

2001

Financial Returns to Northeast Forestland

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**FINANCIAL RETURNS TO NORTHEAST
FORESTLAND**

By

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B.S. University of Wisconsin-Madison, 1998

A THESIS

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Science

(in Forestry)

The Graduate School

The University of Maine

May, 2001

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By Julie Rodenberg

Thesis Advisor: Dr. David B. Field

**An Abstract of the Thesis Presented
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Throughout the past two decades, investors have become increasingly interested in forestland investment. During this time, land has been bought and sold at an increasing pace in the Northeast. Many of the buyers and sellers are interested in timberland exclusively as an investment.

This study was divided into two sections. Part one used statewide stumpage data for 17 species-product combinations from 1960-1999 to explore the impact of property taxes, federal income tax and favorable capital gains treatment on real, after-tax rates of return to forest land in Maine. Property taxes, income taxes, and favorable capital gains taxes were varied to allow estimates of returns under conditions that ranged from the worst for investment purposes to the best. In addition, this study looked at how

timberland compares with other investments over long periods of time. Returns on timber were compared with returns published in the long-term study of stocks and bonds developed by Ibbotson and Sinquefeld. The program to calculate internal rates of return and market risk was written in Visual Basic, with the data stored in Microsoft Access and the output stored in Microsoft Excel.

Part two of the study looked at an actual investment-grade timberland property in the New York/New England region to compare the results from a real piece of land with the Maine statewide averages reported in part one. The study looked at the return on investment from 1970-1999. The focus was on how the average, annual, nominal rates of return have changed over time. The Capital Asset Pricing Model was used to evaluate relationships between risk and expected return and to calculate the beta. Finally the property was compared to other common timber indexes as well as other types of investments.

ACKNOWLEDGEMENTS

The author wishes to extend a special thanks to Dr. David B. Field for his extraordinary efforts and guidance throughout the completion of this thesis. The author also wishes to thank the other members of the committee, Dr. Bret P. Vicary and Dr. Thomas B. Brann, for their advice and review of the thesis.

Graduate school is a cooperative effort in terms of both research and moral support. Thanks to all my friends for their assistance and advice and thanks to Amine who always believed in me.

I am lucky to have the love and support of my family. I cannot thank them enough for their encouragement and guidance. Finally, a special thanks to the newest member of my family, my nephew Alex, who proved the best things in life really do come in small packages.

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INTRODUCTION

The purpose of this study was to quantify historical rates of return and market risk to determine how growing trees compares with other investments. The study was divided into two parts. The goal of part one of the study was to determine the average real rates of return in Maine for an investment in stumpage from 1960-1999. The study did not follow an actual piece of property but used statewide averages.

For part one of this work the objectives were to:

- 1) Observe historical trends in stumpage prices (for 26 different timber species-product combinations) and property taxes.
- 2) Determine the internal rate of return (IRR) of two species-product combinations for even-aged stands age 40-60 harvested between 1960-1999 under various tax structures.
- 3) Analyze the impact that rotation age, property taxes and the federal income tax, have on the internal rate of return.
- 4) Analyze the impact that rotation age, property taxes and the federal income tax have on volatility of returns. In this study, risk was defined as the variation in cash flow. The greater the variation, the higher the risk.
- 5) Compare timberland risk and return to other investments, such as stocks, bonds and treasury bills.

The second part of the study used an actual investment-grade timberland ownership between 50,000-500,000 acres in the New York/New England area. The goal was to observe rates of return from 1970-2000 on this property. The specific objectives for part two of this thesis were to:

- 1) Determine the nominal rates of return for an actual forestland ownership with actual annual costs and revenues.
- 2) Compare the coefficients of variation for the individual components of the timberland ownership.
- 3) Compare the property's rates of return and risk with other investments.
- 4) Compare the rates of return with popular timberland indexes, such as the National Council of Real Estate Investment Fiduciaries (NCREIF) Timberland Index and the Timberland Performance Index (TPI).

BACKGROUND

Investors considering timberland as an investment must project risks and returns peculiar to each investment. There are several methods of looking at timberland investments. Five commonly seen in the literature are:

- 1) Observe short-term changes in the rate of return, usually from stand establishment until the first harvest.
- 2) Look at the entire investment with one discount rate for the life of the investment.
- 3) Separate out different parts of the investment (stumpage price, land values) and analyze the trends.
- 4) Create timberland indexes in order to observe historical trends and compare regional differences in timberland investments.
- 5) Measure the risk of a timberland investment.

These methods are described below.

Short-range rate of return analysis

Short-range rate of return analysis involves looking at the investment for just one life cycle. The investor looks at the tree or stand at a certain age and if the rate of return would increase by letting the tree or stand grow until the next entry, the tree is left. Various factors can be modified in order to determine the optimum age at which to harvest. This information best serves landowners who plan on holding land for a short period of time and want to harvest it during their tenure. The landowner needs to decide the optimum time to harvest the trees based on various conditions. The landowner must decide if the return on the investment will increase by letting the trees grow until the next entry.

Most studies either keep real stumpage prices constant or try to account for fluctuating stumpage prices. One study, by Brazee and Mendelsohn (1988), used fluctuating stumpage prices, while another study by the United States Forest Service kept stumpage prices constant. A study by Herrick (1984) found that rates of return in Pennsylvania increased at an average annual nominal rate of almost 5 percent over a 13-year period. The range of average annual change was from -5.5 percent to 18.8 percent. When stumpage prices were held constant, the research focused on other variables. One article by Flick (1985) looked at the impact that thinning had on changes in the rotation age.

More recent studies have looked at the impact that landowner information has on the IRR. Previous studies assumed that the landowner had perfect information about prices. If timber prices were depressed at the optimum biological rotation age, a landowner with information about future prices would choose to wait. One of the earliest studies was by Binkley (1981), who looked at the impact of landowner preferences and took into account non-timber benefits for landowners. In the last few years, researchers have created models to incorporate landowner characteristics into optimum rotation models. Tahvonen and Salo (1999) included nonindustrial private forest (NIPF) owners' preferences in their optimum rotation model. Characteristics such as the age of the owner, the owner's bequest motives, and current or future debt of the owner were included in the model. A study by Kuuluvainen and Tahvonen (1999) found that the

biggest factor affecting rotation age was landowner expectations about stumpage prices. Landowners who perceived stumpage prices to be high chose shorter rotation ages than more pessimistic landowners.

Discounted cash flow

Discounted cash flow analysis was set forth by Faustmann (1849) and is still used today to determine optimum rotations and the value of the forest. In general, analysts assume that the discount rate associated with each annual net cash flow of a long-term investment is the same, despite the timing of the expected net cash flow (Clutter, 1983 and Fortson and Field, 1979). The problem with this method is choosing the most appropriate discount rate.

One early problem addressed in the literature was adjusting the discount rate based on the duration of the investment. A study by Cubbage and Redmond (1985) found that only two out of 41 forest products firms studied adjusted the discount rate based on the length of the investment. Papers by Binkley (1981), Foster (1979a) and Konrad (1983) discussed the relationship between the duration of an investment and the best discount rate. One study by Zinkhan (1988a) suggested using a discount rate specific to each annual net cash flow. He suggested a procedure for incorporating a compensation of the term structure of interest rates into the determination of a discount rate. Zinkhan found that the

valuation of a timberland tract varied by up to 11 percent depending upon whether the term structure of interest rates was recognized.

Fortson (1986) looked at the factors that impact the outcome of discounted cash flow analysis. The most important aspect of his study was adjusting for risk.

Redmond and Cabbage (1985) modified the discount rate to adjust for risk. This is the most common approach seen in the literature. One problem with this approach is that adjusting the discount rate assumes a compounding of risk over time (Brealy and Myers, 1981 and Chang 1980). This is not necessarily a problem if it is accounted for in the beginning, or if discount rates are derived from market transactions (via IRR analysis) with similar cash flows.

Another approach is using sensitivity analysis and adjusting the inputs in order to see the impact on the outcome. Bentley and Kaiser (1967) studied a Christmas tree investment in Iowa using sensitivity analysis to look at the impact small changes had on the outcome.

A more recent approach to risk in research has been to use Monte Carlo simulation. The values of one or more inputs are assigned a probability. Monte Carlo simulation provides a powerful tool to deal with the problem of variability in long-term investments. A program to run a Monte Carlo simulation was created by Engelhard and Anderson (1983) and Chambers et al. (1986). More

recent Monte Carlo simulations have used a spreadsheet-based simulation model. One model by Lebel and Carruth (1997) was used to predict woodyard supply over a one-year period. Taylor et al. (1995) described methods and developed software for using Monte Carlo simulation to characterize the reliability of structural components in the forest products industry.

Building block survey

The building block survey approach examines separate parts of the investment. Historical trends of stumpage prices, land values, or property taxes are analyzed. Dennis (1989) did a survey of trends in New Hampshire stumpage prices, focusing on the factors on the supply side that impact timber prices. He found that red oak had the largest average annual increase at about seven percent real from 1964-1999. Dennis also found that prices were highest when there was less of the species, and prices dropped as the supply increased. Sugar maple, beech and red maple all had large increases in volume from 1979-1988 and, as the volume increased, the real price fell.

A study by Sendak and McEvoy (1989) looked for seasonal and regional variations in stumpage prices from 1981-1987 in Vermont. Sendak found that there was no statistical difference in seasonal prices for 10 major species, but there was a large regional effect. The two species not impacted by region were yellow birch and eastern hemlock. The study found that stumpage prices were

historically higher in Southern Vermont than in Northern Vermont. This is mostly due to the fact that hard maple and oak are much higher in quality in southern Vermont. Numerous other factors can lead to regional variations in stumpage prices including access to markets, supply and demand, and state and local regulations.

Another study by Sendak (1992) looked at State and federal stumpage prices in Vermont from 1983-1988. Sendak found that overall stumpage prices were higher on State land than on federal land. The largest difference in price was for spruce sawtimber and for hardwood and softwood pulpwood. Throughout the five-year period, all species increased in nominal dollars and most increased in real prices.

Using linear regression, Remington and Dennis (1986) found that rates of price change from 1964-1983 stayed ahead of inflation for stumpage and roadside prices in New Hampshire. Kingsley and DeBald (1986) calculated the actual price difference, and price difference as a percentage of the original price, for stumpage and lumber prices in two eastern hardwood lumber markets over a 21-year period. For their study, prices for only three species stayed ahead of inflation.

A study in Maine by Howard and Chase (1995) found that, from 1963-1993, 18 of the 27 product-species combinations examined gained more than one percent in real terms. Veneer and boltwood stumpage had the most significant increases.

Timberland indexes

The timberland index approach involves creating or using an index measure to compare historical returns from one region to another. Timberland indexes measure timberland returns based on the actual performance of managed forestland. The forestland is managed by timberland investment management organizations (TIMOs). The two currently existing indexes are the NCREIF and the TPI. The NCREIF has returns from as far back as 1987 and has been published since 1994. It has only three contributors: Hancock Timber Resource Group, Forest Investment Associates, and Forest Systems LLC (began contributing during 4th quarter of 1999). Until 1999, Prudential Timber contributed data. The three contributors collect information from approximately 150 properties distributed throughout the United States.

The TPI is published by Jon Caulfield at the University of Georgia and covers mostly the Southern United States. The TPI goes back as far as 1981, but after 1987 several large funds stopped contributing data. The TPI consists of returns from 13 timberland funds managed by three timberland investment managers.

Academicians have also created timberland indexes. They are usually based on the performance of hypothetical investments in timberland. Conroy and Miles (1989) constructed a timberland index for southern pine that was dependent upon farmland values.

Zinkhan and Mitchell (1990) highlighted the two most common reasons for a good timberland index. The first reason is to determine asset allocation, and the second is to evaluate the investment performance relative to other investments. Zinkhan studied the Southern Timberland Index Fund (STIF) to determine how it compared to other performance indexes such as the Standard and Poor's (S&P) 500 Composite Index. Zinkhan found that when he used an indicator called the Jensen Alpha, the STIF outperformed the S&P 500. The Jensen Alpha is one measure of the excess return relative to market risk, and is derived from the Capital Asset Pricing Model (CAPM). Zinkhan also found that the addition of the STIF to a portfolio reduced the risk by an average of 43 percent. Other studies by Binkley and Washburn (1988) and Cubbage, Harris and Redmond (1989) used the Jensen Alpha and found that timber investments outperformed the S&P 500.

A more recent paper by Caulfield (1994) found that a good timberland index should:

- 1) be based on actual returns from real properties,

- 2) be weighted by asset value and the weights should include as many timberland properties as possible,
- 3) have sufficient historical data so that a comparison of average returns and standard deviations with other assets is statistically meaningful,
- 4) be able to recreate an index from publicly available data, and
- 5) be separated into regional sub indexes.

Measuring the risk of a timberland investment

Analyzing timberland investments to determine their risk can be used to find out how timberland risk-return relationships compare to other investments, and to determine how timberland affects portfolio performance. The market risk of an investment is a measure of how sensitive the investment is to changes in the overall investment market. One sensitivity measure, called the beta, can be estimated using the CAPM.

Although studies by Dowdle (1962), Marty (1964), Thompson (1968), and Foster (1979b) have all tried to quantify risk in forestry investments, the more recent studies of risk have tried to use financial management tools like the CAPM to measure risk and to demonstrate the role of timberland in portfolio diversification. Mills and Hoover (1982) used a simple portfolio analysis to show that investments in forestland were more beneficial when included in a diverse portfolio. Redmond and Cubbage (1988) measured market risk using the variation in stumpage prices

compared with other investments. They found that cycles for stumpage prices were often opposite market cycles for the S&P 500 and could therefore reduce the volatility of many portfolios.

Thomson (1987) studied the risk of an investment in selected timber species in the Midwest and South. He created a portfolio of minimum risk for the South, the Midwest, both regions combined and both regions combined with the market.

Thomson and Baumgartner (1988) used eight species to demonstrate that regressing estimated returns on an index consisting of the unweighted averages of the annual price change for each species yielded high betas.

Baumgartner and Hyldahl(1991) used historical stumpage price data from three Midwestern states to determine the risk, return and efficient portfolios for timberland investments of major commercial species. They found that the lowest risk-return portfolios included hickory, silver maple, sugar maple and black walnut. The study also found a large variation in betas for the same species in different states.

Redmond and Cubbage (1988), Zinkhan (1988b), and Binkley and Washburn (1988) all calculated the beta for timber investments to be small and occasionally even negative. Thomson (1991) looked at a portfolio that included investments in Douglas-fir and southern pine over 50 years. The study found that portfolios with

timber investments should restrict timber to between 5-20 percent of the portfolio in order to maximize returns and minimize risk.

Stevens' (1987) study looked at the rates of return on stumpage for a hypothetical piece of land in Maine, excluding management costs. Part one of this study was an update and continuation of Stevens' study. The goal was to have a better understanding of the historical trends and rates of return for the past 40 years in the state of Maine. Part two of this study continued on and looked at a real piece of land in the New York/New England area. Stevens' study did not include data on management costs and all the complex factors impacting the rates of return to stumpage in New England. Part two of this study used real data to explore what actual rates of return a landowner can expect in New England and how those rates of return compare to other investments. Although every landowner is unique and rates of return will be different for every property, part two of this study gives a glimpse of returns to one landowner.

PART ONE-STUMPAGE STUDY

Methods

Data Source

For part one of the study, assumptions were made and averages were used for property and income taxes, forest types, forest yields and stumpage prices. Data used were taken from various published data sources.

Maine stumpage prices were obtained from the Maine Forest Service Stumpage Price Reports. The statewide averages were used for the entire state from 1960-1999.

Forest yields were obtained from yield tables published by Leak (Leak, et al., 1970).

Property tax information (mill rates and valuations) was obtained from the State Bureau of Property Taxation. Prior to 1974, the ad valorem tax rate was used.

From 1974-1999, the assumption was that all property was enrolled in the Tree Growth Tax Law program and those rates were used.

Methodology

In 1987, Stevens wrote a Fortran program and used the University of Maine's mainframe computer to analyze the data and determine rates of return and volatility.

With today's wide variety of programming languages and fast PC's, Visual Basic

was used to write the program. For the first part of the thesis, all the data were entered into a Microsoft Access database and Visual Basic was used to determine the rates of return and volatility. (The Visual Basic program is presented in Appendix A.)

The first objectives of Part One were to look at historical rates of change for stumpage prices and property taxes, and to compare the average returns and volatility for white pine sawlogs and spruce-fir pulpwood.

In order to look at the impact of inflation, the data were analyzed in both real and nominal terms. The producer price index for finished goods was used to determine the real prices (Bureau of Labor Statistics, 2000). The Statistical Analysis System (SAS) was used to determine trends in stumpage prices and property taxes and the variation.

The last two objectives in Part One were to compare rates of return and the volatility to other investments and analyze the impacts of rotation age, property taxes, and federal income taxes on the rate of return. This part of the study looked at the entire investment rather than at individual components. The rates of return were compared with other investments reported by Ibbotson and Sinquefeld. Stumpage prices and taxes were converted to year 1999 dollars using the Producer Price Index for finished goods.

In the Visual Basic program there are two choices for analysis. The default choice is a single-year calculation. The user enters a year of harvest from 1960-1999. Visual Basic then calculates back to find the starting age for a 40-year-old stand. The other choice is to calculate the IRR for multiple harvest years. The Visual Basic interface for multiple harvest years is shown in Appendix B. The user enters the years for which he or she wishes to calculate an IRR and the program uses the same calculations, but instead of outputting the results for one year, it presents the results from all the chosen years. Visual Basic searches in a user-specified increment to solve for the internal rate of return of the investment. The default increment rate used in this study was .0001. The internal rate of return is the rate at which the present value of the revenues equals the present value of the costs. Visual Basic repeats this procedure for the next rotation age of 41 so that the year of harvest remains the same but the stand establishment occurs a year earlier than in the previous cycle. The program continues to increase the rotation age by one year until it reaches a rotation age of 60 for the specified harvest year. The program will have calculated a rate of return for each of the 20 rotation ages. The 20 rates of return were used to calculate an average rate of return, standard deviation, and coefficient of variation for that harvest year. The data are presented on the screen or in a text file. The program allows the user to choose the years of harvest, tax rates, favorable capital gains treatment and species.

Several assumptions were made for this study; natural stocking was 50 percent of normal, site index was 50 feet at base age 50, and management costs were not included. The main reason for not including management costs was the lack of adequate data on the average per-acre management costs in Maine from 1900-1999. The addition of management costs would lower the IRR, but make comparisons with other investments more equitable. Species were limited to choices entered into the database. Only a complete removal of merchantable timber was allowed in the year of harvest. The only type of risk analyzed was market risk; losses from ice storms, fires, outbreaks of pest, or other natural disasters were not considered. Finally, sales from non-bole products were not considered. The sale of the treetops or biomass would increase the rate of return.

