

REDPTHIN: A Red Pine Yield Model with Thinning Options

User's Manual

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INTRODUCTION

REDPTHIN Version 5.0 is a menu-driven computer program for personal computers that simulates the growth and yield of thinned and unthinned even-aged stands of red pine. One of the program options is the derivation of optimal thinning schedules for red pine plantations in the Lake States. The optimal schedules maximize total cubic foot volume production for any initial stand condition of age, site, and basal area stocking. These optimal schedules are derived via a special dynamic programming algorithm that the authors have developed (Chen, Rose, and Leary 1980). User specified thinning schedules can be simulated. Optimal biological rotation age and mean annual increment can be derived from the output table.

REDPTHIN is written in Microsoft Professional Basic Version 7.1 for application on the IBM personal computer and its compatibles. These computers must have at least 175K of available RAM to run **REDPTHIN** and 175K RAM to run the graphing program **THINGRAF** called by **REDPTHIN**. The amount of available RAM is defined as the total amount of RAM in your computer minus the amount allocated to DOS and any utility programs that may be installed. To use the program's graphics output option, a graphics card is required. A color monitor is preferable to a monochrome display with a graphics card. Finally, it requires DOS (Disk Operating System) version 3.0 or later, and the **REDPTHIN** diskette.

Program updates: Users will be notified of any major changes made to the **REDPTHIN** program. Request for modifications of **REDPTHIN** to fit a particular user's need will be handled on an individual case basis.

Disclaimer: Although all software on the **REDPTHIN** diskette has been extensively tested and checked for accuracy and, to the best of the authors knowledge, contains no errors, the authors do not accept any responsibility for the consequences of any errors that do arise. The authors would appreciate having any errors or problems brought to their attention.

INSTALLING REDPTHIN

Program protection: As a first step, the user should backup the **REDPTHIN** diskette. To do this the user should format a new diskette and copy all files on the **REDPTHIN** diskette to the new diskette. Copies should only be made for backup purposes. Put the program disk away in a safe place and use the working copy for your applications. Running the program from a hard disk will make the program run much faster. The user must transfer all files contained on the program diskette to any directory on a hard disk using DOS or the **SETUP** program supplied with **REDPTHIN** as described below.

REDPTHIN can be installed either by using DOS, or by using the **SETUP** program included on the program disk. Both procedures are described below.

Using DOS

1. To copy the program to a hard disk, create a program directory **REDPTHIN** with two subdirectories **DATA** and **OUTPUT** on a selected drive, e.g., C on your computer hard disk using the following DOS commands:

```
CD C:\
```

MKDIR C:\REDPTHIN
CD REDPTHIN
MKDIR DATA
MKDIR OUTPUT

2. Go to the A drive by typing **A:** and then put the REDPTHIN program disk in drive A, type **COPY A:*. * C:\REDPTHIN** and press **<ENTER>** to start the copy procedure.
3. **COPY A:\DATA*. * C:\REDPTHIN\DATA** and press **<ENTER>**
4. Go to the REDPTHIN directory by typing **C:\REDPTHIN**
5. You can run program by typing **REDPTHIN**

Using SETUP Program

A generic installation program **SETUP** on the program diskette can be used also to install the this and other programs developed by the author and all necessary files to any specified hard disk. The advantage of using **SETUP** over the DOS procedures described above is that **SETUP** will automatically create the necessary subdirectories **DATA** and **OUTPUT**. Simply insert the program diskette in a drive, type **<SETUP>** and follow the simple instructions on the screen. The proper files will be copied to the hard disk. Drive "A" is the default input drive, but the system will determine from which drive the **SETUP** program was activated. The default destination drive and directory is **C:\REDPTHIN**. The **SETUP** program itself will not be saved to the hard disk. After an opening screen the user will see a list of install options:

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General Software Installation Program

Version 4.0
June 1998

PROGRAM INSTALL OPTIONS

1. Install REDPTHIN Version 5.0
2. Exit Install

Use Numeric or Arrow Keys to select option
Press <Enter> to execute the option

Select option 1 to install REDPTHIN. A screen with 4 options appears. If the default destination drive is acceptable to the user, option 3, Install REDPTHIN, can be directly executed. If the user wants a different destination directory, option 2 would be executed first, which will require the user to input a new path. If that path does not exist, program **SETUP** will make the directory and a **\DATA** and **\OUTPUT** subdirectories first.

REDPTHIN INSTALLATION PROGRAM

DEFAULT INPUT DRIVE FOR REDPTHIN FILES: A:\
DEFAULT DESTINATION DRIVE FOR REDPTHIN FILES: C:\REDPTHIN

- (1) Change input drive/directory for REDPTHIN files...
- (2) Create destination drive/directory for REDPTHIN files...
- (3) Install REDPTHIN as specified...
- (4) Exit the installation program...

Use Numeric or Arrow Keys to select option
Press <Enter> to execute the option

Option 3 will copy the appropriate files into the destination drive and subdirectories. After the installation is completed, the following message will appear:

REDPTHIN program has been successfully installed in
The created directory C:\REDPTHIN
Press a key to continue...

To run REDPTHIN, simply type <REDPTHIN> from the
created directory C:\REDPTHIN
Press a key to continue...

