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User's Guide to OAKSIM

An Individual-Tree Growth and Yield Simulator for Managed, Even-aged, Upland Oak Stands

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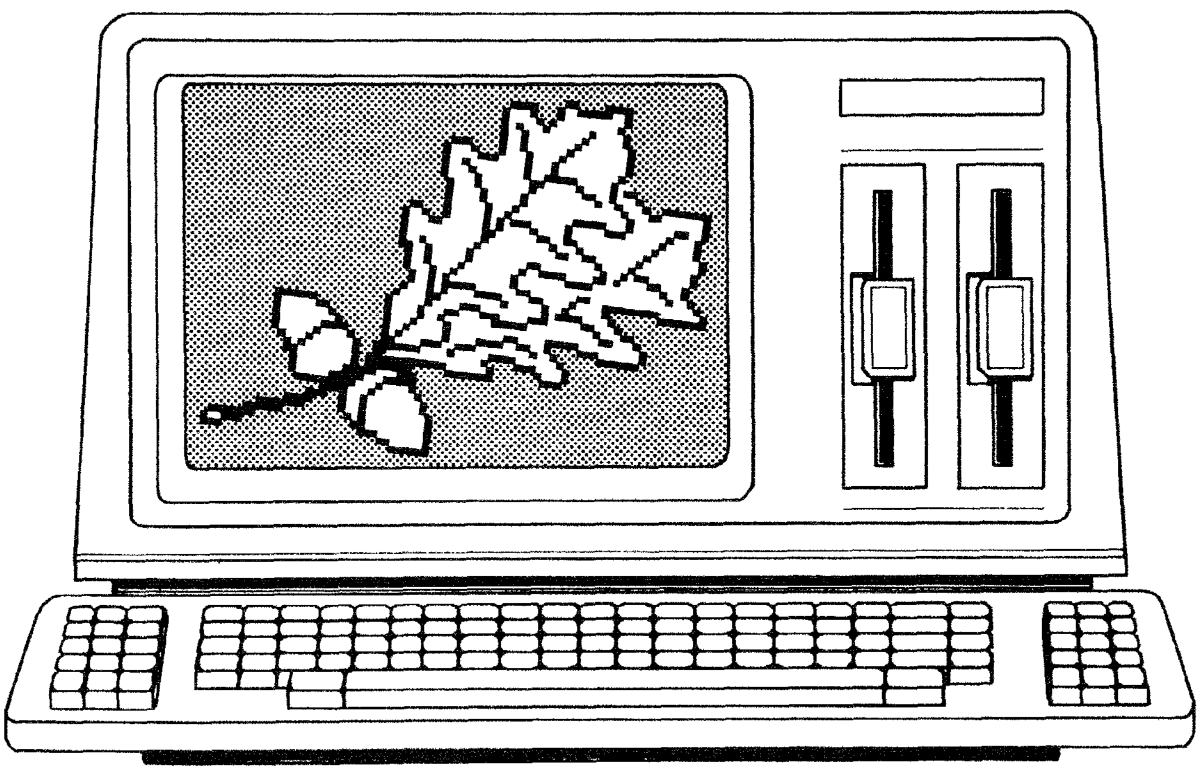

The Author

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Abstract

This user's guide presents operating instructions for OAKSIM, an individual-tree growth and yield simulator for managed, even-aged, upland oak stands. OAKSIM can make growth and yield projections for various thinning alternatives for up to 50 years. The general structure and operation of OAKSIM, program control information, data formats, program output, and examples of thinned and unthinned projections are included.

Note:
The computer program described in this publication is available on request with the understanding that the U.S. Department of Agriculture cannot assure its accuracy, completeness, reliability, or suitability for any other purpose than that reported. The recipient may not assert any proprietary rights thereto nor represent it to anyone as other than a Government-produced computer program. For cost information write Donald E. Hilt, Forestry Sciences Laboratory, USDA Forest Service, Northeastern Forest Experiment Station, 359 Main Road, Delaware, OH 43015.

Preface

This version of OAKSIM represents an initial effort to give users a functional individual-tree growth and yield simulator for managed, even-aged, upland oak stands. Improvements to OAKSIM will continue. A comprehensive statistical validation of growth and yield projections will be made when an improved mortality model and an ingrowth model are completed. A method of projecting individual-tree quality changes in relation to residual stocking following intermediate thinnings will also be incorporated into OAKSIM. Information on tree quality is essential input to an economics subroutine that will be added to determine optimum management alternatives in the upland oak timber type.

Users are encouraged to submit useful changes, extensions, or identified errors to the author for the next version of OAKSIM. OAKSIM can become a valuable tool for forest managers only through close cooperation and coordination between researchers and users.

Introduction

OAKSIM is an individual-tree growth and yield simulator for managed, even-aged, upland oak stands. Although no simulator can make final decisions, OAKSIM, if used properly, is a powerful quantitative tool that will assist forest land managers in the evaluation of various management alternatives for the nearly 109 million acres of upland oak timber type. This initial version of OAKSIM is designed to help managers evaluate management alternatives related to that silvicultural practice most likely to influence tree and stand growth and yield--intermediate thinning. The timing, intensity, and frequency of intermediate thinnings for a wide range of age, site, and stocking conditions can be studied in detail with OAKSIM.

Growth and yield projections for various thinning alternatives can be made with OAKSIM for periods of up to 50 years. And, since OAKSIM grows trees individually, projected stands can be partitioned into various species and size classes. This information is critical for determining the value of trees in the projected stand, an essential ingredient for evaluating the economic aspects of thinning, especially in hardwood stands.

OAKSIM is written in FORTRAN and designed to operate with maximum flexibility on a mainframe computer. The development and structure of the simulator, including all pertinent mathematical models, have been described in a companion publication (Hilt 1985). The objective of this user's guide is to provide users with the instructions necessary to operate the simulator. A brief explanation of how the program works, program applications, and an example are also included. Even though OAKSIM can be used to make growth and yield projections for a single stand, a more logical (and less expensive) approach is to develop management guidelines by exercising the simulator for broader categories of age, site, and stand conditions.

Program Structure

A generalized flow chart of the programming logic used in OAKSIM is shown in Figure 1. A series of control cards govern the following: (1) type of input data, (2) timing, intensity, and frequency of thinning, (3) tree volume calculations, and (4) type of output. If a stand table is provided in lieu of a tree list, OAKSIM generates a tree list as described later. A summary of initial stand conditions by species and size classes is then computed and printed. The stand may be thinned initially or at any 5-year interval to a specified stocking level. A maximum of ten 5-year growth projections may be made. The 5-year intervals provide adequate resolution of growth and yield projections over time for most users. Linear interpolation may be used for estimates between the 5-year intervals.

Diameter growth of each residual tree is predicted for each 5-year period. The probability of mortality for each tree is then determined from this diameter growth, the initial d.b.h. of the tree, and the species of the tree. If the tree is classified as dead on the basis of this probability and a draw from a random number generator, it is removed from the list. If the net stand basal area growth is not within stand-level growth limitations, a modifier is applied to the diameter growth calculations and the 5-year growth cycle is repeated.

Inside- and outside-bark volumes to specified top diameters are calculated for individual trees from predicted total tree height, the appropriate bark ratio equation, and a taper-based volume system. Stand and stock tables by species and size classes are printed after each 5-year interval for the initial stand, thinned trees, residual stand, mortality trees, and projected stand. A stand-level summary is printed for each stand after all 5-year projections have been completed. This summary is useful for comparing overall thinning strategies.

