HYPOTHETICAL HEALTHY EVEN-AGED STAND. BEGIN TABLE AT AGE 30.

	CHARACTERISTICS BEFORE AND AFTER THINNING								PERIODIC INTERMEDIATE CUTS				
STAND AGE (YEARS)	DMR	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	0.0	950	119	4.8	25	1530	380	0					
30	0.0	463	79	5.6	26	940	380	0	487	40	590	0	0
40	0.0	458	109	6.6	35	1520	980	0					
50	0.0	449	134	7.4	44	2200	1660	500					
50	0.0	226	83	8.2	45	1350	1110	500	223	51	850	550	0
60	0.0	225	104	9.2	51	1870	1640	2200					
70	0.0	223	124	10.1	58	2600	2340	5200					
70	0.0	139	90	10.9	59	1930	1750	5100	84	34	670	590	100
80	0.0	139	107	11.9	64	2560	2360	8400					
90	0.0	139	124	12.8	69	3220	2990	11200					
90	0.0	89	90	13.6	70	2350	2200	8500	50	34	870	790	2700
100	0.0	89	103	14.6	74	2890	2730	11100					
110	0.0	89	117	15.5	78	3440	3260	13800					
110	0.0	28	45	17.2	80	1360	1310	6000	61	72	2080	1950	7800
120	0.0	28	53	18.7	83	1680	1620	7900					
130	0.0	28	62	20.1	86	2010	1950	10000					
							TOTAL YIELDS				7070	5830	20500

MERCH. CU. FT. - TREES 6.0 INCHES D.B.H. AND LARGER TO 4.0-INCH TOP.
BD. FT. - TREES 10.0 INCHES D.B.H. AND LARGER TO VARIABLE TOP LIMIT.
INITIAL THINNING FROM ABOVE ALLOWED IN STANDS WITH DWARF MISTLETOE.
DWARF MISTLETOE RATING ABOVE WHICH PERIODIC THINNINGS WILL NOT BE EXECUTED - 3.0.
MINIMUM CUTS FOR INCLUSION IN TOTAL YIELDS-- 320. CUBIC FEET AND 1500. BOARD FEET.
PRECOMMERCIAL INITIAL THINNING ALLOWED. NONCOMMERCIAL SUBSEQUENT THINNINGS NOT ALLOWED.

YIELDS PER ACRE OF SOUTHWESTERN PONDEROSA PINE, STAND NUMBER 2.

SITE INDEX 70
THINNING INTENSITY-- INITIAL- 120. SUBSEQUENT- 90.

HYPOTHETICAL EVEN-AGED STAND. INFESTATION STARTS AT AGE 10.

	CHARACTERISTICS BEFORE AND AFTER THINNING								PERIODIC INTERMEDIATE CUTS				
STAND AGE (YEARS)	DMR	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	1.8	950	119	4.8	25	1530	0	0					
30	.6	405	41	4.3	23	530	0	0	545	78	1000	0	0
40	1.0	403	74	5.8	32	1000	450	0					
50	1.4	399	104	6.9	41	1620	1120	0					
50	1.4	399	104	6.9	41	1620	1120	0	0	0	0	0	0
60	2.3	353	117	7.8	47	2020	1600	0					
70	3.2	299	121	8.6	54	2310	1960	1800					
70	3.2	299	121	8.6	54	2310	1960	1800	0	0	0	0	0
80	4.1	242	117	9.4	60	2500	2200	3500					
90	4.9	188	107	10.2	64	2500	2260	5100					
90	4.9	188	107	10.2	64	2500	2260	5100	0	0	0	0	0
100	5.4	139	92	11.0	69	2310	2100	6300					
110	5.8	101	78	11.9	72	2080	1920	6800					
110	5.0	48	45	13.1	73	1220	1140	4300	53	33	860	780	2500
120	5.4	36	41	14.5	76	1180	1110	4500					
130	5.7	27	37	15.9	79	1110	1050	4600					
							TOTAL YIELDS				2970	1830	7100

