

**ECONOMIC ANALYSIS OF THINNING ALTERNATIVES IN NATURAL STANDS
OF
YELLOW-POPLAR**

by

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**Thesis submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE
in
Forestry**

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**May, 1983
Blacksburg, Virginia**

ACKNOWLEDGEMENTS

I wish to thank my committee members, Harold Burkhart and David Klemperer for their help in the various aspects of the preparation of this thesis. Their excellent counsel and prompt review of earlier drafts of this thesis made this endeavor a much more fruitful and less painful experience.

My thanks go to my committee chairman, Mark Vodak, for both the technical and administrative aid he gave during the completion of this thesis. His pleasant and friendly manner made this experience much more enjoyable.

I also wish to thank the various members of the faculty and staff who contributed not only to the completion of this thesis but also guided me during my studies at VPI. I am especially thankful to Bruce Knoebel for his help in the growth and yield modelling aspects of this study.

Finally, I wish to extend my thanks to my wife Susan whose abilities as proofreader, draftsperson, and scapegoat made the rough times easier. Her understanding and support has been invaluable to me.

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INTRODUCTION

Yellow-poplar (Liriodendron tulipifera L.) has long been and still remains one of the most important eastern hardwood species. The importance of yellow-poplar is attributed to its availability, rapid growth, excellent form, and good working qualities. It is typically used for veneer, core stock, and furniture dimension lumber. Demand for yellow-poplar in these uses is expected to continue. Recent technological developments and market changes have also allowed yellow-poplar to be used as a substitute for increasingly scarce softwoods in the eastern housing market.

Due to the current and projected demand for yellow-poplar, its management and production represent a viable investment alternative for the forest landowner. Owners of stands of yellow-poplar may find it profitable to manipulate stand density via commercial thinnings. By controlling stand density through thinnings, more valuable large diameter trees can be produced than in comparable unthinned stands. Production of large diameter trees is desirable since most markets for yellow-poplar require large diameters. Smaller diameter trees (less than 11 inches DBH) are virtually excluded from these markets.

Response of yellow-poplar to thinning is well documented in the forestry literature. In general, three observations have been made about thinning response:

1. Diameter growth is increased by thinning; diameter growth of individual trees generally increases as stand density decreases.
2. Even older stands will respond to thinning, provided the thinning is heavy.
3. Within a stand, all trees increase in diameter growth after heavy thinnings. But the smallest trees exhibit the greatest response relative to growth before thinning (Allen and Marquis 1970, Bowersox and Ward 1972, Beck and Della-Bianca 1975).

From these observations one can conclude that yellow-poplar is very responsive to thinning, even across a wide range of age classes. However, it is not enough for a landowner to know that thinning will increase production of large trees considerably. In order to allocate limited investment funds in an efficient manner, landowners need definitive information concerning thinning response. It is therefore necessary to develop a means of making both the physical and economic data of thinning accessible to the landowner for investment analyses.

Objectives

The primary objective of this study was to develop a computer-based model to provide the necessary information required by landowners to evaluate thinning alternatives in yellow-poplar stands. The model was to be flexible in design and user friendly in order to be useful to the greatest number of landowners. Furthermore, the computer model was to be adapted to the micro-computer to enhance accessibility and transportability. By using this model, a landowner may determine the optimal number and timing of thins, and the residual densities after thinning for a given stand. Furthermore, the returns generated from a given stand may be compared to alternative investments.

Two secondary objectives were: (1) to use the model developed to compare different yellow-poplar thinning regimes in order to determine which would be optimal under a given set of economic conditions; (2) to determine how sensitive optimal thinning regimes are to changes in the discount rate, thinning costs, and stumpage price variations.

LITERATURE REVIEW

Numerous studies have reported the response of yellow-poplar to thinning. Downs(1946), Holse(1951), and Bowersox and Ward(1972) all found that yellow-poplar responds immediately to release by the removal of adjacent trees. Wahlenberg(1952) and Williams(1976) also found that stands of yellow-poplar respond quickly to thinning with the degree of response being directly proportional to the thinning intensity. Beck and Della-Bianca(1981) concluded that yellow-poplar responds to thinning over a wide range of stand age, tree size, and site quality.

Because of its commerical importance, a considerable amount of mensurational information has been developed for yellow-poplar. Beck (1963,1964) published cubic-foot and International 1/4-inch board-foot volume tables for yellow-poplar. These tables present estimated individual tree volumes for various combinations of diameter and total tree height. In 1970, Beck and Della-Bianca(1970) published cubic-foot volume yields from natural stands at various ages by site index and density class, later they developed equations for predicting basal area growth and cubic-foot growth

and yield in stands thinned to various levels of basal area(Beck and Della-Bianca 1972). The equations predict basal area and cubic-foot volume at some projected age when site index, initial age, and basal area are given. The cubic-foot volume growth equation is used as a yield function when the initial age and projected age are set equal. Beck and Della-Bianca(1975) also developed equations for predicting board-foot and diameter growth after thinning. The board-foot yield equation differs from the earlier cubic-foot yield equation in that board-foot volume is expressed as a function of dominant stand height, residual quadratic mean stand diameter, and residual stand basal area.

Stand level and diameter distribution models for single or multiple thinnings were developed by Knoebel(1982) by using remeasurement data from the Beck and Della-Bianca studies (1972,1975). In the stand level model, Knoebel (1982) used the total cubic-foot volume and basal area model form specified by Beck and Della-Bianca (1972) and fitted two separate sets of coefficients; the first set for after a single thinning, the second set for after a second thinning. Also developed was an equation to predict the number of trees per acre from basal area, site index, and age, and an equation to predict basal area per acre from the number of trees, site index, and age. Knoebel (1982) also computed an

equation to predict the cubic-foot volume removed from thinning as a function of the proportion of basal area removed and the cubic-foot volume before thinning. Finally, Knoebel (1982) specified an equation which predicts board-foot volume from basal area and total cubic-foot volume.

Very little literature exists concerning the economic analysis of yellow-poplar management. Boyce and McClure (1978) state that cultural practices do not commonly increase the sale value of standing trees. They suggest that thinning may change the distribution of diameters without significantly increasing volume. They therefore conclude that investments in thinning or other cultural practices are unnecessary; yellow-poplar should be grown under simple custodial management.

Boyce and McClure's main premise for dismissing the economic feasibility of thinning seems to be based on the inability of thinning to increase volume. However, in their report they do not consider the use of thinning to increase stand value by the production of larger and better quality trees. Since most of the value of yellow-poplar is derived from lumber and veneer products, it follows that practices designed to increase board-foot yields and improve tree quality may indeed be economically feasible. This is consistent with the findings of Beck and Della-Bianca (1975).

They state that thinnings designed to concentrate growth on the best and largest stems is a logical practice for the management of yellow-poplar stands. Beck and Della-Bianca indicate that many stands can produce substantial numbers of sawtimber and veneer size trees without thinning but in unthinned stands as old as 70 years, over half the trees may be under the minimum size for sawtimber. They suggest thinning as a means of increasing the product yields from such stands.

A number of computer programs are available to facilitate forest investment analysis (Hall 1962, Schweitzer et al 1967, Forster 1968, Hepp 1981). The programs are quite varied in terms of completeness and applicability to the private landowner's situation. The programs range from ones which give only the rate of return from a single transaction to those which will handle numerous, often complex inputs with the results in the form of net present value for a finite and/or infinite time horizon, internal rate of return, equivalent annual income, or benefit-cost ratio.

The most basic of these computer investment programs require the user to input the costs, revenues, and physical yields which are expected for a given management regime or investment. These programs then evaluate the regime or investment usually according to two or more economic criteria.

The most commonly used criteria are the internal rate of return and net present value. Several programs of this type are available (Row 1963, Schweitzer et al 1967, Chappelle 1969). Goforth and Mills(1975) developed a program of this type which also analyzes the sensitivity of results to errors in input data.

A limited number of programs have combined both a financial return model with a model to predict physical yields for a given species (Thompson et al 1973, Hepp 1981). These physical yield models may either be deterministic or stochastic in nature. Hepp(1981) developed a model which employed eleven different growth and yield models for selected species and species groups. The physical yield models are deterministic equations developed from previous studies. Beck and Della-Bianca's growth and yield formulas for thinned yellow-poplar stands comprise one of the eleven individual growth and yield simulators. The yields generated by the growth and yield simulators are used as input into the financial return model. The net present value or internal rate of return is calculated for each management regime.

Of the numerous investment programs in existence, only a few are capable of providing an analysis on an after-tax basis. The Tennessee Valley Authority (1975) developed a program to make economic analyses of individual forest stands

receiving Forestry Incentive Program (FIP) cost sharing assistance. Within this program, the future personal income tax and capital gains tax are projected in order to evaluate investments in forestry by private landowners. Thompson et al.(1973), in their program for the evaluation of loblolly pine management, use an after-tax analysis. Economic performance is measured after federal taxes on ordinary and capital gains income.

PROCEDURES AND TECHNIQUES

This project involved five broad steps:

1. developing a computer program for a growth and yield model for natural stands of yellow-poplar which incorporates single or multiple low thinnings with volumes expressed in total cubic-feet, board-feet, and cords;
2. combining the growth and yield model with a forest investment computer model so that economic analyses of thinning may be performed;
3. developing revenue, cost, and income tax data to combine with generated yields which reflect an average Virginia landowner's market situation;
4. generating present values for alternative thinning regimes to facilitate economic evaluation;
5. systematically varying specific economic parameters to determine which have the most pronounced effect on the economic feasibility of thinning.

Programming and Computer Requirements

The computer program was written in Applesoft BASIC for use on the APPLE II + microcomputer. A standard version of the BASIC computer language was used in programming so that the program can be used on most micro and minicomputers with little or no modification. Use of the small computers is preferred to the mainframe computers for the reason of accessibility; potential users of the program will more likely have access to a small computer than to a large mainframe computer.

The program requires at least 48K of microcomputer memory. Output may be displayed on the APPLE monitor or optionally printed in an eighty column format.

The program processing is interactive. Interactive processing means that after a program user makes an entry the computer can immediately respond with a result, a question, an error message, or a request for information. This affords the advantages of making the program easier to use and allowing flexibility in adapting the program to a user's specific needs.

Growth and Yield Model

A stand level growth and yield computer model was developed to generate per acre volumes given an initial age and basal area, site index, and thinning regime. Volumes are presented in terms of total cubic-foot yield outside bark (o.b.), International-1/4 inch board-foot sawtimber volume, and pulpwood cords net of sawtimber. For the most part, the model is constructed from growth and yield equations presented by Knoebel (1982). These equations are the most recent and comprehensive for predicting growth and yield for thinned stands of yellow-poplar.

Data used in the study by Knoebel (1982) were collected by the United States Forest Service, Southeastern Forest Experiment Station, from 141 plots in the Appalachian Mountains of North Carolina, Virginia, and Georgia. The plots had at least 75 percent of the overstory in yellow-poplar, were free from insect and disease damage, and had no evidence of past cutting. All plots were located in even-aged stands that, at the time of plot establishment, ranged from 17 to 74 years of age, site indices (base age 50) from 74 to 138 feet, and initial basal areas from 49 to 209 square feet. Low thinnings were used to reduce stand basal areas. Suppressed trees were removed first, then thinning proceeded into the higher crown classes as needed to obtain a desired

residual basal area in well spaced trees. The thinnings increased the proportion of the growing stock in dominant and codominant crown classes. Species other than yellow-poplar were usually removed in thinning (Beck and Della-Bianca 1972).

The stand level computer model uses a system of compatible growth and yield models (Knoebel 1982). A single equation relates projected stand total cubic-foot volume (o.b.) to initial age, projected age, site index, and initial basal area. When projected age is set equal to initial age, the model simplifies to a conventional yield equation. The projected total cubic-foot equation (4.1) used in the computer program is given below.

$$Y2 = \exp(b0 + b1/S + b2/A2 + b3(A1/A2) (\ln(B1)) + b4(1-A1/A2) + b5(S) (1-A1/A2)) \quad (4.1)$$

Two sets of coefficients are specified for the total cubic-foot volume projection equation (4.1): one set for after a single thinning and the other for after two or more thinnings. Substituting the coefficients for a single thinning into equation (4.1) gives equation (4.2).

$$Y2 = \exp(5.3540 - 102.45728/S - 21.95901/A2 \\ 0.97473(A1/A2) (\ln B1) + 4.11893(1 - A1/A2) \\ 0.01293(S) (1 - A1/A2)) \quad (4.2)$$

Substituting the coefficients for two or more thinnings into equation (4.1) gives equation (4.3).

$$Y2 = \exp(5.33115 - 97.95286/S - 25.19324/A2 \\ 0.98858(A1/A2) (\ln B1) + 5.84476(1 - A1/A2) \\ 0.00018(S) (1 - A1/A2)) \quad (4.3)$$

where

Y2 = projected total cubic-foot volume

S = site index, base age 50

A1 = initial age

A2 = projected age

B1 = initial basal area

ln = natural logarithm

exp = raised to power of e

The implied basal area projection model from the cubic-foot volume projection model is (Knoebel 1982):

$$B2 = \exp\{ (A1/A2) (\ln B1) + (b4/b3) (1 - A1/A2) \\ + (b5/b3) (S) (1 - A1/A2) \} \quad (4.4)$$

Using the same coefficients specified for the cubic-foot volume projection equation, the basal area projection equations for a single thinning and two or more thinnings used within the computer model are given in equations (4.5) and (4.6) respectively.

$$B2 = \exp\left(\left(\frac{A1}{A2}\right) (\ln B1) + \left(\frac{4.11893}{0.97473}\right) (1 - \frac{A1}{A2}) + \left(\frac{0.01293}{0.97473}\right) (S) (1 - \frac{A1}{A2})\right) \quad (4.5)$$

$$B2 = \exp\left(\left(\frac{A1}{A2}\right) (\ln B1) + \left(\frac{5.84476}{0.98858}\right) (1 - \frac{A1}{A2}) + \left(\frac{0.00018}{0.98858}\right) (S) (1 - \frac{A1}{A2})\right) \quad (4.6)$$

where B1 = initial stand total basal area (square feet per acre)
 B2 = projected stand total basal area (square feet per acre)
 S = site index, base age 50
 A1 = initial age
 A2 = projected age
 ln = natural logarithm
 exp = raised to power of e

The growth and yield equations and associated coefficients for after a second thinning are used to project yields for stands thinned more than once. It is assumed that growth and yield relationships after three or more thinnings will differ little from that after a second thinning. Most stand quality improvement will occur during the first two thinnings, with little improvement occurring from subsequent thinnings. Thus stands thinned more than once are assumed to have the same growth and yield relationships regardless of the number of subsequent thinnings.

Unthinned control plots were not established in the original Forest Service yellow-poplar thinning study. This prevented the development of coefficients for an unthinned

stand growth and yield model. However, yields from unthinned stands can be approximated by using the single thin growth and yield equations. This is done within the computer program so that comparisons may be made between thinned and unthinned stands.

International 1/4-inch board-foot volumes are predicted from total cubic-foot volume and basal area using an equation developed by Knoebel (1982). The stand board-foot volume for all trees greater than 11 inches DBH is derived as a function of the current stand basal area and cubic-foot volume. The equation used in the computer model is as follows:

$$BV = 1363.09165 - 306.96647(BA) + 10.26187(CV) \quad (4.7)$$

where

BV = board-foot volume (International 1/4-inch)

BA = current stand total basal area (square feet per acre)

CV = total cubic-foot volume per acre

For the purposes of this study, a model was developed that allows the separation of sawtimber volume into the product categories of sawlogs and peelers. This model is based on the assumption that trees achieving a minimum DBH of 15 inches and trees achieving a DBH of at least 11 inches but

less than 15 inches are classified as peelers and sawlogs respectively. Using plot remeasurement data, the cubic-foot volumes for sawtimber and peelers and the stand quadratic mean diameter were calculated on a per plot basis. The quadratic mean diameter is defined as the diameter of a tree whose basal area is equal to the mean basal area per tree for a given stand. The proportion of peelers obtained from a given plot sawtimber volume was then calculated. This proportion was related to quadratic mean diameter through a linear regression equation. The equation used for calculating quadratic mean diameter and the model for predicting the percent peelers from sawtimber volume are:

$$D = ((BA / NT) / 0.005454)^{1/2} \quad (4.8)$$

$$PP = b_0 + b_1(D) \quad (4.9)$$

where

BA = basal area (square feet)
 NT = number of trees
 D = quadratic mean diameter in inches
 PP = percent peelers from sawtimber

For each remeasurement, a set of coefficients was specified for equation (4.9). Differences among these sets reflect the changes in stand structure produced by thinning. Substituting the coefficients for before a first thinning into equation (4.9) gives equation (4.10).

$$PP = - 0.69710 + 0.09456 (D) \quad (4.10)$$

Substituting the coefficients for after a first thinning into equation (4.9) gives equation (4.11).

$$PP = - 0.89931 + 0.09808 (D) \quad (4.11)$$

Substituting the coefficients for before a second thinning into equation (4.9) gives equation (4.12).

$$PP = - 0.97486 + 0.10312 (D) \quad (4.12)$$

Substituting the coefficients for after a second thinning into equation (4.9) gives equation (4.13).

$$PP = - 1.05860 + 0.10717 (D) \quad (4.13)$$

Substituting the coefficients for growth after thinning into equation (4.9) gives equation (4.14).

$$PP = - 1.07591 + 0.10909 (D) \quad (4.14)$$

where

PP = percent peelers from sawtimber

D = quadratic mean diameter in inches

In the case of three or more thinnings, the prediction of the percent peelers uses the coefficients specified for a second thinning. Also, the coefficients labeled "growth after thin" are applied in the model when a stand has been thinned and then allowed to grow to final harvest.

The number of trees per acre is predicted by an equation that relates number of trees to site index, current stand age, and basal area (Knoebel 1982). The model form is:

$$NT = \exp(b_0 + b_1(1/A) + b_2(S) + b_3(1/BA)) \quad (4.15)$$

Knoebel fit this model to predict the number of trees before a first thin, after a first thin, and after a second thin. Substituting the coefficients for before a first thinning into equation (4.15) gives equation (4.16).

$$NT = \exp(6.43346 + 38.24834(1/A_1) - 0.01309(S) - 67.25874(1/BA)) \quad (4.16)$$

Substituting the coefficients for after a first thinning into equation (4.15) gives equation (4.17).

$$NT = \exp(6.12444 + 59.93859(1/A_1) - 0.01911(S) - 73.59987(1/BA)) \quad (4.17)$$

Substituting the coefficients for after a second thinning into equation (4.15) gives equation (4.18).

$$NT = \exp(6.12335 + 69.03772(1/A1) - 0.02083(S) - 78.12201(1/BA)) \quad (4.18)$$

where

NT = number of trees per acre

A = current stand age

S = site index

BA = current stand total basal area (sq. ft./ac.)

exp = raised to the power of e

The net cord pulpwood volume is calculated within the program using a procedure similar to the one found in YIELD (Hepp 1981). The procedure involves calculating a total cord volume per acre and then subtracting sawtimber cord equivalents to obtain the pulpwood cords net of sawtimber. In the first step of the procedure, the total cord volume is calculated from the stand's total cubic-foot volume and quadratic mean diameter via equation (4.19).

The next step converts the stand board-foot volume into cord equivalents using a ratio of 450 board-feet to 1 cord. Finally, the sawtimber cord equivalents are subtracted from the total cord volume obtained from equation (4.19). These last two steps are shown in equations (4.20) and (4.21) below.

$$TC = CV / (77.1 + 1.433(D)) \quad (4.19)$$

$$SCE = BV / 450 \quad (4.20)$$

$$NCD = TC - SCE \quad (4.21)$$

where

TC = total cords per acre
 CV = total cubic-foot volume per acre
 D = quadratic mean diameter in inches
 SCE = sawtimber cord equivalents
 BV = board-foot volume per acre
 NCD = net cord volume per acre
 TC = total cord volume per acre

Using the equations presented above, the growth and yield model allows the user to simulate a given stand under various thinning regimes. To begin, the user enters such current stand data as the initial age, basal area, and site index. Next the user specifies the thinning regime. The user may choose not to thin and therefore may enter 0 as the number of thinnings. Alternately, the user may specify up to 5 thinnings, entering the year or stand age for each thin and the associated residual basal area. Lastly, the user enters the year or age of the final harvest (clearcut).

After all required information is input, the computer program first calculates stand volumes per acre and attributes for the first year of the analysis. Next the program loops through each specified thinning, calculating stand volumes and attributes on a before and after thinning basis.

Finally, the final harvest volumes are calculated. Output from the growth and yield model is displayed on the APPLE monitor and optionally printed in an 80 column format. Volumes generated by the model are stored in arrays for use in the financial analysis model. Sample output from the growth and yield computer model is displayed in Appendix C.

Forest Investment Model

A financial return model was developed to evaluate the economic feasibility of various thinning regimes on a stand basis. Since an individual landowner's financial situation and expectations tend to be unique, the design of the model emphasizes flexibility. Users may apply all or only part of the program.

By combining volumes generated by the growth and yield model with user supplied cost and revenue data, the program calculates two measures of economic performance on a before or after-tax basis. The economic criteria provided are the internal rate of return and present net worth calculated at the beginning year of the financial analysis (i.e. year 0). The time horizon for economic consideration is from the beginning year of the analysis until the year of the final harvest. Since the growth and yield model may be applied only to existing stands, all financial analyses are res-

stricted to a finite time period. Since landowners typically have a finite holding period for land and timber, the restricted analysis will encompass the vast majority of landowner situations.

Although the investment model operates in the same basic manner for either a before or after-tax analysis, important differences exist in the handling of certain cost and revenue items. In the following explanation of the model's construction, the differences between a before and after-tax analysis will be explained. The various after-tax treatments are made in conjunction with the guidelines established in Agriculture Handbook No. 596 (USDA 1982).

When considering investments in an existing stand, the landowner has the option to immediately harvest and sell the current timber volume and to sell the land -- this will be termed "liquidation value". However, by postponing the liquidation of the land and/or timber, the landowner has foregone the opportunity to reinvest the this forest liquidation value in an alternative investment. Therefore, when considering holding land and/or timber in anticipation of future revenues, the implicit cost involved in doing so must be taken into account. The cost of holding land and/or timber is provided for within the financial model by the inclusion of the forest liquidation value as a cost in the beginning

year of the analysis (i.e. year 0 in the financial analysis). Thus, the present net worth obtained from the financial model will indicate the amount that the present value of future forest incomes exceed the forest liquidation value. The decision to either manage or liquidate the forest may be made on the basis of the present net worth criterion.

If the program user does not wish to sell his land at rotation end, he may enter a current land value of 0. Within the program this implies that there is no cost to holding land. For some landowners this may be the case.

The cost of holding the current timber volume as growing stock for future timber harvests is included in the program by multiplication of current volumes by their associated stumpage prices. In the before-tax analysis, the process of including the forest liquidation value as a cost in year 0 may be summarized by the following simplified equation.

$$FLV = V1(P1) + V2(P4) + CLV \quad (4.22)$$

where

FLV = forest liquidation value at year 0, (includes both land and immediate harvest value of timber).
 V1 = pulpwood volume
 V2 = sawtimber volume
 P1 = price for pulpwood
 P4 = price for sawtimber
 CLV = current land value

Since a landowner would normally be required to pay taxes if he liquidated his forest holding, in the after-tax analy-

sis the calculation of the forest liquidation value at year 0 assumes capital gains treatment of both timber and land sale revenues. The two equations below depict how the financial model calculates the liquidation values involved with timber and land respectively on an after-tax basis. The after-tax forest liquidation value is the simple addition of the after-tax timber and land liquidation values. This forest liquidation value is entered as a cost in year 0 of the financial analysis.

$$ATLV = (V1(P1) + V2(P4) - TB)(1 - CGR) + TB \quad (4.23)$$

$$ALLC = (CLV - LB)(1 - CGR) + LB \quad (4.24)$$

where

ATLV= after-tax timber liquidation value
 ALLV= after-tax land liquidation value
 TB = timber basis (specified by program user)
 LB = land basis (specified by program user)
 CGR = capital gains tax rate
 V1 = pulpwood volume
 V2 = sawtimber volume
 P1 = price for pulpwood
 P4 = price for sawtimber
 CLV = current land value

In the before-tax analysis, all costs, revenues, and interest rates are expressed in real or constant dollars, excluding inflation. This allows the results obtained from any given analysis to be applicable to any rate of inflation. On the other hand, the projected annual rate of in-

flation is incorporated into the after-tax analysis because it affects a specific investment's worth. As the projected rate of inflation increases, the after-tax present net worth will correspondingly decline. The decline occurs because the amount deducted when capital gains tax is computed becomes a decreasing portion of the harvest value as inflation increases. Therefore, the capital gains tax will remove a higher percentage of the harvest value as inflation rises. A detailed discussion of this inflationary tax effect is given by Klemperer (1979). As a result, including inflation in the after-tax analysis causes all costs, revenues, and interest rates to be expressed in current dollars, including inflation. The results obtained for a particular analysis will only hold for the specified inflation rate. Equation (4.25) demonstrates the calculation of the inflated or current interest rate using the user specified real rate of return and projected rate of inflation. This inflated interest rate is used for discounting in the after-tax analyses.

$$i = r + f + (r)(f) \quad (4.25)$$

where

f = projected annual rate of inflation
 r = investor's desired real rate of return
 i = inflated interest rate

Two types of costs may be specified by the program user in a before-tax analysis. One yearly recurring expense and ten non-recurring expenses may be entered.

In the after-tax analysis, four types of expenses may be specified. A yearly recurring ordinary expense may be specified such as an annual management fee. Assuming the landowner has ordinary income to which he may deduct the expense for tax purposes, the effective after-tax amount of the recurring ordinary expense for a given year is calculated as:

$$ATC = (BTE) (1 - OTR) \quad (4.26)$$

where

ATC = after-tax effective cost
 BTE = before-tax ordinary expense
 OTR = ordinary income tax rate

For example, given a \$5.00 annual management fee per acre and a marginal ordinary income tax rate of 30%, the effective cost becomes $(\$5.00) (1 - .30) = \$3.50$.

Ten non-recurring ordinary expenses may be entered. The effective after-tax cost for each expense is found in the same manner as presented in equation (4.26). Ten depreciable capital expenses may be specified along with the corresponding depreciation period and salvage value. For each expense, straight-line depreciation is assumed. The after-tax effective cost is calculated by the following procedure. First, the annual depreciation allowance tax saving is calculated with equation (4.27). Next the annual tax savings and the salvage value are discounted by the interest rate to

obtain a present value used to reduce the before-tax depreciable expense. This operation is shown in equation (4.28). Finally, the after-tax, net of depreciation, cost is obtained by subtracting the depreciation expense reduction from the depreciable expense.

$$DTS = ((BTE - S)/P) (1 - OTR) \quad (4.27)$$

$$DER = S/(1 + i)^{n+k} + \sum_{j=1}^k DTS/(1 + i)^{n+j} \quad (4.28)$$

where

DTS = depreciation allowance tax savings

BTE = before-tax depreciable expense

S = salvage value

P = depreciation period

OTR = marginal ordinary income tax rate

DER = depreciable expense reduction

i = inflated interest rate as determined from equation (4.25)

n = number of years from present that depreciable expense occurs

k = length of depreciation period

The last type of expense in the after-tax analysis is a depletable capital expense. The valuation model allows for ten such expenses. These expenses contribute to the timber basis used in computing the capital gains tax on timber revenue.