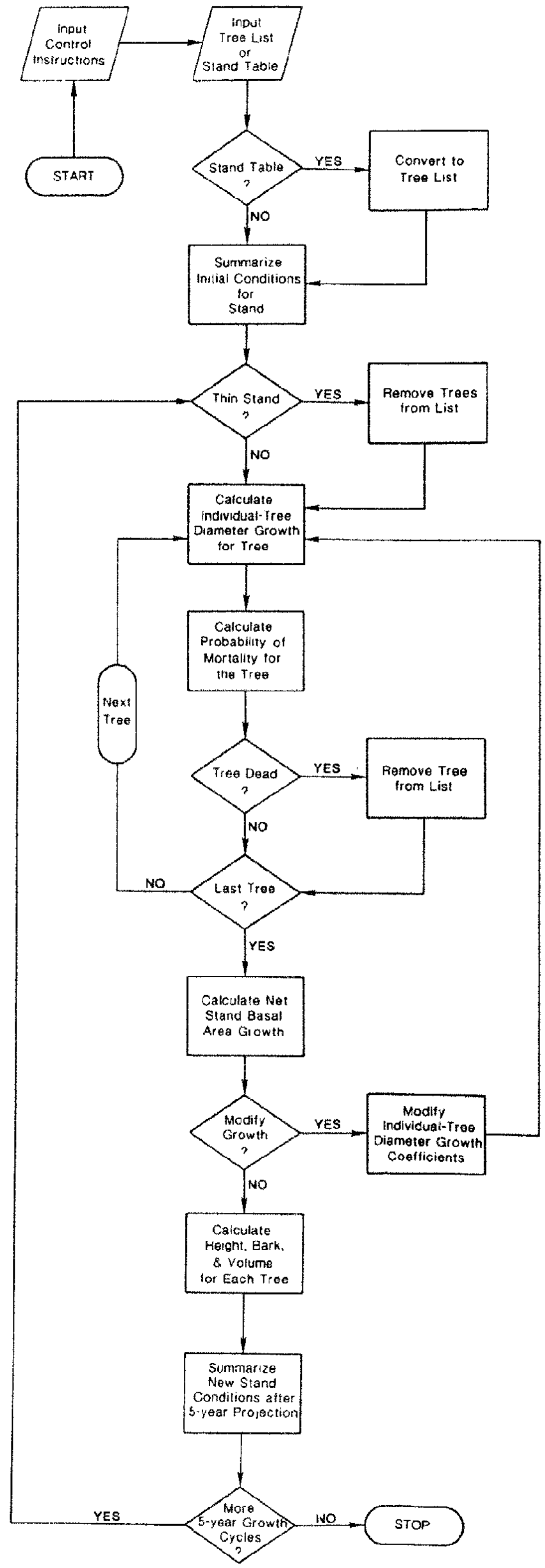

Figure 1.--Generalized flowchart of OAKSIM's operation.

Program Applications

OAKSIM can be applied to a wide range of stand, age, and site conditions. Like all simulators, however, OAKSIM has limitations, imposed primarily by the data bases used to construct the growth and yield models. Users must be cautious not to exceed these limitations, because erroneous projections can occur. OAKSIM applications are limited to the following conditions:

- Even-aged upland oak stands only
- Oak component at least 75 percent of stand basal area
- Stand age 30 to 120 years
- Black oak site index 50 to 85
- Percent stocking 20 to 120 percent
- Tree d.b.h. 2.6 inches and larger
- Maximum 50-year projection

OAKSIM should be applied only to those stands composed primarily of oak species found on upland sites: white,[1] black, scarlet, and chestnut. The simulator is not intended to be used on stands where northern red oak is the major oak component. Application to stands where the northern red oak component is less than 15 percent of the stand basal area, however, is permissible.

Stand structure should not differ radically from even-aged structures normally found on upland oak sites. Initial starting ages may range from 30 to 100 years. If the simulator is started at age 100, then projections should only be made for 20 years to the maximum 120 years. The simulator should not be started over. For example, if projections are made from ages 30 to 80, resulting output should not be used as input for a projection from ages 80 to 120. The program will terminate and error messages will be printed if a tree d.b.h. is less than 2.6 inches, or if stand age or site index fall outside their respective ranges of application. The user is responsible for meeting the other conditions.

[1]See Little (1978) for scientific names of all species referred to in this paper.

Control Cards

General Information

The 13 types of control cards used in OAKSIM guarantee maximum flexibility to meet user needs. A wide range of species and size class groupings is permissible. Merchantability standards are also user-specified. Except for thinning specifications, the control cards are unlikely to be altered for subsequent computer runs for a given stand or set of stands. Frequent changes in species group, size class, and merchantability designations would most likely confuse the analysis of the various simulation runs.

Quick-reference descriptions, formats, and default values for all control cards appear in Table 1. The appropriate number of control cards, as indicated in Table 1, must appear in the program setup for proper execution. If default values are desired, simply insert a blank card as necessary.

Card Type 1

The type of input data is specified on Card Type 1. A value of 1 indicates that data is in the form of a tree list; a value of 2 indicates stand table data. Information to appear on the data cards and appropriate data formats for both options are described later in the Data section.

OAKSIM is designed to operate from a tree list containing the species and d.b.h. of each tree in the stand, but users seldom have access to a complete list of trees in a stand, except perhaps in research situations. A stand table input option, therefore, is included in OAKSIM to make the simulator more compatible with practical applications. The number of trees in each size (d.b.h.) and species (or species group) class must be specified with the stand table option. Size classes may be either 1- or 2-inch d.b.h. classes. A random number generator is called on to distribute the d.b.h.'s of trees in each species and size class uniformly across the d.b.h. class. For example, if there are 25 white oak trees in the 6-inch d.b.h. class (a 1-inch d.b.h. class), the generated tree list will include 25 white oak trees uniformly distributed from 5.55 to 6.54 inches. (This range is used because trees are placed in appropriate d.b.h. classes within the program by adding 0.45 to the tree d.b.h., and then rounding to the last full integer value.) Initial growth projections are then based on this generated tree list. This approach provides a close approximation to the actual distribution of trees across d.b.h. classes.

Table 1.—Control cards for OAKSIM. All values must be right-justified in appropriate columns.

Card type	Number of cards	Information on card	Columns	Format[a]	Default values
1	1	Type of input data: 1=tree list 2=stand table	1	I1	
2	1	Stand number Stand age Site index	1-3 4-6 7-8	I3 F3.0 F2.0	
3	1	Number of species groups. Maximum is 5.	1	I1	
4	1 for each species group[b]	Species group ID: (1,2,3,4, or 5)	1	I1	
		Number of species codes in species group	3-4	I2	
		Height group code: 1=white oak 2=black oak	6	I1	
		Mortality group code: 1=white oak 2=black oak 3=other commercial trees 4=noncommercial trees and shrubs	8	I1	
		Average DBHIB/DBHOB ratio (RBAR)	10-12	F3.2	0.91
		Average BO	14-17	F4.3	0.0
		Average B1	19-22	F4.3	0.0
		Species codes in group[b]. Maximum of 11 codes for each group	26-30, 31-35, etc.	11I5	

Continued

Table 1.—Continued

Card type	Number of cards	Information on card	Columns	Format[a]	Default values
5	1	Number of top d.i.b.'s for cubic volume. Maximum is 2.	1	I1	2
		Top d.i.b.'s for cubic volume. List in descending order.	2-3, 4-5	2F2.0	4.,0.
6	1	Number of top d.i.b.'s for BF volume. Maximum is 2.	1	I1	2
		Top d.i.b.'s for BF volume. List in descending order	2-3, 4-5	2F2.0	10.,8.
7	1	Minimum log length, cubic volume	1-4	F4.1	4.0
		Minimum log length, BF volume	5-8	F4.1	8.0
8	1	Maximum d.b.h. for saplings	1-5	F5.2	4.55
		Maximum d.b.h. for poles	6-10	F5.2	11.55
9	1	Size of d.b.h. classes: 1=1 inch 2=2 inch	1	I1	1
10	1	Number of 5-year projections. Maximum is 10.	1-2	I2	10
11	1	Number of thinnings	1-2	I2	0
		Thinning intensity for each species group	3-4, 5-6, etc.	5(I2)	0
12	1 for each time thinning occurs	Age at thinning (must be 5-year increment of initial stand age)	1-3	I3	
		Percent stocking to leave	4-6	F3.0	

Continued

Like height group codes, mortality group codes require some discretion in assignment when species with different mortality groups are mixed in a species group. Again, use the code that applies to the majority of the trees in the species group. A distinct mortality group code will usually apply to a normal breakdown of species groups.