Results

Historical Trends

Part one of this study looked at the average rates of return for a stumpage investment harvested between 1960-1999. The first objective was to observe the historical trends in stumpage prices and property taxes. The average annual rate of change was determined using the linear regression model:

$$Y_t = b_0 + (b_1 X_t)$$

where:

Y_t = natural logarithm of stumpage price in year t

b_0 = regression constant

b_1 = average annual compound rate of price change

X_t = year t (1960, 1961,...1999)

Many models express the rates of change in compound rates. According to Howard and Chase (1995), the advantage of linear regression is that it incorporates price variation throughout the time series rather than focusing on subjectively chosen time period end-points. Regression models were developed for both nominal and real stumpage prices. White pine sawlog prices increased at a nominal annual average rate of change (AAROC) of 6.41 percent. In real prices, they increased 1.95 percent annually over the 39 years. Spruce-fir pulpwood prices were similar to white pine, with an AAROC in nominal prices of 4.95 percent and a real increase of 0.5 percent. All the results were significant at the .01 level, except the real AAROC for spruce-fir, which was significant at the .05 level. Results were similar to those reported by Howard and Chase (1995). They looked at Maine stumpage prices from 1963-1990 and found that white pine had an average annual increase of 8.0 percent nominal and 2.4 percent real while spruce-fir had an average annual change of 4.9 percent nominal and -0.7 percent real. Graphs of real and nominal stumpage prices for white-pine sawlogs and spruce-fir pulpwood are shown in Figures 1 and 2.

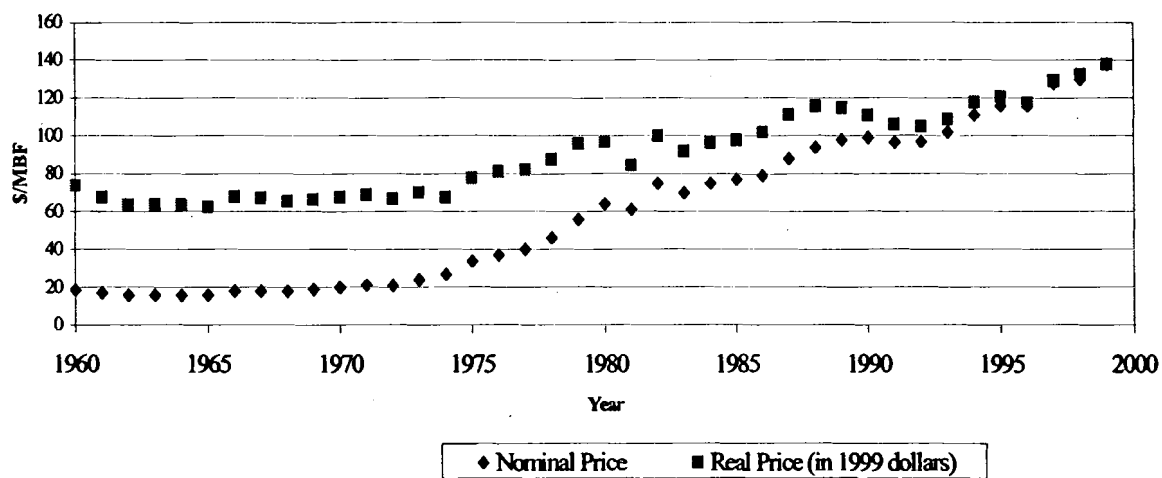


Figure 1. Nominal and real white pine sawlog stumpage prices in Maine from 1960-1999.

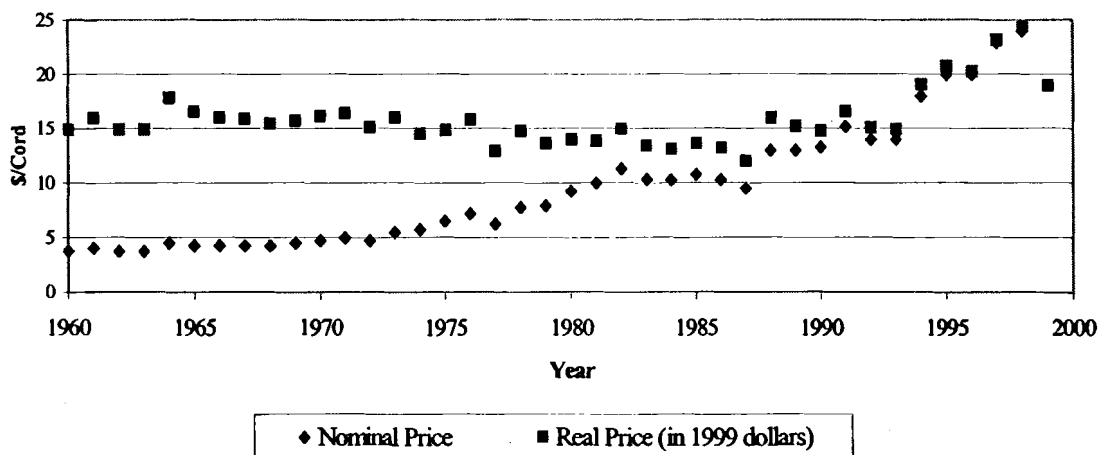


Figure 2. Nominal and real spruce-fir pulpwood stumpage prices in Maine from 1960-1999.

The AAROC for 26 species-product combinations in Maine was determined for the years 1960-1999. The AAROC in nominal dollars ranged from a high of 8.8 percent for oak sawlogs to a low of 3.8 percent for hemlock sawlogs (Table 1). In most cases the coefficient of multiple determination was above 80 percent, which means that most of the variation was explained by the year.

The real AAROC ranged from a high of 4.0 percent for oak sawlogs to a low of -1.0 percent for hemlock sawlogs. The AAROC for the selected species and product combinations were similar to those found by Stevens (1987). Stevens began his analysis with 1961 data due to a sharp spike observed in prices in 1960. However, this spike did not appear to significantly change the AAROC or the R^2 values in this analysis, so 1960 was included. Table 1 shows the AAROC for the 26 species-product combinations in Maine from 1960-1999.

Table 1. Average annual rates of change (compounded continuously) for stumpage in Maine from 1960-1999.

	Nominal		Real	
	AAROC (%)	R ² (%)	AAROC (%)	R ² (%)
SAWLOGS:				
White Pine	6.41	95a	1.95	90a
Hemlock	3.80	92a	-1.00	54a
Spruce-Fir	5.98	96a	1.18	60a
Cedar	4.18	75a	-.62	9.2b
White Birch	6.11	92a	1.31	64a
Yellow Birch	5.79	93a	.99	51a
Hard Maple	6.21	94a	1.41	61a
Red Oak	8.80	96a	4.00	88a
Beech	4.40	94a	-.41	11b
Aspen	4.13	89a	-.67	18b
Soft Maple	4.74	94a	-.06	3c
White Ash	7.32	94a	2.5	83a
Tie/Pallet	2.51	70a	-.62	13b
BOLTWOOD:				
Cedar	5.1	81a	.36	3c
White Birch	6.1	93a	1.30	68a
Yellow Birch	5.48	83a	.67	11b
Hard Maple	5.52	75a	.72	7c
Red Oak	6.36	71a	1.60	18b
Aspen	5.4	57a	.64	3c
Soft Maple	6.41	75a	1.47	16b
White Ash	6.35	83a	1.54	.34c
PULPWOOD:				
White Pine	6.26	92a	1.45	60a
Hemlock	4.80	94a	0.00	0c
Spruce-Fir	4.95	96a	.5	24b
Aspen	5.70	92a	.88	37a
Hardwood	5.42	93a	.62	26b
a significant at the .01 level				
b significant at the .05 level				
c not significant				

The R^2 values for the real AAROC were generally significant at the .05 levels and above. In general, the R^2 values for real AAROC were much higher for short-term predictions. In predictions less than 10 years, the R^2 was always significant at the .01 level. This indicates that short-term predictions of the real price are possible, but long-term predictions are unreliable. This is due to the difficulty in predicting future shortages and other variables.

The final significant historical trend observed was property taxes. Figure 3 shows the graph of real and nominal property taxes.

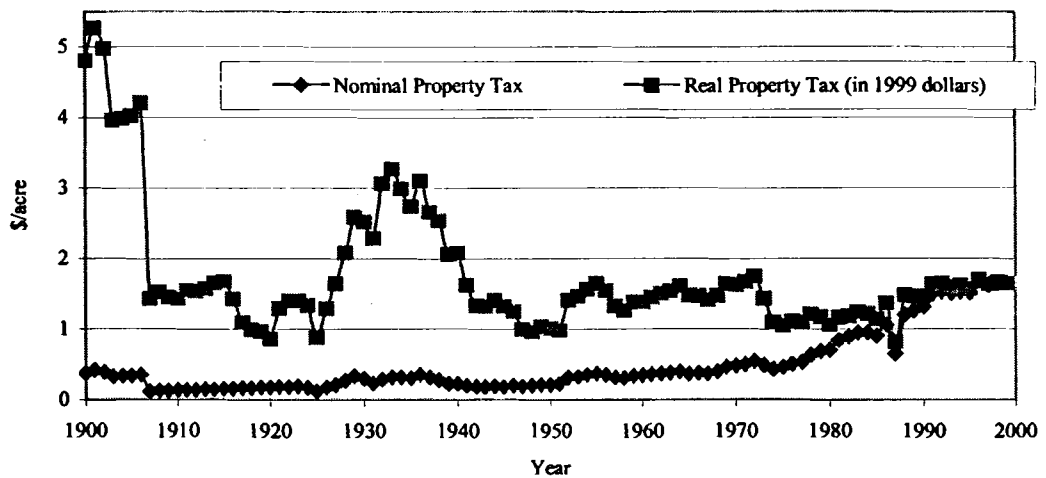


Figure 3. Real and nominal property taxes in Maine from 1900-1999.

From 1900-1999 the AAROC for property taxes increased at a nominal rate of only 2.03 percent but the AAROC in real prices was -0.59 percent. Both rates of change were significant at the .05 level. In real terms, property taxes have actually decreased during the past 99 years. In 1975, Maine started the Tree Growth Tax Law (TGTL) Program. Since the beginning of TGTL, the real and nominal prices for stumpage have been increasing at a consistent rate. From 1975-1999 the nominal AAROC for property taxes was 5.47 percent and the real AAROC was 2.06 percent. Both rates of change were significant at the .001 levels. So, even though real rates have fallen in the past 100 years, since the initiation of the Tree Growth Tax Law in 1974, real property taxes on forestland have risen.

Internal Rates of Return

White Pine Base Run

The second objective for part one of this thesis was to determine the real internal rate of return (IRR) of two species-product combinations for even-aged stands age 40-60 harvested between 1960-1999. The Visual Basic Program used a base case with a site index of 50, favorable capital gains treatment, ordinary income taxed at 20 percent, statewide average property taxes, and all carrying costs expensed. White pine sawlogs and spruce-fir pulpwood were the two species-product combinations analyzed.

The real IRR for white pine sawlogs ranged from a high of 11.09 percent for a 40-year rotation harvested in 1988, to a low of 5.88 percent for a 60-year rotation harvested in 1960. The yearly averages varied from a high of 9.8 percent in 1997 to a low of 7.17 percent in 1972. The average IRR by rotation age varied from a high of 9.37 percent for a 40-year rotation to a low of 7.18 percent for a 60-year rotation. Figure 4 presents a graph of all the internal rates of return for white pine. The graph is set up as a matrix with the year on the x-axis, IRR on the y-axis, and rotation age on the z-axis.

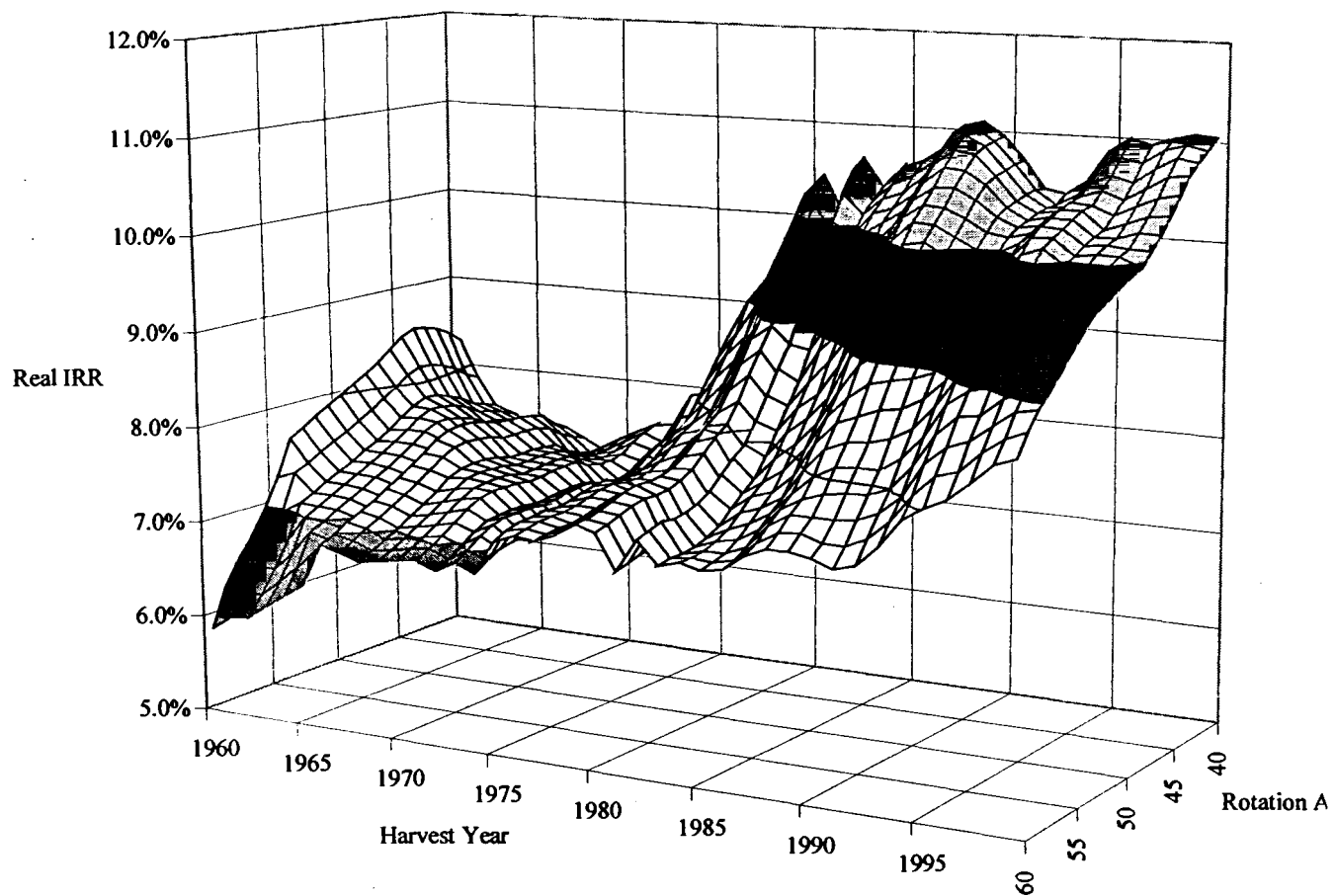


Figure 4. Real internal rate of return on white pine sawlogs in Maine from 1960-1999.

The two most noticeable patterns from the graph are that the IRR was highest in the earlier rotation ages and the later harvest years.

The reason the IRR was highest in the earlier rotation ages was because there was no difference in stumpage price for larger, higher quality logs. The stumpage price per year was the statewide average for all white pine logs. For every rotation age in a given year of harvest, the volume changed but not the stumpage price per unit. The IRR for consecutive rotation ages shows the trade-off between the increase in volume and the cost of holding the investment for an additional year.

The second pattern for white pine sawlogs was that the IRR was higher in later years. Table 1 indicates that the real AAROC for white pine sawlogs was 1.95 percent from 1960-1999 and property taxes decreased from 1900-1999 by 0.59 percent real. This would indicate that the general trend would be an increasing IRR due to higher real stumpage prices and lower real property taxes. After 1974, the increase in IRR is due more to the increase in stumpage prices since property taxes begin increasing in real dollars after 1974.

Spruce-Fir Base Run

The IRR for spruce-fir pulpwood ranged from a high of 7.1 percent at age 50 when cut in 1996, to a low of 3.99 percent at age 60 when cut in 1960. The year 1998 had

the highest average IRR, with 6.91 percent for all rotation ages. The year with the lowest average IRR was 1977, with just 4.34 percent. The average IRR by rotation age was highest in the middle rotation ages. Ages 48, 49 and 50 all had an IRR of 5.43 percent. The rotation age with the lowest IRR was 60, with 4.94 percent.

Figure 5 presents the graph for spruce-fir pulpwood.

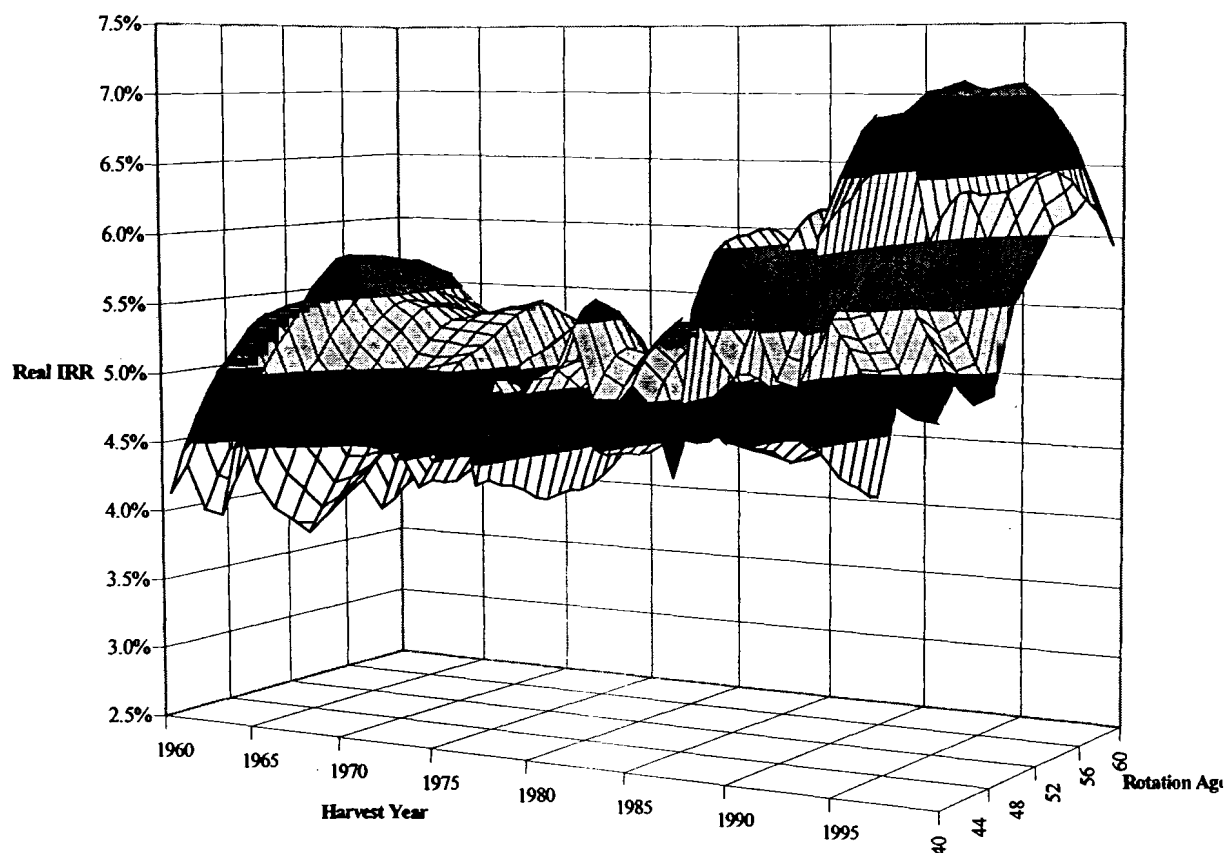


Figure 5. Internal rate of return for spruce-fir pulpwood in Maine from 1960-1999.