In the valuation model, revenues may come from timber harvests and land sale. The method by which revenues are calculated varies somewhat between the before and after-tax analyses. Calculations of the revenues from timber for both

analyses begin with the determination of stumpage values at the time of each intermediate or final harvest. The user specified base level stumpage prices, adjustment for thinned material, and real price appreciation rates for pulpwood, sawlogs, and peelers, are combined with the predicted percent peelers to derive a price per unit for sawtimber and for pulpwood for each harvest in the stand. The base level stumpage prices are the clearcut stumpage values for unthinned stands. These values correspond to the average stumpage values reported by such agencies as the Virginia Division of Forestry and Timber Mart South (a private forest products market reporting firm).

The adjustment for thinned material is the percent of the base level final harvest stumpage values obtained for stumpage removed in thinning. This percentage of clearcut prices implicitly considers such factors as increased logging costs, smaller diameters, and poorer quality of stems removed in thinnings as compared to a clearcut.

The real price appreciation rates reflect the annual increases in stumpage values net of inflationary increases. These rates may be based on past historical data or on the landowner's perceptions of future pricing situations.

Since the peeler volume may only be derived indirectly from quadratic mean diameter and sawtimber volume, the re-

venues from sawlogs and peelers are not calculated separately by multiplication of the two volumes by the associated stumpage values. Instead, a single adjusted stumpage value for sawtimber is determined and applied to the total sawtimber volume at the time of the intermediate or final harvest. This adjusted price reflects the increased value of the sawtimber volume due to the inclusion of a certain proportion of peeler volume.

A linear relation is assumed to exist between the premium paid for peeler stumpage and the proportion of peelers in the stand. Figure 1 demonstrates the relation used in this sawtimber pricing process. In the figure, if $X_1 = \$60/\text{Mbf}$ for sawlogs, $X_2 = \$120/\text{Mbf}$ for peelers, and $PP = 50\%$ peelers, the stumpage price applied to the total sawtimber volume, P_4 , is $\$90/\text{Mbf}$. Equation (4.29) summarizes the sawtimber pricing process as used in the financial model. Equation (4.30) describes the calculation of the pulpwood price when a real price appreciation rate is included.

$$P4 = P2(1 + AR2)^n + PP(P3(1 + AR3)^n + P2(1 + AR2)^n) \quad (4.29)$$

$$P1 = P0(1 + AR1)^n \quad (4.30)$$

where

- P0 = base price per cord for pulpwood
- AR1 = real price appreciation for pulpwood
- P1 = price per cord for pulpwood for year of harvest
- P2 = base price per Mbf for sawlogs
- AR2 = real price appreciation rate for sawlogs
- P3 = base price per Mbf for peelers
- AR3 = real price appreciation rate for peelers
- PP = proportion of sawtimber volume consisting of peelers
- P4 = price per Mbf for sawtimber for year of harvest
- n = number of years until harvest

The gross revenue for a particular cut in the before-tax analysis is found by multiplying the harvested product volumes by the respective stumpage values and then adding the individual product revenues. The complete procedure for calculating a before-tax timber revenue may be summarized by equation (4.31).

$$BTR = (V1)(P1)(AD) + (V2)(P4)(AD) \quad (4.30)$$

where

- BTR = before-tax revenue
- V1 & V2 = volume of pulpwood and sawtimber removed respectively
- P1 & P4 = stumpage value for pulpwood and sawtimber respectively
- AD = price adjustment for thinned material

The revenues in an after-tax analysis differ from the before-tax analysis by the inclusion of a deduction for deple-

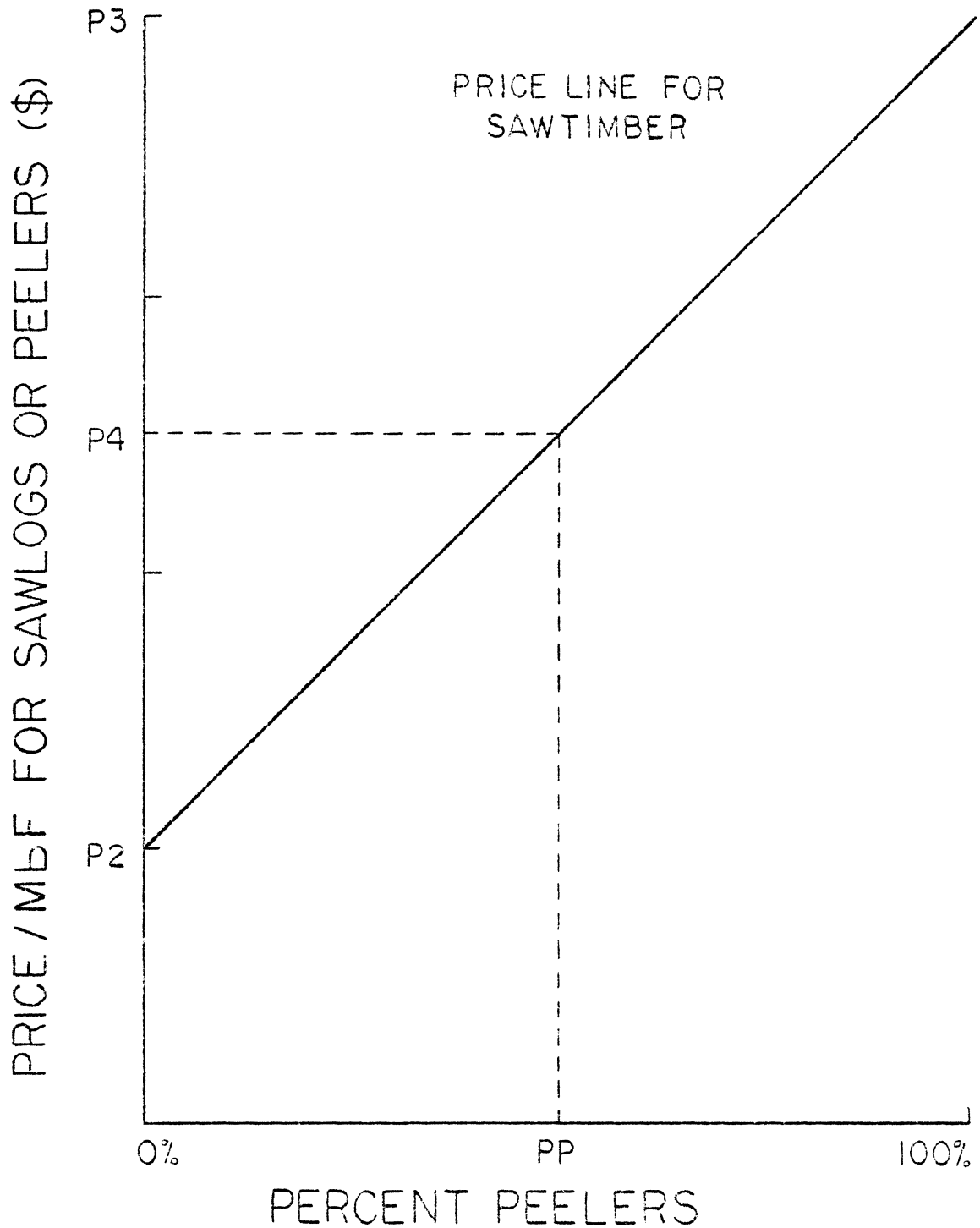


Figure 1. Price paid for sawtimber as a function of the percent peelers, price for sawlogs, and price for peelers.

table expenses, capital gains tax, and inflation. In computing the taxable income for capital gains, the percentage of timber removed in a harvest is calculated. The measure of cords is used as the standard depletion unit, requiring the sawtimber volume to be converted into cord equivalents. By adding the pulpwood cords and sawtimber cord equivalents removed and dividing by the total number of cords before harvest, the proportion of volume removed is obtained. Next, the adjusted timber basis is multiplied by the proportion of volume removed to yield the amount of depletable expenses to be deducted from gross revenues before the capital gains tax is applied. Equations (4.32) and (4.33) summarize the process of determining the depletable expense deduction.

$$PVR = (VC1 + V1) / TV \quad (4.32)$$

$$DED = (ATB) (PVR) \quad (4.33)$$

where

PVR = proportion of total volume removed in harvest

VC1 = sawtimber cord equivalents removed in harvest

V1 = pulpwood cords removed in harvest

TV = total volume in cords before harvest

DED = depletable expense deduction

ATB = adjusted timber basis

Another step in calculating the after-tax revenue involves adjusting the gross revenues to include inflation. In addition, the depletable expense deduction is made from gross before-tax revenue. Finally, the net revenue after-

tax is calculated by applying the capital gains tax rate. The complete process of calculating an after-tax timber revenue is:

$$ATR = (BTR(1 + f)^n - DED)(1 - CGR) + DED \quad (4.34)$$

where

ATR = after-tax revenues
 BTR = before-tax revenues calculated
 from equation (4.31)
 f = projected annual rate of inflation
 DED = depletable expense deduction
 CGR = capital gains tax rate
 n = number of years until intermediate
 or final harvest

In the before-tax analysis, revenue from the sale of land is determined by multiplying the initial land value by the real price appreciation factor for land:

$$BTLR = (CLV)(1 + LAR)^k \quad (4.35)$$

where

BTLR = before-tax revenue from the sale of land
 CLV = current or initial land value
 LAR = real price appreciation rate for land
 k = number of years in the analysis

Revenue from the sale of land in the after-tax analysis differs from the before-tax analysis by the inclusion of inflation and the capital gains tax. Before applying the capital gains tax, the land sale value is expressed in current dollars and the land basis is deducted:

$$ATLR = (BTLR (1 + f)^k - LB) (1 - CGR) + LB \quad (4.35)$$

where

ATLR = after-tax revenue from sale of land
 BTLR = before-tax land revenue calculated from equation (4.34)
 f = projected annual rate of inflation
 LB = land basis (user specified)
 CGR = capital gains tax rate
 k = number of years the revenue occurs from the beginning of the financial analysis

Revenues and costs previously discussed constitute the cash flows for the thinning analysis. Once all these costs and revenues have been generated by the program and/or specified by the user, a net cash flow for each year in the analysis is determined. The present net worth criterion is then calculated by discounting each year's net cash flow. This process is given in equation (4.37). In a before-tax analysis, the cash flows, present net worth, and interest rate will be expressed in real or constant dollars. Alternately, in an after-tax analysis, the cash flows, present net worth, and interest rate will be expressed in current or inflated dollars.

$$PNW = \sum_{k=0}^n NCF(k) / (1 + d)^k \quad (4.37)$$

where

PNW = present net worth
 NCF(k) = net cash flow in year k
 n = number of years in the analysis
 d = discount rate (either real or inflated depending on whether a before or after-tax analysis is used)

The present net worth criterion as used in the context of this program indicates the present value of the thinning investment net of the forest liquidation value. If the present net worth of the investment is greater than or equal to 0 then the forest stand should be held for timber production under the specified harvesting regime. However, if the present net worth is less than 0 then the stand should be clearcut as soon as possible since allowing it to grow for an additional year will result in a loss of wealth to the landowner.

The internal rate of return is the compound annual percentage rate that will make the sum of all discounted costs equal the sum of discounted revenues. This criterion is based on an assumed purchase price which is entered as a cost in year 0 of the investment analysis. The forest liquidation value for the existing stand represents this initial cost. In the financial model, the internal rate of return is calculated in an iterative fashion using equation (4.37). Basically, the internal rate of return calculation searches for the discount rate that will make the present net worth of the investment equal to 0. The search is completed once the internal rate of return is known to the nearest 1/100th of a percent.

For a specific investment, if the internal rate of return is greater than or equal to the discount rate the forest should be managed under the given harvest regime. However, if the internal rate of return is less than the discount rate the stand should be liquidated.

The internal rate of return criterion as well as the present net worth is based strictly on direct costs and revenues. Nonmarket costs and benefits do not affect the economic performance criteria.

In summary, a financial model was developed to examine and evaluate various thinning regimes by combining yields generated by the growth and yield model with user specified financial data. The financial model allows for either a before or after-tax analysis in which two measures of economic performance are calculated. Output consists of cash flow tables displayed on the computer video monitor and an economic criteria summary table displayed either on the monitor or printed in an 80 column format.

Benchmark Analysis: Average Landowner Situation

Costs and Revenues

The beginning analysis was conducted using a set of benchmark costs and revenues which were felt to be representative of both the average landowner's situation and the

current market situation in Virginia. A constant annual management cost of \$2.00 per acre was included to cover such expenses as an annual property tax and fire protection. Land values were omitted from all financial analyses so that the optimal rotations and thinning regimes determined would be a function of only timber growth and yield.

Stumpage price data was obtained from three main sources: the Virginia Department of Agriculture and Commerce Forest Products Report, the Virginia Division of Forestry, and Timber Mart South. The benchmark stumpage prices used were \$4/cord for pulpwood, \$60/Mbf for sawlogs, and \$120/Mbf for peelers. Stumpage prices for thinned material were assumed to be 80 percent of the base level clearcut prices. Thinnings were not considered feasible unless they removed at least 15 percent of the before thinning stand basal area. This translates to an minimum harvested volume of 200 cubic-feet per acre.

Tax Data

The analysis was made using after-tax costs and revenues. Taxes were calculated as they would be for a non-industrial landowner. A marginal ordinary income tax rate of 30 percent (\$29,900 - \$34,900 tax bracket) was assumed. A capital gains tax rate of 12 percent was computed as 40 percent of

the ordinary income tax rate. A 4 percent real interest rate was assumed. This particular rate reflects the interest rate that many landowners may expect from investments with risks similar to that of forestry. Given that a landowner's next best investment alternative in reference to forestry may be the purchase of money market certificates, the alternative rate of return (i.e. real interest rate) will fall within the range of 3 to 5 percent before taxes.

Present Net Worth Criterion

The criterion used for evaluating alternative thinning regimes was the present net worth per acre calculated at year 0. As previously mentioned, this criterion is the present value of the thinning investment net of the current stand liquidation value. A positive present net worth indicates that the thinning regime under consideration will yield a higher return than the investor's alternative rate of return.

The maximization of present net worth is a concept consistent with the theory of financial maturity (Broderick 1978). Such maximization requires the transfer of capital from investments with a rate of return less than the investor's alternative rate of return to projects expected to produce returns at least equal to the alternative rate.

Given the number of possible combinations of thinning parameters, the different present net worth maximizing regimes determined are only approximations of the best thinning regimes. Further refinement in the parameters may yield increases in present net worth.

Stand Data and Rotation Ages

An initial age and basal area of 20 years and 75 square feet was used for each simulated stand. For a stand simulated under a particular set of economic parameters and thinning regime, the rotation age was set to the no thin economic rotation age. This was the age at which present net worth was maximized for the stand without thinning. After the optimal thinning regime was determined for the no thin rotation, a search was made for the optimum rotation age for the given thinning regime.

Sensitivity Analysis

The economic data used in the benchmark analysis are subject to variations over time and among landowners. For example, future stumpage prices can only be predicted on the basis of past trends and the landowner's perceptions of the future. Furthermore, a landowner's desired real rate of return may change as investment opportunities and financial

situation change over time. With such considerations in mind, a sensitivity analysis was conducted to determine how sensitive the optimal thinning regimes are to changes in key economic parameters.

The real rate of interest, thinning costs, and stumpage prices were varied to determine their effect on present net worth. The real interest rate used in calculating present net worth was varied from 2 to 8 percent. Thinning costs were varied by changing the percent of clearcut prices obtained for material removed in thinning. This percentage was varied from 0 to 100 percent. Finally, the base level stumpage prices were varied; the following pricing situations were simulated:

1. benchmark prices: \$4/cord for pulpwood, \$60/Mbf for sawlogs, and \$120/Mbf for peelers.
2. \$2/cord for pulpwood, \$30/Mbf for sawlogs, and \$60/Mbf for peelers.
3. \$8/cord for pulpwood, \$120/Mbf for sawlogs, and \$240/Mbf for peelers.
4. \$4/cord for pulpwood, \$90/Mbf for sawlogs, and \$120/Mbf for peelers.
5. \$4/cord for pulpwood, \$60/Mbf for sawlogs, and \$180/Mbf for peelers.

6. a 2 percent real price appreciation rate for all benchmark stumpage values over the length of the rotation.

For all sensitivity analyses, the initial stand age and basal area were 20 years and 75 square feet while the site index was 100 feet.

RESULTS

Computer Model for Thinning Analysis

The computer model was written in Applesoft BASIC to operate on a micro-computer system with at least 48K of memory. The program has two main segments: growth and yield, and economic evaluation. The growth and yield model calculates stand volumes and attributes on a per acre basis before and after intermediate and final harvests. The model can handle analyses with as many as five thinnings as well as analyses with no thinnings.

The present net worth and internal rate of return are calculated before or after-taxes. The analysis may be a maximum of 70 years long with up to 10 entries in each expense type identified in the valuation model.

Both segments of the program incorporate frequent strategically placed error tests to aid the user in correct program operation. Also, the various program segments are menu driven, providing the user program flexibility. This allows the user to proceed through the program in a manner and speed convenient to him or her.

A flowchart showing the basic program segments is given in Appendix D. A documented version of the complete computer program is given in Appendix E. The working version of the program is without documentation to conserve computer memory.

Benchmark Analysis

Table 1 gives a summary of the benchmark input data. The thinning regimes which maximized present net worth per acre for each of three sites are given in Tables 2, 3, and 4. The rotation ages used in these benchmark simulations were the economic rotation ages for the unthinned stands. For comparison purposes, the unthinned stand data are presented along with the thinned stand data in these tables. With the optimal thinning regime identified for each site and no thin rotation, the rotation which was economically optimal for the given thinning regime was determined. Tables 2, 3, and 4 also present the thinned and unthinned stand data using the economic rotations for thinning.

The unthinned optimum rotation ages varied as a function of site. The rotation ages for site indices 80, 100, and 120 were 53, 47, and 46 years respectively. Given these rotations, the optimal thinning regimes also varied according to site. On site index 80, thinning 15 percent of the basal

TABLE 1

Summary of benchmark input data.

Stand data:	
Initial stand age	20 years
Initial basal area per acre	75 square feet
Cost data:	
Annual management cost per acre	\$2.00
Clearcut stumpage prices:	
Pulpwood	\$4.00/cord
Sawlogs	\$60.00/Mbf
Peelers	\$120.00/Mbf
Percent of clearcut stumpage values received for thinned material:	
	80 %
Tax data:	
marginal ordinary income tax rate	30 %
capital gains tax rate	12 %
Real interest rate	4 %

* Land values excluded from all analyses.

TABLE 2

Optimum thinning regime for site index 80.

	Thin*	No Thin*	Thin**	No Thin**
Rotation age	53	53	58	58
No. of thinnings	2	-	2	-
Age of thinnings	20,30	-	20,30	-
Percent basal area removed	15,15	-	15,15	-
Residual basal area (sq. ft./ac.)	64,79	-	64,79	-
Accumulated yields:				
pulpwood (cords/ac.)	43.7	37.6	43.6	37.0
sawtimber (Mbf/ac.)	10508	7675	13739	9272
total-cubic feet/ac.	5991	4718	6673	4980
Quadratic mean diameter at final harvest (inches)	9.4	6.5	9.8	6.5
Percent of sawtimber volume consisting of peelers	0.0	0.0	0.0	0.0
Present net worth	\$121	\$67	\$124	\$63

* Optimal rotation for the unthinned stand used in the analysis.

** Optimal rotation for the thinned stand used in the analysis.

*** Benchmark input data used, refer to Table 1.

TABLE 3

Optimum thinning regime for site index 100.

	Thin*	No Thin*	Thin**	No Thin**
Rotation age	47	47	57	57
No. of thinnings	2	-	2	-
Age of thinnings	20,40	-	20,40	-
Percent basal area removed	15,15	-	15,15	-
residual basal area (sq. ft./ac.)	64,106	-	64,106	-
Accumulated yields:				
pulpwood(cords/ac.)	28.8	27.5	30.4	23.2
sawtimber(Mbf/ac.)	19319	20332	29573	28141
total cubic-feet/ac.	6456	6409	8255	7610
Quadratic mean diameter at final harvest(inches)	12.4	7.8	13.9	8.1
Percent of sawtimber volume consisting of peelers	27.8	3.7	41.0	7.1
Present net worth	\$399	\$327	\$452	\$295

* Optimal rotation for the unthinned stand used in the analysis.

** Optimal rotation for the thinned stand used in the analysis.

*** Benchmark input data used, refer to Table 1.

TABLE 4

Optimum thinning regime for site index 120.

	Thin*	No Thin*	Thin**	No Thin**
Rotation age	46	46	51	51
No. of thinnings	1	-	1	-
Age of thinnings	40	-	40	-
Percent basal area removed	15	-	15	-
Residual basal area (sq. ft./ac.)	130	-	130	-
Accumulated yields:				
pulpwood (cords/ac.)	16.7	15.0	11.9	10.7
sawtimber (Mbf/ac.)	33652	36000	39923	42642
total-cubic feet/ac.	8407	8613	9386	9606
Quadratic mean diameter at final harvest (inches)	15.3	9.5	15.9	9.8
Percent of sawtimber volume consisting of peelers	59.0	20.2	66.3	22.8
Present net worth	\$935	\$736	\$953	\$724

* Optimal rotation for the unthinned stand used in the analysis.

** Optimal rotation for the thinned stand used in the analysis.

*** Benchmark input data used, refer to Table 1.

area at ages 20 and 30 with a final harvest at age 53 was optimal. For site index 100, thinning 15 percent of the basal area at ages 20 and 40 with a final harvest at age 47 was optimal. On site index 120, a single thinning at age 40 removing 15 percent of the basal area combined with a clear-cut at age 46 was optimal. The optimal rotation ages for thinned stands were 5, 10, and 5 years longer than the rotations for unthinned stands for site index 80, 100, and 120 respectively. Figures 2 and 3 display the effect of site on the optimal rotations for unthinned and thinned stands. In both cases, the general trend is for shorter rotations on the higher sites.

It is interesting to note that for sites 80 and 100, three thinnings were only slightly less advantageous than two thinnings at the same intensity, (see Appendix A). With these sites, three thinnings resulted in maximum present net worths only \$1 to \$2 less than those obtained with two thinnings. Even though the differences in present value are inconsequential, two thinnings were chosen as better than three thinnings for the reason that the stand would have to be entered one less time during the rotation. This may result in a reduction of damage done to the residual stand due to logging.

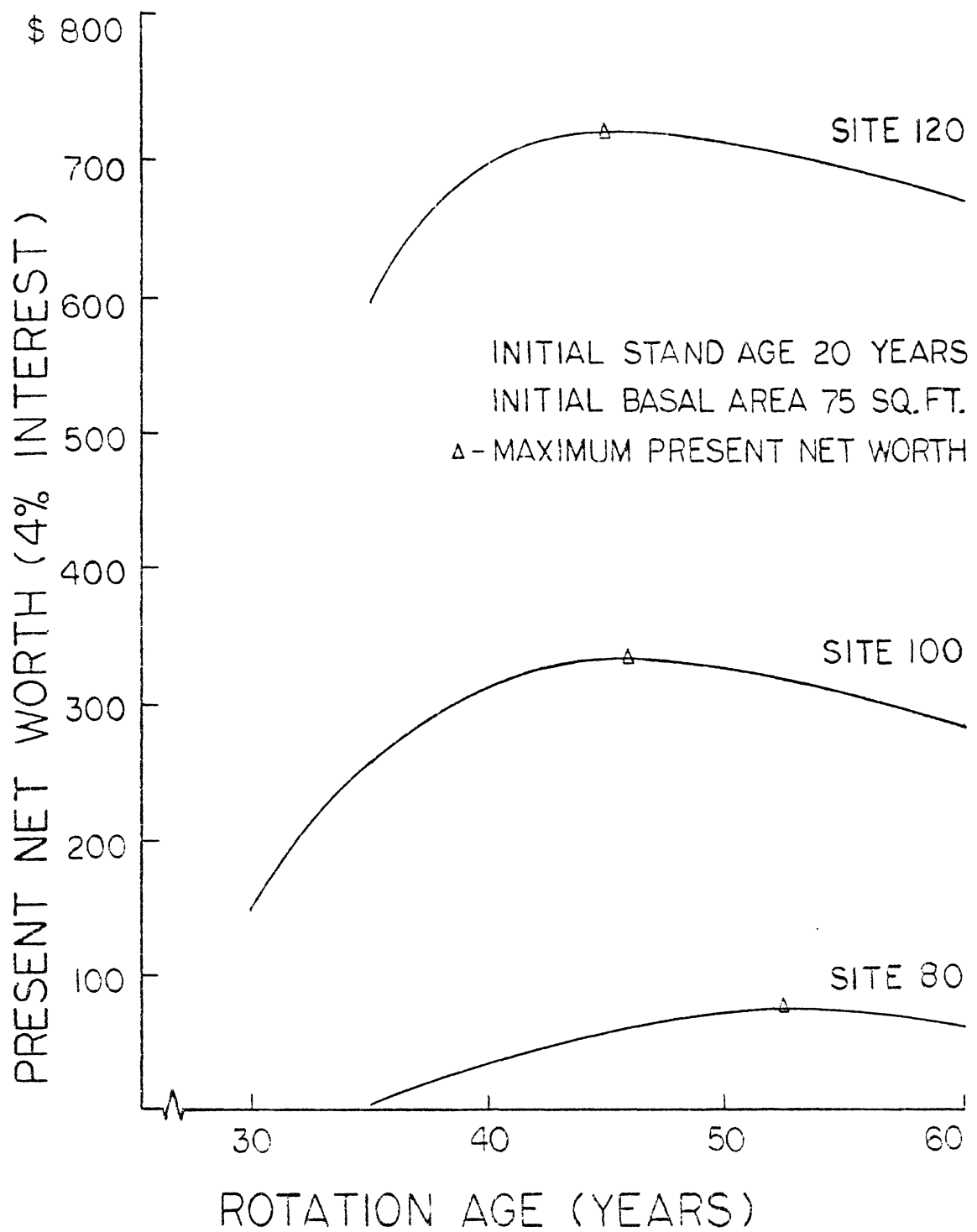


Figure 2. The effect of site quality on present net worth and rotation age for unthinned stands.