MERCH. CU. FT. - TREES 6.0 INCHES D.B.H. AND LARGER TO 4.0-INCH TOP.
BD. FT. - TREES 10.0 INCHES D.B.H. AND LARGER TO VARIABLE TOP LIMIT.
INITIAL THINNING FROM ABOVE ALLOWED IN STANDS WITH DWARF MISTLETOE.
DWARF MISTLETOE RATING ABOVE WHICH PERIODIC THINNINGS WILL NOT BE EXECUTED - 3.0.
MINIMUM CUTS FOR INCLUSION IN TOTAL YIELDS-- 320. CUBIC FEET AND 1500. BOARD FEET.
PRECOMMERCIAL INITIAL THINNING ALLOWED. NONCOMMERCIAL SUBSEQUENT THINNINGS NOT ALLOWED.
DWARF MISTLETOE INFECTION STARTED AT AGE 10.
NOTE THAT NOT ALL SCHEDULED THINNINGS WERE POSSIBLE.

YIELOS PER ACRE OF SOUTHWESTERN PONOEROSA PINE, STANO NUMBER 3., OVERSTORY.

SITE INOEX 70
THINNING INTENSITY-- INITIAL- 120. SUBSEQUENT- 90.

TWO-STORIEO INFESTEO STANO WITH IMMEOIATE OVERSTORY REMOVAL.

CHARACTERISTICS BEFORE ANO AFTER THINNING									PERIOOIC INTERMEOIATE CUTS				
STANO AGE (YEARS)	OMR	TREES NO.	BASAL AREA SQ.FT.	AVERAGE O.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BO.FT.	TREES NO.	BASAL AREA SO.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BO.FT.
150	4.8	20	28	16.1	75	800	760	3300					
							TOTAL YIELOS				800	760	3300

MERCH. CU. FT. - TREES 6.0 INCHES O.B.H. ANO LARGER TO 4.0-INCH TOP.
BO. FT. - TREES 10.0 INCHES O.B.H. ANO LARGER TO VARIABLE TOP LIMIT.
INITIAL THINNING FROM ABOVE ALLOWEO IN STANOS WITH OWARF MISTLETOE.
OWARF MISTLETOE RATING ABOVE WHICH PERIOOIC THINNINGS WILL NOT BE EXECUTEO - 3.0.
MINIMUM CUTS FOR INCLUSION IN TOTAL YIELOS-- 320. CUBIC FEET ANO 1500. BOARO FEET.
PRECOMMERCIAL INITIAL THINNING ALLOWEO. NONCOMMERCIAL SUBSEQUENT THINNINGS NOT ALLOWEO.

YIELOS PER ACRE OF SOUTHWESTERN PONOEROSA PINE, STANO NUMBER 3., UNOERSTORY.

SITE INOEX 70
THINNING INTENSITY-- INITIAL- 120. SUBSEQUENT- 90.

TWO-STORIEO INFESTEO STANO WITH IMMEOIATE OVERSTORY REMOVAL.

CHARACTERISTICS BEFORE ANO AFTER THINNING									PERIOOIC INTERMEOIATE CUTS				
STANO ACE (YEARS)	OMR	TREES NO.	BASAL AREA SO.FT.	AVERAGE O.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BO.FT.	TREES NO.	BASAL AREA SO.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BO.FT.
30	1.0	600	55	4.1	21	710	0	0					
30	.5	512	42	3.9	20	560	0	0	88	13	150	0	0
40	.9	509	78	5.3	29	1020	330	0					
50	1.4	503	109	6.3	38	1630	940	0					
50	1.4	503	109	6.3	38	1630	940	0	0	0	0	0	0
60	2.3	444	122	7.1	44	2010	1450	0					
70	3.2	375	128	7.9	51	2340	1870	0					
70	3.2	375	128	7.9	51	2340	1870	0	0	0	0	0	0
80	4.0	303	122	8.6	56	2440	2060	1900					
90	4.9	234	110	9.3	61	2420	2120	3100					
90	4.9	234	110	9.3	61	2420	2120	3100	0	0	0	0	0
100	5.3	173	96	10.1	65	2280	2050	4400					
110	5.8	125	81	10.9	69	2040	1860	5300					
110	5.0	56	45	12.1	70	1150	1070	3800	69	36	890	790	1500
120	5.3	43	43	13.5	73	1160	1090	4200					
130	5.7	32	39	14.9	76	1100	1040	4300					
							TOTAL YIELOS				2140	1830	5800