The trend for spruce-fir pulpwood was somewhat different than the trend for white pine sawlogs. The IRR was still highest in the later years but unlike white pine sawlogs, the IRR was highest in the middle rotation ages. With the exception of 1999, when spruce-fir pulpwood stumpage prices were at their lowest in five years, the IRR was highest in the later years. Property taxes decreased in real dollars while, in general, real spruce-fir pulpwood prices remained the same causing the IRR to be highest in the later years. Spruce-fir pulpwood had the highest IRR in the middle rotation ages because, from age 40 to 48, the yield increased at a faster annual rate than the IRR for the previous year. From age 48-50, the yield increased at about the same rate as the previous year's rate of return. After age 51 the yield did not increase as fast as the previous year's IRR.

Figures 4 and 5 show the IRR for the base case for white pine sawlogs and spruce-fir pulpwood. This next section will look at what happens to the IRR due to changes in capital gains, property taxes, and income taxes.

Impact of Favorable Capital Gains Tax Treatment

In order to determine the impact of capital gains taxes on the IRR, the capital gains rate was changed from the base of 20 percent to no favorable capital gains taxes (meaning everything was taxed at ordinary income tax rates). Figure 6 shows the effect of favorable capital gains taxes on the IRR for white pine sawlogs. The graph

takes the average IRR for each rotation age. The IRR reflects the average of 40 individual IRR calculations for the harvest years 1960-1999.

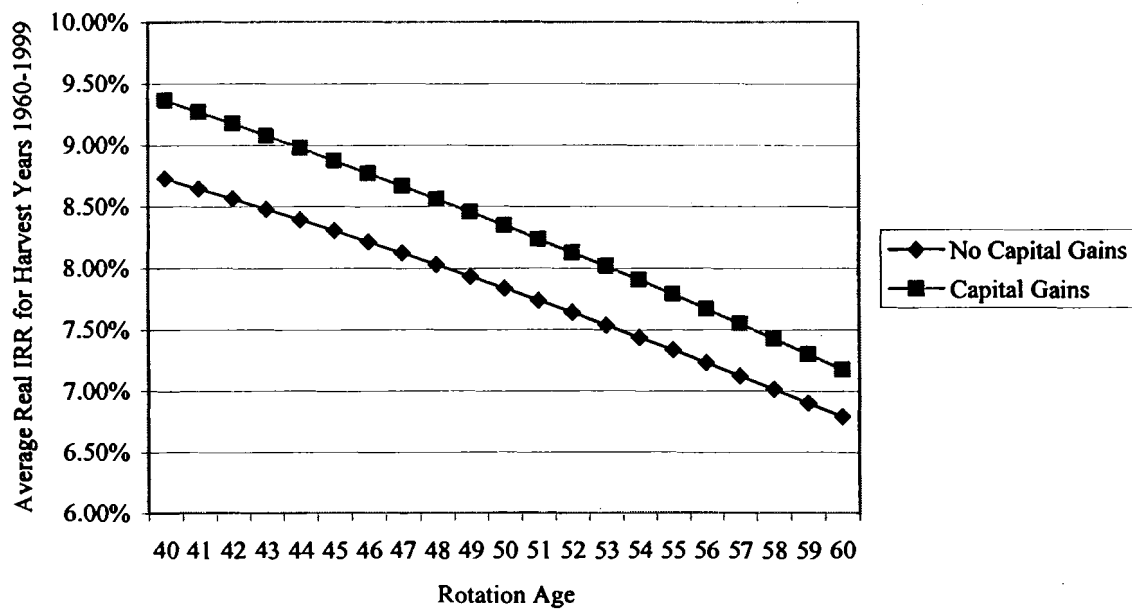


Figure 6. Impact of favorable capital gains treatment on the average IRR by rotation age for white pine sawlogs over a 40-year selling period in Maine.

The returns were higher with favorable capital gains treatment but the effect of favorable capital gains was highest in the earlier rotation ages. This is due to the impact of compounding. The difference between favorable capital gains and no capital gains was always less than one percentage point.

Favorable capital gains treatment had a similar effect on the IRR for spruce-fir pulpwood, increasing returns most in the earlier rotation ages. The difference between favorable capital gains and no capital gains treatment ranged from 42 percent to 71 basis points for each rotation age. Figure 7 shows the real average IRR for each rotation age with harvests from 1960-1999.

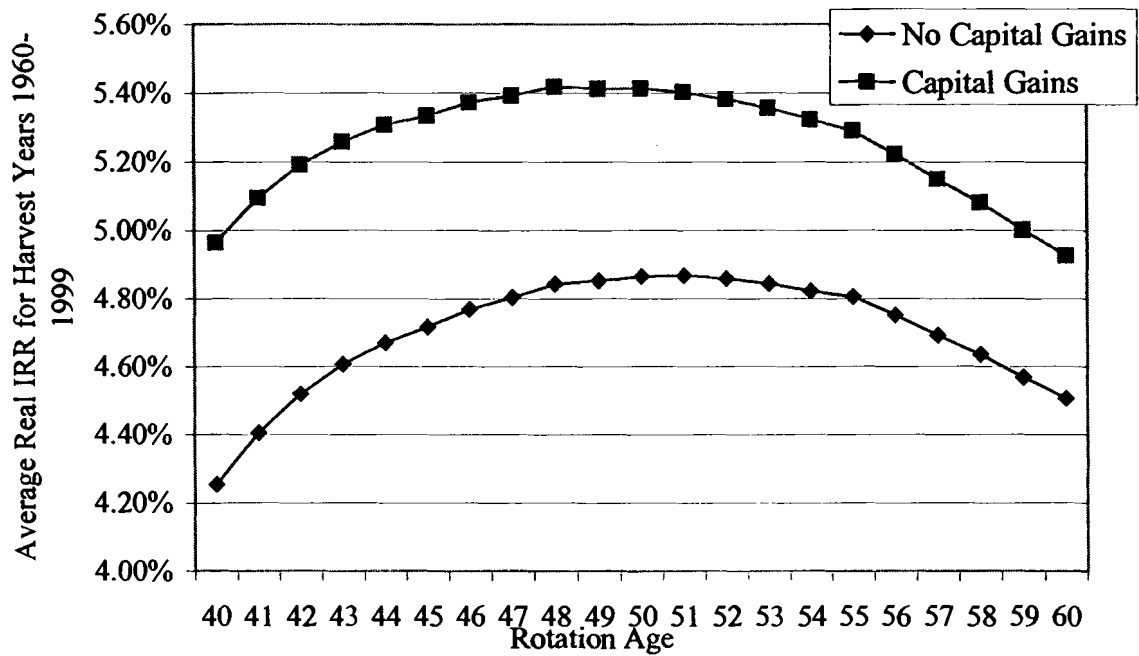


Figure 7. The impact of favorable capital gains treatment on the average IRR for spruce-fir pulpwood over a 40-year selling period in Maine.

Impact of Property Taxes

To measure the impact of property taxes on the IRR, the program was run with low, average, and high property tax data. The low and high data were five percent lower and higher than the average statewide property tax data used in the base case. Figure 8 shows the results for white pine sawlogs.

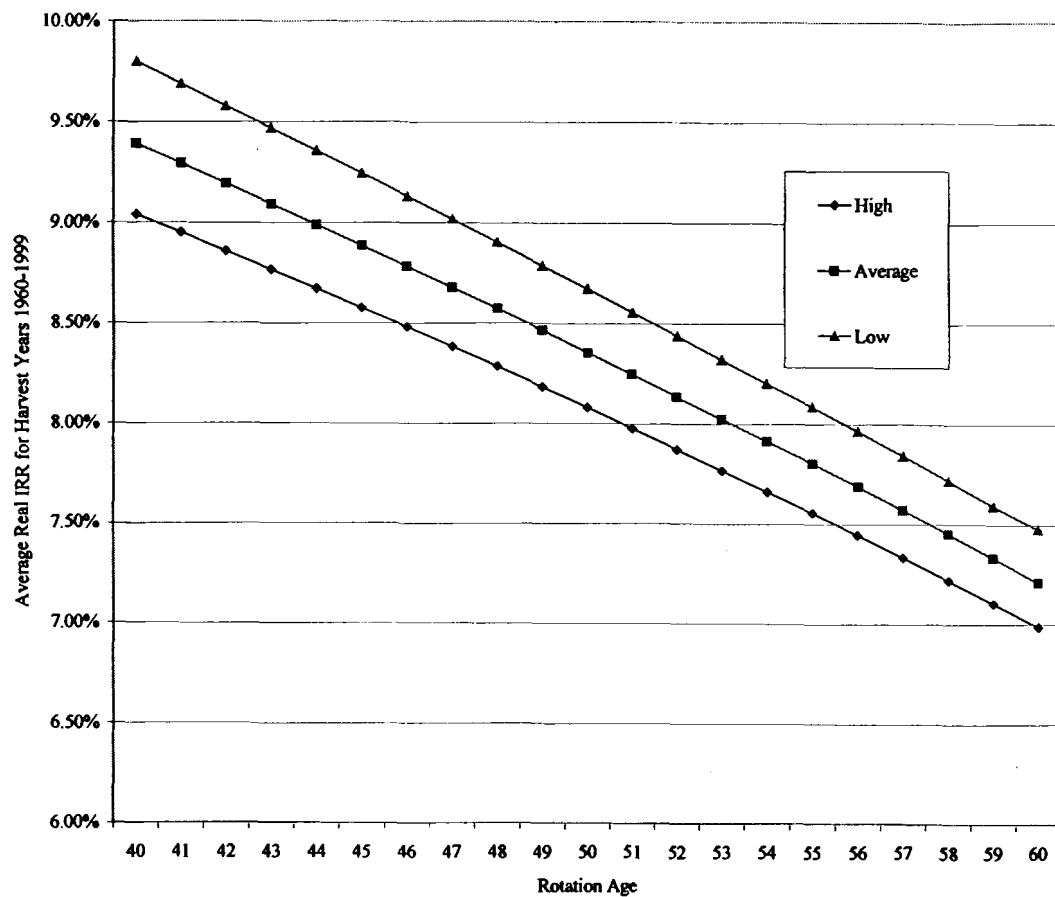


Figure 8. The impact of property taxes on the average IRR for white pine sawlogs over a 40-year selling period in Maine.

The impact of property tax was greatest in the earlier rotation ages. At rotation age 40, the difference in IRR between the high and low property tax was 76 basis points, and at rotation age 60, the difference between high and low property tax narrowed to 49 basis points.

The impact of property taxes on IRR for spruce-fir pulpwood was similar. The high and low property taxes affected the IRR more in the earlier rotation ages. The difference in IRR between the high and low property taxes was 83 basis points at rotation age 40 and by rotation age 60 the difference was just 50 basis points. In the high property tax scenario, the highest IRR occurred at rotation age 50, in contrast to the low property tax scenario where the highest IRR occurred at rotation age 48.

Figure 9 depicts the graph for spruce-fir pulpwood.

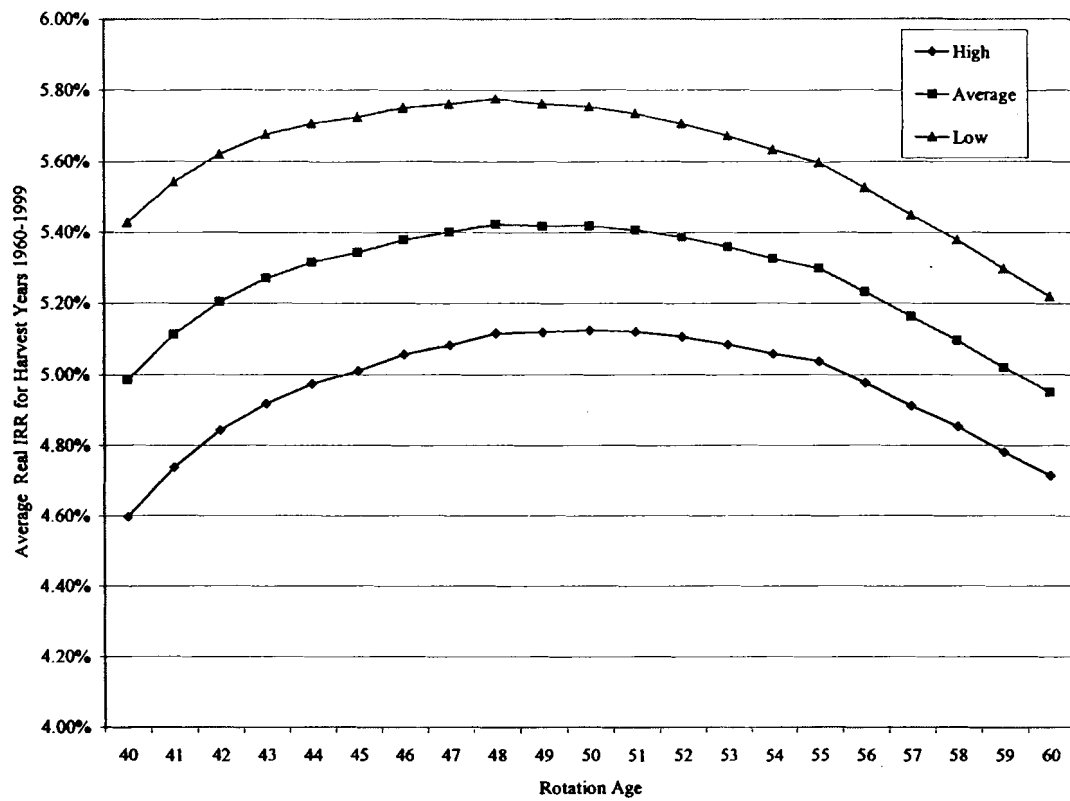


Figure 9. The impact of property taxes on the average IRR for spruce-fir pulpwood over a 40-year selling period in Maine.

Impact of Income Taxes

The final variable studied was the impact of income taxes on the IRR. The program ran with the income from the final harvest taxed at low, average, and high rates. The low rate was 10 percent, average was 20 percent, and high was 35 percent. As expected, the highest tax bracket produced the lowest IRR. In the case of white pine sawlogs, the difference between the high and low bracket was small. The difference between high and low taxes was greatest in the earliest rotation ages, with a difference of 0.19 percent, and smallest in the later rotation ages, with a difference of 0.12 percent. The graph of the IRR for white pine sawlogs is shown in Figure 10.

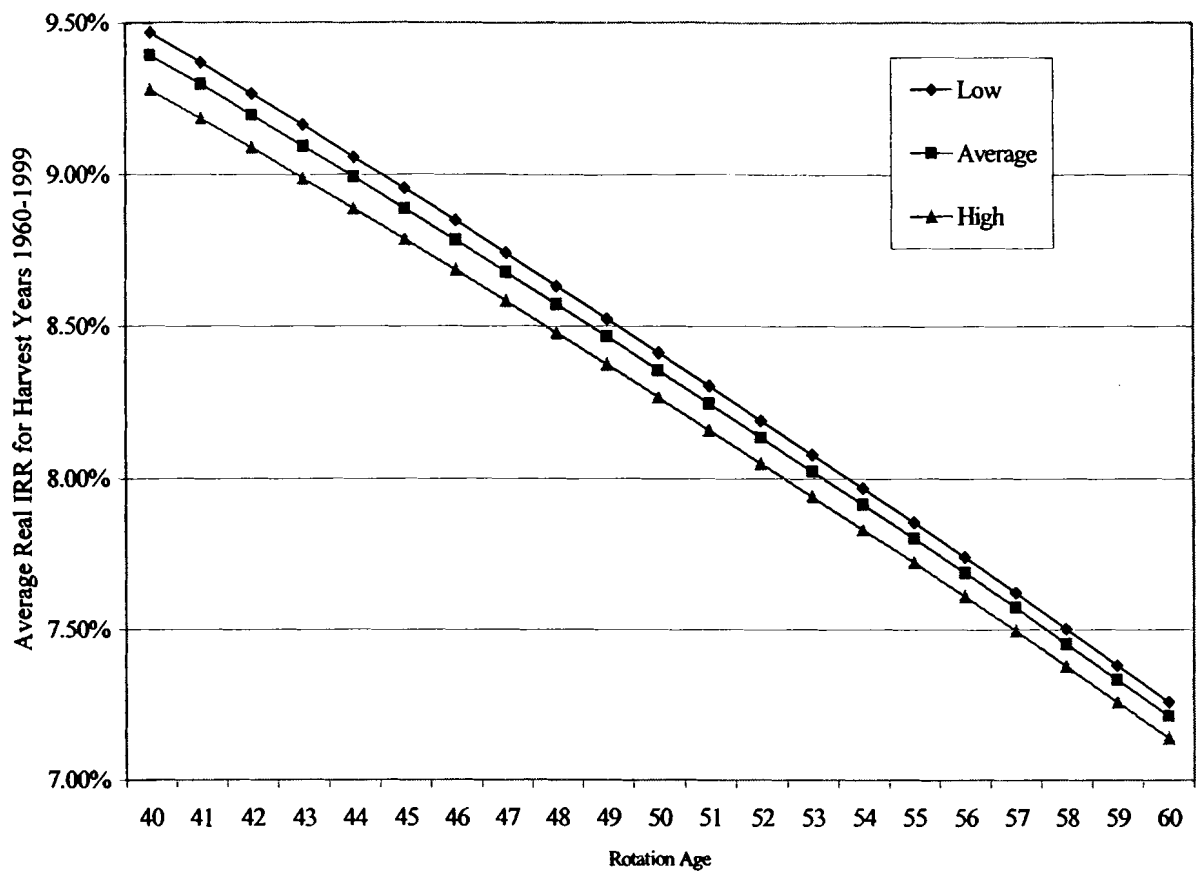


Figure 10. The impact of income taxes on the average IRR for white pine sawlogs over a 40-year selling period in Maine.