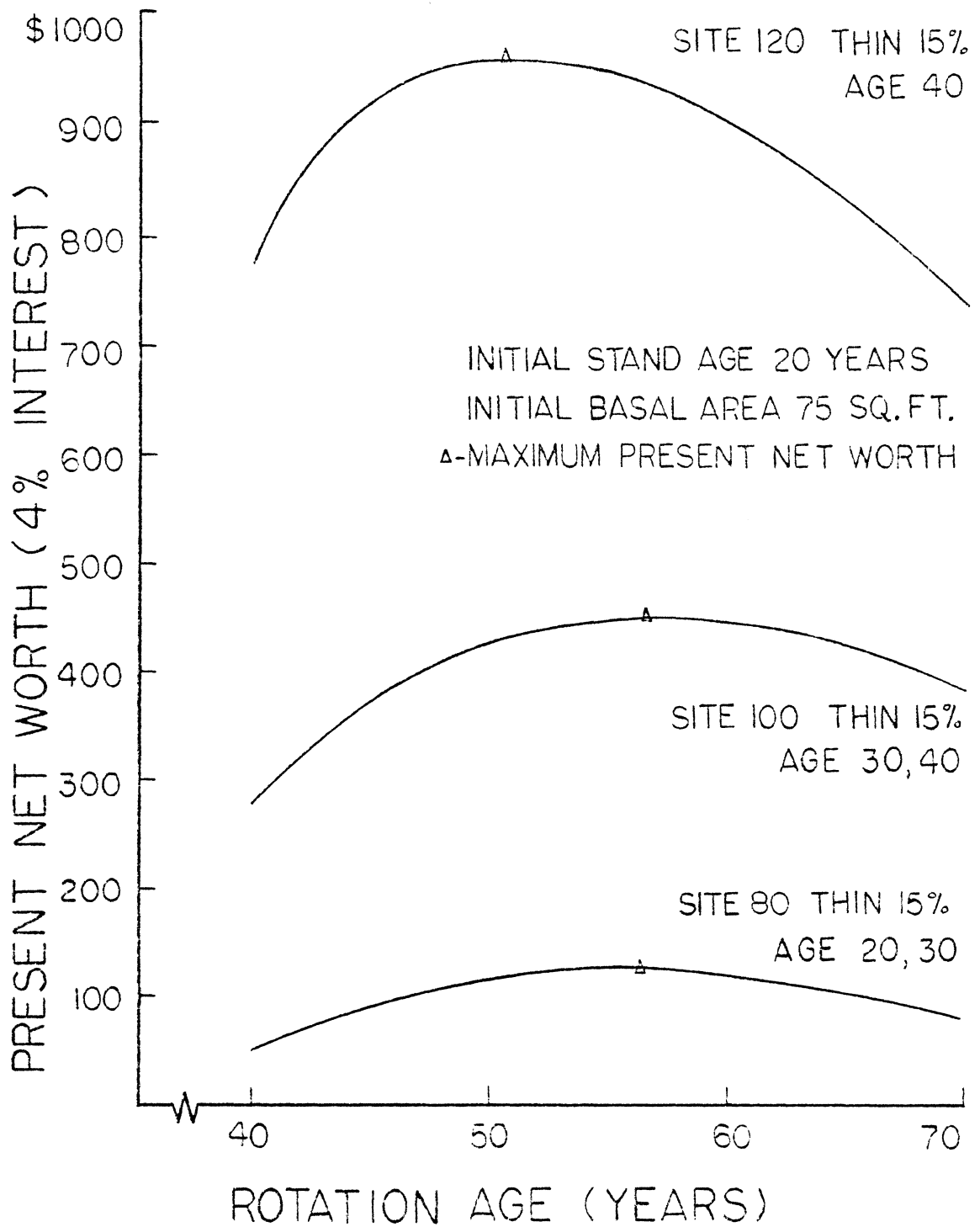


Figure 3. The effect of site quality on present net worth and rotation age for thinned stands.

Sensitivity Analysis

The optimum thinning regime for site index 100 expressed varying degrees of sensitivity to changes in economic parameters depending on the rotation age used. In the instance where the rotation age was held constant at 47 years, (the optimal rotation for an unthinned stand examined with the benchmark input data), the optimal thinning regime changed very little except in a few pricing situations. On the otherhand, when the unthinned rotation age was allowed to vary in response to changes in the economic parameters, substantial changes occurred in the optimum thinning regime.

Variation of the Real Interest Rate

For each thinning regime simulated for site index 100, present net worths were calculated for a 2, 4, 6, and 8 percent real interest rate. Holding the rotation age constant at 47 years, changes in the real interest rate affected the absolute present net worths of the simulated regimes but did not change the relative ranking of the regimes. At all simulated interest rates the optimum regime remained as two thinnings, ages 20 and 40, with 15 percent of the basal area removed.

When the optimal no thin rotation age was re-computed for each interest rate and subsequently used in determining the optimal thinning regime, the optimal regime had a direct response to changes in the interest rate. Table 5 gives a description of the optimal regime and accompanying stand characteristics for each interest rate examined. As the interest rate was increased, the optimal no thin rotation length shortened. Increases in the interest rate from 2 to 6 percent did not affect the optimal number and intensity of thinnings but the time between the first and second thinning shortened. At a rate of 8 percent, a no thin regime produced the highest present net worth with a rotation of 36 years.

Variation of the Thinning Costs

Thinning costs per unit of volume and stumpage price are inversely related; as harvesting costs increase stumpage values decline. By expressing the thinned stumpage values as a percentage of the clearcut values, thinning costs were simulated. To determine the effect of thinning costs on the optimum thinning regime, stumpage values for thinned material were expressed as 100, 80, 60, 40, and 0 percent of final harvest values.

Throughout the range of thinning costs examined, the optimum thinning regime for site index 100 remained unchanged.

TABLE 5

Effect of interest rate on optimum regime.

The effect of interest rates on the optimum thinning regime for site index 100 given benchmark input data.

=====				
	Interest rate			
	2%	4%	6%	8%

Optimal rotation age, unthinned	63	47	41	36
No. of thinnings	2	2	2	0
Age of thinnings	20,50	20,40	20,30	-
Percent basal area removed	15,15	15,15	15,15	-
Residual basal area (sq. ft./ac.)	64,125	64,106	64,86	-
Accumulated yields:				
pulpwood (cords/ac.)	19.8	28.8	31.9	31.6
sawtimber (Mbf/ac.)	33640	19319	14253	10264
total-cubic feet/ac.	8721	6456	5710	4751
Quadratic mean diameter at final harvest (inches)	15.4	12.4	10.1	7.2
Percent of sawtimber volume consisting of peelers	60.8	27.8	2.7	0.0
Present net worth	\$1143	\$399	\$182	\$108

* Refer to Table 1 for benchmark input data.

Figure 4 compares the present net worths of the optimum thinning regime under various thinning costs to that of an unthinned harvesting regime. Even when the prices for thinned material were 0 percent of clearcut prices, the optimum regime remained unchanged from the one specified for the benchmark analysis. Furthermore, the simulated thinning costs had no effect on either the optimal unthinned or thinned rotation age.

Variation of Clearcut Stumpage Values

Rotation ages and thinning regimes expressed different degrees of sensitivity to changes in clearcut stumpage values. When all prices were increased or decreased in equal proportions to the benchmark prices, the optimal thinning regime and rotation ages remained unchanged. Specifically, given the initial benchmark prices of \$4/cord for pulpwood, \$60/Mbf for sawlogs, and \$120/Mbf for peelers, the following two sets of prices had no effect on rotation or thinning regime:

- (a) \$2/cord for pulpwood, \$30/Mbf for sawlogs, and \$60/Mbf for peelers.
- (b) \$8/cord for pulpwood, \$120/Mbf for sawlogs, and \$240/Mbf for peelers.

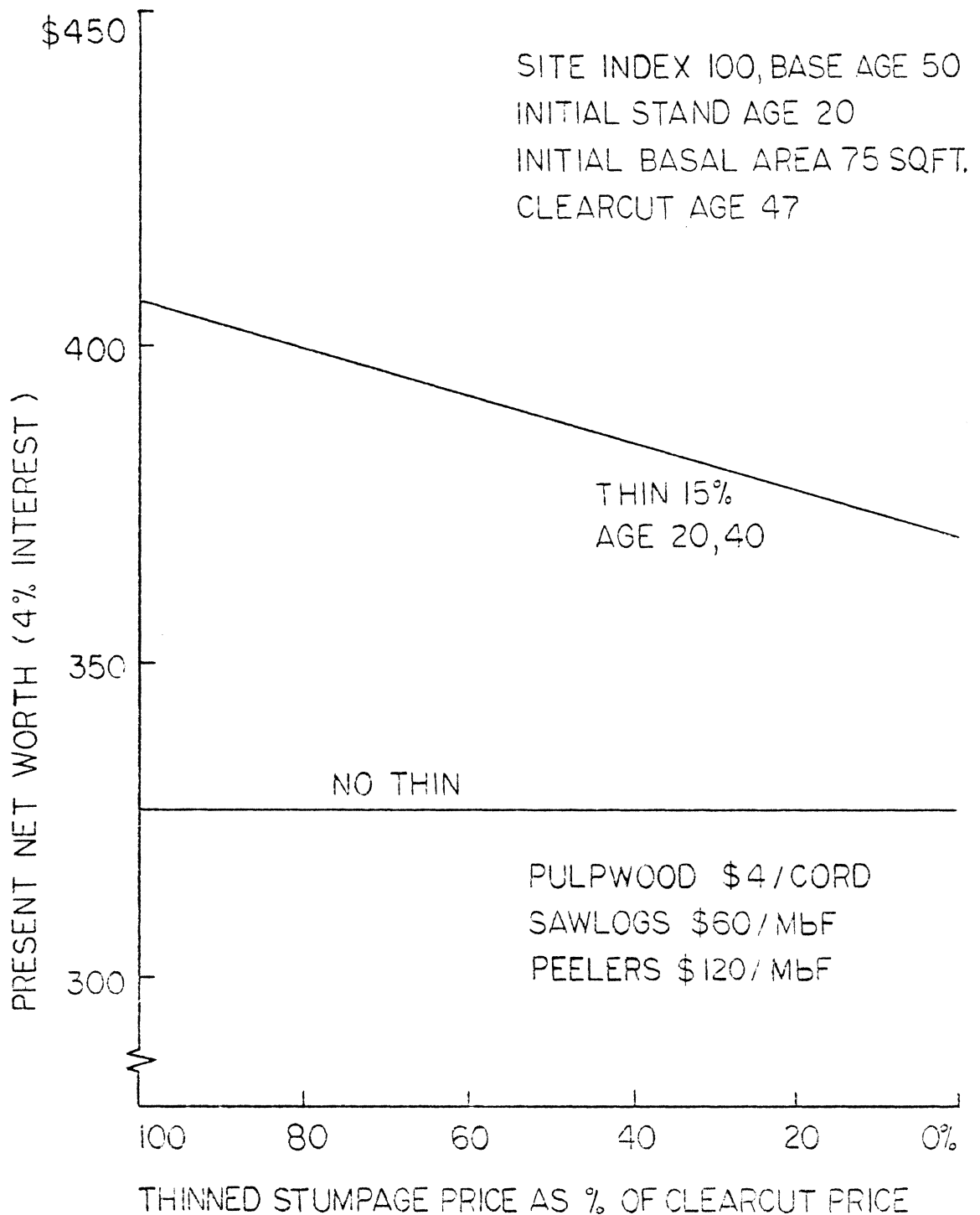


Figure 4. The effect of stumpage price for thinned material on the present net worth of the optimal thinning regime.

An annual 2 percent real price appreciation in all stumpage values over the length of the benchmark rotation caused the optimal thinning regime to shift from two to three thinnings at ages 20, 30, and 40 removing 15 percent of the basal area in each thinning. When the no thin rotation was allowed to vary in response to the price changes, it lengthened to age 65, 18 years longer than the benchmark rotation. At this rotation age the optimal regime still included three thins at 15 percent of the basal area (refer to Table 6, pricing alternative A).

Given the benchmark prices, when the price for sawlogs was increased by 50 percent with the other prices remaining constant, the optimal thinning regime changed slightly while the no thin rotation was unaffected. At price levels of \$4/cord for pulpwood, \$90/Mbf for sawlogs, and \$120/Mbf for peelers, the optimum regime changed from thinnings at ages 20 and 40 to thinnings at ages 20 and 30. With this change in the thinning regime, the optimum rotation lengthened to 54 years for thinned stands (see Table 6, pricing alternative B).

When all other prices were held constant at the benchmark levels and the price for peelers was increased by 50 percent, the optimal unthinned rotation increased by 1 year. Using this slightly longer rotation did not affect the opti-

TABLE 6

Optimum regimes for two pricing alternatives.

	Alternative A#		Alternative B#	
	47*	65*	47**	54**
Rotation age				
No. of thinnings	3	3	2	2
Age of thinnings	20,30,40	20,30,40	20,30	20,30
Percent basal area removed	15,15,15	15,15,15	15,15	15,15
Accumulated yields:				
pulpwood (cords/ac.)	31.4	21.4	29.5	25.8
sawtimber (Mbf/ac.)	18953	37078	20942	28629
total cubic-feet/ac.	6724	9834	6926	8245
Quadratic mean diameter at final harvest (inches)	12.4	15.7	10.8	11.5
Percent of sawtimber volume consisting of peelers	27.6	64.4	10.6	18.3
Present net worth	\$729	\$1283	\$547	\$572

- # Alternative A: 2% real annual price increase from all benchmark prices.
 Alternative B: \$4/cord for pulpwood, \$90/MbF for sawlogs, \$120/MbF for peelers.
 Site index 100, benchmark data excepting price data.
- * Optimal rotation for the unthinned stand.
- ** Optimal rotation for the thinned stand.

mal thinning regime. When the rotation age was held constant at the benchmark rotation of 47 years the optimal thinning regime still remained unchanged.

DISCUSSION

Computer Program for Thinning Analysis

The objective of the modelling effort in this study was to provide a methodology for analyzing the economic feasibility of various thinning regimes for a given stand under a set of economic conditions. The computer model was specifically designed to enable landowners to compare alternate thinning regimes to determine which would be better in their particular situation.

The input data requirements of the program are consistent with the expected capability of model users to provide the information. Also, since the model is likely to be used when certain input data are not known with any certainty, the model is designed to allow the user to vary values of some critical variables (e.g., interest rates, stumpage values, thinning costs, etc.) to determine the sensitivity of the model outputs to changes in the values of these variables.

Several important assumptions are incorporated in the growth and yield model. First, simulated stands are assumed to be free from disease and insect damage, show no signs of past cutting, and have at least 75 percent of yellow-poplar in the overstory. In instances where simulated stands depart from this assumption, the volumes predicted from the model may differ significantly from the volumes actually achieved.

Next, the model assumes all thinnings are from below (low thinnings); thinning starts in the lower diameter classes and proceeds upward until a desired residual basal area is achieved.

It is further assumed that all trees which reach the minimum diameter for sawtimber (11 inches DBH) qualify as sawtimber. Thus, the only restriction on sawtimber class is diameter; crook and limbiness are not explicitly considered. For unthinned stands this assumption may overstate sawtimber volumes because not all trees greater than 11 inches diameter will actually have the quality (e.g., straightness, clear bole) necessary to qualify as sawtimber. However, when considering thinned stands this assumption should be less of a problem. Given that poorly formed trees and otherwise undesirable trees are selected against in thinnings, the residual stand should be comprised of the better trees of the original stand. Depending on the frequency and in-

tensity of the thinnings, it may be reasonable to expect that at final harvest all trees 11 inches and greater will qualify as sawtimber.

In developing the prediction model for the proportion of sawtimber volume qualifying as peelers, the only limiting criterion for peeler selection was a minimum diameter of 15 inches DBH. This selection criteria is based on the assumption that the sawtimber trees less than 15 inches that actually qualify as peelers and the trees at least 15 inches in diameter that do not qualify as peelers will tend to cancel each other out on average. This assumption should be valid for the average stand but it should be noted that deviations may occur due to the sensitivity of peeler selection to management practices which alter tree form and quality (e.g., thinning).

Benchmark Results

There are three primary advantages to thinning. They are:

1. receipt of early returns from the forest investment,
2. recovery of volume otherwise lost to mortality,
3. increased diameter growth on residual trees.

Receipt of early returns from thinning had only a slight effect on present net worth and therefore on the optimum thinning regime. For most of the rotation ages and thinning

regimes examined, pulpwood was the only product removed in thinning. Given the low clearcut stumpage value for pulpwood coupled with the percentage decrease for thinned material, very little revenue was recieved from thinnings as compared to the final harvest. Table 7 displays the contribution of thinning revenues to total after-tax revenue and present value for the optimum thinning regime for site index 100. For the case of receiving 80 percent of clearcut prices for thinned material, the first thin comprises only 0.5 percent of total revenue and 1.4 percent of total present value. Similarly, the second thin comprises 3.5 and 4.5 percent of total revenue and present value respectively.

Given that salvaged mortality comes primarily from the pulpwood class, the recovery of volume otherwise lost to mortality is relatively unimportant in determining the optimum thinning regime. This occurs for the same reasons that early returns from thinning are unimportant; low final harvest stumpage values for pulpwood coupled with the percentage reduction for thinned material makes the value obtained only a small proportion of total stand value.

In Table 8 several different thinning regimes are examined in terms of quadratic mean diameter, percent of sawtimber volume consisting of peelers, total accumulated sawtimber volume, and present net worth. The table demonstrates

TABLE 7

Effect of stumpage price for thinned material.

The effect of stumpage price for thinned material on revenue and present value.*

=====				
Thinned stumpage price as a percent of clear- cut price	40%	60%	80%	100%

Revenues:				
thin at age 20	\$4	\$5	\$7	\$9
thin at age 40	25	36	48	61
clearcut at age 47	1336	1336	1336	1336
<u>Total revenue</u>	<u>\$1365</u>	<u>\$1377</u>	<u>\$1391</u>	<u>\$1406</u>
Percent total revenue:				
thin at age 20	0.3	0.4	0.5	0.7
thin at age 40	1.8	2.6	3.5	4.3
clearcut at age 47	97.9	97.0	96.0	95.0
<u>Total revenue (percent)</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>
Present value of revenues:				
thin at age 20	\$4.00	\$5.00	\$7.00	\$9.00
thin at age 40	11.41	16.43	21.91	27.84
clearcut at age 47	463.32	463.32	463.32	463.32
<u>Total present value</u>	<u>\$478.73</u>	<u>\$484.75</u>	<u>\$492.23</u>	<u>\$500.16</u>
Present total present value:				
thin at age 20	0.8	1.0	1.4	1.8
thin at age 40	2.4	3.4	4.5	5.6
clearcut at age 47	96.8	95.6	94.1	92.6
<u>Total (percent)</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>

* Site index 100 optimal thinning regime; all values on a per acre basis. Benchmark input data used, refer to Table 1.

that stand mean diameter and percent peelers are inversely related to sawtimber yield. Those regimes which produced the highest sawtimber volume generally had the smallest stand diameter and percent peelers, and vice versa. The regime which produced the highest present net worth represents a compromise between diameter and sawtimber volume production. As discussed previously, intermediate harvests of pulpwood contribute very little to total revenues from harvests and hence present net worth. One may conclude that the optimal regime is generally the one which produces maximum total revenue at final harvest. The revenues from pulpwood and sawtimber are a function of price and quantity. For pulpwood, the price remains constant while the quantity produced varies among different regimes. For sawtimber, both price and quantity vary among regimes. The price for the sawtimber volume is a function of the percent peelers in the stand (assuming a price differential exists between sawlog and peeler stumpage values). Since the percent peelers and sawtimber volume tend to be inversely related, an increase in either causes a decrease in the other. Given the objective of maximizing total revenue and subsequently present net worth, the optimum regime is often a compromise between peeler and total sawtimber volume production.

In Table 7 an illogical trend is displayed in two instances; with two or more thinnings which remove only 15 percent of the basal area, the quadratic mean diameter is higher than that obtained when 25 percent of the basal area is removed. This trend is caused by an underprediction of the number of trees when only 15 percent of the basal area is removed. Since the quadratic mean diameter is inversely related to the number of trees, (see equation (4.8), page 17), an underprediction in the number of trees causes an overstatement of the quadratic mean diameter.

Although the number and timing of thinnings varied with site quality, the intensity of thinnings remained constant, removing 15 percent of the basal area. At this intensity, diameter growth was achieved without seriously sacrificing volume growth. The optimum residual density varied with site and stand age. On better sites, higher residual densities were found to be optimal. For example, at age 40, the optimal residual basal areas for site 100 and 120 were 106 and 130 square feet per acre respectively.

For the three sites examined, the residual basal areas were about equal to the site index value at ages of 40 years or more. Given the importance of the sawtimber volume in determining thinning regimes, this result is consistent with the findings and recommendations of Beck and Della-Bianca

TABLE 8

Effect of thinning on various stand attributes.

The effect of alternate thinning regimes on stand quadratic mean diameter, percent peelers, accumulated sawtimber yields, and present net worth (PNW)*.

Thinning regime	Dia- meter**	Peeler % ***	Sawtimber yield(bf)	PNW \$
No thin	7.8	3.7	20332	\$327
Thin 15% at age 30	10.4	6.1	18618	307
Thin 25% at age 30	10.5	7.4	17404	293
Thin 40% at age 30	11.0	11.7	15447	274
Thin 15% at ages 20,40	12.4	27.8	19319	399
Thin 25% at ages 20,40	12.3	27.0	17607	362
Thin 40% at ages 20,40	12.7	31.1	15304	327
Thin 15% at ages 20,30,40	12.4	27.8	18953	397
Thin 25% at ages 20,30,40	12.4	27.8	16101	337

* Benchmark input data for site index 100, rotation age 47 years. All figures on a per acre basis.

** Quadratic mean diameter at final harvest.

*** Percent peelers at final harvest.

(1981). In order to maximize board-foot growth, they suggest that the residual density of stands at least 40 years old be equal to the site index value (Beck and Della-Bianca 1981).

The number and timing of thins varied according to site quality. For site indices of 80 and 100, two thinnings were found to be optimal. For site 120, only a single thinning was optimal. This difference in the number of thins is attributed to the effect site quality has on stand growth. To maintain a given growth rate, the amount of growing space needed per tree must be greater for poorer sites than for better sites. The poorer the site, the more growing space is necessary for the individual tree to obtain enough soil moisture and nutrients for growth. Thus, for the lower sites, the basal area must be maintained at lower levels to achieve a desired rate of growth. Similarly, the timing of thins is related to the influence of site quality on tree growth. For sites 80 and 100, the first thinning occurred at an earlier age than that of site 120. Figure 5 demonstrates the effect the optimal thinning regime for site index 80 has on mean annual increment. As the figure illustrates, the growth rate for the thinned stand is increasing between the ages of 30 and 60 while the growth rate for the unthinned stand has begun to decrease. For the unthinned stand, mean annual increment culminates at age 39; for the thinned stand culmination does not occur until approximately age 70.

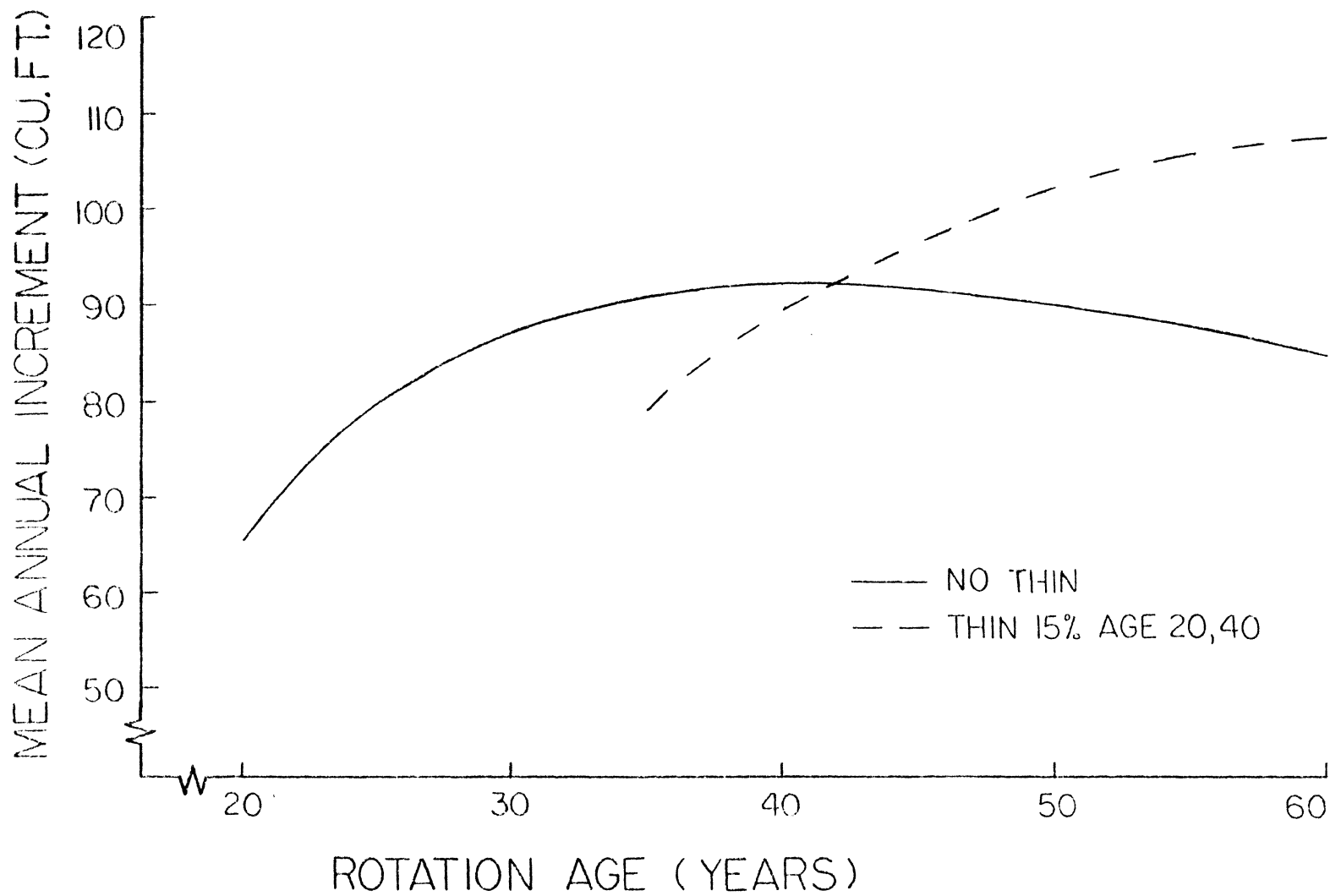


Figure 5. Mean annual increment on site index 80 (base age 50).

For each stand examined, the optimal rotation was set at the age at which present net worth was maximized. At this age the marginal value growth percent of the stand was just equal to the specified interest rate. The marginal value growth percent is the percentage change in the immediate harvest value of the stand from one year to the next. If the stand had been allowed to grow past this age, a loss of wealth to the landowner would have occurred since the forest capital could have been invested elsewhere at a higher rate of return. Without thinning, the optimal rotation ages for site indices 80, 100, and 120 were 53, 47, and 46 respectively. This trend of shorter rotations on better sites occurred in all analyses. Figure 6 relates the marginal value growth percents for the three sites examined to the benchmark rate of return of 4 percent. The point at which the value growth percent curve for a given site intersects the interest line indicates the optimal rotation age.

The reason for the trend of shorter rotations on higher sites is because the optimal rotation is based on the percent value growth rather than the total volume growth per year. For example, given that in any year, the total volume and therefore total value for site index 120 is greater than that of site index 80, if a 4 percent annual increase in value is required, the site 120 stand must produce more total volume and value than the stand of site 80.

