DTREES

A Decision Tree System for Developing Harvest Schedule Prescriptions[1]

User's Manual

by

Matthew H. Pelkki and Dietmar W. Rose[2]

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[2] The authors are research assistant and professor, respectively in the Department of Forest Resources, College of Natural Resources, University of Minnesota, St. Paul, MN 55108.

I. ABOUT THE MANUAL

This manual is designed to facilitate the use of **DTREES** (Decision **TREE** System) and provide the user with information on the structure and use of various **DTREES** functions. It is not intended to teach system analysis or timber management planning, and the authors assume that the users of this system have some expertise in these areas, as well as experience in using personal computers running under the DOS operating system environment.

The manual is broken down into several distinct sections that the user may consult as needed. The first section of the manual contains the software disclaimer, and license and help system agreements which explain the obligations and agreement between the users and the authors. They also explain the authorized uses of this software, and the extent to which the users can expect support from the authors. The next section explains the topology used in this manual and the recommended system requirements for **DTREES**.

Following that section is a brief description of **DTREES**, explaining what **DTREES** does, how **DTREES** fits into the overall planning system, and the basic structure of **DTREES**. After this introduction to **DTREES**, there is a section dealing with the installation of the software for **DTREES** and **ADDREGEN** (a module that allows manipulation and editing of regeneration tree lists), with hints at how to obtain peak performance from this software.

Subsequent sections describe the functions of **ADDREGEN** and **DTREES**, respectively. Each function of the aforementioned systems are described, and brief examples are provided in the appropriate appendices. After these descriptions, short trial runs of both **ADDREGEN** and **DTREES** are provided, along with examples of the reports that can be generated from each system.

Finally, there is a brief discussion on linking the **DTREES** output with the other components of the overall planning system, and a more detailed discussion of the modelling systems used in **DTREES**. The manual ends with the appendices and a list of referenced literature.

SOFTWARE DISCLAIMER FOR DTREES

All of the software on the DTREES diskette(s) has been extensively tested and checked for accuracy. To the best of our knowledge, it contains no errors. However, neither the University of Minnesota, the Department of Forest Resources, nor the authors provide any guarantees and are not responsible for errors that may arise during the use of this software. The authors ask that any errors found by users be brought to the authors attention in order to incorporate appropriate changes into future versions.

For permission to use or copy DTREES and for revised versions or updates to existing DTREES installations contact:

Dr. Dietmar Rose
University of Minnesota
Department of Forest Resources
110 Green Hall
1530 N. Cleveland Ave.
St. Paul, MN 55108
(612) 624-9711

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APPENDIX I.

Example of DTREES Input and Output:

DTREES INPUT:

Inventory Stand:

Good Site Aspen
Site Index = 75
Basal Area Per Acre = 146 sq. ft.
Age = 48 years
NT/Acre = 198
Arithmetic Mean DBH = 11.31
Quadratic Mean DBH = 11.62
Stand Inventoried in 1985

Tree list for stand:

Species	DBH	NT/Acre
Trembling Aspen	12.8	140
Trembling Aspen,	9.7	35
Balsam Fir	4.7	23

Planning Period Parameters:

Period 1 - 5 years
Period 2 - 5 years
Period 3 - 10 years
Period 4 - 10 years
Period 5 - 20 years

DTREES OUTPUT:

1. The Prescription File

Alternative	Planning Period	Action
1	1	Clearcut
	2	Regenerate
	3	Regenerate
	4	Do Nothing
	5	Do Nothing
2	1	Clearcut
	2	Regenerate
	3	Regenerate
	4	Do Nothing
	5	Thin stand

2. The Harvest Output File

Alternative	Period	Species	Harvested Gross Cubic Foot Volumes/Acre Chipped	Pulpwood	Sawtimber
1	1	T. Aspen	713	888	3158
		B. Fir	40	0	0
2	1	T. Aspen	713	888	3158
		B. Fir	40	0	0
	5	T. Aspen	55	259	46
		P. Birch	22	57	2
		B. Gilead	9	33	1

3. The Residual Output File

Alternative	Period	Species	Residual Stand Gross Cubic Foot Volumes/Acre Biomass	Pulpwood	Sawtimber
1	3	T. Aspen	205	139	5
		P. Birch	24	25	1
		B. Gilead	14	9	1
		B. Aspen	.2	.3	.5
	4	T. Aspen	187	873	154
		P. Birch	74	189	4
		B. Gilead	32	114	4
		B. Aspen	1	1	2
	5	T. Aspen	354	1401	586
		P. Birch	111	318	154
		B. Gilead	66	245	27
		B. Aspen	1	1	3
2	3	T. Aspen	205	139	5
		P. Birch	24	25	1
		B. Gilead	14	9	1
		B. Aspen	.2	.3	.5
	4	T. Aspen	187	873	154
		P. Birch	74	189	4
		B. Gilead	32	114	4
		B. Aspen	1	1	2
	5	T. Aspen	288	956	666
		P. Birch	109	228	137
		B. Gilead	56	211	21
		B. Aspen	1	1	3

III. INTRODUCTION TO THE DTREES SIMULATION SYSTEM

III.1 TYPOLOGY CONVENTIONS

To help you better understand this manual, we will explain the conventions used to interact with the **DTREES** system and each of its sub-components. **DTREES** has been thoroughly tested and extensively error-trapped, and careful use of the system should result in quick and effective runs. However, the system is not capable of defeating all deliberate attempts to crash it, so we advise that you think ahead when changing variables to extreme values.

(1) Whenever a key is bracketed by the greater-than and lesser-than signs < >, this symbolizes a key press. For example:

<4><ENTER> - Symbolizes pressing the 4 key and then the enter key.

<SPACEBAR> - Symbolizes pressing the spacebar once.

<5><5><.><0><ENTER> - Pressing 55.0 and then the enter key.

(2) Whenever a numeric key press is requested (i.e. - <4>),it refers to the numeric keys above the alphabetic keys on the keyboard. **DTREES** uses the numeric keypad for cursor control only.

(3) Unless otherwise noted, **DTREES** is not case sensitive. In other words, <E> is equivalent to <e>.

(4) Definition of DOS. DOS refers to the Disk Operation System for IBM or IBM compatible personal computers.

(5) Reverse video refers to reversing the basic foreground and background colors of the text. If the majority of the text is light letters on a dark background, reverse video will be dark letters on a light background.

(6) When the message "Press any key to continue..." appears on the screen, **DTREES** is allowing you to observe the screen contents before continuing. Pressing any of the alpha-numeric keys will then signal **DTREES** to continue.

(7) When cursor control is used to highlight a menu option in reverse video (as in the **SRP** (SET RUN PARAMETERS) module main menu), the up arrow key on the enhanced 101 key keyboard and the 8 key on the numeric keypad are equivalent. Similarly, the down arrow key is equivalent to the 2 key on the numeric keypad. Use these keys to highlight the menu option of interest, then press the spacebar <SPACEBAR> to execute that option.

III.2 SYSTEM REQUIREMENTS AND RECOMMENDATIONS

The **DTREES** system itself can be run from any computer operating DOS 2.1 or higher, and at least 700 Kb of free disk space. However, to properly use the **DTREES** system, the following is a description of the minimum operational system. (The system described here is an IBM PS/2 Model 60.) The need for 20 MB of free disk space is due to the fact that **DTREES** can create up to 6000 bytes of output for each stand processed. Should you process a planning area with 2000 management units, the **DTREES** output alone is 12,000,000 bytes (12 Mb)! This is due to the detail with which **DTREES** processes each stand. This is also the cause for recommending a machine which has a processor running at least 10 Mhz. With the IBM PS/2 model 60 **DTREES** will process one stand completely every 45 seconds. Using the same 2000 stands, that equals about 25 hours of total running time.

Minimum recommended system for **DTREES**

- DOS 3.3 or higher
- VGA graphics
- Computer processor running at 10 Mhz
- At least 20 Mb of free disk space or other peripheral storage device (e.g., Bernoulli box)

However, when operating both **DTREES** and **DUALPLAN**, and later, a geographic information system (**GIS**), even more processing power and memory space is recommended. The optimal system for the total planning system contains these components:

Optimal System Support

- IBM PS/2 Model 70 or 80 running at 20 or 25 Mhz
- A minimum of 100 Mb of on line disk space
- Backup storage capacity of 1000 Mb. Either Bernoulli cartridges, tape storage, optical disks, or mainframe computer storage.
- VGA graphics capacity
- High quality printer
- High quality plotter (support for **GIS**)

Although the total cost of such a hardware expenditure may look imposing, for most organizations already involved in strategic planning the cost is lowered by the fact that most of these components are already owned.

IV. GENERAL INFORMATION ABOUT DTREES

IV.1 WHAT DTREES DOES

A major objective of forest planning is to chose among many available stand management options in such a way that management objectives are achieved in the best possible way. The key here is to provide an optimization model with a selection of technically sound management alternatives. The development of these alternatives is an important, but potentially very tedious process. Decision **TREE** System (**DTREES**) was developed to facilitate the development of management alternatives and functions as the "front-end" to a harvest scheduling algorithm. It provides a list of alternative management sequences for each forest stand by simulating management activities and responses. Included in **DTREES** system objectives are (1) use of a tree-based growth projection system, (2) a modular systems design, (3) an understandable and user accessible silvicultural decision system, (4) avoidance of stand aggregation, and (5) a flexible inventory data interface which will accept current stand-level databases.

The **DTREES** package will generate and simulate alternative management sequences for forest stands in the Great Lakes' Region. For a given inventory file, **DTREES** will produce a database which describes, for each stand in the input file, a series of management actions and the impact of those actions on the physical stand characteristics over time. **DTREES** bases its decisions on silvicultural guidelines derived from management handbooks for each covertype in the Great Lakes Region (Brand, 1981a).

A simple example of the type of input required by **DTREES** is given in Appendix 1 for a single aspen stand. Following the input example is an example of the type of information **DTREES** will provide under a Model I formulation assumption. Most timber management scheduling models found in the forestry literature are formulated in either a Model I or Model II format. The best description of these two model formulations can be found in Johnson and Scheurman (1977). The primary difference between Model I and Model II formulations is in the method of defining the variables that relate to the management alternatives. In Model I, the decision variables are the number of acres of an initial ageclass assigned to a unique management sequence or option over time. In Model II, on the other hand, the decision variables refer to the number of acres in an initial ageclass that are harvested in a given planning period. The major difference between the two formulations is that in model II stands harvested in a specific planning period are merged to form a new ageclass while in model I all stands maintain their original identity. The user needs to understand the distinction between these two formulations in order to make appropriate selections of various run options described in chapter VII.

DTREES makes no assumptions about economic conditions or values. It simply models the biological aspects of a forest as presented in the inventory files.

DTREES uses the GROW subroutine (Brand, 1981b) for growth projections, in the Model I formulation empirical tree lists are used for regenerating stands after final harvests. The ADDREGEN system is used to develop and modify these regeneration tree lists. The harvesting schemes modelled by **DTREES** include clearcutting, random thinning, selection by species or diameter size class, and shelterwood harvests for natural regeneration. A detailed discussion of the concepts and procedures used by **DTREES** to produce alternative management sequences is contained in the overview paper by Rose, Hoganson, Pelkki, and Arthaud (1989).

IV.2 WHERE DTREES FITS INTO THE PLANNING SYSTEM

Figure 4.1 shows the overall structure of the planning system. While **DTREES** is fully capable as a stand-alone system, it is designed to work with the other components of the planning system in an integrated fashion. The stand-level inventory database is the most current representation of the real world (forest). From this current state, **DTREES** models for each stand (or management unit) in the forest several alternative management sequences forward in time. Each of these alternatives are then evaluated by economic criteria and costs of production are defined for each alternative. This modified prescription list is then evaluated by **DUALPLAN**, the microcomputer version of the Hoganson-Rose algorithm (Hoganson and Rose, 1984). **DUALPLAN** finds the lowest cost strategic harvesting plan for the entire forest, for given levels of production. Later versions of the planning system will incorporate geographic information systems (GIS) for analysis, display and reporting on the output from **DTREES** and **DUALPLAN**.

