# ECONOMICS OF EFFECTIVE THINNING OF SHORTLEAF PINES IN OZARK AND OUACHITA NATIONAL FORESTS OF WESTERN ARKANSAS AND SOUTHERN OKLAHOMA

By

JOMALS MATHEWS JOHN

Bachelor of Science in Forestry

Kerala Agricultural University

Thrissur, Kerala, India

2007

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
July, 2011

ECONOMICS OF EFFECTIVE THINNING OF SHORTLEAF PINES IN OZARK AND OUACHITA NATIONAL FORESTS OF WESTERN ARKANSAS AND SOUTHERN OKLAHOMA

Thesis Approved:

Dr. Difei Zhang

Thesis Adviser

Dr. Thomas B. Lynch

Dr. Salim Hiziroglu

Dr. Mark E. Payton

Dean of the Graduate College

# ACKNOWLEDGMENTS

This thesis could not have been written without Dr. Difei Zhang who not only served as my major advisor, but also encouraged and challenged me throughout my academic program. Dr. Difei had been a constant source of encouragement and her valuable suggestions helped me complete this thesis. Words alone cannot express what I owe Dr. Difei for her encouragement, patience and valuable feedback during the entire period of this project.

I am indebted to Dr. Thomas B. Lynch and Dr. Salim Hiziroglu, my committee members who guided me throughout the research and writing accepting no less than my best efforts. I thank them all.

I would like to acknowledge and extend my heartfelt gratitude to Ms. Liz Condit, Ms. Melissa Dunn, Andrew Crosby, Stuart Wilson, Micah Meyer, John Polo, Nino Kiguradze, Achueth Kumar, Harshad Bhapkar, Sanket Kulkarni, Akshay Shedge, Sudip Shrestha and the many people who have been enormously helpful in the preparation of this thesis in one way or the other.

I would also like to express my gratitude to Dr. Keith Owens, Department Head for all his support. I would also like to thank the funding agency, OSU Agricultural experimental station, Mcintire-Stennis grant, Southern Forestry Research Station forest service growth and yield study funding and USDA federal assistance award for giving me an opportunity to participate in this wonderful project.

This thesis is dedicated to my parents who taught me the value of education. I am deeply indebted to them for their continued support and unwavering faith in me.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

Table Page

LIST OF FIGURES

# CHAPTER I

# INTRODUCTION

## Introduction

In a resource scarce world, where each energy source has to be utilized to its maximum potential, with least environmental impact, investigations on new sources of energy deserve more attention. The modern global scenario exerts much pressure on the pristine forests of the world and this in turn can lead to more complicated problems such as global warming. Demands of the people cannot be neglected as well. There originates the challenge of a forest economist in exactly determining the optimal output (without harming the environment) from the available resources such as even aged and uneven aged forests for a better future.

Energy security has been in the forefront of researches in US for more than four decades. Several crises such as the Arab Oil Embargo of 1973 necessitated researchers and policy makers to think and act quickly in this regard. Many researches that sought the possibilities of alternate energy sources. The Energy Independence and Security Act of 2007 (EISA) mandates that 36 billion gallons per year of biofuels be produced in the U.S. by 2022, with 21 billion gallons per year coming from feedstocks other than corn grain Fulfillment of this mandate is expected to require the use of lignocellulosic feedstocks such as forest biomass, urban waste, and biomass from dedicated energy crops. This dream of energy security will be possible only if we effectively utilize our existing resources and explore the unexplored.

Huge perennial trees are potential sources of bioenergy and which requires further investigation. Thus forests comprising varied species have to be studied in detail to know about the possibilities of effective utilization. There are several issues to be taken into serious consideration while dealing with huge perennials.

*Pinus spp*. has always been in the limelight when it comes to the timber market. For a considerable time period various species of pines have been the major constituent of the world timber markets. Shortleaf pine (*Pinus echinata* Mill.), also known southern yellow pine, Arkansas soft pine, old field pine or short straw pine, is one of the most important among the southern US pines. Smith et al. (2001) stated that loblolly-shortleaf pine forests cover 50 million acres or nearly one-fourth of all southern forests and account for over one-half of 95 million acre softwood forests in the eastern United States. Of these, shortleaf pine accounts for one quarter of total southern pine volume (Schulte and Buongiorno, 2004). Many studies have been conducted in loblolly pine, but not many studies were conducted in shortleaf pines. Among all the southern pines of US, shortleaf pines have been the least studied. Researchers such as Murphy (1982), Murphy and Farrar, Jr. 1985, Lynch et al. (1999), Murphy et al. (1991), and recently Budhathoki et al. (2008) attempted to analyze the growth and yield of shortleaf pines. But there are still many gaps to be filled in understanding more about this species.

Forests which are overstocked may cause several catastrophes as wildfires, insects and diseases. Silvicultural operations play a major role in the growth characteristics of pine and thus the final yield. Silvicultural operations such as thinning are required in order to keep the stocking under control and for maximum productivity. The disadvantage is that these operations can be costly and also the question remains whether these operations actually maximize returns to the landowner. So it is important to develop a model based on the effect of silvicultural operations. This study aims to analyze the actual impact of silvicultural operation, thinning on the economics of shortleaf pines.

This study aims to explore this potential species and its various economic aspects. One of the serious issues associated with pine timber market is the actual effect of thinning. In shortleaf pines too, not many studies have been done to investigate the actual effect of thinning practice. How thinning at a certain period influences the optimal age of harvest remains a question still. Finding the optimal rotation age (economical and biological) of shortleaf pines will be beneficial both for industries and for the environment. The end products sawtimber and pulpwood, which are the most common and important use of trees has to be considered and the optimal rotation age based on these products should be determined. It is important to explore the vast potential of this vital species.

**Problem Statement**

Various researchers have differences in opinion about the actual effect of thinning on shortleaf pines.

The questions to be considered in this study are:

1. What is the optimal rotation age of shortleaf pines in the Ouachita and Ozark regions, with thinning and without thinning and does thinning at different periods actually add to the merchantable volume of wood.
2. What is the impact of taxation on the rotation age of shortleaf pines?
3. What is the best stocking?
4. If there is a difference in the economically optimal rotation age and biologically optimal rotation age, what is the role of thinning in determining that age?
5. What are the pros and cons of changing the rotation age according to the industrial needs?
6. What is the revenue and cost based on the volume and price at a particular age and what is the net present value of sawtimber and pulpwood harvested?

**Objective of the Study**

i. This study aims to find out the optimal rotation age of shortleaf pines, without thinning and with thinning, thus to reach a conclusion on the effect of thinning on shortleaf pines.

**ii.** Another aim of this study is to calculate the Net Present Value (NPV), Bare Land Value (BLV) and Mean Annual Increment (MAI) consistent with the rotation age and the thinning results.