MERCH. CU. FT. - TREES 6.0 INCHES O.B.H. ANO LARGER TO 4.0-INCH TOP.
BO. FT. - TREES 10.0 INCHES O.B.H. ANO LARGER TO VARIABLE TOP LIMIT.
INITIAL THINNING FROM ABOVE ALLOWEO IN STANOS WITH OWARF MISTLETOE.
OWARF MISTLETOE RATING ABOVE WHICH PERIOOIC THINNINGS WILL NOT BE EXECUTEO - 3.0.
MINIMUM CUTS FOR INCLUSION IN TOTAL YIELOS-- 320. CUBIC FEET ANO 1500. BOARO FEET.
PRECOMMERCIAL INITIAL THINNING ALLOWEO. NONCOMMERCIAL SUBSEQUENT THINNINGS NOT ALLOWEO.
NOTE THAT NOT ALL SCHEOULEO THINNINGS WERE POSSIBLE.

YIELDS PER ACRE OF SOUTHWESTERN PONDEROSA PINE, STAND NUMBER 4., OVERSTORY.

SITE INDEX 70
THINNING INTENSITY-- INITIAL- 120. SUBSEQUENT- 90.

TWO-STORIED INFESTED STAND. OVERSTORY REMOVAL DELAYED 20 YEARS.

CHARACTERISTICS BEFORE AND AFTER THINNING									PERIODIC INTERMEDIATE CUTS				
STAND AGE (YEARS)	DMR	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
150	4.8	20	28	16.1	75	800	760	3300					
160	5.0	16	26	17.1	77	740	710	3200					
170	5.2	12	21	18.0	79	630	610	2900					
							TOTAL YIELDS				630	610	2900

MERCH. CU. FT. - TREES 6.0 INCHES D.B.H. AND LARGER TO 4.0-INCH TOP.
BD. FT. - TREES 10.0 INCHES D.B.H. AND LARGER TO VARIABLE TOP LIMIT.
INITIAL THINNING FROM ABOVE ALLOWED IN STANDS WITH DWARF MISTLETOE.
DWARF MISTLETOE RATING ABOVE WHICH PERIODIC THINNINGS WILL NOT BE EXECUTED - 3.0.
MINIMUM CUTS FOR INCLUSION IN TOTAL YIELDS-- 320. CUBIC FEET AND 1500. BOARD FEET.
PRECOMMERCIAL INITIAL THINNING ALLOWED. NONCOMMERCIAL SUBSEQUENT THINNINGS NOT ALLOWED.

YIELDS PER ACRE OF SOUTHWESTERN PONDEROSA PINE, STAND NUMBER 4., UNDERSTORY.

SITE INDEX 70
THINNING INTENSITY-- INITIAL- 120. SUBSEQUENT- 90.

TWO-STORIED INFESTED STAND. OVERSTORY REMOVAL DELAYED 20 YEARS.

CHARACTERISTICS BEFORE AND AFTER THINNING									PERIODIC INTERMEDIATE CUTS				
STAND AGE (YEARS)	DMR	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	1.0	600	55	4.1	21	710	0	0					
40	1.5	538	70	4.9	29	980	0	0					
50	2.5	471	83	5.7	38	1300	550	0					
50	1.6	287	44	5.3	36	680	220	0	184	39	620	330	0
60	2.5	253	62	6.7	43	1010	670	0					
70	3.4	213	73	7.9	49	1290	1030	0					
70	3.4	213	73	7.9	49	1290	1030	0	0	0	0	0	0
80	4.2	172	76	9.0	55	1470	1270	1400					
90	5.1	133	74	10.1	60	1590	1430	3000					
90	5.1	133	74	10.1	60	1590	1430	3000	0	0	0	0	0
100	5.5	98	66	11.1	64	1530	1400	4200					
110	5.9	71	58	12.2	67	1430	1320	4800					
110	5.7	50	45	12.9	68	1140	1060	4000	21	13	290	260	800
120	6.0	36	40	14.2	71	1050	990	3900					
130	6.0	26	35	15.6	73	950	910	3900					
							TOTAL YIELDS				1860	1240	3900

