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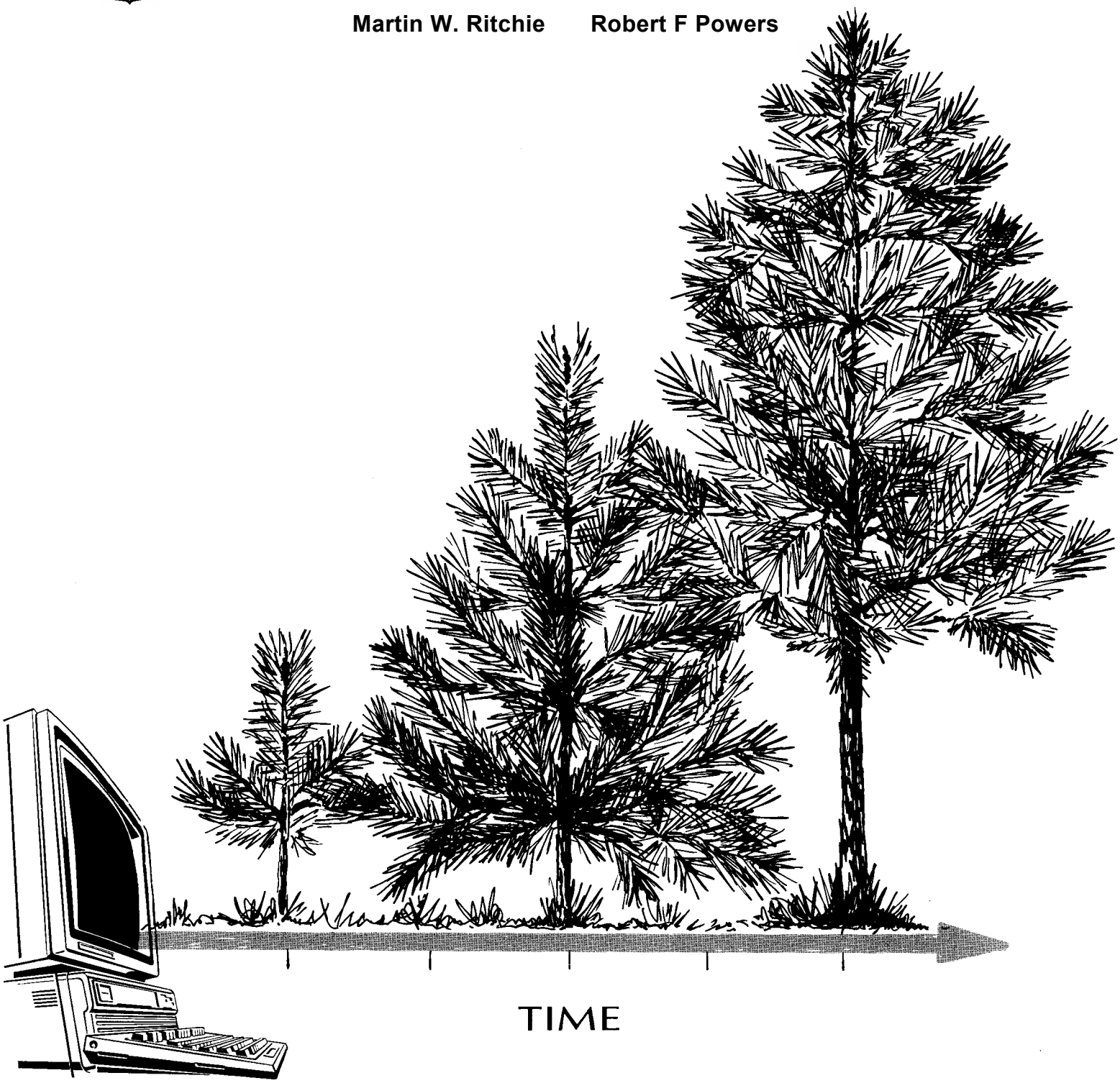
User's Guide for SYSTUM-1 (Version 2.0): A Simulator of Growth Trends in Young Stands Under Management in California and Oregon

Martin W. Ritchie **Robert F Powers**



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SYSTUM-1 is an individual-tree/distance-independent simulator developed for use in young plantations in California and southern Oregon. The program was developed to run under the DOS operating system and requires DOS 3.0 or higher running on an 8086 or higher processor. The simulator is designed to provide a link with existing PC-based simulators (CACTOS and ORGANON) currently in use in northern California and southern Oregon. The input requirements include a sample of trees including heights, species, and expansion factor as well as a sample of competing vegetation including percent cover and height for each species on a given plot. Optional input items for trees are diameter at breast height, live crown ratio, and past periodic annual increment.

Retrieval Terms: growth and yield, simulator, ponderosa pine, Douglas-fir, California, Oregon

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Contents

Preface

SYSTUM-1 is the result of the first phase of the Small Tree Growth Modeling Project sponsored by the California Forest Research Association, a cooperative of public and private forest resource management agencies. This effort is funded by contributions from cooperators. The Pacific Southwest Research Station, USDA Forest Service, was responsible for analyzing the data and developing the computer simulator. Early versions of the simulator were programmed by Larry Ticknor. The project chairman is Charlie Brown, Fruit Growers Supply Company, and Robert Powers of the Station staff is principal investigator.

This document and associated software were produced by Pacific Southwest Research Station, under the auspices of the Small Tree Growth Modeling Project of the California Forest Research Association.

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In Brief ...

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Retrieval Terms: growth and yield, simulator, ponderosa pine, Douglas-fir, California, Oregon

SYSTUM-1 is an individual-tree/distance-independent simulator developed for the DOS operating system. The simulator is designed to predict growth of young plantations up to an age where other simulators (e.g., CACTOS, ORGANON, Prognosis) may be used. Tree-level data input include species, diameter, height, crown ratio. Plot-level data input includes competing vegetation cover and height by species for each plot. Stand-level data input includes stand age and site index.

The simulator will process the major conifer species of the mixed conifer zone. The data used for model development were primarily plantations dominated by either ponderosa pine or Douglas-fir. Data were obtained from stands throughout the northern Sierra Nevada extending northward into southwestern Oregon. The data were provided by industry cooperators, the USDA Forest Service (both Region 5 and Region 6) and the Medford District of the Bureau of Land Management.

The simulator may be used to evaluate both pre-commercial thinning and treatment of non-tree vegetation. Among the thinning options are thinning from below to a target density, thinning proportionately to a target density, and thinning to a specified proportion of density across a range of diameters. The simulator also provides an option for treating competing vegetation.

Among the output options is the creation of tree-list files in either ORGANON or CACTOS format. In addition, the default output file provides a stand summary by species, and summary statistics: stand basal area, quadratic mean diameter, crown competition factor, and stand density index. Output may be directed to a file, the screen, or a printer and may be generated at any point in the simulation.

1. INTRODUCTION

SYSTUM-1 Version 2.0 was developed for the purpose of simulating growth of young stands in southern Oregon and northern California up to a point where established-stand models may be employed to carry simulations forward for long term projections. Currently, models such as CACTOS (Wensel and others 1986) or ORGANON (Hann and others 1993) cannot simulate the growth of young plantations in competition with non-tree vegetation.

The model is an individual-tree based simulator which also incorporates the effects of competing vegetation in stand development. The simulator was originally intended for stands between the ages of 3 and 20, although there are no specific age constraints in the simulator. SYSTUM-1 will, in theory, work for both even- and uneven-aged stands. The simulator is intended for use in northern California and southwest Oregon plantations. Primary tree species included in the simulator are: Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), incense-cedar (*Libocedrus decurrens*), white fir (*Abies concolor*), sugar pine (*Pinus lambertiana*).

This manual is a guide to the execution of SYSTUM-1, Version 2.0. SYSTUM-1 is an interactive computer program written in standard FORTRAN 77 code for the PC environment. The code was compiled using the Microsoft FORTRAN compiler, version 4.01.

1.1 Hardware and Operating System Requirements

The simulator was developed for execution on IBM-PC compatible computers.[1] The simulator's operating system requirement is DOS 3.0 (or later version) and at least 400 Kilobytes (K) of free memory for execution. Note that for all descriptions of DOS directives in this document, all keyboard entries are displayed in **bold type**. DOS and SYSTUM-1 commands are executed by hitting a carriage return, which is designated as ← Enter. Often, SYSTUM-1 will prompt users for a one- or two-letter command in response to a menu. Example responses will be shown as a letter, or letters, in a frame, such as: A ←Enter. You should familiarize yourself with directory structures, file naming conventions and the rudimentary DOS commands such as COPY, CD, and DIR before proceeding with installation and execution of the simulator.

SYSTUM-1 will operate under Microsoft Windows 3.1. Execution under Windows is explained in more detail later.

Because tree and stand level data are maintained in memory for the duration of the simulation, most file input and output (I/O) operations occur when the simulation is started, and when output is routed to a file. There will be a disk access every time the simulator executes a growth directive or some management option. Approximately 400 K is required beyond that used by the operating system and any memory resident (TSR) programs. The two executable files (SYSTUM.EXE and SYSMAK.EXE) will occupy 378 K of disk space. There are also a few small data files which occupy less than 5 K of disk space.

A math coprocessor will speed execution substantially, but it is not required. File I/O, and hence execution speed, is greatly enhanced if the program is executed from a hard disk. Execution speed may be boosted further by reading input from and writing output to a RAM disk. A RAM disk is a section of computer memory that DOS treats as an additional physical disk drive. Of course, since the RAM disk is volatile, caution must be exercised to ensure that vital data is not lost due to a power surge or computer crash requiring a re-boot. If a number of runs are to be made, it is wise to save all output files to a hard disk.

[1] Trade names and commercial products or enterprises are mentioned solely for information. No endorsement by the U.S. Department of Agriculture is implied.

1.2 Interface with ORGANON and CACTOS

One of the primary objectives of this modeling effort was to provide a link with the existing simulators: ORGANON (Hann and others 1993) or the PC version of CACTOS (Wensel and others 1986). Throughout this manual, we will be referring to Edition 4.0 of the Southwest Oregon Version of ORGANON and version 3.3 of CACTUS. There is, however, a more recent version of CACTOS (V 5.0); the reference in Wensel and others (1986) is 3.3.

The "interface" with these other simulators is very simple. SYSTUM-1 merely provides the user with data output for some projected stand/tree conditions written in a format which is consistent with the requirements of ORGANON or CACTOS. You may find discontinuity in the growth projections at the point of transition between simulators. In the current version of SYSTUM-1, Prognosis (Wykoff, and others 1982; Wykoff 1986) formatted files are not included among the simulator output options. At the time this version was developed, Prognosis was not yet available on a PC. However, ORGANON format output can be modified to fit the Prognosis input requirements.

1.3 Overview

The simulator has four different "modes" of operation (*figure 1*). *Data input* includes the input of information on competing vegetation and stand level data. *Data management* includes viewing and manipulation of data. The third mode is that which allows changing of *toggle defaults*. *Execution* includes growth, output, and management options. Although the arrows in *figure 1* show a forward progression through the different modes, it is possible, in many instances, to "back up," as will be discussed later in this manual (Section 4.1.5). The simulator was designed to be operated interactively. However, it is possible to define a "batch" runstream by means of a separate program called SYSMAK. This runstream can be redirected to the simulator, thereby bypassing the need for interactive operation.

Growth is simulated via a number of functions which operate on the tree list stored in memory to update the elements in the tree list over time. Tree growth is a function of site quality (site index), tree size, inter-tree competition and competition from non-tree vegetation. Mortality is simulated by means of a size-density approach to a maximum stand density index (Reineke 1933).

Competing vegetation functions predict levels of cover and average height for each species over time. Competing vegetation functions act on plot level aggregates by species, not individual plants.

Output is limited primarily to data which may be input into CACTOS or ORGANON. It was not our intent to predict volumes over time and there are no volume estimation routines in the simulator. That is left to other simulators. Pre-commercial thinnings may be simulated along with the removal of competing vegetation.

2. PROGRAM SETUP AND EXECUTION

SYSTUM-1 comes on one 360 K floppy 5.25-inch disk, although 3.5-inch disks are available from the Pacific Southwest Research Station in Redding. The executable files have been compressed and therefore must be uncompressed before execution. This is taken care of automatically by the installation routine described below. The disk is the place where your copy of the simulator will reside. Once executed, the instructions are copied into memory. From that point on, disk access is limited to file read and write instructions in the simulator.

2.1 Installation

In order to execute SYSTUM-1 on a computer with a hard disk, a new utility has been provided to take care of installation of the program. This utility, called INSTALL, will first unpack the two executable files, then copy them to the hard disk. If a directory has not been created, the installation program will establish the designated directory. The program is straightforward; at each step you will be prompted for information about the installation. The utility will also check the version of DOS and check for sufficient memory to execute the

program and the presence of a math coprocessor. Installation is executed with the following steps:

1. Place the SYSTUM-1 disk in drive A:,
2. Make A: the current drive (type **A:** ←Enter),
3. Type **INSTALL** ←Enter.

This installation routine will provide you with an option of partial or complete installation. Complete installation will uncompress and copy two executable files (SYSTUM.EXE and SYSMAK.EXE) into the default directory, as well as example data files. Since these two files are now compressed they cannot be copied to disk with a DOS copy command; the installation routine must be used. The resulting installed files will take about 378 K of disk space.