Critical to the entire system is the report writer, which provides a series of management summary and exception reports for the user. Its purpose is to reveal to the user what the planning system has developed and why in a concise and readable format.

IV.3 DTREES SOFTWARE STRUCTURE

DTREES is coded in Microsoft QuickBASIC version 4.5. It requires an IBM or IBM compatible personal computer which supports DOS 2.1 or higher. The structure for **DTREES** is shown in figure 4.2.

DTREES.EXE controls the main program menu and all functions of **DTREES** are accessible through it. While other modules may be executed outside of this module's environment, the **DTREES** is designed to be executed from **DTREES.EXE**! Use of the other modules outside of **DTREES.EXE** can cause unpredictable results, loss of data, or damage to the system software.

DTREES.EXE controls the startup screen and initial user messages. It offers an alternative screen for computers without VGA capabilities.

VE.EXE (View/Edit) controls the display and editing of the decision trees which drive **DTREES**. There are 12 covertypes which can be displayed, and each critical value displayed can be modified and saved. Up to 4 sets (a set consists of critical values for all 12 covertypes) of these "critical" values can be stored at a time.

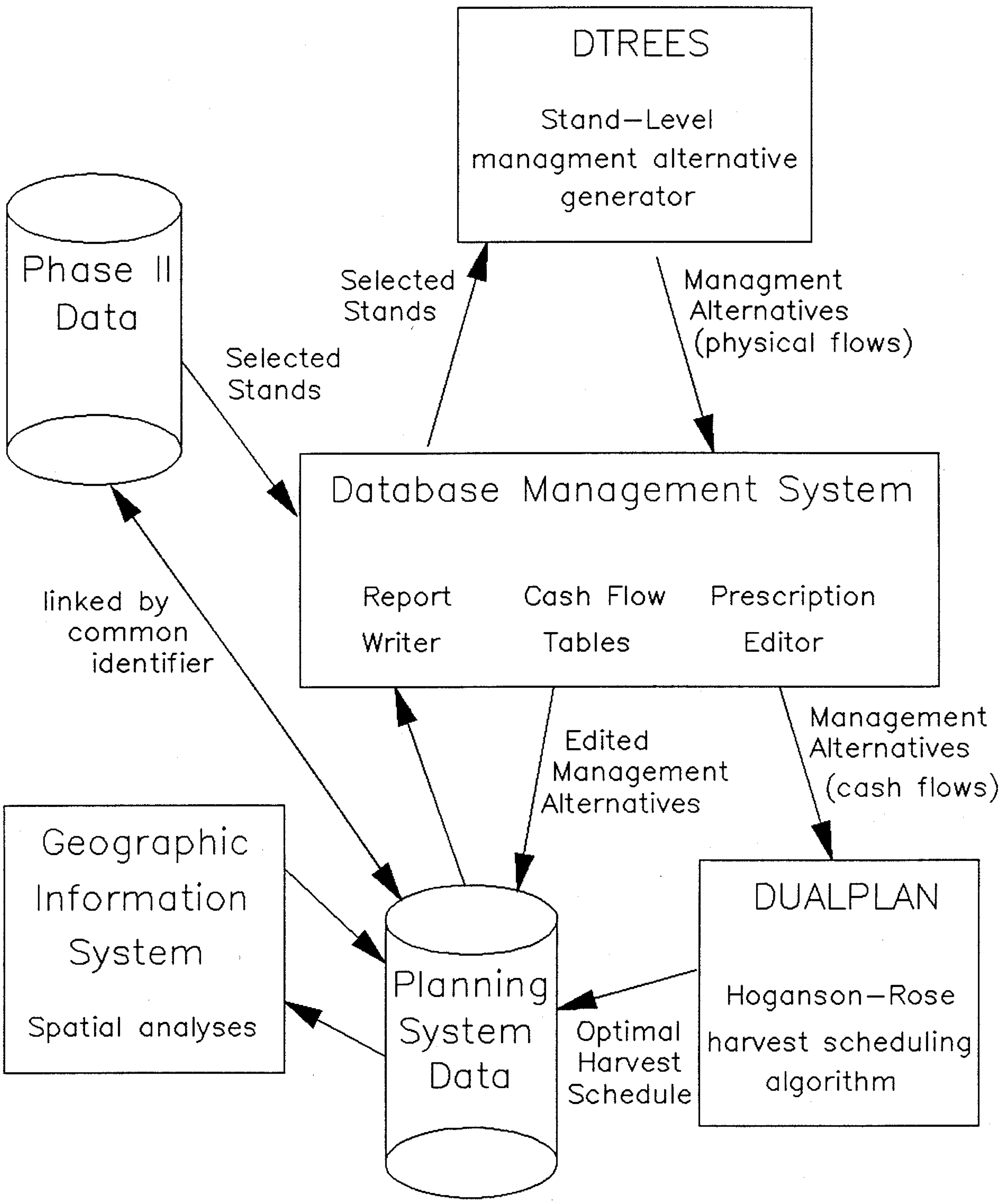


Figure 4 . 1 . Microcomputer Forest Planning System

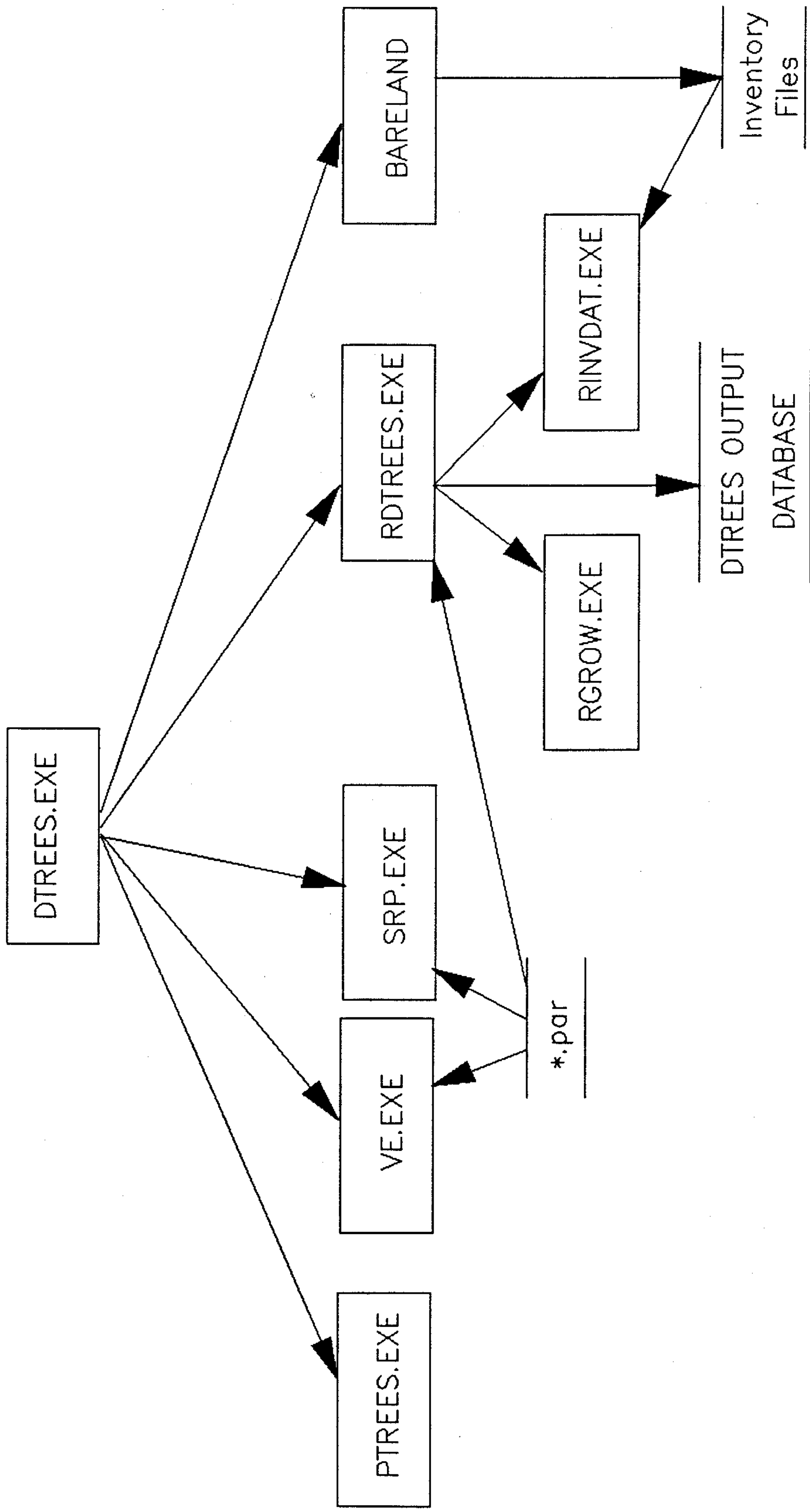


Figure 4.2. Software Structure for DTREES

SRP.EXE (Set Run Parameters) controls all other **DTREES** running parameters. When executing this subsystem, the user can observe and modify the following:

- Inventory source type and file names
- Output file names
- Input and output file paths
- Timber size class codes for all tree species
- Planning horizon length and number of periods
- Modelling formulation (Model 1/Model 2)
- Species and covertype conversion codes
- File start up point
- Update of inventory to current year
- Generation of silvicultural optimal sequence only

SRP.EXE modifies and reads the *.par files, which are read by the **RDTREES.EXE** module and control its actions.

BARELAND.EXE is used with Model II formulations where the user needs bare land stands by cover type and site quality in order to evaluate rotations after each current stand undergoes final harvest. It produces input files that are run through **DTREES** in the same fashion as standard inventory input files.

The **RDTREES.EXE** module actually performs the simulation of management sequences over time. It uses **RGROW.EXE** to make growth projections, and the **RINVDAT.EXE** module reads the inventory data and presents it to the system in a standard form.

V. INSTALLING THE DTREES SIMULATION SYSTEM

V.1 REQUIRED FILES

BACK UP YOUR DTREES DISKETTES BEFORE ANY INSTALLATION PROCEDURE! This will minimize the risk of damage to the original diskettes. **DTREES** has no copy protection.

3.5" Disk Installation

If you are installing **DTREES** from a 3.5" diskette, this disk contains all the necessary files to run **DTREES**. Simply place the disk into your computer's floppy drive and type INSTALL<ENTER>.

5.25" Disk Installation

If you are installing **DTREES** from a 5.25" diskette, you must have both **DTREES** disks 1 and 2. Insert **DTREES** disk 1 into your computer's floppy drive and type INSTALL<ENTER>

At the end of this section is a list of the files that should be included on your **DTREES** disk(s).

V.2 THE INSTALL PROGRAM

After placing your **DTREES** disk into the floppy drive, you execute the INSTALL program by typing INSTALL<ENTER). The install program's initial screen will then appear as in figure 5.1.

```
DTREES INSTALLATION PROGRAM

Part of the DTREES Prescription Writer

Written by: Matthew H. Pelkki
1989

Department of Forest Resources
College of Natural Resources
University of Minnesota

Copyright (C) 1989, REGENTS of the
University of Minnesota
```

Press any key to continue....

Figure 5.1. Initial Screen for **DTREES** installation program.

Pressing any key will cause the SET INSTALLATION PARAMETERS menu to appear as shown in figure 5.2. After pressing keys <1> through <4> a prompt will appear asking for a new drive/directory designation for the appropriate files. Pressing <5> will install **DTREES** according to the specifications as they appear on the screen. Pressing <Q> will exit the program after installation or allow you to quit without changing anything on your computer or the **DTREES** disks. **DTREES** will create the necessary directories unless they already exist.

SET INSTALLATION PARAMETERS

```
  DRIVE/DIRECTORY for DTREES *.EXE and system files:
                 C:\DTREES
  DRIVE/DIRECTORY for DTREES input files:
                 C:\DTREES\INPUT
  DRIVE/DIRECTORY for DTREES output files:
                 C:\DTREES\OUTPUT
DRIVE/DIRECTORY for DTREES regeneration tree list files:
                 C:\DTREES\REGEN
```

Press the key of the function you wish to execute...