**iii.** This study also aims to analyze the impact of taxation on the rotation age of shortleaf pines and forest amenities on the study area combined with the elasticity analysis of the Oklahoma timber market.

**iv.** Another objective of the study is to figure out the best stocking, based on the calculation of holding and liquidation values.

# CHAPTER II

## REVIEW OF LITERATURE

Forest economics research often addresses issues at the core of forest policy debates, and it have had a strong influence on policy rhetoric, perspectives, and, at least indirectly, policy outcomes. Till 1980's, much research in forest economics was targeted at understanding the magnitude of assumed market failures. Later, the resource economics research into material scarcity changed the frame of reference for forest economics research but provided only an incomplete understanding of timber markets and private production. Since the 1980s, the focus shifted to understanding how market behavior could influence forest conditions. Recently, forest economics research has focused both on the behavior of individual forest landowners and on aggregate timber markets, mainly for softwood products. Both approaches have been exploited in the South to develop insights into the ultimate outcomes of forest management on private lands (Rauscher and Johnson (2004)).

McKinley and Zhang, 2011, in their article, "Economics for Forest Landowners" explained the various reasons for which individuals own forest land including aesthetics, wildlife, recreation, timber production and others. In nearly all cases, there is an economic element associated with the landowner's goals and objectives. Forest management involves a number of activities often implemented over a number of years. The evaluation of investments requires more than just determining the difference between total cost and revenues. Determining the economic value of these long term investments requires the application of several principles of economic theory to develop meaningful financial indicators.

Wear and Greis investigated the communication of prices between subregions of the South, exploring the spatial extent of markets for various products. In addition, research aimed at modeling the supply response of private landowners in spatially explicit fashion had begun. Increasingly, concerns were being raised regarding the effects of timber market activity on the structure of forested ecosystems and on the ability of these systems to sustain ecological integrity and a variety of benefits beyond timber products (Wear and Greis (2002)).

The most recent understanding about timber markets suggests that addressing the linkages among all interrelated decisions regarding land and resources, including land use, investment, and harvest choices is required for the better analysis. A better understanding of the influence of landowner characteristics on management choices is also needed. More researches have to be conducted in this regard and conclusions to be reached.

Recently, like in many other fields, forest economics has also stressed on the term “sustainability”. Definitions related to sustainability have failed to explain this concept with precise clarity and consensus because of the highly politically charged atmosphere. There are lots of discussions going on in the scientific world about forest management practices and land tenure involving landowners, forest industry, environmental conservation organizations, aboriginal peoples, the general public, and public agencies at local to national and international levels. The discussions and debates over what sustainability means precisely are still vigorously continuing (Floyd, 2002, Shifley, 2006).

Rio Earth Summit in 1992 was instrumental in defining sustainable management of forests in a more sensible manner. There has been very rapid progress in several important ways since the Rio Summit. The Dictionary of Forestry (Helms 1998) defined sustainability as the capacity of forests, ranging from stands to ecoregions, to maintain their health, productivity, diversity, and overall integrity, in the long-run, in the context of human activity and use."

Since Rio, 1992, several researchers have come forward to seek more about the term sustainability. National policy and legislation are evolving and informed by a science-based understanding of sustainability. The industry and the market place have incorporated concepts of sustainability into regular business practice. Those involved in the business of financially supporting certification systems must have market-driven incentives to achieve sustainable forest management. In effect, all parties are committed to the principle that it is possible to maintain and enhance the site productivity, water quality, and biodiversity of forests managed with varying intensities over the long-term at stand and ecoregion levels of resolution by applying management systems that consider environmental, economic, and social criteria (Angelstam and others 2002; Burger 2002; Neary 2002; Shepard 2006).

Sustainability is an important term which has to be considered while managing plantations. A key concern with respect to the ecological structure of southern forests is the extent, location, and management intensity of pine plantations. These are determined as the outcomes of investment decisions by private landowners. Southern forest managers and beneficiaries require insights into where, within the South, production and investment will respond to expanding demands for southern timber (Rauscher and Johnson (2004)). Overall forest sustainability that addresses the provision of all desired goods and services derived from forests is well understood from the knowledge regarding the organization of timber production by the private sector.

The evolution of policy concerns regarding southern timber markets were partially in response to an improved understanding derived from timber market research. Current concerns are urgent, and improved understanding of how timber markets operate is required for a full understanding of the ultimate sustainability of forests, their functions, and their derivatives at various stages in the production chain. There are several aspects to be investigated which determine the activities in timber markets.

## Forest as capital

Forestry is so capital intensive that thoroughly understanding capital theory applied to forestry is vital before delving deeper into other aspects of forest economics. In a financial sense, Capital and time are the two most important inputs into forestry if the trees and land are considered as capital. The objective is to maximize these inputs such that the satisfaction to the society is maximized (Klemperer (2003)).

Classical economic theory defined capital as durable goods produced by people and used in production. Klemperer (2003) considered capital as any store of wealth yielding satisfaction to its owner. He defined three types of capital assets viz. durable goods (machinery, equipment, tools), financial assets (eg. savings accounts, bonds, stocks) and land and natural resources (e.g. coal, oil, timber).

Klemperer (2003) explains the concept of opportunity cost as the opportunity forgone, i.e. when investing, one gives up an opportunity for earnings elsewhere on that same capital. Some people need a minimum acceptable rate of return (MAR) even higher than available alternatives.

### Optimal rotation age

Searching for an optimal rotation age in forest management has been a major concern of forest managers where the total net present value of cash flows from various management practices such as plantation, site preparation, thinning and final harvest is usually to be maximized in perpetuity (Yoshimoto and Shoji, 1998). Pearson (1967) stated that determination of optimal rotation is among the oldest problems and one among the most important in forestry. Despite the recent advances, there exists a persistent confusion of the correct rotation criterion, the economic meaning of reaching the optimal rotation and the relationship between the most well known rotation criteria (S.J. Chang (1983).

The idea was first introduced by Faustmann in 1849. Later researchers like Samuelson (1976), Bowes and Krutilla (1985) and Clark (1990) have sought financial maturity of forest stand. The major disadvantage is the restricted behavior of the underlying assumptions. This means that all the values used in net present value calculation are deterministic or constant over time. But the reality is that, often the changes in the timber market situation, uncertainty of log prices and other prices result in variations in these values. Even with this drawback, prediction is possible with some accuracy (Yoshimoto and Shoji, 1998).

Several criteria had been applied in choosing the optimal rotation age in the case of commercial timber by various researchers, including maximizing the sustained physical volume of harvest (maximum sustainable yield or MSY), maximizing net present value of timber income (Faustmann rotation), and maximizing the present value of timber and nontimber values (Hartman rotation).