Average DBHIB/DBHOB ratio (RBAR).--OAKSIM uses the RBAR value in calculating inside- and outside-bark volumes. RBAR values can be determined in two ways: by actual field sampling, or by using the recommended values in Table 2. The recommended values are based on previously-reported research studies and also on my experience in the upland oak type. Actual field sampling is preferred if OAKSIM is run for a particular stand of interest. The RBAR for the species group is the average of the RBARs for all trees in the group. An approximate value for the species group is satisfactory since errors in the determination of RBAR are not too serious--perhaps only 1 or 2 percent of tree volumes. When in doubt, use the RBAR value for the predominant species in the group. A default value of 0.91 is supplied by OAKSIM.

Average B0, B1.--Every effort is made in OAKSIM to estimate tree volumes accurately. The d.i.b./d.o.b. ratios for most hardwoods either remain constant or decrease up the stem (Hilt et al. 1983). B0 and B1 are model coefficients that govern volume calculations for species that have decreasing d.i.b./d.o.b. ratios. Recommended values for B0 and B1 are listed in Table 2. The B0 and B1 values for the species group are the averages of the B0 and B1 values for all trees in the group. Again, approximate values are satisfactory because small errors in B0 and B1 only affect volume estimates by about 1 percent. When in doubt, use the B0 and B1 values for the predominant species in the group. Default values of 0.0 are supplied by OAKSIM for both B0 and B1. Values of 0.0 indicate that the d.i.b./d.o.b. ratio, RBAR, remains constant up the stem.

Species codes in group.--User-specified codes for each species group eliminate the need for users to adhere to any prespecified codes for various species. A maximum of 11 species codes (up to 5 digits) are listed in columns 25-80. Species codes do not have to be listed for the last species group. All codes not listed for previous groups are placed in the final group. I usually delineate three or four key species groups, then let the program automatically place all other codes in the final miscellaneous group. All other information on Card Type 4, however, must be specified for the last group.

Card Types 5 and 6

A taper-based volume system used in OAKSIM allows users to specify a wide range of merchantability standards. Virtually any top d.i.b.'s may be specified. A maximum of two top d.i.b.'s can be specified for cubic-foot volumes on Card Type 5, and two top d.i.b.'s for International 1/4-inch board-foot volumes on Card Type 6. The top d.i.b.'s must be listed in descending order, e.g., 10-inch top, then 4-inch top. Both inside-and outside-bark volumes are computed to the specified tops for cubic-foot volume. Default values are 4.0 and 0.0 inches for cubic volumes, and 10.0 and 8.0 inches for board-foot volumes.

Card Type 7

Minimum log lengths for cubic and board-foot volume calculations are specified on Card Type 7. If a tree does not have at least the minimum log length to a specified top diameter, no volume is computed to that top d.i.b. for that tree. Fractional log lengths are included in volume computations, however, if the tree meets minimum requirements. For example, if the minimum log length for cubic volume is specified at 4 feet and the top d.i.b. at 4.0 inches, no volume would be calculated for a tree that has a 4-inch top at, say, 3.9 feet. If the 4-inch top occurred at 7.9 feet, however, volume would be computed for the entire 7.9 feet. The same rule applies to board foot calculations. A specified top d.i.b. of 0.0 inches always results in the calculation of total stem cubic volume, unless an exceptionally long minimum length such as 15 feet is specified. Default values are 4.0 feet for cubic-foot volumes, and 8.0 feet for board-foot volumes.

Card Type 8

Product size classes for saplings, poles, and sawtimber are specified on Card Type 8. The minimum d.b.h. for poletimber is entered in columns 1 to 5, and the minimum d.b.h. for sawtimber is specified in columns 6-10. Follow this simple rule to set threshold diameters: (1) decide on the minimum d.b.h. of the product size class, to the nearest 1/10 inch, (2) subtract 0.05, and (3) enter resulting value on card. The default value for minimum d.b.h. of the poletimber class is 4.6-0.05 = 4.55 inches. The default value for minimum d.b.h. of the sawtimber class is 11.6-0.05 = 11.55 inches.

Card Type 9

The size of d.b.h. classes is entered on Card Type 9. A value of 1 indicates 1-inch classes, and a value of 2 indicates 2-inch classes. If the tree list input option (see Card Type 1 and Data section) is used, the d.b.h. class designation will control output only. If the stand table input option is used, d.b.h. class designations must coincide with the d.b.h. classes of the stand table because this card will then control both the creation of the tree list and the output. A default value of 1 is provided.

Card Type 10

The number of 5-year projections to be made with OAKSIM is listed on Card Type 10. A maximum of ten 5-year projections is allowed. A default value of 10 is provided.

Card Type 11

The number of thinnings to be made and the thinning intensity for each species group appears on Card Type 11. A thinning may be made at the beginning of each of the 10 projection periods if desired.

The thinning rule used in OAKSIM makes every attempt to duplicate the actual thinning method applied by professional foresters on the growth and yield plots used to develop the simulator. The thinning method used is best described as "free thinning"--the marker was free to remove trees from all crown classes. The objective was to leave the specified stocking level distributed on the best trees as evenly spaced as possible throughout the plot. In general, the larger cull and defective trees were cut first, then the competing trees of poor form and quality, then the intermediate and suppressed trees of lower quality and value. Finally, if necessary, lower value species and even some high-quality desirable species were removed from the main canopy to achieve a uniform spatial distribution. In essence, this thinning method represents the most realistic, practical thinning method that can be applied at the present time by professional foresters in even-aged upland oak stands.

OAKSIM is one of the few simulators that uses a thinning rule based on actual data, not artificial rules governed only by computer programming. Until additional plots can be established to study other thinning methods in upland oak stands, such as thinning strictly from above or below, this thinning rule should be used because the growth models are based on this thinning method. There is, however, some flexibility with OAKSIM: three options are available to control the intensity of cut across species groups within a d.b.h. class: (1) a code value of 0 maintains the same proportion of species as the unthinned stand, (2) a value of 1 doubles the allocated cut for specified species groups, and (3) a code equal to 2 eliminates a species group entirely. Only minor species groups such as understory species should be eliminated with the third option. Major species groups such as white oak or black oak should not be eliminated.

Card Type 12

The age of thinning and the desired percent stocking to leave after thinning are specified on Card Type 12. There must be one card for each time the stand is thinned (see Card Type 11 for number of thinnings). The age at thinning must be a 5-year increment of the initial stand age listed on Card Type 2. Residual stocking may range from 20 to 120 percent.

Card Type 13

The code on Card Type 13 controls printing during the program output phase. Information on projected stands is comprehensive. Stand tables are listed by specified d.b.h. classes and species groups. Stock tables are listed by product size classes (see Card Type 8) and species groups. And the information on growth components is listed in a logical order: initial stand conditions, cut trees, residual stand, mortality trees, and projected stand. A numerical code from 0 to 3 controls output as follows:

Code	Output
0	Initial and ending stand and stock tables only.
1	Stand tables for all growth components at all intermediate ages are also printed.
2	Stock tables for all growth components at all intermediate ages are also printed.
3	Stand and stock tables for all growth components at all intermediate ages are also printed. This option generates the most comprehensive output.

In addition to stand and stock tables, a comprehensive summary table for the entire growth and yield simulation run is always printed. Although there is no breakdown by species and size classes in this table, the summary provides an excellent overview of the simulation run and is most valuable for examining the effects of various thinning alternatives.

Data Cards

General Information

As defined on Control Card Type 1, data may be entered as either a tree list or a stand table. Both methods of data entry must represent trees on a per-acre basis. Since OAKSIM does not make any provision for converting data collected from various field sampling schemes to a per-acre basis, the user is responsible for the construction of the appropriate list or stand table. Quick-reference descriptions and formats for data cards appear in Table 3.