(1) Change drive/directory for DTREES *.EXE and system files
(2) Change drive/directory for DTREES input files
(3) Change drive/directory for DTREES output files
(4) Change drive/directory for DTREES regeneration list files
(5) Install DTREES as specified...

Press Q to quit this installation program...

Figure 5.2. INSTALL set parameters menu screen.

When installing, **DTREES** will set its path designators to correspond to the installation procedures so that **DTREES** is ready to run immediately without modification of the path parameters via the SRP.EXE module in **DTREES**. DO NOT EXECUTE **DTREES** FROM YOUR ORIGINAL DISK(S)! To best protect your original **DTREES** disk(s), make a backup copy of the original disk(s) and install or run **DTREES** from the backups and store your original(s) in a safe place.

VI. THE ADDREGEN SYSTEM

VI.1 DESCRIPTION OF ADDREGEN

The regeneration of stands in **DTREES** is accomplished by empirical regeneration lists derived from permanent plots in the Lake States. These are tree lists for each covertype for a 15 year old stand averaged across all site classes. When a stand has been clearcut and the stand is being regenerated, this tree list is used to represent the stand at age 15. From there the GROW subroutine carries out growth and mortality projections. The **ADDREGEN** (**ADD REGEN**eration) system allows the user to modify these standard regeneration lists prior to using them in **DTREES**.

VI.2 ADDREGEN FUNCTIONS

The **ADDREGEN** system is a separate software package which is distributed with **DTREES** on its own diskette. To execute the program, simply type **ADDREGEN** and the main **ADDREGEN** menu appears as shown in figure 6.1. This menu lists the main functions of this system and they are described below.

Regeneration Matrix Program

```
      1. Select regeneration matrix file
      2. Create a new Regen*.mtx file
      3. Upload matrix values from file
      4. Input new regeneration values
      5. Adjust Regen values by a factor
      6. Create Regen file for covertype
      7. Enter new covertype name to matrix
      8. Enter new species name to matrix
      9. Quit this program and return to DOS

     Use Numeric or Arrow Keys to select option
     Press Spacebar to execute the option
```

Figure 6.1. ADDREGEN main menu.

VI.2.1 Select Regeneration Matrix File

This function allows you to see the current regeneration files you have available to you and to input the name of the file you wish to use. When this option is in reverse video, pressing the spacebar activates this subsystem and the screen shown in figure 6.2 will appear. There are 4 menu commands. Pressing <4> will exit you from this menu and return you to the main **ADDREGEN** menu. Pressing <3> will display all files in the current directory with a .MTX extension below the menu box. By pressing key <1>, you will be prompted for a file name (use standard DOS format) of an existing regeneration matrix file. The system will check to see if the file exists! (WARNING! This system does not check these files for correct format at this time!) Pressing <2> allows you to enter any file name for a regeneration matrix file and if such file does not exist, the **ADDREGEN** system will then create the empty file structure for you.

SELECT REGEN MATRIX FILES FOR CORRECTION

```
(1) To change current regen matrix file: REGEN.MTX
(2) To enter name of new regen matrix file:
(3) Directory of all .MTX files from input path
(4) Quit and return to main ADDREGEN menu

                Press a key (1-4)...
```

All regen files located on current directory...

REGEN	MTX	REGEN1	MTX
REGEN2	MTX	REGEN2	MTX

Figure 6.2. Select REGEN Matrix Files.

VI.2.2 Create A New Regen*.mtx File

This function creates a new matrix file with no data values or overwrites an existing matrix file. These matrix files are random access binary files which contain the regeneration lists for each species group in each covertype. The maximum capacity of these matrices are 100 covertypes, and 100 species groups per covertype.

VI.2.3 Upload Matrix Values From File

This option allows you to upload tree lists from a single ASCII file which has the structure shown in figure 6.3. The data that has already been uploaded is from a Phase I forest inventory assessment (FIA). The file name you enter must correspond to DOS naming conventions and may include a drive and path specification. The current module of **ADDREGEN** is set up for Minnesota FIA codes for the covertype code and Minnesota DNR Division of Forestry Phase II inventory codes for the species groups. This function can, however, be modified to suit any user code needs upon request.

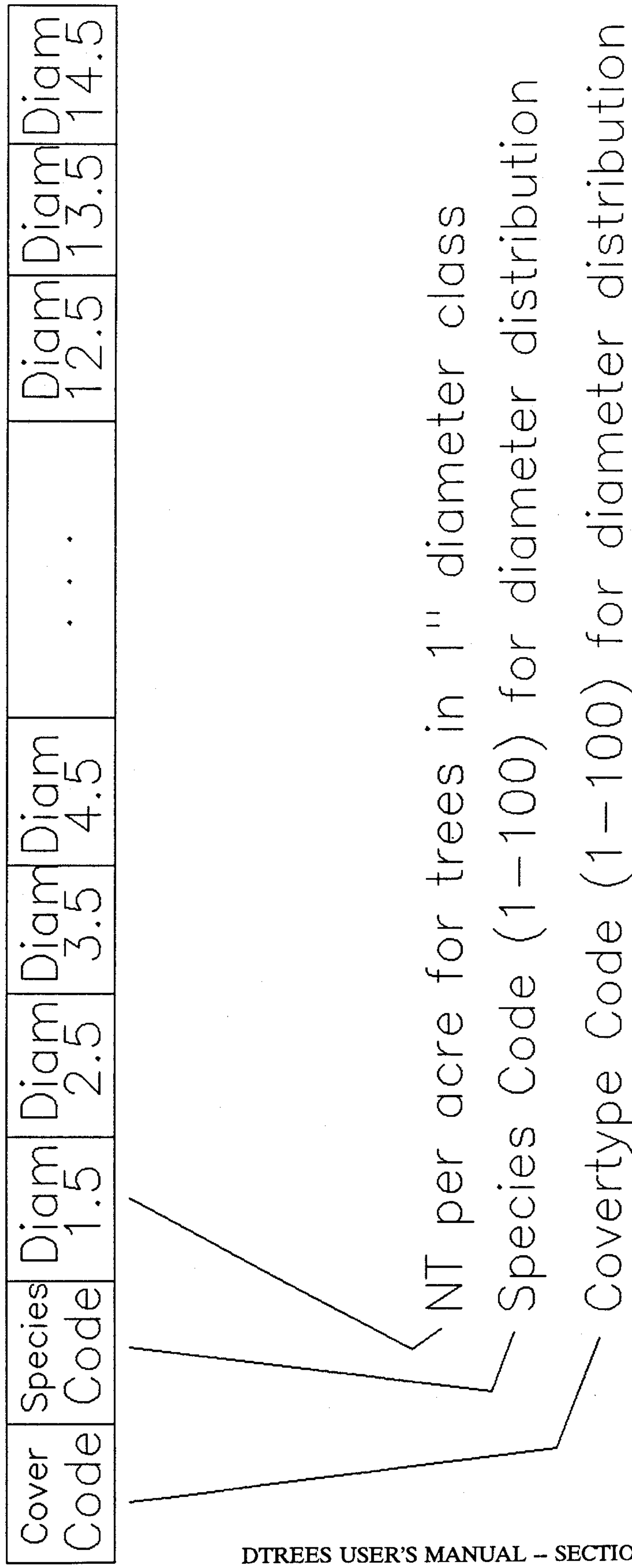


Figure 6.3. Structure for FIA files for upload to ADDREGEN

VI.2.4 Input New Regeneration Values

When this option is selected, you will be prompted for a covertype code number and then a species code number. The current code numbers correspond to the Minnesota DNR Division of Forestry Phase II Inventory codes (State of Minnesota Division of Forestry, 1988). When the covertype and species code numbers are entered, the current regeneration diameter distribution will be displayed on the left-hand column.

Editing this list (inputting new values) is done on the right-hand column. As each size class is shown, simply enter in a numeric value for the number of trees in that size class. If you wish to make no changes for a size class, simply press <RETURN> and no changes will be made to that size class value.

VI.2.5 Adjust Regen Values By A Factor

This function allows rapid editing of a regeneration list for an entire covertype or one species group within a covertype. You will first be prompted for a covertype you wish to edit. The screen shown in figure 6.4 will then be displayed.

Multiply Regen Matrix Values

Input covertype code (0 to quit): 12

This corresponds to cover type: Aspen

(1) Multiply all species groups by factor
(2) Multiply one species group by factor
(3) Do not continue for this cover type

Figure 6.4. Multiplying Regeneration Matrix Values by a Factor.

Pressing <1> will multiply all species groups by the factor for which you will be prompted. Pressing <2> will allow you to specify a single covertype to adjust by the factor entered. Pressing <3> will allow you to choose another covertype. To exit this subsystem, press <0> or just <RETURN> at the input covertype code prompt.

VI.2.6 Create Regen File For A Covertype

This function downloads a covertype regeneration list in a format that the **DTREES** regeneration system used to regenerate stands. You may specify a single covertype to download or you may download all covertypes which have been modified by entering A (for an all covertype update). If you specify a certain covertype, **ADDREGEN** will display the covertype that will be updated and ask for confirmation before continuing.

VI.2.7 Enter New Covertype Name To Matrix

This function allows you to change or add to the current list of covertypes that **ADDREGEN** recognizes. **ADDREGEN** allows covertypes to have codes from 1 to 100, and to each of these codes you may attach a covertype name in this function.

VI.2.8 Enter New Species Name To Matrix

This function is identical to the above operation except it deals with species group codes and names. **ADDREGEN** allows you to name 100 species groups and attach them to code number 1 to 100.

VI.2.9 Quit This Program And Return To DOS

When this option is outlined in reverse video, pressing the spacebar exits you from the **ADDREGEN** system. If you have made any changes to the regeneration lists of any species of any covertype and not updated those regeneration files used by **DTREES**, **ADDREGEN** will beep and remind you to do so. You can, however, override the warning and exit immediately without making any changes.

VI.3 ADDREGEN AND DTREES

VI.3.1 DTREES and Regeneration Files - Model I

DTREES, after any final harvest activity, will regenerate a stand to the same covertype using the files created by the **ADDREGEN** system. These files have a special naming convention as shown below:

REGENxxx.LST

Where xxx can be any integer 1-100 which corresponds to the original inventory covertype code. Thus, if your inventory code for aspen is 12, then the regeneration list file will have the name REGEN12.LST and will be used for regenerating all aspen stands after final harvest.

VI.3.2 DTREES and Regeneration Files - Model II

Since **DTREES** makes no projections after any final harvest in Model II formulations, the regeneration lists are used only for bare land stands. These will occur in two places. The first is the bare land files created by the **BARELAND.EXE** system which must be run through **DTREES** to complete a Model 2 formulation run. The second case where **DTREES** will use the regeneration files is when, in the initial inventory, a stand has recently been clearcut and the average diameter of all trees in the stand is less than 1 inch. **DTREES** will then use the regeneration list and simulate this stand to the end of the planning horizon or until final harvest, whichever comes first.

VI.3.3 Installation of ADDREGEN with DTREES System

ADDREGEN comes entirely on its own diskette, and is not copy protected. There are two recommended places to store and use the **ADDREGEN** system. The first is the **DTREES** system directory, where the **DTREES** .EXE files are stored. This saves space on your disk since both **DTREES.EXE** and the **ADDREGEN** system require the **BRUN45.EXE** run-time module. The other recommended location for **ADDREGEN** is the **DTREES** regeneration directory, since all REGENxxx.LST files created by **ADDREGEN** must be copied to this directory to be used. If all **DTREES** files are on one directory (this is the most simple installation) then simply copy the contents of the **ADDREGEN** diskette to that directory as well.

VII. USING THE DECISION TREE SYSTEM: DTREES

VII.1 THE DTREES MAIN MENU

After entering **DTREES** from the DOS prompt in the appropriate directory, the **DTREES** initial screen will appear. Pressing any key at this point will place you in the main **DTREES** menu. From this menu you can access all of the major **DTREES** subsystems and execute all of DTREES procedures. The **DTREES** main program menu appears as shown in figure 7.1.

```
                DTREES MAIN PROGRAM MENU

    (1) About DTREES...
    (2) View/Edit decision trees
    (3) Set run parameters
    (4) Create bare-land files
    (5) Run Dtrees
    (6) Escape - end program

        Press a number (1-6)
```

Figure 7.1. **DTREES** main program menu.