Changing the income tax had about the same impact on spruce-fir pulpwood. The difference between the high and low taxes was still small. Between the high and low income tax brackets, the biggest difference in IRR was in the lowest rotation ages. At rotation age 40 the difference was 21 basis points and by rotation age 60 the difference narrowed to just 13 basis points. Figure 11 shows the graph of IRR for spruce-fir pulpwood.

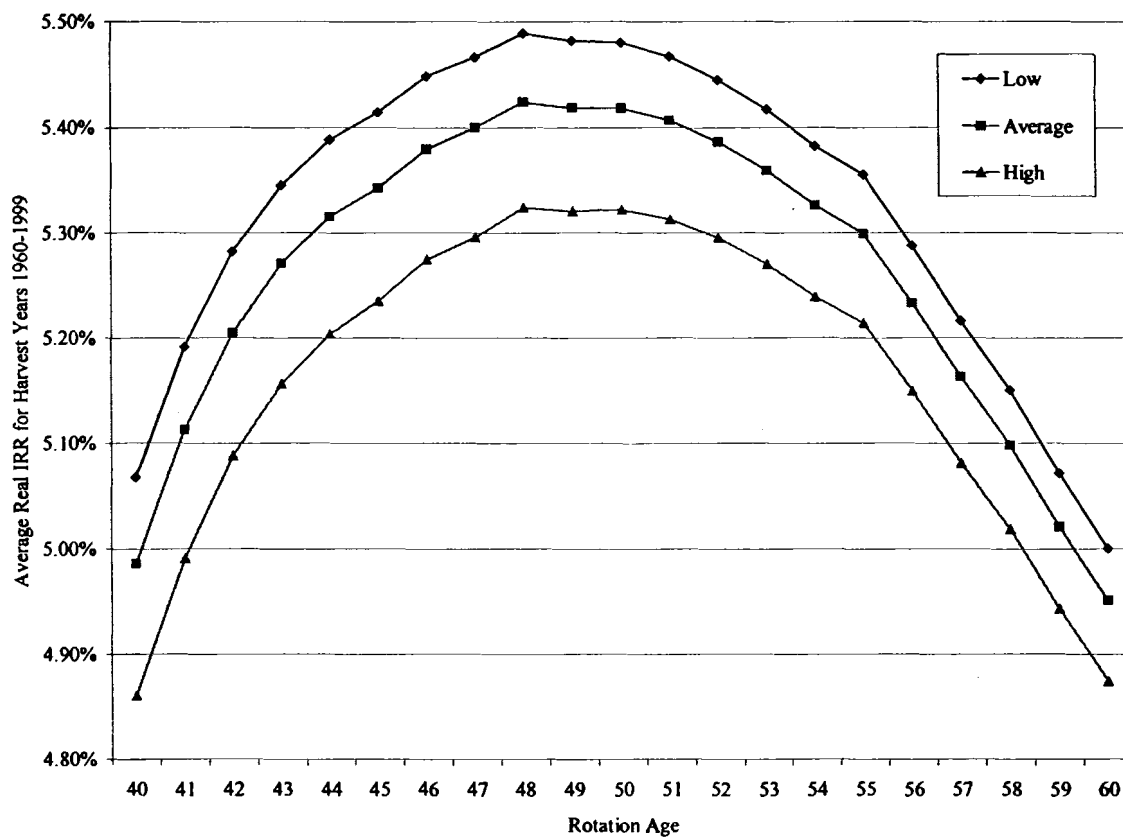


Figure 11. The impact of income taxes on the average IRR for spruce-fir pulpwood over a 40-year selling period in Maine.

Volatility

The third objective for part one of this thesis was to determine the volatility in the investment. In order to compare trials with different means, volatility (risk) was measured using the coefficient of variation, (adjusted for inflation) for each rotation age. The volatility in IRR for capital gains treatment, income tax, and property tax was examined for every rotation age, with the yearly IRR averaged.

Favorable Capital Gains Treatment

The volatility for favorable capital gains treatment for white pine sawlogs ranged from 17.6 percent to 8.8 percent without favorable capital gains treatment and from 16.3 percent to 8.5 percent with favorable capital gains treatment (Figure 12). The volatility was highest in the early rotation ages, which was also when the IRR was the highest. This is comparable to traditional investments, where higher returns have more volatility (or risk). Even a risk-averse investor may be better off choosing the lower rotation age because the lowest IRR for rotation age 40 was only one percentage point different from the highest IRR at rotation age 60. At age 40 the lowest IRR was 7.2 percent in 1965 and the highest IRR at rotation age 60 was 8.5 percent, a difference of only 130 basis points. The volatility and the IRR were higher in the lowest rotation ages and this situation was true for white pine sawlogs in every scenario. It was almost always better to choose the lower rotation age, even though the volatility was higher.

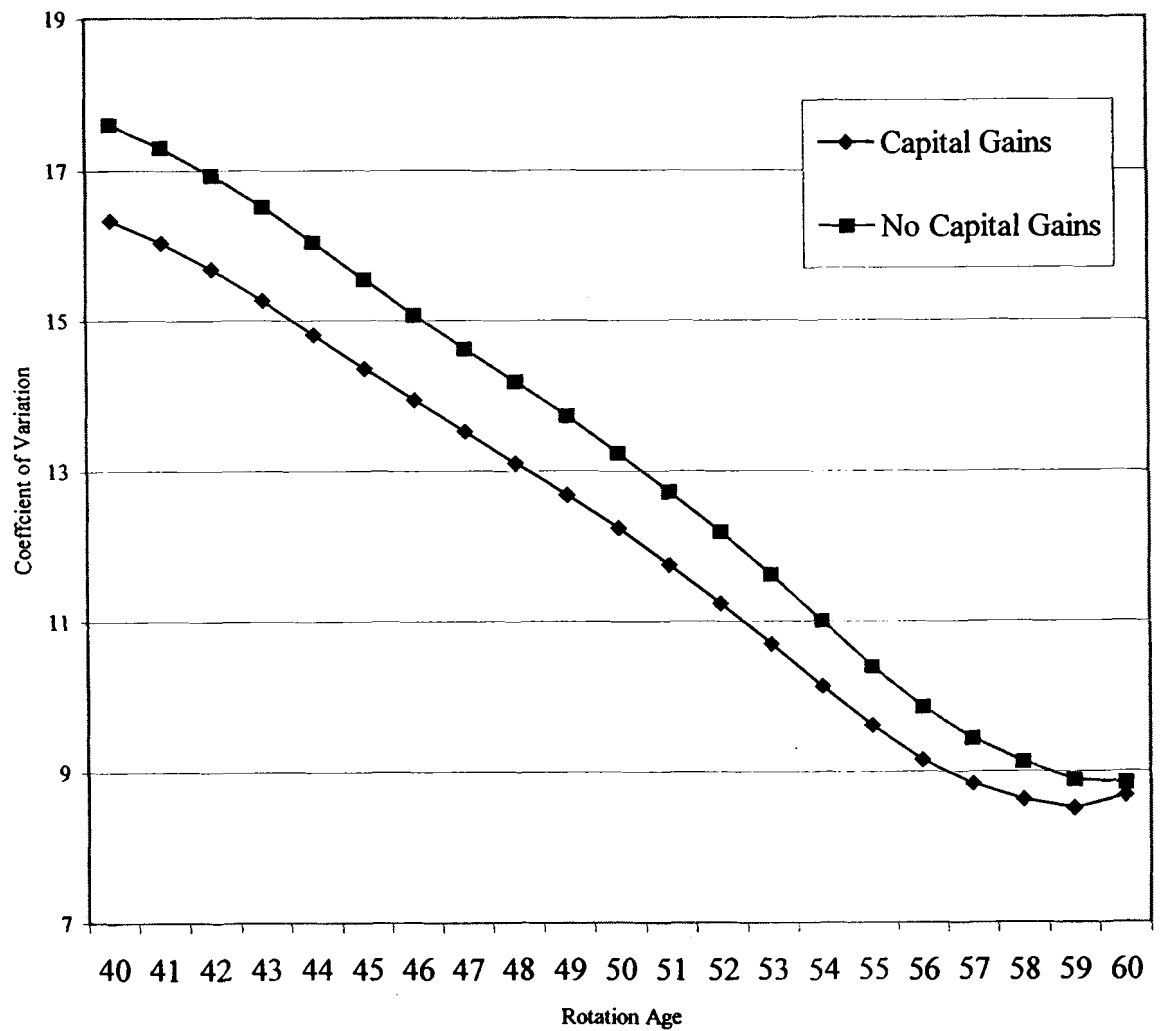


Figure 12. The impact of capital gains tax on the volatility in IRR for white pine sawlogs for selling years 1960-1999 in Maine.

The volatility in spruce-fir pulpwood was similar to white pine sawlogs in that the volatility was higher without favorable capital gains treatment. The difference in volatility was highest in the lower rotation ages. In the later rotation ages, the difference in volatility between favorable capital gains and no capital gains narrowed. The graph of volatility in spruce-fir pulpwood with and without capital gains is shown in Figure 13. The difference between volatility in spruce-fir pulpwood and white pine sawlogs was that, in the former, the highest volatility did not correlate to the highest IRR. In fact, the highest IRR was in the middle rotation ages, which in this case wasn't the highest or lowest volatility. The highest volatility occurred in the early rotation ages and the lowest volatility occurred in the later rotation ages. Unlike with white-pine sawlogs, an investor needs to choose between risk and return. The difference in average IRR between rotation ages 40 and 60 ranged from 4.9 to 5.4 percent, or less than 100 basis points. Risk-averse investors might prefer the lower middle rotation ages because, although the IRR was slightly lower, the volatility was also lower. In year 46, the volatility was 14.14 percent and the average IRR was 5.37 percent. If the investor waited until year 49, the average IRR would increase to 5.4 percent but the volatility would increase to 14.3 percent. For the small trade-off in IRR, the investor might prefer the reduction in risk.

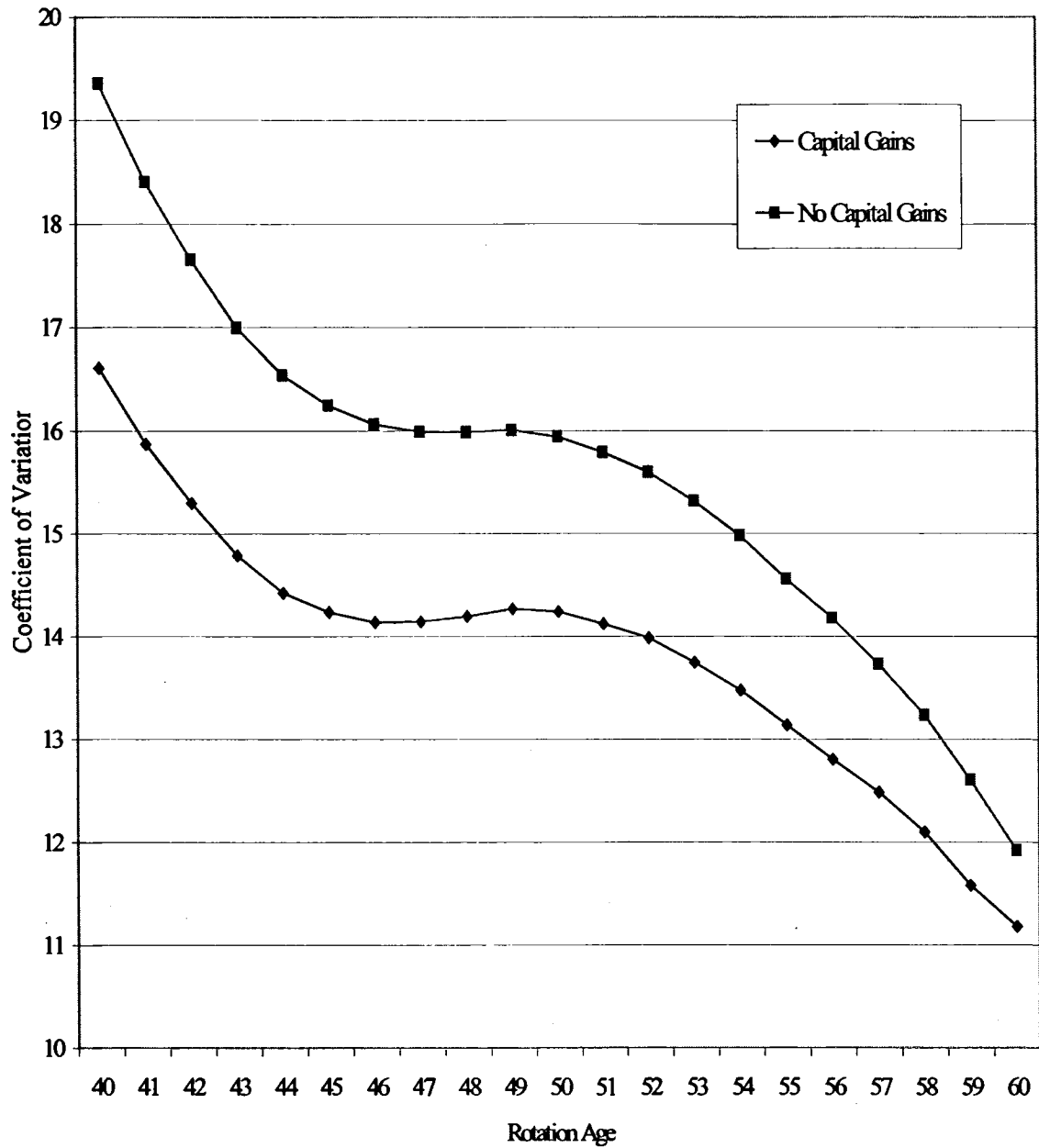


Figure 13. The impact of favorable capital gains treatment on volatility in IRR for spruce-fir pulpwood in Maine for selling years 1960-1999.

Property Taxes

The impact of property taxes on the volatility in white pine sawlog IRR was similar to the impact of capital gains. The rotation ages with the higher returns showed greater volatility. The low property tax had the lowest volatility and the high property tax the highest volatility, mainly because the low property tax had a higher mean IRR and thus a lower coefficient of variation. As the mean IRR decreased in the later rotation ages, the coefficient of variation also decreased. Figure 14 presents the graph for white pine sawlogs.

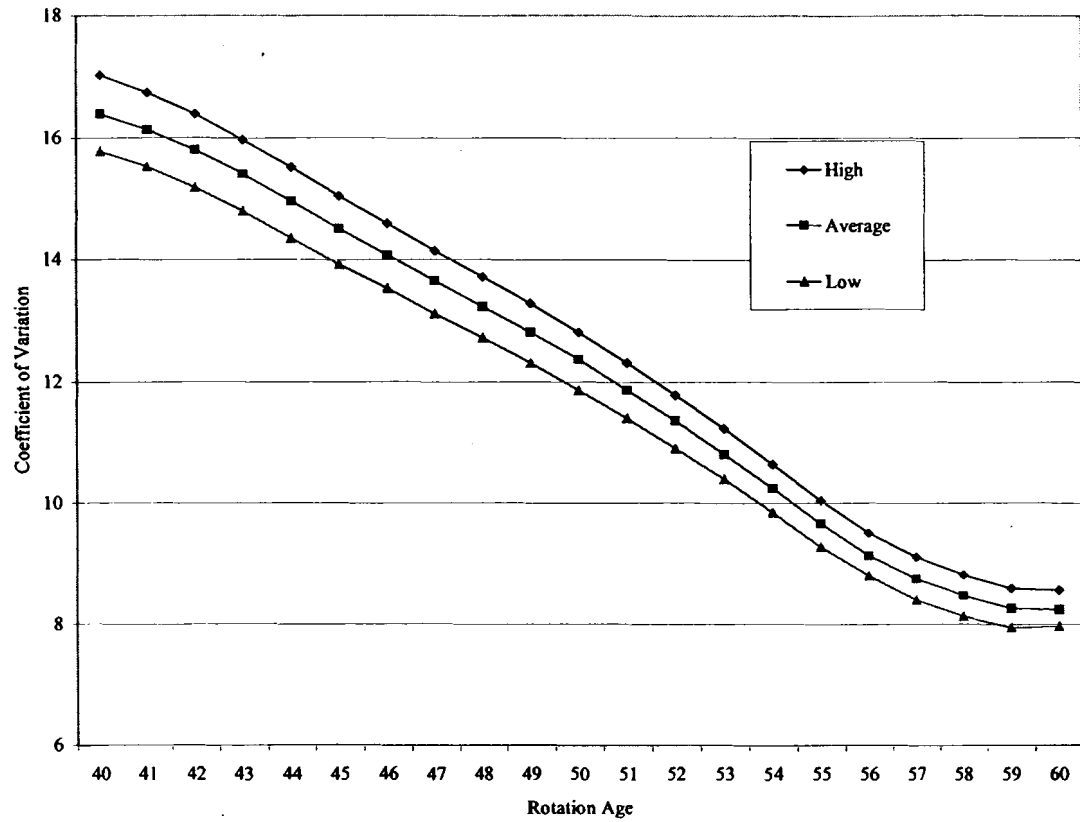


Figure 14. The impact of property taxes on volatility in IRR for white pine sawlogs in Maine for selling years 1960-1999.

Property taxes had a different impact on spruce-fir pulpwood. The middle rotation ages had the highest IRR but not the highest volatility. The shortest rotation ages had the highest volatility and the longest rotation ages had the smallest volatility. The difference in volatility between the high and low taxes was greatest in the earlier rotation ages. At rotation age 40, the difference in volatility between the high and low property taxes was 280 basis points and at rotation age 60, the difference narrowed to 108 basis points. Figure 15 shows the graph for spruce-fir pulpwood.