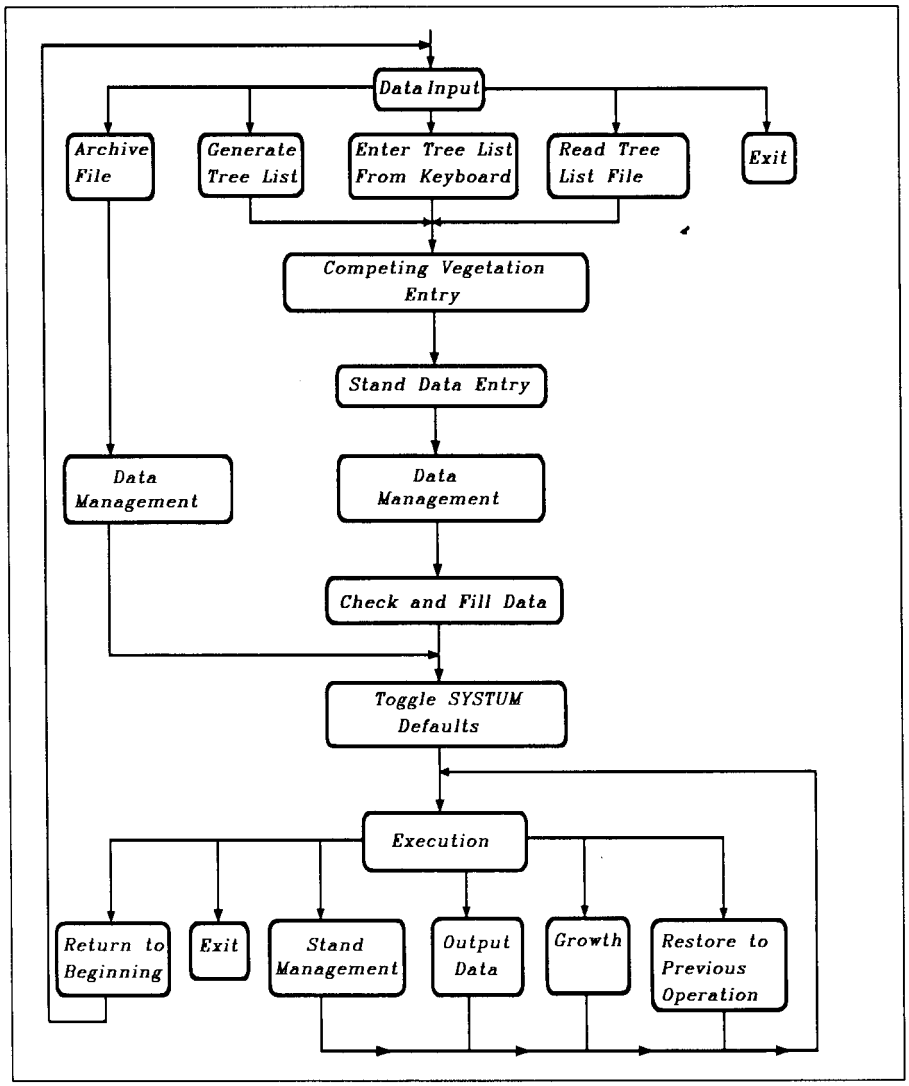

Figure 1 - *A flow diagram for SYSTUM-1*

If the simulator is to be executed from any directory other than that where the simulator is residing, the path statement must be appended. The path statement may be entered at the DOS prompt; however, the path statement is usually found in your AUTOEXEC.BAT file and this can be appended by editing the AUTOEXEC.BAT file. The DOS reference guide contains information on modifying the path and AUTOEXEC.BAT files. However, one option of the installation utility is to handle the modification of the path statement in AUTOEXEC.BAT for you. If the path statement is changed in the AUTOEXEC.BAT file, the

computer must be re-booted before these changes take effect.

The installation utility default operates under the assumption that your hard disk is designated as drive "C," and the drive where the files will be located is \SYSTUM. If you wish to load onto another drive or directory, these changes are easily accomplished in the installation process. During installation you are queried whether files other than the executable SYSTUM-1 file and the SYSMAK utility should be in the same drive and directory. The default is all files in the same directory.

Once the files are copied onto the disk, the simulator may be executed by typing **SYSTUM** ← Enter at the DOS prompt. In response to this command the computer will search for a file called SYSTUM.EXE. This file contains the executable instructions, and it will be recognized as an executable file by virtue of the .EXE extension. If the path has been appended, this command may be entered from any directory. If the path has not been appended, then you must first make the SYSTUM directory the default. If the computer is able to locate the file, SYSTUM-1 will begin execution. You may then proceed interactively with the simulator. Several menus provide the option of terminating execution and returning to DOS. However, you may also exit at any time by responding to any prompt with a Ctrl C (holding down the "control" key and pressing "C").

The installation program will copy a program information file (SYSTUM2.PIF) and an icon file (SYSTUM.ICO). These files are necessary for operation under Microsoft Windows. If your computer does not have Windows, these files may be deleted. To install for operation under Windows, click on File then New, then select Program Item. In the box that follows you will fill in Description, Command Line, and Working Directory fields:

Description: **SYSTUM**
Command Line: **C:\SYSTUM\SYSTUM2.PIF**
Working Directory: **C:\SYSTUM.**

If you have chosen to install the simulator into some other directory or on a drive other than C:, these fields should be modified appropriately. Finally, select the Change Icon button and fill in:

C:\SYSTUM\SYSTUM.ICO

in the file field presented. Then click on one of the icons presented. After exiting this operation, the icon should be present in the selected program group and you may start SYSTUM-1 by double-clicking on the SYSTUM icon. The SYSTUM window will be closed upon normal termination of the simulator.

The PIF editor provided by Microsoft Windows may be used to edit SYSTUM.PIF if for some reason this file is not appropriate for your hardware. Consult your Windows manual for instructions on PIF' editing.

2.2 File Input/Output Conventions

The simulator provides you with the opportunity to print output on several different devices. SYSTUM-1 output files may have any legal name under the DOS operating system. Other growth simulators have additional name limitations, so when creating a file for entry directly into CACTOS or ORGANON you should be aware of any file name limitations or requirements imposed by these programs. ORGANON requires that a tree file have no extension (Hann and others 1993). CACTOS uses the extension ".sd" for stand description files (Wensel and others 1986).

Be careful, however, not to put any spaces in the middle of a file designated to receive simulator output. Doing so will cause this simulator (and some others) to output data to a file under the specified name with blanks; however, you will not be able to access these files with DOS commands.

Data input files may be created in a text editor (or word processing program) for entry into this program, provided that the file created is an ASCII file. Any data entered in this way must contain only one record per line. For example, each tree in a tree list file should be a separate line. Competing vegetation data should have one plot per line.

Some input files are free format, others are fixed format. By free format, we mean that the individual data items for a given line are free to be located in any field so long as they are in the proper order and separated by spaces or commas. Fixed format files must have data items residing in fixed, pre-specified fields for each line of the file. The CACTOS and ORGANON files are fixed format.

All information needed by the simulator can be entered from the keyboard at run time. Although run-

time keyboard entry may be convenient for the novice computer user, experienced users will find the technique tedious. We recommend that you employ some other editing/word processing software for file creation and data entry.

3. DATA REQUIREMENTS

The simulator requires two primary sources of data. The first is a tree list. The second is the plot competing vegetation data. It is imperative that you understand that SYSTUM-1 requires tree input which represents some statistically valid sample from an area of interest or aggregation of trees which is normally referred to as a "stand." These trees will normally be selected from one or more plots located within the stand. In young stands, these plots are usually some small fixed area sample (say 0.004 acre). If all trees from a given plot are included in the sample, then the expansion factor, which is the number of trees represented by a given sample tree, will be the inverse of plot area (250 in this example).

SYSTUM-1 will accept data for a maximum of 600 tree records and 120 plots in any given data file in version 2.0. The tree data may be input from an ASCII file or from the keyboard.

3.1 Tree Data

The tree list includes plot number, species code, diameter at breast height (DBH) (inches), height (feet), crown ratio, expansion factor (trees per acre), and past annual height increment. While it is best if all of these variables are measured, SYSTUM-1 can fill in missing values for some of the variables. Four are required: plot number, species code, tree height, and expansion factor. Measurement of DBH on all sample trees taller than 4.5 feet is strongly recommended in order to obtain reliable projections of growth. Because of a lack of data for crown dynamics, the simulator does not rely on crown measurements as direct input to growth equations. For most young stands, live crown ratio will be at or near 1.0. Crown differentiation is a characteristic which develops in stands more mature than those intended for this simulator.

In order to accommodate users who are accustomed to a given file format and to avoid problems with mixing file formats for input and output, SYSTUM was designed to accept input of several different formats. You have the option of choosing the format which you are most familiar with. These formats are CACTOS, ORGANON, and free format. For first-time data entry, the ORGANON format is probably the easiest to use because it is a fixed format file with no concomitant information. Because it is a fixed format, fields for which values are missing should be left blank. This type of file should not have missing value indicators.

Yet another format referred to herein is an archive file format. Archive files are created by SYSTUM-1 for repeat runs on the same data set. Since they are created by the simulator, they obviously cannot be used for the first run on a given data set. Archive files have all information on tree and competing vegetation incorporated into one file. Formats for the various SYSTUM-1 read and write files are described in *appendix A.*

3.1.1 ORGANON Format

ORGANON input format is described on page 7 of the ORGANON user's guide (Hann and others 1993). We use the ORGANON format somewhat loosely here because we do not accept or use past radial growth input. Missing values should be denoted by no value (blank spaces) with this format, and the species codes should be the same as those used in ORGANON (*e.g.* 202 = Douglas-fir, 122 = ponderosa pine). One minor difference is that SYSTUM-1 will accept Jeffrey pine (116), whereas ORGANON will not. Therefore, one may input an ORGANON format tree list with Jeffrey pine; however, on output in the ORGANON format, these will be converted to 122 (ponderosa pine) because edition 4.0 of the Southwest Oregon Version of ORGANON will not accept the 116 code.

Unstocked plots should be represented by one line with the plot number and a species code of 0 and an expansion factor of 0. The rest of the fields should be blank. Unstocked plots should be maintained in the data set. Elimination of these plots will produce biased estimates of stand level variables such as basal area or trees per acre.

3.1.2 CACTOS Format

Data in the CACTOS format may be used as input into SYSTUM-1. The ASCII format for the CACTOS file is described by Wensel and others (1986) and is the format for the stand description files which typically have the ".sd" extension. CACTOS is structured in such a way that individual plots within an ".sd" file are not distinguishable. This is contrary to the way in which SYSTUM-1 is structured. Therefore, to read data under the CACTOS ".sd" format, plots must be processed separately as "stands", or aggregated into one stand file with the appropriate adjustment to the expansion factors.

3.1.3 Free Format

The free format file is specific to this simulator. This file contains all the Tree List information (in a form similar to that used in ORGANON) but does not require the data to be aligned in specific columns. The information must be entered in the order specified, with one tree per line. However, it is not important which columns hold given values. Missing or unknown values (other than past annual height increment) must be specified as a "-1". Past annual height increment (in feet and tenths) is the last item on each line and may be left out of the file altogether.

To create a free format data file, first enter a text editor or word processor. Again, care must be taken to produce an ASCII file. On the first line of the document, type the values for the first tree in this order: plot number, species code, DBH (inches), total height (feet), crown ratio, expansion factor (trees per acre), and past annual height increment (feet). If DBH or crown ratio is missing, type in a "-1". Each of these items on a line should be separated by commas or by one or more blank spaces. Each line will then have six data items (seven if past annual height increment is recorded). On the second line, type the information for a second tree, continuing in this manner with one line for each tree.

An unstocked plot (one with no trees) should be indicated as such with the appropriate plot number followed by "NS" (not stocked) for the species, then missing value indicators (-1) for DBH, height and crown ratio, and a zero for number of trees per acre. Unstocked plots should not be left out of the file. An example of this is shown in the free format file example in *appendix Al.* This example has a plot number 8 with no trees.

3.1.4 Keyboard Entry

Yet another means of providing input to the simulator is through keyboard input from within the simulator. If you are unfamiliar with text editors you may prefer this method. The simulator will prompt you for all the tree-list data. You may then input directly from field sheets into the simulator. In the long run, you will likely find that this method of data entry is extremely slow because the simulator will prompt for each data entry item.

Missing values are indicated by simply skipping over the item at the prompt (←Enter). If the item is not one which may be missing (such as species), the simulator will alert you and ask for input again.

3.1.5 Data Generation

Tree lists can be generated for 3-year-old plantations from site information (slope, elevation, and aspect) or for any age plantation with information on average tree heights for each species. We strongly recommend sampling existing stands in order to execute SYSTUM-1. These data generation routines allow you to evaluate the simulator's performance under a variety of situations quickly and at little expense. If you decide to generate a tree list, we suggest the use of the tree list recovery system in which a list is recovered from a mean and standard deviation (or range) of heights (the A directive shown in *figure 2*).

You will be able to create as many trees on as many plots as desired. Few restrictions are placed on you here. It is relatively easy to generate ridiculous looking stands of trees. Use caution in executing the simulator with a generated list of trees. SYSTUM-1 operates under the assumption that you are experienced with young stands and their development. The main screen for generating a tree list is shown in *figure 2.*

Three-year-old stands are generated using a regression equation to predict an average height for a particular species. As many trees as specified are randomly generated around this predicted mean. If average tree height data is known (i.e. mean and standard deviation of heights, or the range of heights), then individual tree data can be generated from this information by making use of quasi-normal deviates. If a tree list is to be

generated, we recommend use of the average height method. The data used in development of the regression model were quite limited.

Competing vegetation cover and height may be estimated as well. Presence of individual species cannot be predicted; they must be specified. If cover and height are entered as missing, the simulator will attempt to predict values based on age and site index.

```
ENTER ON ONE LINE:

Type of Generator, Plot Number, Two Letter
Species Code, Number of Trees to Generate, and
Trees Per Acre for that Species on this plot.

Generator Types:
                R --> Generate Trees from [R]EGRESSION MODEL
                A --> Generate Trees from [A]VERAGE HEIGHT

Enter ? for Species Information
   For example: To use the REGRESSION MODEL to generate
PONDEROSA PINE for plot 5 with 400 TPA
type: R 5 PP 25 400
    ENTER Tree Generator Information
(or ?, or <CR> to stop) : _
```

Figure 2 - *Computer-generated tree list menu in SYSTUM-1, Version 2.0*

3.1.6 Unstocked Plots

The simulator allows input of plots which are unstocked. If a given plot has no trees, it should be represented by one line. In the free format file, the line would have a species designated as "NS," for "not stocked." Plots without any trees will obviously lower stocking estimates produced by the simulator in stand summary output. All measures of stand density are calculated with the unstocked plots included in the calculation. Therefore trees per acre represents a stand average value. The number of trees per acre for stocked plots may be obtained by adjusting for the number of plots with no trees.