A selection is made simply by pressing any of the number keys 1 through 6. The appropriate subsystem is immediately activated, and a new menu screen or activity will appear. Any key pressed other than the keys 1-6 will have no effect on the system. What follows is a description of the function of each subsystem available from the main menu.

VII.2 ABOUT DTREES

This option is executed by pressing <1> while the **DTREES** main menu appears on the screen. Upon pressing <1> while in the **DTREES** main menu, the screen options change to those shown in figure 7.2. By pressing <1>, the user can read a general description of **DTREES**, how it fits into the overall planning system, its general structure, and possible uses. By pressing <2> **DTREES** displays the software disclaimer, which outlines the agreement between authorized users and the authors. Pressing <3> returns the system to the main **DTREES** menu.

Information about the DTREES Software

```
(1) General Information about DTREES
(2) Software Disclaimer for DTREES
(3) Return to DTREES Main Menu

        Press 1,2 or 3
```

Figure 7.2. About **DTREES...** menu screen.

VII.3 THE VIEW/EDIT (VE) SUBSYSTEM

VII.3.1 An Introduction to the DTREES decision trees

A brief discussion of the **DTREES** decision system is made prior to describing the **View/Edit** (VE) subsystem. The decision system in **DTREES** is a set of 12 decision trees developed to simulate timber management in the Lake States (Brand, 1981a). An abbreviated decision tree is shown in figure 7.3.

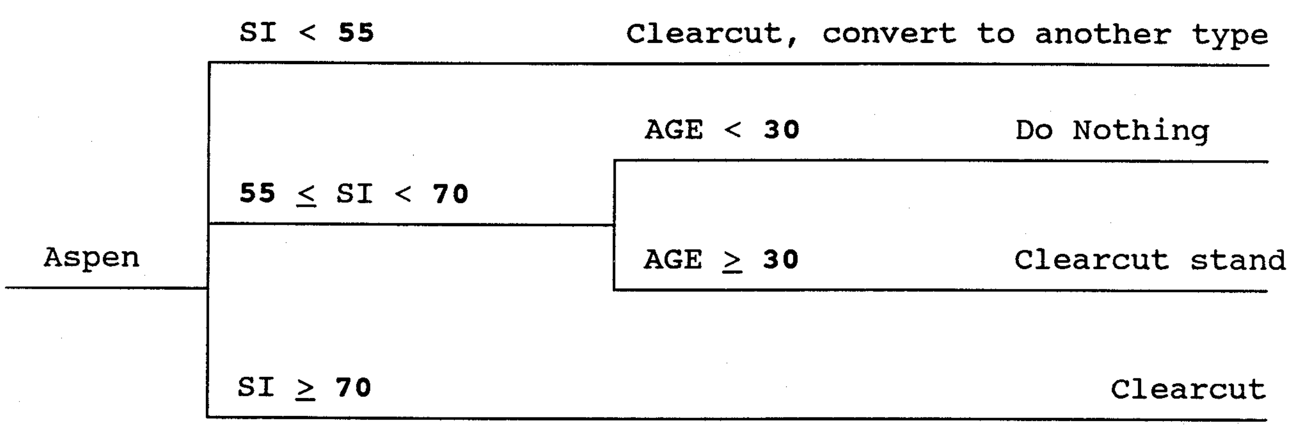


Figure 7.3. Structure of a simple decision tree.

At each node of the decision tree, there is an associated critical stand parameter, here site index (SI) and stand age (AGE). Each critical parameter has an associated value (shown in bold type). The stand's SI value is compared against these values and the appropriate decision path is followed until a management decision is reached. It is important to note that in this unmodified decision tree, there is only one possible management decision for any given state of the stand. For example, an aspen stand with SI = 65 and AGE = 25 would result in a "Do Nothing" recommendation from this decision tree.

By pressing <2> while in the **DTREES** main menu, the VE module is executed. But prior to the actual execution of the VE system, the user is queried as to whether or not they wish to change the current set of critical parameters used in the **DTREES'** run. These critical parameter sets are the sets of all the values (remember the numbers shown in bold in figure 7.3) associated with each of the 12 cover types and their decision trees. **DTREES** allows you to store and maintain 4 sets of these critical parameters. The default set (set 1) is a direct adaptation of silvicultural guidelines published by Brand (1981). These sets allow the user to maintain a base set of parameters while experimenting with different values, or specializing a set of critical parameters for different regions or management objectives. By pressing <Y> or <y> in answer to the query, the user can then select the set of interest by pressing <1>, <2>, <3>, or <4>. The VE module will execute once this decision is made.

VII.3.2 Viewing and Editing Decision Trees

While the **VE** module loads up, a message is flashed on the screen. When the module is loaded and ready to run, the **VE** Menu appears on the screen as shown in figure 7.4 below. To select a cover type enter the number of the type and press the enter key. For example, to select Paper Birch, the keypresses are: <1><0><ENTER>.

```
             View/Edit Current Decision Trees
             (Commercial Forest Types Only)

Enter the number for the decision tree you wish to view...

        (1) Jack Pine                   (7) Northern White Cedar
        (2) Red Pine                    (8) Oak-Hickory
        (3) White Pine                  (9) Aspen
        (4) Spruce-Fir                 (10) Paper Birch
        (5) Black Spruce (Larch)       (11) Northern Hardwoods
        (6) Mixed Swamp Conifers       (12) Lowland Hardwoods

             (13) To escape this menu

Please enter the number of the tree you wish to view
```

Figure 7.4. The View/Edit module main menu.

Once a covertype is selected, you will see part or all of the decision tree on the screen. Some of the decision trees are rather large and therefore take up 2-4 screens while others are simple enough to all fit on one screen. At the bottom of each screen, in reverse video, you will see a list of the available key presses (command line):

Command Options: E-(Edit) C-(Continue) 1 2 3 4

(This happens to be the screen options for the Northern Hardwoods type). These options will allow you to edit (press <E>) the critical values associated with the stand parameters, return to the main VE menu (press <C>), or switch to another screen which shows you more of the decision tree (press <1>, <2>, <3>, or <4>). If you don't see any numbers on the command line, then all of the decision tree is shown on the current screen. The following is a list of the decision trees and the number of screens for each:

Decision Tree Cover Type	Number of Screens
1. Jack Pine	2
2. Red Pine	3
3. White Pine	2
4. Spruce-Fir	3
5. Black Spruce (Larch)	1
6. Mixed Swamp Conifers	2
7. Northern White Cedar	3
8. Oak-Hickory	4
9. Aspen	1
10. Paper Birch	1
11. Northern Hardwoods	4
12. Lowland Hardwoods	1

When editing critical values, you can only edit those which appear on the screen which is currently displayed, unless that decision parameter also occurs on a prior screen.

To begin editing critical values shown on the screen, press <E>. You will notice that the command line will change from

Command Options: E-(Edit) C-(Continue) 1 2 3 4

to

Change this value (Y/N)? (Press E again to escape the editor)

At the same time, a critical value will blink off/on the decision tree. If you press <E> again, the command line will return to its original state and the blinking will stop. If you press <N>, the command line will remain the same, but a new value on the screen will be blinking. You may run through all the critical values on the screen in this manner until the one you wish to edit is blinking. When you have cycled through all the values that can be edited on the screen, the command line will return to its original state (remember, the numbers may not appear on the command line, it depends on which cover type you are currently viewing).

When you find the value you are interested in changing, press <Y> and the command line will change to something like this:

Current critical value (1 9 1) = 40   New value = ##.#

The pound signs (#) will be in reverse video and they represent the format for this critical value. The current critical value should be the same as the value flashing on the screen. The numbers in the parenthesis correspond to critical value set, cover type, and critical value. So in the example above, we are in the first critical parameter set, our cover type is 9 (Aspen), and we are editing the first critical value. To change the critical value, simply press the numbers which will be inserted into the format as you press them, left to right. You do not enter the decimal point as it is assumed. Here are some examples for the above situation:

To change the value from 40 to 60, press:	<6><0><0>
To change the value from 40 to 7.5, press:	<0><7><5>
To change the value from 40 to 80.5, press:	<8><0><5>
To make no changes (40 to 40), press:	<4><0><0>

The editor will only accept numeric keypresses at this point, and when you have made the last accepted keypress, the new value will be displayed on the screen (no blinking) and a new value will be blinking (unless that value was the last to be edited on the screen).

Editing the values associated with the critical parameters is the only editing allowed. Structural alterations of the decision trees themselves, or the harvest actions specified by them (with the exception of thinning intensity) is not possible. However, minor alterations in the tree structure can be accomplished by "pruning" branches of the tree by setting critical values to a minimum or maximum value. Figure 7.5 shows how we could modify the simple decision tree shown in figure 7.3 so that the simulation would never recommend a clearcut followed by a type conversion. The actual decision tree for the aspen cover type is shown in figure 7.6. Here, two branches are "pruned" from the decision tree. Type conversion is eliminated as in our previous example, but now, for stands with site index greater than 70, the option to thin stands between the ages of 30 and 40 is eliminated by setting BA too high to be ever selected.

Additional comments on how the decision trees can be made more flexible can be found in section VII.4.2.5, "Setting Covertype/Species Conversion Codes".

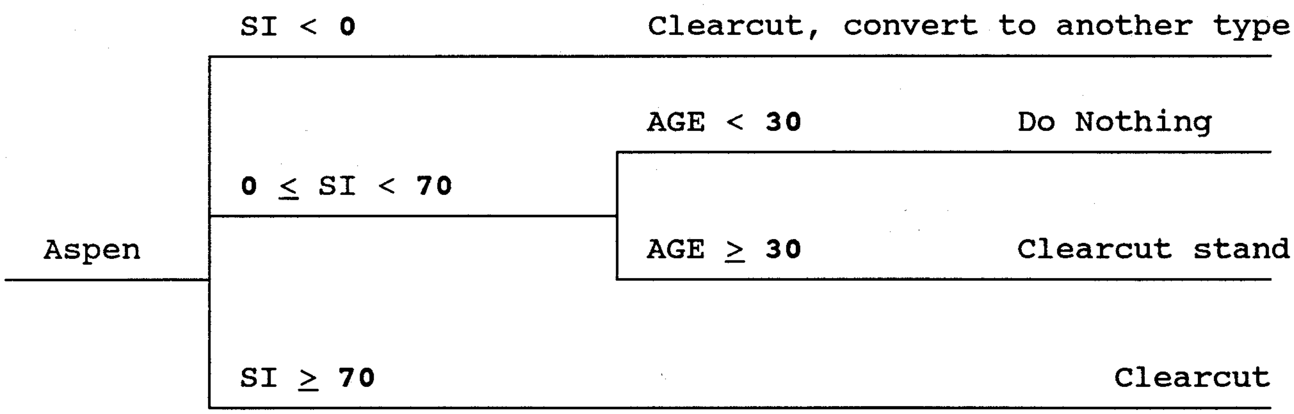


Figure 7.5. Example of "pruning" a decision tree so that the simulation will never recommend type conversion.