If you run the program from a diskette in drive A, go to the A > prompt, type **REDPTHIN** and then press the <ENTER> key. Do not cover the write protect notch on your working copy disk if you want the program to save data files and write output files to the disk during program operation. If you write protect your working disk, you will need access to another drive to save data and program outputs. To run REDPTHIN from a hard disk, you simply type **REDPTHIN** from the directory in which the program files reside.

After the program install or if the "Exit Install" option was chosen, the user can chose to review information on other forestry decision software developed by the author.

Do you want information on other available programs?
Yes No

By answering "yes" to the next prompt, a list of available software programs is displayed. The user can then review information on a program by highlighting the program with the cursor and by using the <Enter> key. The user can scroll through the information or exit by using the <Esc> key.

INFORMATION ON AVAILABLE SOFTWARE

1. ACES Version 8.5
2. ACESDB Version 4.0
3. BIAPREP Version 3.0
4. DNRPREP Version 1.5
5. WDNRPREP Version 2.5
6. ACESREDP Version 5.0
7. REDPTHIN Version 5.0
8. CASH Version 7.5
9. DTREES Version 3.5
10. MEADPREP Version 1.0
11. MEADREDP Version 1.0
12. RPSIM Version 1.5
13. LPPREP Version 1.5
14. EXIT SETUP PROGRAM

Press <Enter> to execute the option
Use Numeric or Arrow Keys
to learn more about program

If for example line 1 were selected, information on program ACES would be displayed.

ACES Version 8.5 OVERVIEW

ACES is a user-friendly microcomputer program written for the IBM personal computer and IBM compatibles in Microsoft BASIC. These computers should have at least 280K of available RAM memory to run ACES and ACESGRAF. ACESGRAF alone can be run with 180K RAM.

ACES calculates allowable cuts for even-aged forest inventories according to area and several volume control methods. It allows study of the impact on growing stock volumes, growth, and harvest volumes produced when various standard cut determination methods are applied to the forest. It is assumed that the user can divide the forest into a finite number of management units. The program is currently dimensioned to handle up to 1000 stands. In the simulation, these stands are grown according to a normal or average yield function adjusted by the stocking percent of the subject stand. Stands maintain their identity throughout, but new stands are created when only partial stands are needed to meet the allowable cut. The user should not start with the maximum of 1000 stands, but leave room for any new stands that will be created through stand splitting.

Use ↑, ↓, <Page Up>, <Page Down>, <Home>, or <End> to view list, <Esc> to quit

A Review of Red Pine Growth and Yield Simulation Programs

Red pine is an important commercial timber species in the Lake States. While before the turn of the century it was widely distributed in the Lake States, its area has declined substantially because red pine was not reestablished very often after the logging of the original virgin timber. Red pine is, however, being planted at higher rates today than for the last 80 years because of its economic value and because of ecological considerations. The references contain a partial list of publications dealing with growth, yield and management of red pine.

Timber yields both in terms of quantity and quality depend on management inputs. Among the most important stand decisions are thinning decisions. The latter deal with the intensity and timing of partial

timber removal to improve timber growth and/or quality. A number of previous programs for personal computers that simulate growth and yield of thinned and unthinned even-aged stands of red pine exist. Program REDPINE, developed by Dr. Allen Lundgren in the 1970's, was the first such program written for main frame computers in FORTRAN. RPAL (1990) is a newer version of REDPINE with the most recent version written in Visual Basic. Program RPSIM is a recent revision of program REDPINE in Professional Basic with a number of new features that previous programs did not have (Rose and Lundgren 1998). These programs let the user set a number of stand and thinning parameters and will grow the stand using these control parameters. To find a good thinning option, the user needs to experiment with many different parameter settings until a thinning regime is found that appears to be desirable.

Derivation of optimal thinning decisions is a complex problem because each thinning decision influences all future thinning options, i.e., the problem is one of deriving an optimal sequence of optimal thinning decisions. Foresters have long been aware of the long-term implications of any given thinning decision. For example, a severe thinning in a young plantation may significantly reduce the range of possible residual densities as the stands gets older. This problem of interrelated decisions can be solved optimally using a technique called dynamic programming (Bellman 1957).

Chen, Rose, and Leary (1980) developed a special dynamic programming algorithm that can derive optimal thinning schedules where the objective function is the maximization of total wood production and where the state variable basal area is continuous, i.e., at each decision stage (age), an infinite number of basal area removal options exist. Rose, Chen, and Leary (1981) demonstrated on an example for red pine how this algorithm could be used to calculate in a number of computational steps an optimal thinning schedule. To facilitate the use of this algorithm for varied initial stand conditions and for various thinning options and constraints, a computer program, REDPTHIN implements this algorithm in this user-friendly program and is a successor of an earlier version of this program with sample application (Rose and Chen 1995).

REDPTHIN implements a different growth and yield model developed by Rose and Chen 1972 and allows the development of optimal thinning regimes based on a dynamic programming (DP) algorithm (Chen et al. 1980a , b). This optimal DP algorithm has been built into the program REDPTHIN and is also utilized in the red pine allowable cut simulation program ACESREDP (Rose 1994). Program REDPTHIN provides flexible data entry, storage, retrieval, viewing and printing of output tables, and provides a graphical interface for review of key results in graphical form.

Input data required for the program consist of a number of run parameters. Run parameter inputs created via keyboard input may be permanently saved before logging off to facilitate future analysis with these data and to reduce the time and effort for data entry. Editing options facilitate the future modifications of any of these data for additional analyses. All input statements are checked by the program for correctness. An error message will appear on the screen if the user enters an unacceptable input value. The user can correct the data entry error at this point and proceed with the analysis.