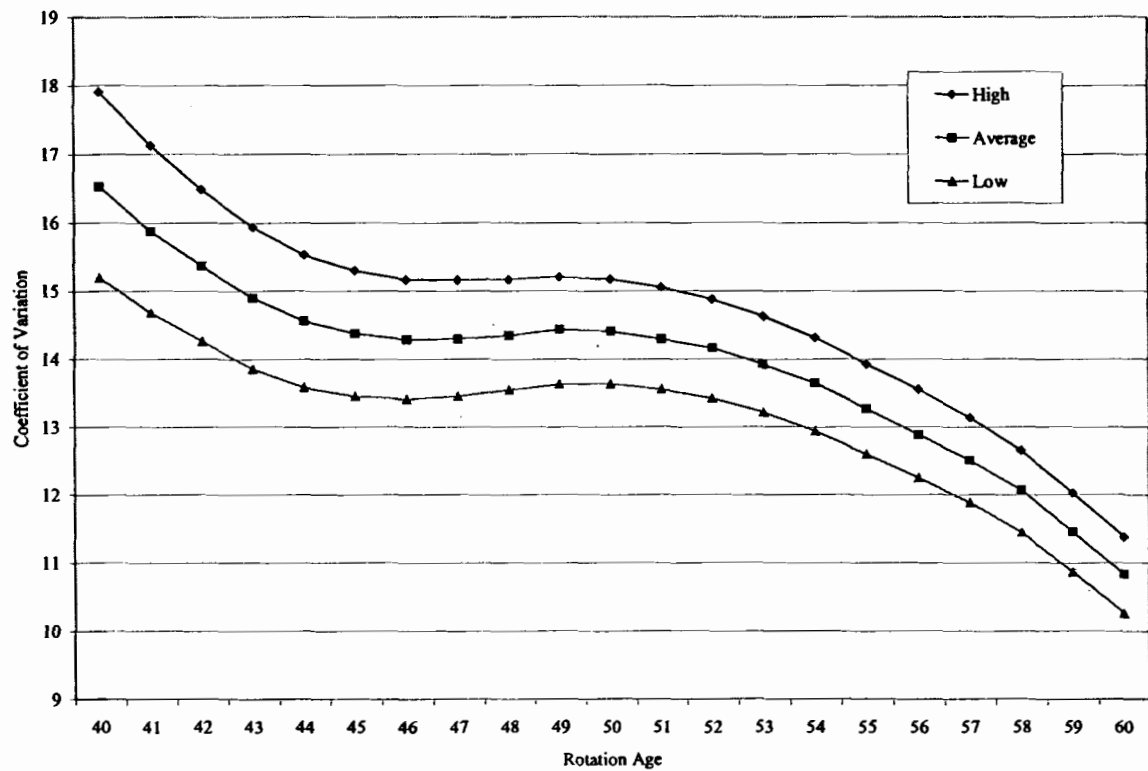


Figure 15. The impact of property taxes on volatility in IRR for spruce-fir pulpwood in Maine for selling years 1960-1999.

Income Taxes

The impact of income tax on the volatility in IRR was extremely small. The difference between the high and low taxes for white pine sawlogs was only .33 basis points at rotation age 40 and dropped to 16 basis points at rotation age 60. The highest income tax bracket had the largest volatility, although this was due to the fact that the lowest income tax bracket had a higher mean IRR for each rotation age and this lowered the coefficient of volatility. Looking at just the standard deviation, the lowest income tax bracket had the highest standard deviation and the average income tax bracket had the lowest standard deviation, although the standard deviation was almost identical for all three income tax scenarios. Figure 16 depicts the graph of the coefficient of variation for white pine sawlogs.

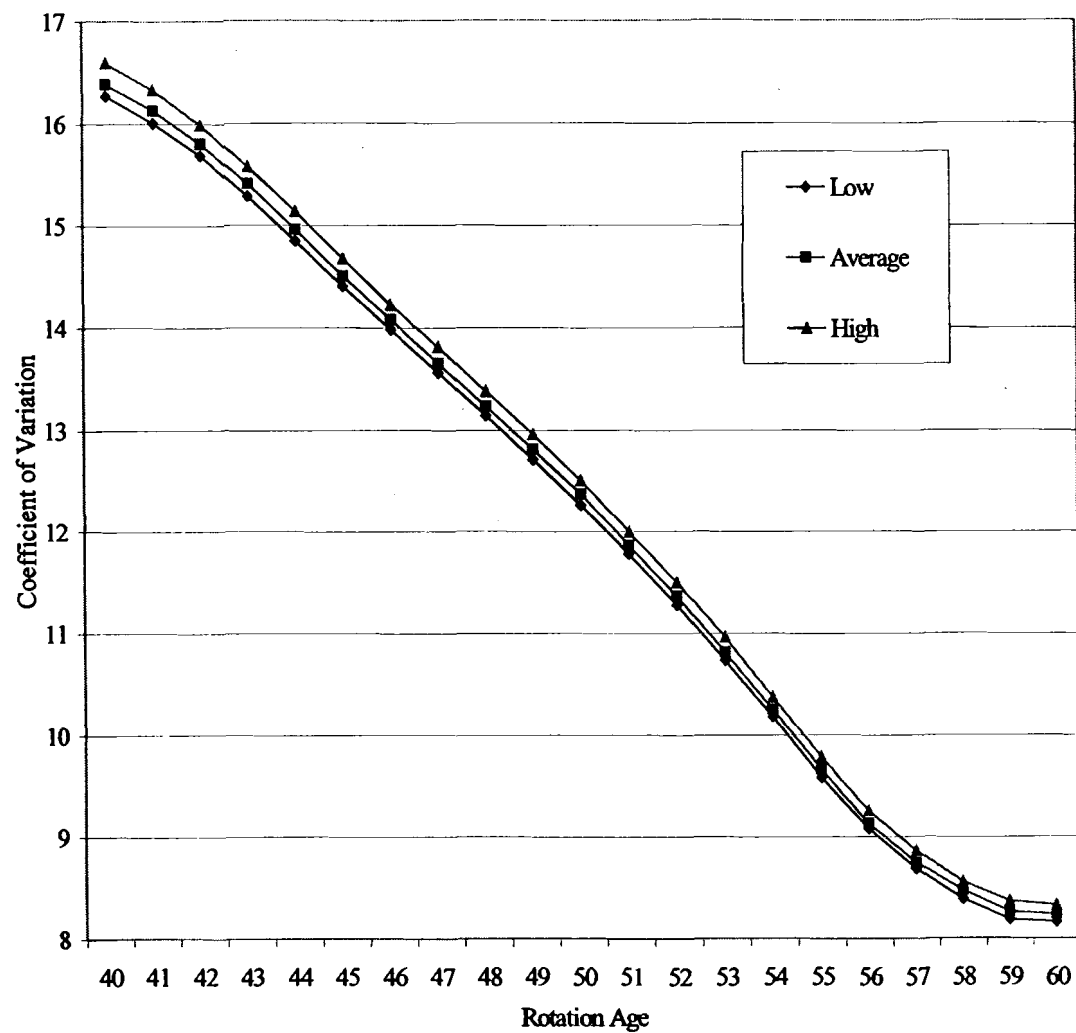


Figure 16. The impact of income tax on volatility in IRR for white pine sawlogs in Maine for selling years 1960-1999.

The impact of income taxes on the volatility for spruce-fir pulpwood was similar to the volatility for white pine sawlogs. Both started out with a volatility between 16-17 percent at rotation age 40 and both showed very little difference in volatility between the high and low tax brackets. One difference was that at age 60, the volatility for white pine sawlogs dropped to less than nine percent and the volatility for spruce-fir dropped to less than 11 percent. The difference in volatility between the tax brackets was small. At rotation age 40, the difference in volatility between the high and low tax brackets was just 70 basis points and at rotation age 60 the difference dropped to 28 basis points. Looking at the volatility for spruce-fir pulpwood, the highest tax bracket had the highest volatility, just like white pine sawlogs. Unlike white pine sawlogs, the standard deviation was the largest in the highest tax bracket and smallest in the lowest tax bracket. Figure 17 shows the volatility in IRR due to income taxes for spruce-fir pulpwood.

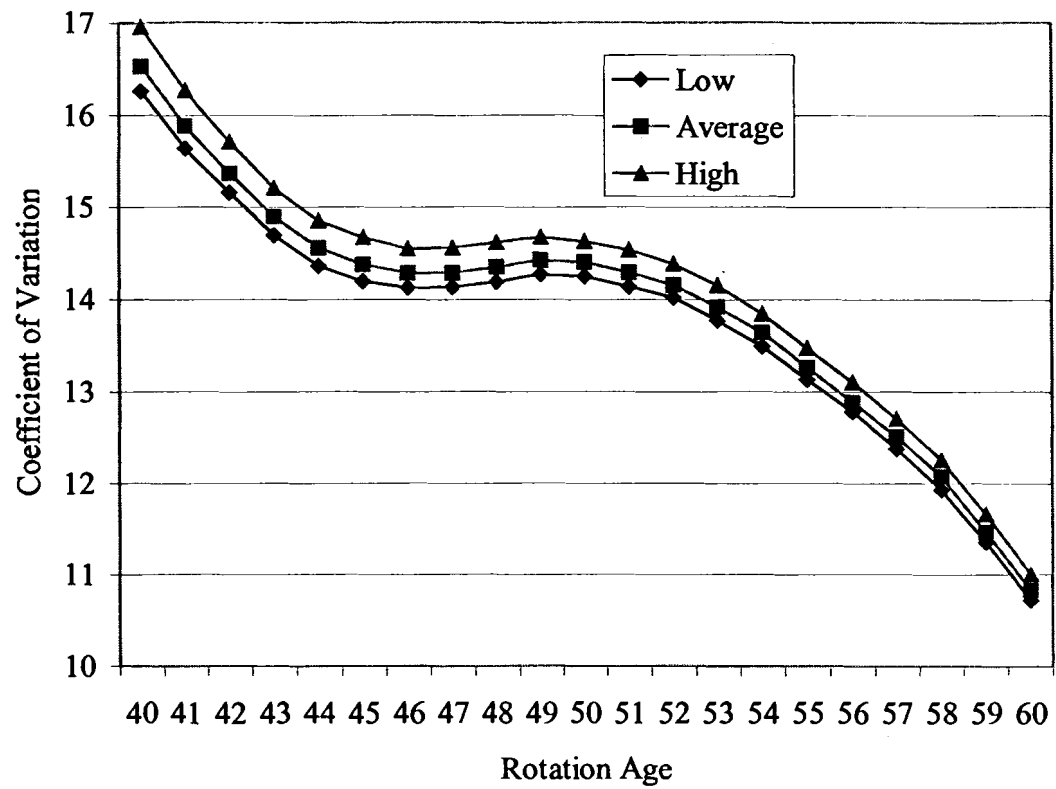


Figure 17. The impact of income tax on volatility in IRR for spruce-fir pulpwood in Maine for selling years 1960-1999.

Discussion

Historical Rates of Return

This study illustrates the benefits of managing for quality and diversity. Figure 18 shows the real prices for six species-product combinations from 1960-1999. In every year, the real prices for sawlogs were higher than for pulpwood. Managing for high quality trees will generally bring a higher price than managing for low quality trees. The graph also depicts the importance of managing for diversity. In 1960, the stumpage prices for spruce-fir sawlogs, white pine sawlogs, and oak sawlogs were almost the same. A landowner who chose to grow just white pine sawlogs would have missed out on the great returns from oak. Since predicting future stumpage prices is difficult, one solution is to manage for diversity.

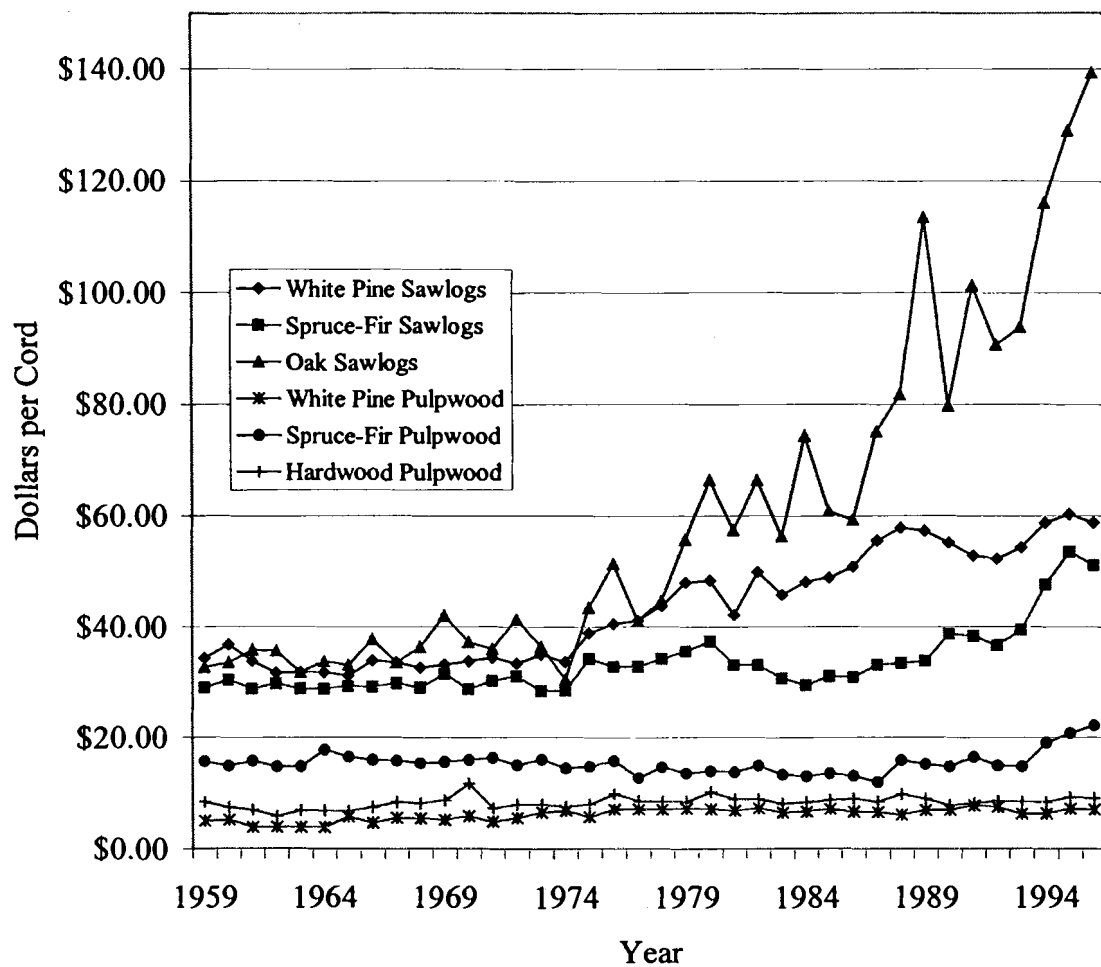


Figure 18. Changes in Maine stumpage in real dollars per cord from 1960-1998.

Internal Rates of Return and Volatility

From the results of this study, it seems that the real rates of return for white pine sawlogs and spruce fir pulpwood are competitive with other investments. The rates of return for stumpage may be lower than the returns for stocks and bonds, but the volatility is also much lower. While the returns on white pine sawlogs and spruce fir pulpwood do not include annual management costs or excise taxes, they do include income taxes whereas the returns from Ibbotson and Sinquefeld are all pre-tax. The returns on all the investments would be lower if the traditional investments were after-tax and the white pine and spruce-fir returns included annual management costs and excise taxes. If the stumpage returns included management costs and the traditional investments included income taxes, the white pine IRR is likely to be similar to large company stocks while the spruce-fir IRRR would be similar or slightly worse than the bonds. The timber investments would still offer far lower volatility. Table 2 shows the average real rates of return and volatility for investments in stocks, bonds, treasury bills, white pine sawlogs in Maine, and spruce-fir pulpwood in Maine from 1960-1999. The information about stocks and bonds came from Ibbotson and Sinquefeld (2000).

Table 2. A comparison of average real rates of return and volatility from various investments 1960-1999.

Investment	Real Rate of Return (%)	Coefficient of Variation (%)
White pine sawlog	8.32	11
Spruce-fir pulpwood	5.25	12
Large company stocks	8.78	181
Small company stocks	12.24	197
Long-term corporate bonds	3.30	352
Long-term government bonds	3.11	389
Intermediate government bonds	3.34	214
U.S. treasury bills	1.48	151
Note: White pine and spruce fir returns do not include management costs and remaining investments are all pre-tax and fees.		

White pine sawlogs and spruce-fir pulpwood had average rates of return comparable to bonds and treasury bills. White pine sawlogs and spruce-fir pulpwood had rates of return lower than small company stocks, but the volatility was also much higher on small company stocks. From 1960-1999, white pine sawlogs and spruce-fir pulpwood stumpage saw fairly steady rates of return, while the rates of return for large and small company stocks ranged from highs of 50 percent to lows of -36 percent. Figure 19 shows the average annual rates of return for investments in large and small company stocks, white pine sawlogs and spruce-fir pulpwood. The graph shows the volatility of stocks compared with Maine stumpage.

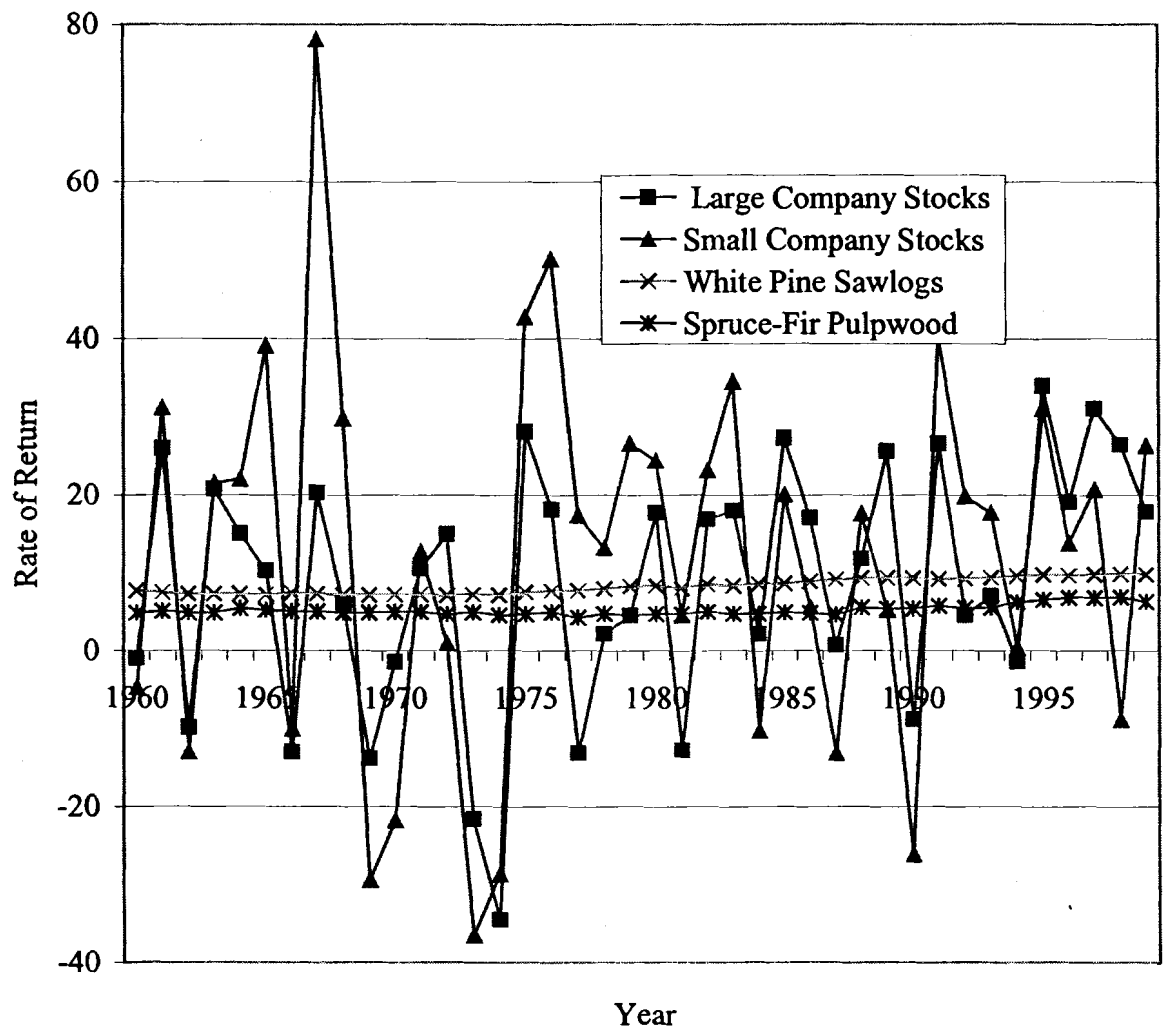


Figure 19. A comparison of real rates of return from investments in stocks and Maine stumpage from 1960-1999.

