ABSTRACT

A COMPUTER TECHNIQUE FOR PROJECTING YIELDS OF EVEN-AGED RED PINE IN THE LAKE STATES

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The projection of stand growth and volume yields for even-aged red pine in the Lake States has been simulated by a computer technique. Capabilities of the model permit the use of various silvicultural treatments throughout the life of a stand, therefore, varying the total yields. This method of projection can give extremely fast results with a high degree of reliability.

An application of the model is presented for a central Wisconsin plantation. By applying a cost-benefit analysis to each silvicultural alternative chosen, the highest possible internal rate of return on investment is determined.

A COMPUTER TECHNIQUE FOR PROJECTING YIELDS OF EVEN-AGED RED PINE IN THE LAKE STATES

By

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Chapter 1

INTRODUCTION

Red pine (Pinus resinosa, Ait.) is widely planted as a commercial timber species in the Lake States. The popularity of the species, for planting purposes, may be contributed to a relative freeness from disease and insect pests. Because of the density of even-aged red pine stands in the Lake States, the proper management of this particular timber type is essential to meet future timber demands.

This study was undertaken to provide a model by which the future growth parameters of an even-aged red pine stand could be predicted with a reasonable degree of reliability. A review of the literature revealed that such a model for even-aged red pine in the Lake States does not exist. A number of stand parameter projection equations have been developed (Ross and Ek, 1972) but incorporation into a growth and yield model has not been accomplished.

The second objective of the study concerned the model itself. Due to the various silvicultural systems applied to even-aged red pine, the final model should be flexible enough to encompass a diversity of management plans. The model would not only have to show the intensity of each thinning, but also an increase in stand growth potential due to the effects of the intensity of the cut.

The third and final objective was to apply the completed model to a central Wisconsin plantation. This objective was

designed to illustrate that the model can be used with relative ease, producing reliable growth and yield projection figures for a variety of management systems. A cost-benefit analysis was implemented to determine which management plan produced the highest internal rate of return on investment.

Chapter 2

METHODS and MATERIALS

The new computer technique (Red Pine Yield - RPYLD) is a modification of an existing program for ponderosa pine in the Black Hills of South Dakota. That program was developed in 1971 by Clifford A. Myers at the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. Originally, the existing program was changed to facilitate the peculiarities of red pine growth. But, finally, not only the growth constants and equations, but the logic of the entire program was rearranged to accommodate the silvicultural systems indigenous to even-aged red pine.

The Goerke Plantation (red pine) in Portage County, Wisconsin, was chosen to demonstrate the capabilities of RPYLD. A number of silvicultural alternatives during the life of the stand were tested to determine the total yields. With these yields, a cost-benefit analysis was applied using the computer technique, developed in 1968 by Robert B. Forster of the Forest Economics Research Institute of Ottawa, Ontario, for the evaluation of investment alternatives. This procedure, which evaluates alternatives by comparison of internal rates of return, has a decided advantage over other methods in that the relative merits of alternatives can be assessed regardless of when costs and/or benefits occur.

The values obtained for the management alternatives chosen for the Goerke Plantation are immaterial to the theme

of this thesis. They are used to demonstrate how RPYLD can be used to supplement management decisions throughout the rotation period of a forest. The user of RPYLD should not limit himself to the alternatives chosen for the Goerke Plantation. Rather it is hoped that the application presented will stimulate the user to try new and innovative silvicultural techniques for every new timber stand encountered.

An almost infinite number of management alternatives are possible with RPYLD. The application within this thesis should only serve as a match to light the candle.

Chapter 3

THE MODEL

A. Description of the program RPYLD

A listing of the final program is included in Appendices A, B and C. The program was written in the FORTRAN IV language and programmed for the IBM 1130 Computing System with 8K core. Table 1, an example of the output, was achieved on an IBM 1132 Printer at 55 lines per minute. The program flow chart is illustrated in Figure 1.

The format for the preparation of input control cards appears in Appendix D.

Control card four (diameter change) indicates how the mean stand diameter varies after a thinning. By implementing various silvicultural systems during a thinning, trees of a predetermined size are removed. For example, during a "low thinning", trees of the suppressed and intermediate crown classes (smaller trees) are removed, thus, the mean stand diameter increases. The increment in mean diameter is entered on control card four for the appropriate thinning.

With a mechanical thinning, trees are removed from the stand irrespective of their diameter, consequently, there are as many large diameter trees removed as small ones. The resulting mean stand diameter remains stable. A zero is entered on control card four for the appropriate thinning.

The prediction of diameter variance during a thinning is a new problem and is not included in the scope of this project.

Figures 2 and 3 illustrate how diameters varied for a low and crown thinning during a study conducted in southern Michigan.

Control card seven (mean stand height after a thinning) is somewhat erroneous due to the logic arrangement of the program. A change in the mean height does not function in the same manner as a change in the mean diameter. The height shown in the projection table of the output is concerned with the site index, and so deals with the dominant and co-dominant trees. Therefore, this height is greater than the mean stand height. For a change in the mean stand height after a thinning to be meaningful, another column, which would encompass the mean height of all the trees, should be added. To do so would involve a major change in the logic of the program and therefore was not feasible at this time. The control card (height change during a thinning) was left in hopes that this option could be added at a later date. Until this alteration is made, the height change after a thinning must be left at zero.

B. Equations used within the model

Basal area growth

The initial basal area is entered on control card three. Projection of this parameter is accomplished for each year from the following equation:

$$Y = 1.6889 + .041066X_1 - .00016303X_1^2 - .076958X_2 + .0002274 1X_2^2 + .06441X_3 \qquad (1)$$

Y = periodic net annual basal area increment

X_1 = basal area in square feet per acre

X_2 = age in years

X_3 = site index

This equation is represented graphically by Figure 4. Determination of the equation by Buckman (1962) was accomplished through the investigation of 324 periodic measurements on 235 permanent sample plots of red pine in Minnesota. Final analysis and equation generation was accomplished with an IBM 650 drum computer.

The standard error of estimate is 0.786 square feet of basal area growth per acre per year. This is 27.7 percent of $\bar{Y}$. The regression surface accounts for 69.5 percent of the total variation of $\bar{Y}$ (Buckman, 1962).

By using the relationship put forward by Buckman, an increase in basal area growth potential following a thinning is realized due to the change in the independent variable X_1 (basal area).

Diameter growth

Prediction of mean stand diameter is calculated from the following equation:

$$\text{mean diameter} = \sqrt{\frac{\frac{\text{basal area}}{\text{trees/acre}}}{.0054542}} \qquad (2)$$

This equation is nothing more than a rearrangement of the standard equation,

$$\text{basal area} = (.0054542)(\text{diam})^2(\text{trees/acre}) \qquad (3)$$

Equation #2 is used in every year except when a thinning is due. At that time, the new diameter is determined from the diameter change entered on control card four.

Trees per acre

This figure remains constant for each year except during a thinning when the residual trees per acre are determined as a function of the residual basal area and mean stand diameter. The equation is only a rearrangement of equations #2 and #3.

$$\text{trees per acre} = \frac{\text{basal area}}{(.0054542)(\text{diam})^2} \qquad (4)$$

Height growth

There are seven, third degree polynomial equations for the calculation of height.

$$H = 373.88 - 742.15X + 480.85X^2 - 93.962X^3 \qquad (5)$$

$$H = 381.35 - 759.41X + 493.15X^2 - 95.770X^3 \qquad (6)$$

$$H = 421.58 - 834.97X + 539.72X^2 - 104.23X^3 \qquad (7)$$

$$H = 452.09 - 893.73X + 576.78X^2 - 110.93X^3 \qquad (8)$$

$$H = 503.14 - 981.65X + 627.31X^2 - 119.56X^3 \qquad (9)$$

$$H = 513.12 - 1001.8X + 641.86X^2 - 122.02X^3 \qquad (10)$$

$$H = 569.53 - 1096.3X + 693.84X^2 - 130.41X^3 \qquad (11)$$

H = mean stand height

X = $\log_{10}$ of the stand age

Each equation is used for a new site index. Equation 5 is for a site index of 40, equation 6 for 45, equation 7 for 50, equation 8 for 55, equation 9 for 60, equation 10 for 65 and equation 11 for a site index of 70.

The data used to compile these equations is summarized in Tables 2 and 3 and graphed in Figure 5. The values in Table 2 were taken from Buckman, 1962, who in turn borrowed them from Gevorkiantz, 1957. Table 3 was extrapolated from the data in Table 2. This was necessitated by the unavailability of the data from another source. In a special request to the North Central Forest Experiment Station at St. Paul, Minnesota, they stated that stand and stocking tables for red pine on the better sites (site indices of 65 and greater) are nonexistent. But, they mentioned that such information may be available by next year. If so, equations #10 and #11 may be updated at that time. A copy of the letter from the North Central Experiment Station appears in Appendix H.

The generation of these equations was accomplished on an IBM 1130 computer, using the least squares procedure for computation (Horn, 1972). Each equation is illustrated graphically in Figure 6, while Table 4 is a summation of the height values obtained by use of the equations between stand age values of 20 and 160.

Cubic foot volume

This variable is calculated each year from the following equation:

$$V = 0.4085\ (B)\ (H) \qquad (12)$$

V = volume in cubic feet per acre

B = basal area per acre

H = mean stand height

Basal area multiplied by height gives the volume of a cylinder. Due to the growth form of the species, only 40.85 percent of the cylinder is considered as a merchantable tree. This percentage was developed by Buckman (1961) from the composite Lake States volume tables of Gevorkiantz and Olsen (1955). It is used for trees 5.0 inches D.B.H. and larger.

The standard error of estimate of an individual volume prediction is 147.2 cubic feet per acre. This is 5.42 percent of $\overline{Y}$ (Buckman, 1961).

Cordwood volume

This variable is calculated each year from the equation:

$$V = -0.907 + .004133\ (B)\ (H) \qquad (13)$$

V = volume in cords per acre

B = basal area per acre

H = mean stand height

This equation was also developed by Buckman (1961) from the composite Lake States volume tables of Gevorkiantz and Olsen (1955). It is used for trees 5.0 inches D.B.H. and larger to a 3 inch top d.i.b.

The standard error of estimate of an individual volume prediction is 1.805 cords per acre. This is 8.77 percent of $\overline{Y}$ (Buckman, 1961).

Board foot volume

This variable is calculated each year from the equation:

$$V = -1{,}707 + 2.283\ (B)\ (H) \qquad (14)$$

V = volume in board feet per acre

B = basal area per acre

H = mean stand height

Here too, the equation was developed by Buckman (1961) from the composite Lake States volume tables of Gevorkiantz and Olsen (1955).

The equation was developed from the Scribner decimal C rule, is species specific for red pine and is used in the program for trees 10.0 inches D.B.H. and larger to a 6 inch top d.i.b.

The standard error of estimate of an individual volume prediction is 1,502 board feet per acre. This is 8.38 percent of $\overline{Y}$ (Buckman, 1961).

C. Recommendations

During the construction of RPYLD, many facets of logic design for the program were encountered, but only a few were employed. Future work with RPYLD should include the following

modifications:

(1) The ability to respond to a fertilization treatment.

(2) The ability to use any site index between 30 and 80.

(3) The ability to indicate the establishment of reproduction.

(4) The ability to split sawtimber and topwood volumes during a periodic harvest.

(5) The ability to respond to a height change during a thinning.

One more area of study should include the ramifications of public reaction to a clearcut in relation to the feasibility of a particular management system.

Chapter 4

VALIDATION OF THE MODEL

A. The Goerke Plantation

The Goerke Plantation is owned by the University Foundation of the University of Wisconsin - Stevens Point, Wisconsin. It is located in the southwest ¼ of the northwest ¼ and the south ½ of the southeast ¼ of the northwest ¼ of section 36, township 23 north, range 7 east, Town of Plover, Portage County, Wisconsin. A total of 60 acres is involved.

The plantation may be divided into two separate tracts. On the twenty acre tract (south ½ of the southwest ¼ of the northwest ¼) 17.6 acres were planted with red pine (3-0 stock) in 1955. On the forty acre tract (southwest ¼ of the northwest ¼) 36.3 acres were planted with red pine in 1943. The stock used for this planting was not known but was assumed as 3-0. The two tracts were treated separately.

For the purpose of clarity and simplification, the analysis of management alternatives was undertaken with the following assumptions:

(1) The land and timber of the Goerke Plantation would be appraised in its present condition.

(2) A management plan would be devised for the entire plantation that would provide the greatest internal rate of return (a measure of the best economic alternative).

(3) All management plans would be devised and analysed from the start of the 1974 growing season.

All values for the analysis were calculated on a per acre basis.

B. Stumpage value

Before an appraisal and/or projection of future incomes could be accomplished, an accepted value for red pine stumpage (pulpwood and sawlogs) had to be determined. Past issues of the Wisconsin Forest Products Price Review were consulted for average statewide stumpage prices for the years of 1956 to 1972 inclusive. Variation in the stumpage price (both pulpwood and sawtimber) for the 17 year period was almost null. Average pulpwood stumpage (red pine) in 1956 was around $4.90 per cord while in 1972, the price was $5.00 per cord. The same pattern of variation (or no variation) held true for sawtimber stumpage (red pine). Due to this elastic supply relationship, an average for both pulpwood and sawtimber stumpage were used for the timber appraisal and future income projections. The averages for the 17 year period were:

pulpwood stumpage: $5.30 per cord

sawtimber stumpage: $28.90 per M.B.F.

C. Land value

The land value (for the appraisal) was arbitrarily set at $100.00 per acre.

D. Analysis of Twenty Acre Tract

Initial measurements

For the appraisal and subsequent growth projections, four initial measurements were made by the Forestry 322, Mensuration class of the University of Wisconsin - Stevens Point. They were as follows:

trees per acre = 331

basal area = 75 square feet per acre

mean diameter breast height = 6.5 inches

mean height (total) = 28 feet

The stand age of 21 (planted in 1955 with 3-0 stock) and the site index of 65 were determined by the author during a field check.

These six initial measurements were used for all of the subsequent stand projections.

The appraisal

For the preceding stand parameters at age 21, RPYLD set the volume at 890 cubic feet per acre and/or 8.11 cords per acre. The appraisal calculations were as follows:

timber value: (8.11 cds/acre)($5.30 /cd) = $42.98/acre

land value: $100.00 per acre

Management alternatives

The final goal of this analysis was to determine the

management alternative which would produce the greatest amount of money in the shortest period of time. With this in mind, several management plans were chosen for analysis.

Plan A - no intermediate cuts

1. Grown to age 40; clearcut for sawlogs
2. Grown to age 50; clearcut for sawlogs

Plan B - One intermediate cut when the present mean annual cubic foot growth rate leveled off. This cut was a low thinning for pulpwood down to a basal area of 80. The final clearcut for sawlogs occurred when the mean annual board foot growth rate began to decline.

Plan C - The first intermediate cut was the same as in plan B. The second intermediate cut occurred when the mean annual board foot growth rate began to decline. This cut was a low thinning down to varying residual basal areas (50, 60, 70, 80, 90 and 100). The product from the second cut was sawtimber. The final cut (clearcut) occurred when the mean annual board foot growth rate again began to decline.

Plan D - Similiar to plan C except the first cut was a mechanical one down to a residual basal area of 90. The second cut occurred when the mean annual cordwood growth rate began to decline. It was a mechanical cut with the residual basal area varied from 50 to 100. The desired product from the second cut was pulpwood. The final cut (clearcut) occurred when the mean annual board foot growth rate began to decline.

For all of the above management plans, the decline in the mean annual growth rate was defined as when the volume

growth began to increase at a decreasing rate. Before this point was reached, the volume growth was increasing at an increasing rate.

a) the first cut

For plans B, C and D, the initial cut was determined from a projection of the present volume growth rates. The initial measurement data was entered into RPYLD and the stand was grown until age 50. The mean annual increment rates for cubic foot and cordwood began to level off when the stand reached age 33, consequently, the first cut was initiated at that age.

Various trials for the first cut were run to determine the desired residual basal area. Residual basal areas were varied from 60 to 120 at ten foot intervals. Tables 5 and 6 show the response in the rate of volume and diameter growth respectively after the first thinning. Table 7 indicates the variation in the intensity of cut for a low and mechanical thinning down to varying residual basal areas for the first cut.

The analysis of the results of this data may be cause for discussion and conflicting views. The selection, or best choice of cutting intensity, for this study was as follows:

(1) For plan B; a residual basal area of 80. This gave the greatest board foot volume increment for the final cut (sawlogs).

(2) For plan C; also a residual basal area of 80. The second intermediate cut for this plan was for sawlogs,

consequently, the greatest increment in board foot volume was desired.

(3) For plan D; a residual basal area of 90. The second intermediate cut for this plan was for pulpwood. A residual basal area of 90 yielded the greatest mean annual growth rate of cordwood.

The preceding choices were made with the idea of keeping the growth at a maximum with the greatest number of trees per acre. This should, theoretically, yield the greatest volumes. As was mentioned earlier, the choices may vary between foresters.

b) the second cut

As a result of making the first cut down to a basal area of 80, the mean annual board foot growth rate began to decline at age 52. The second cut for plan C was made at that time.

As a result of making the first cut down to a basal area of 90, the mean annual cordwood growth rate began to decline at age 49. The second cut for plan D was made at that time.

The second cut for plan B was the rotation cut. This was arbitrarily made at age 55 rather than age 52 (when the mean annual board foot growth rate began to decline).

c) results

Plan A-1 terminated at age 40 with 21,770 board feet per acre worth $629.15 ($28.90 per thousand board feet).

Plan A-2 terminated at age 50 with 33,120 board feet per acre worth $957.17 ($28.90 per thousand board feet).

Plan B had one intermediate cut (a low thinning down to a residual basal area of 80) at age 33 which yielded 13.25 cords per acre worth $70.23 ($5.30 per cord). The rotation cut was made at age 55 yielding 29.880 board feet per acre worth $863.53 ($28.90 per thousand board feet).

Plan C had the first cut (a low thinning down to a residual basal area of 80) at age 33. This is the same as the cut in plan B, yielding $70.23 per acre. The second cut was a low thinning made at age 52. The residual basal area was varied between 50 and 100 square feet per acre. The rotation cut varied due to the intensity of cut during the second thinning. Income figures from the second cut are given in Table 8. Income figures from the rotation cut are given in Table 9.

Plan D had the first cut (a mechanical thinning down to a residual basal area of 90) at age 33 which yielded 11.41 cords per acre worth $60.47 ($5.30 per cord). The second cut, a mechanical one also, occurred at age 49. The residual basal area, here too, was varied between 50 and 100 square feet per acre. The rotation cut varied due to the intensity of cut during the second thinning. Income figures from the second cut are given in Table 10. Income figures from the rotation cut are given in Table 11.

Table 12 summarizes the incomes produced by each thinning for the management alternatives in plans C and D.