RUNNING REDPTHIN

The user needs to be in the program subdirectory to run the program. This is done simply by typing REDPTHIN and then pressing the <ENTER> key. The <ENTER> key must also be pressed after

typing in the appropriate response to the various data entry prompts within the program. After completing the above step, REDPTHIN will display the program title and software disclaimer screens. After these opening screens, the main menu screen provides a number of options::

REDPTHIN: A Stand-Level Red Pine Thinning Program

Written By

Dietmar W. Rose

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Copyright 1993 by Dietmar Rose.

Press any key to continue....

REDPTHIN SOFTWARE DISCLAIMER

All the software on the REDPTHIN diskette has been extensively tested and checked for accuracy and, to the best of the author's knowledge, contains no errors. However, the author does not provide any guarantees and is not responsible for errors that may arise during the use of this software. Any errors found by the users should be brought to the author's attention in order to incorporate appropriate changes in future versions. Future revisions of REDPTHIN will be available by returning the program diskette or a blank diskette and a check for \$15 payable to the author. Please call or write if you have questions. For permission to use or copy this software or obtain program updates write to:

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Press any key to continue....

REDPTHIN MAIN MENU

The program displays 5 main menu items which are activated by highlighting a line with the cursor key or by entering the line number followed by the <Enter> key.

Thinning Main Menu

1. Overview
2. Set Path Defaults
3. Run Thinning Program
4. View/Print Yield Tables
5. View Yield Table Graphs
6. Exit Red Pine Yield Generator

Use Numeric or Arrow Keys to select option
Press <Enter> to execute the option

REDPTHIN Main Menu: 1. Overview

This option provides the user with a short description of the purpose of the program and contains also some useful references. The user can use the cursor keys to scroll through the information and the <Esc> key to return to the main menu:

REDPTHIN VERSION 5 OVERVIEW

RED PINE STAND YIELD GENERATOR WITH THINNING OPTIONS

The red pine simulator is a user-friendly microcomputer program written for IBM personal computers and IBM compatibles in Microsoft Professional Basic Version 7.1. This stand-alone program has been integrated in the allowable cut simulation program ACESREDP. Thinning schedules can be for a number of user controlled run parameters. Optimal thinning schedules can be generated also. This result is possible due to a dynamic programming solution to a thinning formulation. These optimal solutions maximize total biological volume production over the planning period. Economic optima cannot be derived, but the user can control parameters that reflect the technical feasibility and, therefore, the economics of thinning. For information on the dynamic programming solution technique and the red pine basal area growth model, the user should consult the technical references (Main menu item 2).

RED PINE THINNING TECHNICAL REFERENCES

The three references below provide important background information on
Use ↑, ↓, <Page Up>, <Page Down>, <Home>, or <End> to view list, <Esc> to quit

REDPTHIN Main Menu: 2. Set Path Defaults

This option provides the user with the flexibility to set a path for storing any thinning run results. The default path shown can be changed or accepted as is:

SET FILE DRIVE PATHS

1. Current Output Path = C:\ACES\OUTPUT\
2. Finished (Accept current settings)

Enter the path you wish to change
Use Arrow or Number Keys to highlight
Press Spacebar or Enter to execute

If the user wants to change the current path, the following prompt would appear:

Enter new path for output files
▶ ◀

If a file is being requested that was not created by RPSIM (e.g., ACES.PAR), a message that the file was not created by RPSIM will appear and the user will be returned to the program main menu.

File ACES.PAR not an RPSIM Parameter File
Press a key to continue...

Once a file is selected from the list, the following menu with 3 options appears on the screen:

MAIN EDITING MENU

1. View/Edit Run Parameters
2. Run Current Model
3. Return to MAIN MENU

Use Numeric or Arrow Keys to select option
Press <Enter> to execute the option

The description of these three menu options will follow the description of the next data entry option.

REDPTHIN Main Menu: 3. Run Thinning Program

When this option is selected, a screen with the current default settings for a number of run and thinning parameters is displayed. The user can select to accept these parameters or to change any one or more of them before proceeding:

CURRENT THINNING PARAMETER SETTINGS

1. Basal Area Input Unit: sq ft/acre
2. Volume Output Unit: cu ft
3. Site Index Selected: 66 ft at base age 50
4. Initial Age Selected: 20 Year
5. Initial Basal Area Selected: 80 sq ft/acre
6. Ending Age Selected: 120 Years
7. Growth/thinning interval: 10 Years
8. Growth multiplier: 1.00
9. Thin Option: No thinnings

Do you want to change any values?
Yes No

The user will be prompted to change any values. For <Yes>, the program will open an editing screen with all currently set parameters and line one typically highlighted. The user can move the cursor to the line to be changed or simply enter the line number. The input and output units selected are of special importance. The program checks for reasonable ranges of basal area once the input unit has been selected.

Thinning Parameters Editing Menu
Highlight the parameter you wish to edit using the arrow keys.
Press <E> to edit the parameter and <Q> or <ESC> to quit.