3.2 Competing Vegetation Data

Competing vegetation data is entered in a manner similar to that used in free format tree input. The values need not be aligned into specific columns, and all values must be separated by at least one space or a comma. The data for a single plot goes onto a single line. Each plot can have up to six separate species with their associated coverage and average height for the plot. All species are entered as one of the four-letter species codes (*appendix B1*). The format for a given plot is as follows: The first data item on the line should be the plot number; this number should be unique for a given run (no two plots with the same number). The next data items are the four-letter species code, percent cover and height for the first (primary) species on that plot. These should be followed by species code, cover, and height for the second species on the plot, if present, and so on up to the sixth species on the plot. Enter only as many sets of species as needed. For example, if there are only two species recorded for the plot, type in plot number and the information for these two species and nothing more on that line. If the plot has no competing vegetation present, type a plot number only.

If plot data are entered from a file, only those plots appearing in the tree list will be loaded into memory. Those not in the tree list will be ignored. If a plot appears more than once in a file, then the data from the last occurrence of the plot number will be used by the simulator.

3.3 Site Productivity

Site productivity is reflected by site index. The site index used for ponderosa pine is by Powers and Oliver (1978) and for Douglas-fir and other species, a parametrization [SIC] of the Dunning and Reineke (1933). The choice of a curve for Douglas-fir was based on the observation that the Hann and Scrivani (1987) curves for Douglas-fir were almost identical to the Dunning and Reineke curves after adjusting for the difference between base age. Note that both the Powers and Oliver and Dunning and Reineke curves are based on total age. Site indices based on total age are more readily applicable to very small trees (those less than 4.5 feet tall).

3.4 Combined Input: Archive Files

SYSTUM-1 has the capability of producing archive files in a format which can be easily read by the simulator. The archive file is an ASCII file with all information on competing vegetation integrated with the tree list, which speeds the data entry phase of model execution by reading all information in one step. Archive files may be read by the simulator using the "A" option of the input menu. The option of creating an archive file is provided before the main menu is displayed (section 4.1.6). Thereafter, an archive file may be produced by selecting the appropriate directive in the output menu (section 4.1.6b).

4. MODEL EXECUTION

4.1 Interactive Execution

This simulator was designed to be executed in an interactive mode. An interactive simulator gives you flexibility in designating options for individual projections for any given stand. However, interactive execution is slow and may not be expedient for experienced users who are making projections for many stands, for which the run options are well defined in advance.

The first screen displayed by the simulator is the opening banner which contains the version number and the date the program was compiled. The version number is also displayed at the top of the table with the default stand summary information.

There are four phases of operation, in SYSTUM-1. Below, each phase is defined and discussed in chronological order.

4.1.1 Data Entry

The first query prompts you for the file which will contain the run summary.

Enter name for run summary file: **FILE.EXT** ← Enter

The file **FILE.EXT** will be opened by SYSTUM-1 to contain all information about the current run. The file will be closed upon exit from the simulator back to DOS. If no path is provided, the file will reside in the current directory (that directory which was active when the simulator command was entered). If the file already exists, you will be asked to choose between writing over the old file, or changing the file name specified.

4.1.1a Tree Input

After establishing a file for the run summary, the simulator will prompt you for an input format for tree data. There are six different methods (formats) for reading tree data. The ORGANON and free format files contain only a tree list, with no concomitant information. The CACTOS and archive files have additional stand information included with the tree list. A tree list is simply a list of all trees sampled with plot number, diameter, height, crown ratio and expansion factor. The menu for the input format is shown in *figure 3.*

```
Enter the method of Tree data input desired

   A  —>[A]rchived data file
   C  —>[C]ACTOS format data file
   O  —>[O]RGANON format data file
   F  —>[F]ree Format data file
   E  —>[E]nter data from the Keyboard
   G  —>[G]enerate a Tree List
   X  —>e[X]it the program

Enter A, C, O, F , E, G, or X:
```

Figure 3 - *Tree data input menu for SYSTUM-1, version 2.0*

The Menu directive is selected by specifying one of the six input specifiers or an "X" to return to the operating system.

A: [A]rchived Data File
File created by this program from the output section. Tree and competing vegetation data are stored in this file along with some stand characteristics. This file can be edited or changed in the Data Management Section of SYSTUM-1; see *appendix A2* for detailed description.

C: [C]ACTOS Format Data File
File in the form of the stand description file used for CACTOS. CACTOS works on one plot per run; SYSTUM allows more than one plot to describe the stand. To enter several plots for a run, put every plot in one file, one plot following another. This has the form of several stand description files in a list. See *appendix A3* for detailed description.

0: [O]RGANON Format Data File
This is a file in the form of the ORGANON Tree List. ORGANON does not require an expansion factor in the data file because ORGANON provides you with the opportunity to describe the sampling scheme. However, SYSTUM-1 does require you to provide expansion factors directly. For description of the format, refer to *appendix A4.*

F: [F]ree Format Data File
This is a file that does not have data displayed in fixed columns but contains data items in the order of plot number, species code, DBH, total height, crown ratio, and expansion factor, periodic annual height increment (optional). Items should be separated by at least one space or comma. If DBH or crown ratio is not known, a value of -1 must be entered. Species codes are the two-letter codes or the numerical codes used by this simulator (see *appendix B2*). Past annual height increments can be entered after the expansion factor for trees where known. If more than seven trees of a species in the list have this height information, a calibration factor is calculated which can be used when growing trees. Plots need not be in sequential order; however, trees should be grouped by plot number.

E: [E]nter Data From the Keyboard
You will be asked for one tree record at a time and will be prompted for the data. The tree record will be displayed as data are entered. Enter as many trees as desired up to the simulator maximum. This input option is very slow and, for this reason, is not intended for routine use.

G: [G]enerate a Tree List
You can, with this option, generate a hypothetical 3-year-old stand of trees with predictive equations or with user-defined height ranges and (or) mean and variance. You generate a specified number of trees of any allowable species on a specified plot. Also needed is the number of trees per

acre for the species on the plot. Several different species may be generated on a given plot. If predictive equations are used under the "R" option (below), stand age is set to 3 and the average elevation, slope, and aspect for the plot must be specified.

X: e[X]it
This directive closes all files and returns operation to the DOS operating system.

4.1.1b Competing Vegetation Input

You will be prompted to specify the means of data entry for competing vegetation (*figure 4*) and will be provided three options for input of competing vegetation data. The first is to provide stand averages for each species from the keyboard. Providing stand averages implies that competing vegetation is the same on all plots in the stand and will mask some between-plot variability that one would normally find in the simulation. The second input option is to specify a competing vegetation file which contains species averages on a plot-by-plot basis. The file format for competing vegetation is described in *appendix A5.* The third option is to provide plot-level (as opposed to stand-level) species averages from the keyboard. This third option is simply the interactive input of the same data one would find in a competing vegetation file. Even if there is no competing vegetation, this must be so specified using one of the three input options for vegetation.

```
Competing Vegetation information will be entered:
    [S]  for the whole [S]tand from the keyboard
    [F]  for plots from a [F]ile
    [K]  for plots from the [K]eyboard

ENTER   S, F, K, or <CR> to return:
```

Figure 4 - *Menu for entry of competing vegetation data in SYSTUM-1, version 2.0*

S: for the whole Stand from the keyboard
You will be prompted for species, percent cover, and height for up to six separate species. If you enter NONE or ← Enter for any species code, all the percent cover and heights for that and any following species will be set to zero, and species will be listed as NONE. The same set of species will be stored for every plot in the tree list.

F: for plots from a [F]ile
You will be prompted for a file name that contains the competing vegetation data. This file must have data for each plot on a separate line in the sequence: plot number, species 1, percent cover 1, height 1, ..., species 6, percent cover 6, height 6. Up to six species may be entered. If no vegetation data is being entered for a plot, then only the plot number should be on the line. Percent cover and height are optional. If they are not entered, a -1 must be entered instead. For an example of this type of data file, see *appendix A5.*

K: for Plots from the [K]eyboard
You will be prompted for competing vegetation data for each plot, one plot at a time (*figure 5*). You then enter the data as requested. If no competing vegetation exists, or when the last recorded species has been entered, entering "NONE" or a ← Enter will cause all following values for a plot to be zero and will prompt for the next plot if there is one. Note that when entering vegetation data, the species, percent cover, and height all are entered on one line. Respond to the prompt in *figure 5* by entering a line with three data items, separated by spaces or commas: species, percent cover, and height. This is done for each of up to six species on a plot.

```
Data are allowed for up to six Species per Plot.
  Enter missing data as -1 and a <CR> to finish
  entry on a Plot.

Plot Number          1.0

 Species   %Cover     Height
NONE                0.        .0
NONE                0.        .0
NONE                0.        .0
NONE                0.        .0
NONE                0.        .0
NONE                0.        .0

 Input Species 1, % Cover 1, and Height 1
  (enter ? for Species list, - to backup):
```

Figure 5 - *Keyboard entry screen for competing vegetation data in SYSTUM-1, version 2.0*

4.1.1c Input of Stand Level Data

Stand level data include stand age, stand site class, and age of the competing vegetation. These data are requested (*figure 6*) unless you are using an archive file (because archive files already have this information). Stand age is used for description only. Age of the competing vegetation is used to calculate missing competing vegetation cover or height. In most instances age of the competing vegetation should be the same as stand age.

Site index values should refer to the Powers and Oliver site index (Powers and Oliver 1978) for ponderosa pine, or to the Dunning and Reineke site index (1933) for sites occupied predominantly by Douglas-fir or other conifers. The simulator will also accept broad site class specification of "L" for low, "M" for medium, and "H" for high. Site class values are also based on Powers and Oliver (1978). A low site index is approximately 50, medium about 80, and high about 110 (base age 50). When the simulator is initiated, the default value is 80.

```
Current Stand Age:
   Enter the stand Age in years
   ( <CR> to skip, or - to backup):

   Current Stand Site Class:

   Enter the Stand Site Class as L, M, or H
       or the Stand Site Index (40-120)
    ( <CR> to continue, or - to backup)
   Enter site index, L, M, H, <CR> or - :

   Current Competing Vegetation Age:

   Enter the Competing Vegetation Age in Years
   (<CR> to skip, or - to backup):
```

Figure 6 - *Example of screen prompting for stand level data from SYSTUM-1, version 2.0*

4.1.2 Data Management

After data entry is completed, the simulator moves into the data management phase. Here, you have the options of editing data for the tree list, competing vegetation, or growth and mortality adjustments (*figure 7*).

```
        DATA MANAGEMENT MENU

[A]  Edit/View Tree list
[B]  Enter Competing Vegetation
[C]  Edit/View Competing Vegetation Data
[D]  Enter Growth/Mortality Adjustments
[E]  Edit/View Growth Mortality Adjustments
<CR>  Continue
  –   Backup
[X]  eXit

Enter A, B, C, D, E, X, –, or <CR>:_
```

Figure 7 - *Data management screen from SYSTUM-1, version 2.0*

A: Edit/View Tree List
Allows you to display (View) the tree list on the screen, change parts of individual tree records using the change option and the tree number which is seen when viewing the tree list in the screen, add trees to the tree list from the keyboard, delete whole tree records if the record is a duplicate or incorrect.

Screen produced when entering A for data management:

```
Do you want to:
  [V]iew the tree list
  [C]hange the tree list
  [A]dd trees to the tree list
  [D]elete trees from the tree list
  <CR> continue
Enter V, C, A, D, or <CR>:_
```

B. Enter Competing Vegetation
Allows you to enter a new set of competing vegetation data from a file or from the keyboard. These are the same operations as described in the section on competing vegetation entry.

C. Edit/View Competing Vegetation Data
Allows you to display (View) competing vegetation for each plot on the screen or change parts of individual plot records using the change option and the plot "ID Number" seen with the view option. You may also delete plots from the list of plots.

Example of screen produced when responding with C for edit or viewing competing vegetation from the data management menu:

Do you want to:
[V]iew the Competing Vegetation
[C]hange the competing vegetation
<CR> continue
[D]elete a plot record
Enter V, C, D, or <CR> :_

D. Enter Growth/Mortality Adjustments
This feature allows you to enter a set of growth and mortality adjustments for the tree species being used in SYSTUM-1. The simulator asks for the name of the file containing these adjustments. This file can be a free format file and must have at least four values per line separated by spaces or a comma: tree species number, change in growth, change in mortality rate, and species number of height growth model to be used. A fifth optional value on the line is the stand density index (SDI) maximum for the species. The value for species number of the height growth model allows you to select a different species growth model if you think a different model better represents the growth of the species. This option was developed with the minor species in mind for which data may not have been sufficient to develop predictive models. The growth and mortality adjustments stay as specified for the species. Note that all species information here is entered by number codes, not letters. You have the option of creating a file which contains any changes to the growth and mortality adjustments. This option is helpful if one has specified changes which one wishes to maintain for all runs. This file can be created by specifying the factors desired under the "E" option described below and then later directing this output to a file (section 4.1.6b). For reference, see the format in *appendix A6.*

E. Edit/View Growth/Mortality Adjustments
This allows you to display growth and mortality adjustments used for the tree species currently in the simulator, and to edit those values as needed.

The prompt displayed after choosing E for data management:

Do you want to:
[V]iew growth and mortality adjustments
[C]hange growth and mortality adjustments
<CR> continue
Enter V, C, or <CR> :_

Choosing V at this menu will produce a list of growth and mortality information for each species read during data input.