These various management alternatives were then tested to see which one produced the greatest economic return. Or in other words, the greatest internal rate of return.

Internal rate of return

a) assumptions

To test the economic advantage of a particular management system, certain assumptions were made. In this study, an initial value of the land and timber (appraised value during the present year) were used as a starting point. At the end of a rotation, the land was sold for the same price it was appraised for at the beginning. Land values in the future will probably increase, but, this study only assumes that the value will not decrease.

Taxes for this part of the plantation (20 acre tract) have been assumed as $0.20 per acre per year. This is currently the tax rate for the Woodland Tax Law which applies to timber stands under 40 acres.

The following assumptions were made:

initial value of land:	-100.00/acre	single cost
initial value of timber:	- 42.98/acre	single cost
taxes:	- 0.20/acre	annual cost
final value of land:	100.00/acre	single income

b) the analysis

The analysis of the internal rate of return for each management alternative was accomplished on an IBM 1130 computer with the technique developed by R.B. Forster (1968) for the evaluation of investment alternatives.

The above assumptions were made for each alternative. The only additions made were the incomes for each particular thinning. The following is an example of the costs and incomes substituted for plan B:

Type of cost or income	Amount	Year occurred	Identification
single	- 42.98	1	initial value of timber
single	-100.00	1	initial value of land
annual	- 0.20	35	taxes
single	70.23	13	first cut - pulpwood
single	863.53	35	rotation cut - sawlogs
single	100.00	35	final value of land

The internal rate of return for this particular management alternative was 6.5023 percent.

An explanation of the column entitled "Year occurred" is in order. The timber on the 20 acre tract has had approximately 21 seasons for growth. The projection of the internal rate of return for this study began at the present, or rather, when the stand was 21 years old. The computer technique for the computation of the internal rate of return handled the starting year (age 21) as year 1. Consequently, each cost or income was projected proportionally, which was 20 years less than the actual age of the stand. Therefore, the rotation cut would occur 35 years from the present when the stand is 55 years old.

c) results

Table 13 summarizes the analysis of the internal rate of return for each management alternative on the 20 acre tract. From this analysis, plan A-1 (clearcut at age 40, no intermediate cuts) produced the greatest return on investment at 8.3841 percent.

The printouts for the projection table and the internal rate of return for plan A-1 are given in Tables 14 and 15 respectively.

E. Analysis of Forty Acre Tract

The discussion of the procedure used to ascertain the best economic management alternative for the 20 acre tract was covered in some detail. The pattern of analysis for the 40 acre tract follows the same agendum and, therefore, will be discussed in much greater brevity.

The Woodland Tax Law, used in the analysis of the 20 acre tract, could not be applied to the 40 acre tract due to the increased acreage. Therefore, the Forest Crop Tax Law was applied. The specifics of this law state that a set tax shall be paid to the state annually (similiar to the Woodland Tax Law), plus, a severance tax of ten percent of the sold stumpage value during a timber sale.

The value of cordwood and sawtimber stumpage was reduced by ten percent to compensate for the severance tax. The new values were:

cordwood stumpage: $5.30 x .90 = $4.77 /cord

sawtimber stumpage: $28.90 x .90 = $26.00 /M.B.F.

Land value remained the same as before, viz. $100.00/acre.

Initial measurements

Data collection for this tract was also performed by the Forestry 322, Mensuration class of the University of Wisconsin - Stevens Point. Measurements taken were as follows:

trees per acre = 267

basal area = 73 square feet per acre

mean diameter breast height = 7.1 inches

mean height (total) = 44 feet

Stand age and site index were determined by the author as 33 and 65 respectively.

The appraisal

Substitution of the initial measurements into the model produced volume figures of 1,340 cubic feet per acre and/or 12.65 cords per acre. The appraisal calculations were as follows:

timber value: (12.65 cds/acre)($4.77/cd) = $60.34/acre

land value: $100.00 per acre

Management alternatives

Here too, the same goal of ascertaining the management alternative which would produce the greatest economic return was pursued. Three major plans were devised.

Plan A - no intermediate cuts

1. Grown to age 45; clearcut for pulpwood
2. Grown to age 50; clearcut for sawlogs
3. Grown to age 55; clearcut for sawlogs

Plan B - One intermediate cut for pulpwood when the present mean annual cubic foot growth rate began to level off. This cut was a low thinning down to a basal area of 80. The final clearcut for sawlogs occurred at age 60.

Plan C - The first cut for pulpwood was the same as in plan B. The second intermediate cut occurred when the mean annual board foot growth rate began to decline. This cut was a low thinning and was varied between the residual basal areas of 40 and 100 square feet per acre. The product from the second cut was sawtimber. The final cut (clearcut) occurred when the mean annual board foot growth rate again began to decline.

a) the first cut

The first cut for plans B and C were made at age 44. This was when the mean annual cubic foot growth rate began to level off. The residual basal area was varied between 60 and 120 while the type of thinning was varied between a low cut and a mechanical cut. Tables 16 and 17 show the response in the rate of volume and diameter growth respectively after the first thinning. Table 18 indicates the variation in the intensity of cut for a low and mechanical thinning down to varying residual basal areas for the first cut.

As was stated in the analysis of management alternatives for the 20 acre tract, data may be interpreted in many ways. The intention of this study was to maximize the growth rate and trees per acre to obtain the maximum growth potential. Therefore, a residual basal area of 80 was chosen as the most favorable cutting intensity during the first thinning for plans B and C.

The second and rotation cuts were both intended for sawlogs, consequently, the first cut was entered as a low thinning.

b) the second cut

The second cut, for plan C, was initiated at age 60 when the mean annual board foot growth rate from the first cut began to decline. The second cut was a low thinning with residual basal areas varying from 40 to 100 square feet per acre. Each variation was run as a separate management plan.

The rotation cut was made when the mean annual board foot growth rates began to decline after the second cut (rotation variation #1) and also at a constant age for all second cut intensities (rotation variation #2).

c) results

Plan A-1 terminated at age 45 with 33.90 cords per acre worth $161.70 ($4.77 per cord).

Plan A-2 terminated at age 50 with 23,170 board feet per acre worth $602.42 ($26.00 per thousand board feet).

Plan A-3 terminated at age 55 with 28,820 board feet per acre worth $749.32 ($26.00 per thousand board feet).

Plan B had one intermediate cut at age 44 (a low thinning down to a residual basal area of 80) which yielded 13.40 cords per acre worth $63.92 ($4.77 per cord). The rotation cut at age 60 yielded 25,640 board feet per acre worth $666.64 ($26.00 per thousand board feet).

In plan C, the first cut was the same as in plan B, yielding $63.92 per acre. The second cut was a low thinning at age 60. Board foot yields and their dollar value are listed in Table 19. The rotation cut varied due to the intensity of the second cut. The rotation age, board foot volume yields and values are listed in Table 20.

Table 21 summarizes the incomes produced by each thinning for the management alternatives in plan C.

Internal rate of return

a) assumptions

The only change necessary was with the tax rate (Forest Crop Tax Law). Severance tax on stumpage incomes was eliminated by reducing the initial value of stumpage by ten percent. The other half of this tax rate system deals with an annual assessment per acre. Currently, this rate is $0.20 per acre per year. Beginning in 1981, and every ten years hence, a new tax rate will be assessed. For simplicity of this problem, the following was the tax schedule arbitrarily chosen:

Year	Tax	Stand age
present - 1980	0.20/ac/yr	33 - 40
1981 - 1990	0.25/ac/yr	41 - 50
1991 - 2000	0.30/ac/yr	51 - 60
2001 - 2010	0.35/ac/yr	61 - 70
2011 - 2020	0.40/ac/yr	71 - 80
2021 - 2030	0.45/ac/yr	81 - 90

The weighted average of these tax schedules is $0.32/ac/yr. Because future tax rates are not known, and because only a constant figure was needed to simulate taxes, the fabrication of a tax schedule did not effect the analysis.

The following assumptions were made:

initial value of land	-100.00	single cost
initial value of timber	- 60.34	single cost
taxes to age 40	- 0.20	annual cost
taxes to age 50	- 0.25	annual cost
taxes to age 60	- 0.30	annual cost
taxes to age 70	- 0.35	annual cost
taxes to age 80	- 0.40	annual cost
taxes to age 90	- 0.45	annual cost
final value of land	100.00	single income

b) the analysis

The analysis of the internal rate of return was accomplished on an IBM 1130 computer with the same IRR1 program mentioned earlier (Forster, 1968).

The above assumptions were made for each alternative. The only additions made were the incomes produced by each particular management plan.

c) results

Table 22 summarizes the analysis of the internal rate of return for each management alternative on the 40 acre tract. From this analysis, plan A-2 (clearcut at age 50, no intermediate cuts) yielded the greatest return on investment at 8.9793 percent.

The printouts for the projection table and the internal rate of return for plan A-2 are given in Tables 23 and 24 respectively.

Chapter 5

CONCLUSIONS

The three original objectives set for this study have been accomplished. A reliable model for projecting the growth and yield of even-aged red pine in the Lake States was created; the model has flexibility for the employment of various silvicultural systems; and the model was successfully validated against a central Wisconsin plantation.

In conclusion, RPYLD is a simulation. Complete dependency should not be put on the model, but rather it should be used to supplement the decision making process.

Every even-aged red pine stand in the Lake States has its own autecological and synecological relationships intrinsic with a particular site. Consequently, human input is very much needed. The value of RPYLD is in providing a model by which management systems may be artificially tested before being applied to an actual stand. Thus, the model provides a means to an end, but is not the end in itself.

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TABLES

TABLE 1 A sample printout for RPYLD.

THIS IS A SAMPLE PRINTOUT FOR THE COMPUTER PROGRAM RPYLD.
INITIAL STAND MEASUREMENTS WERE, SITE INDEX = 60, BASAL AREA = 114,
TREES PER ACRE = 311, D.B.H. = 8.2, HEIGHT = 28, AGE = 23.

PROJECTIONS FOR A MANAGED STAND OF EVEN-AGED LAKE STATES RED PINE

ALL VALUES ON A PER ACRE BASIS

SITE INDEX = 60

	ENTIRE STAND BEFORE AND AFTER PERIODIC HARVESTS							PERIODIC HARVESTED VOLUMES				
STAND AGE YEARS	TREES PER ACRE	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	CU.FT. VOLUME M.C.F.	CORDWOOD VOLUME CDS/AC	BD.FT. VOLUME M.B.F.	TREES PER ACRE	BASAL AREA SQ.FT.	CU.FT. VOLUME M.C.F.	CORDWOOD VOLUME CDS/AC	BD.FT. VOLUME M.B.F.
23	311	114	8.2	28	1.29	12.29	0.00					
24	311	120	8.4	29	1.42	13.48	0.00					
25	311	127	8.6	30	1.56	14.88	0.00					
26	311	133	8.8	31	1.71	16.35	0.00					
27	311	139	9.0	33	1.86	17.89	0.00					
28	311	145	9.2	34	2.02	19.49	0.00					
29	311	151	9.4	35	2.18	21.14	0.00					
30	311	157	9.6	37	2.35	22.84	0.00					
30	156	80	9.6	37	1.19	11.17	0.00	155	77	1.15	11.67	0.00
31	156	86	10.0	38	1.32	12.47	5.68					
32	156	91	10.3	39	1.46	13.84	6.44					
33	156	97	10.6	40	1.60	15.26	7.22					
34	156	103	10.9	42	1.74	16.74	8.04					
35	156	108	11.2	43	1.89	18.27	8.88					
36	156	114	11.5	44	2.05	19.84	9.75					
37	156	119	11.8	45	2.21	21.46	10.65					
38	156	125	12.1	47	2.38	23.13	11.57					
39	156	130	12.3	48	2.54	24.83	12.51					
40	156	136	12.6	49	2.71	26.56	13.46					
40	84	80	13.1	49	1.60	15.27	7.23	72	56	1.11	11.29	6.23
41	84	85	13.6	50	1.74	16.69	8.01					
42	84	90	14.0	51	1.88	18.16	8.82					
43	84	95	14.4	52	2.03	19.67	9.66					

44	84	100	14.7	53	2.19	21.22	10.51	*
45	84	105	15.1	55	2.34	22.80	11.39	*
46	84	110	15.5	56	2.50	24.42	12.28	*
47	84	115	15.8	57	2.67	26.07	13.19	*
48	84	120	16.1	58	2.83	27.75	14.12	*
49	84	125	16.5	59	3.00	29.44	15.06	*
50	84	130	16.8	60	3.17	31.16	16.01	*
					TOTAL YIELDS		5.44	54.13	22.24

MINIMUM PER ACRE CUTS FOR INCLUSION IN TOTAL YIELDS-
200. CUBIC FEET AND 1. CORDS AND 1000. BOARD FEET

CUBIC FOOT VOLUME INCLUDES THE GROSS CUBIC FOOT PEELED VOLUME OF ALL STEMS PER ACRE 5.0 INCHES D.B.H. AND LARGER.

CORDWOOD VOLUME INCLUDES ALL STEMS PER ACRE 5.0 INCHES D.B.H. AND LARGER TO A VARIABLE TOP D.I.B. OF NOT LESS THAN 3.0 INCHES.

BOARD FOOT VOLUME INCLUDES VOLUME PER ACRE, SCRIBNER DECIMAL C RULE, ALL TREES TO 10.0 INCHES D.B.H. AND LARGER TO A 6.0 INCH TOP D.I.B.

INPUT DATA FOR EACH PARTICULAR THINNING

THINNING	1	2	3	4	5	6	7	8	9	10
AGE	30	40	0	0	0	0	0	0	0	0
BASAL AREA	80	80	0	0	0	0	0	0	0	0
DBH CHANGE	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
HT. CHANGE	0	0	0	0	0	0	0	0	0	0

COMPUTER OUTPUT - COLLEGE OF NATURAL RESOURCES - UNIVERSITY OF WISCONSIN, STEVENS POINT
// *END

// *END

TABLE 1 (continued)

TABLE 2

Average height of dominant and codominant red pine in the Lake States (after Gevorkiantz, 1957).

Age	Site index				
	40	45	50	55	60
20	15.0	17.0	19.0	21.0	24.0
25	19.5	22.0	24.5	27.0	30.5
30	24.0	27.0	30.0	33.0	37.0
35	29.5	32.0	35.5	39.0	43.0
40	33.0	37.0	41.0	45.0	49.0
45	36.5	41.0	45.5	50.0	54.5
50	40.0	45.0	50.0	55.0	60.0
55	43.0	48.5	53.5	59.0	64.5
60	46.0	52.0	57.0	63.0	69.0
65	48.5	54.5	60.0	66.0	72.5
70	51.0	57.0	63.0	69.0	76.0
75	53.0	59.5	66.0	72.0	79.0
80	55.0	62.0	69.0	75.0	82.0
85	57.0	64.0	71.0	77.5	85.0
90	59.0	66.0	73.0	80.0	88.0
95	60.5	67.5	75.0	82.5	90.5
100	62.0	69.0	77.0	85.0	93.0
105	63.0	70.5	78.5	86.5	95.0
110	64.0	72.0	80.0	88.0	97.0
115	64.5	73.0	81.0	89.5	98.5
120	65.0	74.0	82.0	91.0	100.0
125	65.5	74.5	83.0	92.0	101.0
130	66.0	75.0	84.0	93.0	102.0
135	66.5	75.5	84.5	93.5	103.0
140	67.0	76.0	85.0	94.0	104.0
145	67.3	76.5	85.5	94.5	104.5
150	67.5	77.0	86.0	95.0	105.0
155	67.8	77.5	86.5	95.5	105.5
160	68.0	78.0	87.0	96.0	106.0

TABLE 3

Extrapolated average height of dominant and codominant red pine in the Lake States for site indices of 65 and 70.

Age	Site index	
	65	70
20	27.0	30.0
25	34.0	37.5
30	40.5	43.0
35	47.0	51.0
40	54.0	58.0
45	60.0	64.5
50	65.0	70.0
55	70.5	76.0
60	75.0	81.0
65	79.0	85.5
70	83.0	89.0
75	86.5	93.0
80	89.5	96.5
85	92.5	100.0
90	95.5	103.0
95	98.5	106.0
100	101.0	109.0
105	103.0	111.5
110	105.0	114.0
115	106.5	116.0
120	108.5	118.0
125	109.5	119.5
130	111.0	121.0
135	112.0	122.5
140	113.0	123.5
145	114.0	124.5
150	115.0	125.5
155	115.5	126.0
160	116.0	126.5

TABLE 4 Average height of dominant and co-dominant red pine in the Lake States as calculated from the regression equations for height growth within the model RPYLD.