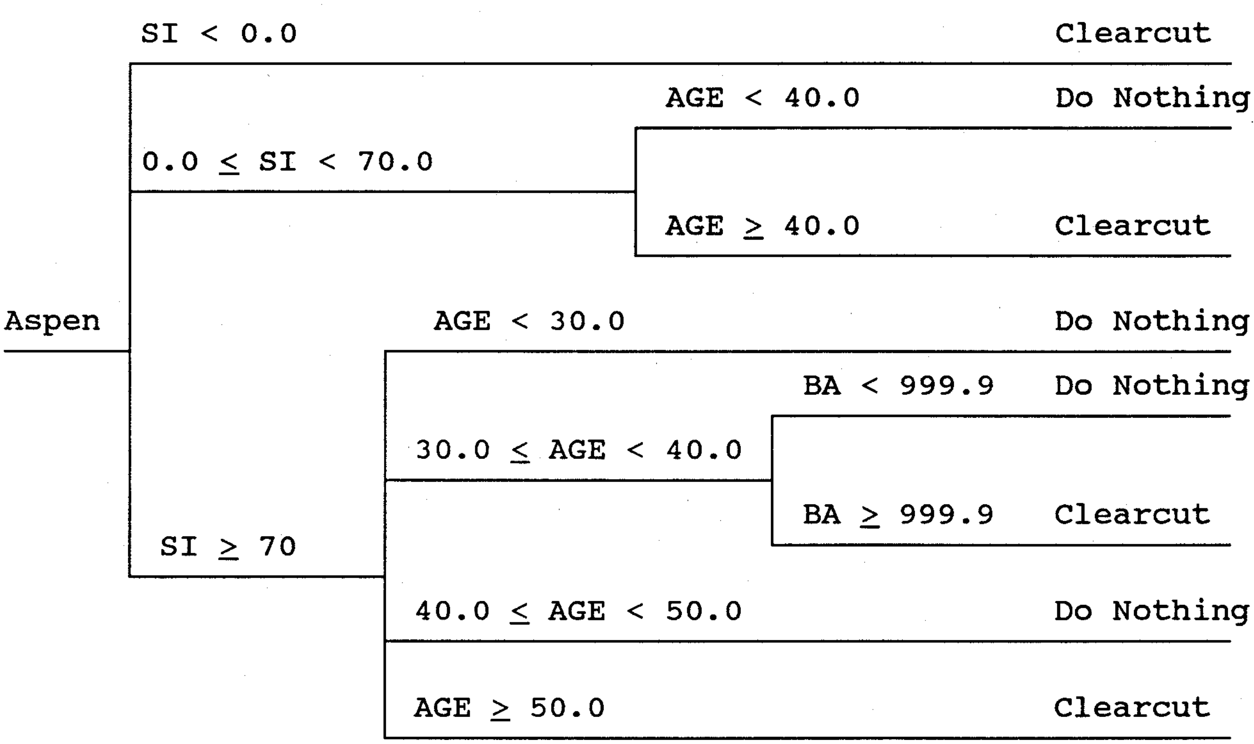


Figure 7.6. "Pruning" on the Aspen decision tree.

VII.4 THE SET RUN PARAMETERS SUBSYSTEM

DTREES is designed to run in a fully automated "batch" style. Once all the decision tree parameters have been set, the user uses the **Set Run Parameters** (**SRP**) subsystem to enter in all the other pertinent parameters needed by **DTREES** to run. This section will explain each component of the **SRP** system and how it is used to control the **DTREES** simulation module **RDTREES**. To enter into the SRP system, press <3> while in the **DTREES** Main Program menu.

The **SRP** menu will appear on the screen after a short loading period. The screen will appear as in figure 7.7, with the first menu option in reverse video. Use either the arrow keys or the numeric keys to highlight the option of interest and key press <SPACEBAR> to select that option.

```
                SET DTREES RUN PARAMETERS

   1. Display saved run parameters
   2. Change source file parameters
   3. Edit name of output files
   4. Change horizon/planning period length
   5. Change type/species code conversion files
   6. Edit timber size class codes
   7. Set File Path Specifications
   8. Set Miscellaneous parameters
   9. Escape this Dtrees menu.

 Use Numeric or Arrow keys to select option
 Press spacebar to execute the option
```

Figure 7.7. Set Run Parameters (SRP) main menu.

VII.4.1 Viewing Current Run Parameters

By pressing <1> <SPACEBAR> in the **SRP** main menu, you can display selected run parameters. A new menu will appear, as shown in figure 7.8 Once the menu in figure 7.8 appears, pressing numeric keys <1>, <2>, <3>, or <4> will allow you to see the corresponding **DTREES** parameters. Pressing <5> will return you to the main **SRP** menu. Pressing <9> <SPACEBAR> in the main **SRP** menu will terminate the **SRP** module execution and return you to the **DTREES** main menu.

```
          DISPLAY CURRENT DTREES CONTROL PARAMETERS

Press (1) to display:    Inventory file parameters
                         Output file names
                         Time control parameters
                         File path parameters
                         Modelling formulation

Press (2) to display:    Covertype conversion codes
                         Species conversion codes

Press (3) to display:    Size class parameters

Press (4) to display:    File start-up point

Press (5) to quit this menu
```

Figure 7.8. Display running parameters menu.

Figures 7.9 through 7.12 show examples of all the **DTREES** control parameters for a typical **DTREES** run. By pressing <1> the user will see the screen shown in figure 7.9. There are four boxes. The box on the upper left corner contains the source file and output file names. Moving clockwise, the box in the upper right-hand corner shows the time control parameters for each planning period, whether or not **DTREES** will update inventory data to the current year, and whether or not **DTREES** will simulate multiple sequences over the planning horizon. The box on the lower right-hand corner displays the paths where **DTREES** will search for the input files, where it will place the output files, and where it will search for the regeneration lists. Finally, in the lower left-hand corner the modelling formulation **DTREES** will use is displayed. This information will stay on the screen until any key press is made, at which point the display control parameters menu will reappear.

```
     Source File Names:
Source of input:
   Minnesota DNR Phase II
Main inventory file:
   phase2a.pro
File with NT/acre:       D
   Tree data in main file
     Output File Names:
Prescription File Name:
        prescrip.dat
Harvest File Name:
        harvest.dat
Residual File Name:
        residual.dat
```

```
MODEL FORMULATION: Model 2
 No projections past any
     final harvest
```

```
    Time Control Parameters
      EQUAL PLANNING PERIOD LENGTHS

         Number of Periods = 5
             Period Length = 10
          Planning Horizon = 50 years

Update Inventory data to current year?  YES

  DTREES will simulate multiple sequences
```

```
         DTREES FILE PATH SPECIFICATIONS
    Input Path for Data Files =
              (Current Directory)
    Output Path for DTREES =
                   C:\DATA\
    Path for Regeneration files =
                C:\DTREES\REGEN\
```

```
Press any key to continue...
```

Figure 7.9. DTREES Control Parameters. File, Path, Model Type, and Time control parameters displayed on this screen.

Pressing <2> in the display control parameters menu will display the covertype conversion codes and then the species conversion codes currently used by **DTREES** to convert inventory codes for covertypes and species to those recognized by **DTREES** and the RGROW growth projection system. The codes are displayed sequentially, when the screen is filled, **DTREES** will wait for a key press before continuing to display more codes.

CURRENT COVERTYPE CONVERSION CODES

Inventory Code	Inventory Type	DTREES Code	Decision Tree Used
1	Ash	12	Lowland Hardwoods
6	Willow	12	Lowland Hardwoods
9	Lowland Hardwoods	12	Lowland Hardwoods
12	Aspen	9	Aspen
13	Paper Birch	10	Paper Birch
14	Balm of Gilead	9	Aspen
15	Cottonwood	12	Lowland Hardwoods
20	Northern Hardwood	11	Northern Hardwoods
25	Walnut	8	Oak-Hickory
30	Oak	8	Oak-Hickory
40	Central Hardwoods	11	Northern Hardwoods
51	White Pine	3	White Pine

Figure 7.10. Covertype conversion codes as displayed by **DTREES**.

SPECIES CONVERSION CODES

Inventory Code	Inventory Species Group	GROW Code	GROW Species Group
1	Black Ash	11	Black Ash
2	American Elm	15	Elm
3	Silver Maple	13	Silver Maple
4	Red Elm	15	Elm
5	Rock Elm	15	Elm
6	Willow	12	Cottonwood
12	Quaking Aspen	25	Quaking Aspen
13	Paper Birch	26	Paper Birch
14	Balm of Gilead	30	Other Comm. Hardwoods
15	Cottonwood	12	Cottonwood
16	Bigtooth Aspen	24	Bigtooth Aspen
17	Hybrid Poplar	12	Cottonwood
22	Sugar Maple	18	Hard Maples

Figure 7.11. Species conversion codes as displayed by **DTREES**.

By pressing <3> in the display control parameters menu, the user will be able to observe the current timber size class codes used for each species group in the inventory. These codes determine, how each tree is assigned to a product class group, either sawtimber or pulpwood. They can be used to restrict certain species groups from a product class by setting the minimum DBH to a very large number (i.e. - 99.99). The minimum top diameters outside bark (DOB) are the smallest top diameters allowed for that species group.

TIMBER SIZE CLASSES

Species Code	Species Group Name	Sawtimber Min DBH	Sawtimber Min Top DOB	Poletimber Min DBH	Poletimber Min Top DOB
1	Black Ash	12.00	8.00	5.00	4.00
2	American Elm	12.00	8.00	5.00	4.00
3	Silver Maple	12.00	8.00	5.00	4.00
4	Rock Elm	12.00	8.00	5.00	4.00
6	Willow	12.00	8.00	5.00	4.00
12	Quaking Aspen	12.00	8.00	5.00	4.00
14	Balm of Gilead	99.00	12.00	6.00	4.00
21	Red Maple	12.00	8.00	5.00	3.50
23	Basswood	10.00	7.00	5.00	3.50

Figure 7.12. Timber size classes as displayed by **DTREES**.

By pressing <4> while in the display control parameters menu the screen shown in figure 7.13 will appear. This screen will display the identifier for the last stand processed or it will indicate that **DTREES** will start processing from the top of the inventory file.

SET STARTING POINT IN INVENTORY FILE

Your current setting for starting point is:

TOP OF FILE (default setting)

This run will start with the first stand in the specified inventory file.

Figure 7.13. Display file starting point screen

VII.4.2 Changing Source File Parameters

By pressing <2> <SPACEBAR> while in the main SRP menu, the menu screen shown in figure 7.14 will appear. You may then choose to input Minnesota DNR Phase II data <1>, Standard Dtrees input data <2>, or quit this control parameter editing procedure <3>.

```
              SELECT INVENTORY SOURCE

           1. Minnesota DNR Phase II
           2. Standard Dtrees Data
           3. Quit this menu

  Please push the number of you data source...
```

Figure 7.14. Select inventory source menu.

VII.4.2.1 Selecting Minnesota phase II data

By pressing <1> in the Select Inventory Source menu, you will be prompted for a file name. This file corresponds to the reformatted Phase II inventory data structure which consists of a single record per stand (Minnesota DNR Division of Forestry, 1988).

VII.4.2.2 Selecting standard DTREES data

By pressing <2> in the Select Inventory Source menu, you will be prompted for two file names. The first file contains stand level parameters such as Site Index, Age, Covertype code, and others. The second file must contain a treelist for each stand, including species code, DBH, and NT/acre or volume/acre value for each tree in the tree list. If the tree list file contains a volume/acre value rather than NT/acre, you must activate the disaggregation function by entering 0 (zero) (<0><ENTER>) at the prompt after inputting the name of the treelist file.

Table 7.1 contains the record structure for each file for both DNR Phase II and Standard **DTREES** data formats. Both are standard flat ASCII files.

NOTE!

```
Source files must have different root names. Extensions
can be identical, but the first 8 characters must be unique!
```

VII.4.2.3 Setting names of DTREES output files

By pressing <3> <SPACEBAR> in the main Set **DTREES** Run Parameters menu, the user can edit the names of the output files created by **DTREES**. **DTREES** outputs three related files described briefly below.

The PRESCRIPTION LIST FILE contains the list of alternative management sequences by stand, alternative, and period. It also contains some stand-level summary data such as stand age, stand size, residual and removed basal area. The default name for this file is PRESCRIP.DAT

FREELANCE FILE STRUCTURE DIAGRAMS HERE

The HARVEST LIST FILE contains, for each record in the PRESCRIPTION LIST FILE, a list of the volumes removed from the stand by species and rough product class. For non-harvest actions recorded in the PRESCRIPTION LIST FILE, there is no record in the HARVEST LIST FILE. The default name for this file is HARVEST.DAT.