If you choose to view growth and mortality adjustments, you will see on the screen the factors currently in use for each of the species present in the data set (example in *figure 8*).

SPECIES NUMBER	SPECIES CODE	GROWTH ADJST.	MORTALITY ADJST.	GROWTH MODEL	SDI MAX	PAI ADJST.
1	PP	1.000	1.000	PP	499.4	1.000
2	SP	1.000	1.000	SP	530.2	1.000
4	DF	1.000	1.000	DF	530.2	1.000

Figure 8 - *Example of growth/mortality display for SYSTUM-1, Version 2.0*

When you direct the simulator to change a growth/mortality adjustment factor, the simulator prompts you for a species number. In the example above, the response to this prompt must be a 1,

2, or 4 because those are the only species present. The simulator will respond by displaying the critical information for the species selected and prompt you to proceed with the modifications. It is best to first view the mortality adjustments to find the species present. The proper species codes are listed in *appendix B2.* The mortality adjustment factor dictates whether there is any endemic mortality and is bounded by 1.0 and 1.1. The default of 1.0 results in no endemic mortality; the value to the right of the decimal point is the proportional rate of annual mortality. For example, a value of 1.02 directs the simulator to incorporate a 2 percent annual rate of mortality for a given species.

<CR>: Continue
When done with this section, press the enter key or "carriage return" key and proceed with the next section of SYSTUM-1 where SYSTUM defaults are changed.

−: Backup
Moves back to last prompt before this menu, where age of competing vegetation is requested.

X: eXit the simulator
Ends SYSTUM-1 program and returns to the DOS operating system.

4.1.3 Default Toggles

The default toggle section basically allows you to toggle on (or off) any of four different SYSTUM options: mortality, random growth component, competing vegetation growth, and tree growth calibration (*figure 9*). These options remain in effect for the duration of the given run. Upon entry to the simulator, the defaults are all set to ON. Once you proceed beyond this section, it is possible to return, as will be shown in the next section, and make changes to the SYSTUM options. For example, you may turn mortality off by responding with M ←Enter. This will cause mortality to be toggled from ON to OFF (or OFF to ON). Of course, the option can be changed back to its original value. If the random component is "on," you will be asked for a random number seed. The random number seed can be entered and kept the same for repeat runs if necessary. Alternatively, SYSTUM-1 can generate a seed with the date/time functions.

```
Currently ...
   Mortality is turned  ON
   Random Growth component is turned  ON
   Competing Vegetation growth is turned  ON
   Tree Growth Calibration is turned  ON

Do you want to change:
   [M]ortality only
   [R]andom growth component only
   [C]ompeting vegetation growth component only
   [T]ree growth calibration only
   <CR>  change no settings
    −    backup to previous menu

Enter  M,  R,  C,  T,  −,  or <CR>:_
```

Figure 9 - *Menu displaying default toggle options in SYSTUM-1, version 2.0*

M: [M]ortality only
Either turns mortality off, resulting in no mortality in model predictions, or turns mortality on.

R: [R]andom growth component only
If the random growth component is ON, SYSTUM-1 includes a stochastic element in the height predictions. If this option is OFF, then the height predictions are deterministic.

C: [C]ompeting Vegetation Growth component only
Changes the competing vegetation growth switch. If turned OFF, competing vegetation remains static.

T: [T]ree growth calibration only
If ON, this option uses the calibration factor calculated from past periodic height increment. If OFF, prediction equations are employed uncalibrated.

<CR>: change no settings
The ← Enter key alone signifies acceptance of toggles and directs the simulator to proceed to the next phase of execution.

−: backup to the previous menu
Directs the simulator to "back up" to the data management phase of execution.

Changing any of the SYSTUM defaults causes the simulator to return to this menu after the change, so more than one default may be changed, or errors may be corrected. The only way to escape from this menu is "−" or ← Enter. Another option is Ctrl C, which interrupts execution and returns to the operating system.

A random component can be applied to the height growth functions. This random variable increases the differentiation among the trees so that there is an increase in the range of tree heights as the stand ages. Without the random component, variability in tree size will remain fairly constant.

The random component of the simulator depends on "random" numbers generated by the program for use in the simulator. These numbers can be thought of as a list more than 30 million numbers in length. A random number seed defines the starting place in the list. In the simulator, a random number seed can be specified which allows separate runs to be affected by the same set of random variates [SIC] in the random component. If the same seed number is used in two separate runs, the same sequence of random numbers and components is generated. If no seed is specified, the simulator will generate one as a function of the current time and date in the computer memory. You will not obtain the same results for two identical runs unless either the random feature is toggled off, or identical seeds are used.

If the toggle is left on, you will be queried for a random number seed (see prompt below). If a carriage return is chosen, the simulator will write out the chosen random number seed in the default output file.

Enter an ODD random number seed,
or <CR> to let the machine pick one
(or - to backup to the previous menu):_

An even-numbered seed will be changed by the simulator to an adjacent odd number. The dash, or minus sign, followed by a carriage return will return the simulator back to the toggles menu. The simulator will proceed to the archive prompt after the random number seed is input.

4.1.4 Archiving Data

After SYSTUM defaults are changed, the simulator provides the option of creating an archive file, which will contain all current tree, plot, and stand data. Archive files are ASCII files that contain all the information necessary for execution. In order to create an archive file, you must provide a file name. There are no constraining naming conventions other than those required by DOS. The file can be located in any directory other than the default directory by including the desired path in the file specification. These files can also be created from the output section of the simulator (section 4.1.6b). You should create an archive file if there is

any possibility that the data will be processed through the simulator more than once. An archive file speeds execution by allowing you to bypass some of the data entry steps.

Archive files contain the current maximum SDI values. Therefore, archive files will override any existing default values in SYSTUM-1 which have been changed. That is, if your archive file was created with an earlier version of SYSTUM-1, the maximum SDI values in this file will override those defaults in Version 2.0.

4.1.5 Backtracking the Simulator

Many pf the menus in SYSTUM include the "–" directive. Whenever this is selected, the simulator will proceed to the section which logically precedes the current menu. This allows you the flexibility of "backing up" to correct errors that may have been made in the data entry or management phase. For example, you may return to the default toggles menu from the main menu at any time when the "–" directive is chosen. Use caution with this directive, as it may be possible for you to direct the simulator to manipulate the data in ways that are not logical, particularly with regard to stand age.

4.1.6 Main Menu

The heart of the simulator is accessed from the main menu. From this menu you direct SYSTUM-1 to simulate growth or management of the stand, as well as output information in any one of several types of output. An example of the main menu appears in *figure 10.* In this example, the current stand age is 3, and the simulator has been directed to enter the growth module with a 2-year increment. The default for years to grow is zero.

```
Current stand age:        3
Current years to grow:    2

OPTIONS:
          I  —>  enter growth [I]nterval for trees
          O  —>  [O]utput data
          M  —>  stand [M]anagement options
          G  —>  [G]row the trees
          R  —>  [R]estore stand to values before last mgmt. or growth
          –  —>  backup to previous menu
          S  —>  return to the [S]tart of the simulator
          X  —>  e[X]it program
                       Enter I, O, M, G, –, R, or X:_
```

Figure 10 - *Example of main menu for SYSTUM-1, Version 2.0*

I: enter growth [I]nterval for trees
This option will direct the simulator to request the number of years to grow. This value is the number of one-year growth intervals the simulator executes each time you select the "G" option. After executing the "I" option, the simulator returns to the main menu with the newly specified current years to grow. This value will remain fixed for the remainder of the simulation unless you direct a change with another I ←Enter directive.

O: [O]utput data
Brings up the output menu. From the output menu, you direct output to the screen, file, or printer. The menu is divided into two parts. The first part contains the output format options. The second section contains device options. The output menu requests that you input a two-letter code. The first letter specifies the format, and the second letter specifies the device(s). The output

options are discussed more fully in the section on SYSTUM-1 output (section 4.1.6b).

M: stand [M]anagement options
You can reduce the percent cover of the competing vegetation and simulate thinning. The competing vegetation option displays the current competing vegetation summary and then prompts for the competing vegetation level remaining after treatment. Several different thinning options may be applied by species. The different thinning options are discussed more fully in the section on management (section 4.1.6h).

G: [G]row the trees
This initiates the routines for tree and competing vegetation growth and simulates growth for the number of years specified with the "I" directive. If the growth period has not been changed from the zero default, the "G" directive will have no effect. Summary statistics are written to the default output file only at the end of the projection.

R: [R]estore stand to values before last management or growth
This directive instructs the simulator to restore the values in the simulator to those before the last management or growth directive. Before any management or growth directive, the current stand and tree parameters are stored in an array, thus allowing for one to back up once.

−: backup to previous menu
Changes the simulator menu "back" to the run default toggle menu (section 4.1.3).

S: return to the [S]tart of the simulator
Returns you to the beginning of SYSTUM-1, as if you had just initialized the simulator.

X: e[X]it the program
Ends the simulation program and returns you to the DOS operating system.

The three main topics of interest in the main menu are growth (section 4.1.6a), management (section 4.1.6h), and output (sections 4.1.6b, c, d, e, f, g). Choosing any one of these options will direct the simulator to perform some task and then return to the main menu. In the case of management and output, a series of menus are displayed which query you for specific applications. In both cases, you may back out to the main menu before the final directive is made. For growth there is no means of escape; once a growth sequence is initialized by choosing G ← Enter, the growth projection will continue until current years to grow is reached. Once this growth is reached, the default stand summary (*figure 11*) is written to the default output file and to the screen.

The summaries by species for DBH only reflect those trees that are taller than 4.5 feet. It is, therefore, possible to actually see a decrease in mean diameter over time if a number of trees pass the 4.5 foot threshold at once. These trees may tend to draw down existing mean diameter if there exist some number of larger diameter trees in the sample. The height statistics represent all trees in the sample. The calculation for trees per acre is based on all trees, not just those greater than 4.5 feet tall. This may produce an apparent incompatibility between basal area and trees per acre which is due to the fact that the trees per acre figure used to calculate the stand density index and quadratic mean diameter and basal area may be less than the displayed trees per acre.

Stand ID: 07/30/1993 09:42:08 v 2.0
Run Description: Test of SYSTUM with FREE.DTA

STAND SUMMARY -- at stand age: 18

Tree Data

Species	TPA	Height Avg	Height Range	DBH Avg	DBH Range
Ponderosa Pine	195.	26.3	18.8 - 35.2	6.7	4.2 - 8.7
Sugar Pine	15.	24.3	20.2 - 27.7	6.1	4.8 - 7.1
Incense-cedar	20.	10.0	7.7 - 14.9	2.4	1.5 - 4.3
Douglas-fir	25.	25.6	18.8 - 31.1	5.8	4.5 - 7.2
	255.	24.8		6.3	

SDI: 126.1 QMD: 6.5 Basal Area: 57.9
CCF: 65.6% Crown Closure: 39.7%
Number non-stocked plots: 1 Percentage non-stocked plots: 5.0%

Competing Vegetation Data

Species	Average %Cover	Average Height	Species	Average %Cover	Average Height
ARPA	37.0	3.6	CEVE	10.5	3.4

Total %Cover: 47.5 Overall Average Height: 3.5

Figure 11 - *Example of default screen and file output from SYSTUM-1, Version 2.0. Note that data are contrived to display a range of tree species.*

The default stand summary contains stand level summaries by species for tree DBH (inches), height (feet) and trees per acre on all plots (TPA). In addition, SDI, stand basal area (square feet), quadratic mean diameter (QMD), crown competition factor (CCF) (Krajicek and others 1961), and an estimate of tree crown closure are provided. In addition, this summary records the percentage of plots with no trees. This figure may be used to obtain the average number of trees per acre on those plots which were stocked (TPA_{sk}). The formula for this is:

$$TPA_{sk} = \frac{100 \cdot TPA}{100 - \%unstocked}$$

Also note that the current SYSTUM-1 version number is printed in the upper right-hand corner of the table (*figure 11*).

4.1.6a Growth

In order for the growth directive to execute, you must first change the default number of years to grow from zero to a positive integer. The proper choice of a growth interval depends entirely on your desires for stand summary statistics to be written to the default output, on the timing of desired management directives, and output (if any). If you wish to grow the stand for 15 years and have no interest in intermediate stand conditions, the keystroke sequence:

[I] [← Enter] [1] [5] [← Enter] [G] [← Enter]

will produce a 15-year projection with no intermediate output to the default file. Stand summary statistics at

the end of the 15-year projection are written to the screen default output file. If, on the other hand, you want to view intermediate stand conditions at 5-year intervals, then the following sequence will result in the first 5-year growth interval being simulated appropriately:

I ← Enter 5 ← Enter G ← Enter

The intermediate stand value appears both on the screen and in the default output file. A sample default screen is shown in *figure 11.* The default screen is cleared and main menu returned to the screen after you enter two successive carriage returns. The first carriage return scrolls down the competing vegetation data, and the second clears the screen and displays the menu. After this, the key sequence G ←Enter will result in another 5-year simulation in this example. The growth interval does not need to be re-entered unless you want to change it from the present value.

No restrictions are placed on you with regard to the length of the simulation which can be executed, although the simulator is really intended for stands less than 20 years of age.

4.1.6b Output

The output menu can be reached by typing O ←Enter from the main menu (*figure 10*). The resulting output menu is shown in *figure 12.* The output menu contains options for directing the simulator to output an ORGANON- or CACTOS-formatted tree list, archive files, competing vegetation data files, growth or mortality adjustment files, summary stand data, or graphs. The chosen output may be directed to the screen, a file, or the printer, or any combination of the three.

In response to this menu, you will input two letters with a space in between (e.g., S SPACE S ←Enter will result in stand summary information directed to the screen).

4.1.6c Default Output

The current stand level status is displayed with the S directive. This will reproduce the default output on the specified device(s). Essentially the simulator will, by default, execute an "S F" and direct the output to the default file each time you execute either a "G," "0," or "M" directive from the main menu.