	SITE INDICES						
AGE	40	45	50	55	60	65	70
20.	15.31	17.17	19.29	21.33	24.52	27.49	30.46
21.	16.04	18.01	20.20	22.32	25.51	28.60	31.54
22.	16.82	18.92	21.17	23.38	26.58	29.78	32.71
23.	17.65	19.86	22.19	24.49	27.72	31.03	33.96
24.	18.51	20.84	23.25	25.64	28.91	32.33	35.27
25.	19.39	21.83	24.33	26.82	30.13	33.66	36.62
26.	20.29	22.84	25.43	28.02	31.38	35.01	38.01
27.	21.20	23.87	26.55	29.23	32.65	36.39	39.42
28.	22.12	24.89	27.67	30.45	33.93	37.77	40.85
29.	23.04	25.92	28.79	31.67	35.22	39.15	42.29
30.	23.96	26.94	29.91	32.89	36.51	40.54	43.74
31.	24.87	27.96	31.02	34.10	37.79	41.92	45.18
32.	25.78	28.97	32.13	35.31	39.08	43.30	46.62
33.	26.68	29.98	33.23	36.51	40.35	44.67	48.06
34.	27.58	30.97	34.32	37.69	41.61	46.02	49.49
35.	28.46	31.95	35.40	38.87	42.87	47.37	50.90
36.	29.33	32.92	36.46	40.03	44.10	48.69	52.31
37.	30.19	33.87	37.51	41.17	45.33	50.01	53.70
38.	31.04	34.81	38.54	42.30	46.54	51.30	55.07
39.	31.88	35.74	39.56	43.41	47.73	52.58	56.43
40.	32.70	36.65	40.57	44.51	48.91	53.84	57.77
41.	33.51	37.55	41.56	45.59	50.07	55.08	59.09
42.	34.30	38.43	42.53	46.65	51.22	56.31	60.40
43.	35.08	39.30	43.49	47.70	52.34	57.51	61.69
44.	35.85	40.15	44.43	48.73	53.45	58.70	62.95
45.	36.60	40.98	45.35	49.74	54.55	59.87	64.20
46.	37.34	41.81	46.26	50.73	55.62	61.01	65.44
47.	38.07	42.61	47.15	51.70	56.68	62.14	66.65
48.	38.78	43.40	48.03	52.66	57.71	63.25	67.84
49.	39.48	44.18	48.89	53.61	58.74	64.35	69.02
50.	40.16	44.94	49.74	54.53	59.74	65.42	70.17
51.	40.83	45.69	50.56	55.44	60.73	66.48	71.31
52.	41.49	46.43	51.38	56.33	61.70	67.51	72.43
53.	42.14	47.15	52.18	57.21	62.65	68.53	73.53
54.	42.77	47.85	52.96	58.07	63.58	69.53	74.61
55.	43.39	48.55	53.73	58.91	64.50	70.52	75.68
56.	44.00	49.22	54.49	59.74	65.41	71.49	76.73
57.	44.59	49.89	55.23	60.55	66.30	72.44	77.76
58.	45.18	50.54	55.96	61.35	67.17	73.37	78.77
59.	45.75	51.19	56.67	62.13	68.02	74.29	79.77
60.	46.31	51.81	57.37	62.90	68.87	75.19	80.75
61.	46.86	52.43	58.06	63.66	69.69	76.08	81.71
62.	47.40	53.03	58.73	64.40	70.50	76.95	82.66
63.	47.92	53.63	59.39	65.13	71.30	77.80	83.59
64.	48.44	54.21	60.04	65.84	72.08	78.64	84.50
65.	48.94	54.78	60.67	66.54	72.85	79.46	85.40
66.	49.44	55.33	61.30	67.23	73.61	80.27	86.29
67.	49.92	55.88	61.91	67.90	74.35	81.07	87.16
68.	50.40	56.42	62.51	68.56	75.08	81.85	88.01
69.	50.86	56.94	63.10	69.21	75.79	82.62	88.86
70.	51.32	57.46	63.68	69.85	76.49	83.38	89.68
71.	51.77	57.97	64.24	70.47	77.18	84.12	90.50
72.	52.20	58.46	64.80	71.09	77.86	84.85	91.30
73.	52.63	58.95	65.34	71.69	78.52	85.56	92.08
74.	53.05	59.42	65.88	72.28	79.18	86.26	92.86
75.	53.46	59.89	66.40	72.86	79.82	86.96	93.62
76.	53.86	60.35	66.92	73.43	80.45	87.63	94.36

TABLE 4 (continued)

Site Indices

Age	40	45	50	55	60	65	70
77.	54.25	60.80	67.42	73.99	81.07	88.30	95.10
78.	54.64	61.24	67.92	74.54	81.68	88.96	95.82
79.	55.01	61.67	68.40	75.07	82.27	89.60	96.53
80.	55.38	62.09	68.88	75.60	82.86	90.23	97.23
81.	55.74	62.50	69.34	76.12	83.43	90.85	97.92
82.	56.09	62.91	69.80	76.63	84.00	91.46	98.59
83.	56.44	63.31	70.25	77.13	84.55	92.06	99.26
84.	56.78	63.70	70.69	77.62	85.10	92.65	99.91
85.	57.11	64.08	71.12	78.10	85.63	93.23	100.55
86.	57.43	64.45	71.55	78.57	86.16	93.80	101.19
87.	57.75	64.82	71.96	79.03	86.68	94.36	101.81
88.	58.06	65.18	72.37	79.48	87.18	94.91	102.42
89.	58.36	65.53	72.77	79.93	87.68	95.45	103.02
90.	58.66	65.88	73.16	80.37	88.17	95.98	103.61
91.	58.95	66.22	73.54	80.80	88.65	96.50	104.19
92.	59.23	66.55	73.92	81.22	89.12	97.01	104.76
93.	59.51	66.87	74.29	81.63	89.58	97.51	105.32
94.	59.78	67.19	74.65	82.03	90.04	98.01	105.88
95.	60.04	67.50	75.00	82.43	90.48	98.49	106.42
96.	60.30	67.81	75.35	82.82	90.92	98.97	106.95
97.	60.55	68.11	75.69	83.20	91.35	99.44	107.48
98.	60.80	68.40	76.03	83.58	91.77	99.90	108.00
99.	61.04	68.68	76.35	83.94	92.19	100.35	108.51
100.	61.28	68.97	76.68	84.30	92.60	100.80	109.01
101.	61.51	69.24	76.99	84.66	92.99	101.23	109.50
102.	61.73	69.51	77.30	85.01	93.39	101.66	109.98
103.	61.95	69.77	77.60	85.35	93.77	102.08	110.46
104.	62.17	70.03	77.90	85.68	94.15	102.50	110.92
105.	62.38	70.28	78.19	86.01	94.52	102.90	111.38
106.	62.58	70.53	78.47	86.33	94.89	103.30	111.83
107.	62.78	70.77	78.75	86.64	95.24	103.69	112.28
108.	62.98	71.01	79.02	86.95	95.59	104.08	112.72
109.	63.17	71.24	79.29	87.25	95.94	104.46	113.15
110.	63.35	71.47	79.55	87.55	96.28	104.83	113.57
111.	63.53	71.69	79.80	87.84	96.61	105.19	113.98
112.	63.71	71.90	80.06	88.12	96.93	105.55	114.39
113.	63.88	72.12	80.30	88.40	97.25	105.90	114.79
114.	64.05	72.32	80.54	88.68	97.57	106.25	115.19
115.	64.21	72.53	80.78	88.94	97.87	106.59	115.58
116.	64.37	72.72	81.01	89.21	98.17	106.92	115.96
117.	64.53	72.92	81.23	89.46	98.47	107.25	116.33
118.	64.68	73.11	81.45	89.72	98.76	107.57	116.70
119.	64.82	73.29	81.67	89.96	99.05	107.89	117.07
120.	64.97	73.47	81.88	90.20	99.32	108.20	117.42
121.	65.10	73.65	82.08	90.44	99.60	108.50	117.77
122.	65.24	73.82	82.29	90.67	99.87	108.80	118.12
123.	65.37	73.99	82.48	90.90	100.13	109.09	118.46
124.	65.50	74.15	82.68	91.12	100.39	109.38	118.79
125.	65.62	74.31	82.86	91.34	100.64	109.66	119.12
126.	65.74	74.47	83.05	91.55	100.89	109.94	119.44
127.	65.86	74.62	83.23	91.76	101.13	110.21	119.75
128.	65.97	74.77	83.40	91.96	101.37	110.48	120.06
129.	66.08	74.91	83.58	92.16	101.60	110.74	120.37
130.	66.18	75.05	83.74	92.36	101.83	111.00	120.67
131.	66.29	75.19	83.91	92.55	102.05	111.25	120.96
132.	66.38	75.32	84.07	92.73	102.27	111.50	121.25
133.	66.48	75.45	84.22	92.92	102.49	111.74	121.53
134.	66.57	75.58	84.37	93.09	102.70	111.97	121.81
135.	66.66	75.70	84.52	93.27	102.90	112.21	122.09
136.	66.75	75.82	84.67	93.44	103.11	112.44	122.36
137.	66.83	75.94	84.81	93.60	103.30	112.66	122.62
138.	66.91	76.05	84.95	93.77	103.50	112.88	122.88
139.	66.99	76.16	85.08	93.92	103.69	113.09	123.14
140.	67.06	76.27	85.21	94.08	103.87	113.30	123.39
141.	67.13	76.38	85.34	94.23	104.05	113.51	123.63
142.	67.20	76.48	85.46	94.38	104.23	113.71	123.87

TABLE 4 (continued)

Site Indices

Age	40	45	50	55	60	65	70
143.	67.27	76.57	85.58	94.52	104.40	113.91	124.11
144.	67.33	76.67	85.70	94.66	104.57	114.11	124.34
145.	67.39	76.76	85.81	94.80	104.73	114.29	124.57
146.	67.45	76.85	85.92	94.93	104.90	114.48	124.79
147.	67.50	76.94	86.03	95.06	105.05	114.66	125.01
148.	67.56	77.02	86.13	95.18	105.21	114.84	125.23
149.	67.61	77.10	86.23	95.31	105.36	115.02	125.44
150.	67.65	77.18	86.33	95.43	105.50	115.19	125.64
151.	67.70	77.25	86.43	95.54	105.65	115.35	125.85
152.	67.74	77.32	86.52	95.65	105.79	115.52	126.05
153.	67.78	77.39	86.61	95.76	105.92	115.68	126.24
154.	67.81	77.46	86.69	95.87	106.05	115.83	126.43
155.	67.85	77.53	86.78	95.97	106.18	115.98	126.62
156.	67.88	77.59	86.86	96.07	106.31	116.13	126.80
157.	67.91	77.65	86.93	96.17	106.43	116.28	126.98
158.	67.94	77.70	87.01	96.27	106.55	116.42	127.16
159.	67.96	77.76	87.08	96.36	106.67	116.56	127.33
160.	67.99	77.81	87.15	96.45	106.78	116.69	127.50

// *END

AGE	RESIDUAL BASAL AREA																				
	60			70			80			90			100			110			120		
*	C.F.	CDS.	B.F.	C.F.	CDS.	B.F.	C.F.	CDS.	B.F.	C.F.	CDS.	B.F.	C.F.	CDS.	B.F.	C.F.	CDS.	B.F.	C.F.	CDS.	B.F.
34	.14	1.36		.14	1.45		.15	1.55		.16	1.63		.17	1.70		.17	1.77		.18	1.83	
35	.14	1.43		.15	1.53		.16	1.61		.17	1.68		.18	1.76		.18	1.83		.19	1.89	
36	.15	1.50	0.83	.16	1.58		.17	1.66		.17	1.75		.18	1.81		.19	1.87		.19	1.92	
37	.15	1.55	0.86	.16	1.65	0.91	.17	1.73	0.98	.18	1.79	0.99	.18	1.86	1.03	.19	1.92		.19	1.97	
38	.16	1.62	0.89	.17	1.70	0.94	.17	1.78	0.98	.18	1.85	1.02	.19	1.91	1.06	.19	1.96	1.09	.20	2.01	1.10
39	.17	1.67	0.92	.17	1.75	0.97	.18	1.82	1.01	.19	1.89	1.04	.19	1.95	1.07	.20	1.99	1.10	.20	2.03	1.13
40	.17	1.72	0.96	.18	1.80	1.00	.19	1.88	1.03	.19	1.93	1.07	.20	1.98	1.10	.20	2.03	1.11	.20	2.06	1.13
41	.17	1.78	0.98	.18	1.85	1.02	.19	1.91	1.06	.19	1.97	1.09	.20	2.01	1.11	.20	2.05	1.14	.21	2.07	1.15
42	.18	1.82	1.00	.19	1.89	1.04	.19	1.95	1.08	.20	2.00	1.10	.20	2.04	1.12	.21	2.06	1.14	.21	2.09	1.16
43	.19	1.86	1.03	.19	1.93	1.06	.20	1.98	1.09	.20	2.02	1.12	.20	2.05	1.14	.20	2.09	1.15	.20	2.10	1.16
44	.18	1.89	1.05	.19	1.95	1.09	.19	2.00	1.11	.20	2.04	1.13	.21	2.07	1.14	.21	2.09	1.15	.21	2.11	1.16
45	.20	1.94	1.07	.20	1.99	1.09	.20	2.03	1.12	.21	2.05	1.13	.20	2.09	1.15	.20	2.09	1.16	.21	2.10	1.16
46	.19	1.96	1.08	.20	2.01	1.11	.21	2.05	1.13	.20	2.08	1.15	.21	2.08	1.16	.21	2.10	1.16	.21	2.10	1.16
47	.20	1.98	1.10	.20	2.03	1.12	.20	2.05	1.13	.21	2.07	1.15	.20	2.09	1.15	.21	2.09	1.15	.20	2.08	1.15
48	.19	2.01	1.10	.20	2.04	1.13	.20	2.07	1.15	.20	2.08	1.14	.21	2.09	1.15	.20	2.08	1.15	.21	2.08	1.14
49	.20	2.02	1.12	.20	2.05	1.13	.21	2.07	1.14	.21	2.08	1.15	.21	2.08	1.15	.21	2.07	1.15	.20	2.05	1.14
50	.20	2.04	1.13	.21	2.06	1.14	.20	2.07	1.14	.20	2.07	1.15	.20	2.06	1.14	.20	2.06	1.13	.20	2.04	1.12
51	.21	2.04	1.12	.20	2.06	1.14	.21	2.07	1.14	.21	2.07	1.14	.20	2.05	1.14	.20	2.03	1.12	.20	2.01	1.11
52	.20	2.05	1.13	.20	2.06	1.13	.20	2.05	1.14	.20	2.04	1.13	.20	2.03	1.13	.20	2.01	1.11	.20	1.98	1.10
53	.20	2.04	1.13	.21	2.04	1.14	.20	2.04	1.13	.20	2.03	1.12	.20	2.01	1.11	.20	1.98	1.10	.19	1.95	1.08
54	.20	2.04	1.13	.20	2.04	1.12	.20	2.03	1.12	.20	2.01	1.11	.20	1.98	1.09	.19	1.95	1.08	.19	1.92	1.06
55	.20	2.04	1.12	.20	2.03	1.12	.20	2.01	1.11	.21	1.98	1.09	.19	1.96	1.08	.19	1.92	1.06	.19	1.88	1.04
56	.20	2.02	1.12	.20	2.00	1.11	.20	1.98	1.09	.20	1.96	1.08	.19	1.92	1.06	.19	1.89	1.04	.18	1.85	1.02
57	.20	2.00	1.11	.19	1.99	1.10	.19	1.96	1.08	.19	1.92	1.07	.19	1.89	1.05	.18	1.85	1.02	.18	1.81	1.00
58	.20	1.99	1.09	.20	1.96	1.08	.19	1.93	1.07	.19	1.90	1.04	.18	1.86	1.02	.18	1.82	1.01	.17	1.77	0.98
59	.19	1.96	1.09	.19	1.93	1.07	.19	1.90	1.05	.18	1.86	1.03	.18	1.82	1.01	.17	1.77	0.98	.17	1.73	0.95
60	.19	1.94	1.07	.19	1.91	1.05	.18	1.87	1.03	.18	1.82	1.01	.18	1.77	0.98	.18	1.73	0.95	.17	1.69	0.93

* C.F. is cubic feet; CDS. is cords; B.F. is board feet; # in columns are rate of vol. increment per year per acre.

TABLE 5 Response in the rate of volume growth for the 17.6 acre stand when thinned to varying residual basal areas at age 33.

Note: cubic feet is expressed in thousand cubic feet; board feet is expressed in thousand board feet.

TABLE 6 Response of diameter growth for the 17.6 acre stand when mechanically and low thinned to varying residual basal areas at age 33.

AGE	RESIDUAL BASAL AREA													
	60		70		80		90		100		110		120	
	*0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5
34	9.6	10.1	9.5	10.0	9.5	10.0	9.5	10.0	9.4	10.0	9.4	9.9	9.4	9.9
35	10.0	10.5	9.9	10.4	9.8	10.4	9.8	10.3	9.7	10.2	9.7	10.2	9.6	10.1
36	10.4	10.9	10.2	10.8	10.1	10.7	10.0	10.6	10.0	10.5	9.9	10.4	9.8	10.4
37	10.7	11.3	10.6	11.1	10.4	11.0	10.3	10.9	10.2	10.8	10.1	10.7	10.0	10.6
38	11.1	11.7	10.9	11.5	10.7	11.3	10.6	11.1	10.4	11.0	10.4	10.9	10.2	10.8
39	11.4	12.1	11.2	11.8	11.0	11.6	10.8	11.4	10.7	11.3	10.6	11.1	10.4	11.0
40	11.8	12.4	11.5	12.1	11.2	11.9	11.1	11.7	10.9	11.5	10.8	11.4	10.6	11.2
41	12.1	12.8	11.8	12.4	11.5	12.2	11.3	11.9	11.1	11.7	11.0	11.6	10.8	11.4
42	12.4	13.1	12.1	12.7	11.8	12.4	11.5	12.2	11.3	12.0	11.2	11.8	11.0	11.6
43	12.7	13.4	12.3	13.0	12.0	12.7	11.8	12.4	11.5	12.2	11.3	12.0	11.2	11.8
44	13.0	13.8	12.6	13.3	12.3	12.9	12.0	12.6	11.7	12.4	11.5	12.2	11.3	11.9
45	13.3	14.1	12.9	13.6	12.5	13.2	12.2	12.8	11.9	12.6	11.7	12.3	11.5	12.1
46	13.6	14.4	13.1	13.8	12.7	13.4	12.4	13.0	12.1	12.8	11.8	12.5	11.6	12.2
47	13.9	14.7	13.4	14.1	12.9	13.7	12.6	13.3	12.3	12.9	12.0	12.7	11.7	12.4
48	14.2	14.9	13.6	14.3	13.1	13.9	12.8	13.4	12.4	13.1	12.2	12.8	11.9	12.5
49	14.4	15.2	13.8	14.6	13.3	14.1	12.9	13.6	12.6	13.3	12.3	13.0	12.0	12.7
50	14.7	15.5	14.0	14.8	13.5	14.3	13.1	13.8	12.7	13.4	12.4	13.1	12.1	12.8
51	14.9	15.7	14.2	15.0	13.7	14.5	13.3	14.0	12.9	13.6	12.6	13.3	12.2	12.9
52	15.1	16.0	14.4	15.2	13.9	14.7	13.4	14.2	13.0	13.7	12.7	13.4	12.4	13.0
53	15.4	16.2	14.6	15.4	14.1	14.8	13.6	14.3	13.2	13.9	12.8	13.5	12.5	13.1
54	15.6	16.4	14.8	15.6	14.2	15.0	13.7	14.5	13.3	14.0	12.9	13.6	12.6	13.2
55	15.8	16.7	15.0	15.8	14.4	15.2	13.9	14.6	13.4	14.1	13.0	13.7	12.7	13.3
56	16.0	16.9	15.2	16.0	14.5	15.3	14.0	14.7	13.5	14.3	13.1	13.8	12.7	13.4
57	16.2	17.1	15.3	16.2	14.7	15.5	14.1	14.9	13.6	14.4	13.2	13.9	12.8	13.5
58	16.4	17.3	15.5	16.3	14.8	15.6	14.2	15.0	13.7	14.5	13.3	14.0	12.9	13.6
59	16.5	17.4	15.6	16.5	14.9	15.8	14.4	15.1	13.8	14.6	13.4	14.1	13.0	13.7
60	16.7	17.7	15.8	16.7	15.1	15.9	14.5	15.3	14.0	14.7	13.5	14.3	13.1	13.8

* Number indicates the change in mean stand diameter during the thinning. A 0.0 indicates no change (a mechanical thinning) while the 0.5 indicates a $\frac{1}{2}$ inch mean stand diameter increment (a low thinning).

TABLE 7 Intensity of cut for the 17.6 acre stand when mechanically and low thinned to varying residual basal areas at age 33.

	RESIDUAL BASAL AREA													
	60		70		80		90		100		110		120	
1/	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5
2/	202	215	180	195	158	176	137	156	115	137	94	118	72	98

2/ Number indicates the total trees per acre removed during the thinning.