The RESIDUAL LIST FILE is identical to the HARVEST LIST FILE in structure, but it contains a list of residual volumes by species group for each record in the PRESCRIPTION LIST FILE. For records in the PRESCRIPTION LIST FILE that have no merchantable volume, there is no record in this file. The default name for this file is RESIDUAL.DAT.

Figure 7.15 shows the **DTREES** screen associated with the changing of the names for these files. When the prompt for the file name appears, pressing <ENTER> alone will cause **DTREES** to insert the default name for that file into its parameter files.

SET DTREES' OUTPUT FILE NAMES

1. Prescription File Name: prescrip.a16
2. Harvest File Name: harvest.a16
3. Residual File Name: residual.a16

Press the number of the file name you wish to change (1,2, or 3)

After pressing <1> to change the PRESCRIPTION LIST FILE name...

SET DTREES' OUTPUT FILE NAMES

1. Prescription File Name: prescrip.a16
2. Harvest File Name: harvest.a16
3. Residual File Name: residual.a16

Enter the name of you prescription file below. This file contains the sequence of actions taken for each stand's management strategy.

REMEMBER! You must follow normal DOS naming conventions!

>> <<

The default file name for this file is Prescrip.dat

Figure 7.15. Set **DTREES** Output File Names.

Each of the output file names may be changed in this manner. The normal DOS naming conventions for files can be found in any DOS User's manual provided with the operation system software.

VII.4.2.4 Setting DTREES time parameters

By pressing <4> <SPACEBAR> in the main Set **DTREES** Run Parameters menu, access to changing the length of each planning period and the total planning horizon is possible. **DTREES** will allow for a maximum of 10 planning periods, each may be from 1 to 50 years in length. First the user will be asked if all the planning periods are of equal length. If the response is yes (use Y or y), then **DTREES** will ask for the length of each planning period, then the number of each planning period. These values are inputted by typing the numeric value (integers only, please) and then pressing <ENTER> **DTREES** will then display what you have entered and ask for confirmation. Pressing n or N will allow you to re-enter your values, pressing y or Y confirms your input and **DTREES** will store it in the time parameter file.

If all planning periods are not of equal length, the user must enter first the number of planning periods (1-10), then for each planning period, the user must enter its length in years (integer only). Again, to enter a value at the prompt, type in the numeric value and press the <ENTER> key to input the data. **DTREES** will then display what was entered an ask for confirmation from the user as described above. Upon confirmation the data is stored in the time parameter file.

VII.4.2.5 Setting Covertype/Species conversion codes

By pressing <5> <SPACEBAR> in the main SRP menu, the screen shown in figure 7.16 appears. The user may chose to edit covertype conversion codes <1>, species conversion codes <2>, both <B>, or return to the main SRP menu with a single keypress <Q>. (Note: **DTREES** is not case sensitive in this menu.)

```
1. Cover type conversion file
2. Species code conversion file

Which do you wish to modify? (1, 2, or Both or Quit)
```

Figure 7.16. Set Conversion Codes Selection Menu.

VII.4.2.6 Setting covertype conversion files

Setting the covertype conversion files is simply assigning each and every possible commercial forest inventory code to one of the 12 **DTREES** decision trees. While it is recommended that each inventory covertype is simulated under the decision tree that most closely corresponds_to the inventory type it is not required. Therefore, the user may find it advantageous to simulate the bulk of the aspen stands under the aspen decision tree, but for some aspen stands, the user may choose to use the birch decision tree, or even the red pine decision tree. **DTREES** will not convert the covertype, the conversion codes simply instruct **DTREES** as to which decision tree structure and critical parameter set to use to make a management decision at a particular point in time. This gives **DTREES** much added flexibility.

When editing covertype conversion codes, the user is prompted as to which inventory covertype code is of interest. Entering <0><ENTER> will return control to the main SRP menu. **DTREES** will then display the current covertype associated with that code, and ask the user if they wish to edit the covertype's name. Following that, **DTREES** will ask the user if they wish to change the **DTREES** decision tree to which the code is currently assigned. If the response is yes (<y> or <Y>), then **DTREES** will prompt the user for a new **DTREES** code (1-12). After the user enters this code (type in code then press <ENTER>), **DTREES** will display the covertype text and the **DTREES** decision tree text in red, and ask the user to confirm this pairing. Pressing <y> or <Y> will store the new pairing in the covertype conversion file. Pressing <n> or <N> will allow the user to enter a new **DTREES** decision tree code. Pressing <q> or <Q> will quit this function and return control to the main SRP menu or to the species conversion function if so selected previously in the set conversion codes selection menu.

VII.4.2.7 Setting species conversion files

This function assigns each inventory species group code to one of the 28 GROW species codes (Brand, 1981b). The original species code is always retained in all projections and in the final output. It is recommended that the user pair inventory species groups with the GROW species group that most closely corresponds to the inventory species group's growth and mortality characteristics.

The editing and pairing procedure for the species conversion codes is identical to that described above for the covertype conversion codes.

VII.4.2.8 Editing timber size class codes

By pressing <6><SPACEBAR> while in the main SRP menu, the user can edit size class codes for any inventory species group. The editing screen is shown in figure 7.17 First the user is prompted for the appropriate inventory species code.

When the sspecies code is entered (type in code then press <ENTER>), the current size class codes are displayed, as shown in figure 7.16. Pressing <1><ENTER> will display the following query below the last line on the screen:

```
Enter new minimum poletimber DBH:
```

at which you can now type in a new minimum DBH for poletimber and press <ENTER>.

EDIT SPECIES GROUP SIZE CLASS CODES

Enter the species group you wish to edit (0 to quit): 12

THE CURRENT SIZE CLASS CODES FOR: Quaking Aspen

1. Minimum Poletimber DBH 4.00	2. Minimum Sawtimber DBH 12.00
3. Poletimber Min. Top DOB 3.00	4. Sawtimber Min. Top DOB 7.00

Enter the size class you wish to edit (1-4, 0 to quit):

Figure 7.17. Edit screen for timber size classes.

Enter new minimum poletimber DBH:4.50<ENTER>

After you have pressed enter, the new value (4.50) will appear in the appropriate row and column, and you may proceed to edit another value. Pressing <4><ENTER> will cause **DTREES** to query:

Enter new sawtimber minimum top DOB:

Again, after typing in the new value and pressing <ENTER>, the new value is displayed on the screen. To escape entering a new value, and to quit this function, simply press return at the appropriate prompt. By pressing <ENTER> or entering zero (<0><ENTER>) at the size class prompt, you will return to the species code selection prompt. Pressing <ENTER> or entering zero here (<0><ENTER>) will return you to the main SRP menu.

As mentioned before, by entering a very large value for a minimum DBH, you can prevent that species from ever being utilized for that product. For example, if you know that black locust is never utilized for sawtimber, enter 99.99 for the minimum DBH. All harvested locust volume will then be assigned to residual wood and pulpwood.

VII.4.2.9 Setting file path specifications

Pressing <7><SPACEBAR> in the main SRP menu allows the user access to this function. With this, you can have your output files, **DTREES** program files, regeneration list files, and your output files all on separate directories or even separate disks or machines (if networked).

The editing procedure is identical to that used to edit the output file names (see section VII.3.3) with one important exception. All paths must start with the drive letter and end with a backslash (\) character to insure proper functioning within **DTREES**. For example, if output files are to be sent to the directory PLAN on drive E, the path specified to **DTREES** must look like this:

E:\PLAN\

Should you wish to send the output to a subdirectory named D_OUT under plan, the path must look like this:

E:\PLAN\D_OUT\

Input file paths and the regeneration file paths must be expressed in a similar fashion. When prompted for a new path, pressing enter alone <ENTER> sets the default, which is no path. **DTREES** will then look for the file under the current drive and directory. Be sure to check these parameters before you execute the RDTREES.EXE module!

VII.4.2.10 Setting miscellaneous control parameters

Pressing <8> <SPACEBAR> while in the main SRP menu allows the user access to the **DTREES** parameters shown in figure 7.18. When in this menu, the numeric keys 1-5 active and act as toggles for the first three functions. Pressing <1> will toggle the inventory update function on/off. Pressing <2> will switch the modelling formulation between model I and model II. A special section below explains the important difference between chosing the model I versus model II option. Pressing <3> will toggle the number of alternatives generated at each decision node between 1 and 2. When only one alternative is generated, **DTREES** will produce only one management sequence per stand, and it will conform to the critical parameters entered in the View/Edit subsystem (see section VII.3).

Pressing <4> will allow you to enter a stand identifier which corresponds to the last processed identifier in the inventory input files **DTREES** will execute upon. In other words, **DTREES** will search sequentially through the input files until it finds the records with this identifier. **DTREES** will start simulation with the <u>next</u> stand in the inventory files. If an identifier is listed on the screen, then pressing <4> will move the start-up point to the top of the current input files. Pressing <5> will escape this function and return control to the main SRP menu.

SET MISCELLANEOUS PARAMETERS

Update Inventory to current year: YES

Current DTREES modelling formulation: Model 2

Number of alternatives generated at each decision node: 2

File start up point: Top of file

To make the following changes...

Turn off inventory update function	Press 1
Change to model 1 formulation	Press 2
Generate only silvicultural management sequence	Press 3
Input last stand entered	Press 4
Escape this menu	Press 5

Figure 7.18. Set Miscellaneous Control Parameters Menu.

VII.5 MODEL I VERSUS MODEL II

DTREES supports development of management alternatives in the format of either Model I or Model II as defined by Johnson and Scheurman (1977). The type of formulation is of importance when the user proceeds to utilize **DTREES** alternatives in the **DUALPLAN** stand management scheduling program. **DUALPLAN** supports the Model II formulation because of the reduced space and memory requirements of that formulation. If **DTREES** is used as a stand-alone module, the user may chose either Model I or Model II. Chosing Model I would have the advantage that each alternative generated by **DTREES** refers to a unique stand that exists throughout the planning horizon as a separate unit. In Model II, stands are merged after the first clearcut, based on user-defined bare-land classes.

VII.5.1 Creating "Bare Land" Stands for Model II

In the Model II harvest scheduling formulation, stands of the same productivity classes which are harvested in the same period are merged into one stand for future simulation efforts. It is for this purpose that BARELAND.EXE creates a list of "bare land" stands which can then be run through **DTREES** and are later linked to the original inventory in the harvest scheduling model. When <4> is pressed in the **DTREES** Main Program Menu, the BARELAND.EXE program screen appears (figure 7.19). Pressing any key will then activate BARELAND's control menu, as shown in figure 7.20.

BARELAND will set up stands for each covertype over a range of site indices specified and create stands under a **DTREES** standard input file format (not Minnesota DNR Phase II format). Within the site index range specified, the user can specify any number of productivity classes. The controls for BARELAND are quite easy. Pressing <1> allows the user to specify the number of productivity classes that will be created for each covertype within the specified site index range. The site index range is modified by pressing <2>, at which point BARELAND will prompt the user for minimum and maximum site index values to define the range. Pressing <3> or <4> will allow the user to change the names used for these "bare land" input files. Pressing <5> executes **BARELAND** and creates the files as specified. Pressing <Q> exits the **BARELAND** program and returns control to the **DTREES** main menu.

```
          SET BARE LAND CLASS INITIAL SETTINGS

                  CURRENT SETTINGS

  1. Number of Productivity Classes for Each Covertype:  4
  2. Range of Productivity Classes:  35  to  80
  3. Name of bare-land stand file:  BARE1.STD
  4. Name of bare-land tree list file: BARE2.TRE
  5. Create new bare-land files
       Press Key for change (1-5) or Q to Quit
```

Figure 7.19. BARELAND control menu.

```
          SET BARE LAND CLASS INITIAL SETTINGS

                  CURRENT SETTINGS

  1. Number of Productivity Classes for Each Covertype:  4
  2. Range of Productivity Classes:  35  to  80
  3. Name of bare-land stand file:  BARE1.STD
  4. Name of bare-land tree list file: BARE2.TRE
  5. Create new bare-land files
       Press Key for change (1-5) or Q to Quit
```

Figure 7.20. BARELAND control menu.