MERCH. CU. FT. - TREES 6.0 INCHES D.B.H. AND LARGER TO 4.0-INCH TOP.
BD. FT. - TREES 10.0 INCHES D.B.H. AND LARGER TO VARIABLE TOP LIMIT.
INITIAL THINNING FROM ABOVE ALLOWED IN STANDS WITH DWARF MISTLETOE.
DWARF MISTLETOE RATING ABOVE WHICH PERIODIC THINNINGS WILL NOT BE EXECUTED - 3.0.
MINIMUM CUTS FOR INCLUSION IN TOTAL YIELDS-- 320. CUBIC FEET AND 1500. BOARD FEET.
PRECOMMERCIAL INITIAL THINNING ALLOWED. NONCOMMERCIAL SUBSEQUENT THINNINGS NOT ALLOWED.
NOTE THAT NOT ALL SCHEDULED THINNINGS WERE POSSIBLE.

Myers, Clifford A., Carleton B. Edminster, and Frank G. Hawksworth. 1976. SWYLD2: Yield tables for even-aged and two-storied stands of southwestern ponderosa pine, including effects of dwarf mistletoe. USDA For. Serv. Res. Pap. RM-163, 25 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 80521.

Presents a procedure for computation of yield tables for ponderosa pines in Arizona and New Mexico. Possible alternatives include: even-aged or two-storied stands, healthy or diseased stands, and managed or unmanaged stand densities. Stand conditions and severity of dwarf mistletoe infestation change with time and in response to intermediate cuttings. Supersedes SWYLD, published in 1972 as USDA For. Serv. Res. Pap. RM-87. A concise user's guide for program SWYLD2 is available as USDA For. Serv. Gen. Tech. Rep. RM-23, 1976.

Keywords: Stand yield tables, timber management, forest management, simulation, *Arceuthobium vaginatum*, *Pinus ponderosa*.

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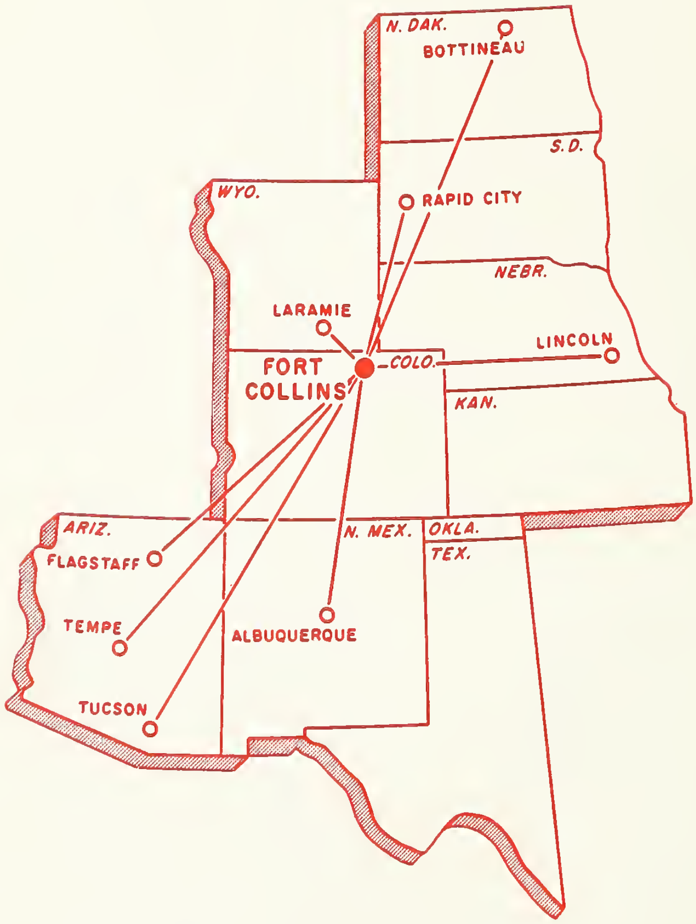
Keywords: Stand yield tables, timber management, forest management, simulation, *Arceuthobium vaginatum*, *Pinus ponderosa*.



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