1/ Number indicates the change in mean stand diameter during the thinning. A 0.0 indicates no change (a mechanical thinning) while the 0.5 indicates a $\frac{1}{2}$ inch mean stand diameter increment (a low thinning).

TABLE 8 Predicted yields and values obtained from the second cut at age 52 in plan C for the 17.6 acre stand.

residual basal area after cut	board foot volume harvested 1/	value of volume harvested 2/
50	20.51	$592.74
60	18.97	$548.23
70	17.43	$503.73
80	15.89	$459.22
90	14.35	$414.72
100	12.81	$370.21

1/ All values expressed in thousand board feet, and on a per acre basis.

2/ Value calculated from $28.90 per thousand board feet.

TABLE 9 Predicted yields and values of rotation cuts in plan C for the 17.6 acre stand when thinned to varying residual basal areas at age 52.

PLAN C 1/

residual BA 2/	yr growth declines 3/	volume at decline 4/	value at decline 5/	volume at age 70 6/	value at age 70 7/
50	74	26.43	$763.83	22.39	$647.07
60	71	25.74	$743.89	24.71	$714.12
70	70	26.89	$777.12	26.89	$777.12
80	67	25.80	$745.62	28.93	$836.08
90	66	26.67	$770.76	30.85	$891.57
100	64	26.37	$762.09	32.65	$943.59

1/ First cut, low thinning, residual basal area = 80; age = 33.

2/ Second cut, low thinning, age = 52.

3/ Year when the rotation cut would be made.

4/ Volume in thousand board feet.

5/ Value calculated from $28.90 per thousand board feet.

6/ Comparison of volumes at a set age (in thousand board feet).

7/ Value calculated from $28.90 per thousand board feet.

TABLE 10 Predicted yields and values obtained from the second cut at age 49 in plan D for the 17.6 acre stand.

residual basal area after cut	cordwood vol harvested 1/	value of vol harvested 2/
50	34.24	$181.47
60	31.58	$167.37
70	28.92	$153.28
80	26.26	$139.18
90	23.60	$125.08
100	20.94	$110.98

1/ All values on a per acre basis.

2/ Value calculated from $5.30 per cord.

TABLE 11 Predicted yields and values of rotation cuts in plan D for the 17.6 acre stand when thinned to varying residual basal areas at age 49.

PLAN D 1/

residual BA 2/	yr growth declines 3/	volume at decline 4/	value at decline 5/	volume at age 65 6/	value at age 65 7/
50	71	26.38	$762.38	20.20	$583.78
60	69	26.59	$768.45	22.41	$647.65
70	67	29.73	$859.20	24.48	$707.47
80	65	26.45	$764.41	26.45	$764.41
90	64	27.24	$787.24	28.31	$818.16
100	62	26.85	$775.97	30.07	$869.02

1/ First cut, mechanical thinning, residual basal area = 80; age = 33.

2/ Second cut, mechanical thinning, age = 49.

3/ Year when the rotation cut would be made.

4/ Volume in thousand board feet.

5/ Value calculated from $28.90 per thousand board feet.

6/ Comparison of volumes at a set age (in thousand board feet).

7/ Value calculated from $28.90 per thousand board feet.

TABLE 12 Summary of predicted incomes from harvested volumes for each cut in both plans C and D for the 17.6 acre stand.

PLAN C

	Residual basal area after second cut					
	50	60	70	80	90	100
first cut	$ 70.23	$ 70.23	$ 70.23	$ 70.23	$ 70.23	$ 70.23
second cut	$592.74	$548.23	$503.73	$459.22	$414.72	$370.21
rotation 1/	$763.83	$743.89	$777.12	$745.62	$770.76	$762.09
rotation 2/	$647.07	$714.12	$777.12	$836.08	$891.57	$943.59

1/ Rotation cut when the rate of board foot volume growth starts to decline after the second cut.

2/ Rotation cut at age 70, irrespective of the intensity of the second cut.

PLAN D

	Residual basal area after second cut					
	50	60	70	80	90	100
first cut	$ 60.47	$ 60.47	$ 60.47	$ 60.47	$ 60.47	$ 60.47
second cut	$181.47	$167.37	$153.28	$139.18	$125.08	$110.98
rotation 1/	$762.38	$768.45	$859.20	$764.41	$787.24	$775.97
rotation 2/	$583.78	$647.65	$707.47	$764.41	$818.16	$869.02

1/ Rotation cut when the rate of cordwood volume growth starts to decline after the second cut.

2/ Rotation cut at age 65, irrespective of the intensity of the second cut.

TABLE 13 Summary of the analysis for internal rate of return for the various management alternatives selected for the 17.6 acre stand.

Plan A-1: 8.8841

Plan A-2: 7.0739

Plan B: 6.5023

Plan C			Plan D		
residual BA 1/	rotation age	internal rate of return	residual BA 2/	rotation age	internal rate of return
50	74	6.5499	50	71	5.1685
60	71	6.5023	60	69	5.2637
70	70	6.4546	70	67	5.3590
80	67	6.4546	80	65	5.4543
90	66	6.4070	90	64	5.4595
100	64	6.4070	100	62	5.6448
50	70	6.5975	50	65	5.2637
60	70	6.5499	60	65	5.3590
70	70	6.4546	70	65	5.4066
80	70	6.3594	80	65	5.4543
90	70	6.3117	90	65	5.5019
100	70	6.2165	100	65	5.5495

1/ Residual basal area after the second cut, age 52.

2/ Residual basal area after the second cut, age 49.

PROJECTIONS FOR A MANAGED STAND OF EVEN-AGED LAKE STATES RED PINE

ALL VALUES ON A PER ACRE BASIS

SITE INDEX = 65

STAND AGE YEARS	ENTIRE STAND BEFORE AND AFTER PERIODIC HARVESTS							PERIODIC HARVESTED VOLUMES				
	TREES PER ACRE	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	CU.FT. VOLUME M.C.F.	CORDWOOD VOLUME CDS/AC	BD.FT. VOLUME M.B.F.	TREES PER ACRE	BASAL AREA SQ.FT.	CU.FT. VOLUME M.C.F.	CORDWOOD VOLUME CDS/AC	BD.FT. VOLUME M.B.F.
21	331	75	6.5	28	0.89	8.11	0.00					
22	331	81	6.7	30	0.99	9.12	0.00					
23	331	88	6.9	31	1.11	10.37	0.00					
24	331	94	7.2	32	1.25	11.71	0.00					
25	331	101	7.4	34	1.39	13.14	0.00					
26	331	107	7.7	35	1.54	14.65	0.00					
27	331	114	7.9	36	1.69	16.24	0.00					
28	331	120	8.1	38	1.86	17.90	0.00					
29	331	127	8.3	39	2.03	19.62	0.00					
30	331	133	8.5	41	2.21	21.42	0.00					
31	331	140	8.7	42	2.39	23.27	0.00					
32	331	146	8.9	43	2.58	25.17	0.00					
33	331	152	9.1	45	2.77	27.12	0.00					
34	331	158	9.3	46	2.97	29.11	0.00					
35	331	164	9.5	47	3.17	31.14	0.00					
36	331	169	9.6	49	3.37	33.20	0.00					
37	331	175	9.8	50	3.58	35.28	0.00					
38	331	181	9.9	51	3.78	37.37	0.00					
39	331	186	10.1	53	3.99	39.48	20.60					
40	331	191	10.3	54	4.20	41.60	21.77					
TOTAL YIELDS								4.20		41.60		21.77

TABLE 14

THE GOERKE PLANTATION, TOWN OF PLOVER, PORTAGE COUNTY, WISCONSIN
17.6 ACRE STAND PLAN A-1, NO INTERMEDIATE CUTS
CLEARCUT AT AGE 40 FOR SAWLOGS

MINIMUM PER ACRE CUTS FOR INCLUSION IN TOTAL YIELDS-
300. CUBIC FEET AND 2. CORDS AND 1000. BOARD FEET

CUBIC FOOT VOLUME INCLUDES THE GROSS CUBIC FOOT PEELED VOLUME OF ALL STEMS PER ACRE 5.0 INCHES D.B.H. AND LARGER.

CORDWOOD VOLUME INCLUDES ALL STEMS PER ACRE 5.0 INCHES D.B.H. AND LARGER TO A VARIABLE TOP D.I.B. OF NOT LESS THAN 3.0 INCHES.

BOARD FOOT VOLUME INCLUDES VOLUME PER ACRE, SCRIBNER DECIMAL C RULE, ALL TREES TO 10.0 INCHES D.B.H. AND LARGER TO A 6.0 INCH TOP D.I.B.

INPUT DATA FOR EACH PARTICULAR THINNING

THINNING	1	2	3	4	5	6	7	8	9	10
AGE	0	0	0	0	0	0	0	0	0	0
BASAL AREA	0	0	0	0	0	0	0	0	0	0
DBH CHANGE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
HT. CHANGE	0	0	0	0	0	0	0	0	0	0

COMPUTER OUTPUT - COLLEGE OF NATURAL RESOURCES - UNIVERSITY OF WISCONSIN, STEVENS POINT
// *END

// *END

TABLE 14 (continued)

TABLE 15 Computer output for the internal rate of return, plan A-1, 17.6 acre stand.

```
COURSE 799.  SEC  1.  17.6 ACRE STAND, PLAN A-1, NO THINNINGS, ROTATION AGE 40
E-X-1  A COMPUTER TECHNIQUE FOR THE EVALUATION OF INVESTMENT ALTERNATIVES

   -KIND-     -AMOUNT-  -YEARS-   -IDENTIFICATION-

   SINGLE       -42.98      1.     INITIAL VALUE OF TIMBER
   SINGLE      -100.00      1.     INITIAL VALUE OF LAND
   ANNUAL        -0.20     20.     TAXES
   SINGLE       629.15     20.     ROTATION CUT FOR SAWLOGS
   SINGLE       100.00     20.     FINAL VALUE OF LAND


  THE INTERNAL RATE OF RETURN IS  8.8841  PERCENT.
// *END

// *END
```

AGE	RESIDUAL BASAL AREA																				
	60			70			80			90			100			110			120		
*	C.F.	CDS.	B.F.	C.F.	CDS.	B.F.	C.F.	CDS.	B.F.	C.F.	CDS.	B.F.	C.F.	CDS.	B.F.	C.F.	CDS.	B.F.	C.F.	CDS.	B.F.
45	.14	1.46		.15	1.56		.16	1.65		.17	1.73		.18	1.81		.18	1.87		.19	1.93	
46	.15	1.52	0.84	.16	1.61	0.89	.17	1.70	0.93	.18	1.78		.18	1.85		.19	1.91		.19	1.95	
47	.16	1.57	0.86	.17	1.66	0.91	.17	1.74	0.97	.17	1.81	1.01	.18	1.88	1.04	.19	1.93	1.07	.20	1.99	1.10
48	.16	1.61	0.90	.16	1.70	0.94	.18	1.79	0.98	.19	1.85	1.02	.19	1.91	1.06	.20	1.97	1.09	.20	2.00	1.10
49	.16	1.65	0.91	.18	1.74	0.97	.18	1.81	1.01	.18	1.89	1.04	.20	1.94	1.07	.19	1.98	1.09	.20	2.02	1.12
50	.17	1.70	0.94	.17	1.78	0.98	.18	1.86	1.02	.19	1.91	1.06	.19	1.86	1.08	.20	2.00	1.11	.20	2.04	1.12
51	.17	1.74	0.96	.18	1.82	1.00	.19	1.88	1.04	.19	1.94	1.07	.20	1.98	1.10	.20	2.02	1.11	.20	2.04	1.13
52	.18	1.77	0.98	.18	1.84	1.02	.19	1.91	1.05	.20	1.96	1.08	.19	2.00	1.10	.20	2.03	1.12	.20	2.04	1.13
53	.17	1.80	0.99	.18	1.88	1.04	.19	1.93	1.07	.19	1.97	1.09	.20	2.01	1.11	.20	2.03	1.12	.20	2.05	1.13
54	.19	1.84	1.02	.19	1.90	1.05	.19	1.95	1.08	.20	1.99	1.10	.20	2.01	1.11	.20	2.03	1.13	.20	2.04	1.13
55	.18	1.86	1.02	.19	1.92	1.06	.19	1.96	1.08	.20	2.00	1.10	.20	2.02	1.12	.20	2.03	1.12	.21	2.03	1.12
56	.19	1.88	1.04	.19	1.93	1.07	.20	1.98	1.09	.19	2.00	1.11	.20	2.02	1.11	.20	2.03	1.12	.19	2.02	1.12
57	.18	1.91	1.06	.19	1.95	1.07	.19	1.98	1.10	.20	2.00	1.10	.20	2.01	1.12	.20	2.01	1.11	.20	2.01	1.10
58	.19	1.92	1.06	.19	1.96	1.09	.20	1.99	1.10	.20	2.01	1.11	.20	2.01	1.10	.20	2.00	1.10	.20	1.98	1.10
59	.19	1.93	1.06	.20	1.97	1.08	.20	1.98	1.09	.20	1.99	1.10	.19	2.00	1.11	.20	1.98	1.10	.19	1.97	1.09
60	.20	1.94	1.07	.19	1.97	1.09	.19	1.99	1.10	.19	1.99	1.10	.20	1.97	1.09	.19	1.97	1.08	.20	1.94	1.07
61	.19	1.94	1.08	.20	1.97	1.09	.20	1.97	1.09	.20	1.97	1.09	.19	1.97	1.08	.19	1.94	1.08	.18	1.91	1.06
62	.19	1.95	1.08	.19	1.96	1.08	.19	1.97	1.09	.19	1.96	1.08	.20	1.94	1.07	.19	1.91	1.05	.19	1.89	1.04
63	.19	1.95	1.07	.20	1.96	1.08	.20	1.95	1.08	.19	1.94	1.07	.18	1.91	1.06	.19	1.89	1.05	.18	1.85	1.02
64	.20	1.94	1.08	.19	1.94	1.08	.19	1.94	1.06	.19	1.92	1.06	.19	1.89	1.05	.18	1.86	1.02	.18	1.82	1.00
65	.19	1.94	1.06	.19	1.93	1.06	.19	1.92	1.06	.19	1.89	1.05	.19	1.86	1.02	.18	1.82	1.01	.18	1.78	0.99
66	.19	1.92	1.07	.19	1.92	1.06	.18	1.89	1.05	.19	1.87	1.03	.18	1.84	1.02	.18	1.77	0.99	.17	1.76	0.96
67	.19	1.91	1.05	.19	1.89	1.05	.19	1.87	1.03	.18	1.83	1.01	.17	1.79	1.01	.17	1.76	0.97	.17	1.71	0.95
68	.18	1.90	1.05	.18	1.88	1.03	.18	1.84	1.02	.18	1.81	1.00	.18	1.77	0.97	.17	1.71	0.95	.17	1.67	0.92
69	.19	1.87	1.03	.18	1.85	1.02	.18	1.82	1.00	.17	1.77	0.99	.17	1.72	0.96	.17	1.68	0.92	.16	1.63	0.90
70	.18	1.85	1.03	.18	1.82	1.01	.18	1.78	0.99	.17	1.74	0.96	.17	1.69	0.93	.16	1.64	0.91	.15	1.58	0.87

* C.F. is thousand cubic feet; CDS. is cords; B.F. is thousand board feet; #'s in columns refer to the rate of volume increment per acre per year.

TABLE 16 Response in the rate of volume growth for the 36.3 acre stand when thinned to varying residual basal areas at age 44.

TABLE 17 Response of diameter growth for the 36.3 acre stand when mechanically and low thinned to varying residual basal areas at age 44.

AGE	RESIDUAL BASAL AREA													
	60		70		80		90		100		110		120	
	*0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5
45	10.0	10.5	10.0	10.5	10.0	10.5	9.9	10.4	9.9	10.4	9.9	10.4	9.9	10.4
46	10.4	10.9	10.3	10.8	10.2	10.8	10.2	10.7	10.2	10.7	10.1	10.6	10.1	10.6
47	10.7	11.3	10.6	11.2	10.5	11.1	10.4	11.0	10.4	10.9	10.3	10.9	10.3	10.8
48	11.1	11.7	10.9	11.5	10.8	11.4	10.7	11.3	10.6	11.2	10.5	11.1	10.5	11.0
49	11.4	12.0	11.2	11.8	11.1	11.7	11.0	11.5	10.9	11.4	10.7	11.3	10.7	11.2
50	11.8	12.4	11.5	12.1	11.4	12.0	11.2	11.8	11.1	11.6	10.9	11.5	10.9	11.4
51	12.1	12.7	11.8	12.4	11.6	12.2	11.4	12.0	11.3	11.9	11.1	11.7	11.0	11.6
52	12.4	13.0	12.1	12.7	11.9	12.5	11.7	12.3	11.5	12.1	11.3	11.9	11.2	11.8
53	12.7	13.3	12.4	13.0	12.1	12.7	11.9	12.5	11.7	12.3	11.5	12.1	11.4	12.0
54	13.0	13.7	12.6	13.3	12.4	13.0	12.1	12.7	11.9	12.5	11.7	12.3	11.5	12.1
55	13.3	14.0	12.9	13.5	12.6	13.2	12.3	12.9	12.1	12.7	11.9	12.5	11.7	12.3
56	13.6	14.3	13.1	13.8	12.8	13.5	12.5	13.2	12.3	12.9	12.0	12.7	11.8	12.4
57	13.8	14.5	13.4	14.1	13.0	13.7	12.7	13.4	12.4	13.1	12.2	12.8	12.0	12.6
58	14.1	14.8	13.6	14.3	13.2	13.9	12.9	13.6	12.6	13.2	12.3	13.0	12.1	12.7
59	14.4	15.1	13.8	14.5	13.4	14.1	13.1	13.7	12.8	13.4	12.5	13.1	12.2	12.9
60	14.6	15.4	14.1	14.8	13.6	14.3	13.2	13.9	12.9	13.6	12.6	13.3	12.4	13.0
61	14.9	15.6	14.3	15.0	13.8	14.5	13.4	14.1	13.1	13.7	12.8	13.4	12.5	13.1
62	15.1	15.9	14.5	15.2	14.0	14.7	13.6	14.3	13.2	13.9	12.9	13.6	12.6	13.2
63	15.3	16.1	14.7	15.4	14.2	14.9	13.7	14.4	13.4	14.0	13.0	13.7	12.7	13.4
64	15.5	16.3	14.9	15.6	14.3	15.1	13.9	14.6	13.5	14.2	13.1	13.8	12.8	13.5
65	15.8	16.6	15.0	15.8	14.5	15.3	14.0	14.7	13.6	14.3	13.2	13.9	12.9	13.6
66	16.0	16.8	15.2	16.0	14.7	15.4	14.1	14.9	13.7	14.4	13.3	14.0	13.0	13.7
67	16.2	17.0	15.4	16.2	14.8	15.6	14.3	15.0	13.8	14.5	13.4	14.1	13.1	13.8
68	16.4	17.2	15.6	16.4	15.0	15.7	14.4	15.2	14.0	14.7	13.5	14.2	13.2	13.8
69	16.5	17.4	15.7	16.5	15.1	15.9	14.5	15.3	14.1	14.8	13.6	14.3	13.3	13.9
70	16.8	17.6	15.9	16.7	15.3	16.1	14.7	15.5	14.2	14.9	13.8	14.5	13.4	14.1

* Number indicates the change in mean stand diameter during the thinning. A 0.0 indicates no change (a mechanical thinning) while the 0.5 indicates a $\frac{1}{2}$ inch mean stand diameter increment (a low thinning).