The simulator will also output other information to the default file, including a description of all files created during the simulation. The simulator will also make a note in the default file of any thinning or treatment of competing vegetation.

4.1.6.d Tree List Output

Tree list files may be created in either of two formats: ORGANON or CACTOS. The ORGANON output consists of a tree list formatted in such a way that it can be read as input to ORGANON. ORGANON species codes are listed in *appendix B3.* You are required to specify site index in the ORGANON simulation, as this tree list has no site productivity information.

The CACTOS format file has space for site index as well. You are prompted for the site index value to be used for each species present in the sampled stand. The appropriate site index value must have a base age 50 (breast height age). Site index curves appropriate for the CACTOS simulator have been developed by Biging and Wensel (1985).

As mentioned earlier, archive files may also be produced. However, these are not merely tree lists, because, like the CACTOS file, they contain other information on the stand. Format specifications for these files are provided in *appendix A2.*

```
OUTPUT FORMAT OPTIONS:
  O —> [O]RGANON style tree list
  C —> [C]ACTOS] style tree list
  A —> [A]rchive data file
  V —> competing [V]egetation data file
  M —> growth/[M]ortality adjustment file
  S —> [S]ummary stand data
  G —> [G]raph data
  – —> Backup to previous menu

 OUTPUT DESTINATION OPTIONS:
  F —> output to [F]ile only
  S —> output to [S]creen only
  B —> output to [B]oth file and screen
  P —> output to [P]rinter only
  A —> output to printer [A]nd screen
  D —> output to printer and file
  T —> output to all [T]hree, file, screen and printer
  – —> Backup to previous menu

Enter one letter from each option menu,
 for example; for summary data to a file enter S F
            Options desired: _
```

Figure 12 - *SYSTUM-1, Version 2.0, output menu*

4.1.6e Competing Vegetation Output

Competing vegetation output can be generated at any point in the simulation. The competing vegetation file is an ASCII file, formatted such that each line contains the competing vegetation data for each plot. This file format is described in greater detail in section 3.2. This file can be used to read in data on competing vegetation into the simulator. A sample competing vegetation file is shown in *appendix A5.*

4.1.6f Growth and Mortality Adjustment Output

If you have changed the growth or mortality adjustment factors and wish to use these changes in other simulations, they may be saved to a file. This file will contain adjustment factors for all the species of trees, including those which were not modified. These unchanged species may be removed by editing the file. When SYSTUM-1 reads such a file, any species not present are left at default values. An example of this file is shown in *appendix A6.*

4.1.6g Graphical Output

Graphical output may be made either in the form of a graph or an ASCII file containing the data used to generate a graph. A graph may be created by choosing a directive A through H from the graph menu (*figure 13*). The data used to generate a given graph may be output using directives J through M. The file formats for graphical data (directives J through M) are described in detail in *appendix A7.*

```
Graphs (vs Stand Age):
    A —> Tree Heights for all species
    B —> Stand Average Tree heights
    C —> Tree Diameters for all species
    D —> Stand Average Tree Diameters
    E —> Competing Vegetation Heights for all species
    F —> Stand Average Competing Vegetation Heights
    G —> Competing Vegetation Covers for all species
    H —> Stand Total Competing Vegetation covers

Data (used in graphs):
    J —> Tree Heights for all species
    K —> Tree Diameters for all species
    L —> Competing Vegetation Heights for all species
    M —> Competing Vegetation Covers for all species
  <CR> —> Continue
 Enter A, B, C, D, E, F, G, H, J, K, L, M, or <CR>: _
```

Figure 13 - *Graph option menu for SYSTUM-1, version 2.0*

4.1.6h Management

In the current version of SYSTUM-1, you have the option of thinning or removing competing vegetation from the stand. Management may be simulated by entering [M] [←Enter] in response to the main menu. SYSTUM-1 will respond by displaying a menu of management options (*figure 14*).

For thinning, you will be requested to provide a minimum number of trees per acre in any given plot. This step is included in order to avoid simulating a thinning which ignores varying densities within the stand and this prevents the simulator from reducing the density below the specified minimum on any given plot within the stand. If this particular option seems confusing, it can be nullified by setting the minimum to any arbitrarily small positive number.

There are three different thinning options. These are thinning to a target trees per acre from below, thinning to a target number of trees per acre proportionately, and a diameter based percentage. Thinning from below to a target TPA simply removes trees, starting with the smallest diameter and working upward in the diameter distribution, until the target is reached. The proportional thinning removes trees from the diameter distribution proportional to their frequency until the target is reached. The diameter based percentage thinning routine allows you to specify a lower and upper limit of diameters for the thinning and then linearly interpolates between the percentages specified for removal at each of these limits.

```
Management Options

C —>  control [C]ompeting vegetation
D —>  [D]BH based percentage thinning
T —>  [T]PA based proportional thinning
B —>  TPA based thinning from [B]elow
– —>  backup to previous menu
    Enter C, D, T, B, or –  :_
```

Figure 14 - *Management options menu for SYSTUM-1, version 2.0*

For treatment of competing vegetation, you are prompted to specify species treated and the remaining level of competing vegetation after treatment. As with other management activities, this may be "un-done" by use of the "R" (restore) directive in the main menu.

4.2 Batch Execution

You can use SYSTUM-1 in a non-interactive mode, although the process has changed since early versions of the simulator. Early versions of the simulator employed a different set of executable instructions to process in batch mode. This file, called SYSBAT.EXE, has been eliminated. In the current version, runstream instructions are generated with a program called SYSMAK.EXE. This runstream file is then read into SYSTUM-1 in place of keyboard input, using redirection.

Exercise caution when operating in batch mode. One incorrect command may cause the simulator to do things you never intended. When operating in batch mode, it is imperative that you have correctly specified each element of the simulation. There must be no missing files for input, and output should be directed to new files. We do not recommend trying to overwrite old files in batch mode.

Batch execution may be used to process the data from a number of stands in a similar manner. This can be done by first setting up a run which performs the desired tasks and then using SYSMAK to generate a runstream file for this run. This runstream file may be duplicated, and you may make changes to the runstream file accordingly. Duplicating the runstream file can be dangerous. We suggest that you change only input and output file names in the runstream file. An example of a runstream file is shown in *figure 15*. In this example, the default output file is SUMI.OUT, and an ORGANON format tree list is output to a file called OUTORGI.DAT after a 15-year simulation. The blank lines are not arbitrary, and they should not be altered. Modification of the runstream file can cause some very unwanted results if mistakes are made in the editing of the file.

Changing input and output file names is fairly safe. However, you should ensure that the output file does not already exist in the default (or specified) directory. If a file of that name already exists, the sequence of commands will be misinterpreted by the simulator and the entire run could be suspect.

The example in *figure 15* also illustrates the fact that SYSTUM-1 is not case sensitive. SYSTUM-1 cannot distinguish between upper and lower case letters. SYSMAK will write out either lower- or upper-case letters, as directed. But SYSTUM-1 will ignore case. The only exception to this is the run description (shown on line 6 of *figure 15*) which is duplicated exactly in those instances where it is output.

4.2.1 Batch Runstream Creation with SYSMAK.EXE

A separate program has been developed to create a batch runstream. This program, SYSMAK.EXE, shows many of the same menus used in SYSTUM-1. Many of the menus in SYSMAK do not contain all the options offered in SYSTUM. For example, there is no option for keyboard input in SYSMAK. SYSMAK will create a file which can be redirected (section 4.2.2) as input into SYSTUM-1. To execute the batch runstream utility, type **SYSMAK** at the "C:\" prompt. Then answer the menu prompts just as in SYSTUM-1.

One of the first prompts requests a file name for the batch runstream:

Enter the name for batch run command file:_

You should respond to this prompt with any legal DOS path/filename which will be used to hold the SYSTUM-1 commands. The resulting file is an ASCII file containing the SYSTUM-1 directives that you have specified in SYSMAK.

4.2.2 Redirected Input

Redirection is discussed in detail in the DOS reference guide. Briefly, the computer is directed to read keyboard input from another device. If the answer to the SYSMAK prompt for a batch run command file was RUN.FIL, then the following command at the DOS prompt will result in SYSTUM-1 executing the directives in the file RUN.FIL:

C:\SYSTUM**>SYSTUM <RUN.FIL** ← Enter,

provided RUN.FIL is in the default directory. If you also wish to redirect the screen output to a file called

OUT.FIL, this can be done by executing the command:

C:\SYSTUM>**SYSTUM <RUN.FIL >OUT.FIL** ← Enter,

which will result in the file OUT.FIL being overwritten if it already exists. If you wish to append to an existing file, OUT.FIL, use the following command at the DOS prompt.

C:\SYSTUM>**SYSTUM <RUN.FIL >>OUT.FIL** ← Enter.

Line	SYSTUM-1 directive
1	
2	
3	**>>sum1.out**
4	**a**
5	**data1.sts**
6	**Test of SYSTUM-1 batch execution**
7	
8	**r**
9	
10	
11	
12	**I**
13	**5**
14	**G**
15	
16	
17	**G**
18	
19	
20	**G**
21	
22	
23	**O**
24	**O F**
25	
26	**>>outorg1.dat**
27	**N**
28	**x**

Figure 15 - *Example of SYSMAK, version 2.0, runstream file. Note: line numbers do not appear in the file but are shown here for clarity*

4.2.3 Input Options

The batch input options are slightly different from the options presented in SYSTUM-1. The options menu for SYSMAK tree input is shown in *figure 16.* The options for keyboard input and generating stands are not offered in SYSMAK. It is assumed that you have already prepared the necessary files. For a description of these options, see section 4.1.1a. You will be queried for a file name for the tree list file after responding to the tree input menu. Subsequently, you will be asked to specify a file containing competing vegetation data, unless the archive input format was chosen. This file must be read in even if there is no competing vegetation in the stand. The keyboard input option is not available in SYSMAK. The competing vegetation file must be of the format described in *appendix A5.*

```
Enter the method of Tree data input desired

      A  —>  [A]rchived data file
      C  —>  [C]ACTOS format data file
      O  —>  [O]RGANON format data file
      F  —>  [F]ree Format data file
      X  —>  e[X]it the program

Enter A,  C,  O,  F,  or X:_
```

Figure 16 - *Tree input file menu for SYSMAK, version 2.0*

4.2.4 Main Menu

The main menu in SYSMAK is essentially the same as that in SYSTUM-1, the primary difference being that the current stand age is replaced with number of years grown or simulated. Because SYSMAK never actually reads a data file, it has no access to stand age. You may exit from SYSMAK by entering X ← Enter.

4.2.5 Output Options

The output destination options provided in SYSMAK are slightly different than those presented in SYSTUM-1 (*figure 17*). No screen output option is provided in SYSMAK. The only options provided are for file, printer, or both file and printer output. When executing in batch mode, screen output scrolls by too quickly for you to read. You are not given the option of creating a CACTOS file in the batch mode because SYSTUM-1 must query you for species specific information in order to create the CACTOS file. These queries are dictated by the data at run time.

```
OUTPUT FORMAT OPTIONS:
  O —> [O]RGANON style tree list
  A —> [A]rchive data file
  V —> competing [V]egetation data file
  M —> growth/[M]ortality adjustment file
  S —> [S]ummary stand data
  G —> [G]raph data
  – —> Backup to previous menu

OUTPUT DESTINATION OPTIONS:
  F —>        output to [F]ile only
  P —>        output to [P]rinter only
  D —>        output to printer and file
  – —>        Backup to previous menu

Enter one letter from each option menu,
 for example; for summary data to a file enter S F
          Options desired: _
```

Figure 17 - *Example of output menu from SYSMAK-1 Version 2.0*

If the ORGANON format is chosen, you will be prompted to direct whether the simulator should output crown ratio in the file. If you choose not to output crown ratio in an ORGANON file, the field will be left blank. This option is given so that you may choose between the crown ratio prediction system in ORGANON and that in SYS`TUM-1. If crown ratio is not output, then ORGANON will fill in those values.

Upon exiting from SYSMAK, you will be returned to the DOS prompt, and a runstream file will be written to the appropriate directory (the default directory, if you do not specify one). We recommend that you closely inspect the default output file from the run in order to ensure that the simulator has actually done what you intended in the setup using SYSMAK.

You may encounter error messages when executing either SYSTUM.EXE or SYSMAK.EXE. These are described in *appendix C.*

5. PREDICTIVE FUNCTIONS

5.1 Tree Functions

The simulator contains a suite of functions for predicting tree attributes. The simulator maintains in memory a list of sampled individuals for which key attributes are predicted and updated periodically. We cannot provide reliable confidence limits for these functions. It is incumbent upon users to evaluate the output of the simulator and compare predictions with expected or known stand development.

5.1.1 Height Growth

The height growth function is the driving dynamic component for the simulator. Unique functions have been established for five tree species. The function has three major components. The first is potential growth (ΔPH), which uses the model form employed by Powers and Oliver (1978). The other two components are modifiers of potential height growth, one for inter-tree influence (M_t) and one for competing vegetation influence (M_v,). Annual height increment (ΔH) is predicted by the function:

$$\Delta H = \beta_1 \bullet \Delta PH \bullet M_t \bullet M_v, \qquad [1]$$

where:

$$\Delta PH = [\, S \bullet \beta_2 - \beta_3 \,] \bullet \left\{ 1 - exp^{\left[\beta_4 \bullet (GEA+1)\right]} \right\}^{\beta_5} - H, \qquad [2]$$

$$GEA = (1/\beta_4)\ ln \left\{ 1 - \left(\frac{H}{S \bullet \beta_2 - \beta_3} \right)^{(1/\beta_5)} \right\},$$

S = site index, in feet, at a reference of 50 years total age,
H = current height in feet,
ln = natural logarithm,
exp = base of natural logarithms ($exp \approx 2.71828...$),

$$M_v = exp^{\left\{ \left(\beta_6 + \beta_7 S + \beta_8 S^2 \right) \bullet \sqrt{\%COV} - 0.0001 \bullet (H/BH)^3 \right\}},$$

$$M_t = 1 - 0.8 \bullet exp^{\left\{ \beta_9 CCF^{-1} + \beta_{10} (H/SH)^{\beta_{11}} \right\}},$$

$\%COV$ = competing vegetation percent cover,
BH = competing vegetation mean height,
CCF = crown competition factor,
SH = height of the forty largest trees,
β_i = ith height growth parameter (i=1,2, ...11).