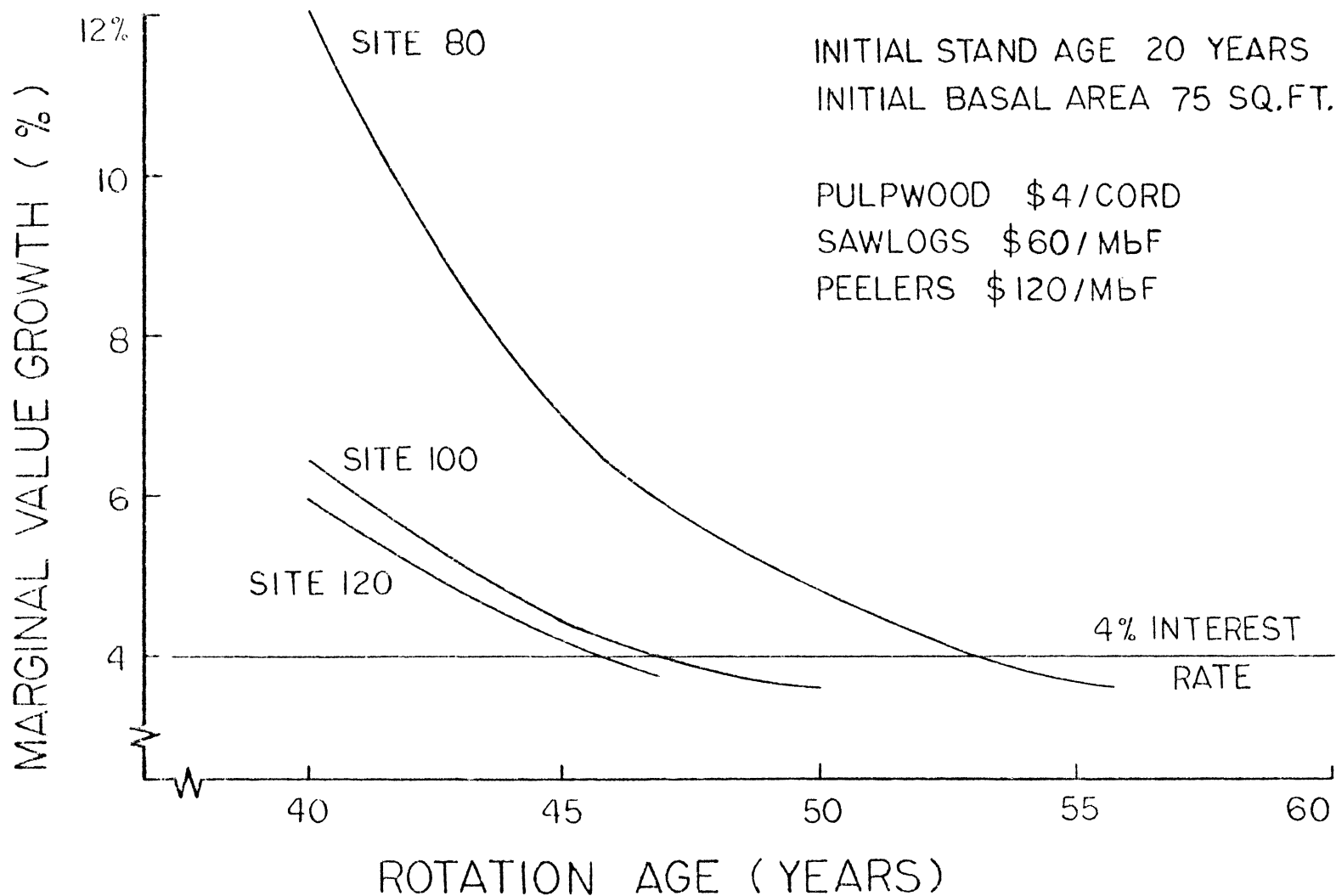


Figure 6. Optimal unthinned rotation ages for three site indices as determined by the marginal value growth percent (benchmark input data).

The rotation ages for the thinned stands were longer than the unthinned stands on each of the three sites. This occurred for two reasons. First, in response to release the thinned stands maintained a higher annual volume growth rate than the unthinned stands. Second, as a result of thinning, often a greater percentage of trees in the stands grew into the sawtimber class and for the those trees already in the sawtimber class, a greater percentage qualified as peelers. The net effect was the maintenance of higher marginal value growth percents for the thinned versus unthinned stands. These higher marginal value growth rates caused a delay in the ages at which they became equal to the interest rate, thus lengthening the rotation.

Since land values were omitted from all financial analyses, the optimal rotations determined may be too long. If the land values had been entered in the analyses, the marginal value growth percents would have been lower for all harvest ages considered (assuming no real price appreciation in land). This reduction in the value growth percents would occur because the addition of a constant land value would cause a higher stand immediate harvest value in a given year without producing any additional stand marginal value growth. These lower marginal value growth rates would yield a decrease in the ages at which they become equal to the interest rate, thus shortening the rotation.

Sensitivity Analysis

Variation of the Real Interest Rate

Increasing or decreasing the interest rate had the effect of increasing or decreasing the optimal rotation length in both the thinned and unthinned stands. Because the marginal value growth percent is declining over the range of ages examined, an increase in the interest rate causes the age at which the marginal value growth percent equals the interest rate to shorten (refer to Figure 6, page 71). Similarly, a decrease in the interest rate lengthens the rotation by postponing the age at which the value growth percent and interest rate become equal.

Changes in the optimal thinning regime are induced by changes in the rotation. With increases in the interest rate, the rotation used in determining the optimal thinning regime shortens. This causes a shift in the ranking of the alternative thinning regimes. For site index 100, increasing the interest rate from 2 to 8 percent causes the time between successive thinnings to shorten until finally a no thin regime becomes optimal at a rotation age of 36 years. At 8 percent the rotation is so short that the benefits of thinning never have time to materialize.

Variation in Thinning Costs

Variations in the thinning costs had no effect on the optimal thinning regime or rotation. As previously discussed, the revenues received from thinning are a small proportion of the total revenues produced over the rotation. Reductions in these revenues by incorporating increases in thinning costs correspondingly have a small impact on total stand revenues and therefore present net worth. The price for thinned material was able to decline to 0 percent of clearcut prices without changing the optimal regime (see Figure 4, page 56). In instances where the pulpwood component normally removed in thinnings is a significant component of total stand volume and value (e.g., low sites and/or short rotations), the effects of thinning costs on present net worth may be more pronounced.

Variation of the Clearcut Stumpage Prices

When the benchmark prices were increased or decreased by proportionate amounts, the optimal rotation age and thinning regime remained unchanged. Such price changes have no effect on the optimal rotation since they do not produce any change in the marginal value growth percent. As the value of incremental growth is either increased or decreased, the value of the growing stock is correspondingly increased or decreased.

Thus, a cancelling effect occurs when the marginal value growth percent is calculated. Also, when all prices are changed in proportion to each other, there is not any change in the price differentials between the different products. Thus, the optimal thinning regime does not change since there is no impetus for a change in the proportion of volume produced from each product class.

A real price appreciation rate of 2 percent per year caused the unthinned rotation in the benchmark analysis to lengthen significantly. The 2 percent appreciation rate caused a 2 percent increase in the marginal value growth percent, thus lengthening the time for which acceptable returns were being made on the thinning investment. The optimal thinning regime also changed in response to the lengthened rotation. With a rotation of 65 years, (an increase of 18 years from the benchmark rotation), an additional thinning was necessary to maintain volume growth. Thus, the optimal thinning regime for a rotation of 65 years became three thinnings at ages 20, 30, and 40 years.

Increasing the price paid for sawlogs by 50 percent while other prices remained constant caused a change in the optimal thinning regime without changing the rotation. For the benchmark case, two thinnings at ages 20 and 40 were optimal. With the price for sawlogs increased from \$60 to

\$90/Mbf, the age of the second thinning decreased to age 30. The effect of this was to increase the total volume of sawtimber from 19.3 Mbf to 21.0 Mbf while decreasing the percent peelers from 28 to 11 percent. Since the price differential between peelers and sawlogs declined, the sacrifice of sawtimber volume for peeler production was less advantageous.

Increasing the price paid for peeler stumpage by 50 percent to \$180/Mbf had a very slight effect on the unthinned rotation while the optimal thinning regime remained unchanged. The rotation lengthened from 47 to 48 years. This somewhat surprising result occurred for two reasons. First, considering the benchmark pricing situation, the marginal value growth percent is rapidly declining between the ages of 40 and 60 years (refer to Figure 6, page 71). This decline was not easily offset by an increase of \$60/Mbf for peelers. Second, although an increase in peeler price caused an increase in the value of incremental growth, the value of the growing stock also increased. Thus, to a certain degree, the value changes cancelled out.

In considering alternate thinning regimes, the absolute present net worths increased with the peeler price increase but the optimal thinning regime did not change from the benchmark situation. However, the regimes which produced a

greater proportion of peelers did gain relative position in ranking. This is a result of the increase in the price differential between sawlogs and peelers. Nevertheless, the price increase was not sufficient for any of these regimes to become optimal.

RECOMMENDATIONS

The computer program presented in this study may be used by consulting foresters or landowners to develop general guidelines for thinning yellow-poplar stands. These guidelines may play a key role in the decision process concerning the management of yellow-poplar. However, the program should not be used as the sole determinate of how thinnings are to be applied. It should be used in combination with the forester's reasonable understanding of forest management and stand dynamics. For example, if inputs to the model are not biologically sound, then unreasonable results and sub-optimal management regimes may be obtained. The model is meant as an aid to the forester, not as a replacement for him.

In the benchmark and sensitivity analyses, a specific set of computer model inputs were used. In several instances, some of these inputs were artificially controlled (e.g., beginning age and basal area, rotation ages). Given totally different input assumptions, the model may yield quite different results from those given in this study. However, the general trends and relationships established in this study should still be applicable. The conclusions reached

here should not be viewed as recommendations but as a spring-board for further analysis.

There are two primary areas of the computer program which are in need of improvement. The first concerns the prediction of the proportion of sawtimber volume consisting of peelers. There needs to be a more empirically based method for this prediction. For the purposes of this study, it was assumed that only trees which reached a minimum DBH of 15 inches qualified as peelers. However, in actuality, peelers may be obtained across a wide range of diameters, beginning at 11 inches DBH. A model needs to be developed which predicts the percent frequency with which trees of a given diameter will qualify as peelers. With this model, the peeler volumes could be predicted more realistically and accurately thus increasing the confidence with which the model results may be used.

The second area of needed improvement concerns the prediction of the number of trees per acre after a thinning. Three sets of coefficients are specified for the model which relates the number of trees to age and basal area. The differences among these coefficients reflect the differences in stand structure for stands before a first thin, after a first thin, and after a second thin. The problem involved with this model construct is that the coefficients used in

the model are selected in terms of the number of thinnings only; the intensity of thinning is not taken into account. Thus a stand that has been thinned once with only 5 percent of the basal area removed will be assumed to have the same stand structure as stands thinned much more heavily. However, given this light thinning intensity, the stand should have a stand structure similar to an unthinned stand. This treatment can cause severe biases when the unthinned and thinned stands deviate significantly in stand structure from the stands used to fit the coefficients of the model. Until some means of relating the stand structure to the intensity of thinning is devised, use of this model and coefficients should be limited to the range of thinning intensities used to develop the coefficients. The biases that may otherwise result may cause severe errors in the calculation of the quadratic mean diameter, the sole determinant of the percent peelers in the stand.

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Appendix A
PRESENT NET WORTHS, BENCHMARK ANALYSIS

Appendix Table I. Present net worths, benchmark analysis.*
Site index 80.

Thinning regime-		Present net worth
Age	Percent basal area removed	(\$)
-	-	\$67
20	15%	65
20	25	65
20	40	62
30	25	61
40	25	59
20,30	15,15	121
20,30	25,25	113
20,30	25,15	118
20,30	40,40	118
20,40	25,25	100
30,40	25,25	96
20,30,40	15,15,15	120
20,30,40	40,15,15	111

* Site index 80, base age 50.
Rotation age 53 years.
Benchmark input data.
All values on a per acre basis.

Appendix Table II. Present net worths, benchmark analysis.*
Site index 100.

Thinning regime-		Present net worth
Age	Percent basal area removed	(\$)
-	-	\$327
20	25%	283
20	40	262
30	25	293
30	40	274
40	15	371
40	25	354
40	40	340
20,30	25,25	349
20,35	25,25	356
20,40	15,15	399
20,40	25,25	362
20,40	40,15	349
30,40	25,25	344
20,30,40	15,15,15	397
20,30,40	25,25,25	337

* Site index 100, base age 50.
Rotation age 47 years.
Benchmark input data.
All values on a per acre basis.

Appendix Table III. Present net worths, benchmark analysis.*
Site index 120.

Thinning regime-		Present net worth
Age	Percent basal area removed	(\$)
-	-	\$736
20	25%	589
30	25	755
40	15	935
40	25	894
40	40	852
20,30	25,25	734
30,40	25,25	824
20,40	15,15	914
20,40	25,25	827
20,40	40,40	732
20,30,40	15,15,15	854
20,30,40	25,25,25	748
20,30,40	40,15,15	733

* Site index 100, base age 50.
Rotation age 46 years.
Benchmark input data.
All values on a per acre basis.

Appendix B

PRESENT NET WORTHS, SENSITIVITY ANALYSIS

Appendix Table I. Present net worths, sensitivity analysis.*
2 % Interest Rate.

Thinning regime-		Present net worth
Age	Percent basal area removed	(\$)
-	-	\$711
20	25%	598
30	25	694
40	25	836
50	15	965
50	25	930
20,30	25,25	973
30,40	25,25	1011
40,50	25,25	1022
20,40	25,25	1040
20,50	15,15	1143
20,50	25,25	1050
20,50	40,15	1021
20,30,40	15,15,15	1099
20,30,40	25,25,25	994
30,40,50	25,25,25	965

* Site index 100, base age 50.
Rotation age 63 years.
Benchmark input data, except interest rate.
All values on a per acre basis.

Appendix Table II. Present net worths, sensitivity analysis.*
6% Interest Rate.

Thinning regime-		Present net worth
Age	Percent basal area removed	(\$)
-	-	\$180
20	15%	168
20	25	160
20	40	147
30	25	152
30	40	138
20,30	15,15	182
20,30	25,25	165
20,30	40,15	165
20,30	45,10	168

* Site index 100, base age 50.
Rotation age 41 years.
Benchmark input data, except interest rate.
All values on a per acre basis.

Appendix Table III. Present net worths, sensitivity analysis.*
8% Interest Rate.

Thinning regime-		Present net worth
Age	Percent basal area removed	(\$)
-	-	\$108
20	15%	102
20	25	97
20	40	94
25	15	99
25	25	93
25	40	83
20,30	15,15	94
20,30	25,25	80
20,30	40,15	81
20,30	40,40	79

* Site index 100, base age 50.
Rotation age 36 years.
Benchmark input data, except interest rate.
All values on a per acre basis.

Appendix Table IV. Present net worths, sensitivity analysis.*

Variation in the percent of clearcut prices received
for thinned material.

Thinning regime-		Present net worth-		
Age	Percent basal area removed	Percent of clearcut prices		
		0%	40%	100%
-	-	\$327	\$327	\$327
20	25%	271	277	286
30	25	273	282	297
40	15	348	359	377
40	25	304	329	366
40	40	243	291	364
20,30	15,15	358	367	380
20,30	25,25	321	335	356
30,40	25,25	285	314	358
20,40	15,15	370	386	407
20,40	25,25	306	334	376

* Site index 100, base age 50.

Rotation age 47 years.

Benchmark input data, except % clearcut price for thinned material.

All values on a per acre basis.

Appendix Table V. Present net worths, sensitivity analysis.*
Variation in Clearcut Prices:

Pricing alternative A: pulpwood=\$2/cord, sawlogs=\$30/Mbf,
peelers=\$60/Mbf.

Pricing alternative B: pulpwood=\$8/cord, sawlogs=\$120/Mbf,
peelers=\$240/Mbf.

Thinning regime-		Present net worth-	
Age	Percent basal area removed	Pricing alternative	
		A	B
-	-	\$152	\$674
20	25%	130	588
30	25	134	606
40	15	174	764
40	25	166	729
20,30	15,15	177	771
20,30	25,25	160	709
20,30	40,40	168	740
20,40	15,15	189	821
20,40	25,25	169	746
20,30,40	15,15,15	186	729

* Site index 100, base age 50.

Rotation age 47 years.

Benchmark input data, except clearcut prices.

All values on a per acre basis.

Appendix Table VI. Present net worths, sensitivity analysis.*
Variation in clearcut prices:

pulpwood=\$4/cord, sawlogs=\$60/Mbf, peelers=\$180/Mbf.

Thinning regime-		Present net worth
Age	Percent basal area removed	(\$)
-	-	\$342
20	25%	281
30	25	325
40	15	471
40	25	448
40	40	433
20,30	25,25	428
30,40	25,25	461
20,40	15,15	530
20,40	25,25	483
20,40	40,40	452
20,30,40	15,15,15	525
20,30,40	40,15,15	462

* Site index 100, base age 50.
Rotation age 49 years.
Benchmark input data, except clearcut prices.
All values on a per acre basis.

Appendix Table VII. Present net worths, sensitivity analysis*
Variation of clearcut prices:

pulpwood=\$4/cord, sawlogs=\$90/Mbf, peelers=\$120/Mbf.

Thinning regime-		Present net worth
Age	Percent basal area removed	(\$)
-	-	\$506
20	25%	451
30	25	440
40	15	497
40	25	478
20,30	15,15	547
20,30	25,25	493
30,40	25,25	456
20,40	15,15	527
20,40	25,25	480
20,40	40,40	471

* Site index 100, base age 50.

Rotation age 47 years.

Benchmark input data, except clearcut prices.

All values on a per acre basis.

Appendix Table VIII. Present net worths, sensitivity analysis.
Variation in Clearcut Prices:*

2% real price appreciation in all products over the
length of the rotation.

Thinning regime-		Present net worth
Age	Percent basal area removed	(\$)
-	-	\$736
20	25%	620
30	25	725
40	25	873
50	15	1004
50	25	972
50	40	944
20,30	25,25	1029
20,40	25,25	1103
20,50	15,15	1210
20,50	25,25	1075
20,50	40,40	1017
20,50	40,15	1087
30,40	25,25	1073
30,50	25,25	1075
20,30,40	25,25,25	1058
20,30,50	15,15,15	1283
20,30,50	25,25,25	1123

* Site index 100, base age 50.
Rotation age 65 years.
Benchmark input data, except clearcut prices.
All values on a per acre basis.

Appendix C

SAMPLE OUTPUT FROM COMPUTER MODEL

=====

THINNING ANALYSIS FOR YELLOW-POPLAR

=====

PREPARED BY: DARRELL BROOKS
STAND NAME: SAMPLE OUTPUT

STAND DATA SUMMARY:

SITE INDEX= 90 INITIAL AGE= 20 INITIAL B.A.= 75
BEGINNING YEAR OF ANALYSIS= 1983 NUMBER OF THINS= 2

VOLUMES BEFORE AND AFTER CUT (PER ACRE)

=====

TYPE CUT	YEAR	STAND AGE	BEFORE					AFTER				
			BA	NT	CV	BV	NCD	RBA	RNT	RCV	RBV	RNCD
NONE	1983	20	/ 75	529	1524	0	17.9	/				
THIN	1988	25	/ 93	529	2354	0	27.4	/ 60	264	1594	0	18.3
THIN	2003	40	/ 99	264	3447	6463	24.1	/ 85	157	3058	6463	18.9
HARV	2023	60	/ 139	157	6030	20423	17.4	/				

AVERAGE DIAMETER AND PERCENT PEELERS AT FINAL HARVEST = 13.2 IN., 36.9%

=====

BA = BASAL AREA IN SQ. FT. NT = NUMBER OF TREES CV = CU. FT. VOLUME
BV = 9D. FT. VOLUME, INTERNATIONAL 1/4 IN. NCD = NET CORD VOLUME
PREFIX R IN AFTER CUT INDICATES RESIDUAL.

=====

ECONOMIC DATA SUMMARY:

TAX TREATMENT= AFTER TAX REAL DISCOUNT RATE= 4% INFLATION RATE= 6%
 MARGINAL TAX RATE= 30% CAPITAL GAINS RATE= 12%
 LAND BASIS= 250 TIMBER BASIS= 50 CURRENT LAND VALUE= 300
 PRICE/CORD= 4 PRICE/MBF FOR SAWLOGS AND PEELERS RESPECTIVELY= 60,140
 PRICE APPREC. FOR PULP., SAWLOGS, AND PEELERS RESPECTIVELY = 0.0,0%
 PRICE ADJUSTMENT FOR THINNED MATERIAL= 80% OF FINAL HARVEST STUMPAGE VALUES.

EXPENSE DATA SUMMARY:

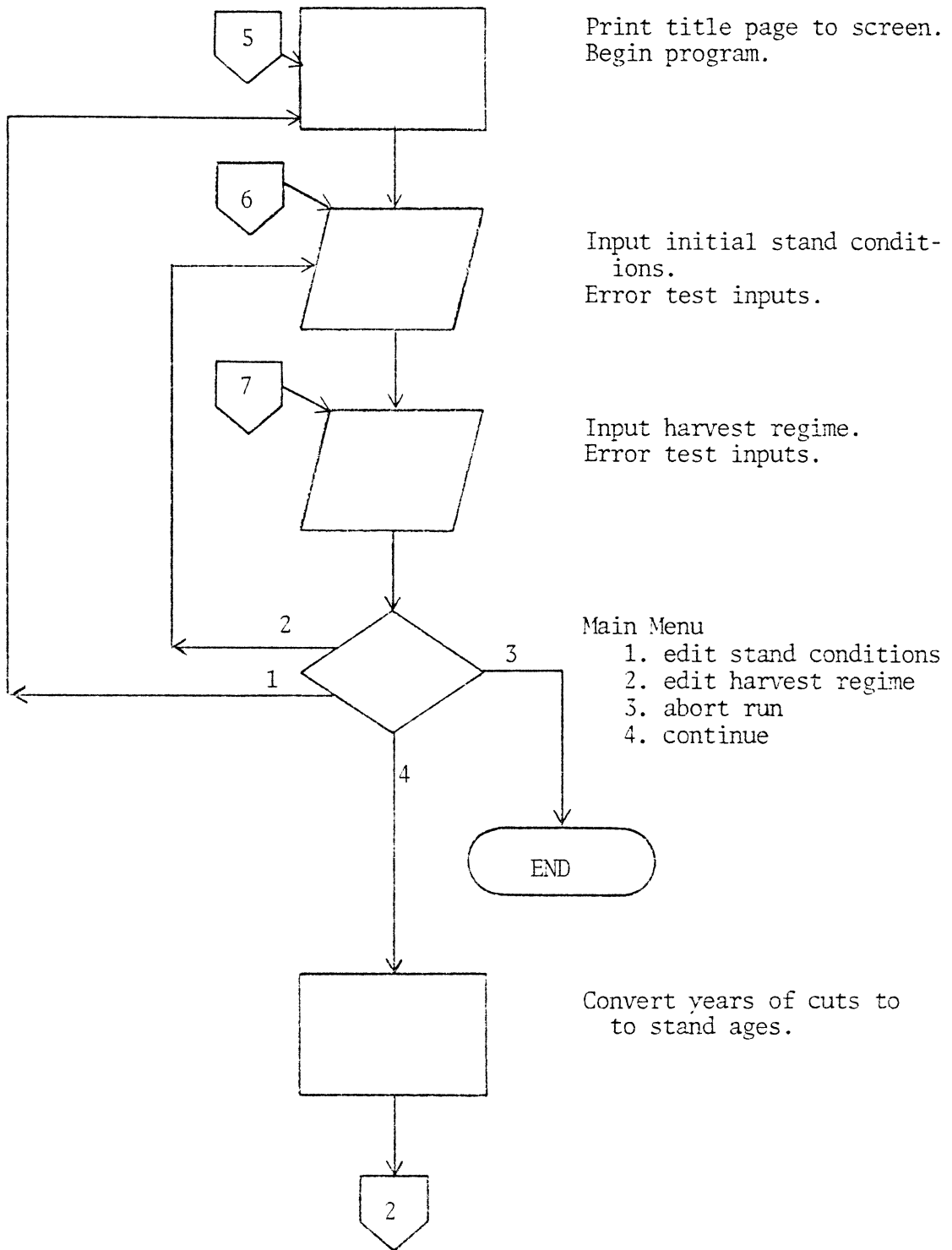
TYPE OF EXPENSE	YEAR	AMOUNT	
YEARLY RECUR., ORDINARY	--	2	
NON-RECURRING, ORDINARY	1988	10	
DEPRECIABLE, CAPITAL	1983	15	PERIOD= 40 SALVAGE= 0
DEPLETABLE, CAPITAL	1983	10	
CURRENT STAND VALUE	1983	363	

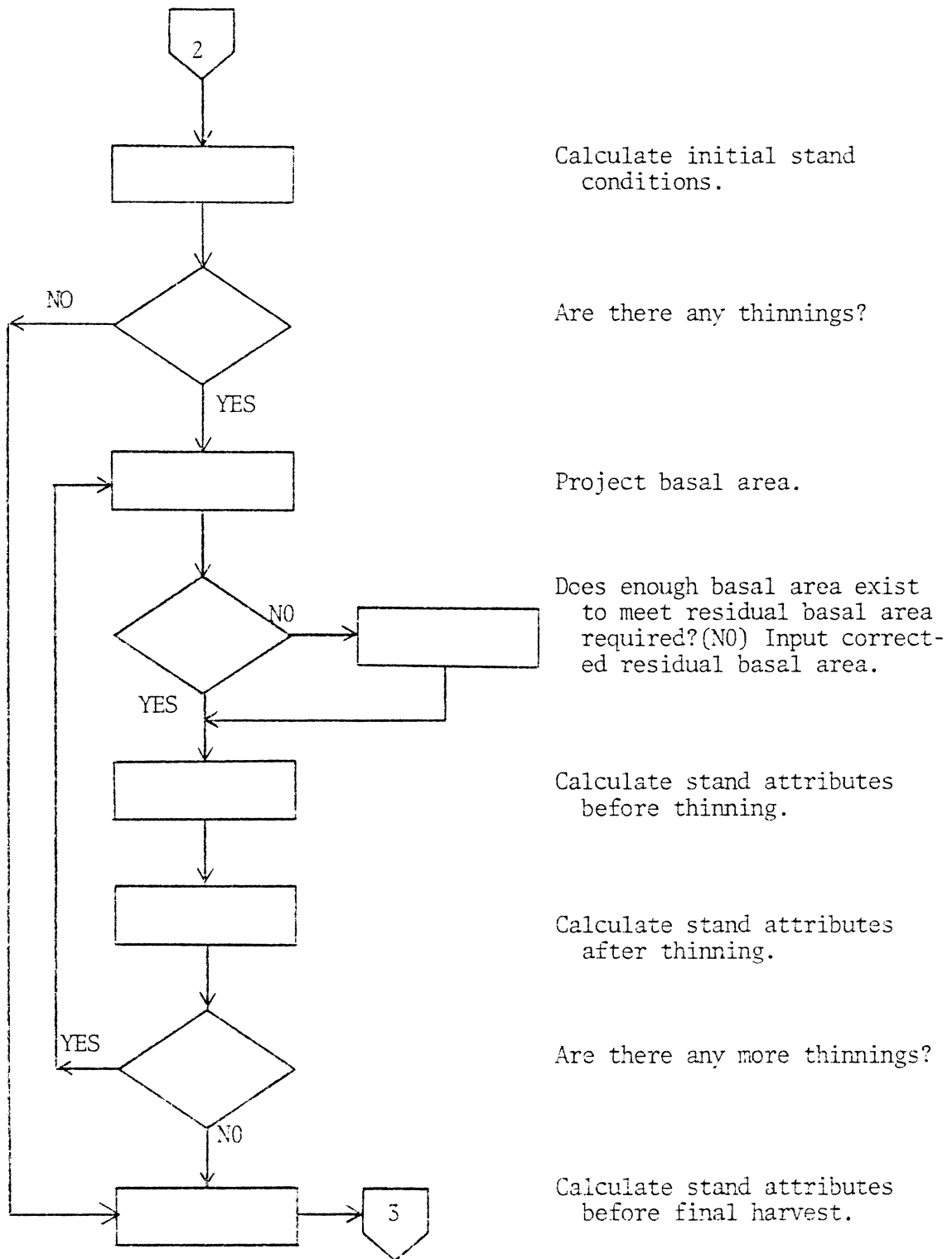
ECONOMIC CRITERIA (PER ACRE)