TABLE 18 Intensity of cut for the 36.3 acre stand when mechanically and low thinned to varying residual basal areas at age 44.

	RESIDUAL BASAL AREA													
	60		70		80		90		100		110		120	
1/	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5
2/	150	161	130	143	111	126	91	108	72	90	52	73	33	55

1/ Number indicates the change in mean stand diameter during the thinning. A 0.0 indicates no change (a mechanical thinning) while the 0.5 indicates a $\frac{1}{2}$ inch mean stand diameter increment (a low thinning).

2/ Number indicates the total trees per acre removed during the thinning.

TABLE 19 Predicted yields and values obtained from the second cut at age 60 in plan C for the 36.3 acre stand.

residual basal area after cut	board foot vol harvested 1/	value of vol harvested 2/
40	20.47	$532.22
60	17.04	$443.04
80	13.61	$353.86
100	10.17	$262.42

1/ All values expressed in thousand board feet, and on a per acre basis.

2/ Value calculated from $26.00 per thousand board feet.

TABLE 20 Predicted yields and values of rotation cuts in plan C for the 36.3 acre stand when thinned to varying residual basal areas at age 60.

residual BA	yr growth declines 1/	volume at decline 2/	value at decline 3/	volume at age 75 4/	value at age 75 5/
40	85	26.28	$683.28	17.07	$443.82
60	80	26.97	$701.22	22.12	$575.12
80	75	26.65	$692.90	26.65	$692.90
100	68	23.58	$613.08	30.73	$798.98

1/ Year when the rotation cut would be made.

2/ Volume in thousand board feet.

3/ Value calculated from $26.00 per thousand board feet.

4/ Comparison of volumes at a set age (in thousand board feet).

5/ Value calculated from $26.00 per thousand board feet.

TABLE 21 Summary of predicted incomes from harvested volumes for each cut in plan C for the 36.3 acre stand.

	Residual basal area after second cut			
	40	60	80	100
first cut	$ 63.92	$ 63.92	$ 63.92	$ 63.92
second cut	$532.22	$443.04	$353.86	$264.42
rotation 1/	$683.28	$701.22	$692.90	$613.08
rotation 2/	$443.82	$575.12	$692.90	$798.98

1/ Rotation cut when the rate of board foot volume growth starts to decline after the second cut.

2/ Rotation cut at age 75, irrespective of the intensity of the second cut.

TABLE 22 Summary of the analysis for internal rate of return for the various management alternatives selected for the 36.3 acre stand.

Plan A-1: 4.0252

Plan A-2: 8.9793

Plan A-3: 7.7408

Plan B: 6.6452

Plan C:

residual BA 1/	rotation age	internal rate of return
40	85	6.1688
60	80	6.1212
80	75	6.1212
100	68	6.2641
40	75	6.4546
60	75	6.2641
80	75	6.1212
100	75	5.9306

1/ Residual basal area after the second cut.

TABLE 23

THE GOERKE PLANTATION, TOWN OF PLOVER, PORTAGE COUNTY, WISCONSIN
36.3 ACRE STAND PLAN A-2 NO INTERMEDIATE CUTS
CLEARCUT AT AGE 50 FOR SAWLOGS

PROJECTIONS FOR A MANAGED STAND OF EVEN-AGED LAKE STATES RED PINE

ALL VALUES ON A PER ACRE BASIS

SITE INDEX = 65

STAND AGE YEARS	ENTIRE STAND BEFORE AND AFTER PERIODIC HARVESTS: TREES PER ACRE	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	CU.FT. VOLUME M.C.F.	CORDWOOD VOLUME CDS/AC	BD.FT. VOLUME M.B.F.	PERIODIC HARVESTED VOLUMES: TREES PER ACRE	BASAL AREA SQ.FT.	CU.FT. VOLUME M.C.F.	CORDWOOD VOLUME CDS/AC	BD.FT. VOLUME M.B.F.
33	267	73	7.1	44	1.34	12.65	0.00					
34	267	79	7.3	46	1.48	14.06	0.00					
35	267	84	7.6	47	1.63	15.60	0.00					
36	267	90	7.8	49	1.79	17.21	0.00					
37	267	96	8.1	50	1.96	18.88	0.00					
38	267	101	8.3	51	2.13	20.61	0.00					
39	267	107	8.5	53	2.30	22.39	0.00					
40	267	113	8.8	54	2.48	24.21	0.00					
41	267	119	9.0	55	2.67	26.08	0.00					
42	267	124	9.2	56	2.86	27.99	0.00					
43	267	130	9.4	58	3.05	29.93	0.00					
44	267	135	9.6	59	3.24	31.90	0.00					
45	267	141	9.8	60	3.44	33.90	0.00					
46	267	146	10.0	61	3.64	35.92	18.64					
47	267	151	10.1	62	3.84	37.96	19.76					
48	267	157	10.3	63	4.04	40.01	20.90					
49	267	162	10.5	64	4.25	42.07	22.03					
50	267	167	10.7	65	4.45	44.13	23.17					
TOTAL YIELDS										4.45	44.13	23.17

MINIMUM PER ACRE CUTS FOR INCLUSION IN TOTAL YIELDS-
300. CUBIC FEET AND 2. CORDS AND 1000. BOARD FEET

CUBIC FOOT VOLUME INCLUDES THE GROSS CUBIC FOOT PEELED VOLUME OF ALL STEMS PER ACRE 5.0 INCHES D.B.H. AND LARGER.

CORDWOOD VOLUME INCLUDES ALL STEMS PER ACRE 5.0 INCHES D.B.H. AND LARGER TO A VARIABLE TOP D.I.B. OF NOT LESS THAN 3.0 INCHES.

BOARD FOOT VOLUME INCLUDES VOLUME PER ACRE, SCRIBNER DECIMAL C RULE, ALL TREES TO 10.0 INCHES D.B.H. AND LARGER TO A 6.0 INCH TOP D.I.B.

INPUT DATA FOR EACH PARTICULAR THINNING

THINNING	1	2	3	4	5	6	7	8	9	10
AGE	0	0	0	0	0	0	0	0	0	0
BASAL AREA	0	0	0	0	0	0	0	0	0	0
DBH CHANGE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
HT. CHANGE	0	0	0	0	0	0	0	0	0	0

COMPUTER OUTPUT - COLLEGE OF NATURAL RESOURCES - UNIVERSITY OF WISCONSIN, STEVENS POINT
// *END

// *END

TABLE 23 (continued)

TABLE 24 Computer output for the internal rate of return, plan A-2, 36.3 acre stand.

COURSE 799. SEC 1. 36.3 ACRE STAND, PLAN A-2, NO THINNINGS, ROTATION AGE 50

E-X-1 A COMPUTER TECHNIQUE FOR THE EVALUATION OF INVESTMENT ALTERNATIVES

-KIND-	-AMOUNT-	-YEARS-	-IDENTIFICATION-
SINGLE	-60.34	1.	INITIAL VALUE OF TIMBER
SINGLE	-100.00	1.	INITIAL VALUE OF LAND
ANNUAL	-0.20	8.	TAXES TO YEAR 40
ANNUAL	-0.25	10.	TAXES TO YEAR 50
SINGLE	602.42	18.	ROTATION CUT - SAWLOGS
SINGLE	100.00	18.	FINAL VALUE OF LAND

THE INTERNAL RATE OF RETURN IS 8.9793 PERCENT.

// *END

// *END

FIGURES

FIGURE 1 Flow chart for RPYLD.

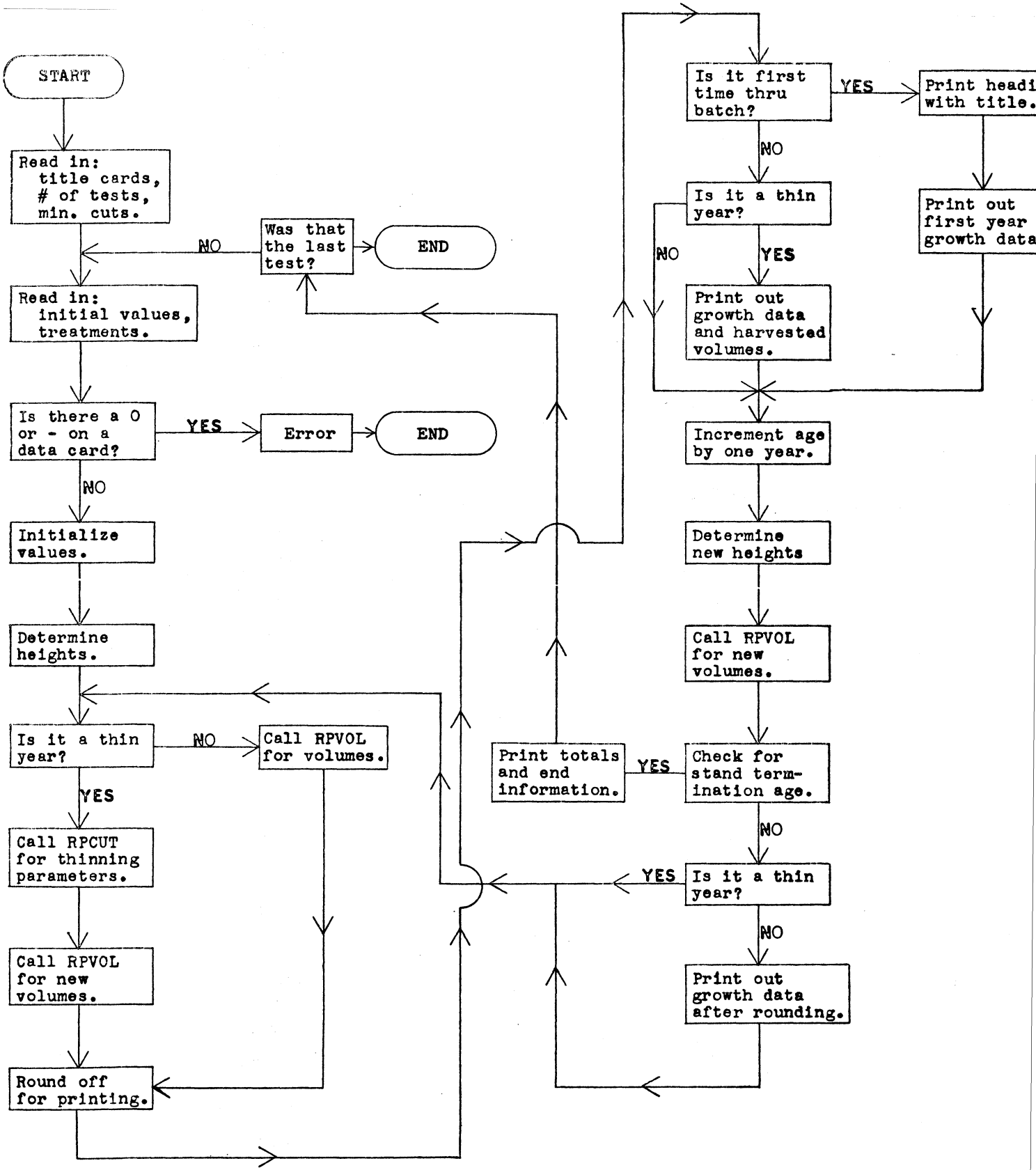


FIGURE 2

Effect of thinning from above down to varying residual basal areas upon the mean stand diameter (COOLEY, 1969)

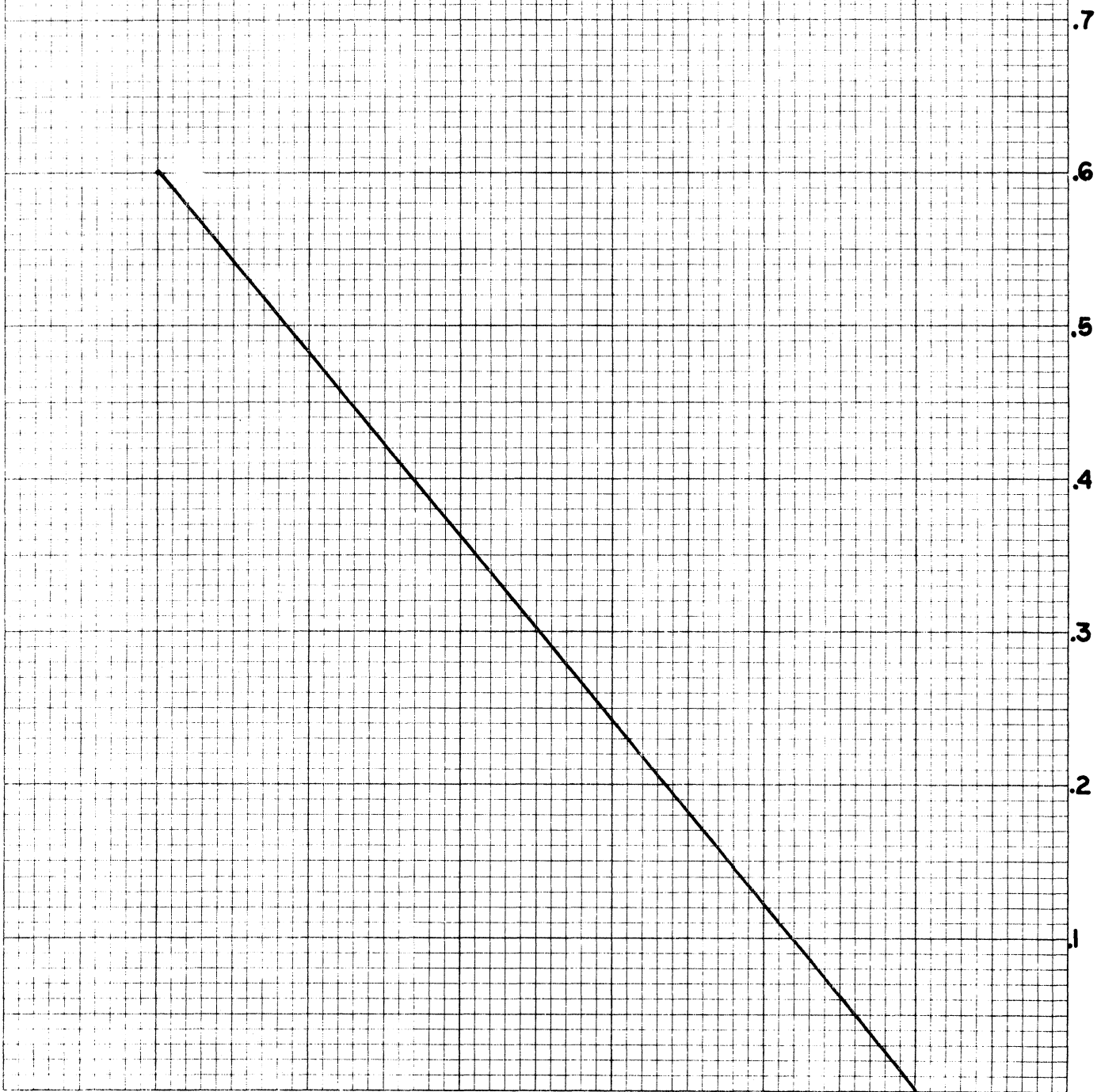
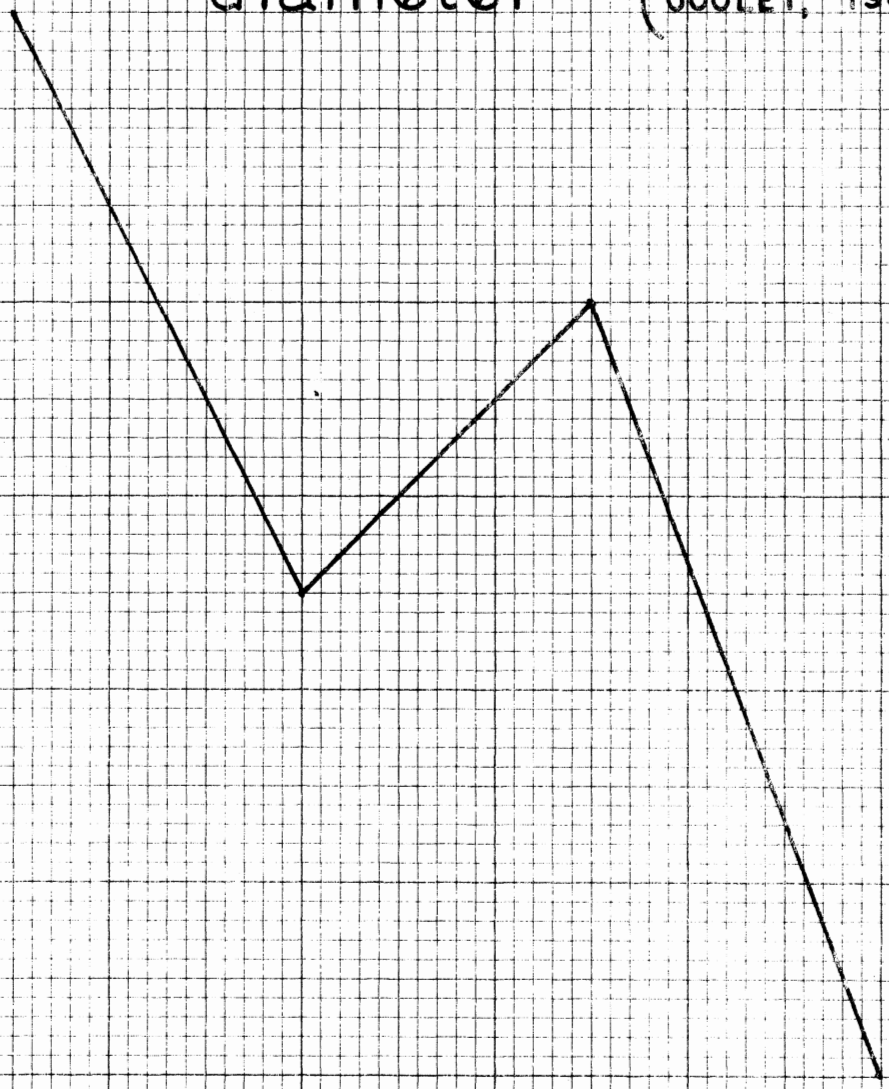