Parameters for these equations are presented in *table 1.*

Table 1 - *Coefficients for the height growth model in SYSTUM-1, version 2.0*

β	Ponderosa pine	Sugar pine	Incense-cedar	Douglas-fir	White fir
1	1.06	1.06	0.8401	1.06	1.06
2	1.88	2.513	1.5	2.513	1.88
3	7.178	0.0	7.178	0.0	7.178
4	-0.025	-0.01449	-0.025	-0.01449	-0.034
5	1.72	1.397	1.72	1.397	2.5
6	-0.3017	-0.2905	-0.2900	-0.2905	-0.3379
7	0.004434	0.004434	0.001905	0.004434	0.004434
8	-0.00001721	-0.00001721	-0.00001860	-0.00001721	-0.00001721
9	-57.44	-57.44	-57.44	-57.44	-57.44
10	-2.208	-2.208	-2.208	-2.208	-2.208
11	3.312	3.312	3.312	3.312	3.312

5.1.2 Height-Diameter Relationship

The height-diameter relationship is based on the relationship between height and diameter for open grown trees. The function used in this simulator is structured such that for trees growing in open conditions, the relationship is nearly linear. This function is:

$$DBH = \left(\alpha_1 + \alpha_2\sqrt{TPA}\right) \bullet (H - 4.5)^{\left(1+\alpha_3 \bullet TPA^{0.25}+\alpha_4 \bullet \sqrt{\%COV}\right)}, \quad [3]$$

where

TPA = Trees per acre,
DBH = Diameter at Breast Height, in inches.
α_i = ith height-diameter parameter for height diameter function.

The diameter function is further constrained by the relationship between height and diameter for open-grown trees (H_o and DBH_o, respectively). This function was obtained from an analysis of open-grown ponderosa pine trees, in which the relationship between H_o and DBH_o was found to be linear:

$DBH_o = 0.4351\ (H_o - 4.5)$.

An estimate of DBH is made for both the starting and ending of the growth interval, and the difference is used as an estimate of diameter growth. Coefficients for this function are in *table 2.*

Table 2 - *Coefficients for the height diameter model in SYSTUM-1, version 2.0*

α	Ponderosa pine	Sugar pine	Incense-cedar	Douglas-fir	White fir
1	0.6245	0.4669	0.2858	0.7078	0.3642
2	0.009054	0.0	0.0	0.0	0.0
3	-0.06923	-0.03281	-0.03443	-0.06923	-0.01212
4	-0.003542	0.0	-0.005973	-0.003542	-0.004878

5.1.3 Crown Ratio

A static crown ratio function is used to update crown ratio annually. Crown ratio is not used in the current version of SYSTUM-1 to predict growth directly. However, crown ratio, and hence crown closure, does affect predicted development of competing vegetation. Crown ratio values may also be written to an output file. The predictive equation for crown ratio (CR) is:

$$CR = H^{\left(\theta_1 \bullet SDI^{\theta_2} + \theta_3 \bullet \sqrt{\%COV \bullet CVH} + \theta_4 \bullet \sqrt{\%COV}\right)}, \quad [4]$$

where

CVH = height of competing vegetation,
SDI = stand density index (Reineke 1933),

θ_i = *i*th parameter estimate for crown ratio.

Crown ratio parameters (θ_1, θ_2, ..., θ_4) are presented in *table 3.*

Table 3 - *Coefficients for the crown ratio model in SYSTUM-1, version 2.0*

θ	Ponderosa pine	Sugar pine	Incense-cedar	Douglas-fir	White fir
1	-0.03606	-0.03606	-0.008749	-0.01083	-0.009207
2	0.25	0.25	0.50	0.25	0.50
3	-0.0007074	-0.0007074	0.0	-0.001017	0.0
4	0.0	0.0	0.0	0.0	-0.002662

5.1.4 Mortality

Because of a lack of observed tree mortality data obtained for this simulator, the only mortality estimation included in the simulator is driven by an equation to predict the approach to the maximum size-density line (Hann and Wang 1990). This equation employs the mortality model originally produced by Smith and Hann (1984). The Hann and Wang application distributes mortality on the basis of an equation for individual tree mortality rates. Since we have no such equation for young trees, the mortality is distributed uniformly across all trees. The zone of imminent mortality is not reached with this system until a relative density (RD) of 0.60:

$$RD = \frac{SDI}{SDI_{\mathrm{m}}},$$

where,

SDI_m. = maximum stand density index.

This *RD* value of 0.6 is based on the suggestion by Long (1985) that self-thinning begins at a relative density of *0.6* for Douglas-fir and ponderosa pine.

Because relative densities greater than 0.6 are unusual for young stands, this threshold is rarely reached by the simulator. No mortality will be predicted for stands with $RD \leq 0.6$. There is no endemic, or background mortality function in the simulator, unless you so specify by changing the mortality adjustment factor. If you do specify a background mortality rate, it will be applied evenly for all associated species.

This system for predicting mortality is quite different from that used in early versions of the simulator in that the threshold for mortality (*RD*=0.6) is lower than that used in earlier versions. The defaults for maximum *SDI* values employed are displayed in *table 4.*

However, you may force a constant background annual mortality on a given species via the mortality adjustment factor. The default for this factor is 1.00, which corresponds to no background mortality. However, the default may be changed to take on any value between 1.00 and 1.10, where 1.10 would result in 10 percent annual mortality for a given species, before any size-density related mortality.

Table 4 - *Default for maximum stand density index values for SYSTUM-1, Version 2.0*

Species Name	Maximum SDI
Ponderosa pine	499
Sugar pine	530
Incense-cedar	530
Douglas-fir	530
White fir	751

5.2 Functions for Competing Vegetation

Competing vegetation is quantified by species, percent cover, and height for each plot. Each plot may have up to six separate species. The simulator will update cover and height annually, if not directed otherwise, by switching off the competing vegetation growth toggle.

5.2.1 Percent Cover

Competing vegetation growth is handled separately for each species, with all species following a general growth equation. The growth equation is the product of two exponential functions: one causes the increase in vegetation cover or height, the second effects the reduction in cover due to crown closure in trees. In this version of the simulator, the coefficients have been estimated graphically by looking at time trends, where they exist, in plantation data on file at the Pacific Southwest Research Station's Silviculture Laboratory in Redding, California.

5.2.2 Height

Height growth is handled in much the same manner as percent cover. Conceptual models have been developed from graphical analysis of limited time-trend data on file at the Station's Silviculture Laboratory in Redding. As with percent cover, this function has an upper asymptote which is dictated by the site index. In general, we found that high sites produce greater cover potential than low sites. These models will also predict increases in height with increases in site index.

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APPENDIX A. FILE FORMATS

Appendix A1 - Free format files

Entries in free format files are in the sequence of plot number, species code, DBH (inches), height (feet), crown ratio (decimal between 0 and 1), expansion factor (trees per acre), and past annual height increment (feet). Past annual height increment can be excluded, as in the example provided below. A "-1" is not necessary for missing past annual height increment because it is the last item in the field. However, for all other data items, "-1" must be used in place of a missing value. Non-stocked plots (those with no trees falling on a given plot) are designated by NS and an expansion factor of 0, as shown in plot 8 in this example. Plots do not have to be in numerical order; however, trees should be grouped within plots.

An example of free format file format for SYSTUM-1, version 2.0, is shown below.

```
1 PP -1  2.2  -1 100
1 PP -1  3.1  -1 100
1 PP -1  4.8  -1 100
5 PP -1  3.8  -1 200
6 PP -1  4.1  -1 100
6 PP -1  2.7  -1 200
2 PP -1  7.4  -1 100
2 PP -1  3.6  -1 100
2 DF -1  6.6  -1 100
2 IC  -1  1.1  -1 100
2 SP -1  2    -1 100
3 IC  -1  1.3  -1 100
3 PP -1  5.2  -1 100
4 PP -1  2.8  -1 100
4 PP -1  3.5  -1 100
14 PP -1 5.7  -1 200
14 PP -1 5.5  -1 100
14 PP -1 6.0  -1 100
15 PP -1 3.0  -1 100
15 IC  -1 .9   -1 100
16 PP -1 4.9  -1 100
16 PP -1 5.3  -1 100
17 PP -1 6.1  -1 100
17 PP -1 4.6  -1 100
17 PP -1 8.0  -1 100
18 PP -1 6    -1 100
18 DF -1 5.3  -1 100
18 PP -1 6.4  -1 100
19 PP -1 4.3  -1 100
19 PP -1 .3   -1 100
8 NS  -1 -1   -1 0
20 PP -1 4.6  -1 100
20 PP -1 2.4  -1 100
```

Appendix A2 - Archive file format

The format used when SYSTUM-1 creates an archive file is shown below. The description below assumes *p* plots and *n* trees. In general, you are not required to manipulate the archive files. The whole purpose of this file is to provide a simpler method of access to the simulator. Once the archive file is created, you simply read the file into the simulator using the "A" directive.

SECTION 1.
Line 1, Stand description:

- Stand name (1:20, Character string)
- Number of plots *p* (22:24, F3.0)
- Number of trees *n* (26:29, F4.0)
- Stand Age (31:33, F3.0)
- Competing vegetation age (35:37, F3.0)
- Site Class (39:41, F3.0)

SECTION 2.
Line 2 - Line *p*+1, Plot data:

- Plot number (1:7, F7.0)
- Plot TPA (8:12, F5.0)
- Combined percent cover for competing vegetation (14:20, F7.2)
- Combined height for competing vegetation (22:29, F7.2)
- Not used in Version 2.0 (31:34, F4.0)
- Trees per plot (36:39, F4.0)
- Elevation (40:44, F5.0)
- Slope (46:49, F4.0)
- Aspect (51:54, F4.0)
- Competing vegetation species 1 (61:63, F3.0)
- Competing vegetation cover 1 (65:70, F6.2)
- Competing vegetation height 1 (72:77, F6.2)
- Competing vegetation species2 (79:81, F3.0)
- Competing vegetation cover 2 (83:88, F6.2)
- Competing vegetation height 2 (90:95, F6.2)
- Competing vegetation species 3 (97:99, F3.0)
- Competing vegetation cover 3 (101:106, F6.2)
- Competing vegetation height 3 (108:113, F6.2)
- Competing vegetation species 4 (115:117, F3.0)
- Competing vegetation cover 4 (119:124, F6.2)
- Competing vegetation height 4 (126:131, F6.2)
- Competing vegetation species 5 (133:135, F3.0)
- Competing vegetation cover 5 (137:142, F6.2)
- Competing vegetation height 5 (144:149)
- Competing vegetation species 6 (151:153)
- Competing vegetation cover 6 (155:160)
- Competing vegetation height 6 (162:167)
- Species 1 code (169:171, F3.0)
- Species 2 code (173:175, F3.0)
- Species 3 code (177:179, F3.0)
- Species 4 code (181:183, F3.0)
- Species 5 code (185:187, F3.0)
- Species 6 code (189:191, F3.0)
- Plot CCF (193:198, F6.1)
- Plot crown closure (200:205, F6.1)
- Old plot CCF (207:214, F8.2)
- Scratch variable (216:223, F8.2)
- Scratch variable (225:232, F8.2)
- Scratch variable (234:241, F8.2)

- Mean tree height for plot (243:241, F6.1)
- Plot tree height standard deviation (250:255, F6.2)
- Plot SDI, prior to last growth (257:262, F6.1)
- Current plot QMD (264:269, F6.1)

SECTION 3. Line p+2 to Line n+p+1
Tree Data:
- Plot number (1:7, F7.0)
- Species code (9:11, F3.0)
- Diameter at breast height (13:17, F5.1)
- Total height (19:23, F5.1)
- Crown ratio (25:29, F5.2)
- Expansion factor (31:36, F6.2)
- Predicted crown ratio (38:42, F5.2)
- Past periodic annual height increment (44:48, F5.2)

SECTION 4. Line n+p+2 to Line n+p+23
Species Data:
- Growth adjustment (1:5, F5.3)
- Mortality adjustment (7:11, F5.3)
- Species number of growth model to use (13:15, F3.0)
- Indicator for species in associated tree data above (1 $\Rightarrow$ in list, 0 otherwise) (17:19, F3.0)
- Stand density index Maximum for species (21:26, F6.1)
- PAI Adjustment (28:32, F5.3)

SECTION 5. Line n+p+24
CACTOS site index vector:
- Site index values for 14 CACTOS species (1:70, 14F5.0)

SECTION 6. Line n+p+25
CACTOS breast height age vector:
- Breast height age values for 14 CACTOS species (1:70, 14F5.0)

Appendix A3 - CACTOS stand description file format

Line 1
- Stand identifier (1:20, A20).
- Tree record count (21:30, I10).

Line 2
- Fifty-year (breast-height age) site index for 14 species of trees (1:70, 14F5.0).

Line 3
- Breast-height ages for the same 14 species in Line 2 (1:70, 14F5.0).

Line 4, 5, ..., n
- Species code (1:8, F8.3)
- DBH (9:16, F8.3)
- Total height (17:24, F8.3)
- Crown ratio (25:32, F8.3)
- Expansion factor (33:40, F8.3)

Appendix A4 - ORGANON file format

The ORGANON file format (listed below) is a fixed format tree list in the order of plot, species code, diameter at breast height, total height, crown ratio, expansion factor (expressed in terms of stems per acre for a given plot within a stand), radial growth, and user code. Refer to the ORGANON user's guide (Hann and others 1993), pages 12-16. The columns holding the given variable are provided, as well as the FORTRAN format specifier. Variables designated with an open circle will be ignored on input to SYSTUM-1 and they will be blank in SYSTUM-1 output.