1. Basal Area Input Units: sq ft/acre
2. Volume Output Units: cu ft
3. Site Index: 66 ft at base age 50
4. Initial Age: 20 Years
5. Initial BA: 60 sq ft/acre
6. Ending Age: 120 Years
7. Growth/thinning interval: 10 Years
8. Growth multiplier: 1
9. Thin Option 1: No thinnings

Edit

Quit

Basal area input units can be in sq ft/acre or sq m/ha. The site index and all basal areas on the input screen have to be in the corresponding units. Volume output units can be in English or metric units. For English units, the user gets the option to choose between three output units, cu ft, cords, or bd ft/acre. If the <Cords> or <Bd ft> options are chosen, the user is also required to enter a conversion factor from cubic foot to cords and board feet respectively or accepting the default values of 79 and 0.158 respectively by simply hitting the <Enter> key.

When thin option (9) is selected (currently with the no thinning default), the program will offer the user four different thinning options, 1) No Thinning, 2) Thinning to User Specified Basal Area, 3) Optimal Thinning, and 4) Optimal Thinning with Min. Basal Area Cut Constraint. Each of these thin options in turn will request different additional parameters. For options 2-4, the following three additional inputs are requested from the user: 1) the first permissible age for thinning, 2) the last permissible age for thinning, and 3) the minimum interval between last thin and final harvest. In addition, option 4 requires specification of a minimum basal area that would make the thinning operation economically feasible.

After these various parameters have been entered, the edit screen will display these values which now can further be edited by moving the cursor to the desired parameter or by entering the line number. Most of these parameters do not need any special explanation except the growth multiplier. This parameter allows the user to scale the yield table results by a factor greater or smaller than 1. For example, a factor of 0.8 would scale down all yields by 20 percent. This factor can be used to fine tune the growth model to specific management situations.

Thinning Parameters Editing Menu
Highlight the parameter you wish to edit using the arrow keys.
Press <E> to edit the parameter and <Q> or <ESC> to quit.

1. Basal Area Input Units: sq ft/acre
2. Volume Output Units: cu ft

3. Site Index: 66 ft at base age 50
4. Initial Age: 20 years
5. Initial BA: 60 sq ft/acre
6. Ending Age: 120 years
7. Growth/thinning interval: 10 years
8. Growth multiplier: 1
9. Thin option: Opt. thinnings with min. BA removal
10. First permissible thinning age: 20 years
11. Last permissible thinning age: 100 years
12. Interval between last thin and harvest: 20 years
13. Minimum BA removed in thinning: 40 sq ft/acre

Edit

Quit

If units are changed:

Thinning Parameters Editing Menu

Highlight the parameter you wish to edit using the arrow keys.
Press <E> to edit the parameter and <Q> or <ESC> to quit.

1. Basal Area Input Units: sq ft/acre
2. Volume Output Units: cu ft
3. Site Index: 66 ft at base age 50
4. Initial Age: 20 Years
5. Initial
6. Ending Make sure that site index is in ft
7. Growth/ and all basal areas are in sq ft/acre.
8. Growth
9. Thin Op Press a key to continue...

Edit

Quit

Thinning Parameters Editing Menu

Highlight the parameter you wish to edit using the arrow keys.
Press <E> to edit the parameter and <Q> or <ESC> to quit.

1. Basal Area Input Units: sq ft/acre
2. Volume Output Units: cu ft
3. Site Index: 66 ft at base age 50
4. Initial Age: 20 Years
5. Initial BA: 60 sq ft/acre
6. Ending Age: 120 Years
7. Growth/thinning interval: 10 Years
8. Growth multiplier: 1
9. Thin option: No thinnings

Do you want to use metric units??

Yes

No

Edit

Quit

Thinning Parameters Editing Menu
Highlight the parameter you wish to edit using the arrow keys.
Press <E> to edit the parameter and <Q> or <ESC> to quit.

1. Basal Area Input Units: sq ft/acre
2. Volume Output Units: cu ft
3. Site Index: 66 ft at base age 50
4. Initial
5. Initial Do you want to input basal area in:
6. Ending 1. Sq Ft/Ac
7. Growth/ 2. Sq M/Ha
8. Growth
9. Thin Op Enter corresponding letter from below

| | | | |
|--|----------|---------|------|
| | Sq Ft/Ac | Sq M/Ha | |
| | Edit | | Quit |

For <No>, the user gets the option to choose between three output units as shown on the next screen:

Thinning Parameters Editing Menu
Highlight the parameter you wish to edit using the arrow keys.
Press <E> to edit the parameter and <Q> or <ESC> to quit.

1. Basal Area Input Units: sq ft/acre
2. Volume Output Units: cu ft
3. Site Index: 66 ft at base age 50
4. Ini
5. Ini Do you want volume output in:
6. End 1. Cu Ft/acre
7. Gro 2. Cords/acre
8. Gro 3. Bd Ft/acre
9. Thi Enter corresponding letter from below

| | | | | |
|--|-------|-------|-------|--|
| | Cu Ft | Cords | Bd Ft | |
| | Edit | | Quit | |

If the <Cords> or <Bd ft> options are chosen, the user is also required to enter a conversion factor from cubic foot to cords and board feet respectively or accepting the default values of 79 and 0.158 respectively by simply hitting the <Enter> key:

Input cu ft/cord conversion (default 79)?

Input cu ft/bd ft conversion (default 0.158)?

When line 9 is selected (currently with the no thinning default), the program will offer the user four different thinning options, each of which in turn will request for different additional parameters:

Thinning Parameters Editing Menu
Highlight the parameter you wish to edit using the arrow keys.
Press <E> to edit the parameter and <Q> or <ESC> to quit.