FIGURE 3

Effect of thinning from below down to varying residual basal areas upon the mean stand diameter (COOLEY, 1969)



1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2

MEAN STAND DIAMETER INCREMENT INCHES

FIGURE 4

Basal area growth of red pine in relation to age and stand density for a site index of 50 (from Buckman, 1962)

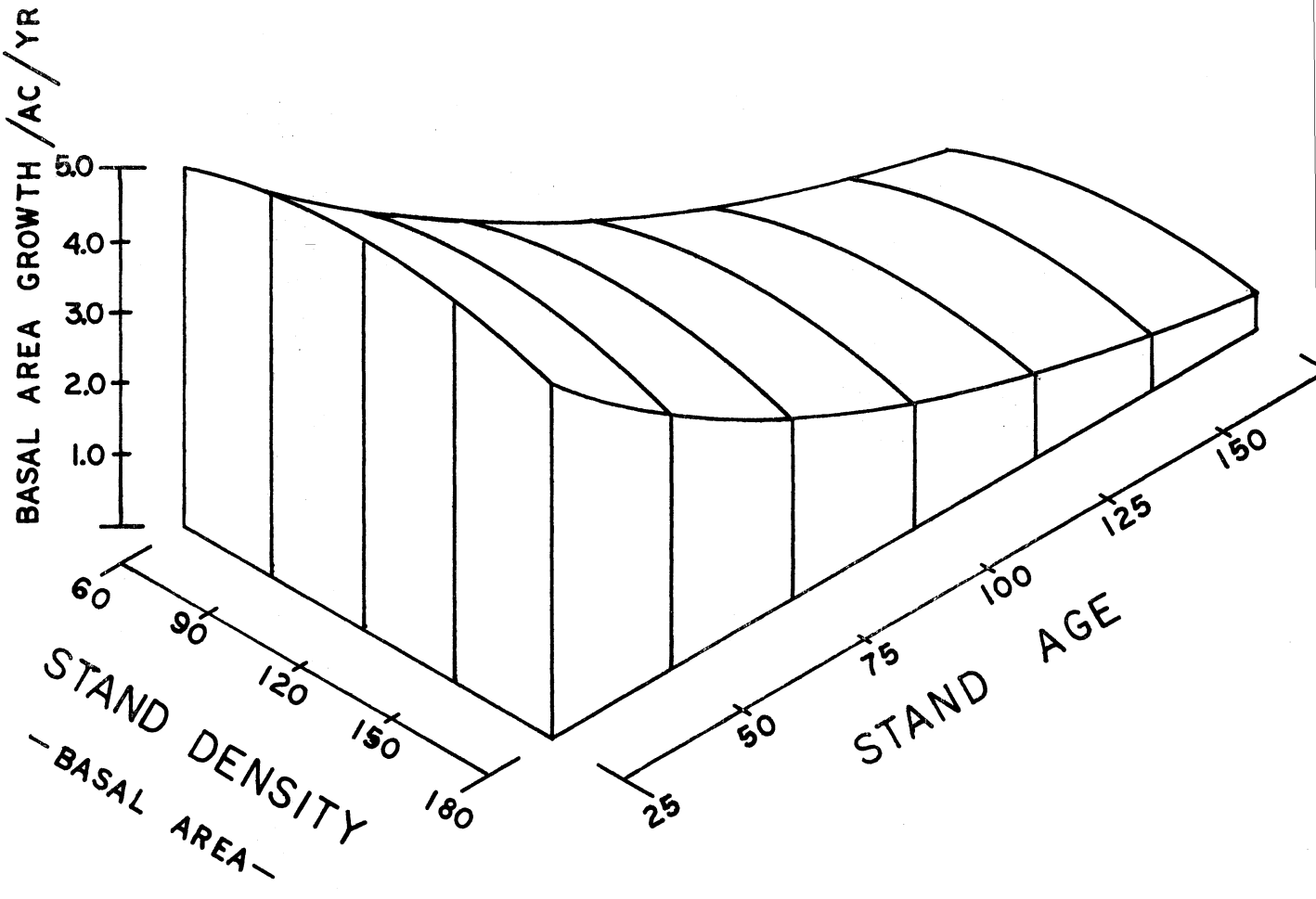


FIGURE 5

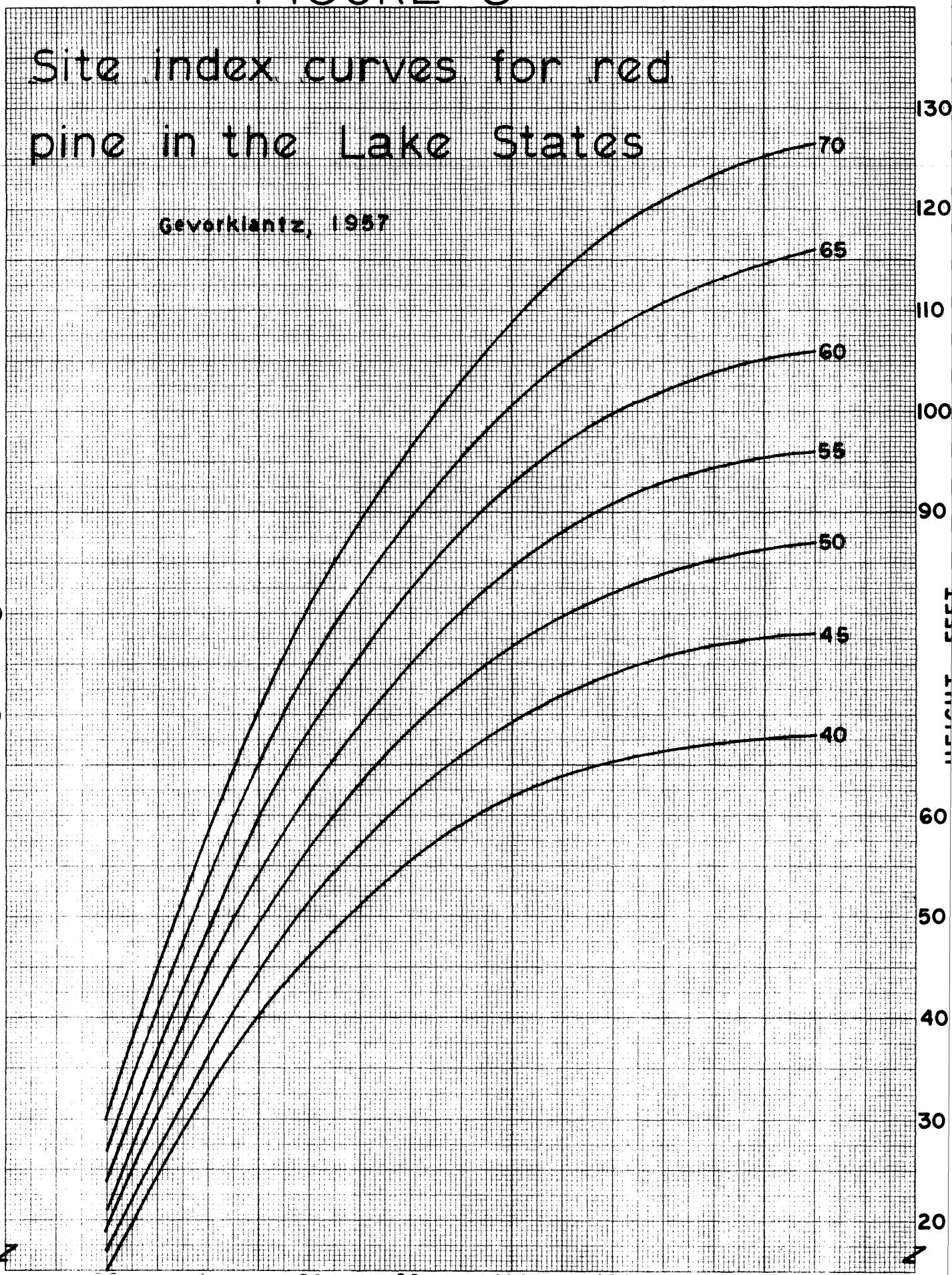
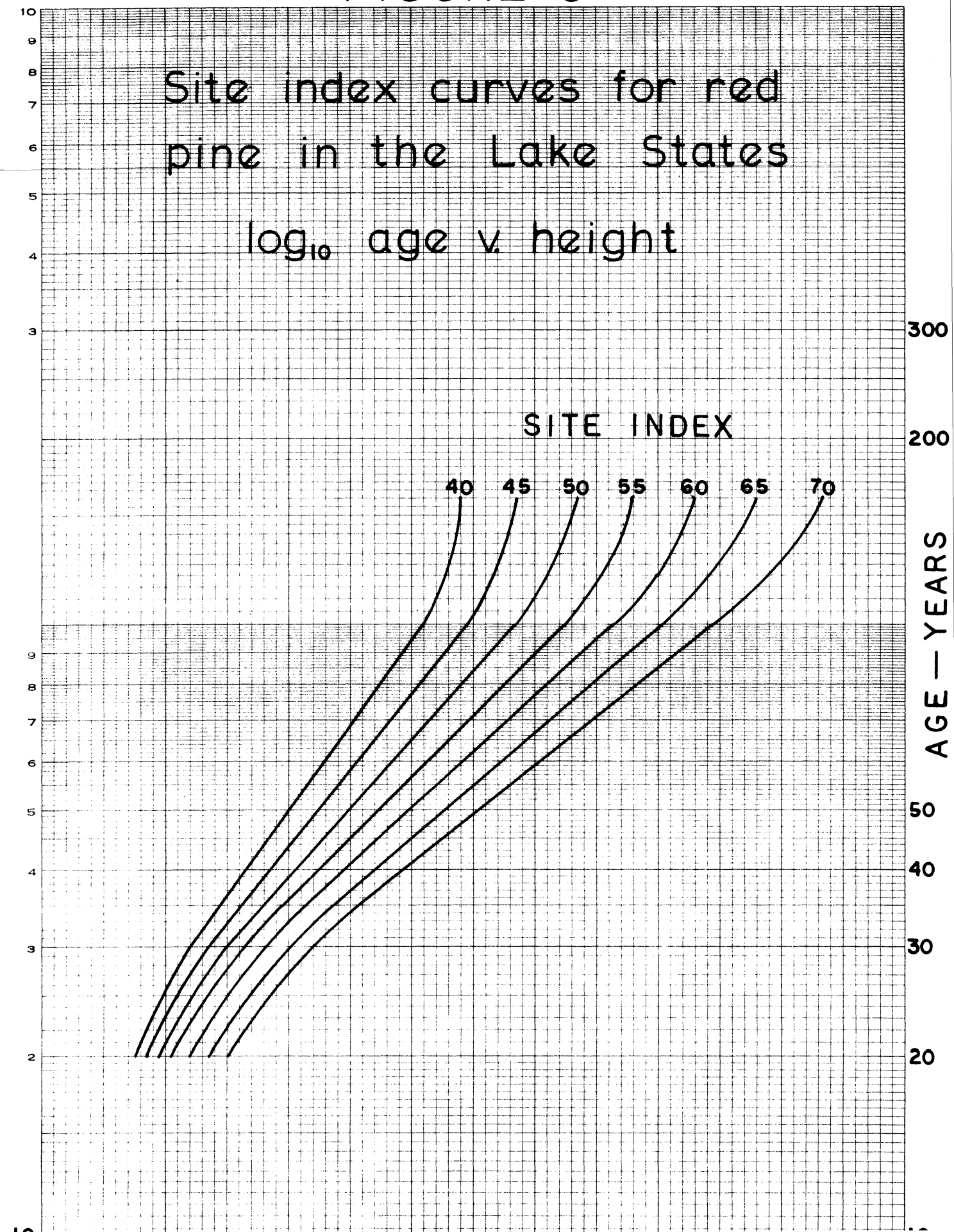

Site index curves for red pine in the Lake States
Gevorkiantz, 1957
70
65
60
55
50
45
40
130
120
110
100
90
80
70
60
50
40
30
20

FIGURE 6


Site index curves for red pine in the Lake States
log10 age v. height
SITE INDEX
40
45
50
55
60
65
70
AGE — YEARS
300
200
50
40
30
20
10
9
8
7
6
5
4
3
2

APPENDICES

APPENDIX A List source for Red Pine Yield (RPYLD).

```
// FOR                                                                  RPYLD000
*ONE WORD INTEGERS                                                      RPYLD001
*IOCS(CARD,1132 PRINTER)                                                RPYLD002
C                                                                       RPYLD003
C PROGRAM RPYLD--MODIFICATION AND REVISION OF PONYLD                    RPYLD004
C         FOR A DESCRIPTION OF PONYLD SEE USDA FOREST SERVICE RESEARCH  RPYLD005
C         PAPER RM-79                                                   RPYLD006
C                                                                       RPYLD007
C WRITTEN FOR THE IBM 1130 COMPUTER                                     RPYLD008
C     PROGRAMED BY TOM HANSON AND TOM ZEISLER   (1974)                  RPYLD009
C TO COMPUTE AND PRINT YIELD TABLES FOR MANAGED EVEN-AGED STANDS        RPYLD010
C                                                                       RPYLD011
C DEFINITIONS OF VARIABLES                                              RPYLD012
C     AGEO      AGE OF STAND                                            RPYLD013
C     BAST      BASAL AREA AFTER THINNING AND INITIAL BASAL AREA        RPYLD014
C     BDFO      BOARD FOOT VOLUME AFTER THINNING                        RPYLD015
C     BDFT      BOARD FEET AFTER THINNING (PER ACRE)                    RPYLD016
C     CFMO      CORD WOOD VOLUME BEFORE THINNING                        RPYLD017
C     CFMT      CORD WOOD VOLUME AFTER THINNING                         RPYLD018
C     COMBF     MINIMUM COMMERCIAL CUT--BOARD FEET                      RPYLD019
C     COMCU     MINIMUM COMMERCIAL CUT--CUBIC FEET                      RPYLD020
C     COMCW     MINIMUM COMMERCIAL CUT--CORD WOOD                       RPYLD021
C     CUFT      CUBIC FOOT VOLUME                                       RPYLD022
C     DBHIN     INPUT-DBH (DIMENSIONED AT 10)                           RPYLD023
C     DBHT      DBH AFTER THINNING AND INITIAL DBH                      RPYLD024
C     DENO      TREES PER ACRE BEFORE THINNING                          RPYLD025
C     DENT      TREES PER ACRE AFTER THINNING AND INITIAL TREES PER ACRE RPYLD026
C     HTCUM     CUMULATIVE HEIGHT                                       RPYLD027
C     HTSO      HEIGHT BEFORE THINNING                                  RPYLD028
C   HTST        TREE HGT. AFTER THINNING AND INITIAL BASAL AREA          RPYLD029
C     I AND II  THINNING NUMBER                                         RPYLD030
C     INAGE     INPUT-THINNING AGE (DIMENSIONED AT 10)                  RPYLD031
C     IADHT     INPUT-HEIGHT INCREASE AFTER THINNING (DEMENSIONED AT 10) RPYLD032
C     IRBA      INPUT-RESIDUAL BASAL AREA (DIMENSION AT 10)             RPYLD033
C     JSBD      SUM OF BOARD FEET FROM ALL CUTS WITH A YIELD OF COMBF OR RPYLD034
C             LARGER                                                    RPYLD035
C     JSMC      SUM OF CORDS FROM ALL CUTS WITH A YIELD OF COMCW OR      RPYLD036
C             LARGER                                                    RPYLD037
C     JSTF      SUM OF CUBIC FEET FROM ALL CUTS WITH A YIELD OF COMCU   RPYLD038
C             OR LARGER                                                 RPYLD039
C     ROTA      STAND TERMINATION AGE                                   RPYLD040
C     SITE      SITE INDEX                                              RPYLD041
C     NTSTS     NUMBER OF TESTS PER BATCH                               RPYLD042
C     TITL1     TITLE LINE 1                                            RPYLD043
C     TITL2     TITLE LINE2                                             RPYLD044
C     TITL3     TITLE LINE3                                             RPYLD045
C     TOTO      CUBIC FEET BEFORE THINNING  (PER ACRE)                  RPYLD046
C     TOTT      CUBIC FEET AFTER THINNING (PER ACRE)                    RPYLD047
C     VAR(X)    VARIABLE USED TO TEST FOR ILLEGAL ZERO OR NEGATIVE NO.  RPYLD048
C                                                                       RPYLD049
      REAL JTOTO,JCFMO,JTOTC,JCFMC,JCFMT,JTOTT,KTOTO,KCFMO,JSTF,JSMC    RPYLD050
      REAL          JSBD,KBDFO,JBDFO,JBDFC,JBDFT                      RPYLD051
      DIMENSION          VAR(10)          ,TITL1(20),TITL2(20),TITL3(20), RPYLD052
     1INAGE(10),IADHT(10),ITCNT(10)                                     RPYLD053
      COMMON BA,BAST,CUFT,DBHC,DBHT,DENO,FCTR,HITE,                     RPYLD054
     1TAND,VDM,DLEV,DBHIN(10),IRBA(10),VBDFO,VCFMO,ITHNC                RPYLD055
C INITIALIZE THIN COUNT                                                 RPYLD056
      ITHNC=0                                                           RPYLD057
C READ IN THREE TITLE CARDS                                             RPYLD058
      READ(2,4) TITL1,TITL2,TITL3                                       RPYLD059
    4 FORMAT(20A4)                                                      RPYLD060
C READ NUMBER OF TESTS PER BATCH AND BASE OF GROWING STOCK LEVELS FROM  RPYLD061
C CARD TYPE ONE                                                         RPYLD062
      READ(2,5) NTSTS                                                   RPYLD063
    5 FORMAT(I4)                                                        RPYLD064
```