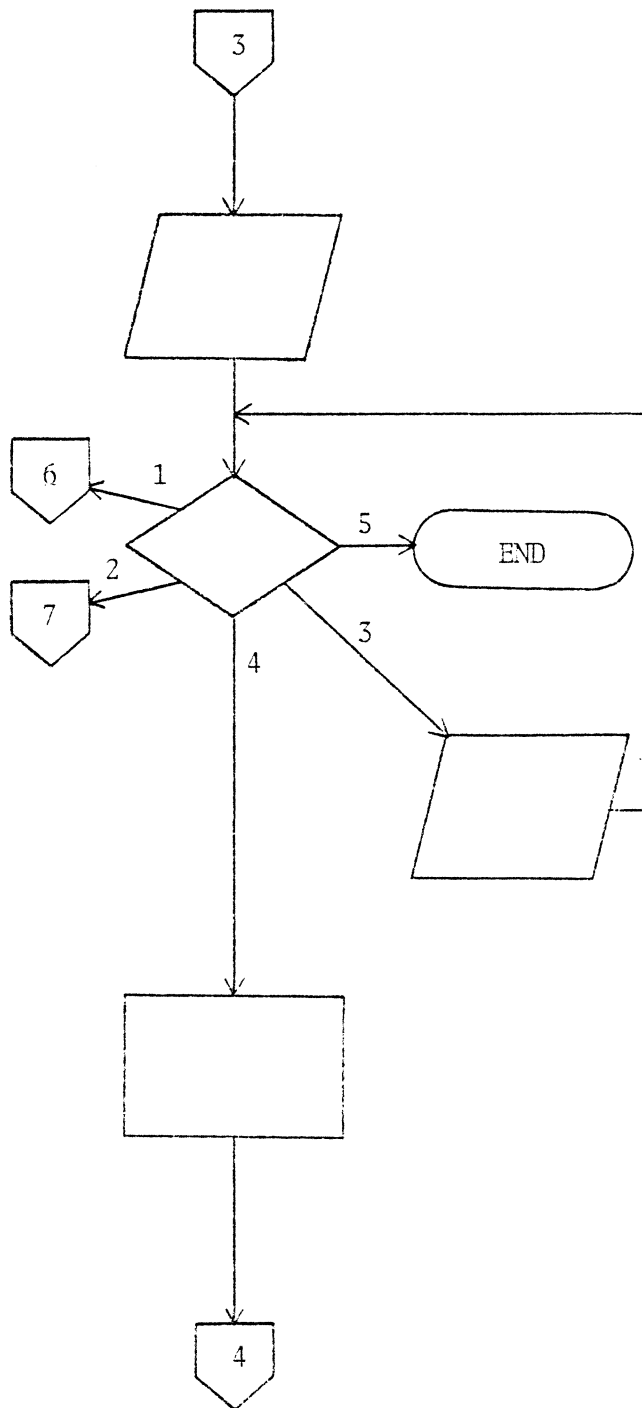
=====
 PRESENT NET WORTH @ 10.24% = 13
 INTERNAL RATE OF RETURN = 10.3%

=====

Appendix D
FLOWCHART OF COMPUTER MODEL







Display growth & yield results.

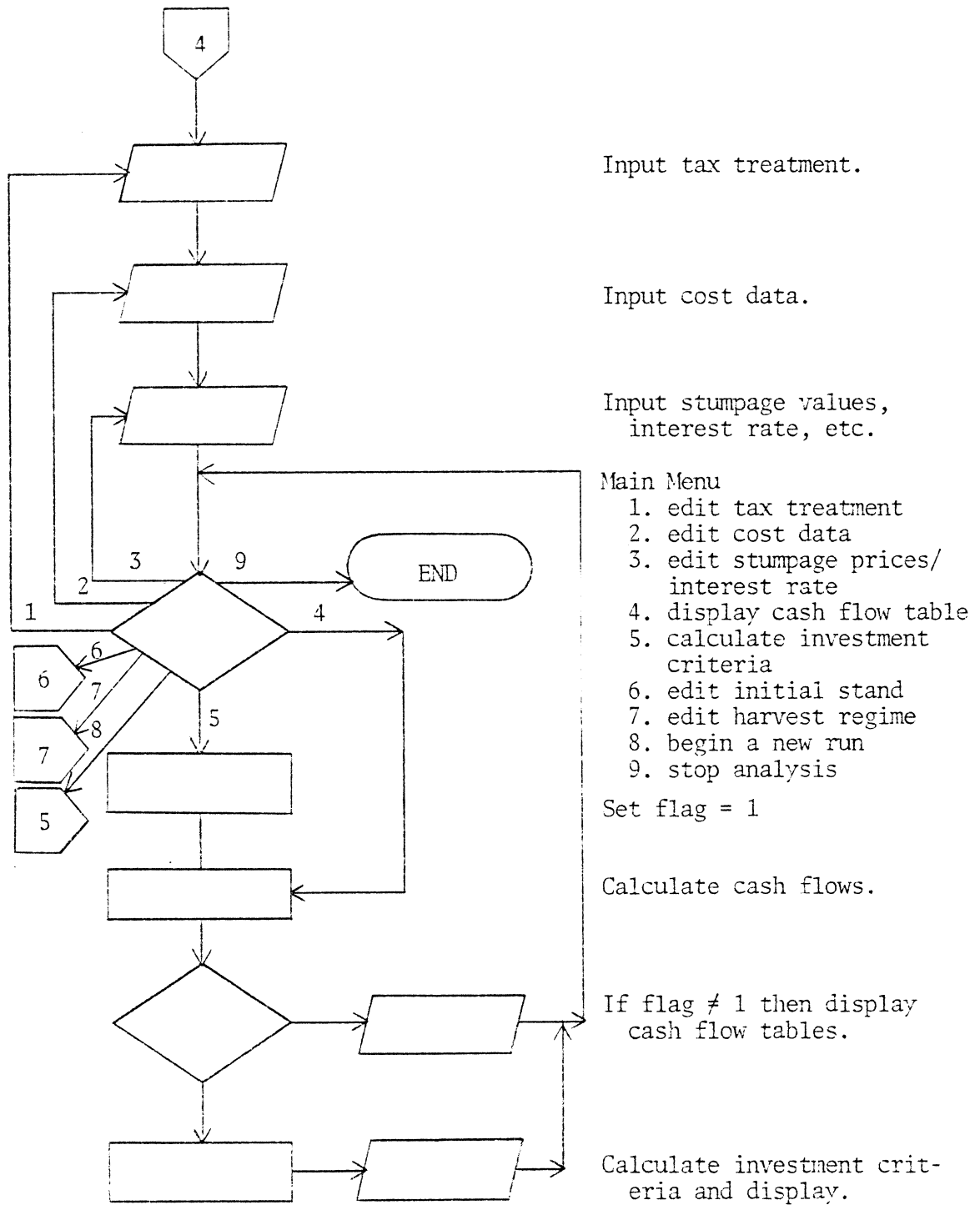
Main Menu

1. edit initial stand conditions
2. edit harvest regime
3. line print growth & yield results
4. continue
5. abort run

Output growth & yield results in 80 column format.

Calculate volumes removed from each harvest.

Proceed to financial analysis model.



Appendix E
DOCUMENTED COMPUTER PROGRAM LISTING

JI FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #1
 PAGE-1

```

10  REM *****
20  REM ==> THINNING ANALYSIS FOR YELLOW-POPLAR
30  REM *****
40  REM
50  REM PROGRAM CREATED BY D.G. BROOKS & M.C. VODAK
60  REM LAST UPDATE 5/16/83
70  REM
80  REM *****
90  REM
100 REM ==> ARRAY AND VARIABLE INITIALIZATIONS
110 REM
120 REM YR(L) = YEAR OF THIN (L)
130 REM RB(L) = RESIDUAL BASAL AREA OF THIN (L)
140 REM C(L) = AGE OF STAND AT THIN (L)
150 REM T1(J,I) = COEFF. FOR NO. OF TREES/AC.
160 REM CF(I) = COEFF. FOR CU.FT. VOL./B.A. EQTN.
170 REM BF(I) = COEFF. FOR CU.FT. TO BD.FT. EQTN.
180 REM TC(I) = COEFF. FOR CU.FT. TO CORDS EQTN.
190 REM RM = COEFF. FOR VOLUME REMOVED IN THIN
200 REM RE(L,I) = THE (I)TH RESULT FROM THIN (L)
210 REM P*(L,I) = STRING ARRAY FOR OUTPUT
220 REM P(L,I) = LENGTH OF STRING ARRAY
230 REM TR(L) = GROSS REVENUE FROM CUT (L)
240 REM TY(L) = NO. YEARS CUT(L) IS FROM BEG ANAL
250 REM C2(I) = NON-REC. EXP. IN YEAR(I), BEFORE TAX
260 REM E1(I,J) = EDIT ARRAY FOR C2(I)
270 REM E2(I,J) = EDIT ARRAY FOR C2(I), AFTER TAX
280 REM C2(I) = NON-REC. ORDINARY EXP., AFTER TAX
290 REM C3(J,I) = DEPRECIABLE EXP. #J IN YEAR(I)
300 REM C7(J,I) = DEPRECIATION PERIOD FOR DEPREC. EXP.
310 REM C8(J,I) = SALVAGE VALUE FOR DEPREC. EXP.
320 REM E3(I,J) = EDIT ARRAY FOR DEPREC. EXP.
330 REM C4(I) = DEPLETABLE EXP. IN YEAR(I)
340 REM E4(I,J) = EDIT ARRAY FOR DEPREC. EXP.
350 REM C5(I) = CASH OUTFLOW FOR YEAR (I)
360 REM C6(I) = YEARLY RECURRING EXP. FOR YEAR (I)
370 REM W(I) = TOTAL DEPREC. EXPENSES FOR YEAR (I)
380 REM C9(I) = NET CASH FLOW FOR YEAR(I)
390 REM R8(I) = CASH INFLOW FOR YEAR(I)
400 REM M0 = 1 - CAPITAL GAINS RATE
410 REM M1 = 1 - MARGINAL TAX RATE
420 REM M2 = 1 + INFLATION RATE
430 REM M3 = 1 + REAL PRICE APPREC. FOR PULP.
440 REM M4 = 1 + REAL PRICE APPREC. FOR SAWLOGS
450 REM M5 = 1 + REAL PRICE APPREC. FOR PEELERS
460 REM M9 = 1 + REAL PRICE APPREC. FOR LAND
470 REM D1 = 1 + INTEREST RATE
480 REM TP = % C.CUT PRICES FOR THIN MAT.
490 REM
500 CLEAR :
    HOME :
    DIM YR(5), RB(5), C(5), T1(4,3), CF(6,2), BF(3), TC(2), RE(6,20),
    P*(6,15), P(6,15), PP(1,4)
510 DIM TR(6), TY(5)
520 DIM C2(60), E1(5,2), E2(5,2), C3(2,60), C7(2,60), C9(2,60), E3
    (5,5)
530 DIM C4(60), E4(5,2), C5(60), C6(60), W(60), C9(60), R8(60)
  
```

11 FORMATTED LISTING

FILE: APPENDIX E. DOCUMENTATION FILE #1
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```

540 REM
550 LET M0 = 1:
    LET M1 = 1:
    LET M2 = 1:
    LET M3 = 1:
    LET M4 = 1:
    LET M5 = 1:
    LET M9 = 1:
    LET D1 = 1:
    LET TP = 1
560 REM
570 FOR J = 1 TO 3:
    FOR I = 1 TO 4:
        READ T1(I,J):
    NEXT I:
NEXT J
580 FOR J = 1 TO 2:
    FOR I = 1 TO 6:
        READ CF(I,J):
    NEXT I:
NEXT J
590 READ RM
600 FOR I = 1 TO 3:
    READ BF(I):
NEXT I
610 FOR I = 1 TO 2:
    READ TC(I):
NEXT I
620 FOR J = 0 TO 4:
    FOR I = 0 TO 1:
        READ PP(I,J):
    NEXT I:
NEXT J
630 REM
640 DATA 6.43346,38.24834,-0.01309,-67.25874
650 DATA 6.12444,59.93859,-0.01911,-73.59987
660 DATA 6.12335,69.03772,-0.02083,-78.12201
670 DATA 5.35740,-102.45728,-21.95901,0.97473,4.11893,0.0
    1293
680 DATA 5.33115,-97.95286,-25.19324,0.98858,5.84476,0.00
    018
690 DATA 1.10158
700 DATA 1363.09165,-306.96647,10.26187
710 DATA 77.1,1.433
720 DATA -.6971,.09456
730 DATA -.97486,.10312
740 DATA -.89931,.09808
750 DATA -1.0586,.10717
760 DATA -1.07591,.10909
770 REM
780 REM ==> DISPLAY PROGRAM HEADER PAGE
790 REM
800 LET TR = 0:
    HOME :
    VTAB 4:
    FOR I = 1 TO 39:
        PRINT "*":
    NEXT I:

```

JC FORMATTED LISTING

FILE: APPENDIX E. DOCUMENTATION FILE #1

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```

      PRINT "":
      FOR I = 1 TO 10:
        PRINT "*"; TAB( 39);"*":
      NEXT I:
      FOR I = 1 TO 39:
        PRINT "*";:
      NEXT I
810  LET G$ = "====":
      LET T$ = G$ + G$:
      VTAB 5:
      PRINT " *";T$;T$;T$;G$;"==*":

820  PRINT "":
      VTAB 8:
      PRINT " *";T$;T$;T$;G$;"==*":

830  VTAB 7:
      PRINT "* ";:
      INVERSE :
      PRINT "THINNING ANALYSIS FOR YELLOW-POPLAR";:
      NORMAL :
      PRINT " *":

840  VTAB 10:
      HTAB 7:
      PRINT "VPI & SU DIVISION OF FORESTRY"
850  HTAB 9:
      PRINT "PROGRAM BY D.G. BROOKS
860  HTAB 9:
      PRINT "LAST UPDATE      5/10/83"
870  VTAB 22:
      HTAB 8:
      INVERSE :
      INPUT " HIT (RETURN) TO BEGIN. ";Z$:
      NORMAL :
      HOME
880  REM
890  REM ==> SET CONTROL G VALUE
900  REM
910  LET X$ = "":
      LET R$ = CHR$ (7)
920  REM
930  REM *****
940  REM ==>      STAND DATA INPUT PHASE
950  REM *****
960  REM
970  REM NA$ = ANALYST NAME
980  REM SN$ = STAND NAME
990  REM YE = BEGINNING YEAR OF THE ANALYSIS
1000 REM AG = INITIAL AGE OF STAND
1010 REM BA = INITIAL BASAL AREA
1020 REM SI = SITE INDEX
1030 REM TN% = NO. OF THINS
1040 REM YR(L) = YEAR OF THIN
1050 REM RB(L) = RESIDUAL B.A. FOR THIN#L
1060 REM FH   = YEAR OF FINAL HARVEST
1070 REM
1080 REM      THE CURRENT VALUE IN MEMORY FOR EACH STAND

```

J1 FORMATTED LISTING

FILE: APPENDIX E. DOCUMENTATION FILE #1

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```

1090 REM  PARAMETER IS GIVEN IN HIGHLIGHTED AREA.AFTER
1100 REM  INITIAL INPUT, EACH DATA ENTRY MAY BE
1110 REM  REVIEWED OR EDITED.FOR SELECTED STAND
1120 REM  PARAMETERS, THE INPUT VALUES ARE TESTED TO
1130 REM  DETERMINE IF THEY FALL WITHIN MODEL DATA
1140 REM  RANGES. IF NOT, WARNING MESSAGE IS GIVEN AND
1150 REM  USER IS GIVEN OPPORTUNITY TO EDIT VALUE(S).
1160 REM
1170 REM
1180 PRINT :
      PRINT "ENTER YOUR NAME (MAX 30 CHARACTERS). "
1190 INPUT Z$:
      IF Z$ < > "" THEN
        LET NAME$ = Z$
1200 REM
1210 PRINT :
      PRINT "ENTER STAND NAME (MAX 30 CHARACTERS). "
1220 INPUT Z$:
      IF Z$ < > "" THEN
        LET SN$ = Z$
1230 REM
1240 PRINT :
      PRINT "ENTER PRESENT YEAR.      ";
      INVERSE :
      PRINT "(";YEAR;")":
      NORMAL
1250 INPUT Z$:
      IF Z$ < > "" THEN
        LET YEAR = VAL (Z$)
1260 REM
1270 PRINT :
      PRINT "ENTER PRESENT AGE OF STAND. ";
      INVERSE :
      PRINT "(";AGE;")":
      NORMAL
1280 INPUT Z$:
      IF Z$ < > "" THEN
        LET AGE = VAL (Z$):
        IF AGE < 17 OR AGE > 76 THEN
          GOSUB 5450:
          GOTO 1270:
          REM  CALL WARNING ROUTINE.
1290 REM
1300 PRINT :
      PRINT "ENTER CURRENT BASAL AREA. ";
      INVERSE :
      PRINT "(";BASAL;")":
      NORMAL
1310 INPUT Z$:
      IF Z$ < > "" THEN
        LET BASAL = VAL (Z$):
        IF BASAL < 49 OR BASAL > 209 THEN
          GOSUB 5480:
          GOTO 1300:
          REM  CALL WARNING ROUTINE.
1320 REM
1330 PRINT :
      PRINT "ENTER SITE INDEX (BASE AGE 50). ";

```

[[FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #1
 PAGE-5

```

      INVERSE :
      PRINT "(";SITE;")":
      NORMAL
1340 INPUT Z$:
      IF Z$ ( ) "" THEN
        LET SITE = VAL (Z$):
        IF SITE < 49 OR SITE > 138 THEN
          GOSUB 5510:
          GOTO 1330:
          REM CALL WARNING ROUTINE.
1350 REM
1360 IF TR > 0 THEN
      GOTQ 1590:
      REM RETURN TO MAIN MENU FROM EDIT/REVIEW ROUTINE.
1370 REM
1380 HOME :
      VTAB 1
1390 REM
1400 PRINT "HOW MANY THINNINGS? (MAX 5)":
      INVERSE :
      PRINT "(";TN%;")":
      NORMAL
1410 INPUT Z$:
      IF Z$ ( ) "" THEN
        LET TN% = INT ( VAL (Z$))
1420 IF TN% < 0 OR TN% > 5 THEN
      GOSUB 5540:
      REM CALL ERROR ROUTINE.
1430 REM
1440 VTAB 4:
      IF TN% = 0 GOTO 1550
1450 REM
1460 FOR L = 1 TO TN%
1470 PRINT "ENTER YEAR AND RESIDUAL BASAL AREA FOR"
1480 PRINT "THIN NUMBER ":L;". SEPARATE YEAR AND BASAL"
1490 PRINT "AREA BY A COMMA. "":
      INVERSE :
      PRINT "(";YR(L);", ";RB(L);")":
      NORMAL :
      INPUT " ";Y$,Z$
1500 IF Y$ ( ) "" THEN
        LET YR(L) = VAL (Y$)
1510 IF Z$ ( ) "" THEN
        LET RB(L) = VAL (Z$)
1520 IF TN% < 5 THEN
      PRINT " "
1530 NEXT L
1540 REM
1550 HOME :
      VTAB 7:
      PRINT "ENTER YEAR OF FINAL HARVEST. "":
      INVERSE :
      PRINT "(";FH;")":
      NORMAL :
      INPUT " ";Z$:
      IF Z$ ( ) "" THEN
        LET FH = VAL (Z$)
1560 REM

```

J[FORMATTED LISTING

FILE: APPENDIX E. DOCUMENTATION FILE #1

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```

1570 VTAB 15:
      PRINT "STAND DATA INPUT PHASE COMPLETED ...."
1580 FOR PAUSE = 1 TO 500:
      NEXT PAUSE
1590 HOME
1600 REM
1610 REM *****
1620 REM ==>          MAIN MENU
1630 REM *****
1640 REM
1650 REM M = MENU ITEM NO.
1660 REM TR = TRIGGER TO ALLOW USER TO RETURN TO MENU.
1670 REM
1680 GOSUB 5600:
      REM DISPLAY MENU HEADING.
1690 PRINT TAB( 6)"1. EDIT INITIAL STAND CONDITIONS"
1700 PRINT TAB( 6)"2. EDIT HARVEST REGIME"
1710 PRINT TAB( 6)"3. ABORT RUN"
1720 PRINT TAB( 6)"4. CONTINUE"
1730 VTAB 17:
      GOSUB 5660:
      REM DISPLAYMENU # REQUEST.
1740 REM
1750 LET M = INT ( VAL (Z$)):
      IF M < 1 OR M > 4 THEN
          GOSUB 5630:
          REM CALL THE ERROR ROUTINE.
1760 LET TR = 1:
      HOME :
      ON M GOTO 1080,1380,5380,1770:
      REM SET MENU RETURN TRIGGER, BRANCH TO PROGRAM SEGMENT
      .
1770 LET TR = 0:
      LET X = FRE (0)
1780 REM
1790 REM *****
1800 REM ==>          GROWTH AND YIELD MODEL
1810 REM *****
1820 REM
1830 REM A1 = INITIAL AGE FOR PROJECTION MODELS.
1840 REM A2 = PROJECTED AGE FOR PROJECTION MODELS.
1850 REM B = INITIAL B.A. FOR PROJECTION MODELS.
1860 REM BT = INITIAL NO. TREES/AC.
1870 REM K = INDEX FOR COEFF. FOR TREES/AC. EQTN.
1880 REM N = INDEX FOR COEFF. FOR CU.FT./B.A. EQTN.
1890 REM T = TRIGGER TO CALCULATE NO. OF TREES/AC.
1900 REM Q = INDEX FOR COEFF. FOR % PEELERS EQTN.
1910 REM I1 = TRIGGER FOR BD.FT. VOL. CALCULATION.
1920 REM L = INDEX FOR NO. OF THINNING(S).
1930 REM
1940 REM THE GROWTH & YIELD MODEL CALCULATES STAND
1950 REM ATTRIBUTES FOR THE BEGINNING STAND,BEFORE
1960 REM AND AFTER EACH THINNING, AND BEFORE THE
1970 REM FINAL HARVEST. THE COEFFICIENTS FOR THE
1980 REM VARIOUS MODELS ARE SELECTED AS A FUNCTION
1990 REM OF THE TYPE OF CUT AND WHETHER IT IS
2000 REM BEFORE OR AFTER THE CUT.
2010 REM

```

11 FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #1
 PAGE-7

```

2020 REM
2030 REM ==> CALCULATE INITIAL STAND ATTRIBUTES.
2040 REM
2050 GOSUB 5580:
      LET A1 = AGE:
      LET A2 = AGE:
      LET B = BA:
      LET BT = 100000:
      LET K = 1:
      LET N = 1:
      LET L = 0:
      LET T = 1:
      LET I1 = 0:
      LET Q = 0:
      GOSUB 6020:
      REM CALL ROUTINE TO CALC. STAND ATTRIBUTES.
2060 IF TN% = 0 THEN
      GOTO 2110:
      REM IF THERE ARE NO THINS GOTO FINAL HARVEST.
2070 REM
2080 REM ==> CALC. AGE OF EACH CUT IN STAND.
2090 REM
2100 FOR L = 1 TO TN%:
      LET C(L) = AGE + YR(L) - YEAR:
    NEXT L:
      REM AGE(S) OF THINNING(S).
2110 LET FC = AGE + FH - YEAR:
      REM AGE OF THE FINAL HARVEST.
2120 LET A1 = AGE:
      LET BB = BA:
      REM SET AGE AND BASAL AREA FOR THE FIRST PROJECTION.
2130 REM
2140 REM ==> LOOP THROUGH EACH THINNING.
2150 REM
2160 IF TN% = 0 GOTO 2440:
      REM IF THERE ARE NO THINNINGS, CLEARCUT.
2170 FOR L = 1 TO TN%
2180   IF L = 1 GOTO 2200:
      REM SELECT SINGLE THIN COEFF.
2190   IF L > 1 GOTO 2320:
      REM SELECT COEFF. FOR 2 OR MORE THINS.
2200   LET A2 = C(1):
      LET K = 1:
      LET N = 1:
      LET T = 0:
      LET I1 = 0:
      LET Q = 0
2210   LET F = 0:
      REM RESET ERROR CONDITION.
2220   GOSUB 5750:
      IF B - RB(L) < 0 THEN
        GOSUB 5670:
        REM PROJECT B.A. IF RESID. B.A. EXCEEDS PROJEC
        T. B.A. CALL ERROR ROUTINE.
2230   IF F = 1 GOTO 2210:
      REM RECALC. AFTER ERROR.
2240   GOSUB 6020:
      REM CALC. STAND ATTRIBUTES BEFORE THIN.