1. Basal Area Input Units: sq ft/acre
2. Volume Output Units: cu ft
3. Site Index: 66 ft at base age 50
4. Initial Age: 20 years

5. Initial BA: 60 sq ft/acre
6. Ending Age: 120 years
7. Growth/thinning interval: 10 years
8. Growth multiplier: 1
9. Thin option: No thinnings

Edit

Quit

In the following, outputs from all four thinning options are shown. It is apparent that total volume production is quite sensitive to how various thin parameters are set.

THINNING OPTIONS

- 1 = No Thinning
- 2 = Thinning to User Specified Basal Area
- 3 = Optimal Thinning
- 4 = Optimal Thinning with Min. Basal Area Cut Constraint

Use Numeric or Arrow Keys to select option
Press <Enter> to execute the option

For options 2-4, the following three additional inputs are requested from the user:

Enter first permissible age for thinning?

Enter last permissible age for thinning?

Enter minimum interval between last thin and final harvest?

In addition, option 4 requires specification of a minimum basal area that would make the thinning operation economically feasible:

Enter minimum cut (sq ft/ac) for thinning?

After these various parameters have been entered, the edit screen will display these values which now can further be edited by moving the cursor to the desired parameter or by entering the line number. Most of these parameters do not need any special explanation except the growth multiplier. This parameter allows the user to scale the yield table results by a factor greater or smaller than 1. For example, a factor of 0.8 would scale down all yields by 20 percent. This factor can be used to fine tune the growth model to specific management situations.

Thinning Parameters Editing Menu
Highlight the parameter you wish to edit using the arrow keys.
Press <E> to edit the parameter and <Q> or <ESC> to quit.

1. Basal Area Input Units: sq ft/acre
2. Volume Output Units: cu ft
3. Site Index: 66 ft at base age 50
4. Initial Age: 20 years
5. Initial BA: 60 sq ft/acre
6. Ending Age: 120 years
7. Growth/thinning interval: 10 years
8. Growth multiplier: 1
9. Thin option: Opt. thinnings with min. BA removal
10. First permissible thinning age: 20 years
11. Last permissible thinning age: 100 years
12. Interval between last thin and harvest: 20 years
13. Minimum BA removed in thinning: 40 sq ft/acre

Edit

Quit

Outputs from all four thinning options are shown in the appendix.

The program allows the user to save any yield table to create a collection of tables that can be distributed to managers in the field. The user will be prompted for a path and file name to store the yield table as an ASCII file. The default path can be used or a new path can be specified. Any of these yield tables can later be recalled for viewing or printing (see descriptions of these options below).

Do you want to save yield table on a file?
Yes No

Saving Red Pine Thinning Yield Table
Enter path or <ENTER> for default path: C:\REDPTHIN\OUTPUT\
▶ ◀

Enter data filename, or press only <ENTER> to return

▶OPHTHINMN◀

If an indicated file name already exists in the selected directory, the program will give a warning message and then allow the user to either override the file with the new information or to enter a new file name.

File already exists
Press a key to continue...

Enter R to rename file, or <ENTER> to overwrite
C:\REDPTHIN\OUTPUT\OPHTHINMN.Y1d ▶ ◀

To rename the entered file name, i.e, not to override an existing file, the user would enter <R> or <R> or simply <Enter> if he/she changed their mind and wanted to overwrite the old file.

Enter data filename, or press only <ENTER> to use
default name: C:\REDPTHIN\OUTPUT\OPHTHINMN.Y1d
▶ ◀

REDPTHIN Main Menu: 4. View/Print Yield Tables

These two options allow the user to view or print any previously created yield table. The user can select from a list of potential file names with extension ".PLT" from any directory in the system or by directly entering the file name and path.

REDPTHIN YIELD TABLE FILE SELECTION

1. View yield tables
2. Return to REDPTHIN program

Use Numeric or Arrow Keys to select option
Press <Enter> to execute the option

YIELD TABLE FILE CHOICES

Use the arrow keys to move through the list.
Hit the <Enter> key to select the highlighted file.
There are 6 files.

RDPTH90C.YLD
REDPINE1.YLD
REDPNOTH.YLD
REDPTH90.YLD
REDTHIN9.YLD
RPNOTHCD.YLD

Change Path Change File Specification Quit

Path = C:\ACES\OUTPUT\ File extension = *.YLD

Listing for C:\ACES\OUTPUT\RDPTH90C.YLD

RED PINE YIELD TABLE THINNING PARAMETERS

1. Basal Area Input Unit: sq ft/acre
2. Volume Output Unit: cords
3. Site Index Selected: 57 ft at base age 50
4. Initial Age Selected: 20 Years
5. Initial Basal Area Selected: 120 sq ft/acre
6. Ending Age Selected: 120 Years
7. Growth/thinning interval: 10 Years
8. Growth multiplier: 1.00
9. Thin Option: Thinning to user specified BA
10. First permissible thinning age: 35 Years
11. Last permissible thinning age: 60 Years
12. Min. interval: last thin and harvest: 20 Years
13. User specified BA after each thin: 90 sq ft/acre

Growth multiplier = 1

| Age | BA bef | BA for opt. | BA | BA Cut | Cum BA | Cut Hght | CumVol | Cut | MAI | Avg # of |
|------|--------|-------------|-------|--------|--------|----------|--------|-----|-----|-----------|
| thin | Vol | BA | Grwth | plus | BA | in | plus | Vol | | Dbh Trees |

Use ↑, ↓, <Page Up>, <Page Down>, <Home>, or <End> to view list, <Esc> to quit

YIELD TABLE FILE CHOICES

Use the arrow keys to move through the list.
Hit the <Enter> key to select the highlighted file.
There are 6 files.