APPENDIX A (continued)

```
      IF(NTSTS)170,170,7                                                RPYLD065
C READ MINIMUM COMMERCIAL CUTS FOR COMPUTATION OF COLUMN TOTALS         RPYLD066
C FROM CARD TYPE TWO                                                    RPYLD067
    7 READ(2,10) COMCU,COMCW,COMBF                                      RPYLD068
   10 FORMAT (10F8.3)                                                   RPYLD069
      VAR(1)=COMBF                                                      RPYLD070
      VAR(2)=COMCU                                                      RPYLD071
      VAR(3)=COMCW                                                      RPYLD072
C EXECUTE PROGRAM ONCE FOR EACH SET OF INTIAL VALUES OF INTEREST.       RPYLD073
      DO 160 III=1,NTSTS                                                RPYLD074
C CARD TYPE THREE                                                       RPYLD075
      READ(2,10)DBHT,DENT,HTST,BAST,AGEO,SITE                           RPYLD076
      VAR(4)=AGEO                                                       RPYLD077
      VAR(5)=SITE                                                       RPYLD078
      VAR( 6)=DBHT                                                      RPYLD079
      VAR( 7)=DENT                                                      RPYLD080
      VAR( 8)=HTST                                                      RPYLD081
      VAR( 9)=BAST                                                      RPYLD082
      DENO=DENT                                                         RPYLD083
      DBHO=DBHT                                                         RPYLD084
C CARD TYPE 4 - DIA. CHANGES AFTER THINNING                             RPYLD085
      READ(2,212)DBHIN                                                  RPYLD086
212   FORMAT(10F6.3)                                                    RPYLD087
C-----CARD TYPE 5  - RESIDUAL BASAL AREA                                RPYLD088
      READ(2,213) IRBA                                                  RPYLD089
  213 FORMAT(10I3)                                                      RPYLD090
C CARD TYPE 6 - AGE OF STAND AT THINNINGS                               RPYLD091
      READ(2,213) INAGE                                                 RPYLD092
C CARD TYPE 7 - HEIGHT AFTER THINNING                                   RPYLD093
      READ(2,213) IADHT                                                 RPYLD094
C CARD TYPE 8 - STAND TERMINATION AGE                                   RPYLD095
      READ(2,10) ROTA                                                   RPYLD096
      VAR(10)=ROTA                                                      RPYLD097
      DO 20 L=1,10                                                      RPYLD098
      IF(VAR(L))170,170,20                                              RPYLD099
   20 CONTINUE                                                          RPYLD100
C PROVIDE FOR SEVERAL GROWING STOCK LEVELS PER TEST                     RPYLD101
      CUFT=0.0                                                          RPYLD102
      BDFO=0.0                                                          RPYLD103
      BDFT=0.0                                                          RPYLD104
      CFMO=0.0                                                          RPYLD105
      CFMT=0.0                                                          RPYLD106
      HTCUM=0.0                                                         RPYLD107
      JSBD=0                                                            RPYLD108
      JSMC=0                                                            RPYLD109
      JSTF=0                                                            RPYLD110
      I=1                                                               RPYLD111
      II=1                                                              RPYLD112
      BASO=DENO*0.0054542*DBHO*DBHO                                     RPYLD113
C OBTAIN AVERAGE HEIGHT AND VOLUMES PER ACRE.                           RPYLD114
C-----STATEMENTS FOR HTSO AND IF STATEMENT ARE SPECIES-SPECIFIC.        RPYLD115
      X=ALOG(AGEO)/ALOG(10.)                                            RPYLD116
      ISITE=SITE+0.5                                                    RPYLD117
      IF (ISITE.EQ.40) HTSO=373.88-742.15*X+480.85*X**2-93.962*X**3     RPYLD118
      IF (ISITE.EQ.45) HTSO=381.35-759.41*X+493.15*X**2-95.770*X**3     RPYLD119
      IF (ISITE.EQ.50) HTSO=421.58-834.97*X+539.72*X**2-104.23*X**3     RPYLD120
      IF (ISITE.EQ.55) HTSO=452.09-893.73*X+576.78*X**2-110.93*X**3     RPYLD121
      IF (ISITE.EQ.60) HTSO=503.14-981.65*X+627.31*X**2-119.56*X**3     RPYLD122
      IF (ISITE.EQ.65) HTSO=513.12-1001.8*X+641.86*X**2-122.02*X**3     RPYLD123
      IF (ISITE.EQ.70) HTSO=569.53-1096.3*X+693.84*X**2-130.41*X**3     RPYLD124
      HITE=HTSO                                                         RPYLD125
      BA=BASO                                                           RPYLD126
      STAND=DENO                                                        RPYLD127
      DBHO=DBHT                                                         RPYLD128
      VOM=DBHO                                                          RPYLD129
      CALL RPVOL                                                        RPYLD130
```

APPENDIX A (continued).

```
      TOTO=CUFT                                                          RPYLD131
      BDFO=VBDFO                                                         RPYLD132
      CFMO=VCFMO                                                         RPYLD133
C ENTER LOOP FOR REMAINING COMPUTATIONS AND PRINTOUT.                    RPYLD134
      DO 130 K=1,100                                                     RPYLD135
C TEST FOR FINAL CUT                                                     RPYLD136
   43 IF(AGEO-ROTA)55,60,60                                              RPYLD137
C INCREASE D.B.H. BY THINNING AND COMPUTE POST-THINNING VALUES.          RPYLD138
   55 IF(K.EQ.1) GO TO 56                                                RPYLD139
      IF(INAGE(I)-IFIX(AGEO))56,551,56                                   RPYLD140
  551 CALL RPCUT                                                         RPYLD141
      I=I+1                                                              RPYLD142
      JDENT=(BAST/(0.0054542*DBHT*DBHT))+0.5                             RPYLD143
      DENT=JDENT                                                         RPYLD144
      IF(BAST-BASO)58,57,57                                              RPYLD145
   57 BAST=BASO                                                          RPYLD146
      HTST=HTSO                                                          RPYLD147
      DENT=DENO                                                          RPYLD148
      JDENT=DENO+0.5                                                     RPYLD149
      DBHT=DBHO                                                          RPYLD150
      TOTT=TOTO                                                          RPYLD151
      BDFT=BDFO                                                          RPYLD152
      CFMT=CFMO                                                          RPYLD153
      GO TO 60                                                           RPYLD154
56    DBHO=DBHT                                                          RPYLD155
      DENO=DENT                                                          RPYLD156
      HTSO=HTST                                                          RPYLD157
      BASO=BAST                                                          RPYLD158
      JDENT=DENT                                                         RPYLD159
      GO TO 59                                                           RPYLD160
C-----STATEMENT FOR ADDHT IS SPECIES-SPECIFIC.                           RPYLD161
   58 ADDHT=IADHT(ITHNC)                                                 RPYLD162
      HTCUM=HTCUM+ADDHT                                                  RPYLD163
      HTST=HTSO+ADDHT                                                    RPYLD164
   59 STAND=DENT                                                         RPYLD165
      VOM=DBHT                                                           RPYLD166
      HITE=HTST                                                          RPYLD167
      BA=BAST                                                            RPYLD168
      CALL RPVOL                                                         RPYLD169
      TOTT=CUFT                                                          RPYLD170
      CFMT=VCFMO                                                         RPYLD171
      BDFT=VBDFO                                                         RPYLD172
C ROUND OFF FOR PRINTING.                                                RPYLD173
   60 JAGEO=AGEO                                                         RPYLD174
      DBHO=DBHO+.05                                                      RPYLD175
      JSITE=SITE+0.5                                                     RPYLD176
      JDENO=DENO+0.5                                                     RPYLD177
      JHTSO=HTSO+0.5                                                     RPYLD178
      JTOTO=TOTO+.005                                                    RPYLD179
      JBASO=BASO+0.5                                                     RPYLD180
      JCFMO=CFMO+.005                                                    RPYLD181
      JBDFO=BDFO+.005                                                    RPYLD182
      JHTST=HTST+0.5                                                     RPYLD183
      JTOTT=TOTT+.005                                                    RPYLD184
      JCFMT=CFMT+.005                                                    RPYLD185
      IF(JCFMT-JCFMO)62,62,61                                            RPYLD186
   61 JCFMO=JCFMT                                                        RPYLD187
62    JBDFT=BDFT+.005                                                    RPYLD188
      IF(JBDFT-JBDFO)64,64,63                                            RPYLD189
   63 JBDFO=JBDFT                                                        RPYLD190
   64 JBAST=BAST+0.5                                                     RPYLD191
      JDENC=JDENO-JDENT                                                  RPYLD192
      JBASC=JBASO-JBAST                                                  RPYLD193
      JTOTC=JTOTO-JTOTT                                                  RPYLD194
      JCFMC=JCFMO-JCFMT                                                  RPYLD195
      IF(JCFMC)640,640,641                                               RPYLD196
```

APPENDIX A (continued).

```
  640 JCFMC=0.0                                                          RPYLD197
  641 JBDFC=JBDFO-JBDFT                                                  RPYLD198
      IF(JBDFC)642,642,643                                               RPYLD199
  642 JBDFC=0                                                            RPYLD200
C SUM PERIODIC CUTS FOR LAST LINE OF YIELD TABLE.                        RPYLD201
  643 IF(AGEO-ROTA)644,921,921                                           RPYLD202
  644 IF(INAGE(II)-IFIX(AGEO))70,645,70                                  RPYLD203
  645 TOTC=JTOTC                                                         RPYLD204
      IF((TOTC*1000.)-COMCU)6452,6451,6451                               RPYLD205
 6451 JSTF=JSTF+JTOTC                                                    RPYLD206
 6452 CFMC=JCFMC                                                         RPYLD207
      IF(CFMC-COMCW)65,646,646                                           RPYLD208
  646 JSMC=JSMC+JCFMC                                                    RPYLD209
   65 BDFC=JBDFC                                                         RPYLD210
      IF((BDFC*1000.)-COMBF)70,69,69                                     RPYLD211
   69 JSBD=JSBD+JBDFC                                                    RPYLD212
C WRITE HEADINGS FOR YIELD TABLE.                                        RPYLD213
   70 IF(K-2)71,701,701                                                  RPYLD214
  701 IF(INAGE(II)-IFIX(AGEO))961,92,961                                 RPYLD215
C-----CHANGE TABLE HEADING FOR OTHER SPECIES.                            RPYLD216
   71 WRITE(3,79)TITL1,TITL2,TITL3                                       RPYLD217
   79 FORMAT ('1'//3(20X,20A4/))                                         RPYLD218
      WRITE(3,80) JSITE                                                  RPYLD219
   80 FORMAT('0'//28X,'PROJECTIONS FOR A MANAGED STAND OF EVEN-AGED LAKERPYLD220
     1 STATES RED PINE'//45X'ALL VALUES ON A PER ACRE BASIS'//52X,'SITE RPYLD221
     2INDEX = 'I3)                                                       RPYLD222
      WRITE(3,84)                                                        RPYLD223
   84 FORMAT('0',11X,'ENTIRE STAND BEFORE AND AFTER PERIODIC HARVESTS'   RPYLD224
     125X,'PERIODIC HARVESTED VOLUMES')                                  RPYLD225
      WRITE(3,86)                                                        RPYLD226
   86 FORMAT('0',1X,'STAND'3X'TREES'2X'BASAL'3X'AVERAGE'2X'AVERAGE'2X'CURPYLD227
     1.FT.'3X'CORDWOOD'5X'BD.FT.  * TREES'3X'BASAL'3X'CU.FT.'2X'CORDWOODRPYLD228
     2'6X'BD.FT.')                                                       RPYLD229
      WRITE(3,88)                                                        RPYLD230
   88 FORMAT(2H  ,1X,'AGE'5X'PER'3X'AREA'5X'D.B.H.'3X'HEIGHT'2X'VOLUME'4RPYLD231
     1X'VOLUME'6X'VOLUME'2X'*'2X'PER'4X'AREA'4X'VOLUME'3X'VOLUME'7X'VOLURPYLD232
     2ME')                                                               RPYLD233
      WRITE(3,90)                                                        RPYLD234
   90 FORMAT(1H , 1X,'YEARS'3X'ACRE'3X'SQ.FT.'4X'IN.'6X'FT.'4X'M.C.F.'4XRPYLD235
     1'CDS/AC'6X'M.B.F.'2X'*'1X'ACRE'4X'SQ.FT.'2X'M.C.F.'3X'CDS/AC'7X'M.RPYLD236
     2B.F.')                                                             RPYLD237
      GO TO 921                                                          RPYLD238
C WRITE TABLE ENTRIES OF DIAMETER, VOLUMES, ETC.                         RPYLD239
   92 II=II+1                                                            RPYLD240
  921 WRITE(3,94)JAGEO,JDENO,JBASO,DBHO,JHTSO,JTOTO,JCFMO,JBDFO          RPYLD241
   94 FORMAT(1H ,72X,'*',/,1H I4,4X,I5,2X,I4,5X,F5.1,5X,I3,4X,F5.2,5X,F6RPYLD242
     1.2,6X,F6.2,3X'*')                                                  RPYLD243
      IF(K-1)941,961,941                                                 RPYLD244
941   IF(AGEO-ROTA)95,135,135                                            RPYLD245
   95 WRITE(3,96) JAGEO,JDENT,JBAST,DBHT,JHTST,JTOTT,JCFMT,JBDFT,JDENC,JRPYLD246
     1BASC,JTOTC,JCFMC,JBDFC                                             RPYLD247
   96 FORMAT(1H ,I4,4X,I5,2X,I4,5X,F5.1,5X,I3,4X,F5.2,5X,F6.2,6X,F6.2,3XRPYLD248
     1,'*',I5                                                            RPYLD249
     2,3X,I3,5X,F5.2,5X,F6.2,8X,F6.2)                                    RPYLD250
C COMPUTE VALUES FOR EACH PERIOD. THIN AS SPECIFIED.                     RPYLD251
  961 AGEO=AGEO+1                                                        RPYLD252
      IF(AGEO-ROTA)97,97,135                                             RPYLD253
C COMPUTE NEW D.B.H. BEFORE THINNING AND ROUND OFF TO 0.1 INCH.          RPYLD254
C-----STATEMENT FOR DBHO IS SPECIES SPECIFIC.                            RPYLD255
   97 BASO=BAST                                                          RPYLD256
      BASG=1.6889+.041066*BASO-.000163u3*BASO**2-.076958*AGEO+.00022741*RPYLD257
     1AGEO**2+.06441*SITE                                                RPYLD258
      BASN=BASG+BASO                                                     RPYLD259
      BASO=BASN                                                          RPYLD260
      DENO=DENT                                                          RPYLD261
      DBHO=SQRT((BASO/DENO)/.0054542)                                    RPYLD262
```

APPENDIX A (continued).

```
  100 DENO=DENT                                                          RPYLD263
  105 CONTINUE                                                           RPYLD264
C OBTAIN AVERAGE HEIGHT AND VOLUME PER ACRE.                             RPYLD265
C-----STATEMENTS FOR HTSO AND IF STATEMENT ARE SPECIES-SPECIFIC.         RPYLD266
      X=ALOG(AGEO)/ALOG(10.)                                             RPYLD267
      ISITE=SITE+0.5                                                     RPYLD268
      IF (ISITE.EQ.40) HTSO=373.88-742.15*X+480.85*X**2-93.962*X**3      RPYLD269
      IF (ISITE.EQ.45) HTSO=381.35-759.41*X+493.15*X**2-95.770*X**3      RPYLD270
      IF (ISITE.EQ.50) HTSO=421.58-834.97*X+539.72*X**2-104.23*X**3      RPYLD271
      IF (ISITE.EQ.55) HTSO=452.09-893.73*X+576.78*X**2-110.93*X**3      RPYLD272
      IF (ISITE.EQ.60) HTSO=503.14-981.65*X+627.31*X**2-119.56*X**3      RPYLD273
      IF (ISITE.EQ.65) HTSO=513.12-1001.8*X+641.86*X**2-122.02*X**3      RPYLD274
      IF (ISITE.EQ.70) HTSO=569.53-1096.3*X+693.84*X**2-130.41*X**3      RPYLD275
      HTSO=HTSO+HTCUM                                                    RPYLD276
      STAND=DENO                                                         RPYLD277
      VOM=DBHO                                                           RPYLD278
      HITE=HTSO                                                          RPYLD279
      BA=BASO                                                            RPYLD280
      CALL RPVOL                                                         RPYLD281
      TOTO=CUFT                                                          RPYLD282
      CFMO=VCFMO                                                         RPYLD283
      BDFO=VBDFO                                                         RPYLD284
C TEST FOR STAND TERMINATION                                             RPYLD285
      IF(AGEO-ROTA   )118,43,118                                         RPYLD286
  118 CONTINUE                                                           RPYLD287
C TEST IF THINNING IS DUE                                                RPYLD288
      IF(INAGE(II)-IFIX(AGEO))119,125,119                                RPYLD289
C ROUND OFF FOR PRINTING                                                 RPYLD290
  119 KDENO=DENO+0.5                                                     RPYLD291
      KAGEO=AGEO                                                         RPYLD292
      KHTSO=HTSO+0.5                                                     RPYLD293
      KBASO=BASO+0.5                                                     RPYLD294
      KTOTO=TOTO+.005                                                    RPYLD295
      KCFMO=CFMO+.005                                                    RPYLD296
      KBDFO=BDFO+.005                                                    RPYLD297
C WRITE VALUES FOR THE PERIOD IF THINNING IS NOT DUE.                    RPYLD298
      WRITE(3,94) KAGEO,KDENO,KBASO,DBHO,KHTSO,KTOTO,KCFMO,KBDFO         RPYLD299
      DBHT=DBHO                                                          RPYLD300
      BAST=BASO                                                          RPYLD301
      DENT=DENO                                                          RPYLD302
  125 REST=DLEV                                                          RPYLD303
  130 CONTINUE                                                           RPYLD304
C ADD FINAL CUTS TO TOTAL YIELDS AND WRITE TOTAL YIELDS.                 RPYLD305
 135  TOTO=JTOTO                                                         RPYLD306
      IF((TOTO*1000.)-COMCU)1352,1351,1351                               RPYLD307
 1351 JSTF=JSTF+JTOTO                                                    RPYLD308
 1352 CFMO=JCFMO                                                         RPYLD309
      IF(CFMO-COMCW)140,136,136                                          RPYLD310
  136 JSMC=JSMC+JCFMO                                                    RPYLD311
  140 BDFO=JBDFO                                                         RPYLD312
      IF((BDFO*1000.)-COMBF)145,141,141                                  RPYLD313
  141 JSBD=JSBD+JBDFO                                                    RPYLD314
  145 WRITE(3,150) JSTF,JSMC,JSBD                                        RPYLD315
  150 FORMAT(1H0,/58X,12HTOTAL YIELDS,19X,F5.2,4X,F6.2,5X,F8.2)          RPYLD316
      WRITE(3,155) COMCU,COMCW,COMBF                                     RPYLD317
  155 FORMAT(1H0// 11X,'MINIMUM PER ACRE CUTS FOR INCLUSION IN TOTAL YIERPYLD318
     1LDS-'/1H ,10X,F6.0' CUBIC FEET AND'F6.0' CORDS AND'F6.0' BOARD FEERPYLD319
     2T')                                                                RPYLD320
      WRITE(3,156)                                                       RPYLD321
  156 FORMAT(1H0,10X,'CUBIC FOOT VOLUME INCLUDES THE GROSS CUBIC FOOT PERPYLD322
     1ELED VOLUME OF ALL STEMS PER ACRE 5.0 '/1H ,10X,'INCHES D.B.H. ANDRPYLD323
     3 LARGER.'/1H0,10X,'CORDWOOD VOLUME INCLUDES ALL STEMS PER ACRE 5.0RPYLD324
     4 INCHES D.B.H. AND LARGER TO A VARIABLE TOP D.I.B.'/1H ,10X,'OF NORPYLD325
                                                                         RPYLD326
     5T LESS THAN 3.0 INCHES.'/1H0,10X,'BOARD FOOT VOLUME INCLUDES VOLUMRPYLD327
     6E PER ACRE, SCRIBNER DECIMAL C RULE, ALL TREES TO 10.0 INCHES D.B.RPYLD328
```