Interest rates vary depending upon the item purchased, time involved and current market conditions. Opposite to the interest rate is the discount rate or sometimes referred to as the capitalization rate. The discount rate is used to adjust future payments or revenues to today's value –future values are discounted to present. For practical purposes, the discount rate can be assumed to be equal to the interest rate that might be applied to current investments (McKinley and Zhang, 2011).

Simple interest is paid at the designated rate on a regular interval, and then is kept separate from the initial deposit, investment or amount borrowed. The initial amount is usually called principle, or in the case of an investment is called the capital. Compound interest assumes that interest that is earned on the principle is added to that principle and in the following years, the interest is earned, or paid on the total of principle plus accumulated interest (McKinley and Zhang, 2011).

**1. LEV model**

Past studies in timber management and forest economics have attempted to explain rotation age determination in terms of marginal analysis (Chang, 1983). For example, in 1849, Faustmann tried to solve the problem of optimal rotation age by maximizing the Land Expectation Value (LEV).

$$\textbf{Max LEV} = (V(t)-C) / ((1+r)^{t}-1)-C$$

Where C is the regeneration cost, V (t) =P (t) Q (t), is the stumpage value of t years old stand with V (t) > 0 and V' (t) < 0 for t>a. P (t) is the current stumpage price for trees of various ages; Q (t) is the timber volume of the stand at age t, r is the interest rate and t, the rotation age.

Inorder to allow discounting at intervals more frequent than one year, the above equation was modified. Thy resultant modified equation was

$$\textbf{Max LEV} = (V(t)-C)/((1+r/k)^{kt}-1)-C$$

When k equals 2, it is LEV with semi-annual discounting and when k equals 12, it is monthly discounting. The discounting is done continuously in the case where k equals infinity, i.e. when the, the equation becomes

$$\textbf{Max LEV} = (V(t)-C)/((e)^{rt}-1)-C$$

When the LEV is multiplied by the interest rate, Soil Rent (R) is obtained which is the maximum annual rent that could be extracted. R can be expressed as

$$R = r\,[(V(t)-C)/((e)^{rt}-1)-C]$$

The maximization of the LEV requires

$$dLEV/dt = V'(t)(e^{rt}-1)-re^{rt}[V(t)-C]/(e^{rt}-1)^2 \quad =0$$

where $V'(t) = dV(t)/dt$, represents the the marginal revenue product (MRP) of waiting out the rotation and $re^{rt}[V(t)-C]/(e^{rt}-1)^2$ represents the marginal input cost (MIC) of waiting out the rotation. The cost of holding the growing stock (Type A cost) and the cost of holding the land for future rotations (type B cost) were included (Duerr, 1960) (Chang, 1984).

Chang, in his 1984 study, suggested that at the optimal rotation age, the marginal revenue product (MRP) of waiting out the rotation must equal the marginal input cost (MIC) of doing so, since time is an input to the production of timber (Chang, 1984).

The other notable approaches in determining the optimal rotation age in the literature include the Present Net worth method, the Forest Rent Method and the traditional biological method.

### 2. PNW method

Fischer (1930) introduced the Present Net Worth model which is also known by the name guiding rate of return model. In this model, the management objective is to maximize the present Net Worth of one rotation.

$$\textbf{Max PNW} = V(t)\, e^{-rt} - C$$

Such maximization requires that at the optimal rotation age called $t_1$,

$$dPNW/dt = V'(t)\, e^{-rt} - re^{-rt}\, V(t) = 0$$

As per PNW model, harvest should when the rate of value increment equals the guiding rate of return. The major disadvantage of this model compared to the LEV model is that this model disregards all the income that could be obtained from future rotations. Another drawback is that it does not include the opportunity cost of holding the land leading to a longer rotation. Also, regeneration cost will have no effect on determining the optimal rotation age.

### 3. Forest Rent method

The Forest Rent model advocated by scientists like Chapman (1931) and Markus (1967) determined the optimal rotation by the maximization of the mean annual net revenue which is also called the Forest Rent (FR).

$$\textbf{Max FR} = \frac{V(t) - C}{t}$$

The relationship between LEV model and FR model is given by L'Hospital's rule which is

$$\lim_{x \to a} \frac{f(x)}{g(x)} = \lim_{x \to a} \frac{f'(x)}{g'(x)}$$

This model represents the limiting case of the soil rent model when the interest rate approaches zero. Also, the Forest Rent model the limiting case of the LEV model when the interest rate approaches zero (Bentley and Fight, 1966).

### 4. Biological Model

The biological Model maximizes the mean annual increment (MAI) of the stand inorder to find the optimal rotation age.

$$\textbf{Max M.A.I.} = \frac{Q(t)}{t}$$

When trees of different ages command the same price, regeneration cost equals zero, and interest rate equals zero, the biological model is the most appropriate model to determine the optimal rotation age.

**Relationship between LEV, FR and Biological Model**

When P(t) =p, a constant stumpage price for all age class and C=0,

$$\mathbf{R} = \frac{V\,(t) - C}{t} = \frac{pQ(t)}{t}$$

S.J. Chang (1983) systematically analyzed the problem of the determination of the optimal rotation age. He suggested that the efforts based on the marginal analysis have not been totally successful. Traditionally, dV(t)/dt, representing the marginal revenue product (MRP) of waiting out the rotation has been mislabeled as marginal revenue (MR). (e.g. , Gregory, 1972). This may lead to error as marginal revenue (MR) means change in total revenue per unit change in total output whereas the marginal revenue product (MRP) is the change in total revenue per unit change in input. Since time is an input to, rather than an output of timber production, dV(t)/dt, should be labeled as MRP rather than MR (Chang,1983).

Chang, also considered the analyses based on the discrete discounting version of the LEV formula. Analyses by this method had trouble separating the MIC into the cost of holding trees and the cost of holding the land which they obtained from intuitive deduction (Pearse, 1967).

Pindyck, 1988 found out that the present net value rule, i.e. invest when the value of a unit of capital is at least as large as the cost of the unit, is not valid when the market conditions change adversely. This indicates that the deterministic present net value approach might fail in giving the optimal rotation age and in evaluating forest land. This necessitated the need for evaluation under uncertainty or a stochastic environment, where stochastic modeling of the future prices and costs from all management activities has a crucial role. Yoshimoto and Shoji (1998) suggests that such a model makes feasible, the assessment of the probabilities of the alternative outcome and an optimal decision can be derived under a stochastic environment (Yoshimoto and Shoji, 1998).