Tree List

One data card is required for each tree in the stand. The species code is any integer value, up to five digits long, that the user desires. OAKSIM uses the species codes to assemble trees into species groups, as defined on Control Card Type 4. The d.b.h. of each tree is entered on the data card without a decimal point, but read by an F4.1 format because diameters of trees in a list are usually measured to the nearest 1/10 inch. For example, a 10.8-inch tree would be entered as 108, and a 3.0-inch tree as 30, right justified. If the d.b.h.'s of trees in the list are measured to the nearest inch rather than the nearest tenth inch, enter a 0 for the tenths. For example, a 10-inch tree would be entered as 100, and a 3-inch tree as 30.

Stand Table

One card is required for each species code and d.b.h. class used in the stand table. Species codes, like those used in the tree list, are integer values up to five digits long. Any number of species codes may be used in the input data. OAKSIM will group the codes later according to the information specified on Control Card Type 4. The midpoint of each d.b.h. class (either a 1-or 2-inch class) is specified as a two-digit code without a decimal point, and read by an F2.0 format. The number of trees in each species code by d.b.h. class is an integer value up to three digits long. If there were 27 trees in the 10-inch d.b.h. class, species code 710, the data card would appear as __71010_27.

Random Number Generator

A random number generator is used in OAKSIM to convert stand tables to tree lists and to calculate individual-tree diameter growth rates and probabilities of mortality. The CALL statements in OAKSIM used to invoke the random number generator are based on local computing commands, and will require some modification by the user. The generator used in OAKSIM is almost identical to IBM's RANDOM Subroutine Package. If RANDOM or its local counterpart are not available, users are advised to use a well-tested random number generator.

Table 3.—Data cards for OAKSIM. All values must be right-justified in appropriate columns.

Number of cards	Information on card	Columns	Format[a]
Tree list			
One for each tree	Species code	1-5	I5
	Tree d.b.h.	6-9	F4.1
Stand table			
One for each species code and d.b.h. class used.	Species code	1-5	I5
	D.b.h. class	6-8	F3.0
	Number of trees	9-11	I3

[a]Format for entire data card is combination of formats for each element of information on card.

Use of random numbers makes OAKSIM a stochastic simulator. Output is somewhat dependent on the random numbers generated and can be altered by changing the seed used to initialize the generator (although this is not recommended). The seed statement in OAKSIM is IX = 111111. Testing has revealed that changing the seed, and hence the sequence of random numbers, varies output only slightly, especially if long projections such as 50 years are specified. Slight variations in output reflect only the natural variation inherent in the complex growth and yield of a forest stand.

Example Using Oaksim

Program control cards and data used for this sample run of OAKSIM appear in Table 4. Initial conditions for the 30-year-old upland oak stand are the same as those for the "average" normal stand described in Schnur's (1937) yield and stand tables. Site index is 70.

Stand table data were segregated into four species groups: (1) white and chestnut oaks, (2) black and scarlet oaks, (3) red maple and dogwood, and (4) hickory, yellow-poplar, and red elm. Species codes are those used regularly in our collection of research data. Height and mortality group codes were readily determined from Table 2. For example, mortality group code 3 was assigned to species group 3 because it contained more red maple than dogwood.