```

JC FORMATTED LISTING

FILE: APPENDIX E. DOCUMENTATION FILE #1

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```

2250      REM
2260      LET K = 2:
      LET N = 1:
      LET I1 = 1:
      LET Q = 2:
      GOSUB 6050:
      REM  CALC. STAND ATTRIBUTES AFTER 1ST THIN.
2270      LET BA = B:
      LET A1 = A2:
      GOTO 2410:
      REM  PREPARE FOR THE NEXT GROWTH/YIELD PROJECTION.
2280      REM
2290      REM
2300      REM ==>GROWTH/YIELD PROJECTION FOR 2 / MORE THINS.
2310      REM
2320      LET A2 = C(L):
      LET N = 2:
      LET I1 = 0:
      LET Q = 1:
      IF L = 2 THEN
        LET N = 1:
        REM  SELECT PROPER EQTN. COEFF.
2330      IF L = 2 THEN
        LET K = 2
2340      IF L > 2 THEN
        LET K = 3
2350      LET F = 0:
      REM  RESET ERROR TRIGGER.
2360      GOSUB 5750:
      IF B - RB(L) < 0 THEN
        GOSUB 5670:
        REM  PROJECT B.A., TEST IF RESID. B.A. EXCEEDS
        PROJECT. B.A.
2370      IF F = 1 GOTO 2350
2380      GOSUB 6020:
      REM  CALC. STAND ATTRIBUTES BEFORE THIN.
2390      LET K = 3:
      LET I1 = 1:
      LET Q = 3:
      GOSUB 6050:
      REM  CALC. STAND ATTRIBUTES AFTER THIN.
2400      LET BA = B:
      LET A1 = A2:
      REM  PREPARE FOR NEXT GROWTH/YIELD PROJECTION.
2410      NEXT L
2420      REM
2430      REM ==>  YIELD PROJECTION FOR CLEARCUT.
2440      LET A2 = FC
2450      ON TN% GOTO 2470,2480,2480,2480,2480:
      REM  SELECT PROPER EQTN. COEFF.
2460      LET K = 1:
      LET N = 1:
      LET T = 0:
      LET I1 = 0:
      LET Q = 0:
      GOTO 2500
2470      LET K = 2:
      LET N = 1:

```

JI FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #1
 PAGE-9

```

      LET T = 0:
      LET I1 = 0:
      LET Q = 4:
      GOTO 2500
2480 LET K = 3:
      LET N = 2:
      LET T = 0:
      LET I1 = 0:
      LET Q = 4
2490 REM
2500 LET L = 6:
      GOSUB 5750:
      GOSUB 6020:
      REM PROJECT B.A.,CALC. STAND ATTRIBUTES BEFORE HARVEST.
2510 REM
2520 REM ==> CALCULATE VOLUMES REMOVED.
2530 REM
2540 IF TN% = 0 GOTO 2690
2550 FOR L = 1 TO TN%
2560   LET RE(L,11) = RE(L,4) - RE(L,9):
      REM   BD.FT. VOL. REMOVED.
2570   LET RE(L,12) = RE(L,5) - RE(L,10):
      REM   CORDS REMOVED.
2580   LET RE(L,13) = RE(L,11) / 450:
      REM   BD.FT. CORD EQUIVALENTS.
2590   LET RE(L,15) = RE(L,12) + RE(L,13):
      REM   TOTAL CORD EQUIV. REMOVED.
2600 NEXT L
2610 REM
2620 REM ==> ROUND OFF RESULTS.
2630 REM
2640 FOR L = 1 TO TN%
2650   FOR I = 1 TO 4:
      LET RE(L,I) = INT (RE(L,I) + 0.5):
    NEXT I
2660   FOR I = 6 TO 9:
      LET RE(L,I) = INT (RE(L,I) + 0.5):
    NEXT I
2670   LET RE(L,5) = INT (RE(L,5) * 10 + 0.5) / 10:
      LET RE(L,10) = INT (RE(L,10) * 10 + 0.5) / 10
2680 NEXT L
2690 FOR I = 1 TO 4:
      LET RE(6,I) = INT (RE(6,I) + 0.5):
      LET RE(0,I) = INT (RE(0,I) + 0.5):
    NEXT I
2700 LET RE(6,5) = INT (RE(6,5) * 10 + 0.5) / 10:
      LET RE(0,5) = INT (RE(0,5) * 10 + 0.5) / 10
2710 REM
2720 REM
2730 REM ==> DISPLAY GROWTH & YIELD RESULTS.
2740 REM
2750 NORMAL :
      HOME :
      LET X = FRE (0):
      LET BA = BB
2760 LET A$ = "INITIAL STAND: YEAR= ":
      LET B$ = "CURRENT VOLUME":
      LET L = 0:
  
```

11 FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #1
 PAGE-10

```

      LET X = YEAR:
      LET Y = AGE:
      GOSUB 6360:
      REM  DISPLAY INITIAL STAND ATTRIBUTES.
2770  REM
2780  IF TN% = 0 GOTO 2840
2790  FOR L = 1 TO TN%:
      REM  DISPLAY STAND ATTRIBUTES FOR EACH THIN.
2800  PRINT R$:
      GOSUB 6090:
      GOSUB 6130:
      REM  CALL HEADING & TABLE OUTPUT.
2810  NEXT L
2820  REM
2830  REM
2840  LET A$ = "FINAL HARVEST: YEAR= ":
      LET B$ = "BEFORE HARVEST":
      LET X = FH:
      LET Y = FC:
      LET L = 6:
      GOSUB 6360:
      REM  DISPLAY STAND ATTRIBUTES FOR FINAL HARVEST.
2850  REM
2860  REM *****
2870  REM ==>      MAIN MENU
2880  REM *****
2890  REM
2900  GOSUB 5600:
      REM  DISPLAY HEADING.
2910  PRINT TAB( 4)"1. EDIT INITIAL STAND CONDITIONS"
2920  PRINT TAB( 4)"2. EDIT HARVEST REGIME"
2930  PRINT TAB( 4)"3. LINE PRINT VOLUME TABLES"
2940  PRINT TAB( 4)"4. CONTINUE TO INVESTMENT ANALYSIS"
2950  PRINT TAB( 4)"5. ABORT RUN"
2960  VTAB 17:
      GOSUB 5660:
      REM  INPUT MENU NUMBER.
2970  LET M = INT ( VAL (Z$)):
      IF M < 1 OR M > 5 THEN
        GOSUB 5630:
        REM  IF ERROR, CALL ERROR ROUTINE.
2980  HOME :
      LET TR = 2
2990  ON M GOTO 1080,1380,3040,3550,5380:
      REM  BRANCH TO PROGRAM SEGMENT.
3000  REM
3010  REM *****
3020  REM ==>      PRINTED OUTPUT ROUTINE.
3030  REM *****
3040  VTAB 4:
      INPUT "ENTER PRINTER SLOT NUMBER.      ":Z$:
      LET SL = INT ( VAL (Z$))
3050  LET TR = 0:
      VTAB 6:
      PRINT "MAKE SURE PRINTER IS ON AND READY."
3060  INPUT "HIT (RETURN) TO BEGIN PRINTING.      ":Z$:
      HOME
3070  PR# SL:

```

[[FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #1
 PAGE-11

```

      PRINT X*"80N":
      REM CTRL I 80N
3080 LET G$ = "      ":
      LET T$ = G$ + G$
3090 FOR J = 1 TO 2:
      FOR I = 1 TO 80:
      PRINT "=";:
      NEXT I:
      PRINT :
      NEXT J
3100 PRINT TAB( 22)"THINNING ANALYSIS FOR YELLOW-POPLAR"
3110 FOR J = 1 TO 2:
      FOR I = 1 TO 80:
      PRINT "=";:
      NEXT I:
      PRINT :
      NEXT J
3120 PRINT "PREPARED BY: ";NAME$:
      PRINT "STAND NAME: ";SN$:
      PRINT
3130 PRINT "STAND DATA SUMMARY:":
      FOR I = 1 TO 18:
      PRINT "-";:
      NEXT I:
      PRINT
3140 PRINT "SITE INDEX= ";SITE;G$;"INITIAL AGE= ";AGE;G$;"INI
      TIAL B.A.= ";BB
3150 PRINT "BEGINNING YEAR OF ANALYSIS= ";YEAR;G$;"NUMBER OF
      THINS= ";TN%
3160 FOR I = 1 TO 3:
      PRINT :
      NEXT I
3170 PRINT TAB( 22)"VOLUMES BEFORE AND AFTER CUT (PER ACRE)"
3180 HTAB 18:
      FOR I = 1 TO 45:
      PRINT "=";:
      NEXT I:
      PRINT
3190 FOR I = 1 TO 80:
      PRINT "-";:
      NEXT I:
      PRINT
3200 PRINT T$;T$;"/";T$;T$;G$;"  /"
3210 PRINT T$;T$;"/";T$;" BEFORE ";T$;"/";T$;"AFTER"
3220 PRINT "  TYPE";G$;" STAND";"  /";T$;T$;G$;"  /"
3230 PRINT TAB( 3)"CUT YEAR AGE  / BA  NT  CV  BV
      NCD  / RBA RNT RCV  RBV  RNCD"
3240 FOR I = 1 TO 80:
      PRINT "=";:
      NEXT I:
      PRINT
3250 PRINT T$;T$;"/";T$;T$;G$;"  /"
3260 LET L = 0:
      LET B$ = "NONE ":
3270 LET P$(L,0) = STR$(AGE):
      LET P(L,0) = LEN (P$(L,0)):
      LET P$(L,11) = STR$(YE):

```

10 FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #1
 PAGE-12

```

      LET P(L,11) = LEN (P$(L,11)):
      GOSUB 6490
3280 IF TN% = 0 GOTO 3310
3290 FOR L = 1 TO TN%:
      LET B$ = "THIN "
3300   LET P$(L,0) = STR$ (C(L)):
      LET P(L,0) = LEN (P$(L,0)):
      LET P$(L,11) = STR$ (YR(L)):
      LET P(L,11) = LEN (P$(L,11)):
      GOSUB 6490:
    NEXT L
3310 LET L = 6:
      LET B$ = "HARV ":
      LET P$(6,0) = STR$ (FC):
      LET P(6,0) = LEN (P$(6,0)):
      LET P$(6,11) = STR$ (FH):
      LET P(6,11) = LEN (P$(6,11)):
      GOSUB 6490
3320 PRINT :
      PRINT "AVERAGE DIAMETER AND PERCENT PEELERS AT FINAL HAR
      VEST = ";RE(6,17);" IN., ";RE(6,19) * 100;"%":

3330 FOR I = 1 TO 80:
      PRINT "-";:
    NEXT I
3340 PRINT :
      PRINT :
      PRINT "BA = BASAL AREA IN SQ. FT. ";G$;"NT = NUMBER OF TR
      EES";G$;"CV = CU. FT. VOLUME":

3350 PRINT "BV = BD. FT. VOLUME, INTERNATIONAL 1/4 IN. ";G$;"N
      CD = NET CORD VOLUME";G$:
      PRINT "PREFIX R IN AFTER CUT INDICATES RESIDUAL."
3360 PRINT :
      PRINT :
      PRINT :
      FOR J = 1 TO 2:
        FOR I = 1 TO 80:
          PRINT "=";:
        NEXT I:
      NEXT J:
      PRINT :
      PRINT :
      PRINT
3370 PR# 0
3380 REM
3390 REM *****
3400 REM ==>      MAIN MENU
3410 REM *****
3420 REM
3430 GOSUB 5600:
      LET TR = 3:
      REM  DISPLAY MENU HEADING.
3440 VTAB 9:
      PRINT TAB( 4)"1. EDIT INITIAL STAND CONDITIONS"
3450 PRINT TAB( 4)"2. EDIT HARVEST REGIME"
3460 PRINT TAB( 4)"3. CONTINUE TO INVESTMENT ANALYSIS"
3470 PRINT TAB( 4)"4. ABORT RUN"
3480 VTAB 15:
  
```

[[FORMATTED LISTING
FILE: APPENDIX E. DOCUMENTATION FILE #1
PAGE-13

```
      GOSUB 5660
3490  LET M = INT ( VAL (Z$)):
      IF M < 1 OR M > 4 THEN
          GOSUB 5630
3500  HOME :
      ON M GOTO 1080,1380,3550,5380:
      REM  BRANCH TO PROGRAM SEGMENT.
```

11 FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
 PAGE-1

```

3510 REM
3520 REM *****
3530 REM      FINANCIAL ANALYSIS MODEL.
3540 REM *****
3542 REM
3543 REM      Y1      = YEARS IN ANALYSIS
3544 REM      E1-E4  = NO. OF ITEMS IN EACH TYPE OF EXP.
3545 REM      F1      = CODE FOR BEFORE/AFTER TAX ANAL.
3546 REM      L0      = INITIAL LAND VALUE
3547 REM      L1      = FUTURE LAND VALUE
3548 REM
3550 LET Y1 = FH - YEAR + 1:
      LET TR = 0:
      LET E1 = 0:
      LET E2 = 0:
      LET E3 = 0:
      LET E4 = 0:
      LET X = FRE (0):
      HOME :
      REM      INITIALIZE VARIABLES.
3552 REM
3553 REM      ==>      ENTER TAX TREATMENT
3554 REM
3560 VTAB 3:
      GOSUB 5390:
      INVERSE :
      PRINT "  FINANCIAL ANALYSIS OF HARVEST REGIME"; TAB( 41)
      :
      NORMAL :
      GOSUB 5390
      VTAB 9:
3570 INPUT "AFTER TAX TREATMENT DESIRED? Y/N ";Z$:
      PRINT :
      IF Z$ = "" THEN
          GOTO 3600
3580 IF LEFT$(Z$,1) = "Y" THEN
          LET F1 = 1
3590 IF LEFT$(Z$,1) = "N" THEN
          LET F1 = 2
3592 REM
3593 REM      ==>      ENTER LAND VALUE.
3594 REM
3600 HOME :
      GOSUB 6520:
      HOME :
      PRINT "ENTER CURRENT LAND VALUE. ";:
      INVERSE :
      PRINT "(<";L0;">";:
      NORMAL :
      INPUT " ";Z$:
      IF Z$ ( ) "" THEN
          LET L0 = VAL (Z$)
3602 REM
3603 REM      ==>      ENTER LAND APPRECIATION.
3604 REM      M9 = 1 + ANNUAL LAND APPREC.
3605 REM
3610 PRINT :

```

JC FORMATTED LISTING

FILE: APPENDIX E. DOCUMENTATION FILE #2

PAGE-2

```

        PRINT "ENTER RATE OF REAL PRICE APPRECIATION"
3620 PRINT "FOR LAND IN DECIMALS.  ";
        INVERSE :
        PRINT "("; (INT ((M9 - 1 + .005) * 100)) / 100; ")";
        NORMAL :
        INPUT " "; Z$:
        IF VAL (Z$) > 1 THEN
            GOSUB 6620:
            GOTO 3610:
        REM IF ENTRY ERROR, CALL ERROR ROUTINE.
3630 IF Z$ < > "" THEN
        LET M9 = VAL (Z$) + 1
3640 IF F1 = 2 THEN
        LET L1 = INT (L0 * M9 ^ (Y1 - 1) + .5)
3642 REM
3650 IF F1 = 1 GOTO 3770:
        REM IF AFT. TAX ANAL. GOTO AFT. TAX EXPENSES.
3652 REM
3653 REM ==> ENTER YEARLY REC. EXP.
3654 REM C1 = YEAR. REC. EXP.
3655 REM C6(I) = REC. EXP. IN YEAR (I).
3656 REM
3660 PRINT :
        PRINT "ENTER YEARLY RECURRING EXP.  ";
        INVERSE :
        PRINT "("; C1; ")";
        NORMAL :
        INPUT " "; Z$:
        IF Z$ = "" THEN
            FOR I = 2 TO Y1:
                LET C6(I) = C1:
            NEXT I:
            LET C6(1) = 0
3670 IF Z$ < > "" THEN
            LET C1 = VAL (Z$):
            FOR I = 2 TO Y1:
                LET C6(I) = C1:
            NEXT I:
            LET C6(1) = 0
3672 REM
3680 IF TR < > 4 OR E1 < > 0 THEN
            GOTO 3740:
            REM IF INITIAL INPUT OR NO ENTRY, BYPASS EDIT ROUTINE.
3682 REM
3683 REM ==> EDIT ROUTINE FOR NON-REC. EXP.
3684 REM E1(I,J) = ARRAY FOR EDITING NON-REC. EXP.
3685 REM
3690 FOR I = 1 TO E1:
        PRINT :
        PRINT "ENTER NON-RECURRING EXPENSE AND THE":
        PRINT "YEAR INCURRED.  ";
        INVERSE :
        PRINT "("; E1(I,0); ", "; E1(I,2); ")";
        NORMAL :
        INPUT " "; Y$, Z$:
        IF Z$ = "" THEN
            LET Y$ = STR$ (E1(I,0)):

```

]I FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
 PAGE-3

```

      LET Z$ = STR$ (E1(I,2))
3700   LET C = VAL (Y$):
      LET YZ = VAL (Z$):
      LET E1(I,2) = YZ
3710   LET Y = YZ - YEAR + 1:
      IF Y < = 0 THEN
        LET Y = E1(I,1)
3720   LET C2(Y) = C2(Y) + C:
      LET E1(I,0) = C:
      LET E1(I,1) = Y:

3730 NEXT I
3732 REM
3733 REM ==> ENTER NON. REC. EXPENSES.
3734 REM
3740 PRINT :
      PRINT "ENTER NON-RECURRING EXPENSE AND THE":
      PRINT "YEAR INCURRED.      ";
      INVERSE :
      PRINT "(0,0)";
      NORMAL :
      INPUT " ";Y$,Z$:
      IF Z$ = "" THEN
        GOTO 3770
3750 LET C = VAL (Y$):
      LET YZ = VAL (Z$):
      LET E1 = E1 + 1:
      LET E1(E1,2) = YZ
3760 IF C > 0 THEN
      LET Y = YZ - YEAR + 1:
      LET C2(Y) = C2(Y) + C:
      LET E1(E1,0) = C:
      LET E1(E1,1) = Y:
      GOTO 3740

3762 REM
3770 IF F1 = 2 THEN
      GOTO 4260:
      REM IF BEFORE TAX ANAL. SKIP AFT. TAX EXP. INPUT.

3772 REM
3773 REM ==> ENTER LAND AND TIMBER BASIS.
3774 REM LB = LAND BASIS
3775 REM TB = TIMBER BASIS
3776 REM
3780 PRINT :
      PRINT "ENTER LAND BASIS AND TIMBER BASIS.":
      INVERSE :
      PRINT "(";LB;"",";TB;"")";
      NORMAL :
      INPUT " ";Y$,Z$:
      IF Y$ < > "" THEN
        LET LB = VAL (Y$):
        LET TB = VAL (Z$)

3782 REM
3783 REM ==> ENTER YEARLY RE. ORDINARY EXP.
3784 REM C1 = YEAR. REC. ORD. EXP.
3785 REM C6(I) = REC. ORD. EXP. IN YEAR (I)
3786 REM
3790 PRINT :

```

JC FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
 PAGE-4

```

      PRINT "ENTER YEARLY RECUR. ORD. EXP. ";:
      INVERSE :
      PRINT "(";C1;")";:
      NORMAL :
      INPUT " ";Z$:
      IF Z$ = "" THEN
        FOR I = 2 TO Y1:
          LET C6(I) = C1:
        NEXT I:
      LET C6(1) = 0
3800 IF Z$ ( ) "" THEN
      LET C1 = VAL (Z$):
      FOR I = 2 TO Y1:
        LET C6(I) = C1:
      NEXT I:
      LET C6(1) = 0
3802 REM
3803 REM ==> EDIT ROUTINE, NON-REC. ORD. EXPENSES.
3804 REM E2(I,J) = ARRAY FOR EDITING NON-REC. EXP.
3805 REM C2(Y) = NON-REC. ORD. EXPENSES.
3806 REM
3810 IF TR ( ) 4 OR E2 ( ) = 0 THEN
      GOTO 3880:
      REM IF INITIAL INPUT OR NO EXPENSE ITEMS, BYPASS
      EDIT ROUTINE.
3820 FOR I = 1 TO E2:
      PRINT :
      PRINT "ENTER NON-RECURRING ORDINARY EXPENSE"
3830 PRINT "AND YEAR INCURRED. ";:
      INVERSE :
      PRINT "(";E2(I,0);",";E2(I,2);")";:
      NORMAL :
      INPUT " ";Y$,Z$:
      IF Y$ = "" THEN
        LET Y$ = STR$ (E2(I,0)):
        LET Z$ = STR$ (E2(I,2))
3840 LET C = VAL (Y$):
      LET YZ = VAL (Z$):
      LET E2(I,2) = YZ
3850 LET Y = YZ - YEAR + 1:
      IF Y ( ) = 0 THEN
        LET Y = E2(I,1)
3860 LET E2(I,0) = C:
      LET C2(Y) = C2(Y) + C:
      LET E2(I,1) = Y
3870 NEXT I
3872 REM
3873 REM ==> ENTER NON-RECURRING ORDINARY EXPENSES.
3874 REM
3880 PRINT :
      PRINT "ENTER NON-RECURRING ORDINARY EXPENSE"
3890 PRINT "AND YEAR INCURRED. ";:
      INVERSE :
      PRINT "(0,0)";:
      NORMAL :
      INPUT " ";Y$,Z$:
      IF Y$ = "" THEN
        GOTO 3920

```

J1 FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
 PAGE-5

```

3900 LET C = VAL (Y$):
    LET YZ = VAL (Z$):
    LET E2 = E2 + 1:
    LET E2(E2,2) = YZ
3910 IF C > 0 THEN
    LET Y = YZ - YEAR + 1:
    LET C2(Y) = C2(Y) + C:
    LET E2(E2,0) = C:
    LET E2(E2,1) = Y:
    GOTO 3880

3912 REM
3913 REM ==> EDIT DEPRECIABLE EXPENSES.
3914 REM E3(J,I) = ARRAY FOR EDITING DEPREC. EXP.
3915 REM C3(J,I) = DEPREC. EXPENSE J IN YEAR I.
3916 REM
3920 IF TR < > 4 OR E3 < = 0 THEN
    GOTO 4020
3930 FOR J = 1 TO E3:
    PRINT :
    PRINT "ENTER DEPRECIABLE CAPITAL EXPENSE AND"
    PRINT "YEAR INCURRED. " ;:
    INVERSE :
    PRINT "(" ; E3(J,3) ; "," ; E3(J,2) ; ")" ;:
    NORMAL :
    INPUT " " ; Y$, Z$:
    IF Y$ = "" THEN
        LET Y$ = STR$ (E3(J,3)):
        LET Z$ = STR$ (E3(J,2))
3950 LET C = VAL (Y$):
    LET YZ = VAL (Z$):
    LET E3(J,2) = YZ
3960 LET Y = YZ - YEAR + 1:
    IF Y < = 0 THEN
        LET Y = E3(J,1)
3970 LET C3(E3(J,0),Y) = C:
    LET E3(J,3) = C:
    LET E3(J,1) = Y
3972 REM
3973 REM ==> EDIT DEPREC. LENGTH & SALVAGE VALUE.
3974 REM C7(I,Y) = DEPREC. LENGTH FOR EXP I IN YEAR Y.
3975 REM C8(I,Y) = SALVAGE FOR EXP. I IN YEAR Y.
3976 REM
3980 PRINT :
    PRINT "ENTER LENGTH OF DEPRECIATION PERIOD"
    PRINT "AND SALVAGE VALUE. " ;:
    INVERSE :
    PRINT "(" ; E3(J,4) ; "," ; E3(J,5) ; ")" ;:
    NORMAL :
    INPUT " " ; Y$, Z$:
    IF Y$ = "" THEN
        LET Y$ = STR$ (E3(J,4)):
        LET Z$ = STR$ (E3(J,5))
4000 LET G = VAL (Z$):
    LET E3(J,5) = G:
    LET C8(E3(J,0),Y) = G:
    LET N = VAL (Y$):
    LET E3(J,4) = N:
    LET C7(E3(J,0),Y) = N:
  
```

JIC FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
 PAGE-6

```

4010 NEXT J
4012 REM
4013 REM ==> INPUT DEPRECIABLE EXPENSE.
4014 REM
4020 PRINT :
      PRINT "ENTER DEPRECIABLE CAPITAL EXPENSE AND"
4030 PRINT "YEAR INCURRED. ";;
      INVERSE :
      PRINT "(0,0)";
      NORMAL :
      INPUT " ";Y$,Z$:
      IF Y$ = "" THEN
        GOTO 4160
4040 LET C = VAL (Y$):
      LET YZ = VAL (Z$):
      IF C = 0 GOTO 4220
4050 LET I = 0:
      LET Y = YZ - YEAR + 1
4060 IF C3(I,Y) < 0 THEN
      LET I = I + 1:
      IF I = 3 GOTO 4140
4070 IF C3(I,Y) = 0 GOTO 4090
4080 GOTO 4060
4090 LET C3(I,Y) = C:
      LET E3 = E3 + 1:
      LET E3(E3,0) = I:
      LET E3(E3,1) = Y:
      LET E3(E3,2) = YZ:
      LET E3(E3,3) = C
4092 REM
4093 REM ==> ENTER DEPREC. PERIOD & SALVAGE.
4094 REM
4100 PRINT :
      PRINT "ENTER LENGTH OF DEPRECIATION PERIOD"
4110 PRINT "AND SALVAGE VALUE. ";;
      INVERSE :
      PRINT "(0,0)";
      NORMAL :
      INPUT " ";Y$,Z$:
      IF Y$ = "" THEN
        GOTO 4160
4120 LET N = VAL (Y$):
      LET G = VAL (Z$):
      LET C7(I,Y) = N:
      LET C8(I,Y) = G:
      LET E3(E3,4) = N:
      LET E3(E3,5) = G:
      IF I = 2 THEN
        GOTO 4140
4130 GOTO 4020
4140 PRINT "ONLY THREE DEPRECIABLE CAPITAL EXPENSES ALLOWED P
      ER YEAR. ";;
      FOR PAUSE = 1 TO 600:
      NEXT PAUSE:
      GOTO 4020
4152 REM
4153 REM ==> EDIT DEPLETABLE EXPENSES.
  
```

J1 FORMATTED LISTING

FILE: APPENDIX E. DOCUMENTATION FILE #2

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```

4154 REM E4(I,J) = ARRAY FOR EDITING DEPLET. EXP.
4155 REM C4(Y) = DEPLETABLE EXP. IN YEAR Y.
4156 REM
4160 IF TR < > 4 OR E4 < = 0 THEN
      GOTO 4220
4170 FOR I = 1 TO E4:
      PRINT :
      PRINT "ENTER DEPLETABLE EXPENSE AND":
      PRINT "YEAR INCURRED.      ";:
      INVERSE :
      PRINT "(";E4(I,0);",",";E4(I,2);")";:
      NORMAL :
      INPUT " ";Y$,Z$:
      IF Y$ = "" THEN
        LET Y$ = STR$ (E4(I,0)):
        LET Z$ = STR$ (E4(I,2))
4180 LET C = VAL (Y$):
      LET YZ = VAL (Z$):
      LET E4(I,2) = YZ
4190 LET Y = YZ - YEAR + 1:
      IF Y < = 0 THEN
        LET Y = E4(I,1)
4200 LET C4(Y) = C4(Y) + C:
      LET E4(I,0) = C:
      LET E4(I,1) = Y
4210 NEXT I
4212 REM
4213 REM ==> ENTER DEPLETABLE EXPENSE.
4214 REM
4220 PRINT :
      PRINT "ENTER DEPLETABLE EXPENSE AND"
4230 PRINT "YEAR INCURRED.      ";:
      INVERSE :
      PRINT "(0,0)";:
      NORMAL :
      INPUT " ";Y$,Z$:
      IF Y$ = "" THEN
        GOTO 4260
4240 LET C = VAL (Y$):
      LET YZ = VAL (Z$):
      LET E4 = E4 + 1:
      LET E4(E4,2) = YZ
4250 IF C > 0 THEN
      LET Y = YZ - YEAR + 1:
      LET C4(Y) = C4(Y) + C:
      LET E4(E4,0) = C:
      LET E4(E4,1) = Y:
      GOTO 4220
4252 REM
4260 HOME :
      IF TR = 4 GOTO 4620:
      REM RETURN TO MAIN MENU.
4262 REM
4263 REM ==> ENTER STUMPAGE PRICES.
4264 REM P1 = PRICE FOR PULP.
4265 REM P2 = PRICE FOR SAWLOGS.
4266 REM P3 = PRICE FOR PEELERS.
4267 REM