Yoshimoto and Shoji (1998) modeled Stochastic log prices by a continuous time stochastic process (geometric Brownian motion), and binomial option pricing approximation for valuation of the forest land has been embedded into a two state stochastic dynamic programming model. When compared with the deterministic Faustmann approach, the stochastic model showed that the rotation age under stochastic log prices deviated from that of the Faustmann approach, and showed longer rotation age as the current log price decreased within the range. The total expected present net value for the stochastic model by Yoshimoto and Shoji (1998) was larger than that of the Faustmann approach. Research showed that when the current log price is high enough to cover all costs, the optimal rotation age from the stochastic model and the Faustmann approach coincides.

### NPV and BLV calculations

Discounted Cash Flow (DCF) techniques have been used by appraisers to value timber and timberland. Land Expectation value (LEV) is a standard DCF technique applied to many timberland situations. This has been found very useful in evaluating even aged pine plantations. LEV is a special case of DCF where a perpetual stream of revenues and costs are considered. This can be interpreted as the maximum price possible for a tract of timberland if a rate of return equal to the discount rate used to calculate LEV is expected. The LEV criterion is also called Bare Land Value (BLV) or Faustmann Formula.

**Bare Land Value (BLV) and Net Present Value (NPV)**

The name originates from the assumption that cash flow stream begins with bare land. Bare Land Value measures the net present value of bare timberland if used in perpetual timber production, i.e. one rotation after another following a constant rotation length and the same silvicultural treatments. It is the present value of the net returns from all continuing series of rotations. This is also known by the name Soil Expectation Value (SEV).

The higher the Bare Land Value, the better the investment. The NPV (Net Present Value) and BLV criteria yield the same ranking for investment projects with equal rotation lengths. BLV criterion is necessitated when the rotation lengths of the management practices are different, since the NPV criterion becomes inadequate in such a situation.(ie. the NPV criterion does not take into account the opportunity costs of the land over the years. The BLV criterion takes into account all the land costs in the infinitive time horizon.

BLV is calculated using the formula

$$\mathbf{BLV = NR/((1 + r)^n\text{-}1)}$$

where BLV is the bare land value, NR is the net return at the end of the first rotation, r is the discount rate and n is the rotation age. In the case of timberland, it is assumed to follow the same management regime rotation after rotation, hence should receive a perpetual series of cash flows every n years.

Net Present value calculations have been done by many researchers. In loblolly-shortleaf pine, Baker and others (1991) and Guldin and Guldin (1990) evaluated several studies. Their study was conducted in loblolly-shortleaf pine stands on the West Gulf Coastal Plain. Their studies included plantations, natural even-aged stands, and natural unevenaged stands. When the initial growing stock was not considered a cost, the uneven-aged stands ranked highest in terms of net present value. However, if initial growing stock was considered as a cost, the uneven-aged standsranked lower than most even-aged alternatives. The evenaged natural stands ranked higher than both plantations and uneven-aged stands in terms of benefit/cost and cost efficiency. With a decrease in the differential paid for sawtimber versus small roundwood, net present value of uneven-aged stands decreased while that for even-aged systems increased. When growing stock was a cost and the interest rate was 4 percent, uneven-aged stands with highinitial growing stock had higher net present value than thosestands with lower initial volumes. But at higher interest rates (7 and 10 percent), uneven-aged stands with low initial growing stock had higher net present values than those with higher initial volumes.

Klemperer (2003) in his book, "Forest Resource Economics and Finance" assumed that initially, potential buyers project land income in perpetuity. For even aged timber production, the major income is a perpetual periodic series of clear cutting revenues 'p' per acre at the end of every rotation of't' years. At afforestation date, the present value $V_0$ of such income, using a discount rate of r is given by the equation

$$\mathbf{V_0} = \frac{p}{(1+r)^{t-1}}$$

The major drawback of this equation was that not all the forestry net revenue p occurs every t years. By compounding each rotation's cash flows to rotation-end into one net value p, one can fit the above equation with forestry cases. In equation form, the compounded value occurring every t years is given below.

$$\textbf{Net Compounded Value} = \mathbf{p} = \sum_{y=0}^{t} Ry(1+r)^{(t-y)} - \sum_{y=0}^{t} Cy(1+r)^{(t-y)}$$

Where Ry and Cy are the revenues and costs respectively. Since p occurs every t years in perpetuity, Net compounded value can be substituted into equation $V_0$ giving the formula for the willingness to pay for land per unit area ($WPL_\infty$), assuming perpetual rotations. Annual revenues (a) and costs (c) are cumbersome to accumulate to rotation end and are added as a perpetual series (a-c)/r:

$$\mathbf{WPL_\infty} = \frac{\sum_{y=0}^{t} Ry(1+r)^{(t-y)} - \sum_{y=0}^{t} Cy(1+r)^{(t-y)}}{(1+r)^{t-1}} + \frac{a-c}{r}$$

The notation $WPL_{\infty}$, is more descriptive and also allows distinction between an infinite series of rotations and one rotation followed by landsale, $WPL_1$. The $WPL_1$ is a net present value designed for bare forest land, the present value of future revenues minus the present value of future costs, calculating just before reforestation. Assuming only the cash flows in the equation, $WPL_\infty$ is the maximum an investor could pay for bareland and still earn the minimum acceptable rate of return r (Klemperer, 2003).

$WPL_1$ is the willingness to pay for land, considering future land value. This arises from the fact that many forest owners change land use or sell land before or after harvest, or at least consider the option. To adapt the $WPL_\infty$ equation for land sale after harvest, simply calculate for one rotation, for each year y, the present value of all revenues minus the present value of all costs, making sure to include the market value of Bare Land (Lt) as a revenue after clear-cutting in year t. The equation can be written as

$$\mathbf{WPL_1} = \sum_{y=0}^{t} \frac{Ry}{(1+r)^y} - \sum_{y=0}^{t} \frac{Cy}{(1+r)^y} + \frac{Lt}{(1+r)^t}$$

To stress the importance of including the projected land value, Lt is shown separately rather than assuming it is part of the summed present value of revenues. Since $WPL_1$ is not a perpetual series of net revenues, there is no need to accumulate cash flows to rotation end (year t). WPL equations represent net present values for one investor. The collective bidding behavior of all buyers sets the market value of land. Individual landowner's unique forestry costs or revenues do not affect what they can receive for their bare land on the open market (Klemperer, 2003).

**Weibull distribution**

The Weibull distribution is a continuous probability distribution, named after Waloddi Weibull who described it in detail in 1951, although it was first identified by Fréchet (1927). This distribution was first applied by Rosin and Rammler (1933) to describe the size distribution of particles. The Weibull distribution has been used in many areas of forestry research.

The Weibull distribution had been used by Cao, 2004 to characterize the diameter distribution of loblolly pines. The probability density function (pdf) of the Weibull is

$$\mathbf{f(x)} = \left(\frac{c}{b}\right) \left(\frac{(x-a)}{b}\right)^{c-1} \mathbf{exp}\left[-\left(\frac{(x-a)}{b}\right)^{c}\right.$$

where a, b, and c are the location, scale, and shape parameters of the Weibull distribution, respectively, and x is tree diameter at breast height (dbh).