TABLE 4.--Data cards for sample run of OAKSIM.

```
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
2                                      TYPE OF INPUT DATA
  1 3070                               STAND NUMBER,AGE,&SITE
4                                      NUMBER OF SPECIES GROUPS
1  2 1 1 091 0881 0056    01   04
2  2 2 2 090 0832 0103    02   03
3  2 1 3 093 0919 0045    18   23
4  3 1 3 090 0000 0000
2 4 0                                  CUBIC VOLUME TOP DIBS
2 8 5                                  BDFT TOP DIBS
4.0 16.0                               MINIMUM CUBIC & BDFT LENGTHS
 4.55 8.55                             SAPD,POLED
1                                      DCLASS SIZE 1 OR 2 INCHES
10                                     NUMBER OF PROJECTIONS
 1 0 0 0 0                             NUMBER THINNINGS & THINLV
 30 40                                 AGE & PS OF THINNING
1                                      PRINT OPTIONS
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
    1  3 59
    1  4 69
    1  5 51
    1  6 31   White Oak
    1  7 14
    1  8  6
    1  9  3
    2  3 15
    2  4 27
    2  5 42
    2  6 35   Black Oak
    2  7 20
    2  8 12
    2  9  5
    2 10  3
    3  3  7
    3  4 20
    3  5 20
    3  6 19   Scarlet Oak
    3  7 12
    3  8  5
    3  9  2
    4  3 10
    4  4  9
    4  5  8   Chestnut Oak
    4  6  7
    4  7  2
   10  3  2   Yellow-Poplar
   10  4  2
   12  3 10
   12  4  2   Hickory
   12  5  1
   12  6  1
   18  3 10
   18  4 10
   18  5 13
   18  6  7   Red Maple
   18  7  4
   18  8  2
   18  9  1
   23  3 13   Dogwood
   23  4  9
   32  3  1   Red Elm
   32  4  1
----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

Assignment of the RBAR, B0, and B1 values to various species groups for bark calculations requires some judgement by the user. However, since these values are not critical for the execution of OAKSIM, make reasonable assignments and proceed without worry. I used white oak values for species group 1 because white oak is the predominant species in the group. Black and scarlet oak in group 2 have identical values. I used red maple B0 and B1 values for species group 3 because red maple is the predominant species. The RBAR value, however, was lowered slightly from 0.95 to 0.93 by the presence of dogwood in the group. Values for hickory were used for group 4 because it is the predominant species.

Cubic-foot volumes are specified to be calculated to a 4-inch top d.i.b. and also total stem (0.0-inch top). The tree must have at least 4 feet to the specified top d.i.b. for volume to be calculated.

International 1/4-inch board-foot volumes are specified to be calculated to 8- and 5-inch tops. Each tree must have at least a 16-foot log to the top d.i.b. Also, all trees greater than 8.55 inches will fall into the sawtimber size class. These specifications were used so that board-foot yields could be compared to Schnur's (1937) yield tables. Larger top d.i.b.'s and a threshold d.b.h. of 11.55 inches would be more common for sawtimber.

One-inch d.b.h. size classes are specified for the input data, and ten 5-year projections are requested. One thinning to 40 percent residual stocking at age 30 is specified. Thinnings will leave approximately the same proportion of trees for each species group in every d.b.h. class as were in the initial stand, since zero codes were specified for all groups. The print code was set equal to 1 so that all intermediate stand tables would be printed.

Bracketed numbers that follow in this section refer to annotations on the OAKSIM output in Tables 5 and 6. Output for the thinned stand appears in Table 5. Only the final summary table of the unthinned OAKSIM run for the same stand is shown in Table 6.

OAKSIM always prints out a summary of all control card information [1]. The initial stock table for age 30 [2] includes a comprehensive breakdown by species groups and product size classes for all major stand characteristics. Average d.b.h. values [3] listed in the stock tables are arithmetic means, not quadratic. The initial stock and stand [4] tables are always printed. Since all intermediate stand tables were requested for this run of OAKSIM, stand tables for trees removed in thinning [5], residual trees after thinning [6], mortality trees [7], and trees in the projected stand [8] for all 5-year intervals are printed (only those to age 35 are listed in Table 1). Final stand [9] and stock [10] tables are always printed.

It is evident from [5] that the majority of the 399 trees removed with the thinning rule were in the lower crown classes. Nearly 91 percent of the trees in the 3-inch d.b.h. class were cut. Some of the largest trees, however, were also removed. These larger trees are representative of the larger cull and rough trees often found in upland oak stands. The percentage of trees by species group in each d.b.h. class, as specified by the control cards, remained nearly the same after thinning. For example, the 38 trees in the white oak group accounted for 38 percent of the 100 trees in the 6-inch d.b.h. class before thinning, and the 20 residual trees accounted for 39 percent of the 51 trees in the 6-inch class after thinning.

All of the detailed information available in the stand and stock tables must be utilized for a comprehensive evaluation of various thinning regimes. The size and species determine the value of a tree. For example, the changes that occurred in the white oak group should be examined closely because of the high value of this species relative to the other three groups. On the other hand, the final summary table [11,12] provides a good overall look at stand development over the projection period and is most useful for narrowing the choices of various thinning regimes.

(Text continued on page 20)

TABLE 5

DATA TYPE AND STAND INFORMATION.

TYPE OF INPUT DATA: STAND TABLE
NUMBER OF STANDS: 1

STAND NUMBER	AGE	SITE INDEX
1	30.0	70.0

1

HEIGHT AND BARK DATA.

SPECIES GROUP	HTGRP	RBAR	BO	B1
1	WO	0.910	0.881	0.056
2	BO	0.900	0.832	0.103
3	WC	0.930	0.919	0.045
4	WO	0.900	0.000	0.000

PROJECTIONS.

NUMBER OF 5-YEAP PROJECTIONS: 10