Crown ratio is an optional output variable in SYSTUM-1. This option is provided because you may prefer to use the ORGANON crown ratio prediction system rather than that in SYSTUM-1. If actual crown ratios were used in the initial file read into SYSTUM-1 and the simulation in SYSTUM-1 is relatively brief, these values should be written out to the ORGANON file. Otherwise it is a judgment call for the user.

- Plot number (1:3, I3)
- Species code (5:7, I3)
- DBH (9:13, F5.1)
- Total height (15:19, F5.1)
- Crown ratio (21:24, F4.2)
- Expansion factor (26:31, F6.1)
- Radial growth (33:37, F5.2)
- User code (39:40, I2)

Appendix A5 - File format for competing vegetation

The competing vegetation file for a given stand must have the same number of lines as plots in the tree list. Even if there is no competing vegetation on a plot, there must be a line in this file corresponding to that plot.

The format for each line in the file is plot number, followed by (for each species on the plot up to six) species 1, percent cover for species 1, total height for species 1, species 2, percent cover for species 2, total height for species 2, ... etc. A plot with no competing vegetation would be represented by a plot number only.

An example of a competing vegetation file is shown below for a stand with 11 plots; plot number 7 has no competing vegetation.

```
1 ARPA  12  2.1
2 CECO  15  1.3  ARPA  5   1.1
3 ARPA  25  1.4
4 ARPA  15  1.8
5 CEC   10  2.1
6 ARPA  15  1.4  FORB  5   1.0
7
8 CECO  15  1.8  FORB  10  1.0
9 ARPA  20  1.3  CECO  15  1.0  RISP  5  1.0
10  CECO 10 1.5
11  ARPA  25 1.5  CECO  10  1.8
```

Appendix A6 - File format for growth and mortality adjustment factor

The growth mortality adjustment file produced by SYSTUM-1 contains 21 lines, one for each species in the species array, even if these species are not present in a given data set. However, if you wish to change fewer species, you may create a free format file with only those species of interest. The data items should be in the same order as shown below, with each data item separated by a comma or one or more spaces. In the example below, the line for species 2 has the stand density index (SDI) maximum reduced to 300. If you wish to leave all other values at the default, all but the second line could be deleted from this file. That is, only those species that are being changed from the default need be in the file. The range of acceptable values for growth adjustment is 0.0 to 2.0. The acceptable range for mortality adjustment is 1.0 to 1.1. The SDI maximum may take on values between 300 and 1100.

The FORTRAN format for the file created by SYSTUM-1 is: (I3, F6.3, F6.3, 3X, F2.0, F6.1). The data items are as follows:

- Species number (1:3,I3)
- Growth Adjustment (4:9,F6.3)
- Mortality Adjustment (10:15,F6.3)
- Growth Model to Implement (19:20,F2.0)
- Maximum SDI (Optional) (21:26,F6.1).

Example of a growth and mortality adjustment file:

```
  1 1.000  1.000  1. 499.
  2 1.000  1.000  2. 300.
  3 1.000  1.000  3. 530.
  4 1.000  1.000  4. 530.
  5 1.000  1.000  5. 752.
  6 1.000  1.000  1. 752.
  7 1.000  1.000  1. 800.
  8 1.000  1.000  1. 499.
  9 1.000  1.000   1.530.
 10 1.000  1.000   1.530.
 11 1.000  1.000   1.530.
 12 1.000  1.000   1.530.
 13 1.000  1.000   1.530.
 14 1.000  1.000   1.530.
 15 1.000  1.000   1.530.
 16 1.000  1.000   1.530.
 17 1.000  1.000   1.530.
 18 1.000  1.000   1.530.
 19 1.000  1.000   1.530.
 20 1.000  1.000   1.530.
 21 1.000  1.000   1.530.
```

Appendix A7 - Graphics file format

There are two basic file formats for output of data used to generate graphs in SYSTUM-1. In both file formats, each line represents one year in the simulation and is numbered from 1 to the number of years in the simulation at the time the output file is generated. For trees, the line number is followed by 22 data items: average height or diameter for each of the 21 different species (in the same order of the 21 species presented in *table A1*) which may be input into the simulator and the average across species existing in the stand. Missing species are represented by a "-1" in this file.

The FORTRAN format for the two tree graph data files (height and diameter) is:

1X, I2, 22(1X, F5.2).

For competing vegetation output (cover or height), the line number is followed by 39 data items: average cover (or height) for each of the 38 allowable species in the simulator followed by the average across all species. These species are presented in the same order as the 38 codes presented in *appendix A*. Missing species are represented by a "-1" in this file.

The FORTRAN format for the two vegetation graph data files (cover and height) is:

1X, I2, 39(1X, F5.2).

APPENDIX B. SPECIES CODES

Appendix B1 - Competing Vegetation Species Codes

The species codes for competing vegetation, as well as internal codes for arrays and graphical output, are shown in *table B1.*

Table B1 - *Competing vegetation species codes (SC) recognized by SYSTUM-1, the internal code (IC), and the graph code (GC) used by the simulator*

IC	SC	GC	Scientific name	Common name
1	ACCI	(A)	*Acer circinatum*	Vine maple
2	ACMA	(B)	*Acer macrophyllum*	Bigleaf maple
3	ACMU	(C)	*Amelanchier florida*	Western serviceberry
4	AMAL	(D)	*Amelanchier anlifolia*	Saskatoon serviceberry
5	ARME	(E)	*Arbutus menziesii*	Pacific madrone
6	ARPA	(F)	*Arctostaphylos patula*	Greenleaf manzanita
7	ARVI	(G)	*Arctostaphylos viscida*	Whiteleaf manzanita
8	CACH	(H)	*Castanopsis chrysophylla*	Golden chinkapin
9	CASE	(I)	*Castanopsis sempervirens*	Bush chinkapin
10	CECO	(J)	*Ceanothus cordulatus*	Mountain whitethorn
11	CEIN	(K)	*Ceanothus integerrimus*	Deerbrush
12	CEVE	(L)	*Ceanothus velutinus*	Snowbrush
13	CEPR	(M)	*Ceanothus prostratus*	Squawcarpet
14	CHFO	(N)	*Chamaebatia foliolosa*	Bearclover
15	CYSC	(0)	*Cytisus scoparius*	Scotch broom
16	GASH	(P)	*Gaultheria shallon*	Salal
17	HODI	(Q)	*Holodiscus discolor*	Oceanspray
18	LIDE	(R)	*Lithocarpus densiflorus*	Tanoak
19	QUCH	(S)	*Quercus chrysolepis*	Canyon live oak
20	QUGA	(T)	*Quercus garryana*	Oregon white oak
21	QUKE	(U)	*Quercus kellogii*	California black oak
22	RHDI	(V)	*Rhus diversiloba*	Poisonoak
23	RHMA	(W)	*Rhododendron macrophyllum*	Pacific rhododendron
24	RHOC	(X)	*Rhododendron occidentale*	Western azalea
25	AMSP	(Y)	*Amelanchier sp.*	Serviceberry
26	ARSP	(Z)	*Arctosaphylos sp.*	Manzanita
27	CESP	(a)	*Ceanothus sp.*	Ceanothus
28	LOSP	(b)	*Lonicera sp.*	Honeysuckle
29	QUSP	(c)	*Quecus sp.*	Oak
30	RHSP	(d)	*Rhododendron sp.*	Rhododendron
31	RISP	(e)	*Ribes sp.*	Ribes
32	RUSP	(f)	*Rubus sp.*	Blackberry
33	SASP	(g)	*Salix sp.*	Willow
34	FORB	(h)		Forbs
35	GRAS	(i)		Grasses
36	TOMD	(j)		Tanoak/madrone
37	MACE	(k)		Manzanita/ceanothus
38	NONE			

Appendix B2 - SYSTUM-1 Species Codes

Species codes are shown in *table B2.* Note that the species number for the first 14 species corresponds to the same number in CACTOS. These are the species associated with the 14 elements in the site index vector and for age at breast height vector in the archive file (*appendix A4,* Archive File, sections V and VI).

Table B2 - *Tree species codes specific to SYSTUM-1, Version 2.0.*

Species Name	Species Code	Species Number	Graphics Letter
Ponderosa pine	PP	1	A
Sugar pine	SP	2	B
Incense-cedar	IC	3	C
Douglas-fir	DF	4	D
White fir	WF	5	E
Red fir	RF	6	F
Lodgepole pine	LP	7	G
Western white pine	WP	8	H
Jeffrey pine	JP	9	I
Other conifers	OC	10	J
Golden chinquapin	GC	11	K
California black oak	BO	12	L
Tanoak	TO	13	M
Other hardwood	OH	14	N
Grand fir	GF	15	0
Western hemlock	WH	16	P
Bigleaf maple	BM	17	Q
Pacific madrone	PM	18	R
Canyon live oak	LO	19	S
Oregon white oak	WO	20	T
Giant sequoia	GS	21	U
Unstocked	NS	0	

Appendix B3 - ORGANON Species Codes

The ORGANON simulator uses a 3-digit Forest Service code for species designation (*table B3*). SYSTUM-1 will accept these, and one other; Jeffrey Pine 116. ORGANON does not accept Jeffrey pine as a separate species. Therefore, when creating an ORGANON file for output, SYSTUM-1 will convert all Jeffrey pine trees to ponderosa pine (122).

Table B3 - *ORGANON Species Codes*

Species Name	Species Number Code
White fir	015
Grand fir	017
Incense-cedar	081
Sugar pine	117
Ponderosa pine	122
Douglas-fir	202
Western hemlock	263
Bigleaf maple	312
Pacific madrone	361
Golden chinquapin	431
Tanoak	631
Canyon live oak	805
Oregon white oak	815
California black oak	818

APPENDIX C - WARNING AND ERROR MESSAGES

A1001 ****NON-FATAL SYSTUM ERROR**
UNRECOGNIZED NUMBER INPUT:#
SYSTUM does not recognize your input as an acceptable integer input.

A1002 **NON-FATAL SYSTUM ERROR**
AGE MUST BE AT LEAST 3
SYSTUM requires age to be an integer greater than or equal to 3.

A1003 **NON-FATAL SYSTUM ERROR**
UNRECOGNIZED ANSWER:CHAR
SYSTUM will only accept L, M, and H as acceptable site input.

A1004 **NON-FATAL SYSTUM ERROR**
SITE INDEX MUST BE BETWEEN 30 AND 140
Site index to be input into SYSTUM must be between 30 and 140.

A1005 **NON-FATAL SYSTUM ERROR**
AGE MUST BE AT LEAST 1
You have attempted to input a competing vegetation age less than 1. This age must be greater than 1.

A2001 **FATAL SYSTUM ERROR**
FAILURE IN OPENING "FILE"
SYSTUM has been unable to open the file you have specified.

A2101 ****FATAL SYSTUM ERROR - INPUT ERROR**
REBUILD ARCHIVED DATA FILE
FROM ORIGINAL TREE LIST
FATAL INPUT ERROR FROM ARCHIV
SYSTUM cannot read this archive file. This message indicates an error in the stand description (first line in Archive File, section 1). Either the archive file you have specified is not really an archive file, or there are some unacceptable data items in the first line, or perhaps some field in the file has been exceeded. This error is in ARCHIV.FOR.

A2102 ****FATAL SYSTUM ERROR - INPUT ERROR**
REBUILD ARCHIVED DATA FILE
FROM ORIGINAL TREE LIST
FATAL INPUT ERROR FROM ARCHIV
SYSTUM cannot read this archive file. This message indicates an error in the plot description section of the archive file (Archive File, section 2). Either the archive file you have specified is not really an archive file, or there are some unacceptable data items, or perhaps some field has been exceeded in section 2. This error is in ARCHIV.FOR.

A2103 ****FATAL SYSTUM ERROR - INPUT ERROR**
REBUILD ARCHIVED DATA FILE
FROM ORIGINAL TREE LIST
FATAL INPUT ERROR FROM ARCHIV
SYSTUM cannot read this archive file. This message indicates an error in the tree description section of the archive file (Archive File, section 3). Either the archive file you have specified is not really an archive file, or there are some unacceptable data items, or perhaps some field has been exceeded in section 3. This error is in ARCHIV.FOR.

A2104 ****FATAL SYSTUM ERROR - INPUT ERROR**
REBUILD ARCHIVED DATA FILE
FROM ORIGINAL TREE LIST
FATAL INPUT ERROR FROM ARCHIV
SYSTUM cannot read this archive file. This message indicates an error in the species description section of the archive file (Archive File, section 4). Either the archive file you have specified is not really an archive file, or there are some unacceptable data items, or perhaps some field has been exceeded in section 4. This error is in ARCHIV.FOR

A2105 ****FATAL SYSTUM ERROR- INPUT ERROR**
REBUILD ARCHIVED DATA FILE
FROM ORIGINAL TREE LIST
FATAL INPUT ERROR FROM ARCHIV
SYSTUM cannot read this archive file. This message indicates an error in the site index description (required by CACTOS) section of the archive file (Archive File, section 5). Either the archive file you have specified is not really an archive file, or there are some unacceptable data items, or perhaps some field has been exceeded in section 5. This error is in ARCHIV.FOR.

A2106 ****FATAL SYSTUM ERROR - INPUT ERROR**
REBUILD ARCHIVED DATA FILE
FROM ORIGINAL TREE LIST
FATAL INPUT ERROR FROM ARCHIV
SYSTUM cannot read this archive file. This message indicates an error in the age description (required by CACTOS) section of the archive file (Archive File, section 6). Either the archive file you have specified is not really an archive file, or there are some unacceptable data items, or perhaps some field has been exceeded in section 6. This error is in ARCHIV.FOR.