Long-term corporate and government bonds, intermediate government bonds and U.S treasury bills were also very volatile. They did not vary as much as stocks but still varied much more than white pine sawlog and spruce-fir pulpwood stumpage. From 1960-1999, the return on white pine sawlogs in Maine varied from a high of 9.88 percent to a low of 7.18 percent and spruce-fir pulpwood varied from a high of 6.91 percent to a low of 4.34 percent. During that same time period, long-term and intermediate bonds varied from a high of 37.25 percent to a low of -15.43 percent. Treasury bills varied from a high of 6.42 percent to a low of -3.74 percent. The graph of the average real rates of return for bonds, treasury bills, and Maine stumpage from 1960-1999 is shown in Figure 20.

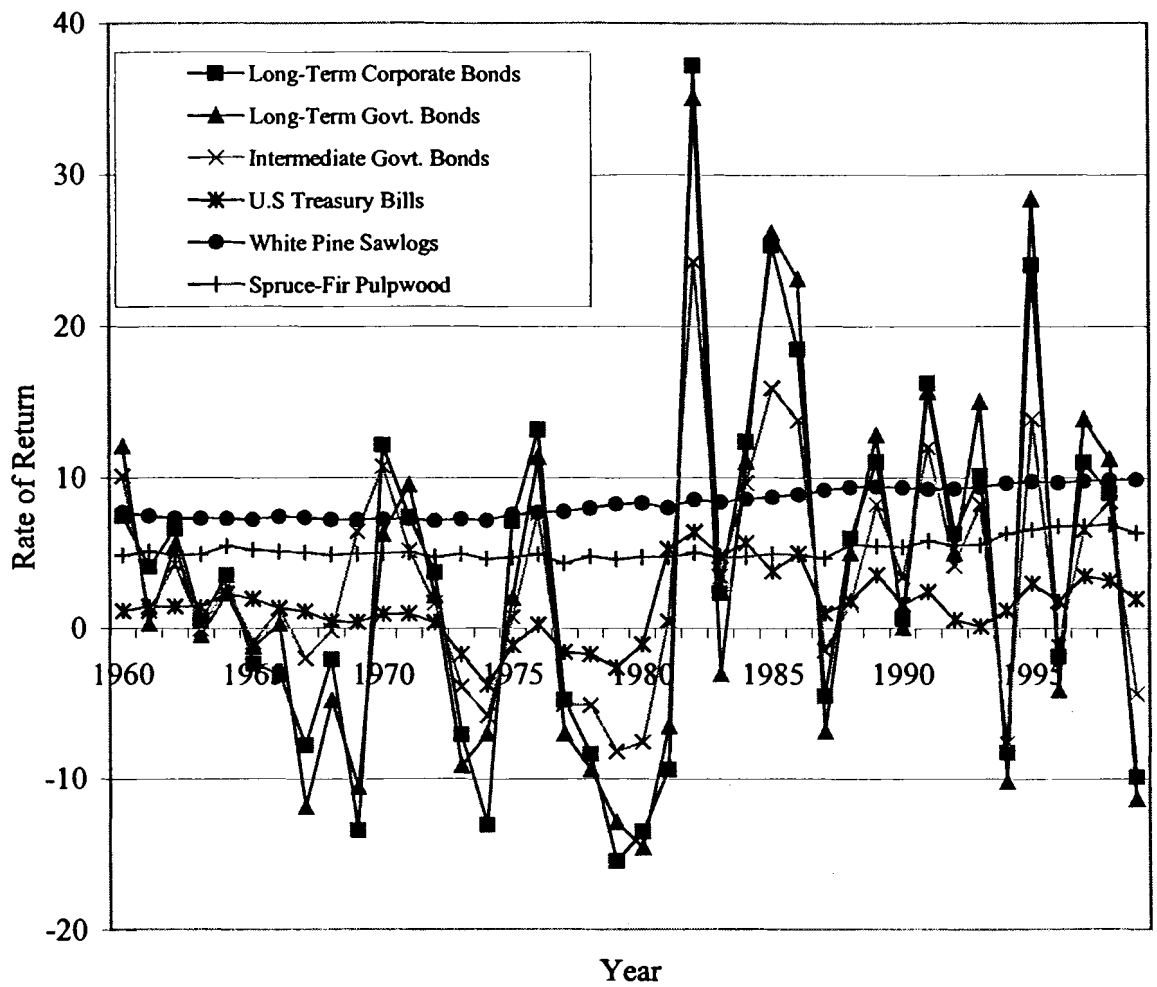


Figure 20. Average annual real rates of return from investments in Maine stumpage, bonds, and treasury bills from 1960-1999.

Real rates of return for white pine sawlogs and spruce-fir pulpwood stumpage appear to be competitive with alternative investments. The occasional lower rates of return were made up for in the lower volatility in stumpage. The biggest advantage of other investments is the ease of liquidation.

PART TWO-TIMBERLAND STUDY

Methods

Data Source

All the data for Part Two of this thesis were obtained from unpublished reports from a private landowner in the NY/New England area. Data and results are reported as per acre figures. The income was all from timber. Income from camp leases, gravel sales or other income was not included. The costs included property and excise taxes, forestry expenses (mapping, inventory, etc.), road maintenance, office expenses, salaries, outside professional services (legal, consultants, etc.), depreciation, and depletion. The market values were based on sales of similar timberland properties in each year.

The returns for stocks, bonds, and treasury bills were obtained from Ibbotson and Sinquefeld (2000). Information on the TPI was obtained from Caulfield (1999) and

Lutz (1999). Data for the NCREIF were obtained from Hancock Timber Resource Group (1999).

Methodology

For the second part of this study, the data were analyzed using Microsoft Excel. The first objective was to determine the rates of return for the forestland. Since the property had received only two appraisals in the past 30 years, the value of the land was determined by using average per acre timberland values for similar properties in the New York/New England region. The 28 average market values are no more significant than the two estimates from appraisals. All 30 values are based on analysis of similar market transactions.¹

The final objectives were to compare the real rates of return and risk with other investments. This was done using data published by Ibbotson and Sinquefield, the NCREIF Timberland Index, and the TPI. Ibbotson and Sinquefield (2000) described a method for calculating beta using historical data. Using this method, the beta was determined by carrying out the following regression analysis:

¹ Data on market values provided by Dr. Bret Vicary (2001) at James Sewall Company; Old Town, Maine.

$$(r_a - r_f) = \alpha_a + \beta_a (r_m - r_f) + \varepsilon_a$$

Where:

r_a = return on the asset

r_f = expected return on the riskless asset

r_m = return on the market

α_a = regression constant term

β_a = the beta of asset

ε_a = the regression error term

The regression was performed using the annual returns from 1970-1999.

Results

Rates of Return

Part two of this study looked at an actual forestland ownership in the New York/New England region. The first objective was to determine the rates of return to the forestland. The reported rates of return are all nominal, pre-income tax, IRR. The average annual rates IRR varied from a high of 24.62 percent to a low of -4.93 percent.

Table 3. Nominal, Before-Tax, IRR for a Timberland Property in New York/New England from 1970-1999.

	From:															
To:	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	
1971	7.82%															
1972	4.11%	1.03%														
1973	5.10%	4.03%	7.67%													
1974	4.48%	3.55%	5.12%	3.82%												
1975	6.05%	5.74%	7.58%	8.18%	15.85%											
1976	7.82%	7.93%	9.93%	11.16%	16.69%	19.39%										
1977	8.15%	8.30%	9.99%	10.94%	14.55%	14.79%	12.76%									
1978	7.33%	7.34%	8.58%	9.04%	11.21%	10.23%	6.98%	2.91%								
1979	8.80%	9.00%	10.34%	11.05%	13.26%	13.04%	11.77%	12.09%	23.99%							
1980	10.00%	10.32%	11.69%	12.51%	14.66%	14.78%	14.26%	15.34%	23.15%	24.62%						
1981	9.22%	9.43%	10.54%	11.11%	12.72%	12.48%	11.59%	11.70%	15.46%	12.36%	3.07%					
1982	8.27%	8.37%	9.26%	9.61%	10.81%	10.32%	9.20%	8.79%	10.79%	7.24%	0.25%	-1.45%				
1983	8.22%	8.31%	9.11%	9.41%	10.46%	9.98%	8.97%	8.59%	10.15%	7.31%	2.61%	2.94%	7.82%			
1984	7.70%	7.74%	8.42%	8.63%	9.48%	8.94%	7.92%	7.44%	8.52%	5.94%	2.11%	2.15%	4.14%	0.03%		
1985	6.84%	6.80%	7.36%	7.45%	8.10%	7.47%	6.39%	5.77%	6.44%	3.96%	0.54%	0.19%	0.83%	-2.77%	-4.93%	
1986	7.07%	7.05%	7.59%	7.69%	8.32%	7.76%	6.82%	6.31%	6.97%	4.92%	2.19%	2.23%	3.25%	1.57%	2.67%	
1987	6.85%	6.82%	7.31%	7.38%	7.93%	7.38%	6.48%	5.99%	6.54%	4.69%	2.32%	2.38%	3.22%	1.95%	2.81%	
1988	6.67%	6.64%	7.08%	7.13%	7.63%	7.09%	6.24%	5.77%	6.24%	4.56%	2.47%	2.54%	3.27%	2.26%	2.99%	
1989	6.54%	6.50%	6.91%	6.94%	7.39%	6.87%	6.07%	5.63%	6.04%	4.50%	2.63%	2.71%	3.37%	2.54%	3.18%	
1990	6.26%	6.20%	6.57%	6.58%	6.98%	6.47%	5.69%	5.24%	5.59%	4.15%	2.43%	2.48%	3.02%	2.27%	2.75%	
1991	5.90%	5.82%	6.15%	6.13%	6.48%	5.96%	5.19%	4.74%	5.02%	3.65%	2.04%	2.05%	2.48%	1.76%	2.10%	
1992	5.82%	5.74%	6.05%	6.03%	6.35%	5.85%	5.12%	4.69%	4.95%	3.68%	2.20%	2.22%	2.63%	1.99%	2.33%	
1993	5.87%	5.80%	6.10%	6.08%	6.38%	5.91%	5.23%	4.84%	5.08%	3.91%	2.55%	2.61%	3.01%	2.48%	2.83%	
1994	6.00%	5.94%	6.24%	6.23%	6.53%	6.09%	5.45%	5.09%	5.34%	4.26%	3.02%	3.10%	3.52%	3.08%	3.46%	
1995	6.18%	6.13%	6.42%	6.42%	6.72%	6.32%	5.72%	5.40%	5.66%	4.65%	3.51%	3.63%	4.06%	3.70%	4.11%	
1996	6.39%	6.35%	6.65%	6.66%	6.96%	6.58%	6.03%	5.74%	6.00%	5.08%	4.03%	4.17%	4.62%	4.32%	4.75%	
1997	6.54%	6.51%	6.80%	6.82%	7.11%	6.76%	6.24%	5.97%	6.24%	5.37%	4.40%	4.56%	5.01%	4.76%	5.19%	
1998	6.57%	6.54%	6.82%	6.84%	7.13%	6.79%	6.30%	6.04%	6.30%	5.48%	4.56%	4.72%	5.15%	4.93%	5.35%	
1999	6.43%	6.40%	6.66%	6.68%	6.95%	6.61%	6.12%	5.87%	6.11%	5.31%	4.43%	4.57%	4.97%	4.75%	5.13%	

	From:													
To:	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1986	11.14%													
1987	7.04%	3.34%												
1988	5.86%	3.44%	3.68%											
1989	5.39%	3.61%	3.82%	4.65%										
1990	4.43%	2.86%	2.75%	2.62%	1.78%									
1991	3.37%	1.92%	1.60%	1.12%	-0.04%	-1.24%								
1992	3.46%	2.25%	2.06%	1.82%	1.27%	1.32%	4.91%							
1993	3.90%	2.92%	2.87%	2.84%	2.68%	3.20%	6.00%	8.38%						
1994	4.49%	3.70%	3.77%	3.90%	4.00%	4.73%	7.17%	8.98%	11.41%					
1995	5.11%	4.47%	4.64%	4.88%	5.13%	5.96%	8.14%	9.70%	11.30%	13.20%				
1996	5.74%	5.22%	5.45%	5.78%	6.13%	7.01%	9.00%	10.42%	11.74%	12.93%	14.40%			
1997	6.14%	5.70%	5.97%	6.32%	6.70%	7.55%	9.33%	10.54%	11.57%	12.30%	12.72%	12.84%		
1998	6.24%	5.85%	6.11%	6.44%	6.79%	7.55%	9.09%	10.06%	10.80%	11.14%	11.02%	10.22%	10.70%	
1999	5.95%	5.56%	5.77%	6.05%	6.33%	6.95%	8.22%	8.92%	9.33%	9.30%	8.73%	7.42%	6.22%	3.84%

Table 3 shows the IRR between all possible years from 1970-1999. The IRR between 1970-1999 was 6.43 percent. The highest IRR occurred from year 1979-1980 and the lowest IRR occurred from year 1984-1985. The higher IRR in 1979-1980 is due to a temporary increase in timberland prices.² During that time, Brown Company sold their timberland in three New England states. Boise Cascade, James River, and International Paper were all competing aggressively for the land.

Component Analysis

The rates in Table 3 were calculated as nominal rates of return in order to allow for easy comparison with common timberland indexes and other published returns. The individual components of the ownership were all compared in real dollars to look at the historical changes not due to inflation. Figure 21 shows the real, annual, dollar per acre cost, revenue, and asset value from 1970-1999 for the timberland ownership in New York/New England. The Primary Y-Axis is the cost and revenue per acre. The Secondary Y-Axis is the asset value per acre.

² This emphasizes the overwhelming positive influence of buying low and selling high.

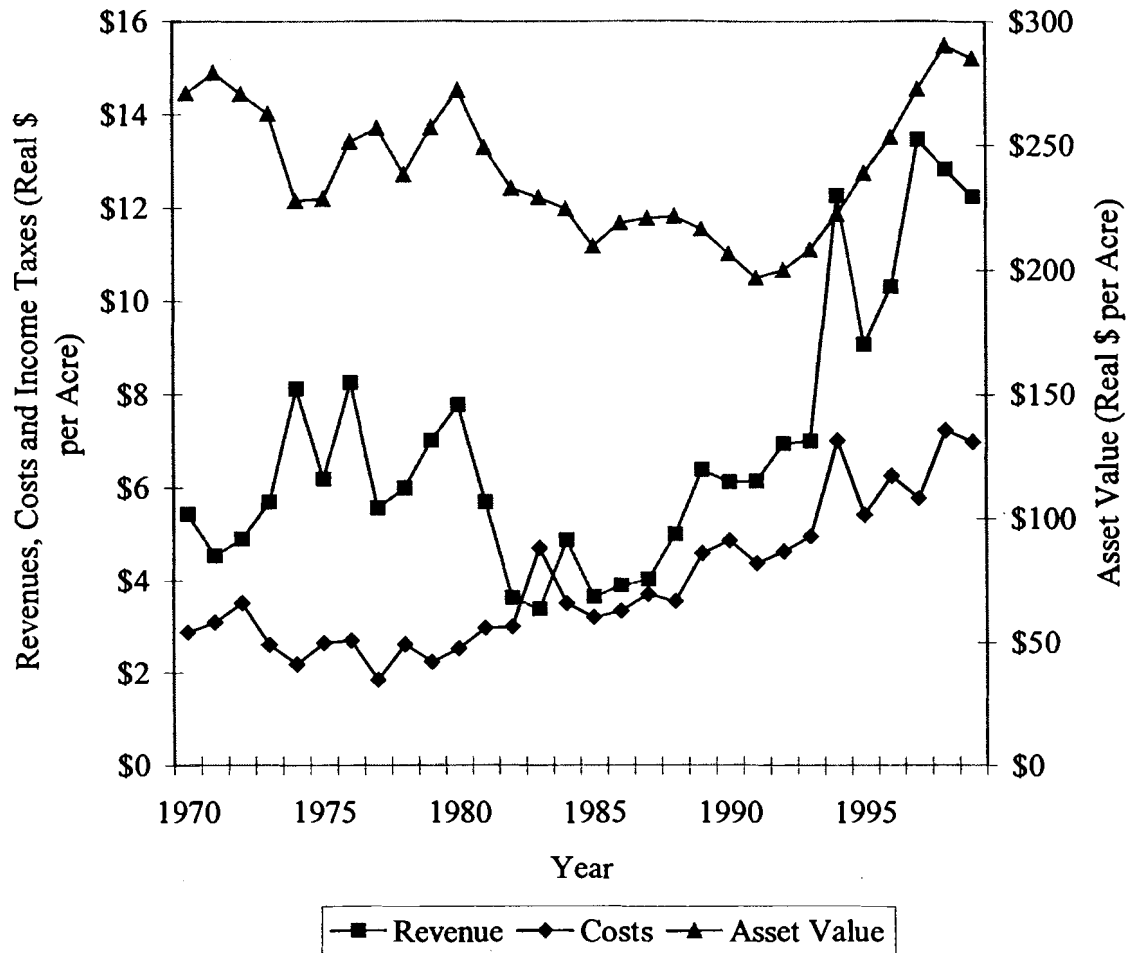


Figure 21. Real annual per acre cost, revenue and asset value on an actual timberland ownership in New York/New England from 1970-1999.

The coefficients of variation for the three components ranged from 11 to 41. The least volatile component was the asset value, which ranged from a high of \$290 per acre in 1998 to a low of \$197 per acre in 1991. Costs and revenues had similar volatility. Table 4 shows the average dollar per acre and coefficient of variation for the three components.

Table 4. Average dollar per acre and coefficient of variation for three components of an actual timberland investment in New York/New England from 1970-1999.