- RDPTH90C.YLD
- REDPINE1.YLD
- REDPNOTH.YLD
- REDPTH90.YLD
- REDTHIN9.YLD
- RPNOTHCD.YLD

Change Path Change File Specification Quit

Path = C:\REDPTHIN\OUTPUT\ File extension = *.YLD

Selecting the highlighted file will produce the next screen listing of the yield table file. The user can use the cursor keys to scroll through the file and return to the main program with the <Esc> key.

Listing for C:\REDPTHIN\OUTPUT\RDPTH90C.YLD

RED PINE YIELD TABLE
THINNING PARAMETERS

1. Basal Area Input Unit: sq ft/acre
2. Volume Output Unit: cords
3. Site Index Selected: 57 ft at base age 50
4. Initial Age Selected: 20 Years
5. Initial Basal Area Selected: 120 sq ft/acre
6. Ending Age Selected: 120 Years
7. Growth/thinning interval: 10 Years
8. Growth multiplier: 1.00
9. Thin Option: Thinning to user specified BA
10. First permissible thinning age: 35 Years
11. Last permissible thinning age: 60 Years
12. Min. interval: last thin and harvest: 20 Years
13. User specified BA after each thin: 90 sq ft/acre

Growth multiplier = 1

| Age | BA bef thin | BA for opt. Vol | BA | BA Grwth | BA Cut | Cum BA plus | BA Cut in | Hght | CumVol plus | Cut Vol | MAI | Avg # of Dbh Trees |
|-----|-------------|-----------------|----|----------|--------|-------------|-----------|------|-------------|---------|-----|--------------------|
|-----|-------------|-----------------|----|----------|--------|-------------|-----------|------|-------------|---------|-----|--------------------|

Use ↑, ↓, <Page Up>, <Page Down>, <Home>, or <End> to view list, <Esc> to quit

REDPTHIN Main Menu: 6. Exit Red Pine Yield Generator

With this option the user will leave the program and receive some information about contacts for the author.

Thank you for using REDPTHIN

If you have any questions or comments
concerning the use of this program, contact:

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1539 12th Terrace NW
New Brighton, Minnesota 55112
Tel. (612)636-7395 or (612)624-9711
E-Mail: drose@forestry.umn.edu

Press any key to continue....

Pressing any key terminates the program.

The author is very interested in any feedback on the program, especially any problems that the user might encounter with specific run parameter combinations. While the program has been tested extensively with a large number of run parameter combinations, it was impossible to test all possible combinations. The author is also interested in any comments concerning the possible improvement of the program interphase or desirable additional program features.

SUMMARY

This program gives the manager a very flexible tool for making thinning decisions for red pine stands in the Lake States. By comparing different thinning strategies, the manager can begin understand the trade-offs between different thinning approaches. The yield model can be calibrated to reflect more closely local growth patterns of red pine by experimenting with the growth multiplier. This thinning program has also been integrated into a forest regulation model, ACESREDP, which generates allowable cuts with or without thinning options for a number of volume and area control procedures. Runs of that model for state-wide red pine inventories have illustrated the significant impact of thinning strategies on long-run sustainable allowable cut levels. The reader should contact the author to learn more about this program.

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Appendix - Sample Runs

From the 4 sample runs shown below, it is apparent that total volume production is quite sensitive to how various thin parameters are set.

No Thinning Option

RED PINE YIELD TABLE THINNING PARAMETERS

1. Basal Area Input Unit: sq ft/acre
2. Volume Output Unit: cu ft
3. Site Index Selected: 66 ft at base age 50
4. Initial Age Selected: 20 Years
5. Initial Basal Area Selected: 80 sq ft/acre
6. Ending Age Selected: 120 Years
7. Growth/thinning interval: 10 Years
8. Growth multiplier: 1.00
9. Thin Option: No thinnings

| Age | Pres | Optimal BA | BA for Vol | BA for BA | BA Grwth | BA Cut | Cum BA | Cum BA Cut | Hght | CumVolCut | MAI | Avg | # of |
|-----|------|--------------------------|------------|-----------|----------|--------|---------|------------|-------|-----------|-------|------|-------|
| | | BA | for Vol | for BA | Grwth | Cut | plus BA | Cut | in | plus Vol | cu ft | inch | Trees |
| | | -----Sq Ft per acre----- | | | | | | | ft | cu ft | cu ft | | /ac |
| 20 | 80 | 162 | 111 | 77 | 0 | 80 | 26.4 | 887 | 44.3 | 5.8 | 717 | | |
| 30 | 157 | 176 | 120 | 56 | 0 | 157 | 40.8 | 2702 | 90.1 | 6.0 | 666 | | |
| 40 | 213 | 184 | 127 | 35 | 0 | 213 | 53.9 | 4827 | 120.7 | 6.4 | 585 | | |
| 50 | 248 | 187 | 132 | 24 | 0 | 248 | 65.4 | 6820 | 136.4 | 6.9 | 491 | | |
| 60 | 272 | 189 | 137 | 17 | 0 | 272 | 75.2 | 8596 | 143.3 | 7.5 | 406 | | |
| 70 | 289 | 189 | 141 | 13 | 0 | 289 | 83.6 | 10157 | 145.1 | 8.2 | 335 | | |
| 80 | 303 | 188 | 145 | 11 | 0 | 303 | 90.6 | 11525 | 144.1 | 8.9 | 278 | | |
| 90 | 314 | 187 | 148 | 9 | 0 | 314 | 96.5 | 12721 | 141.3 | 9.6 | 231 | | |
| 100 | 323 | 186 | 151 | 8 | 0 | 323 | 101.5 | 13767 | 137.7 | 10.3 | 194 | | |
| 110 | 331 | 185 | 154 | 7 | 0 | 331 | 105.5 | 14683 | 133.5 | 11.1 | 163 | | |
| 120 | 339 | 184 | 156 | 7 | 339 | 339 | 108.9 | 15485 | 129.0 | 11.8 | 137 | | |