**Southern Forest Research**

Little research was done on the vast resources of the rich Southern forests prior to World War II, apart from the programs established by the Federal Government. One of the earliest studies undertaken by the USDA Forest Service Southern Station made use of temporary sample plots in even-aged, second-growth stands throughout the South. The data obtained were compiled into normal volume, stand, and yield tables for unmanaged second-growth loblolly, shortleaf, longleaf, and slash pines. Based on this, several tables were published in 1929 as Miscellaneous Publication 50 of the U.S. Department of Agriculture (U.S. Department of Agriculture, Forest service, 1929). These tables were used widely and contributed greatly to an understanding of the growth potential of the four principal southern pines and the practical forest management of the pine types (Wakeley and Barnett, in press).

A number of spacing and thinning studies were established with both pines and hardwoods. Early on, there was no replication in these or any other studies and the studies failed to provide good management guidelines. The arrival of Roy Chapman to the Southern Station in 1927, introduced the application of practical statistical techniques to the forest management in the south and later on these statistical techniques began to be more widely applied across the region.

During the second half of the 20th century, southern pine plantation forestry evolved from a publicly subsidized social welfare/land reclamation effort into an intensive cropping system providing raw material for a multi-billion dollar industry (Carter and Foster, 2006). In 1950, pine plantations accounted for less than 1percent of the area of southern forest. By 1999, plantations covered 12 million ha or 15percent of the South's timberland area and 47percent of the area of pine forests (Conner and Hartsell (2002)). Extensive harvesting in the early 1900s without regard for regeneration left millions of hectares of once well stocked southern pine forest land denuded of trees. During the Great Depression of the 1930s, widespread abandonment of crop land followed by severe soil erosion added to the lands in need of reclamation. Wakeley (1954) estimated that over 5 million ha in the South needed to be planted, nearly all of which was pineland.

Regarding to forest economics, research on individual investment behavior has directly addressed whether landowners were pursuing optimal management regimes—as defined by the economist—within their forests. Differences between optimal and actual investment levels were viewed as an untapped potential to produce timber from private lands. These foregone investments were labeled timber investment opportunities (TIO). Suboptimal management was attributed to various market failures, including information failures with respect to technical knowledge of forest management, but more importantly with respect to timber prices and timber price trends, and due to prohibitive upfront costs, failure of markets to reflect the future value of standing timber, and limited access to capital (Adams and others, 1982).

TIO research results were central arguments for programs that subsidize forest planting, including cost-share programs such as the Forestry Incentives Program and the Agricultural Conservation Program. Assessments of timber markets through the 1980s identified TIOs on private lands as clear evidence that information and capital failures impeded timber supply and as a strong indication that public assistance could leverage additional timber supply from the private lands.

Most of the research conducted in the field of timber markets, has addressed the structure of timber supply at various levels of aggregation, but the focus has been mainly on the supply response of relatively homogeneous regions. Aggregate analysis which is a form of amortized analysis, involves computing the total cost of performing ‘n’ operations and dividing by ‘n’. The advantage of aggregate analysis is that it provides a framework for evaluating the feedbacks between timber demand and supply in defining the response of the private sector to scarcity signals.

The normative and positive approaches, originally used in harvest choice models, were applied to timber supply by certain researchers.

**Normative timber supply models**

In the Normative approach, optimal rotation for each quality class of forests for a given price was defined and then summed the average annual harvest implied for each forest class to define total harvest. In this method, the aggregate supply relationship was defined by solving the problem for a large number of prices. Research using this approach was conducted for the State of Georgia by Montgomery and others (1975), and for Louisiana by Hotvedt and Thomas (1986). Normative approach models the supply that would occur when each forest class has achieved a uniform age distribution between zero and its optimal harvest age (the forester's "normal" forest), an outcome that could result in a long-run static equilibrium for the given price.

Merits of this system include, provision of insights into the maximum potential timber output and provision of an extremely rich supply specification (Hyde (1980) and Jackson (1980)), as well as provision of a tractable approach to examining the market consequences of various forest sector policies. Another advantage is that the detailed supply specification made possible by the normative approach allows for analysis of market effects of technological or environmental changes. Normative models can also be implemented to address conversion of land from forest use to nonforest uses and vice versa. Thus normative models demonstrate an explicit linkage between individual behavior and aggregate outcomes, which can account for heterogeneous forests and forest owners. Normative supply models provided an important and explicit bridge from stand-level analysis to market-level assessment. The first economically grounded estimates of timber supply and credible measures of maximum supply potential for a region. Vaux (1954) was given by normative approach. He provided an early mechanism for exploration of the potential welfare implications of various management and policy strategies. A set of questions framed by the normative approach will eventually be addressed by the use of increasingly sophisticated analysis. Extensions of this mechanistic or an engineering approach, especially using linear programming, expanded their usefulness. Dynamic adjustment processes can be modeled to address short-run responses. Quadratic programming can be used to simulate the interaction of supply and demand (Greber and Wisdom 1985, Samuelson 1952). Entropy constraints can be used to simulate the variability of observed market responses (Sallnas and Eriksson 1989). The strength of this modeling approach is its rich supply specification, which allows for analysis of the economic and welfare implications of new technologies and new or hypothetical policy instruments (Wear 2003).

The major defect of this system is that it defines only a long-run supply, as it does not explicitly address the existing age structure of forests.

**Positive timber models**

Positive models of timber supply are developed by applying statistical methods to observed behavior. These models implicitly link the biological model of timber production to a behavioral model of harvest choice.

McKillop (1967) provided the initial positive analysis of aggregate timber markets. Robinson (1974) examined regional stumpage and lumber markets for the South and the Pacific Northwest for the period 1947 to 1967. His study raised a set of questions regarding the magnitude of the supply response (quantified by the price elasticity of timber supply) that were addressed by subsequent research. Adams and Haynes (1980) specified southern sawtimber supply functions for two subregions of the South as part of their national timber market analysis for RPA. Daniels and Hyde (1986) applied a regional supply and demand model to the total (hardwood and softwood) wood products sector in North Carolina.

Newman (1987) was the first to model markets for different products in the South concurrently. He used a profit-maximization approach to derive timber demand and supply equations to model the southern pulpwood and solid wood markets in the South. This allowed for the delineation of substitution possibilities by stumpage producers in the region. Newman found solid wood timber to be a weak complement to pulpwood supply as owners jointly produce both goods and, more significantly, this study clarified the important part that the joint production of different timber products may play in determining the structure of timber supply. Prestemon and Wear (2000) further characterized the implications of joint production on timber supply.