```

JC FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

4270 VTAB 3:
      PRINT "ENTER PRICE/CORD FOR PULPWOOD, PRICE/MBF"
4280 PRINT "FOR SAWLOGS, AND PRICE/MBF FOR PEELERS.":
      INVERSE :
      PRINT "(:;P1",":;P2:",":;P3;")":;
      NORMAL :
      INPUT " ";Y$,Z$,T$:
      IF Y$ ( ) "" THEN
        LET P1 = VAL (Y$):
        LET X = FRE (0)
4290 IF ( NOT (Z$ = "")) THEN
        LET P2 = VAL (Z$)
4300 IF T$ ( ) "" THEN
        LET P3 = VAL (T$)
4302 REM
4303 REM ==> ENTER % PRICE FOR THINNED MATERIAL.
4304 REM TP = PRICE ADJUSTMENT FOR THINNINGS.
4305 REM
4310 PRINT :
      PRINT "ENTER AS A DECIMAL THE PRICE ADJUSTMENT":
      PRINT "FOR THINNED MATERIAL AS A PERCENTAGE OF"
4320 PRINT "FINAL HARVEST STUMPAGE VALUES. ":;
      INVERSE :
      PRINT "(:;TP;")":;
      NORMAL :
      INPUT " ";Z$:
      IF Z$ ( ) "" THEN
        LET TP = VAL (Z$)
4330 IF TP > 1 THEN
        GOSUB 6620:
        GOTO 4310:
        REM IF DATA ENTRY ERROR, CALL ERROR ROUTINE.
4332 REM
4333 REM ==> ENTER PRICE APPRECIATIONS.
4334 REM M3 = APPREC. FOR PULP.
4335 REM M4 = APPREC. FOR SAWLOGS.
4336 REM M5 = APPREC. FOR PEELERS.
4337 REM
4340 PRINT :
      PRINT "ENTER THE REAL PRICE APPRECIATION RATES"
4350 PRINT "AS DECIMALS FOR PULPWOOD,SAWLOGS,"
4360 PRINT "AND PEELERS RESPECTIVELY.":;
      INVERSE :
      PRINT "(:;( INT ((M3 - 1 + .005) * 100)) / 100;".";(
        INT ((M4 - 1 + .005) * 100)) / 100;","; ( INT ((M5 - 1
        + .005) * 100)) / 100;")":;
      NORMAL :
      INPUT " ";Y$,Z$,T$:
4370 IF VAL (Y$) > 1 OR VAL (Z$) > 1 THEN
        GOSUB 6620:
        GOTO 4340
4380 IF Z$ ( ) "" THEN
        LET M4 = VAL (Z$) + 1
4390 IF Y$ ( ) "" THEN
        LET M3 = VAL (Y$) + 1
4400 IF T$ ( ) "" THEN
        LET M5 = VAL (T$) + 1
4410 IF F1 = 1 THEN

```

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 FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

      GOTO 4460:
      REM IF AFTER TAX, SKIP TO AFT. TAX DATA ENTRY.
4412 REM
4413 REM ==> ENTER DISCOUNT RATE (BEFORE TAX).
4414 REM D0 = BEFORE TAX DISCOUNT RATE.
4415 REM D2 = 1 + DISCOUNT RATE.
4416 REM
4420 PRINT :
      PRINT "ENTER REAL DISCOUNT RATE AS A":
      PRINT "DECIMAL.          ";:
      INVERSE :
      PRINT "("";D0;")";:
      NORMAL :
      INPUT " ";Z$:

4430 IF VAL (Z$) > 1 THEN
      GOSUB 6620:
      GOTO 4420:
      REM IF DATA ENTRY ERROR, CALL ERROR ROUTINE.
4440 IF Z$ ( ) "" THEN
      LET D0 = VAL (Z$):
      LET D2 = D0 + 1
4442 REM
4450 HOME :
      IF F1 = 2 GOTO 4620:
      REM IF BEFORE TAX, SKIP AFT. TAX DATA ENTRY.
4452 REM
4453 REM ==> ENTER DISCOUNT RATE.
4454 REM D0 = AFT. TAX DISCOUNT RATE.
4455 REM D1 = 1 + DISC. RATE.
4456 REM
4460 PRINT :
      PRINT "ENTER REAL DISCOUNT RATE AS A":
      PRINT "DECIMAL.          ";:
      INVERSE :
      PRINT "("";D0;")";:
      NORMAL :
      INPUT " ";Z$
4470 IF VAL (Z$) > 1 THEN
      GOSUB 6620:
      GOTO 4460:
      REM IF DATA ENTRY ERROR, CALL ERROR ROUTINE.
4480 IF Z$ ( ) "" THEN
      LET D0 = VAL (Z$):
      LET D1 = D0 + 1
4482 REM
4483 REM ==> ENTER MARGINAL TAX RATE.
4484 REM M1 = 1 - MARGINAL TAX RATE.
4485 REM
4490 LET M1 = ( INT ((M1 + .005) * 100) ) / 100:

4500 PRINT :
      PRINT "ENTER MARGINAL TAX RATE AS A ":
      PRINT "DECIMAL.          ";:
      INVERSE :
      PRINT "("";1 - M1;")";:
      NORMAL :
      INPUT " ";Z$

```

JI FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

4510 IF VAL (Z$) > 1 THEN
      GOSUB 6620:
      GOTO 4500
4520 IF Z$ ( ) "" THEN
      LET M1 = 1 - VAL (Z$)
4522 REM
4523 REM ==> ENTER INFLATION RATE.
4524 REM M2 = 1 + INFLATION RATE.
4525 REM
4530 PRINT :
      PRINT "ENTER THE INFLATION RATE AS A "
4540 PRINT "DECIMAL. ";:
      INVERSE :
      PRINT "("; (INT ((M2 - 1 + .005) * 100)) / 100; ")"::
      NORMAL :
      INPUT " ";Z$
4550 IF VAL (Z$) > 1 THEN
      GOSUB 6620:
      GOTO 4530
4560 IF Z$ ( ) "" THEN
      LET M2 = VAL (Z$) + 1
4570 LET D2 = D1 * M2:
      REM CALC. CURRENT INTEREST RATE.
4572 REM
4573 REM ==> ENTER CAPITAL GAINS TAX RATE.
4574 REM M0 = 1 - CAP. GAINS TAX RATE.
4575 REM
4580 PRINT :
      PRINT "ENTER CAPITAL GAINS TAX RATE AS A "
4590 PRINT "DECIMAL. ";:
      INVERSE :
      PRINT "("; 1 - M0; ")"::
      NORMAL :
      INPUT " ";Z$:
      IF VAL (Z$) > 1 THEN
        GOSUB 6620:
        GOTO 4580
4600 IF Z$ ( ) "" THEN
      LET M0 = 1 - VAL (Z$)
4602 REM
4603 REM *****
4604 REM ==> MAIN MENU
4605 REM *****
4606 REM
4610 IF TR = 4 THEN
      GOSUB 7880:
      REM CLEAR ARRAYS.
4620 HOME :
      LET TR = 4:
      GOSUB 5600:
      REM DISPLAY HEADING.
4630 PRINT TAB( 6)"1. CHANGE TAX TREATMENT "
4640 PRINT TAB( 6)"2. EDIT COST DATA"
4650 PRINT TAB( 6)"3. EDIT STUMPAGE PRICES AND
4660 PRINT TAB( 9)"INTEREST RATES "
4670 PRINT TAB( 6)"4. DISPLAY CASH FLOW TABLES"
4680 PRINT TAB( 6)"5. CALCULATE INVESTMENT CRITERIA"
4690 PRINT TAB( 6)"6. EDIT INITIAL STAND CONDITIONS"

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J1 FORMATTED LISTING

FILE: APPENDIX E. DOCUMENTATION FILE #2
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4700 PRINT TAB( 6)"7. EDIT HARVEST REGIME"
4710 PRINT TAB( 6)"8. BEGIN A NEW RUN"
4720 PRINT TAB( 6)"9. STOP ANALYSIS"
4730 VTAB 22:
      GOSUB 5660:
      IF VAL (Z$) < 1 OR VAL (Z$) > 9 THEN
        GOSUB 5630:
        GOTO 4750:
      REM INPUT MENU ITEM, TEST FOR ERROR, CORRECT ERROR.
4740 LET M = INT ( VAL (Z$))
4750 HOME :
      ON M GOTO 4760, 3600, 4270, 4780, 4770, 1080, 1380, 800, 5380
4760 LET TR = 3:
      GOTO 3560
4770 LET TR = 3:
      GOTO 4780
4780 IF F1 = 1 THEN
      GOSUB 7800:
      REM CLEAR ARRAYS.
4782 REM
4783 REM ==> CALC. LAND AND TIMBER HOLDING COSTS.
4784 REM TR(0) = TIMBER VALUE AT YEAR (0).
4785 REM OL = LAND HOLDING COST.
4786 REM TB = TIMBER BASIS.
4787 REM LB = LAND BASIS.
4788 REM
4790 LET YI = 0:
      GOSUB 6810:
      LET TR(0) = INT (RE(0,5) * P1 + (RE(0,4) / 1000) * P6
        + .5):
      LET OL = L0:
      IF F1 = 1 THEN
        LET TR(0) = INT ((TR(0) - TB) * M0 + TB + .5):
        LET OL = INT ((L0 - LB) * M0 + LB + .5)
4792 REM
4793 REM ==> CALC. REVENUES FROM THINS.
4794 REM TY(L) = NO. OF YEARS THIN IS FROM YEAR 0.
4795 REM TR(L) = REVENUE FROM THIN (L).
4796 REM P6 = PRICE FOR SAWTIMBER.
4797 REM
4800 IF TN% = 0 GOTO 4850
4810 FOR L = 1 TO TN%
4820 LET TY(L) = YR(L) - YEAR
4830 LET YI = TY(L):
      GOSUB 6810:
      LET TR(L) = RE(L,12) * (P1 * M3 ^ TY(L) * TP) + RE(L
        ,11) / 1000 * P6 * TP:
      LET TR(L) = INT (TR(L) + .5)
4840 NEXT L
4842 REM
4843 REM ==> CALC. REVENUES FROM FINAL HARVEST.
4844 REM TR(6) = REVENUE FROM FINAL HARVEST.
4845 REM
4850 LET FY = FH - YEAR
4860 LET YI = FY:
      GOSUB 6810:
      LET TR(6) = RE(6,5) * (P1 * M3 ^ FY) + (RE(6,4) / 1000)
        * P6:

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11 FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

      LET TR(6) = INT (TR(6) + .5)
4862 REM
4863 REM ==> CALCULATE AFTER TAX CASH FLOWS.
4864 REM
4870 LET D2 = D0 + 1:
      IF F1 = 1 THEN
        LET D2 = D1 * M2:
        GOSUB 6820
4872 REM
4873 REM ==> LOAD CASH INFLOW ARRAY, R8(I).
4874 REM
4880 IF TN% > 0 THEN
      FOR L = 1 TO TN%:
        LET R8(YR(L) - YEAR + 1) = TR(L):
      NEXT L
4890 LET R8(FH - YEAR + 1) = TR(6) + L1
4892 REM
4893 REM ==> LOAD CASH OUTFLOW ARRAY, AFTER TAX.
4894 REM C5(I) = CASH OUTFLOW FOR YEAR I.
4895 REM
4900 IF F1 = 1 THEN
      FOR I = 1 TO Y1:
        LET W(I) = 0:
        FOR J = 0 TO 2:
          LET W(I) = W(I) + C3(J, I):
        NEXT J:
        LET C5(I) = ( INT ((C6(I) + C2(I) + C4(I) + W(I) + .
          05) * 10)) / 10:
      NEXT I:
      LET C5(1) = C5(1) + OL + TR(0)
4902 REM
4903 REM ==>LOAD CASH OUTFLOW ARRAY,BEFORE TAX.
4904 REM C5(I) = CASH OUTFLOW FOR YEAR I.
4905 REM C9(I) = NET CASH FLOW FOR YEAR I.
4906 REM
4910 IF F1 = 2 THEN
      LET C2(1) = C2(1):
      FOR I = 1 TO Y1:
        LET C5(I) = C5(I) + C2(I):
      NEXT I:
      LET C5(1) = C5(1) + OL + TR(0)
4920 FOR I = 1 TO Y1:
      LET C9(I) = R8(I) - C5(I):
    NEXT I
4922 REM
4923 REM ==> SET COLUMN HEADINGS.
4924 REM
4930 IF TR = 3 THEN
      GOTO 5330
4940 LET P$(2,1) = "CASH FLOW BEFORE TAX"
4950 LET P$(2,2) = "CASH FLOW AFTER TAX":
      LET C5(1) = C5(1) - OL - TR(0)
4960 IF F1 = 2 THEN
      GOTO 5120
4970 LET P$(2,10) = "--- DIRECT EXPENSES ---"
4980 LET P$(2,3) = " / ORDINARY / CAPITAL /"
4990 LET P$(2,11) = "YEAR /RECUR NONREC /DEPRECDPL / TOTAL"
5000 LET P$(2,4) = "=====/"

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]I FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

5002 REM
5003 REM *****
5004 REM ==> DISPLAY CASH FLOW TABLES.
5005 REM *****
5006 REM
5007 REM ==> AFT. TAX. EXP. TABLE.
5008 REM
5010 PRINT R$:
      HOME :
      GOSUB 6700:
      GOSUB 6750:
      REM  DISPLAY TABLE HEADING.
5020 LET I1 = 0
5030 FOR I = 1 TO Y1
5040   LET Y = YEAR + I - 1
5050   FOR J = 1 TO 5:
      LET P$(1,J) = "":
    NEXT J
5060   LET P$(1,1) = STR$(C5(I)):
      LET P$(1,2) = STR$(C2(I)):
      LET P$(1,3) = STR$(W(I)):
      LET P$(1,4) = STR$(C4(I)):
      LET P$(1,5) = STR$(C5(I)):
      LET X = FRE (0)
5070   LET P(1,1) = LEN (P$(1,1)):
      LET P(1,2) = LEN (P$(1,2)):
      LET P(1,3) = LEN (P$(1,3)):
      LET P(1,4) = LEN (P$(1,4)):
      LET P(1,5) = LEN (P$(1,5))
5080   PRINT TAB( 1)Y; TAB( 6);"/"; TAB( 11 - P(1,1));P$(1
,1); TAB( 19 - P(1,2));P$(1,2); TAB( 31);"/"; TAB( 2
7 - P(1,3));P$(1,3); TAB( 32 - P(1,4));P$(1,4);
      TAB( 33);"/"; TAB( 40 - P(1,5));P$(1,5)
5090   LET I1 = I1 + 1:
      IF I1 <= 11 THEN
        GOTO 5110
5100   VTAB 24:
      GOSUB 7870:
      HOME :
      LET I1 = 0:
      HOME :
      PRINT R$:
      GOSUB 6700:
      GOSUB 6750
5110   NEXT I:
      VTAB 24:
      GOSUB 7870:
      HOME
5120   LET P$(4,0) = " LAND/TIMBER HOLDING COSTS ":
      LET X = FRE (0):
      PRINT R$:
      HOME :
      GOSUB 6700:
      IF F1 = 2 THEN
        LET OL = L0:
        LET P$(4,4) = "A"
5122 REM
5123 REM ==> DISPLAY LAND/TIMBER HOLDING COST TABLE.

```

10 FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

5124 REM
5130 IF F1 = 1 THEN
      LET P$(4,4) = "A NON-TAX"
5140 VTAB 7:
      HTAB 5:
      PRINT "----";P$(4,0);"----":
      VTAB 10:
      PRINT TAB( 7);"CURRENT TIMBER VALUE = ";TR(0):
      PRINT TAB( 7);"CURRENT LAND VALUE   = ";OL:
      VTAB 12:
      HTAB 6:
      FOR I = 1 TO 28:
          PRINT "-";:
      NEXT I:
      PRINT " "
5150 PRINT TAB( 7);"TOTAL STAND VALUE     = ";OL + TR(0):
      VTAB 17:
      PRINT "$";OL + TR(0);" HAS BEEN ENTERED IN YEAR ";YE;" A
      S " :
      PRINT P$(4,4);" COST OF HOLDING LAND AND":
      PRINT "TIMBER.":
      VTAB 24:
      GOSUB 7870
5152 REM
5153 REM ==> DISPLAY REVENUES FROM CUTS TABLE.
5154 REM
5160 LET P$(2,5) = "---- REVENUES ----":
      PRINT R$:
      HOME
5170 GOSUB 6700:
      GOSUB 6770
5180 IF TN% = 0 GOTO 5210
5190 FOR L = 1 TO TN%
      PRINT YR(L); TAB( 15);TR(L):
5200 NEXT L
5210 PRINT FH; TAB( 16);TR(6); TAB( 32);L1
5220 VTAB 24:
      GOSUB 7870
5222 REM
5223 REM ==> DISPLAY NET CASH FLOW TABLE.
5224 REM
5230 LET P$(3,1) = "---- NET CASH FLOWS ----":
      LET C5(1) = C5(1) + OL + TR(0)
5240 LET P$(3,2) = "YEAR      IN      OUT      TOTAL"
5250 PRINT R$:
      HOME :
      GOSUB 6700:
      GOSUB 6790
5260 LET I1 = 0:
      FOR I = 1 TO Y1:
          LET Y = I - 1 + YEAR
5270 PRINT Y; TAB( 11);R9(I); TAB( 21);C5(I); TAB( 31);C9
          (I)
5280 LET I1 = I1 + 1:
          IF I1 < = 11 THEN
              GOTO 5310
5290 VTAB 24:
      GOSUB 7870:

```

J1 FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

      HOME :
      LET I1 = 0
5300  HOME :
      PRINT R$:
      GOSUB 6700:
      GOSUB 6790
5310  NEXT I:
      VTAB 24:
      GOSUB 7970
5320  IF TR = 4 THEN
      GOTO 4620
5322  REM
5323  REM ==> BEGIN CRITERIA CALCULATION & OUTPUT.
5324  REM
5330  HOME :
      VTAB 10:
      HTAB 4:
      FLASH :
      PRINT "CALCULATING INVESTMENT CRITERIA"
5340  LET D2 = D0 + 1:
      IF F1 = 1 THEN
      LET D2 = D1 * M2:
      REM RESET INTEREST RATES.
5350  GOSUB 7150:
      LET PNW = NPV:
      GOSUB 7170:
      REM CALL ROUTINES TO CALC. PNW & IRR.
5360  NORMAL :
      HOME
5370  GOSUB 7360:
      HOME :
      GOTO 4620:
      REM CALL OUTPUT ROUTINE FOR FINANCIAL ANALYSIS.
5372  REM
5373  REM
5380  HOME :
      STOP :
      REM *** END OF MAIN PROGRAM ***
5382  REM
5393  REM *****
5394  REM ==> SUBROUTINES
5395  REM *****
5396  REM
5397  REM ==> PRINT HORIZONTAL LINE(40 CHARACTERS).
5398  REM
5399  FOR I = 1 TO 40:
      PRINT "=";:
      NEXT I
5400  RETURN
5402  REM
5403  REM ==> BLANK OUT WARNING/ERROR MESSAGES.
5404  REM
5410  FOR I = 21 TO 24
5420  VTAB (I):
      FOR J = 1 TO 40:
      PRINT " ";:
      NEXT J
5430  NEXT I

```

11 FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

5440 RETURN
5442 REM
5443 REM ==> WARNING MESSAGE FOR AGE.
5444 REM
5450 PRINT R*;;
PRINT :
PRINT "WARNING-- ";AGE;" IS OUTSIDE THE RANGE OF "
5460 PRINT "THE DATA. MIN= 17 MAX= 76 ":
PRINT :
GOSUB 7870:

5470 RETURN
5472 REM
5473 REM ==> WARNING MESS. FOR BASAL AREA.
5474 REM
5480 PRINT R*;;
PRINT :
PRINT "WARNING-- ";BASAL;" IS OUTSIDE THE RANGE OF "
5490 PRINT "THE DATA. MIN= 49 MAX= 209":
PRINT :
GOSUB 7870

5500 RETURN
5502 REM
5503 REM ==> WARNING MESS. FOR SITE INDEX.
5504 REM
5510 PRINT R*;;
PRINT :
PRINT "WARNING-- ";SITE;" IS OUTSIDE THE RANGE OF "
5520 PRINT "THE DATA. MIN= 74 MAX= 138":
PRINT :
GOSUB 7870

5530 RETURN
5532 REM
5533 REM ==> ERROR MESSAGE FOR INC. OF THINS.
5534 REM
5540 PRINT R*:
PRINT R*:
VTAB 2:
5550 PRINT "*** ERROR ** ";I*;" IS NOT A VALID NUMBER"
5560 INPUT "OF THINS. RE-ENTER NUMBER OF THINS. ";INX:
GOSUB 5410

5570 RETURN
5572 REM
5573 REM ==> "CALCULATING VOLUMES" FLASHED.
5574 REM
5580 HOME :
FLASH :
VTAB 8:
HTAB 10:
PRINT "CALCULATING VOLUMES"
5590 RETURN
5592 REM
5593 REM ==> MAIN MENU PAGE HEADING.
5594 REM
5600 HOME :
VTAB 2:
FOR I = 1 TO 40:
PRINT "=";;

```

11 FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

      NEXT I
5610  INVERSE :
      PRINT TAB( 1); TAB( 5)"** THINNING ANALYSIS FOR Y-2 **"
      ; TAB( 41):
      PRINT TAB( 1); TAB( 15);"MAIN MENU"; TAB( 41):
      NORMAL :
      FOR I = 1 TO 40:
        PRINT "=";:
      NEXT I:
      VTAB 8
5620  RETURN
5622  REM
5623  REM ==> ERROR MESS. FOR MENU.
5624  REM
5630  PRINT R$:
      PRINT R$:
      VTAB 21
5640  PRINT Z$;:
      INPUT " IS NOT A VALID MENU NUMBER. RE-ENTER ";M:
      GOSUB 5410
5650  RETURN
5652  REM
5653  REM ==> INPUT MENU NUMBER.
5654  REM
5660  :
      INPUT "      ENTER A MENU NUMBER.      ";Z$:
      RETURN
5662  REM
5663  REM ==> INFEASIBLE THIN ERROR MESSAGE.
5664  REM
5670  NORMAL :
      PRINT R$:
      PRINT R$:
      VTAB 4
5680  LET Z = INT (8 + 0.5)
5690  PRINT "** ERROR ** THIN #";L;" IS NOT FEASIBLE."
5700  PRINT "ONLY ";Z;" SQ.FT. OF BASAL AREA EXIST IN"
5710  PRINT YR(L);". YOU SPECIFIED A RESIDUAL BASAL "
5720  PRINT "AREA OF ";RB(L);". RE-ENTER RESIDUAL "
5730  INPUT "BASAL AREA FOR THIS THIN.      ";RB(L):
      LET F = 1:
      GOSUB 5580
5740  RETURN
5742  REM
5743  REM ==> BASAL AREA PROJ. EQTN. (KNOEBEL 1982)
5744  REM
5750  LET B = EXP (A1 / A2 * LOG (BA) + CF(5,N) / CF(4,N) *
      (1 - A1 / A2) + CF(6,N) / CF(4,N) * SI * (1 - A1 / A2))
5760  RETURN
5762  REM
5763  REM ==> CU.FT. PROJ. EQTN. (KNOEBEL 1982).
5764  REM
5770  LET CV = EXP (CF(1,N) + CF(2,N) / SI + CF(3,N) / A2 + C
      F(4,N) * (A1 / A2) * LOG (BA) + CF(5,N) * (1 - A1 / A2)
      + CF(6,N) * SI * (1 - A1 / A2))
5780  RETURN
5782  REM
5783  REM ==> BD.FT. CONVERSION EQTN. (KNOEBEL 1982).