It is important to note that the current verision of **DUALPLAN**, the harvest scheduling model, will only accept problems formulated using Model II conventions. Therefore it is necessary for users to user BARELAND.EXE to create "bare land" stands, simulate them in **DTREES**, and link them to the initial stand prescriptions in **DUALPLAN**.

VII.6 THE RDTREES MODULE

RDTREES.EXE is the run time simulator of the **DTREES** system. **RDTREES** performs the actual simulation of multiple harvesting sequences over time and creates the output files which are then used to create economic alternatives and then fed into the harvest simulator, **DUALPLAN**. **RDTREES** is activated by pressing <5> in the main **DTREES** menu. This should be done only after all decision tree and control parameters are set correctly for the **DTREES** run. When key <5> is pressed, the **RDTREES** module will load and begin its run. The **RDTREES** screen will appear with certain information about the current state of the simulation. The **RDTREES** screen is shown below in figure 7.21.

The **RDTREES** screen displays some information about the stand currently being simulated and the state of that simulation process. Stand information includes the original inventory stand identifier, the inventory covertype code, the date of the inventory data, the stand size in acres, the stand site index, and the stand's initial age (not current simulation stand age). Facts about the simulation include the **DTREES** decision tree under which the stand is being simulated, the current planning period which **DTREES** is simulating, and the decision node **DTREES** is working from. For a detailed explanation of these desision nodes, see Pelkki, (1988). **DTREES** also displays how many stands it has simulated already in the current run of the **RDTREES** module.

```
          DTREES IS RUNNING, CURRENTLY ON STAND:     23
                 Working on Planning Period:  1
                 Working from decision node:  5

                                          Model 2
  Stand Identifier:                            Inventory Year
    3105522w150452310061                            85

  Inventory Covertype code = 51

  DTREE Covertype = White Pine

  Acres = 40
  Site Index = 75
  Initial Stand Age = 81

              USE F1 KEY TO STOP RUN AFTER THIS STAND
                 USE F2 KEY TO STOP RUN IMMEDIATELY
```

Figure 7.21. RDTREES Display screen.

There are two more important keys to remember while the **RDTREES** system is executing. The F1 key (one of 10 or twelve function keys on your keyboard) will, when pressed, stop the execution of the **RDTREES** module when the current stand is finished processing. The F2 key, on the other hand, will terminate the running of the **RDTREES** module immediately, without updating any work done to the current stand. For example, if you press the F1 key, **RDTREES** will finish processing the current stand, update the output files and return to the main menu. If F2 is pressed, **RDTREES** erases all work done on the current stand and returns you immediately to the **DTREES** main program menu. In either case, the processing completed on previous stands is already saved and **RDTREES**, when reactivated, will resume processing with the first unprocessed stand. The F1 and F2 keys are designed to allow the user to escape **RDTREES** and process large input files in a piecemeal fashion and allow the computer on which **DTREES** is installed to be used for other purposes when necessary.

VIII. MODELLING SYSTEMS USED IN DTREES

The following is a more detailed description of the models and assumptions used by **RDTREES** in simulating the alternative harvest sequences. More details can be found in a Master's thesis by Pelkki (1988).

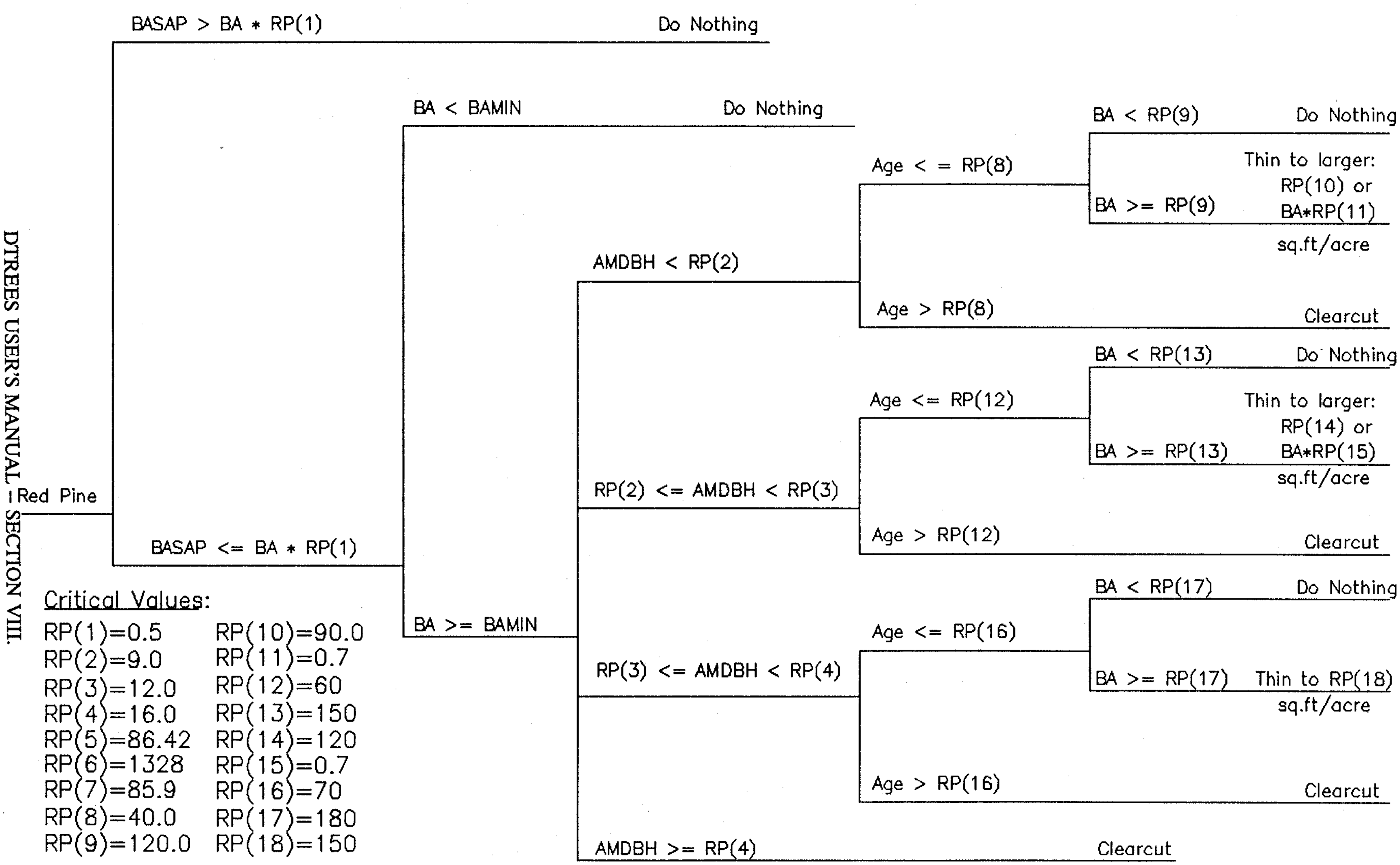
VIII.1 DECISION TREE SYSTEM

In order to make silvicultural evaluations, some type of expert knowledge must be encoded into **DTREES** in a decision subsystem. This decision making system must be automated in order to accommodate the batch processing style of **DTREES**. Recent work in simplifying the silvicultural decision making process has been done in the form of simple decision trees (Brand, 1981a). These decision trees were developed to be used in a computerized format in the STEMS growth-projection system. They are based on silvicultural guidelines found in manager's handbooks for Lake States' covertypes.

Figure 8.1 show an example of a decision tree for the red pine covertype. The decision tree uses stand-level characteristics to evaluate a stand and determine the appropriate harvest action at a given moment. The decision trees are aptly named. Starting at the far left of the tree (root) the stand is evaluated at each junction of branches until it reaches the far right of the tree, arriving at a harvest action. At each junction a different stand characteristic is compared to the critical values, and one of the paths is taken to the next decision junction. The critical values are the governing factors in the determination of a harvest prescription. It should be pointed out that the decision tree as shown in Figure 8.1 will only produce one management action for a given stand at a point in time (decision node). The mechanism for arriving at a different ending branch in the decision tree will be discussed later.

Decision trees were selected for **DTREES** for several reasons. They are easily understood by silviculturalists and foresters, and they have a clear and simple logic. Decision trees are easily implemented in a computer program, and provide a quick evaluation of the stand at a given point in time. Finally, modifying the critical values and simple structural modifications are very easy to make. For example, in the aspen decision tree, to prevent the conversion of any aspen stands to red pine, simple alter the critical value at that junction to equal zero. Since no aspen stand will have a site index of zero, the conversion prescription will never be made.

The decision tree, as shown in Figure 8.1 will only produce a single harvest alternative for a stand at a given point in time. If the first alternative is to "Do Nothing", the system, in order to produce a second alternative, iterates each critical value both positively and negatively in 5% increments until a second, unique harvest determination is made. If the first alterative is any harvesting activity, then the second alternative is assumed to be "Do Nothing". This assures that harvesting alternatives for each stand's set of management sequences will be spread over the planning horizon. When a stand has not reached a merchantable average diameter, or when a stand is still in the regeneration phase of its rotation, only one harvest alternative (do nothing or regenerate) will be provided by the decision subsystem.



Critical Values:

RP(1)=0.5	RP(10)=90.0
RP(2)=9.0	RP(11)=0.7
RP(3)=12.0	RP(12)=60
RP(4)=16.0	RP(13)=150
RP(5)=86.42	RP(14)=120
RP(6)=1328	RP(15)=0.7
RP(7)=85.9	RP(16)=70
RP(8)=40.0	RP(17)=180
RP(9)=120.0	RP(18)=150

BAMIN = RP(5)+[QMDBH*RP(6)/1000]−[NT*RP(7)/1000]

Figure 8 . 1 Red Pine Decision Tree

VIII.2 GROWTH PROJECTION SYSTEM

Since the decision trees can only evaluate a stand at a given point in time, **DTREES** must have some method of projecting stands forward in time to the next planning period. For this purpose, a microcomputer growth-projection system (**RGROW**) based on the **GROW** subroutine (Brand, 1981b) has been adapted from **RUNGROW** (Eriksson, Ek and Weber, 1986).

Although obtaining the necessary tree-list data may require some extra data manipulation, several factors made the use of such an interface indispensable. The current trend is towards distance-independent growth models which provide the best projections and unfortunately have the most demanding input data requirements. The use of tree lists allows easy simulation of harvest activities and permits more sophisticated selection harvest methods to be simulated as well. The use of the **GROW** subroutine meant that any combination of species and stand structure could be modelled (Brand, 1981b and Holdaway, 1983). This growth-projection system was already adapted for microcomputer use in **RUNGROW**, and only required minor modifications which allowed it to be integrated into **DTREES**.

The advantages in using **RGROW** are numerous. Since the **GROW** subroutine is part of the STEMS growth-projection system (Belcher, et al., 1982), updates in the growth and mortality coefficients will be easily installed into **RGROW** and **DTREES**. This is of great value, as work is currently being done that would permit this growth-projection system to model ingrowth into a forest stand[1]. Also, the volume yields presented by **DTREES** should then be reasonably similar to volumes produced by STEMS. Also, this particular growth projection system is widely used and accepted in the Lake States (Holdaway, 1983 and Ffolliot et al., 1985). Projection times for **RGROW** are less than two seconds for an abbreviated tree list over a 10-year period on an IBM PC-AT class computer. Performance of several **DTREES** components will be discussed in a later section. However, the time required to invoke and run the growth simulator does not, at this time, present a major problem in the matrix generating process.

It should be noted that to keep data requirements and processing time to a minimum, the tree lists used by **DTREES** are aggregated. The entire stand must be represented with 10 or less trees in the tree list. It has been shown that aggregate or "short" tree lists do not result in a great loss of precision (Ek, et al., 1985). More recent work has supported these findings and improved methods of condensing or aggregating tree lists are being developed[2].

However, their are some disadvantages to using this growth projection model. The system is slower than look-up tables (Ek, Hoganson, and Hahn, 1984). Also, in cases similar to that encountered when using the Minnesota DNR Phase II Intensive database, the approximated tree list may not adequately represent the stand. Because this growth system does not deal with trees of less than 1.0" diameter properly, a separate regeneration function is required. Also, Brand (1981b) noted that this growth projection system projects diameter growth well in the lower diameter classes, but over predicts diameter growth for large diameter classes.