The major advantage of the positive models is calibration to observed behavior. Positive models help to test hypotheses regarding the structure and function of timber markets and the effects of forest policies. More sophisticated approaches have permitted more refined testing which addresses increasingly refined hypotheses regarding investment response, policy effects, market structure, and market extent. Developing forecasts of market activity has been another advantage. Forecasts on both harvest quantities and timber prices can be of immense help to Public and private planners. Timber forecasting models are generally hybrids of both empirical and simulation approaches, constructed by linking empirical estimates of supply response and timber demand to mechanistic models of timber growth, as well as models of land use change and timber investment behavior.

The major defect of this modeling approach was statistical methodologies and access to adequate data. But this defect has been solved recently through the development of simultaneous equation and other estimation techniques and improvements in computational power that allows their application. But there are still concerns about the data availability and quality.

In the South, models developed by Abt and others (2000) have been used for timber market assessments (e.g., Prestemon and Abt, 2002). An important area of research that developed through the 1990s involved testing the extent of markets and the linkages between spatially separated markets; in effect, this tests the law of one price, which was defined by scientists as “all identical goods must have only one price in an efficient market" (Kenneth and Judd, 1983).

Tests of “market integration” have been conducted for various levels of production and at various spatial grains. Asche et al., 1999 in their study states that market integration occurs when prices among different location or related goods follow similar patterns in a long period. Group of prices often move proportionally to each other and when this relation is very clear among different markets it is said that the markets are integrated. Thus market integration is an indicator that explains how much different markets are related to each other. Analysis of markets for materials at higher stages of production (e.g., finished materials such as lumber) generally supports market integration, even between broad regions (Jung and Doroodian (1994), Murray and Wear (1998), Uri and Boyd (1990)). Studies of stumpage markets have not generally supported market integration hypotheses (Bingham and others (2003), Nagubadi and others (2001), Prestemon and Holmes (2000)) defining a set of questions regarding not only the structure of stumpage markets, but also the linkages between markets.

Research into supply responses at finer scales has begun to explicitly bridge from the findings of individual choice models to the implications at regional levels. The key to this research is linking harvest behavior to supply responses through a forest inventory. Prestemon and Wear (2000) accomplished this by modeling harvest choices for individual inventory plots, based on a general optimal harvest choice framework, and then estimating supply impacts by applying a harvest probability to the area expansion factor of each plot. This link between a behavioral model and the area frame structure of an inventory was first developed by Hardie and Parks (1991). Pattanayak and others (2002) also use the forest inventory and analysis inventory to model supply responses from partitions of the inventory defined by ownership, location, and quality. Both approaches provide promise for building spatial, ownership, and productivity detail into market forecasting models.

Newman and Wear (1993) modeled timber supply and investment in a common analytical framework. Research on the function and structure of timber markets in the South, has clearly illustrated that the private sector can generate an orderly market for a commodities like timber with a long production period. Investment responses to scarcity signals in the South demonstrate that timber capital is viewed as a reasonably liquid asset and that market failure with respect to intertemporal allocation does not hold. This timber supply model found out that the timber production from public forests which are more strongly influenced by policy shifts and administrative process is much less reliable or stable than private timber supply.

Research into industrial organization showed that markets that are not completely competitive can exhibit aggregate behavior that is qualitatively similar to the perfectly competitive case. However, inefficiencies can impose substantive welfare costs on consumers. In the case of timber markets, findings of inefficiency derived from integration studies raise some concerns in this regard. Research into individual landowner choices has not yet fully addressed whether observed investment is suboptimal due to capital constraints, tax structure, risk perspectives, or combinations of these factors. Wear (2003) states that, "in general, research into the presence and effects of market power is generally underdeveloped".

**Thinning and its effects on trees**

Deliberate control of stand density by thinning can improve the vigor, growth rate and quality of remaining crop trees. The benefits of thinning include concentration of growth on fewer, faster growing trees, reduction in the time required to reach harvestable size, and larger trees bringing higher stumpage prices. One of the major objectives of thinning is to permit only the high quality trees to grow to final harvest, eliminating volume accumulation on low value trees. Trees which would stagnate or die before final harvest can be utilized. Intermediate harvests can provide periodic income and enhance fire protection and wildlife values.

Meadows and Goelz (2002), opined that a well designed thinning should improve average bole quality throughout the residual stand, but there may be a trade-off between improved diameter growth and the potential for adverse effects on bole quality of residual trees, as thinning intensity increases and residual stand density decreases. The four components of thinning, increased diameter and volume growth of individual trees, increased stand-level basal area and volume growth, enhanced bole quality, and improved species composition, are critically important for the profitable management of hardwood stands for high-quality saw timber production (Meadows and Goelz,(2002)).

Thinning is a key element in the silviculture of uneven-aged forests as it combines harvesting, regulation of between tree competition and openings necessary for the development of seedlings (Schutz, (1997)). A combination of thinning and improvement cutting can be used in most mixed-species bottomland hardwood forests to enhance growth of individual residual trees, improve stand-level growth, maintain and improve bole quality of residual trees, and improve species composition of the stand (Meadows 1996).

The potential of thinning to regulate stand density and to increase diameter growth of residual trees, has been reported for several hardwood forest types, by several scientists such as Hilt 1979 and Lamson et al. 1990. The general inference from these studies was that, the heavier the thinning, the greater the diameter growth response of individual trees. However, very heavy thinning may reduce residual stand density to the point where stand-level basal area growth and volume growth are greatly diminished, even though diameter growth and volume growth of individual residual trees are greatly enhanced (Meadows and Goelz, 2002).

Hasenauer (1994) stated that thinning release variable was not significant in Norway spruce or Scots pine. Its contribution to the explained variation for beech was small. But Monserud and Sterba (1996) in their study assumed that released trees will respond to post thinning stand density just as trees in unthinned stands respond to current stand density. The study concluded that the above statement does not mean that thinning effect do not exist but the dominant factor determining subsequent growth is density.

Thinning or the combination of thinning and fertilization is used to accelerate diameter growth of lodgepole pine (Farnden and Herring 2002, Yang 1998). In addition to reducing intraspecific competition, thinning can also alter soil temperature and soil moisture and nutrient availabilities (Stogsdill et al. 1992, Vesterdal et al. 1995).

Commercial thinning in combination with nitrogen fertilization has become an increasingly common forestry practice in boreal forests. This is because of the fast increase in basal area growth of remaining trees observed in field trials (e.g. Moller and Pettersson, 1979) and in experiments (Weetman et al, (1990).

Tan et al. (2008) found that current annual diameter increment of the largest 1,000 trees $ha^{-1}$ was greater in the thinned than in the unthinned plots. Diameter growth was positively correlated with net N mineralization and soil available N. In this stand, thinning still influenced N availability and soil processes with the trees continuing to respond 24 years after thinning.