Thinning to User-Specified Basal Area

RED PINE YIELD TABLE THINNING PARAMETERS

1. Basal Area Input Unit: sq ft/acre
2. Volume Output Unit: cu ft
3. Site Index Selected: 66 ft at base age 50
4. Initial Age Selected: 20 Years
5. Initial Basal Area Selected: 80 sq ft/acre
6. Ending Age Selected: 120 Years
7. Growth/thinning interval: 10 Years
8. Growth multiplier: 1.00
9. Thin Option: Thinning to user specified BA
10. First permissible thinning age: 30 Years
11. Last permissible thinning age: 100 Years
12. Min. interval: last thin and harvest: 20 Years
13. User specified BA after each thin: 90 sq ft/acre

| Age | Pres | Optimal BA | BA | BA | BA | Cum BA | Cut | Hght | CumVolCut | MAI | Avg | # of |
|-----|------|------------|--------|-------|-----|---------|-----|-------|-----------|-------|------|-------|
| | | for Vol | for BA | Grwth | | plus BA | | in | plus Vol | cu ft | inch | Trees |
| | | Sq Ft | per | acre | | | | ft | cu ft | cu ft | | /ac |
| 20 | 80 | 162 | 111 | 77 | 0 | 80 | | 26.4 | 887 | 44.3 | 5.8 | 717 |
| 30 | 157 | 176 | 120 | 57 | 67 | 157 | | 40.8 | 1544 | 51.5 | 6.0 | 666 |
| 40 | 147 | 184 | 127 | 44 | 57 | 214 | | 53.9 | 3196 | 79.9 | 6.9 | 493 |
| 50 | 134 | 187 | 132 | 36 | 44 | 258 | | 65.4 | 4910 | 98.2 | 7.8 | 376 |
| 60 | 126 | 189 | 137 | 31 | 36 | 294 | | 75.2 | 6494 | 108.2 | 8.7 | 296 |
| 70 | 121 | 189 | 141 | 27 | 31 | 326 | | 83.6 | 7959 | 113.7 | 9.5 | 238 |
| 80 | 117 | 188 | 145 | 24 | 27 | 353 | | 90.6 | 9315 | 116.4 | 10.3 | 194 |
| 90 | 114 | 187 | 148 | 23 | 0 | 377 | | 96.5 | 11548 | 128.3 | 11.2 | 160 |
| 100 | 138 | 186 | 151 | 22 | 0 | 400 | | 101.5 | 12784 | 127.8 | 11.8 | 139 |
| 110 | 160 | 185 | 154 | 21 | 0 | 422 | | 105.5 | 14005 | 127.3 | 12.4 | 121 |
| 120 | 180 | 184 | 156 | 19 | 180 | 443 | | 108.9 | 15177 | 126.5 | 13.1 | 105 |

Optimal Thinning

RED PINE YIELD TABLE THINNING PARAMETERS

1. Basal Area Input Unit: sq ft/acre
2. Volume Output Unit: cu ft
3. Site Index Selected: 66 ft at base age 50
4. Initial Age Selected: 20 Years
5. Initial Basal Area Selected: 80 sq ft/acre
6. Ending Age Selected: 120 Years
7. Growth/thinning interval: 10 Years
8. Growth multiplier: 1.00
9. Thin Option: Optimal thinnings
10. First permissible thinning age: 30 Years
11. Last permissible thinning age: 100 Years
12. Min. interval: last thin and harvest: 20 Years