APPENDIX A (continued).

```
     6H.'/1H , 9X,' AND LARGER TO A 6.0 INCH TOP D.I.B.')                    RPYLD329
      DO 1571 I=1,10                                                         RPYLD330
 1571 ITCNT(I)=I                                                             RPYLD331
      WRITE(3,158)ITCNT,INAGE,IRBA,DBHIN,IADHT                               RPYLD332
  158 FORMAT('0'//42X'INPUT DATA FOR EACH PARTICULAR THINNING'/'0',          RPYLD333
     1'THINNING'9X,I2,9(8X,I2)/'0AGE'13X,I3,9(7X,I3)/                       RPYLD334
     2'0BASAL AREA'6X,I3,9(7X,I3)/'0DBH CHANGE'4X,F6.3,9(4X,F6.3)/          RPYLD335
     3'0HT. CHANGE'6X,I3,9(7X,I3)////'   COMPUTER OUTPUT - COLLEGE OF NARPYLD336
     4TURAL RESOURCES - UNIVERSITY OF WISCONSIN, STEVENS POINT')             RPYLD337
      ITHNC=0                                                                RPYLD338
  160 CONTINUE                                                               RPYLD339
      GO TO 200                                                              RPYLD340
  170 WRITE(3,175)                                                           RPYLD341
  175 FORMAT(1H1,///,10X,66HEXECUTION STOPPED BECAUSE OF NEGATIVE OR ZERRPYLD342
     1O ITEM ON A DATA CARD.)                                                RPYLD343
  200 CALL EXIT                                                              RPYLD344
      END                                                                    RPYLD345
// DUP                                                                       RPYLD346
*DELETE              RPYLD                                                  RPYLD347
*STORE      WS  UA  RPYLD                                                   RPYLD348

// *END

// *END
```

APPENDIX B List source for subroutine RPVOL.

```
// FOR                                                                  RPVOL000
*ONE WORD INTEGERS                                                      RPVOL001
      SUBROUTINE RPVOL                                                  RPVOL002
C TO COMPUTE VOLUMES PER ACRE IN VARIOUS UNITS.                         RPVOL003
      COMMON BA,BAST,CUFT,DBHO,DBHT,DENO,FCTR,HITE,                     RPVOL004
     1TAND,VDM,DLEV,DBHIN(10),IRBA(10),VBDFO,VCFMO,ITHNC                RPVOL005
      CUFT=0.0                                                          RPVOL006
      VBDFO=0.0                                                         RPVOL007
      VCFMO=0.0                                                         RPVOL008
C COMPUTE TOTAL CUBIC FEET PER ACRE.                                    RPVOL009
      IF(VDM-5.001  )40,10,10                                           RPVOL010
   10 CUFT=.4085*BA*HITE                                                RPVOL011
C-----CONVERT TO M.C.F.                                                 RPVOL012
      CUFT=CUFT/1000.0                                                  RPVOL013
      IF(CUFT)101,11,11                                                 RPVOL014
  101 CUFT=0.0                                                          RPVOL015
C CORD WOOD VOLUME                                                      RPVOL016
   11 VCFMO=-0.907+0.004133*BA*HITE                                     RPVOL017
      IF(VDM-10.)40,1212,1212                                           RPVOL018
C VD. FT. VOLUME (SCRIBNER DECIMAL C)                                   RPVOL019
 1212 VBDFO=-1707+2.283*BA*HITE                                         RPVOL020
C     CONVERT TO M. B. F. VALUES                                        RPVOL021
      VBDFO=VBDFO/1000.                                                 RPVOL022
40    RETURN                                                            RPVOL023
      END                                                               RPVOL024
// DUP                                                                  RPVOL025
*DELETE              RPVOL                                              RPVOL026
*STORE      WS  UA   RPVOL                                              RPVOL027

// *END

// *END
```

APPENDIX C List source for subroutine RPCUT.

```
// FOR                                                                    RPCUT000
*ONE WORD INTEGERS                                                        RPCUT001
      SUBROUTINE RPCUT                                                    RPCUT002
C TO CALCULATE DBH INCREASE AFTER THINNING                                RPCUT003
C      INCREASE IS READ OFF CARD 4B IN MAINLINE                           RPCUT004
C     DBHIN - DBH INCREASE                                                RPCUT005
C     DBHO - DBH FROM MAINELINE                                           RPCUT006
C     DBHT - DBH AFTER THINNING                                           RPCUT007
C     BAST + DSTY - FROM MAINELINE                                        RPCUT008
      COMMON BA,BAST,CUFT,DBHO,DBHT,DENO,FCTR,HITE,                       RPCUT009
     1TAND,VDM,DLEV,DBHIN(10),IRBA(10),VBDFO,VCFMO,ITHNC                  RPCUT010
      ITHNC=ITHNC+1                                                       RPCUT011
      IF(ITHNC-10)10,10,20                                                RPCUT012
10    DBHT=DBHO+.05+DBHIN(ITHNC)                                          RPCUT013
      BAST=IRBA(ITHNC)                                                    RPCUT014
      RETURN                                                              RPCUT015
20    DBHT=DBHO                                                           RPCUT016
      RETURN                                                              RPCUT017
      END                                                                 RPCUT018
// DUP                                                                    RPCUT019
*DELETE              RPCUT                                                RPCUT020
*STORE      WS  UA   RPCUT                                                RPCUT021

// *END

// *END
```

APPENDIX D Control cards

Each set of control cards begins with two separate data cards. The first card contains the number of tests which are to be performed within a particular set of data. The second card contains the minimum cuts for inclusion in the total yields for cubic foot, cordwood and board foot volumes.

Card	Format	Columns	Variable
1	I4	1-4	Number of tests to be performed
2	F8.3	1-8	Minimum cubic feet to be included in the total yields
	F8.3	9-16	Minimum cordwood to be included in the total yields
	F8.3	17-24	Minimum board feet to be included in the total yields

The remaining six control cards are repeated for each test desired. Their format is as follows:

Card	Format	Columns	Variable
3	F8.3	1-8	Mean stand diameter (inches)
	F8.3	9-16	Trees per acre
	F8.3	17-24	Mean stand height (feet)
	F8.3	25-32	Basal area (square feet/acre)
	F8.3	33-40	Stand age
	F8.3	41-48	Site index
4	F6.3	1-60	Diameter change (for thinning)
5	I3	1-30	Residual basal area
6	I3	1-30	Stand age (for thinning)
7	I3	1-30	Height change (for thinning)
8	F8.3	1-8	Stand termination age

For control cards 4, 5, 6 and 7, a total of ten thinnings are possible. Each value is entered consecutively (one through ten) with the specified format in the specified columns. If less than ten thinnings are desired, the unused columns remain blank.

APPENDIX E Special notes to the user of RPYLD.

The following is a list of statements which the user should be familiar with before attempting to utilize RPYLD.

(1) When entering stand data, the trees per acre, basal area and mean stand diameter all must correspond. If only two varibles are known, the third may be found through one of the following equations.

$$\text{mean diameter} = \sqrt{\frac{\frac{\text{basal area}}{\text{trees/acre}}}{.0054542}} \qquad (2)$$

$$\text{basal area} = (.0054542)(\text{diameter})^2(\text{trees/acre}) \qquad (3)$$

$$\text{trees/acre} = \frac{\text{basal area}}{(.0054542)(\text{diameter})^2} \qquad (4)$$

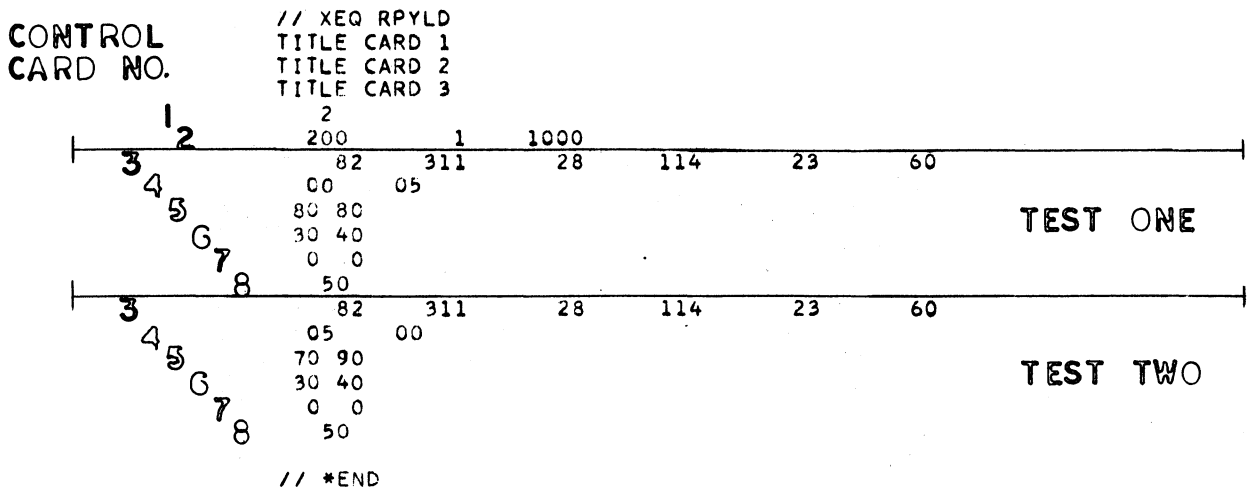
If all three variables were previously determined, it is still reccommended these equations be used to make certain all three values correspond.

(2) The mean height entered must be the mean height of the dominant and co-dominant trees. If only the stand age and site index are known, the mean height may be read directly from Table 4. The figure given must be rounded off to the nearest foot.

(3) Only site indices between 40 and 70 at five year intervals may be used; viz. 40, 45, 50, 55, 60, 65 and 70.

(4) If the model is allowed to run for a number of years without any silvicultural treatments, the limits of the basal area growth equation will eventually be reached. When this occurs, the basal area will begin to decrease annually without any decrement in the number of trees per acre.

APPENDIX F Sample of input control cards for RPYLD. The output information for this data is given in APPENDIX G



TITLE CARD 2
TITLE CARD 3

PROJECTIONS FOR A MANAGED STAND OF EVEN-AGED LAKE STATES RED PINE

ALL VALUES ON A PER ACRE BASIS

SITE INDEX = 60

ND E RS	ENTIRE STAND BEFORE AND AFTER PERIODIC HARVESTS							PERIODIC HARVESTED VOLUMES				
	TREES PER ACRE	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	CU.FT. VOLUME M.C.F.	CORDWOOD VOLUME CDS/AC	BD.FT. VOLUME M.B.F.	TREES PER ACRE	BASAL AREA SQ.FT.	CU.FT. VOLUME M.C.F.	CORDWOOD VOLUME CDS/AC	BD.FT. VOLUME M.B.F.
	311	114	8.2	28	1.29	12.29	0.00					
	311	120	8.4	29	1.42	13.48	0.00					
	311	127	8.6	30	1.56	14.88	0.00					
	311	133	8.8	31	1.71	16.35	0.00					
	311	139	9.0	33	1.86	17.89	0.00					
	311	145	9.2	34	2.02	19.49	0.00					
	311	151	9.4	35	2.18	21.14	0.00					
	311	157	9.6	37	2.35	22.84	0.00					
	156	80	9.6	37	1.19	11.17	0.00	155	77	1.15	11.67	0.00
	156	86	10.0	38	1.32	12.47	5.68					
	156	91	10.3	39	1.46	13.84	6.44					
	156	97	10.6	40	1.60	15.26	7.22					
	156	103	10.9	42	1.74	16.74	8.04					
	156	108	11.2	43	1.89	18.27	8.88					
	156	114	11.5	44	2.05	19.84	9.75					
	156	119	11.8	45	2.21	21.46	10.65					
	156	125	12.1	47	2.38	23.13	11.57					
	156	130	12.3	48	2.54	24.83	12.51					
	156	136	12.6	49	2.71	26.56	13.46					
	84	80	13.1	49	1.60	15.27	7.23	72	56	1.11	11.29	6.23
	84	85	13.6	50	1.74	16.69	8.01					
	84	90	14.0	51	1.88	18.16	8.82					

APPENDIX G Output obtained from the sample input in APPENDIX F

84	95	14.4	52	2.03	19.67	9.66	*
84	100	14.7	53	2.19	21.22	10.51	*
84	105	15.1	55	2.34	22.80	11.39	*
84	110	15.5	56	2.50	24.42	12.28	*
84	115	15.8	57	2.67	26.07	13.19	*
84	120	16.1	58	2.83	27.75	14.12	*
84	125	16.5	59	3.00	29.44	15.06	*
84	130	16.8	60	3.17	31.16	16.01	*

TOTAL YIELDS	5.44	54.13	22.24

MINIMUM PER ACRE CUTS FOR INCLUSION IN TOTAL YIELDS-
200. CUBIC FEET AND 1. CORDS AND 1000. BOARD FEET

CUBIC FOOT VOLUME INCLUDES THE GROSS CUBIC FOOT PEELED VOLUME OF ALL STEMS PER ACRE 5.0 INCHES D.B.H. AND LARGER.

CORDWOOD VOLUME INCLUDES ALL STEMS PER ACRE 5.0 INCHES D.B.H. AND LARGER TO A VARIABLE TOP D.I.B. OF NOT LESS THAN 3.0 INCHES.

BOARD FOOT VOLUME INCLUDES VOLUME PER ACRE, SCRIBNER DECIMAL C RULE, ALL TREES TO 10.0 INCHES D.B.H. AND LARGER TO A 6.0 INCH TOP D.I.B.

INPUT DATA FOR EACH PARTICULAR THINNING

NNING	1	2	3	4	5	6	7	8	9	10
	30	40	0	0	0	0	0	0	0	0
AL AREA	80	80	0	0	0	0	0	0	0	0
CHANGE	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CHANGE	0	0	0	0	0	0	0	0	0	0

TITLE CARD 2
TITLE CARD 3

PROJECTIONS FOR A MANAGED STAND OF EVEN-AGED LAKE STATES RED PINE

ALL VALUES ON A PER ACRE BASIS

SITE INDEX = 60

	ENTIRE STAND BEFORE AND AFTER PERIODIC HARVESTS							PERIODIC HARVESTED VOLUMES				
STAND AGE YEARS	TREES PER ACRE	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	CU.FT. VOLUME M.C.F.	CORDWOOD VOLUME CDS/AC	BD.FT. VOLUME M.B.F.	TREES PER ACRE	BASAL AREA SQ.FT.	CU.FT. VOLUME M.C.F.	CORDWOOD VOLUME CDS/AC	BD.FT. VOLUME M.B.F.
23	311	114	8.2	28	1.29	12.29	0.00					
24	311	120	8.4	29	1.42	13.48	0.00					
25	311	127	8.6	30	1.56	14.88	0.00					
26	311	133	8.8	31	1.71	16.35	0.00					
27	311	139	9.0	33	1.86	17.89	0.00					
28	311	145	9.2	34	2.02	19.49	0.00					
29	311	151	9.4	35	2.18	21.14	0.00					
30	311	157	9.6	37	2.35	22.84	4.13					
30	124	70	10.1	37	1.04	9.66	4.13	187	87	1.30	13.18	0.00
31	124	75	10.5	38	1.17	10.88	4.80					
32	124	81	10.9	39	1.29	12.17	5.52					
33	124	86	11.3	40	1.43	13.52	6.26					
34	124	92	11.6	42	1.56	14.92	7.03					
35	124	98	12.0	43	1.71	16.38	7.84					
36	124	103	12.3	44	1.86	17.88	8.67					
37	124	109	12.6	45	2.01	19.44	9.53					
38	124	114	12.9	47	2.17	21.04	10.42					
39	124	120	13.2	48	2.33	22.68	11.32					
40	124	125	13.6	49	2.50	24.36	12.25					
40	89	90	13.6	49	1.80	17.29	8.34	35	35	0.69	7.06	3.90
41	89	95	14.0	50	1.95	18.79	9.17					
42	89	100	14.3	51	2.10	20.33	10.02					

APPENDIX G Continuation of output from input of APPENDIX F

43	89	105	14.7	52	2.26	21.91	10.90	*
44	89	111	15.0	53	2.41	23.52	11.79	*
45	89	116	15.4	55	2.58	25.17	12.70	*
46	89	121	15.7	56	2.74	26.85	13.63	*
47	89	126	16.0	57	2.91	28.55	14.57	*
48	89	131	16.4	58	3.08	30.28	15.52	*
49	89	136	16.7	59	3.25	32.02	16.48	*
50	89	140	17.0	60	3.43	33.78	17.45	*
					TOTAL YIELDS		5.43	54.04	21.36

MINIMUM PER ACRE CUTS FOR INCLUSION IN TOTAL YIELDS-
200. CUBIC FEET AND 1. CORDS AND 1000. BOARD FEET

CUBIC FOOT VOLUME INCLUDES THE GROSS CUBIC FOOT PEELED VOLUME OF ALL STEMS PER ACRE 5.0 INCHES D.B.H. AND LARGER.

CORDWOOD VOLUME INCLUDES ALL STEMS PER ACRE 5.0 INCHES D.B.H. AND LARGER TO A VARIABLE TOP D.I.B. OF NOT LESS THAN 3.0 INCHES.

BOARD FOOT VOLUME INCLUDES VOLUME PER ACRE, SCRIBNER DECIMAL C RULE, ALL TREES TO 10.0 INCHES D.B.H. AND LARGER TO A 6.0 INCH TOP D.I.B.

INPUT DATA FOR EACH PARTICULAR THINNING

THINNING	1	2	3	4	5	6	7	8	9	10
AGE	30	40	0	0	0	0	0	0	0	0
BASAL AREA	70	90	0	0	0	0	0	0	0	0
DBH CHANGE	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
HT. CHANGE	0	0	0	0	0	0	0	0	0	0

COMPUTER OUTPUT - COLLEGE OF NATURAL RESOURCES - UNIVERSITY OF WISCONSIN, STEVENS POINT
// *END

// *END

APPENDIX H Copy of letter received from North Central Forest Experiment Station explaining the deficiency of data available for red pine on the better sites.

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
North Central Forest Experiment Station
Folwell Avenue
St. Paul, Minnesota 55101

1600
November 16, 1973

Mr. Thomas J. Hanson
Room 316, Nelson Hall
University of Wisconsin
Stevens Point, Wisconsin 54481

Dear Mr. Hanson:

We have no stand and stocking tables for red pine on the better sites. Our economists are trying to assemble such data and hope to have it ready for publication next year. At present, however, the data are too fragmentary to be reliable or usable in your study.

I am sorry we could not provide the information you need. When our study is completed, we will be glad to send you a copy of the publication if you wish.

Sincerely,

Robert D. Wray

ROBERT D. WRAY, Chief
Information Services