1ST & LAST STAND-STOCK TABLES ALWAYS PRINTED.
ALL STAND TABLES PRINTED: YES
ALL STOCK TABLES PRINTED: NO

VOLUMES TO BE CALCULATED.

	TOP DIAMETERS	
CUBIC VOLUME	4.0	0.0
BOARD FOOT VOLUME	8.0	5.0

MINIMUM LENGTH FOR CUBIC VOLUMES IS 4.0 FEET,
AND 16.0 FEET FOR BD FT VOLUMES.
PRODUCT SIZE CLASSES ARE 4.55 INCHES FOR POLES,
AND 8.55 INCHES FOR SAWLOGS.

SPECIES CODES.

SPECIES GPOUP	SPECIES CODES	
1	1	4
2	2	3
3	18	23
4	ALL OTHER CODES ARE IN THIS GROUP.	

THINNING OPTIONS.

NUMBER OF THINNINGS: 1
THINNING METHOD: FREE THINNING
THINNING INTENSITIES BY SPECIES
GROUPS: 0 0 0 0

AGE THINNED	PERCENT STOCKING
30	40.0

2

SUMMARY STAND STATISTICS: INITIAL CONDITIONS FOR STAND AT AGE 30.

SPECIES :	1	2	3	4	5	TOTALS
N TREES:						
SAP	147.0	69.0	42.0	18.0		276.0
POLE	119.0	165.0	26.0	2.0		312.0
SAW	3.0	10.0	1.0	0.0		14.0
TOTAL	269.0	244.0	69.0	20.0		602.0
BA:						
SAP	10.3	5.2	2.9	1.1		19.5
POLE	22.4	34.2	5.0	0.3		61.9
SAW	1.3	4.8	0.4	0.0		6.5
TOTAL	34.0	44.2	8.3	1.5		87.9
PS:						
SAP	14.1	7.0	4.0	1.6		26.6
POLE	24.1	36.0	5.4	0.4		65.8
SAW	1.2	4.3	0.4	0.0		5.9
TOTAL	39.4	47.3	9.7	2.0		98.4
AVG DBH:						
SAP	3.5	3.7	3.5	3.3		3.6
POLE	5.8	6.1	5.8	5.6		5.9
SAW	8.9	9.3	9.0	0.0		9.2
CVOB 4.0:						
SAP	0.0	0.0	0.0	0.0		0.0
POLE	349.3	574.3	81.9	4.9		1010.4
SAW	32.7	116.0	10.8	0.0		159.5
TOTAL	382.0	690.2	92.7	4.9		1169.9
CVIB 4.0:						
SAP	0.0	0.0	0.0	0.0		0.0
POLE	303.6	491.0	75.4	4.0		874.0
SAW	28.2	98.1	9.9	0.0		136.2
TOTAL	331.8	589.1	85.3	4.0		1010.2
CVOB 0.0:						
SAP	195.2	104.6	52.0	20.7		372.6
POLE	513.0	807.6	114.1	7.9		1442.6
SAW	35.1	124.3	11.5	0.0		170.9
TOTAL	743.3	1036.5	177.6	28.6		1986.0
CVIB 0.0:						
SAP	168.0	87.9	47.5	16.8		320.1
POLE	440.8	677.6	104.2	6.4		1229.0
SAW	30.2	104.4	10.5	0.0		145.1
TOTAL	638.9	869.9	162.2	23.2		1694.2
BFVOL 8.0:						
SAW	0.0	0.0	0.0	0.0		0.0
BFVOL 5.0:						
SAW	103.3	361.5	36.4	0.0		501.2

3

STAND TABLE: INITIAL CONDITIONS FOR STAND AT AGE 30.

DBH CLASS	SPECIES GROUPS 1	2	3	4	5	TOTALS
3	69.0	22.0	23.0	13.0		127.0
4	78.0	47.0	19.0	5.0		149.0
5	59.0	62.0	13.0	1.0		135.0
6	38.0	54.0	7.0	1.0		100.0
7	16.0	32.0	4.0	0.0		52.0
8	6.0	17.0	2.0	0.0		25.0
9	3.0	7.0	1.0	0.0		11.0
10	0.0	3.0	0.0	0.0		3.0
TOTALS	269.0	244.0	69.0	20.0		602.0

4

STAND TABLE: TREES REMOVED IN THINNING AT AGE 30.

DBH CLASS	SPECIES GROUPS 1	2	3	4	5	TOTALS
3	62.0	20.0	21.0	12.0		115.0
4	63.0	34.0	14.0	4.0		115.0
5	34.0	35.0	8.0	1.0		78.0
6	18.0	26.0	4.0	1.0		49.0
7	7.0	14.0	2.0	0.0		23.0
8	3.0	7.0	1.0	0.0		11.0
9	2.0	3.0	1.0	0.0		6.0
10	0.0	2.0	0.0	0.0		2.0
11	0.0	0.0	0.0	0.0		0.0
12	0.0	0.0	0.0	0.0		0.0
TOTALS	189.0	141.0	51.0	18.0		399.0

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STAND TABLE: RESIDUAL STAND AFTER THINNING AT AGE 30.

DBH CLASS	SPECIES GROUPS 1	2	3	4	5	TOTALS
3	7.0	2.0	2.0	1.0		12.0
4	15.0	13.0	5.0	1.0		34.0
5	25.0	27.0	5.0	0.0		57.0
6	20.0	28.0	3.0	0.0		51.0
7	9.0	18.0	2.0	0.0		29.0
8	3.0	10.0	1.0	0.0		14.0
9	1.0	4.0	0.0	0.0		5.0
10	0.0	1.0	0.0	0.0		1.0
11	0.0	0.0	0.0	0.0		0.0
12	0.0	0.0	0.0	0.0		0.0
TOTALS	80.0	103.0	18.0	2.0		203.0

6

STAND TABLE: MORTALITY FOR GROWTH PERIOD BEGINNING AT AGE 30 -

DBH CLASS	SPECIES GROUPS 1	2	3	4	5	TOTALS
3	1.0	0.0	0.0	0.0		1.0
4	0.0	0.0	0.0	0.0		0.0
5	0.0	0.0	0.0	0.0		0.0
6	0.0	0.0	0.0	0.0		0.0
7	0.0	0.0	0.0	0.0		0.0
8	0.0	0.0	0.0	0.0		0.0
9	0.0	1.0	0.0	0.0		1.0
10	0.0	0.0	0.0	0.0		0.0
11	0.0	0.0	0.0	0.0		0.0
12	0.0	0.0	0.0	0.0		0.0
TOTALS	1.0	1.0	0.0	0.0		2.0

7

STAND TABLE: INITIAL CONDITIONS FOR STAND AT AGE 35.

DBH CLASS	SPECIES GROUPS 1	2	3	4	5	TOTALS
3	4.0	2.0	2.0	1.0		9.0
4	5.0	5.0	3.0	0.0		13.0
5	16.0	14.0	4.0	1.0		35.0
6	22.0	23.0	2.0	0.0		47.0
7	15.0	24.0	4.0	0.0		43.0
8	11.0	12.0	2.0	0.0		25.0
9	4.0	12.0	1.0	0.0		17.0
10	2.0	8.0	0.0	0.0		10.0
11	0.0	1.0	0.0	0.0		1.0
12	0.0	1.0	0.0	0.0		1.0
TOTALS	79.0	102.0	18.0	2.0		201.0

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STAND TABLE: INITIAL CONDITIONS FOR STAND AT AGE 80.

DBH CLASS	SPECIES GROUPS 1	2	3	4	5	TOTALS
6	0.0	0.0	0.0	0.0		0.0
7	2.0	2.0	1.0	0.0		5.0
8	7.0	1.0	2.0	0.0		10.0
9	10.0	4.0	2.0	0.0		16.0
10	12.0	10.0	2.0	0.0		24.0
11	8.0	7.0	2.0	0.0		17.0
12	10.0	12.0	2.0	0.0		24.0
13	7.0	6.0	2.0	0.0		15.0
14	6.0	8.0	1.0	0.0		15.0
15	0.0	7.0	0.0	0.0		7.0
16	0.0	3.0	0.0	0.0		3.0
17	1.0	3.0	0.0	0.0		4.0
18	0.0	1.0	0.0	0.0		1.0
TOTALS	63.0	64.0	14.0	0.0		141.0

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SUMMARY STAND STATISTICS: INITIAL CONDITIONS FOR STAND AT AGE 80.

SPECIES :	1	2	3	4	5	TOTALS
N TREES:						
SAP	0.0	0.0	0.0	0.0		0.0
POLE	9.0	3.0	3.0	0.0		15.0
SAW	54.0	61.0	11.0	0.0		126.0
TOTAL	63.0	64.0	14.0	0.0		141.0
BA:						
SAP	0.0	0.0	0.0	0.0		0.0
POLE	3.0	0.9	1.0	0.0		4.9
SAW	38.8	55.0	8.0	0.0		101.8
TOTAL	41.8	55.9	9.0	0.0		106.8
PS:						
SAP	0.0	0.0	0.0	0.0		0.0
POLE	2.9	0.9	1.0	0.0		4.8
SAW	32.7	44.7	6.7	0.0		84.2
TOTAL	35.6	45.6	7.7	0.0		88.9
AVG DBH:						
SAP	0.0	0.0	0.0	0.0		0.0
POLE	7.8	7.5	7.8	0.0		7.8
SAW	11.3	12.7	11.4	0.0		12.0
CVOB 4.0:						
SAP	0.0	0.0	0.0	0.0		0.0
POLE	90.2	25.0	28.7	0.0		143.9
SAW	1492.4	2171.2	296.0	0.0		3959.5
TOTAL	1582.5	2196.2	324.6	0.0		4103.4
CVIB 4.0:						
SAP	0.0	0.0	0.0	0.0		0.0
POLE	77.7	21.2	26.3	0.0		125.2
SAW	1280.8	1816.8	270.0	0.0		3367.6
TOTAL	1358.5	1838.0	296.3	0.0		3492.8
CVOB 0.0:						
SAP	0.0	0.0	0.0	0.0		0.0
POLE	102.1	29.6	32.3	0.0		164.0
SAW	1542.7	2226.2	305.1	0.0		4074.0
TOTAL	1644.8	2255.8	337.5	0.0		4238.0
CVIB 0.0:						
SAP	0.0	0.0	0.0	0.0		0.0
POLE	87.5	24.8	29.5	0.0		141.7
SAW	1321.4	1857.8	278.0	0.0		3457.3
TOTAL	1409.0	1882.6	307.5	0.0		3599.0
BFVOL 8.0:						
SAW	3874.7	7063.6	851.7	0.0		11790.0
BFVOL 5.0:						
SAW	6189.1	9091.5	1310.1	0.0		16590.7

STAND NUMBER 1 SITE INDEX 70.

SUMMARY STATISTICS FOR ENTIRE GROWTH PROJECTION: **11**

ATTRIBUTE	STAND AGE 30	35	40	45	50	55	60	65	70	75	80	TOTALS
N TREES:												
INITIAL	602.0	201.0	197.0	192.0	187.0	178.0	170.0	161.0	153.0	146.0	141.0	
CUT	399.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		399.0
RESIDUAL	203.0	201.0	197.0	192.0	187.0	178.0	170.0	161.0	153.0	146.0		
MORTALITY	2.0	4.0	5.0	5.0	9.0	8.0	9.0	8.0	7.0	5.0		62.0
BA:												
INITIAL	87.9	50.2	61.3	70.8	78.8	85.4	91.1	95.9	100.0	103.6	106.8	