The projection system performs quite well for the most part, but there are some indications that the **GROW** system does not provide sufficient mortality for the aspen covertype when interfaced

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[1] Work in progress by Stephen Shiffley, USDA Forest Service North Central Forest Experiment Station, St. Paul, MN 55108.

[2] Stegemoeller, Katie. Master's thesis, in progress. The University of Minnesota College of Natural Resources, St. Paul, MN 55108.

with the aspen regeneration system. The projected volumes and stand characteristics shown in Table 8.1 are taken from an actual **DTREES** run, on site classes 60 and 79 aspen stands.

Table 8.1. Aspen stand regeneration and growth data.

Site Class	Parent Stand BA	Stand Percent Aspen	Stand Age	Number of Stems per acre	Average DBH	Cubic Foot Volume
The following are DTREES projections:						
60	90	63%	2	6634	0.0	0
			10	4073	1.18	0
			20	1859	2.47	0
			30	982	3.87	1202
			40	776	5.20	1518
79	199	70%	2	4414	0.0	0
			10	2722	1.73	0
			20	1325	3.45	1375
			30	1041	4.7	1666
			40	814	5.8	2231
The following is from Ek and Brodie (1975):						
60	N-G	N-G	2	5000	0.2	0
			10	3221	1.3	0
			20	1605	2.6	147
			30	N-G	N-G	N-G
			40	560	5.4	1411
80	N-G	N-G	2	5000	0.3	0
			10	2870	1.7	1
			20	1304	3.5	532
			30	N-G	N-G	N-G
			40	431	7.4	3074

From this data we can see that for the stand, once projections are made with **GROW** (from year 20 to end of rotation), mortality falls off and so does diameter growth. This reduces the total volume projected. This disjoint growth curve is to be expected when merging two independently developed models. Hopefully, when regeneration is handled within **GROW**, this will be less apparent. The volumes as shown in Table 8.1 are fairly representative of the aspen covertype for those site classes and ages.

Another possible cause of the disjoint growth curves for aspen is the fact that the Ek and Brodie model returns only one diameter average for all trees. The mortality function is known to be nonlinear, with mortality occurring most heavily in the smaller diameter classes. Thus, when all trees are averaged, the mortality function of **RGROW** cannot properly model the mortality of the lower size classes. This problem may be solved adequately by providing 3 trees per species, each representing a different size class component for that species.

In Table 8.2 are the yield data for red pine plantations on site classes 60 and 80 that were regenerated and grown over a 50 year planning horizon. The data assumes a 2-1 planting stock and an initial density of 1210 stems per acre.

Table 8.2. Red pine regeneration and growth data.

Site Class	Age	NT/acre	Avg. DBH	Volume/acre
60	3	1210	0	0
	13	918	2.2	0
	23	918	4.7	1103
	33	909	6.1	2012
	43	899	7.0	2729
	53	887	7.6	3250
80	3	1210	0	0
	13	918	2.9	0
	23	918	5.3	1474
	33	911	6.7	2496
	43	901	7.5	3201
	53	883	7.9	3540

All ages end in "3" because seedlings are 3 years old and projection periods are 10 years.

From age 23 on, **RGROW** handled diameter growth and projection. It should be noted that the **DTREES** volumes reported are gross cubic foot volume per acre, calculated by Stone's equations (Hahn, 1984). The volume calculation procedure will be discussed in more detail later. Comparison of the volumes given by **DTREES** with those in empirical yield tables for Minnesota (Hahn and Raile, 1982) shows that for the red pine covertype, **RGROW** provides an acceptable model, though perhaps not over predicting the diameter growth of red pine in the older age classes.

VIII.3 REGENERATION SYSTEM

The regeneration system used by the current version of **DTREES** differs considerably from the intial version. **DTREES** originally used two empiracal regression models to calculate NT per acre for pure red pine and aspen stands. These models, however, did not allow for mixed stands or certain covertypes. In order to develop a regeneration system which would cover all major covertypes in Minnesota, the Phase I FIA data for all plots in with average age 10 to 20 were aggregated by covertype and average "regeneration lists" were developed. For more information on the regeneration system, see chapter VI, which discusses the ADDREGEN system in detail.

VIII.4 HARVESTING SYSTEMS

Several harvesting systems are currently employed in **RDTREES**. They include:

1. Do nothing
   - No harvest of any tree on stand
2. Clearcut
   - Cut and remove every tree
3. Random thin
   - Randomly remove to a specified basal area
4. Diameter section cut
   - Randomly thin within certain diameter or product classes. (i.e. - Thin basal area of sawtimber to 70 $ft.^2$ per acre.)
5. Shelterwood regeneration harvest
   - Thin from above to a certain basal area, then remove residual overstory in 10 years.

The basic method of selecting and executing these systems is discussed in Pelkki (1988).

VIII.5 VOLUME EQUATIONS

VOLCALC is a subsystem within **RDTREES** that calculates gross cubic foot volume given a simple tree list. VOLCALC calculates a per acre volume by species and product class, and passes this information back to an update function which records this information in both residual and harvest data files which is linked to the final decision matrix when that is formulated. All volumes shown in previous tables were calculated with this module unless otherwise noted.

VOLCALC uses Stone's equations for calculating volume (Hahn, 1984). These require the following information: (1) diameter at breast height, (2) merchantable height, and (3) diameter outside bark at merchantable height to estimate gross cubic foot volume from a 1 foot stump to the merchantable top for an individual tree. These are the same equations used by STEMS for its gross volume calculations. The tree list that **RGROW** uses is well suited for these equations. Diameter at breast height and number of stems per acre is provided by **DTREES**. The user has inputted merchantable top diameters in the module "Set Run Parameters". Merchantable height is calculated from a height-estimation model (Ek, et al., 1981) which uses the parameters: (1) diameter at breast height, (2) site index, (3) merchantable top diameter outside bark, and (4) stand basal area. All trees with a diameter greater than the user specified merchantable top diameter for pulpwood have a volume estimate calculated. This assures that all stand volumes are recorded, even though the trees may not be harvestable. Volume per tree is calculated and then multiplied by the number of stems per acre to obtain volume per acre. This is then tallied by product class and species type. Currently, only three product classes, pulpwood, sawtimber and biomass(volume above merchantable pulpwood top diameter) are provided. User inputted product size class limits determine the product category into which each tree will be recorded.

The advantages to using these models is the fact that the equations used are found in the STEMS growth projection system. Any updates or improvements in the volume equations for the STEMS system can be incorporated directly into VOLCALC. Also, the use of common height and volume equations provides for a measure of compatibility between the two systems.

VIII.6 TREE LIST EMULATOR WITH MINNESOTA DNR PHASE II DATA

The Minnesota DNR Phase II database does not have a tree list associated with each stand in an automated format. In order to obtain a tree list, the original inventory forms would have to be obtained and a tree list tallied from these forms. This task would be far to time consuming and costly to perform for thousands upon thousands of stands, so an alternative approach was used. The Phase II database contains a list of from 1 to 5 "characteristic" trees for that stand. They represent the dominant tree species in that stand. Associated with each characteristic tree is an average diameter and a measure of volume per acre for that particular tree. In the Phase II database all trees are recorded in board feet or cords per acre. These are converted to cubic foot volumes, using the following conversion ratios:

1000 Board Feet = 200 cubic feet
1 cord = 79 cubic feet

From an independent regression equation, an estimate of total number of trees per acre is obtained. The data contained in the individual characteristic trees is then used to disaggregate the total number of trees per acre and allocate tree expansion factors or multipliers to each characteristic tree. The result is a "tree list" that is used by **DTREES** for processing.

The method of disaggregating the total NT into its species components is done through a simple volume-diameter ratio. It is assumed that a the relationship between tree diameter and tree volume can be expressed in the following manner:

$$RVD_i = V_i/DBH_i^2$$

$$(RVD_i/SRVD) * NT = NT_i$$

Where:

- V_i = volume per acre for tree_i
- NT = total number of trees/acre in the stand
- RVD_i = ratio of volume to diameter for tree_i
- SRVD = summation of all RVD_i for this stand
- NT_i = number of trees/acre for tree_i

Each NT_i is then written to a tree list with associated tree diameter and species code. This is the basic tree list which **RGROW** requires to make its projections.

The formulation of these "characteristic" trees in the Minnesota Phase II database is of importance, because the tree list is based on these trees. The procedure is given in the Forest Survey Manual, Phase II Intensive Inventory (State of Minnesota Department of Natural Resources, Forestry Division). All species that are of merchantable size are recorded, up to a maximum of 5 species or species-groups, by product type. If a species or species-group has been tallied as having both pulpwood and sawtimber volume, it requires two entries in the database. If more than 4 species or species groups have merchantable volume, the 4 predominant species are recorded, and all minor species and their volumes are recorded as the fifth characteristic tree, and given the species code corresponding to miscellaneous species.

Though this method does record all merchantable tree species and the corresponding volumes, the method has several problems. The aggregation of all minor species into a single miscellaneous species-group class means that the species groups entered into this class are of relatively low importance. While quite often this may be the case, it would be far preferable to have those species represented individually in the tree list so that any possible impact on the prescriptions and final optimization runs could be modeled. This data recording problem can defeat the logic behind some of the decision trees for the covertypes, northern hardwoods, spruce-fir, and white pine, which have different branches based on stand composition. Also, when all minor species are aggregated in this fashion, the growth simulator (**RGROW**) cannot accurately predict growth, since species-specific information is no longer available.

APPENDIX I.

Example of DTREES Input and Output:

DTREES INPUT:

Inventory Stand:

Good Site Aspen
Site Index = 75
Basal Area Per Acre = 146 sq. ft.
Age = 48 years
NT/Acre = 198
Arithmetic Mean DBH = 11.31
Quadratic Mean DBH = 11.62
Stand Inventoried in 1985

Tree list for stand:

Species	DBH	NT/Acre
Trembling Aspen	12.8	140
Trembling Aspen,	9.7	35
Balsam Fir	4.7	23

Planning Period Parameters:

Period 1 - 5 years
Period 2 - 5 years
Period 3 - 10 years
Period 4 - 10 years
Period 5 - 20 years

DTREES OUTPUT:

1. The Prescription File

Alternative	Planning Period	Action
1	1	Clearcut
	2	Regenerate
	3	Regenerate
	4	Do Nothing
	5	Do Nothing
2	1	Clearcut
	2	Regenerate
	3	Regenerate
	4	Do Nothing
	5	Thin stand

2. The Harvest Output File

Alternative	Period	Species	Harvested Gross Cubic Foot Volumes/Acre Chipped	Pulpwood	Sawtimber
1	1	T. Aspen	713	888	3158
		B. Fir	40	0	0
2	1	T. Aspen	713	888	3158
		B. Fir	40	0	0
	5	T. Aspen	55	259	46
		P. Birch	22	57	2
		B. Gilead	9	33	1

3. The Residual Output File

Alternative	Period	Species	Residual Stand Gross Cubic Foot Volumes/Acre Biomass	Pulpwood	Sawtimber
1	3	T. Aspen	205	139	5
		P. Birch	24	25	1
		B. Gilead	14	9	1
		B. Aspen	.2	.3	.5
	4	T. Aspen	187	873	154
		P. Birch	74	189	4
		B. Gilead	32	114	4
		B. Aspen	1	1	2
	5	T. Aspen	354	1401	586
		P. Birch	111	318	154
		B. Gilead	66	245	27
		B. Aspen	1	1	3
2	3	T. Aspen	205	139	5
		P. Birch	24	25	1
		B. Gilead	14	9	1
		B. Aspen	.2	.3	.5
	4	T. Aspen	187	873	154
		P. Birch	74	189	4
		B. Gilead	32	114	4
		B. Aspen	1	1	2
	5	T. Aspen	288	956	666
		P. Birch	109	228	137
		B. Gilead	56	211	21
		B. Aspen	1	1	3

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