Component	Average (per Acre)	Coefficient of Variation (%)
Costs	\$3.97	39
Revenues	\$6.88	41
Asset Value	\$240.55	11

Alternative Investments

The rates of return on this piece of forestland have been on average less than the rates of return generated by stocks and bonds (Table 5), but the volatility has been slightly lower. From 1971-1999, small company stocks ranged from a high nominal pre-tax IRR of 57 percent in 1976 to a low of -31 percent in 1973. The average annual rate of return for large company stocks from 1970-1999 was 10.81 percent, but the coefficient of variation was 140. During the same period, the New

York/New England timberland had an average annual rate of return of 7.84 percent but a coefficient of variation of just 93. Table 5 shows the average annual rates of return from 1971-1999 and the coefficients of variation.

Table 5. Average Annual Nominal Pre-Tax IRR for Various Investments from 1971-1999.

Investment	IRR (%)	Coefficient of Variation (%)	Range (%)
A Private New York/New England Timberland Ownership	7.84	93	-5 to 25
Large Company Stocks	10.81	140	-26 to 31
Small Company Stocks	17.60	126	-31 to 57
Long-Term Govt. Bonds	11.69	136	-9 to 65
Intermediate-term Govt. Bond	8.61	80	-5 to 29
Treasury Bills	6.73	40	3 to 15

From Table 5, it is clear that although the average IRR for the private landowner was lower than stocks and bonds, the coefficient of variation was also lower. The only coefficients of variation that were lower than the timberland investment were the intermediate-term government bonds and U.S. treasury bills. The lower coefficient of variation for U.S. treasury bills was also accompanied by a lower IRR than the

private timberland investment. The only investment that had both a higher IRR and a lower coefficient of variation was intermediate-term government bonds.

Beta

Another way to calculate the volatility is to look at the beta for the investment. Beta measures the volatility of the market compared with the volatility to the asset's returns. An asset with a beta of 1.0 is as risky as the overall stock market and should provide returns to investors equal to the market. If the beta of the asset is greater than 1.0, the asset is riskier than the stock market and should provide higher returns. A beta of 2.0 means that, on average, the asset should rise (or fall) twice as much as the overall stock market during periods of rising (falling) stock prices. An asset with a beta of less than 1.0 means the asset has returns and risk levels lower than that of the overall stock market. A negative beta means the asset has patterns counter-cyclical to the stock market. In general, beta is a measure of an expected future value. Expected beta is not observable in the market, but is estimated using historical data. In general, the overall stock market is measured using the S&P 500 and the riskless asset is measured using treasury bills. Wagner, Cubbage, and Redmond (1995) did a survey of betas for forestland in Georgia, Louisiana, Wisconsin, Northern New Hampshire, and national forest sawtimber. They found betas for the years 1990-1995 from -0.936 for oak sawtimber on national forests to 0.159 for spruce pulpwood in Wisconsin. For this study, the beta for the private

forestland ownership was 0.07 from 1971-1999. When the beta was calculated for the years 1990-1999 it was -0.21. This result was similar to Wagner, Cubbage and Redmond's results for New Hampshire. They found a beta of 0.0687 for spruce and fir pulpwood and a beta of -0.334 for hemlock and pine pulpwood. So, although the average annual pre-tax returns to the timberland investment were lower than the returns to the S&P 500, the beta was lower and in some cases even negative. The Counter-cyclical pattern makes timberland attractive for portfolio diversification, which has been its greatest selling point to TIMOs.

Timberland Indexes

The third objective of part two of this study was to compare the rates of return for the private timberland investment with timberland indexes. The two most common timberland indexes are the NCREIF and the TPI. Both indexes have limitations. The biggest limitation with the TPI is that it covers mostly the Southern United States.

The NCREIF has returns for the Northeast since only 1994. Prior to 1994, the timberland returns for the Northeast were calculated using the John Hancock Timber Index (JHTI). The JHTI historical returns were based on timberland values in Northern New York and New England. This further complicates the index because, since 1994, the properties in New York and Pennsylvania have had a large impact on the rates of return. According to Lutz (1999), one large timberland transaction in 1998 caused a tremendous jump in the total market value of the properties. In 1999,

about 60 percent of the market value of the Northeast NCREIF properties was located in Pennsylvania and New York. The large Pennsylvania property was withdrawn from the NCREIF in 2000 and won't be part of the index in the future.

The NCREIF historical returns compiled by Hancock Timber Resource Group (1999) were compared with the private timberland considered in this study. The historical returns were developed for the years 1960-1999 using the JHTI. The results showed that a portfolio containing a mix of timberland from the South, Northeast, and the Pacific Northwest provided the best combination of high returns and low standard deviation. Figure 22 compares the NCREIF returns and the private northeast timberland from 1970-1998. The NCREIF Northeast is only from 1994-1998.

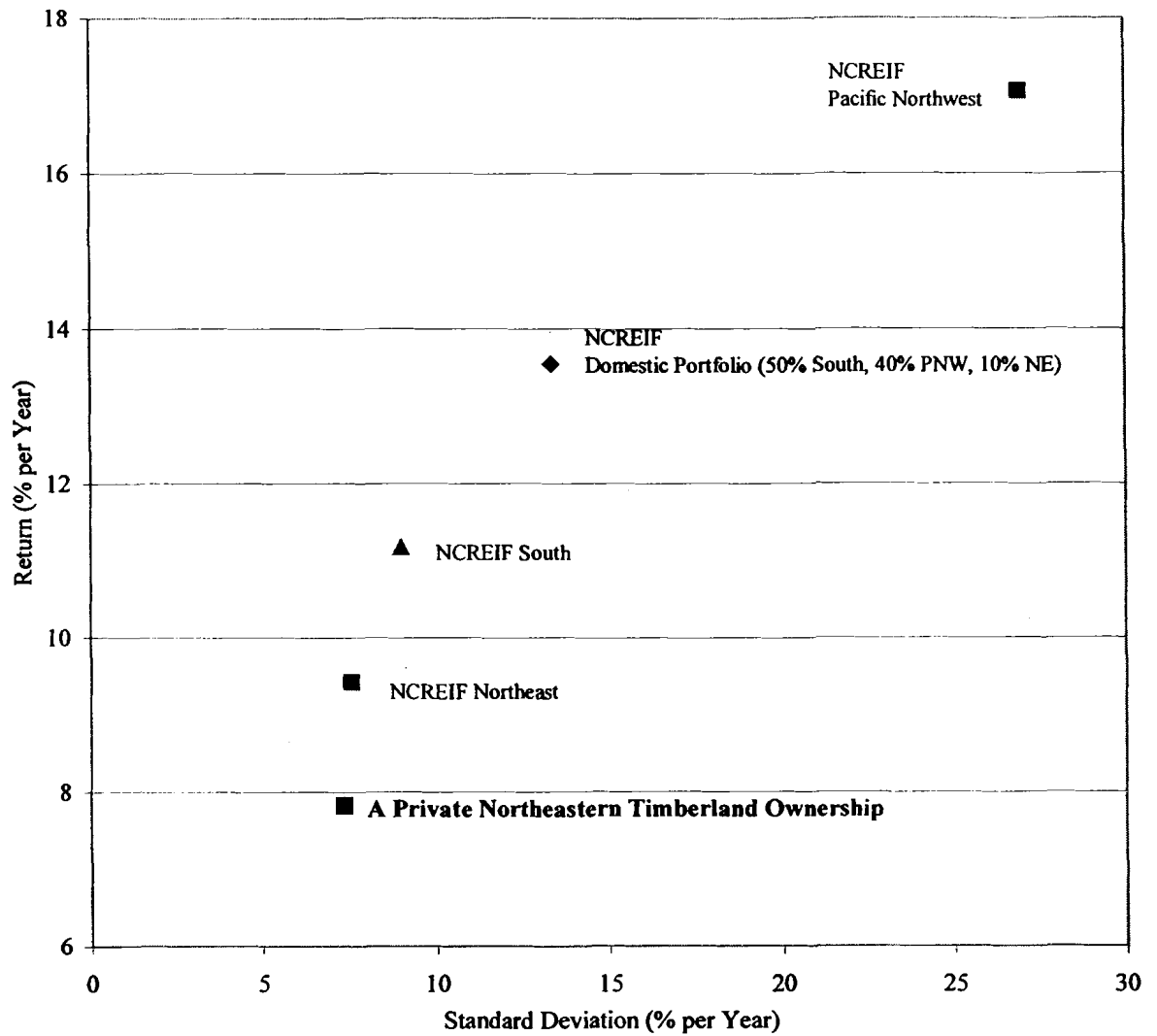


Figure 22. Average annual regional returns and standard deviation for United States timberland from 1970-1998

Starting in 1991, the NCREIF calculated the returns and standard deviations for two international locations, New Zealand and British Columbia, Canada. The international timberland returns tended to have a higher than average standard deviation combined with lower returns. New Zealand had both lower returns and a higher standard deviation than the private northeast timberland property. From 1991-1998, New Zealand had 6.32 percent returns and 18.54 percent standard deviation. During that same period, the private northeast timberland property had returns of 9.33 percent and a standard deviation of 5.22 percent. The property in British Columbia had higher returns but a much higher standard deviation. From 1991-1998, British Columbia averaged returns of 11.61 percent but the standard deviation was 21.53 percent. Figure 23 shows the returns and standard deviations from 1991-1998 for the domestic regions, international locations, and the private northeastern timberland.

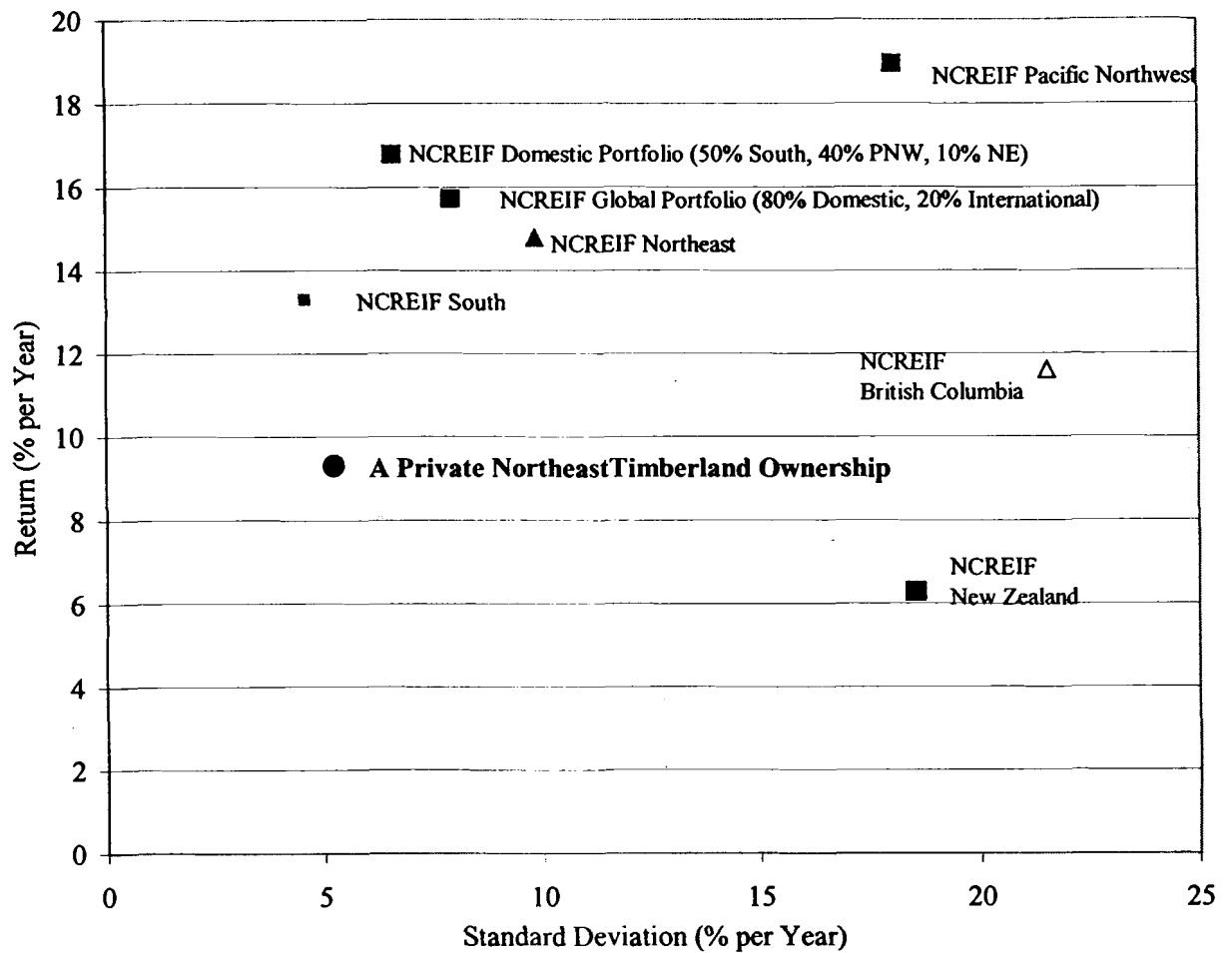


Figure 23. Average annual rate of return and standard deviation for regional and global timberland from 1991-1998.

Figure 23 shows that the best selection for high returns and low standard deviation was the domestic portfolio, with the global portfolio close behind. The domestic portfolio had returns of 16.81 percent and a standard deviation of 6.58 percent. The global portfolio was similar, with returns of 15.75 percent and a standard deviation of 7.92 percent. Together they show the benefits of geographic diversification.

The TPI contains only southern timberland but has been published since 1981. From 1981 to 1998 the average returns were 11.79 percent and the standard deviation was 7.1 percent. This number was similar to the NCREIF returns for the south, but was not comparable to the Northeast since the TPI only looked at timberland in the Southeast.

Discussion

Rates of Return

The table showing the IRR between any two (Table 3) years has a noticeable peak in 1979 to 1980 and then a sharp drop off from 1981-1982. From 1981-1985, the low returns were likely due to an increase in money spent on spruce budworm spraying. In addition, the amount spent on salaries, forestry expenses and other expenses

doubled from 1980 to 1981 while the cords harvested dropped almost in half from 1980-1982. The timber income started increasing again in the late 1980's.

Component Analysis

The graph of the individual components (Figure 21) showed the most volatility in revenues and costs. The sharp peak in the asset value in the early 1980's matched the peak in the rates of return for that year.

Alternative Investments and Beta

From 1970-1999, the timber property examined in Part Two of this study was competitive with other investments. Although the rates of return were lower than alternative investments in stocks and bonds, the coefficient of variation was also lower. The only investment that had a lower coefficient of variation and a higher return was intermediate-term government bonds. The beta for the northeast timberland investment proves what a good addition timber is to an investment portfolio. The beta from 1971-1999 was only 0.07, meaning that the investment in timber was much less risky than an investment in the S&P 500. From 1990-1999 the timberland beta was actually negative, meaning that the northeast timberland property was actually moving counter-cyclically to the S&P 500, making it a good addition to a portfolio comprised mostly of traditional investments.

Timberland Indexes

From this study, it is clear that the timberland property studied was not comparable to any currently available timberland indexes. The TPI is based in the southern United States and is therefore not comparable to the northeastern property studied. The NCREIF is based in the Northeast, but much of the asset value in the NCREIF is based on high-value properties in New York and Pennsylvania, so it is not comparable to the property studied. The most important thing to notice about the NCREIF is that, although the private Northeast timberland property studied had a lower rate of return than the NCREIF return for the Northeast, the private Northeast property also had a much lower coefficient of variation. Another important observation from the NCREIF is that the portfolios with a mix of timber from all regions had the best combination of high returns and low standard deviation. Again, diversity was important. Owning timber in different regions is a good way to reduce the risk of a timber investment. For a small tradeoff in the annual rate of return, the result was a much lower risk.

LITERATURE CITED

- Baumgarten, D.C. and C.A. Hyldahl. 1991. Using price data to consider risk in the evaluation of forest management investments. Gen. Tech. Rep. NC-144. St. Paul, MN. USDA Forest Service. North Central Forest Experiment Station. 8p.
- Bentley, W.R. and F.H. Kaiser. 1967. Sequential decisions in timber management-a Christmas tree case study. *J. of Forestry*. 65(10): 714-719.
- Binkley, C.S. 1981. Duration-dependent discounting? *Can. J. Forest Resources*. 11(2): 454-56.
- Binkley, C.S. and C.L. Washburn. 1988. The financial risk of private timberland investments in South Carolina. SCFER Working Paper No. 69, Southeastern Center for Forest Economics Research, Research Triangle Park, NC.
- Brazee, R.J. and R. Mendelsohn. 1988. Timber harvesting with fluctuating prices. *Forest Science*. 34:359-72.
- Brealey, R. and S. Myers. 1981. Principles of corporate finance. McGraw-Hill Book Co. New York, NY. 847p.
- Bureau of Labor Statistics. 2000. Historical series. Producer Price Index-Finished Goods. Bureau of Labor Statistics. Washington, D.C.
- Caulfield, J.P. 1994. Assessing timberland investment performance. *Real Estate Review*. 24(1): 76-81.
- Caulfield, J.P. 1999. Timberland performance. *Timber Mart-South Market Newsletter*. 4th quarter 1999.
- Chambers, P.C., S. A. Sinclair, C.C. Hassler, and B.G. Hansen. 1986. Forest products investment model: a microcomputer tool for incorporating risk into capital budgeting. *Forest Products J.* 36(1): 64-68.
- Chang, S.J. 1980. Discounting under risk: comments on adjusting discount rates. *J. of Forestry*. 78(10): 634-635.
- Clutter, J.L. 1983. Timber management: a quantitative approach. Wiley, New York. 161p.

Conroy, R. and M. Miles. 1989. Commercial forestland in the pension portfolio. *Financial Analysts J.* 45(Sept.-Oct.): 46-54.

Cubbage, F.W., T.G. Harris, and C.H. Redmond. 1989. Measuring risk and returns of timber investments using the Capital Asset Pricing Model. Res. Rep. 562. The Georgia Agricultural Exp. Station. University of Georgia. 31p.

Cubbage, F.W. and C.H. Redmond. 1985. Capital budgeting practices in the forest products industry. *Forest Products J.* 35(9): 55-60.

Dennis, D.F. 1989. Trends in New Hampshire stumpage prices: a supply perspective. *Northern J. of Applied Forestry.* 6:189-190.

Dowdle, B. 1962. Investment Theory and Forest Management Planning. Yale University, School of Forestry. Bull. 67. 63p.

Englehard, R.J. and W.C. Anderson. 1983. A method of assessing risk in forestry investments. Research Paper, SO-189. USDA Forest Service. Southern Experiment Station. 13p.

Faustmann, M. 1849. On the determination of the value which forest land and immature stands possess for forestry. Oxford paper #42 in M. Gane, ed. Martin Faustmann and the evolution of discounted cash flow. 1968.

Flick, W.A. 1985. Economics of timer sale decisions. *Southern J. of Applied Forestry.* 9(August): 146-150.

Fortson, J.C. 1986. Factors affecting the discount rate for forestry investments. *Forest Products J.* 36(6): 67-72.