Peterson et al. (1997) conducted studies on growth and physiological responses of young loblolly pine stands to thinning. The study findings concluded that since the crowns of the trees in thinned stands were wider and deeper thinned trees had nearly twice the litter fall of control trees and thinned trees had double the crown volumes of control trees after 4 yr. The larger leaf areas and crown volumes per tree in thinned plots undoubtedly contributed greatly to increased bole diameter growth. Past research has clearly established the relationship between leaf areas and bole diameter growth in conifers (Peterson et al., 1997).

Early experiments gave the general notion that thinning does not influence stand volume growth significantly for a range of thinning grades or stocking densities, whereas heavier thinning beyond this range reduces volume growth. This thinning response hypothesis has had a major influence on thinning practices for even-aged monospecific forest types in many parts of the world and details of the thinning response have been quantified for many different tree species, site types, stand ages and thinning regimes (e.g. Nyland, 1996). Skovsgaard, 2009 reported that lighter thinnings influence stand volume growth less, whereas heavier thinning lead to larger reductions.

Several early studies concluded that rates of increase in basal area growth were the greatest in the most heavily thinned stands. These stands also exhibited the highest gain in trees per acre. Actual growth per tree was minimal in stands with intermediate levels of thinning. Many studies show that basal area can be substantially reduced if the stand is thinned so severely that many years elapse before the trees gain full occupancy of the site. It is probable that growth in basal area is reduced if the stand becomes exceedingly dense although physiological reasons for this reduction are obscure. However, within the wide range of density of stocking, ordinarily found in well managed stands, growth in basal area tend to remain constant and optimum regardless of stand density (Moller, 1946,1947, Hawley and Smith, 1954). Holsoe, 1951 explains the reason why increment of basal area can be increased by releasing a tree during thinning as the expansion of the crown and resulting increase of foliar space, reduced root competition and increased solar radiation.

Walsh (2002), used diameter at breast height of thinned trees reconstructed from the remaining stumps on the plots to estimate thinning effects on yield. Initially, volume on each thinned plot was calculated as if the stand was unthinned. Calculated yield was then subtracted from the actual yield. The difference was added to merchantable yield realized at the time of thinning. Final volume obtained was used as a dependent variable which represented the extra yield attributed to thinning. Independent variables used by Walsh's study included site index, number of trees removed in thinning, basal area removed in thinning and age when thinned.

The analysis by Walsh used several equations in determining diameter/basal area increment for loblolly pine trees in cutover, site-prepared plantations.

$$\Delta B = b_0 + b_1 . ba/A_t + b_2 . B_a + b_3 . B_b$$

where, $\Delta B$ was the Periodic basal area growth, ba, the initial tree basal area, $A_t$ was the age at thinning, $B_a$ was the basal area after thinning and $B_b$ was the basal area before thinning.

Other equations used by Walsh, 2002 included

$$\Delta D / \Delta t = b_0 + b_1 . (D/A)^{b2} + b_3 \, CR. \, (1 - e^{-b4/BA})$$

where A was the plantation age, CR, the Crown Ratio and all the rest as described above

$$\Delta D / \Delta t = (b_1 . D/A)(1 - e^{-b2/BA})$$

where BA was the total basal area

$$\Delta D / \Delta t = b_0 + b_1 . f(D) + b_2 f(H_d) + b_3 f(CR) + b_4 f(BA_p) + b_5 f(BA_h)$$

$$Ln(\Delta D / \Delta t) = b_0 + b_1 . f(D) + b_2 f(H_d) + b_3 f(CR) + b_4 f(BA_p) + b_5 f(BA_h)$$

where $H_d$ was the average height of dominant and co dominant trees, $BA_p$ was the pine basal area and $BA_h$ was the hardwood basal area.

Clutter (1963) used a basal area equation which helped in predicting the basal area increment between 2 different periods.

$$B_2 = B_1^{(A_1/A_2)} \{ e^{B1(1-A_1/A_2)} + B_2(1/A_2 - 1/A_1)/A_1A_2 + B_3 S \, (1 - A_1/A_2) \}$$

where, $B_1$ was the Basal area at age $A_1$, $B_2$, the basal area at age $A_2$ and S was the site index.

Hahn and Leary (1979) and Leary and Holdaway (1979) used an equation to find diameter increment,

$$\Delta D / \Delta t = b_0 + b_1 . D^{b2} + b_3 S \, CR \, D^{\, b4}$$

where, $\Delta D/\Delta t$ was the instantaneous change in diameter at breast height, D was the initial tree diameter at breast height, S was the site index and CR, the crown ratio.

Thinning of overstocked forest stands will help in the bioenergy production. Such operations will allow producing high-quality timber and/or reducing wildfire risk. Providing better opportunities to manage for higher-value products will encourage landowners to retain land in forests.

**Earlier studies on shortleaf pines (Growth and yield modeling and thinning effects)**

Several attempts have been made to analyze short leaf pine forest growth by researchers across United States including Murphy (1982), Murphy and Farrar, Jr. (1985), Lynch et al. (1999). Still, when compared the importance, shortleaf pine has been the most neglected of the major southern pines in terms of research information. Also, there is only little being done regarding growth and yield modeling (Murphy and Farrar, 1985).

Murphy and Farrar, 1985 formulated a system of equations for predicting projected basal areas and current and projected volumes for selection-managed stands of shortleaf pine for the interior highlands. Selection management in shortleaf pine forests has been studied by Murphy et al. (1991). Budhathoki et al. (2008) developed a mixed model for the shortleaf pine dbh-height relationship using a dataset in which plot specific random-effects were included.

Lawson (1990), reported that natural shortleaf pine stands in Missouri showed significantly higher net volume yields when thinned to about 21 $m^2/ha$ (90 $ft^2/acre$) or above, at age 51. The results of the study conducted by M. D Cain in 1996, on naturally regenerated loblolly-shortleaf pine stands showed that precommercial thinning enhanced pine growth in total height and in diameter at breast height.

### Forest taxation

There is hardly any argument against the increasing importance of trees and forests and the crucial role, private landowners can play. Approximately three-fourths of the commercial forestland in the southern United States is divided among more than one million nonindustrial, private owners (McLemore, 1981; Reynolds et al., 1984; Phillips and Abercrombie, 1987; Baker et al., 1996). Since growing timber is a long-term and often high-risk investment, tax implications and incentives associated with forestland ownership are of vital importance. The tax incentives which are offered to the small private landowners may encourage them to grow timber and reforest their lands after timber harvest (Schulte and Buongiorno, (1998)).