CUT	50.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		50.6
RESIDUAL	37.3	50.2	61.3	70.8	78.8	85.4	91.1	95.9	100.0	103.6		
MORTALITY	0.5	0.4	0.7	1.1	2.7	2.2	3.3	2.7	3.2	2.1		18.8
NET GROWTH	12.8	11.2	9.5	7.9	6.7	5.6	4.8	4.1	3.6	3.2		69.5
GROSS GROWTH	13.3	11.5	10.1	9.1	9.3	7.9	8.1	6.8	6.8	5.2		88.3
PS:												
INITIAL	98.4	50.5	59.1	66.2	71.9	76.3	80.0	82.8	85.1	87.1	88.9	
CUT	58.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		58.4
RESIDUAL	40.0	50.5	59.1	66.2	71.9	76.3	80.0	82.8	85.1	87.1		
MORTALITY	0.5	0.4	0.8	1.2	2.5	2.2	3.1	2.6	2.9	1.9		18.1
NET GROWTH	10.5	8.7	7.0	5.7	4.5	3.6	2.8	2.4	2.0	1.8		48.9
GROSS GROWTH	11.0	9.1	7.8	6.9	7.0	5.8	5.9	5.0	4.9	3.7		67.0
QUADRATIC DBH:												
INITIAL	5.2	6.8	7.6	8.2	8.8	9.4	9.9	10.4	10.9	11.4	11.8	-----
CUT	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
RESIDUAL	5.8	6.8	7.6	8.2	8.8	9.4	9.9	10.4	10.9	11.4		-----
MORTALITY	6.8	4.0	4.9	6.5	7.4	7.2	8.2	7.9	9.1	8.7		
CVOB 4.0:												
INITIAL	1169.9	1033.0	1460.4	1902.6	2274.5	2711.1	2973.0	3358.8	3589.5	3823.7	4103.4	
CUT	580.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		580.5
RESIDUAL	589.4	1033.0	1460.4	1902.6	2274.5	2711.1	2973.0	3358.8	3589.5	3823.7		
MORTALITY	10.7	1.4	6.0	22.6	68.0	56.5	92.3	82.2	100.6	67.8		508.0
NET GROWTH	443.6	427.4	442.1	372.0	436.6	261.8	385.8	230.8	234.2	279.7		3514.0
GROSS GROWTH	454.3	428.8	448.1	394.6	504.6	318.3	478.1	312.9	334.8	347.5		4022.0
CVIB 4.0:												
INITIAL	1010.2	887.2	1251.5	1627.0	1943.1	2312.9	2536.2	2861.5	3059.0	3257.3	3492.8	
CUT	502.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		502.0
RESIDUAL	508.2	887.2	1251.5	1627.0	1943.1	2312.9	2536.2	2861.5	3059.0	3257.3		
MORTALITY	9.0	1.2	5.1	19.2	57.3	47.8	78.4	69.5	84.9	57.6		430.1
NET GROWTH	379.0	364.3	375.5	316.2	369.8	223.3	325.2	197.5	198.3	235.6		2984.7
GROSS GROWTH	388.0	365.5	380.6	335.4	427.0	271.1	403.6	267.1	283.2	293.1		3414.8
CVOB 0.0:												
INITIAL	1986.0	1292.9	1713.5	2138.4	2496.7	2912.7	3158.0	3526.9	3743.2	3965.7	4238.0	
CUT	1115.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		1115.7
RESIDUAL	870.3	1292.9	1713.5	2138.4	2496.7	2912.7	3158.0	3526.9	3743.2	3965.7		
MORTALITY	12.4	6.9	15.1	30.8	82.1	68.7	104.2	93.2	109.3	74.2		596.9
NET GROWTH	422.6	420.6	424.8	358.3	416.0	245.3	368.9	216.3	222.5	272.3		3367.7
GROSS GROWTH	435.0	427.6	439.5	389.1	498.1	314.0	473.1	309.5	331.8	346.5		3964.6

ATTRIBUTE	30	35	40	45	50	55	60	65	70	75	80	TOTALS
CVIB 0.0:												
INITIAL	1694.2	1099.9	1457.2	1817.2	2121.6	2473.3	2683.4	2994.7	3180.4	3369.4	3599.0	-----
CUT	953.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		953.4
RESIDUAL	740.8	1099.9	1457.2	1817.2	2121.6	2473.9	2683.4	2994.7	3180.4	3369.4		-----
MORTALITY	10.4	5.6	12.8	25.8	68.9	57.7	37.9	78.4	91.7	62.6		502.1
NET GROWTH	359.1	357.3	360.0	304.4	352.2	209.6	311.3	185.7	189.0	229.6		2858.2
GROSS GROWTH	369.5	363.2	372.8	330.2	421.1	267.3	399.2	264.1	280.7	292.2		3360.3
BFVOL 8.0:												
INITIAL	0.0	0.0	452.5	1296.4	2454.8	4025.4	5245.6	7227.0	8680.7	10206.1	11790.0	-----
CUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RESIDUAL	0.0	0.0	452.5	1296.4	2454.8	4025.4	5245.6	7227.0	8680.7	10206.1		-----
MORTALITY	0.0	0.0	0.0	0.0	138.8	0.0	0.0	0.0	59.5	61.0		259.7
NET GROWTH	0.0	452.5	843.8	1158.4	1570.6	1220.2	1981.4	1453.6	1525.5	1583.9		11790.0
GROSS GROWTH	0.0	452.5	843.8	1158.4	1709.4	1220.2	1981.4	1453.6	1585.4	1644.8		12049.7
BFVCL 5.0:												
INITIAL	501.2	1140.5	2525.0	4340.6	5952.0	8083.2	9577.5	12100.5	13697.6	15081.7	16590.7	-----
CUT	291.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		291.8
RESIDUAL	209.4	1140.5	2525.0	4340.6	5952.0	8083.2	9577.5	12100.5	13697.6	15081.7		-----
MORTALITY	32.7	0.0	0.0	0.0	198.3	93.6	115.8	217.9	267.4	148.9		1074.6
NET GROWTH	931.0	1384.5	1815.6	1611.4	2131.2	1494.3	2523.0	1597.0	1384.1	1509.0		16381.3
GROSS GROWTH	963.7	1384.5	1815.6	1611.4	2329.5	1587.9	2638.8	1814.9	1651.6	1657.9		17455.9

TABLE 6

STAND NUMBER 1 SITE INDEX 70.

SUMMARY STATISTICS FOR ENTIRE GROWTH PROJECTION: 12

ATTRIBUTE	STAND AGE											
	30	35	40	45	50	55	60	65	70	75	80	TOTALS
N TREES:												
INITIAL	602.0	494.0	432.0	383.0	340.0	303.0	281.0	260.0	238.0	218.0	200.0	-----
CUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RESIDUAL	602.0	494.0	432.0	383.0	340.0	303.0	281.0	260.0	238.0	218.0		-----
MORTALITY	108.0	62.0	49.0	43.0	37.0	22.0	21.0	22.0	20.0	18.0		402.0
BA:												
INITIAL	87.9	94.0	98.6	102.4	105.5	108.1	110.5	112.6	114.4	116.2	117.7	-----
CUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RESIDUAL	87.9	94.0	98.6	102.4	105.5	108.1	110.5	112.6	114.4	116.2		-----
MORTALITY	8.6	7.2	7.9	7.1	6.8	5.9	6.4	5.6	6.2	5.9		67.6
NET GROWTH	6.0	4.7	3.7	3.1	2.7	2.3	2.1	1.9	1.7	1.6		29.8
GROSS GROWTH	14.6	11.8	11.6	10.2	9.4	8.3	8.5	7.5	8.0	7.5		97.4
PS:												
INITIAL	98.4	99.5	100.7	101.4	101.6	101.6	102.1	102.2	102.2	102.0	101.8	-----
CUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RESIDUAL	98.4	99.5	100.7	101.4	101.6	101.6	102.1	102.2	102.2	102.0		-----
MORTALITY	11.3	8.5	8.7	7.8	7.3	5.9	6.2	5.6	6.1	5.7		73.1
NET GROWTH	1.2	1.2	0.6	0.2	0.0	0.4	0.2	-0.0	-0.2	-0.2		3.5
GROSS GROWTH	12.5	9.7	9.4	8.1	7.3	6.3	6.4	5.6	5.9	5.5		76.6

QUADRATIC DBH:											
INITIAL	5.2	5.9	6.5	7.0	7.5	8.1	8.5	8.9	9.4	9.9	10.4	-----
CUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		----
RESIDUAL	5.2	5.9	6.5	7.0	7.5	8.1	8.5	8.9	9.4	9.9		-----
MORTALITY	3.8	4.6	5.4	5.5	5.8	7.0	7.5	6.8	7.6	7.8		----
CVOB 4.0:												
INITIAL	1169.9	1627.6	2021.9	2368.8	2795.4	3013.5	3383.6	3506.4	3842.1	4037.2	4290.1	-----
CUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RESIDUAL	1169.9	1627.6	2021.9	2368.8	2795.4	3013.5	3383.6	3506.4	3842.1	4037.2		-----
MORTALITY	33.7	71.0	116.5	124.5	130.3	146.2	175.6	140.8	185.2	173.9		1297.9
NET GROWTH	457.7	394.3	346.9	426.6	218.1	370.1	122.8	335.8	195.1	252.8		3120.2
GROSS GROWTH	491.4	465.3	463.4	551.1	348.4	516.3	298.4	476.6	380.3	426.8		4418.1
CVIB 4.0:												
INITIAL	1010.2	1402.1	1738.9	2033.5	2355.3	2581.5	2895.1	2999.8	3282.9	3448.4	3662.9	-----
CUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RESIDUAL	1010.2	1402.1	1738.9	2033.5	2355.3	2581.5	2895.1	2999.8	3282.9	3448.4		-----