Fortson, J.C. and R.C. Field. 1979. Capital budgeting techniques for forestry: A review. *Southern J. of Applied Forestry.* 3(4): 141-143.

Foster, B.B. 1979a. Adjusting discount rates for forestry. *J. of Forestry.* 5:287-288.

Foster, B.B. 1979b. Multiple discount rates for evaluation of public forestry investments. *Forestry Chronicles.* 55(1): 17-20.

Hancock Timber Resource Group. 1999. Historical returns for timberland. Research Note 1. 12p.

Herrick, Owen W. 1984. Rate of value change in Pennsylvania timber stands. USDA Forest Service Res. Pap. NE-547. 5p.

Howard, T.E. and W.F Chase. 1995. Maine stumpage prices: characteristics and trends from 1963-1990. *Forest Prod. J.* 45 (1): 31-36.

Ibbotson R.G. and R.A. Sinquefield. 2000. *Stocks, Bonds, Bills and Inflation*. Financial Analysis Research Foundation, Charlottesville, Va.

Kingsley, N. P. and P.S. Debal. 1986. Hardwood lumber and stumpage prices in two eastern hardwood markets: the real story. Res. Pap. NE-601. USDA Forest Service, Northeastern Forest Experiment Station. 17p.

Konrad, G.D. and J.E. De Steiguer. 1983. Relationships between discount rates and investment lengths among nonindustrial private forest landowners. A Review of Economic and Policy Studies. Duke University School of Forestry and Environmental Studies. Durham, NC. P. 109-112.

Kuuluvainen, J. and O. Tahvonen. 1999. Testing the forest rotation model: evidence from the panel data. *Forest Science*. 45(4): 539-551.

Leak, W.B., P.H. Allen, J.P. Barrett, F.K Beger, D.L Mader, J.C. Mawson, and R.K Wilson. 1970. Yields of Eastern White Pine in New England Related to Age, Site, and Stocking. USDA Forest Service Res. Pap. NE-176. 15p.

Lebel and Carruth. 1997. Simulation of a woodyard inventory variations using a stochastic model. *Forest Products J.* 47(3): 52-57.

Lutz, J. 1999. Northeast timberlands. *Timberland Report*. James W. Sewall Company. 1(2). 4p.

Maine Forest Service. 1959-1999. *Stumpage Price Reports*. Maine Forest Service. Augusta, Maine.

Marty, R. 1964. Analyzing uncertain timber investments. Research Paper NE-23. U.SDA Forest Service, Northeastern Forest Experiment Station. 21p.

Mills, W.L. and W.L. Hoover. 1982. Investment in forestland: aspects of risk and diversification. *Land Economics*. 58(Feb): 33-51.

Redmond, C.H. and F.W. Cubbage. 1985. Capital budgeting practices in the forest products industry. *Forest Products J.* 35(9): 55-60.

Redmond, C.H. and F.W. Cubbage. 1988. Portfolio risk and returns from timber asset investments. *Land Economics*. 64(4): 325-337.

Remington, S.B. and D.F. Dennis. 1986. New Hampshire's stumpage and roadside prices: characteristics and trends. Research Note NE-332. USDA Forest Service Northeastern Forest Experiment Station. 8p.

Sendak, P.E. 1992. State and federal timber prices in Vermont. *Northern J. of Applied Forestry*. 9: 97-101.

Sendak P.E. and T.J. McEvoy. 1989. Recent trends in Vermont stumpage prices. *Forest Prod. J.* 39 (4):20-26.

Stevens, D.A. 1987. Rates of return to forestland in Maine-1961 to 1986. Unpublished M.S. Thesis. University of Maine, Orono, Maine. 134pp.

Tahvonen, O. and S. Salo. 1998. Optimal forest rotation with in situ preferences. *J. of Environ. Econ. Management*. 37: 106-128.

Taylor, S.E., M.H. Triche, D.A. Bender, and F.E. Woeste. 1995. Monte-Carlo simulation methods for engineered wood systems. *Forest Products J.* 45(7/8): 43-50.

Thompson, E.F. 1968. The theory of decision under uncertainty and possible applications in forest management. *Forest Science*. 14(2): 156-163.

Thomson, T.A. 1987. Financial risk and timber portfolios for some southern and Midwestern species. *Proceedings of the 1987 Joint Annual Meeting of the Southern Forest Economist Workers-Midwestern Forest Economists*. April 8-10, Asheville, NC: 46-55.

Thomson, T.A. and D.C. Baumgartner. 1988. Alternative specifications and solutions of the timber management portfolio problem. *Gen. Tech. Report*. RM-161. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: 123-130.

Thomson, T.A. 1991. Timber and financial asset portfolios: 1937-1986. *Proceedings of the 1991 Symposium on Systems Analysis in Forest Resources*. March 3-6, Charleston, SC: 217-224.

Wagner, J.E., F.W. Cubbage, and C.H. Redmond. Comparing the capital asset pricing model and capital budgeting techniques to analyze timber investments. *Forest Products J.* 45(7/8): 69-77.

Zinkhan, F.C. 1988a. Forestry projects, modern portfolio theory, and discount rate selection. *Southern J. of Applied Forestry*. 12(2): 132-135.

Zinkhan, F.C. 1988b. The term structure of interest rates and the evaluation of forestry investments: a note. *Southern J. of Applied Forestry*. 12(4): 256-258.

Zinkhan, F.C. and K. Mitchell. 1990. Timberland indexes and portfolio management. *Southern J. of Applied Forestry*. 14(3): 119-123.

APPENDICES

Appendix A. Visual Basic program to calculate internal rate of return to forestland in Maine from 1960-1999.

'FIRST FORM TO LOAD TO GET THE PATH OF THE DATABASE FILES
Option Explicit ' enforces declaration of variables

Public pathofdatabase1 As String ' path of databases Main and Yield
Public pathofdatabase2 As String

Private Sub Command1_Click()
' hide this form and load the single year calculation form as default
Form1.Hide
Form2.Show

pathofdatabase1 = Form2.Text1 & "Main.mdb"
pathofdatabase2 = Form2.Text1 & "Yield.mdb"

End Sub

Private Sub Form_Load()
Form2.Hide
Form1.Show
Form3.Hide
End Sub

'FOR MULTIPLE YEAR CALCULATIONS

Option Explicit ' forces declaration of variables

Public db1 As Database
Public db2 As Database

Public rstMain As Recordset
Public rstYield As Recordset

' constant of program
Const maindbheight As Integer = 99 '(100 records for main database)

Const yielddbheight As Integer = 20 '(21 records for yield database)

Dim pathofdatabase1 As String

Dim pathofdatabase2 As String

' Data base declaration for main database

Dim pyear(0 To maindbheight) As Double

Dim pppi(0 To maindbheight) As Double

Dim ppropertytaxes(0 To maindbheight) As Double

Dim pwpsawlogs(0 To maindbheight) As Double

Dim psfsawLogs(0 To maindbheight) As Double

' Data base declaration for Yield database

Dim page(0 To yielddbheight)

Dim pwhitepineyield(0 To yielddbheight)

Dim psprucefiryield(0 To yielddbheight)

' ---- tax constant

Dim capitalgaintax As Double

Dim taxrate As Double

Dim expensetax As Double

' real prices for the 2 species

Dim realpricewp(0 To maindbheight) As Double ' real WP price

Dim realpricesf(0 To maindbheight) As Double ' real SF price

Dim yieldwp(0 To yielddbheight) ' 21 values

Dim yieldsf(0 To yielddbheight) ' 21 values

Dim profitwp(0 To yielddbheight)

Dim profitsf(0 To yielddbheight)

Dim npvc(0 To yielddbheight) As Double

Dim npvrwp(0 To yielddbheight) As Double

Dim npvrsf(0 To yielddbheight) As Double

' r

Dim rincrement As Double

' real taxes

Dim realtaxes(0 To maindbheight) As Double ' real property taxes

Public Function findpower(r, powerindex)

' This function calculates $(1+r)^{\text{powerindex}}$

Dim powercalculated As Double

Dim i As Integer

If powerindex = 1 Then

 powercalculated = (1 + r)

Else

 powercalculated = 1

 For i = 1 To powerindex

```

    powercalculated = powercalculated * (1 + r)
Next

End If

findpower = powercalculated

End Function

'Run this sub on startup.
Private Sub Form_Load()
Form2.Hide
Form1.Show
End Sub

Public Sub convertprice(realpricewp, realpricesf)
' get real prices for wp and sf
Dim i As Integer ' counter for index array

For i = 0 To maindbheight

If pppi(i) = 0 Then
    realpricewp(i) = 0
    realpricesf(i) = 0
Else
    realpricewp(i) = pwpsawlogs(i) / pppi(i)
    realpricesf(i) = psfsawLogs(i) / pppi(i)
End If
Next

End Sub

Public Sub openthedatabase()
Set db1 = OpenDatabase(pathofdatabase1)
Set db2 = OpenDatabase(pathofdatabase2)
End Sub

Public Sub initialize()
' read the data from the database

Dim i As Integer ' index for array
' main database-----
With db1

    Set rstMain = .OpenRecordset("Main")

    'If rstMain.RecordCount = 0 Then Exit Sub
    With rstMain
        .MoveFirst

        For i = 0 To maindbheight

            pyear(i) = !Year

```

```

        pppi(i) = !ppi
        ppropertytaxes(i) = !propertytaxes
        pwpsawlogs(i) = !wpsawlogs
        psfsawLogs(i) = !sfsawlogs

        .MoveNext
    Next

    End With
End With

' Yield database ----

With db2

    Set rstYield = .OpenRecordset("Yield")

    'If rstMain.RecordCount = 0 Then Exit Sub
    With rstYield
        .MoveFirst

        For i = 0 To yielddbheight

            page(i) = !Age
            pwhitepineyield(i) = !WhitePineYield
            psprucefiryield(i) = !SpruceFirYield

            .MoveNext
        Next

    End With
End With

' initialize taxes
capitalgaintax = Text3.Text / 100
taxrate = Text4.Text / 100
expensetax = Text3.Text / 100

' initialize r
rincrement = Text9.Text

End Sub

Public Sub converttaxes(realtaxes)
Dim i As Integer ' counter for index array

For i = 0 To maindbheight
    realtaxes(i) = (ppropertytaxes(i) / pppi(i)) * (-1) * (1 - expensetax)
Next

End Sub

```

```

Private Sub mnuRun_Click()
If Check1 = vbChecked Then
    Open Form3.Text6 For Output As #1
End If

Dim selectedyear As Integer ' year selected by user
Dim selectedindex As Integer ' find index of array for year selected
Dim i As Integer ' counter for array
Dim icount As Integer ' count from 1 to 20

Dim selectedrealpricewp As Double ' selected real price in year harvested (WP)
Dim selectedrealpricesf As Double ' selected real price in year harvested for (SF)

Dim rmax As Double
rmax = Text11.Text

Dim r As Double

Const startyear As Integer = 1 ' start from 1940
Const endyear As Integer = 20 ' end at 1960

Dim yearcount1 As Integer
Dim yearcount2 As Integer
Dim sumnpvc As Double

Dim minvaluewp(0 To yielddbheight) As Double

Dim minvaluesf(0 To yielddbheight) As Double

Dim mindistancewp(0 To yielddbheight) As Double
Dim mindistancesf(0 To yielddbheight) As Double

Dim saverwp(0 To yielddbheight) As Double
Dim saversf(0 To yielddbheight) As Double
Dim saveiwp(0 To yielddbheight) As Double
Dim saveisf(0 To yielddbheight) As Double

'----- Initialize
pathofdatabase1 = Form1.Text1 & "Main.mdb"
pathofdatabase2 = Form1.Text1 & "Yield.mdb"
Call openthedatabase ' open database at certain path
Call initialize ' read data from database (initialize)
Call convertprice(realpricewp, realpricesf) ' will convert WP, SF prices to real prices
Call converttaxes(realtaxes)
'-----

selectedyear = Text1.Text

Dim iallyear As Integer
Dim endselectedyear As Double
endselectedyear = Text2.Text

For iallyear = selectedyear To endselectedyear

```

```

' clear the lists
'List1.Clear
'List16.Clear
'List17.Clear

r = 0

'selectedyear = Text1.Text
If selectedyear >= 2000 Then ' if more values are added to the database...(year 2000 compatible)
    selectedindex = selectedyear + 100
End If

If (selectedyear < 2000) And (selectedyear >= 1000) Then
    selectedindex = selectedyear - 1900
End If

If (selectedyear < 1000) And (selectedyear > 0) Then
    selectedindex = selectedyear
End If

selectedrealpricewp = realpricewp(selectedindex)
selectedrealpricesf = realpricesf(selectedindex)

For i = 0 To yielddbheight

    yieldwp(i) = pwhitepineyield(i) • selectedrealpricewp
    yieldsf(i) = pspucefiryield(i) • selectedrealpricesf

    ' Initialize min values
    mindistancewp(i) = 1
    mindistancesf(i) = 1
    minvaluewp(i) = 1
    minvaluesf(i) = 1

    ' Find profit
    profitwp(i) = yieldwp(i) - (yieldwp(i) • capitalgaintax • taxrate)
    profitsf(i) = yieldsf(i) - (yieldsf(i) • capitalgaintax • taxrate)

Next

'sequential search

Do While r <= rmax

    yearcount1 = 40 ' initialize again for different r
    yearcount2 = 40
    sumnpvc = 0

    For i = 0 To yielddbheight

        For icount = 1 To yearcount1

```

```

        sumnpvc = sumnpvc + (realtaxes(icount + selectedyear - 1900 - 40 - i) / findpower(r,
icount))
    Next

    npvc(i) = sumnpvc
    yearcount1 = yearcount1 + 1 ' add one more year

    'List21.AddItem npvc(i)
    sumnpvc = 0 ' reset the sum to 0

    'calculate NPVR for both species

    npvrwp(i) = (profitwp(i) / findpower(r, yearcount2))
    npvrsf(i) = (profitsf(i) / findpower(r, yearcount2))
    yearcount2 = yearcount2 + 1

If ((npvrwp(i) + npvc(i)) < mindistancewp(i)) Then

    If (npvrwp(i) + npvc(i) < 0) Then
        If (0 - npvrwp(i) - npvc(i)) < mindistancewp(i) Then
            mindistancewp(i) = 0 - npvrwp(i) - npvc(i)
            minvaluewp(i) = npvrwp(i) + npvc(i)
            saverwp(i) = r
            saveiwp(i) = i
        End If
    End If

    If ((npvrwp(i) + npvc(i)) = 0) Then
        minvaluewp(i) = 0
        saverwp(i) = r
        saveiwp(i) = i
    End If

    If ((npvrwp(i) + npvc(i)) > 0) Then
        If ((npvrwp(i) + npvc(i)) < mindistancewp(i)) Then
            mindistancewp(i) = npvrwp(i) + npvc(i)
            minvaluewp(i) = npvrwp(i) + npvc(i)
            saverwp(i) = r
            saveiwp(i) = i
        End If
    End If

    End If

Else
    'do nothing, there is no close value
End If

If ((npvrsf(i) + npvc(i)) < mindistancesf(i)) Then

    If (npvrwp(i) + npvc(i) < 0) Then
        If (0 - npvrsf(i) - npvc(i)) < mindistancesf(i) Then
            mindistancesf(i) = 0 - npvrsf(i) - npvc(i)

```

```

        minvaluesf(i) = npvrsf(i) + npvc(i)
        saversf(i) = r
        saveisf(i) = i
    End If
End If

If ((npvrsf(i) + npvc(i)) = 0) Then
    minvaluesf(i) = 0
    saversf(i) = r
    saveisf(i) = i
End If

If ((npvrsf(i) + npvc(i)) > 0) Then
    If ((npvrsf(i) + npvc(i)) < mindistancesf(i)) Then
        mindistancesf(i) = npvrsf(i) + npvc(i)
        minvaluesf(i) = npvrsf(i) + npvc(i)
        saversf(i) = r
        saveisf(i) = i
    End If
End If

Else
    ' do nothing, there is no close value
End If

Next

r = r + rincrement

Loop

'check if 0 for wp and sf
Dim i2 As Integer
'FOR EVERY YEAR , CHECK ALL R, TRY TO FIND A MATCH (= 0) OR CLOSEST VALUE

If Check1.Value = vbChecked Then

    Print #1, " Year of harvest: ", selectedyear
End If
If Check2 = vbChecked Then
    List16.AddItem selectedyear
    List17.AddItem selectedyear
    List1.AddItem selectedyear
End If

For i2 = 0 To yielddbheight

    If Check2 = vbChecked Then
        List16.AddItem saverwp(i2)
        List17.AddItem saversf(i2)
        List1.AddItem 40 + i2
    End If
End For

```

```

End If

If Check1.Value = vbChecked Then
'Open Form2.Text2 For Output As #1
  Print #1, 40 + i2, " ", saversf(i2), " ", saverwp(i2)
End If

Next

selectedyear = selectedyear + 1

Next ' loop for all years

If Check1.Value = vbChecked Then
  Close #1 'close output file at the end
End If

' loop of r ends here =====

End Sub
' menu-----
Private Sub mnuSingle_Click()
Form2.Show
Form3.Hide
End Sub
Private Sub mnufileprint_Click()
PrintForm
End Sub
Private Sub mnuOpen_Click()
Form1.Show
End Sub

Private Sub mnuMultiple_Click()
Form3.Show
Form2.Hide
End Sub

Private Sub mnuQuit_Click()
' quit application
End
End Sub

```

Appendix B. Visual Basic input form for multiple harvest selection.

Form3

File Run View Quit

Enter Year of Harvest
(Between 1961 and 1999)

From year: 1965

To year: 1984

☒ Output to a file

d:\program\output.txt

Expense Taxes: 20 %

Capital Gains: 20 %

Tax Rate: 20 %

r increment: 0.0001

r max: 0.3

☐ Output to list

Multiple Year Calculation

Rotation Age	Result: white pine	Result: spruce-fir

BIOGRAPHY OF THE AUTHOR

Julie M. Rodenberg was born and raised in Madison, Wisconsin on 8 April 1976. She graduated from Memorial High School in June 1994. She attended University of Wisconsin-Madison from 1994-1998. During her studies she was inducted into the Xi Sigma Pi forestry honor society, the Phi Eta Sigma honor society, and selected to do research in the Dominican Republic. She worked as a program assistant for the Department of Natural Resources Best Management Practices Program in the Bureau of Forestry. In May 1998 she was awarded a Bachelor of Science degree in International Forestry, a degree accredited by the Society of American Foresters (SAF).

Julie accepted funding at the University of Maine as a teaching assistant in the Department of Forest Management. She began her Master of Science in Forestry under the direction of David B. Field, Giddings Professor of Forest Policy and Chair of the Department of Forest Management in August of 1998. Julie is a candidate for the Master of Science degree in Forestry from The University of Maine in May, 2001.