A2107 **FATAL SYSTUM ERROR - INPUT ERROR**
EOF FOUND PREMATURELY
FATAL READ ERROR FROM ARCHIV
SYSTUM cannot read this archive file because it has encountered an end-of-file marker earlier in the file than expected. This error indicates that you have specified a non-archive file, or that the file has been corrupted.

A2108 ****FATAL SYSTUM ERROR**
WRITE ERROR FROM ARCHIV
For some unknown reason, SYSTUM cannot write this archive file. Contact the Pacific Southwest Research Station Silviculture Laboratory in Redding, California.

B1001 **NON-FATAL SYSTUM ERROR**
UNKNOWN SPECIES CODE, REENTER
Unacceptable species code for competing vegetation.

B1002 ****SYSTUM ERROR - NEED SPECIES CODE LETTERS, REENTER**
SYSTUM requires 4-letter species code for competing vegetation.

B1003 ****SYSTUM ERROR - VALUE MUST BE BETWEEN 0 AND 100**
SYSTUM requires percent cover for a given species between 0 and 100.

B1004 ****SYSTUM ERROR**
UNRECOGNIZED VALUE - TRY AGAIN
The value input for competing vegetation cover is not acceptable. Input a value between 0 and 100.

B1005 ****SYSTUM ERROR - VALUE MUST BE BETWEEN 0 AND 50**
The competing vegetation height must be between 0 and 50 feet.

B1006 ****NON-FATAL SYSTUM ERROR**
UNABLE TO OPEN, FNAME
SYSTUM is unable to open the file; you should reenter the file name.

B1007 ****SYSTUM ERROR**
UNRECOGNIZED VALUE: VAL
SYSTUM does not recognize one of the values input on the data line.

B1008 ****NON-FATAL SYSTUM ERROR**
TOO FEW PLOTS IN BRUSH FILE
EDIT THE BRUSH FILE TO FILL IN MISSING DATA
Enter <CR> to continue:
The competing vegetation input file did not contain the requisite number of plot entries. SYSTUM will return execution to the data management portion of the simulator and request that you input the data for the plot(s) in question.

B1009 ****FATAL SYSTUM ERROR B1009**
BAD LINE OF DATA - LINE IS:
****BAD DATA LINE****
CHECK FILE AND TRY AGAIN
ABNORMAL TERMINATION FROM BRDAT
SYSTUM found information in the competing vegetation file which was not of the required format, or was incorrectly specified. Edit the file, and make the necessary modifications to format the file correctly.

B3001 ****SYSTUM ERROR**
SP# OUT OF RANGE -
Enter <CR> to continue:
The species number is not within the range displayed by the simulator. Check the range of numbers displayed. Each species in the list has a separate number. Choose a species number in this range of numbers.

B6001 ****FATAL SYSTUM ERROR**
- UNKNOWN BRUSH IN BRSPCO: NUM.

ABNORMAL TERMINATION FROM BRSPCO
The simulator has established unacceptable species codes. Contact the Pacific Southwest Research Station's Silviculture Laboratory in Redding, California.

C1001 ****FATAL SYSTUM READ ERROR**
MORE THAN ONE STAND
FATAL ERROR ON READ IN CACIO
SYSTUM has read more than one stand identifier. SYSTUM-1 will process only one stand at a time.

C1002 ****FATAL SYSTUM ERROR**
BAD TREE RECORD COUNT
SYSTUM has encountered a problem in number of trees. Either no trees per acre were entered or the value input is not in the proper format.

C1003 ****NON-FATAL SYSTUM ERROR**
- CHARACTER DATA IN LINE: "LINE"
Enter STOP to quit or <CR> to skip:
SYSTUM has encountered unexpected character input in the given line. Input with the CACTOS format should be numeric.

C1004 ****NON-FATAL SYSTUM ERROR**
- BAD COLUMNS OF DATA IN LINE: "LINE"
Enter STOP to quit or <CR> to skip:
SYSTUM has encountered unrecognizable input in the given line. Check input file for improper input.

C1005 ****FATAL SYSTUM ERROR**
UNKNOWN INPUT ERROR IN CACIO
TERMINATE AND RETURN TO OPERATING SYSTEM
SYSTUM has encountered an unspecified error on reading CACTOS file input. You should check input file for proper format and integrity of data items.

C1006 ****FATAL SYSTUM ERROR**
MISSING SI OR BHAGE LINE IN CACIO INPUT
TERMINATE AND RETURN TO OPERATING SYSTEM
SYSTUM has terminated due to an improperly formatted input file. You should check the format of the CACTOS file; make sure that all lines required under the CACTOS input format are present and data items are in the proper columns.

C1007 ****FATAL SYSTUM ERROR**
EOF FOUND PREMATURELY IN CACIO INPUT
TERMINATE AND RETURN TO OPERATING SYSTEM
SYSTUM encountered the end of the input file before reading all the expected information. Under the CACTOS input format, the simulator will expect to see a certain number of input lines, depending on the data. If there are fewer lines than expected by the simulator this error will result.

C1008 ****FATAL SYSTUM ERROR**
OUTPUT ERROR IN CACIO
TERMINATE AND RETURN TO OPERATING SYSTEM
The simulator has encountered difficulty in correctly formatting data for CACTOS output. This error should, in theory, never be encountered. You should contact the Pacific Southwest Research Stations's[sic] Silviculture Laboratory in Redding, California.

D1001 ****FATAL SYSTUM ERROR**
NON-POSITIVE HEIGHT IN DBHFIL
TERMINATE AND RETURN TO OPERATING SYSTEM
In attempting to fill in missing DBH values, SYSTUM has encountered a negative, or 0, value for height of a tree. Make certain that all heights are positive.

D1002 ****FATAL SYSTUM ERROR**
NON-POSITIVE HEIGHT IN DBHFIL
TERMINATE AND RETURN TO OPERATING SYSTEM
In attempting to fill in missing DBH values, SYSTUM has encountered illogical competing vegetation values. Make certain that competing vegetation cover is between 0 and 100 percent.

E2001 ****FATAL SYSTUM ERROR**
UNKNOWN READ ERROR IN EDGDAT
TERMINATE AND RETURN TO OPERATING SYSTEM
SYSTUM encountered a read error in keyboard input for growth and mortality adjustments. Data input was improper. This error occurs within the module that performs data management tasks on growth and mortality adjustments.

E3001 ****FATAL SYSTUM ERROR**
UNKNOWN READ ERROR IN EDTDAT
TERMINATE AND RETURN TO OPERATING SYSTEM
SYSTUM encountered a read error in keyboard input for tree data. Data input was improper. This error occurs within the module for doing data management on tree data.

F1001 ****FATAL SYSTUM ERROR**
WRONG AMOUNT OF DATA ELEMENTS ON LINE:#.
SYSTUM is looking for six separate elements on this particular line of data when reading free format tree input. SYSTUM is aborted and returns to the operating system. Error is in FREFRM SUBROUTINE. Check the input file for strange characters, specifically for fewer than six elements n in the line indicated in the input line.

F1002 ****SYSTUM ERROR**
IMPROPER CHARACTER IN LINE:
SYSTUM found a non-numeric element where it does not belong in your data. SYSTUM must have numeric input for all fields other than species codes. SYSTUM will process if you wish, but you will have to make a correction eventually; you might as well abort (STOP) and correct the problem. Check to see that only the species field in each line contains non-numeric characters. If you choose STOP, you will see "DIRECTED SYSTUM ABORT". Error is located in FREFRM.

F1003 ****SYSTUM ERROR**
UNKNOWN SPECIES CODE IN LINE:
SYSTUM came across a species code it does not recognize when reading in free format data. It is best to abort (STOP) and fix the problem even though SYSTUM will continue to process this run. It will not allow the growth module to work until the data are corrected. If you correct the problem in SYSTUM, the original data file will still contain the error. Error is located in FREFRM.

F1004 ****SYSTUM ERROR**
IMPROPER CHARACTER FOR PAI IN LINE:
If past increment is found, it was not numeric. Again, it is best to abort (STOP) and then edit the tree file to correct the data. Error is located in FREFRM.

F1005 ****FATAL SYSTUM INPUT ERROR**
LAST SUCCESSFULLY READ LINE OF DATA WAS:

TERMINATE AND RETURN TO OPERATING SYSTEM
SYSTUM tripped on something in the code that caused the program to set the error code when reading the file. This is a fatal error which returns to the operating system. See the line after the line displayed on the screen for the likely location of the problem. Error is located in FREFRM.

F1006 ****SYSTUM ERROR**
EXITING FREFRM ON CNTL Z
SYSTUM encountered a control Z (EOF marker) when reading keyboard input. Error is located in FREFRM. This is not really an error; it returns processing back to the main SYSTUM input so that you can actually provide another file to input or exit the simulator.

G4001 ****FATAL SYSTUM ERROR**
READING MORTALITY FILE
TERMINATE AND RETURN TO OPERATING SYSTEM
An unspecified read error was encountered by SYSTUM while reading a growth/mortality adjustment file. Check this file for proper format.

G4002 ****SYSTUM ERROR**
IMPROPER DATA LINE:

ENTER QUIT TO STOP OR <CR> TO CONTINUE
This is a generic error message for reading information on growth/mortality adjustments. It usually indicates that some value was out of range or perhaps that a non numeric value was present in the file. The file should be closely examined for unreasonable values.

I1001 ****UNKNOWN SYSTUM ERROR**
OPENING frame
OR USER ENDED OPEN
SYSTUM was unable to open the file: **fname.** Try renaming the file, or make sure that the file is not already opened.

M1001 ****FATAL SYSTUM ERROR**
MORTALITY ERROR
NO CONVERGENCE REACHED
SYSTUM did not reach convergence on mortality estimate for the binary search algorithm. Contact the Pacific Southwest Research Station's Silviculture Laboratory in Redding, California.

01001 ****FATAL SYSTUM INPUT ERROR**
LAST SUCCESSFULLY READ LINE OF DATA WAS: LINENO
FATAL ERROR IN ORGIO
SYSTUM encountered an error in the ORGANON formatted input. This error is found in the ORGIO subroutine. The error is likely in the line immediately following line number #lineno#. The input file should be edited to locate and remove the error.

01002 ****FATAL SYSTUM ERROR**
TOO MANY POINTS FOR PROGRAM TO USE
TERMINATE AND RETURN TO OPERATING SYSTEM
Number of points in the stand data exceeds allowable array size. Current array size for version 2.0 is 120 for plots.

P6001 ****FATAL SYSTUM ERROR**
TOO MANY PLOTS FOR SIMULATOR IN PLTFIX
TERMINATE AND RETURN TO OPERATING SYSTEM
Number of points in the stand data exceeds allowable array size. Current array size for version 2.0 is 120 for plots.

S1201 ****SYSTUM ERROR**
OPENING: file
OR USER ENDED OPEN
This a non-fatal error. SYSTUM encountered problems opening a file or encountered an end-of-file marker to end the process (Control Z). Check to see that you have specified the correct file.

S1202 **SYSTUM ERROR**
UNRECOGNIZED NUMBER: #
Enter <CR> to continue:
You gave a response which SYSTUM does not recognize as an acceptable age. Age should be an integer greater than 0.

S1203 ****SYSTUM ERROR**
AGE MUST BE AT LEAST 1
Enter <CR> to continue:
You input an age not within the acceptable range for the simulator. Age must be an integer greater than 0.

S1204 ****UNKNOWN SYSTUM ERROR**
OUTPUTTING TO PRINTER',
INTERNAL ERROR - CONTACT PROGRAMMER
This is a strange error message. Theoretically you should never encounter this error. There is some difficulty in accessing the printer. It is not a problem with the printer being off line or being shut off. Contact the Pacific Southwest Research Station's Silviculture Laboratory in Redding, California**.**

S3001 ****FATAL SYSTUM ERROR**
QUESTIONABLE EXPANSION FACTOR IN SHCALC
TERMINATE AND RETURN TO OPERATING SYSTEM
SYSTUM has encountered a questionable expansion factor in the tree data. Search for negative expansion factors in the data set.

T3001 ****FATAL SYSTUM ERROR**
NON-POSITIVE HEIGHT IN TREGRW

TERMINATE AND RETURN TO OPERATING SYSTEM
The simulator has encountered a negative value for tree height in the tree array. In all likelihood, erroneous data input caused this error. Check the tree list for negative values.

T3002 ****FATAL SYSTUM ERROR**
PERCENT COVER WRONG IN TREGRW
TREE, PLOT, PCOV: # # #

TERMINATE AND RETURN TO OPERATING SYSTEM
The simulator has encountered a negative value for percent cover of competing vegetation. The suspect tree is array element #1, found on plot #2, and the percent cover value is #3.

T3003 ****FATAL SYSTUM ERROR**
NEGATIVE VALUE FOUND FOR SECONDARY
GROWTH MODIFIER

TERMINATE AND RETURN TO OPERATING SYSTEM
The growth modifier for height growth is negative. This error is in TREGRW.FOR. Growth modifiers, if used at all, must be positive. The defaults are all 1.0.

INDEX

The Forest Service, U.S. Department of Agriculture, is responsible for Federal leadership in forestry. It carries out this role through four main activities:

- Protection and management of resources on 191 million acres of National Forest System lands
- Cooperation with State and local governments, forest industries, and private landowners to help protect and manage non-Federal forest and associated range and watershed lands
- Participation with other agencies in human resource and community assistance programs to improve living conditions in rural areas
- Research on all aspects of forestry, rangeland management, and forest resources utilization.

The Pacific Southwest Research Station

- Represents the research branch of the Forest Service in California, Hawaii, American Samoa and the western Pacific.

United States
Department
of Agriculture

Forest Service

**Pacific Southwest
Research Station**

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User's Guide for SYSTUM-1 (Version 2.0): A Simulator of Growth Trends in Young Stands Under Management in California and Oregon

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