| Age | Pres | Optimal BA | BA | BA | BA | Cum BA | Cut | Hght | CumVolCut | MAI | Avg | # of |
|-----|------|------------|--------|-------|-----|---------|-----|-------|-----------|-------|------|-------|
| | | for Vol | for BA | Grwth | | plus BA | | in | plus Vol | cu ft | inch | Trees |
| | | Sq Ft | per | acre | | | | ft | cu ft | cu ft | | /ac |
| 20 | 80 | 162 | 111 | 77 | 0 | 80 | | 26.4 | 887 | 44.3 | 5.8 | 717 |
| 30 | 157 | 176 | 120 | 56 | 0 | 157 | | 40.8 | 2702 | 90.1 | 6.0 | 666 |
| 40 | 213 | 184 | 127 | 41 | 29 | 213 | | 53.9 | 4164 | 104.1 | 6.4 | 585 |
| 50 | 225 | 187 | 132 | 35 | 38 | 255 | | 65.4 | 5807 | 116.1 | 7.1 | 464 |
| 60 | 223 | 189 | 137 | 31 | 34 | 290 | | 75.2 | 7666 | 127.8 | 7.9 | 363 |
| 70 | 220 | 189 | 141 | 28 | 31 | 321 | | 83.6 | 9403 | 134.3 | 8.7 | 289 |
| 80 | 216 | 188 | 145 | 25 | 28 | 349 | | 90.6 | 11024 | 137.8 | 9.6 | 234 |
| 90 | 213 | 187 | 148 | 22 | 0 | 374 | | 96.5 | 13601 | 151.1 | 10.4 | 191 |
| 100 | 235 | 186 | 151 | 19 | 0 | 396 | | 101.5 | 14965 | 149.7 | 11.0 | 165 |
| 110 | 254 | 185 | 154 | 16 | 0 | 414 | | 105.5 | 16192 | 147.2 | 11.7 | 142 |
| 120 | 270 | 184 | 156 | 14 | 270 | 430 | | 108.9 | 17286 | 144.0 | 12.4 | 122 |

Optimal Thinning with Minimum Basal Area Cut

RED PINE YIELD TABLE THINNING PARAMETERS

1. Basal Area Input Unit: sq ft/acre
2. Volume Output Unit: cu ft
3. Site Index Selected: 66 ft at base age 50
4. Initial Age Selected: 20 Years
5. Initial Basal Area Selected: 80 sq ft/acre
6. Ending Age Selected: 120 Years
7. Growth/thinning interval: 10 Years
8. Growth multiplier: 1.00
9. Thin Option: Opt. thinnings with minimum BA removal
10. First permissible thinning age: 30 Years
11. Last permissible thinning age: 100 Years
12. Min. interval: last thin and harvest: 20 Years
13. Minimum BA removed in thinning: 40 sq ft/acre

| Age | Pres BA | Optimal BA for Vol | BA for BA Grwth | BA Cut | BA Cut plus BA | Cum BA Cut | Cum Hgt in | CumVolCut plus Vol | MAI | Avg Dbh | # of Trees /ac |
|-----|---------|--------------------|-----------------|--------|----------------|------------|------------|--------------------|-------|---------|----------------|
| | | Sq Ft | per acre | | | | ft | cu ft | cu ft | inch | |
| 20 | 80 | 162 | 111 | 77 | 0 | 80 | 26.4 | 887 | 44.3 | 5.8 | 717 |
| 30 | 157 | 176 | 120 | 56 | 0 | 157 | 40.8 | 2702 | 90.1 | 6.0 | 666 |
| 40 | 213 | 184 | 127 | 35 | 0 | 213 | 53.9 | 4827 | 120.7 | 6.4 | 585 |
| 50 | 248 | 187 | 132 | 35 | 61 | 248 | 65.4 | 5144 | 102.9 | 6.9 | 491 |
| 60 | 223 | 189 | 137 | 27 | 0 | 284 | 75.2 | 8709 | 145.2 | 7.9 | 363 |
| 70 | 249 | 189 | 141 | 28 | 61 | 310 | 83.6 | 8300 | 118.6 | 8.5 | 308 |
| 80 | 216 | 188 | 145 | 23 | 0 | 338 | 90.6 | 12044 | 150.6 | 9.6 | 234 |
| 90 | 240 | 187 | 148 | 19 | 0 | 361 | 96.5 | 13518 | 150.2 | 10.2 | 201 |
| 100 | 259 | 186 | 151 | 16 | 0 | 381 | 101.5 | 14835 | 148.4 | 10.9 | 172 |
| 110 | 275 | 185 | 154 | 14 | 0 | 397 | 105.5 | 16003 | 145.5 | 11.5 | 147 |
| 120 | 289 | 184 | 156 | 12 | 289 | 411 | 108.9 | 17035 | 142.0 | 12.2 | 126 |

Table 1 summarizes results from these four runs.

Table 1. Summary of Four Thinning Strategies at End Age 120

| Run Option | No Thinning | Thinning to User Specified Basal Area | Optimal Thinning | Optimal Thinning with Minimum Basal Area Removal Requirement |
|--------------------------------------------------------------------------|-------------|---------------------------------------|------------------|--------------------------------------------------------------|
| Cumulative Volume Cut including Thinning Volumes (ft ³ /acre) | 15,485 | 15,177 | 17,286 | 17,035 |
| Basal Area (ft ² /acre) | 339 | 180 | 270 | 289 |
| Avg. Tree DBH (inch) | 11.8 | 13.1 | 12.4 | 12.2 |
| No. of Trees/Acre | 137 | 105 | 122 | 126 |

Thinning in most cases produces more total volume than the no-thinning option. An additional benefit are the larger average tree diameters in thinned stands. The average stand diameter is assumed proportionally to site index and age and inversely related to basal area per acre in multiple regression. The number of trees per acre is inversely related to the average diameter and site index:

Dbh = $-0.66205 + 0.082531 \times \text{Site Index} + 0.080891 \times \text{Age} - 0.007816 \times \text{Basal Area}$
 $R^2 = 0.731$, SE = 197.732, n = 148 plots

No. of Trees = $27.995 + 25383 / \text{Dbh}^{**2} - 1.0833 \times \text{Site Index}$
 $R^2 = 0.855$, SE = 0.979, n = 148 plots