MORTALITY	29.2	61.3	100.6	107.4	111.5	125.0	150.4	120.1	156.6	148.3		1112.4
NET GROWTH	391.9	336.8	294.6	361.8	186.1	313.6	104.7	283.1	165.5	214.6		2652.7
GROSS GROWTH	421.1	398.1	395.2	469.2	297.6	438.7	255.0	403.2	324.1	362.9		3765.1
CVOB 0.0:												
INITIAL	1986.0	2324.7	2640.0	2909.6	3264.1	3413.1	3742.2	3828.6	4124.9	4284.9	4507.2	-----
CUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RESIDUAL	1986.0	2324.7	2640.0	2909.6	3264.1	3413.1	3742.2	3828.6	4124.9	4284.9		-----
MORTALITY	176.7	164.0	194.3	194.0	191.4	179.5	205.0	175.9	213.1	199.6		1893.6
NET GROWTH	338.7	315.3	269.6	354.5	149.0	329.2	86.3	296.3	160.0	222.3		2521.1
GROSS GROWTH	515.4	479.3	463.9	548.5	340.5	508.7	291.3	472.2	373.2	421.9		4414.8
CVIB 0.0:												
INITIAL	1694.2	1981.7	2249.5	2477.9	2778.1	2906.4	3185.4	3260.0	3510.3	3647.1	3836.5	-----
CUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RESIDUAL	1694.2	1981.7	2249.5	2477.9	2778.1	2906.4	3185.4	3260.0	3510.3	3647.1		-----
MORTALITY	150.9	139.7	165.1	165.3	161.8	152.4	174.2	148.8	181.1	169.0		1608.3
NET GROWTH	287.5	267.8	228.4	300.2	128.3	279.0	74.5	250.3	136.8	189.4		2142.3
GROSS GROWTH	438.4	407.4	393.5	465.5	290.1	431.4	248.7	399.1	317.9	358.5		3750.7
BFVOL 8.0:												
INITIAL	0.0	0.0	151.0	535.7	1343.5	1884.5	3388.4	4263.9	5946.8	7553.2	9109.6	-----
CUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RESIDUAL	0.0	0.0	151.0	535.7	1343.5	1884.5	3388.4	4263.9	5946.8	7553.2		-----
MORTALITY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.7	0.0	61.0		119.7
NET GROWTH	0.0	151.0	384.7	807.8	541.0	1503.9	875.5	1682.9	1606.4	1556.4		9109.6
GROSS GROWTH	0.0	151.0	384.7	807.8	541.0	1503.9	875.5	1741.6	1606.4	1617.4		9229.3
BFVOL 5.0:												
INITIAL	501.2	1132.0	2303.3	3720.0	5523.7	6734.2	8725.5	9937.8	11997.8	13671.0	15463.9	-----
CUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RESIDUAL	501.2	1132.0	2303.3	3720.0	5523.7	6734.2	8725.5	9937.8	11997.8	13671.0		-----
MORTALITY	0.0	0.0	0.0	0.0	62.5	224.2	263.6	190.7	259.1	293.3		1293.4
NET GROWTH	630.8	1171.3	1416.6	1803.7	1210.6	1991.2	1212.4	2060.0	1673.2	1792.9		14962.7
GROSS GROWTH	630.8	1171.3	1416.6	1803.7	1273.1	2215.4	1476.0	2250.6	1932.3	2086.2		16256.1

Basal area, total cubic-foot volume inside bark and International 1/4-inch board-foot volume growth and yield information extracted from [11] and [12] are plotted in Figure 2. Gross growth for the 50-year projection was reduced in the heavily thinned stand—88.3 square feet of basal area growth, compared to 97.4 for the unthinned stand, and 3369 cubic feet compared to 3750, respectively. Net growth, however, showed a marked increase for the thinned stand. Net basal area growth for the thinned stand was 69.5 square feet; for the unthinned stand it was only 29.8. Net cubic volume growth was 2858 cubic feet, compared to 2142. Mortality was sharply reduced with thinning, particularly for the first 20 years after thinning.

The thinned stand had 16,590 board feet per acre at age 80—7 percent more than the unthinned stand. (Board foot yields for the unthinned stand also compare favorably with those from Schnur's yield tables.) Since the unthinned stand had 145 trees in the sawtimber size class compared to only 126 for the thinned stand, the gain in sawtimber volume was due to the increase in tree size—the arithmetic mean d.b.h. for sawtimber was 12.0 inches in the thinned stand and only 11.1 inches in the unthinned stand. Larger trees also have more value.

Even though gross growth rates were reduced somewhat by thinning this stand to 40 percent stocking, gains in net growth and board-foot yields indicate that a heavy thinning at age 30 is still a viable option. This run of OAKSIM also suggests another alternative: to thin initially to 40 percent and again at age 50 to perhaps 60 percent, since mortality started to increase at that age. However, a considerable number of other options regarding the frequency, timing, and intensity of thinning need to be explored to arrive at optimum management guidelines for this stand.

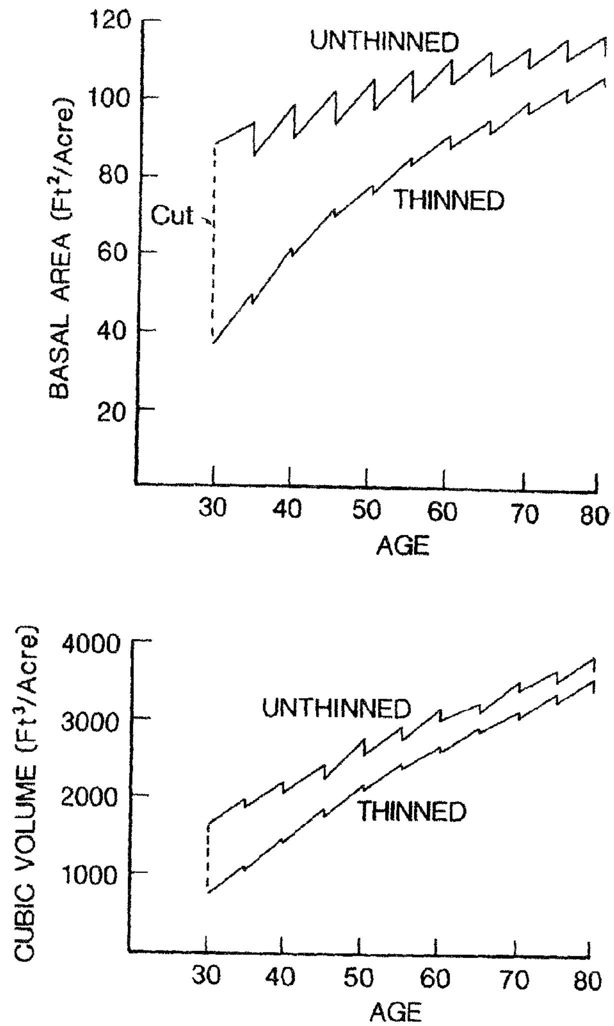
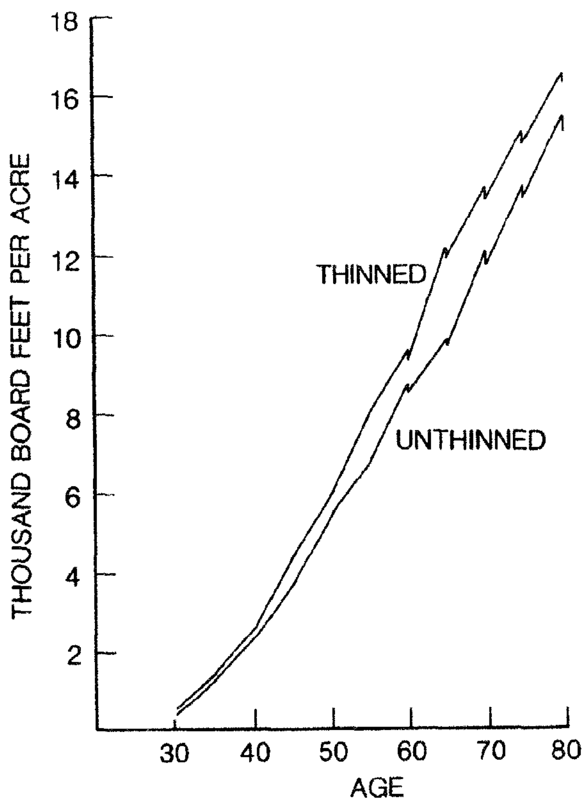


Figure 2.—Basal area, cubic-foot volume (total stem, inside bark), and International 1/4-inch board-foot volume (all trees 8.6 inches d.b.h. and larger to a 5-inch top) per acre for sample run of OAKSIM.



Discussion

OAKSIM is available from the author upon request. The program consists of approximately 1500 cards, and should be compiled to save computing costs. Control cards and data can be stored in a separate data file and read during execution. Use of a CRT screen and a text editor language package maximizes the program's flexibility. The ages and intensities of thinning can then be changed easily to test a variety of management alternatives. Execution time on the AMDAHL/IBM 470 V/6 computer is approximately 10 seconds for a 50-year projection for one stand.

This initial version of OAKSIM is applicable to a wide range of age, site, and stocking conditions for a large portion of the upland oak timber type. The ultimate goal is to produce a complete simulator capable of generating the entire growth cycle--not just the growth of the present stand, but also ingrowth and regeneration. Ingrowth can be substantial in heavily thinned upland oak stands. And once these ingrowth trees are cut during the rotation harvest, the resulting stump sprouts will most likely determine the species composition of the next stand. Timber management planning for the current rotation, however, should be based primarily on those trees already covered by this version of OAKSIM, not on ingrowth trees.

Future enhancements planned for OAKSIM should also encourage application of the simulator. Computer programming statements will be added to allow input from variable-plot (prism) timber cruises. This will eliminate the need for users to construct their own stand tables for input into OAKSIM. A microcomputer version of OAKSIM will also give more users access to the simulator.

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