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FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

5784 REM
5790 LET BV = BF(1) + BF(2) * B + BF(3) * CV:
      IF I1 = 1 THEN
        IF BV > RE(L,4) THEN
          LET BV = RE(L,4)
5800 IF BV < 100 THEN
      LET BV = 0
5810 RETURN
5812 REM
5813 REM ==> NO. TREES PROJ. EQTN. (KNOEBEL 1982).
5814 REM
5820 LET NT = EXP (T1(1,K) + T1(2,K) / A2 + T1(3,K) * SI + T
      1(4,K) / 9)
5830 IF BT < NT THEN
      LET NT = BT
5840 LET BT = NT
5850 RETURN
5852 REM
5853 REM ==> QUADRATIC MEAN DIAMETER
5854 REM
5860 LET D = SQR ((B / NT) / .005454)
5870 LET D = ( INT ((D + .5) * 10) ) / 10
5880 RETURN
5882 REM
5883 REM ==> CORD VOL. CONVERSION EQTN.
5884 REM
5890 LET CD = CV / (TC(1) + TC(2) * D)
5900 LET NC = CD - BV / 450.0:
      IF NC < 0 THEN
        LET NC = 0
5910 RETURN
5912 REM
5913 REM ==> CU. FT. VOL. REMOVED FROM THIN.
5914 REM
5920 LET R = CV * ((B - RB(L)) / B) ^ RM
5930 RETURN
5932 REM
5933 REM ==> PROPORTION OF SAWTIMBER VOLUME
5934 REM == CONSISTING OF PEELERS.
5935 REM
5940 LET PP = PP(0,Q) + PP(1,Q) * D:
      IF PP < 0 THEN
        LET PP = 0.0
5950 IF PP > 1 THEN
        LET PP = 1
5960 LET PP = ( INT ((PP + .005) * 1000) ) / 1000:
      IF PP < .01 THEN
        LET PP = 0.0
5970 RETURN
5972 REM
5973 REM ==> RECORD STAND ATTRIBUTES BEFORE THIN.
5974 REM
5980 LET RE(L,1) = B:
      LET RE(L,2) = NT:
      LET RE(L,3) = CV:
      LET RE(L,4) = BV:
      LET RE(L,5) = NC:
      LET RE(L,14) = CD:

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II FORMATTED LISTING

FILE: APPENDIX E. DOCUMENTATION FILE #2

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```

        LET RE(L,17) = D:
        LET RE(L,19) = PP
5990  RETURN
5992  REM
5993  REM ==> RECORD STAND ATTRIB. AFTER THIN.
5994  REM
6000  LET RE(L,6) = B:
        LET RE(L,7) = NT:
        LET RE(L,8) = CV:
        LET RE(L,9) = BV:
        LET RE(L,10) = NC:
        LET RE(L,18) = D:
        LET RE(L,20) = PP
6010  RETURN
6012  REM
6013  REM ==> CALC. STAND ATTRIBUTES BEFORE THIN.
6014  REM
6020  GOSUB 5770:
        GOSUB 5790:
        IF T = 1 THEN
            GOSUB 5820
6030  GOSUB 5860:
        GOSUB 5890:
        GOSUB 5940:
        GOSUB 5980
6040  RETURN
6042  REM
6043  REM ==> CALC. STAND ATTRIBUTES AFT. THIN.
6044  REM
6050  GOSUB 5920:
        LET B = RB(L)
6060  LET CV = CV - R
6070  GOSUB 5790:
        GOSUB 5820:
        GOSUB 5860:
        GOSUB 5890:
        GOSUB 5940:
        GOSUB 6000
6080  RETURN
6082  REM
6083  REM ==> PRINT VOL. TABLE HEADING.
6094  REM
6090  HOME :
        GOSUB 5390:
        INVERSE :
        PRINT TAB( 1);" THINNING ANALYSIS FOR YELLOW-POPLAR";
        TAB( 41):

6100  PRINT TAB( 1); TAB( 9);"PER ACRE VOLUME TABLE3"; TAB( 4
1):
        NORMAL
6110  GOSUB 5390
6120  RETURN
6122  REM
6123  REM ==> PRINT VOL. TABLE FOR THINS.
6124  REM
6130  PRINT "THIN #";L;" YEAR= ";YR(L);" STAND AGE= ";C(L)
6140  FOR I = 1 TO 40:

```

11 FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
 PAGE-20

```

      PRINT "-";:
    NEXT I:
    PRINT
6150  LET B1$ = "-----";

6160  PRINT TAB( 3)"BEFORE THIN"; TAB( 27);"AFTER THIN":
      PRINT TAB( 4)B1$; TAB( 26);B1$
6170  FOR I = 1 TO 11
6180      LET P$(L,I) = " ":
          LET P$(L,I) = STR$(RE(L,I)):
          LET P(L,I) = LEN (P$(L,I))
6190  NEXT I
6200  PRINT TAB( 4)"BA"; TAB( 16 - P(L,1));P$(L,1); TAB( 26);
      "REA"; TAB( 37 - P(L,6));P$(L,6)
6210  PRINT TAB( 4)"NT"; TAB( 16 - P(L,2));P$(L,2); TAB( 26);
      "RNT"; TAB( 37 - P(L,7));P$(L,7)
6220  LET P$(L,12) = STR$(RE(L,17)):
      LET P(L,12) = LEN (P$(L,12)):
      LET P$(L,13) = STR$(RE(L,18)):
      LET P(L,13) = LEN (P$(L,13))
6230  PRINT TAB( 4)"QMD"; TAB( 16 - P(L,12));P$(L,12); TAB( 2
6) "RQMD"; TAB( 37 - P(L,13));P$(L,13):

6240  PRINT TAB( 4)"CV"; TAB( 16 - P(L,3));P$(L,3); TAB( 26);
      "RCV"; TAB( 37 - P(L,8));P$(L,8)
6250  PRINT TAB( 4)"BV"; TAB( 16 - P(L,4));P$(L,4); TAB( 26);
      "RBV"; TAB( 37 - P(L,9));P$(L,9)
6260  LET P$(L,14) = STR$(RE(L,19) * 100):
      LET P(L,14) = LEN (P$(L,14)):
      LET P$(L,15) = STR$(RE(L,20) * 100):
      LET P(L,15) = LEN (P$(L,15))
6270  PRINT TAB( 4)"APV"; TAB( 16 - P(L,14));P$(L,14); TAB( 2
6) "APV"; TAB( 37 - P(L,15));P$(L,15):

6280  PRINT TAB( 4)"CDV"; TAB( 16 - P(L,5));P$(L,5); TAB( 26)
      ;"RCDV"; TAB( 37 - P(L,10));P$(L,10)
6290  GOSUB 5310:
      VTAB 24:
      GOSUB 7872:
      HOME
6300  RETURN
6302  REM
6303  REM ==> PRINT VOL. TABLE LEGEND.
6304  REM
6310  GOSUB 5390:
      PRINT "LEGEND: BA=BASAL AREA, NT=NO. OF TREES"
6320  PRINT "CV=CU.FT. VOL., BV=BD.FT. VOL."
6330  PRINT "CDV=CORD VOL., RBA=RESIDUAL BA, RNT="
6340  PRINT "RESIDUAL NO. OF TREES, ETC."
6350  RETURN
6352  REM
6353  REM ==> PRINT VOL. TABLE FOR INITIAL STAND
6354  REM == AND FINAL HARVEST.
6355  REM
6360  PRINT R$:
      GOSUB 5090:
      PRINT A$;X";,STAND AGE= ";Y:

```

11 FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

6370 FOR I = 1 TO 40:
      PRINT "-";
    NEXT I:
    PRINT :
    PRINT TAB( 4)B$
6380 PRINT TAB( 3)"-----":
.
6390 FOR I = 1 TO 11:
      LET P$(L,I) = "":
    NEXT :
    FOR I = 1 TO 5:
      LET P$(L,I) = STR$(RE(L,I)):
      LET P(L,I) = LEN (P$(L,I)):
    NEXT :
    IF L = 0 THEN
      FOR I = 6 TO 10:
        LET P$(L,I) = " ":
      NEXT
6400 FOR I = 6 TO 10:
      LET P(L,I) = LEN (P$(L,I)):
    NEXT
6410 PRINT TAB( 4)"BA"; TAB( 15 - P(L,1));P$(L,1):
    PRINT TAB( 4)"NT"; TAB( 15 - P(L,2));P$(L,2)
6420 LET P$(L,12) = STR$(RE(L,17)):
    LET P(L,12) = LEN (P$(L,12)):
    LET P$(L,13) = STR$(RE(L,19) * 120):
    LET P(L,13) = LEN (P$(L,13))
6430 PRINT TAB( 4)"QMD"; TAB( 15 - P(L,13));P$(L,12)
6440 PRINT TAB( 4)"OV"; TAB( 15 - P(L,3));P$(L,3):
    PRINT TAB( 4)"SV"; TAB( 15 - P(L,4));P$(L,4)
6450 PRINT TAB( 4)"XDV"; TAB( 15 - P(L,13));P$(L,13)
6460 PRINT TAB( 4)"CDV"; TAB( 15 - P(L,3));P$(L,3):
    PRINT
6470 GOSUB 6310:
    VTAB 24:
    GOSUB 7870
6480 RETURN
6482 REM
6483 REM ==> PRINT LINE OF VOL. TABLE ON PRINTER.
6484 REM
6490 PRINT TAB( 3);B$: TAB( 5 - P(L,11));P$(L,11); TAB( 6 -
    P(L,3));P$(L,3); TAB( 5)"/"; TAB( 4 - P(L,1));P$(L,1);
    TAB( 5 - P(L,3));P$(L,3); TAB( 7 - P(L,3));P$(L,3);
    TAB( 7 - P(L,4));P$(L,4); TAB( 7 - P(L,5));P$(L,5);" /
    ";
6500 PRINT TAB( 5 - P(L,6));P$(L,6); TAB( 5 - P(L,7));P$(L,7
    ); TAB( 7 - P(L,3));P$(L,3); TAB( 7 - P(L,9));P$(L,9);
    TAB( 7 - P(L,10));P$(L,10)
6510 PRINT T$;T$;"/";T$;T$;G$;" /":
    RETURN
6512 REM
6513 REM ==> INITIALIZE COST ARRAYS.
6514 REM
6520 VTAB 9:
    HTAB 8:
    FLASH :
    PRINT "INITIALIZING COST ARRAYS"
6530 FOR I = 1 TO Y1

```

11 FORMATTED LISTING

FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

6540      LET C2(I) = 0:
          LET C4(I) = 0:
          LET C5(I) = 0:
          LET C6(I) = 0:
          LET C9(I) = 0
6550      LET R8(I) = 0
6560      FOR J = 0 TO 2
6570          LET C3(J,I) = 0:
          LET C7(J,I) = 0:
          LET C8(J,I) = 0
6580      NEXT J
6590      NEXT I
6600      NORMAL :
          HOME
6610      RETURN
6612      REM
6613      REM ==> ERROR MESSAGE FOR INCORRECT RATE.
6614      REM
6620      PRINT R$:
          PRINT R$:
          PRINT
6630      PRINT "*** ERROR **      ALL RATES MUST BE"
6640      PRINT "ENTERED IN DECIMAL FORM. HIT (RETURN)"
6650      INPUT "TO CORRECT ERROR. ";Z$
6660      RETURN
6662      REM
6663      REM ==> ERROR MESSAGE FOR TAX OPTION.
6664      REM
6670      PRINT R$:
          PRINT R$:
          VTAB 21
6680      INPUT "INVALID CODE. RE-ENTER CODE.      ";F1:
          GOSUB 5410
6690      RETURN
6692      REM
6693      REM ==> DISPLAY TABLE HEADING FOR EXPENSES.
6694      REM
6700      FOR K = 1 TO 40:
          PRINT "=";:
      NEXT K:
      INVERSE
6710      IF F1 = 1 THEN
          PRINT TAB( 10)P$(2,2); TAB( 41):
6720      IF F1 < > 1 THEN
          PRINT TAB( 10)P$(2,1); TAB( 41):
6730      NORMAL :
          FOR K = 1 TO 40:
              PRINT "=";:
          NEXT K:
          PRINT :
          PRINT
6740      RETURN
6742      REM
6743      REM ==> DISPLAY SUBHEADING FOR EXP. TABLE.
6744      REM
6750      PRINT TAB( 3)P$(2,10):

```

JI FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

      PRINT :
      PRINT P*(2,3):
      PRINT P*(2,11):
      PRINT P*(2,4):
      PRINT
6760 RETURN
6762 REM
6763 REM ==> DISPLAY REVENUES TABLE HEADING.
6764 REM
6770 PRINT TAB( 11)P*(2,5):
      PRINT :
      PRINT "YEAR"; TAB( 10);"REVENUES/ACRE CUT"; TAB( 32);"LA
      ND":
      FOR K = 1 TO 36:
        PRINT "-";:
      NEXT K:
      PRINT :
      PRINT :

6780 RETURN
6782 REM
6783 REM ==> SUBHEADING FOR NET CASH FLOWS.
6784 REM
6790 PRINT TAB( 8);P*(3,1):
      PRINT :
      PRINT P*(3,2):
      FOR K = 1 TO 36:
        PRINT "-";:
      NEXT K:
      PRINT

6800 RETURN
6802 REM
6803 REM ==> CALC. PRICE FOR SAWTIMBER.
6804 REM
6810 LET P4 = P2 * M4 ^ Y1:
      LET P5 = P3 * M5 ^ Y1:
      LET P6 = P4 + (P5 - P4) * PP:
      RETURN

6812 REM
6813 REM ==> CALC. AFTER TAX CASH FLOWS.
6814 REM
6815 REM --> INFLATE EXPENSES.
6816 REM
6820 HOME :
      VTAB 10:
      HTAB 8:
      FLASH :
      PRINT "CALCULATING CASH FLOWS"
6830 FOR I = 1 TO Y1:
      LET J = I - 1:
      LET C6(I) = ( INT ((C5(I) * M2 ^ J * M1 + .25) * 10)
      ) / 10:
      NEXT I
6840 FOR I = 1 TO Y1:
      LET J = I - 1:
      LET C2(I) = INT (C2(I) * M2 ^ J * M1 + .5):
      NEXT I
6850 FOR Y = 1 TO Y1

```

11 FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
 PAGE-24

```

6860     FOR I = 0 TO 2:
          LET J = Y - 1:
          LET C3(I,Y) = INT (C3(I,Y) * M2 ^ J + .5):
          LET C8(I,Y) = INT (C8(I,Y) * M2 ^ J + .5)
6870     NEXT I
6880   NEXT Y
6882   REM
6883   REM --> CALC. DEPRECIABLE EXPENSES.
6884   REM
6890   FOR Y = 1 TO Y1
6900     FOR I = 0 TO 2:
          IF C3(I,Y) = 0 THEN
            6950
6910             LET H = 0:
             LET XX = (C3(I,Y) - C8(I,Y)) / C7(I,Y)
6920             FOR J = 1 TO C7(I,Y):
                 LET U = XX * (1 - M1) / D2 ^ J:
                 LET H = U + H:
             NEXT J
6930             LET W = C8(I,Y) / D2 ^ C7(I,Y):
             LET C3(I,Y) = INT (C3(I,Y) - H - W + .5)
6940         NEXT I
6950     NEXT Y
6960     FOR I = 2 TO Y1:
          LET J = I - 1:
          LET C4(I) = INT (C4(I) * M2 ^ J + .5):
        NEXT I
6962     REM
6963     REM --> CALC. DEPLETABLE EXPENSE DEDUCTIONS.
6964     REM
6970     LET W = T2:
     LET Q = 0:
     LET G1 = 1
6980     IF TNX = 0 GOTO 7070
6990     FOR L = 1 TO TNX
7000       LET G2 = C(L) - AGE + 1
7010       FOR I = G1 TO G2:
           LET W = C4(I) + W:
       NEXT I
7020       LET W = W - Q
7030       LET U = RS(L,15) / RS(L,14):
       LET T1 = W * U
7040       LET TR(L) = INT ((TR(L) + M2 ^ (G2 - 1) - T1) * M2
          + T1 + .5)
7050       LET Q = W - T1:
       LET W = 0:
       LET G1 = G2 + 1
7060     NEXT L
7070     IF TNX = 0 THEN
       LET G1 = 1:
       LET Q = 0
7080     LET G2 = FD - AGE + 1
7090     FOR I = G1 TO G2:
       LET W = C4(I) + W:
     NEXT I
7100     LET W = W + Q:
     LET T1 = W
7110     LET TR(5) = INT ((TR(5) + M2 ^ (G2 - 1) - T1) * M2 + T1

```

11 FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

      F .5)
7120 LET L1 = INT ((L2 * (M2 * M9) ^ (Y1 - 1) - L3) * M2 + L
      3 + .5)
7130 NORMAL :
      HOME
7140 RETURN
7142 REM
7143 REM ==> CALC. PRESENT NET WORTH.
7144 REM
7150 LET NPV = 0:
      FOR I = 1 TO Y1:
          LET Y = I - 1:
          IF C9(I) ( ) 0 THEN
              LET NPV = C9(I) / D2 ^ Y + NPV:
      NEXT I:
      RETURN .
7152 REM
7162 REM ==> CALC. INTERNAL RATE OF RETURN.
7164 REM
7170 LET D2 = 1.000000001:
      GOSUB 7150:
      LET D2 = 1.0
7180 IF NPV ( ) = 0 THEN
          LET IRR = 0:
          RETURN
7190 LET I1 = .1:
      GOSUB 7290
7200 IF T = 9 THEN
          RETURN
7210 LET I1 = - .03:
      GOSUB 7290
7220 LET I1 = .01:
      GOSUB 7290
7230 LET I1 = - .003:
      GOSUB 7290
7240 LET I1 = .001:
      GOSUB 7290
7250 LET I1 = - .0003:
      GOSUB 7290
7260 LET I1 = .0001:
      GOSUB 7290
7270 LET IRR = (D2 - 1) * 610
7280 RETURN
7290 LET T = SGN (NPV)
7300 FOR I2 = 1 TO 30
7310 LET D2 = D2 + I1:
      GOSUB 7150
7320 IF SGN (NPV) ( ) T THEN
          RETURN
7330 NEXT I2
7340 LET IRR = 300:
      LET T = 9
7350 RETURN
7351 REM *** END INTERNAL RATE OF RETURN SUBROUTINE.
7352 REM
7353 REM
7354 REM ==> OUTPUT OF FINANCIAL RESULTS.
7355 REM

```

10 FORMATTED LISTING

FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

7360 LET PNW = INT (PNW + .5):
      LET IRR = ( INT ((IRR + .05) * 10)) / 10:
      LET D = D0 * 100:
      IF F1 = 1 THEN
        LET D = (D1 * M2 - 1) * 100
7370 LET P$(2,6) = " -- BEFORE TAX FINANCIAL ANALYSIS -- "
7380 LET P$(2,7) = " -- AFTER TAX FINANCIAL ANALYSIS -- "
7390 LET P$(2,8) = "DISCOUNT RATE = ":
      LET G$ = " ":
      LET T$ = G$ + G$:
      LET X = FRE (0)
7400 IF IRR < = 0 THEN
      LET P$(4,1) = "< " + " 0 ":
      LET P$(4,2) = " < " + G$ + " 0 ":

7410 IF IRR > 0 AND IRR < 300 THEN
      LET P$(4,1) = "=" + " " + STR$ (IRR):
      LET P$(4,2) = " = " + G$ + " " + STR$ (IRR)
7420 IF IRR > = 300 THEN
      LET P$(4,1) = "> " + " " + "300":
      LET P$(4,2) = " > " + G$ + " " + "300"
7430 PRINT P$:
      VTAB 3:
      GOSUB 5390:
      INVERSE :
      PRINT " THINNING ANALYSIS FOR YELLOW-POPLAR "; TAB( 41
    ):
      IF F1 = 1 THEN
        PRINT P$(2,7); TAB( 41)
7440 IF F1 = 2 THEN
        PRINT P$(2,8); TAB( 41)
7450 NORMAL :
      GOSUB 5390:
      PRINT :
      PRINT TAB( 10)"DISCOUNT RATE = ";D;"%":
      HTAB 3:
      FOR I = 1 TO 36:
        PRINT "-";:
      NEXT I:
      PRINT :
      PRINT :
      PRINT :
7460 PRINT "PRESENT NET WORTH = ";PNW
7470 PRINT "INTERNAL RATE OF RETURN ";P$(4,1);"%"
7480 VTAB 22:
      INPUT "LINE PRINT INVESTMENT CRITERIA? Y/N ";Z$
7490 IF LEFT$(Z$,1) = "N" THEN
        GOTO 4620
7500 HOME :
      VTAB 6:
      PRINT "ENTER THE PRINTER SLOT NUMBER.":
      INPUT " ";SL:
      VTAB 8:
      PRINT "MAKE SURE PRINTER IS ON AND 'READY'"
7510 PRINT "HIT (RETURN) TO BEGIN PRINTING. ";:
      INPUT " ";Z$
7520 PR# SL:
      PRINT X$"B0N":

```

11 FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

      REM CTRL I 30N
7530 PRINT "ECONOMIC DATA SUMMARY: ":
      FOR I = 1 TO 21:
        PRINT "-";:
      NEXT I:
      PRINT
7540 LET P$(2,6) = "BEFORE TAX":
      LET P$(2,7) = "AFTER TAX":
      LET X = FRE (0)
7550 PRINT "TAX TREATMENT= "::
      IF F1 = 1 THEN
        PRINT P$(2,7);:

7560 IF F1 = 2 THEN
        PRINT P$(2,6);:

7570 PRINT G$;"REAL DISCOUNT RATE= ";D0 * 100;"%";G$;:
      IF F1 = 1 THEN
        PRINT "INFLATION RATE= "; INT ((M2 - 1 + .005) * 10
          0);"%"
7580 IF F1 = 2 THEN
        PRINT "CURRENT LAND VALUE= ";L0
7590 IF F1 = 1 THEN
        PRINT "MARGINAL TAX RATE= ";(1 - M1) * 100;"%";G$;"
          CAPITAL GAINS RATE= ";(1 - M0) * 100;"%";:
        PRINT "LAND BASIS= ";L3;G$;"TIMBER BASIS= ";TB;G$;"C
          URRENT LAND VALUE= ";L0
7600 PRINT "PRICE/CORD= ";P1;" PRICE/MBF FOR SAWLOGS AND .PE
          ELSERS RESPECTIVELY= ";P2;"",";P3:

7610 PRINT "PRICE APPREC. FOR PULP., SAWLOGS, AND PEELERS RESP
          ECTIVELY = "; INT ((M3 - 1 + .005) * 100);","; INT ((M4
          - 1 + .005) * 100);","; INT ((M5 - 1 + .005) * 100);"%"
          :

7620 PRINT "PRICE ADJUSTMENT FOR THINNED MATERIAL= ";TP * 610
          ;"% OF FINAL HARVEST STUMPAGE VALUES. ":

7630 PRINT :
      PRINT :
      PRINT "EXPENSE DATA SUMMARY:":
      FOR I = 1 TO 20:
        PRINT "-";:
      NEXT :
      PRINT :
      PRINT :
      PRINT TAB( 11)"TYPE OF EXPENSE";T$;G$;"YEAR";G$;"AMOUNT
        ":
      PRINT :
      IF F1 = 2 THEN
        GOTO 7710
7640 IF C1 > 0 THEN
        :
        LET A$ = "YEARLY RECUR., ":
        LET B$ = "ORDINARY ":
        LET Y$ = " -- ":
        LET Z$ = STR$(C1):
        LET I1 = 0:

```

11 FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

      GOSUB 7850
7650  IF E2 > 0 THEN
      :
      FOR I = 1 TO E2:
        LET A$ = "NON-RECURRING, ":
        LET B$ = "ORDINARY ":
        LET Y$ = STR$ (E2(I,2)):
        LET Z$ = STR$ (E2(I,0)):
        LET I1 = 0:
        IF Y$ < > "0" THEN
          GOSUB 7850:
          LET X = FRE (0)
7660  IF E2 > 0 THEN
        NEXT
7670  IF E3 > 0 THEN
      :
      FOR I = 1 TO E3:
        LET A$ = "DEPRECIABLE, ":
        LET B$ = "CAPITAL ":
        LET Y$ = STR$ (E3(I,2)):
        LET Z$ = STR$ (E3(I,3)):
        LET I1 = 1:
        IF Y$ < > "0" THEN
          GOSUB 7850
7680  IF E3 > 0 THEN
        NEXT
7690  IF E4 > 0 THEN
      :
      FOR I = 1 TO E4:
        LET A$ = "DEPLETABLE, ":
        LET B$ = "CAPITAL ":
        LET Y$ = STR$ (E4(I,2)):
        LET Z$ = STR$ (E4(I,0)):
        LET I1 = 0:
        IF Y$ < > "0" THEN
          GOSUB 7850:
          LET X = FRE (0)
7700  IF E4 > 0 THEN
        NEXT
7710  IF F1 = 2 THEN
      :
      IF C1 > 0 THEN
      :
        LET A$ = "YEARLY RECURRING " + G$:
        LET B$ = " ":
        LET Y$ = " -- ":
        LET Z$ = STR$ (C1):
        LET I1 = 0:
        GOSUB 7850:
7720  IF F1 = 2 THEN
      :
      IF E1 > 0 THEN
      :
      FOR I = 1 TO E1:
        LET A$ = "NON-RECURRING" + T$:
        LET B$ = " ":
        LET Y$ = STR$ (E1(I,2)):

```

JC FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

                                LET Z$ = STR$ (E1(I,0)):
                                LET I1 = 0:
                                IF Y$ ( ) "0" THEN
                                    GOSUB 7850:
                                    LET X = FRE (0)
7730      IF F1 = 2 AND E1 > 0 THEN
                                NEXT
7740      LET A$ = "CURRENT STAND VALUE" + G$:
      LET B$ = " ":
      LET Y$ = STR$ (YE):
      LET Z$ = STR$ (CL + TR(0)):
      LET I1 = 0:
      GOSUB 7850:
      LET X = FRE (0):
      PRINT :
      PRINT :
      PRINT
7750      FOR I = 1 TO 3:
            PRINT :
      NEXT I
7760      PRINT T$;T$;G$;" ECONOMIC CRITERIA (PER
            ACRE)
7770      PRINT TAB( 22);:
      FOR I = 1 TO 40:
            PRINT "=";:
      NEXT I:
      PRINT :
      PRINT :
      PRINT
7780      LET X = LEN ( STR$ (D)):
      PRINT T$;T$;" PRESENT NET WORTH @ ";D;"%
            "; TAB( 6 - X);" = ";G$;PNW
7790      PRINT :
      PRINT T$;T$;" INTERNAL RATE OF RETURN
            ";P$(4,2);"%"
7800      FOR I = 1 TO 3:
            PRINT :
      NEXT I
7810      FOR J = 1 TO 3:
            FOR I = 1 TO 80:
                  PRINT "=";:
            NEXT I:
      NEXT J
7820      FOR I = 1 TO 10:
            PRINT :
      NEXT I
7830      PR# 0
7840      RETURN
7850      PRINT T$;A$;B$;G$; TAB( 5 - LEN (Y$));Y
            $;G$; TAB( 6 - LEN (Z$));Z$;:
      IF I1 = 1 THEN
            PRINT " PERIOD= ";E3(I,4);" SALVA
            GE= ";E3(I,5);:

7860      PRINT " ":
      RETURN
7870      INPUT "          HIT (RETURN) TO CONTINUE.
            ";Z$:
  
```

IC FORMATTED LISTING
 FILE: APPENDIX E. DOCUMENTATION FILE #2
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```

                                LET X = FRE (0):
                                RETURN
7872      REM
7873      REM ==> CLEAR ARRAYS USED TO EDIT EXPEN
                                SES.
7874      REM
7880      FOR I = 2 TO Y1:
                                LET C6(I) = C1:
                                NEXT :
                                LET C6(1) = 0
7890      IF E2 > 0 THEN
                                FOR I = 1 TO E2:
                                    LET Y = E2(I,1):
                                    LET C2(Y) = E2(I,0):
                                NEXT
7900      IF E3 > 0 THEN
                                FOR I = 1 TO E3:
                                    LET J = E3(I,0):
                                    LET Y = E3(I,1):
                                    LET C2(J,Y) = E3(I,3):
                                NEXT
7910      IF E4 > 0 THEN
                                FOR I = 1 TO E4:
                                    LET Y = E4(I,1):
                                    LET C4(Y) = E4(I,0)
7920      RETURN
  
```

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ECONOMIC ANALYSIS OF THINNING ALTERNATIVES IN NATURAL STANDS
OF YELLOW-POPLAR

by

Darrell Glenn Brooks

(Abstract)

A computer program was developed which provides the necessary information required by landowners to evaluate thinning alternatives in yellow-poplar stands. The program is written Applesoft BASIC for the APPLE II+ microcomputer with a design which emphasizes flexibility and ease of use. The program consists of two primary segments: growth and yield, and economic evaluation. The growth and yield segment is composed of a stand level growth and yield model which consists primarily of a collection of equations specified by Knoebel (1982). The economic evaluation segment calculates two measures of economic performance for before or after taxes. The performance criteria are the present net worth and internal rate of return.

Using the computer program developed in the study, optimum thinning regimes were estimated for existing stands of yellow-poplar under a variety of economic and biological conditions. Given a set of benchmark costs and revenues,

optimum thinning regimes were estimated for three sites (80, 100, and 120, base age 50). A sensitivity analysis was conducted in which interest rates, thinning costs, and clearcut stumpage values were varied. The optimum regimes expressed varying degrees of sensitivity to changes in the economic parameters.