In 1982, Chang classified the major types of taxes that can be imposed on a forest property. They were annual property taxes and harvest taxes. Annual property taxes include the "unmodified property tax" and the “site value tax." Every year, the "unmodified property tax" takes a percentage of the value of the land plus the value of the trees, and the “site value tax" takes a percentage of the value of the land only. A third type of property tax, called the timber tax, takes a percentage of the value of the trees only every year. Harvest taxes include yield taxes and severance taxes. At the time of harvest, the "yield tax" takes a percentage of the stumpage value of timber and the "severance tax" imposes a charge per unit of timber volume harvested.

Englin and Klan (1989), classified taxation of forests as (1) a profit (or productivity) tax, (2) a site-value and an unmodified property tax, (3) a yield (or revenue) tax, and (4) a severance tax.

### Forest taxation studies in the US and the south

Since the time long term management of land for forestry purposes has been taken seriously by land owners in US, several research studies have been conducted in this regard by several scientists to make it sustainable. Folweiler and Vaux (1944), suggested financial incentives should be given to owners who demonstrate an interest in managing their forest. Fecso and others (1982) stated that interested owners should be charged reduced property, estate and inheritance taxes, more favorable tax credits and deductions, more favorable capital gains treatment of timber income, and more cost-sharing of forest management expenses.

Incentive programs for non-market forest products, such as wildlife and recreation were proposed by Greene and Blatner in 1986. Blatner and Greene (1989) suggested assistance to manage forests to maintain and improve standing timber values. Also, Greene (1998) developed incentives linked to specific stewardship practices, such as reforestation.

The major problems faced were analyzed by researchers. Klosowski and others 2001 reported that only a small percentage of owners would consent to coordinated management of their land. Another problem was that large fractions of owners are unaware that financial and tax incentive programs exist or didn't know what the programs could do for them (Yoho and James (1958), Greene and others (2004)). Although the incentive enables the owners to treat additional acres (Royer (1987), Bliss and Martin (1990)); favorable property tax and capital gains provisions have little effect on forest owner behavior (Stoddard (1961), Brockett and Gerhard (1999)). Hibbard and others 2003 pointed out that forest property tax programs are only modestly successful in accomplishing their objectives (Report to the National Commission on Science for Sustainable Forestry, 2005)

The final Report to the National Commission on Science for Sustainable Forestry, 2005, also concluded that federal and state financial incentive programs currently play a limited role in promoting sustainable forestry practices on the nation's non-industrial private forests. This was mainly due to the fact that the programs play only a minor role in forest owners' decisions regarding the management and use of their land. This study, named "Existing and potential incentives for practicing sustainable forestry on Non-industrial Private Forest Lands", as part of NCSSF Research Project C2 revealed that the highest program priority among forest owners is one-on-one access to a forester or other natural resource professional to "walk the land" with them and discuss their management alternatives. This study also noticed that the most effective way to increase the impact of financial incentive programs is to ensure adequate funding and stable program requirements over time. Also, there is a need for some flexibility in financial incentive programs to address regional differences in forest characteristics and owner objectives.

The report suggested some recommendations for future policy making. Increases in the funding and availability of one-on-one technical assistance from both extension foresters and state service foresters will be beneficial. Use of technical assistance rather than certification to convey sustainability ideas; approaching sustainability through owners' long-term stewardship and family legacy objectives was highly recommended. Formulation of a written forest management plan is a requirement for all incentive programs. Designing incentive programs to put forest owners in direct contact with a forester or other natural resource professional was recommended. Regional differences should be addressed in incentive program designs. Linking incentives directly to stewardship practices instead of general forest management practices and fund cost-share applications according to their expected environmental benefit instead of first come-first-served will be helpful. The report also recommended making the requirements for owners to participate in incentive programs more uniform and delivering the programs from a single source in each state. Care should be taken to maintain adequate funding and stable program requirements for financial incentives over the long term.

The U.S. Department of Agriculture Forest Service, Southern Region has updated tax tips for Forest Landowners for the 2010 Tax Year. Depending on whether the private owned woodland is personal, income-producing (investment), or business property, the tax rules can vary. This classification is based on the profit motive and management activity. Timber may be personal property, if there is no profit motive at all and an investment property, if there is a clear profit motive. The property can be termed business property if the management activity is more regular, frequent, and intensive than required for an investment.

A written management plan is the best tool for the documentation of the profit motive. Determining whether the private owner materially participate in the business operation, is important for timber which is held as a business. This will help to establish whether the private owner face restrictions, known as passive loss restrictions, on the deduction of business losses.

Taxation on timber sale is based on the net sale amount, not the gross proceeds from a sale. Depletion and expenses from the sale will be deducted. The sale of timber, which is held as an investment should be reported on Schedule D, as a long-term capital gain if the private party has owned the timber more than 1 year or a short-term capital gain if not. The sale of timber, which is classified as a business property should be reported on Form 4797 and Schedule D, whether the private owner sold it outright (lump-sum) or pay-as-cut (sec. 631(b)).

The difference between the fair market value (FMV) of the standing timber on the first day of the tax year and the timber basis in it is taxed as a capital gain. The difference between the proceeds from the sale of the cut products and the sum of the FMV of the standing timber and the cost of converting it into products for sale is taxed as ordinary income (sec. 631(a)).

In the case of installment sale, which involves receiving one or more payments after the year of sale, the interest is charged on deferred payments. The installment sale has an advantage that it allows the owner to defer tax by spreading the gain over two or more years.

In the case of profit motive management of the woodland, deductions can be made from the ordinary and necessary timber management expenses, such as costs incurred to protect the woodland from insects, disease or fire, control brush, or do a precommercial thinning or mid-rotation fertilization. Management expenses for property held as an investment are subject to a 2percent of adjusted gross income (AGI) reduction on Schedule A. A full deduction is done in the case of expenses for business property on Schedule C. You may add to your timber basis expenses subject to the 2percent AGI reduction and recover them when you sell the timber.

If the private owner has reforested the woodland, tax deductions can be allowed as per Sec. 194. Deduction is done for the first $10,000 ($5,000 for married couples filing separately) per year of such expenses per qualified timber property. Any additional amount may be deducted (amortized) over 84 months. This is applicable for both artificial and natural regeneration.

Capital expenditures such as those for logging equipment, bridges, culverts, fences, temporary roads, or the surfaces of permanent roads may be depreciated over the property's useful life. A bonus depreciation equal to 50percent of the cost of qualified property placed in service on or before Sep. 8, 2010, and 100percent through the end of year. If the purchased qualifying property (generally tangible personal property, but not improvements to land, buildings, or components of buildings) for the forest business in 2010, the owner can elect to expense up to $500,000, subject to a $2 million phaseout and business taxable income limitations (first-year expensing).

Sec. 126 allows recipients of payments from approved public cost share programs to exclude all or part of the payments from their income. Approved federal programs include the Forest Health Protection Program (e.g., the southern pine beetle and mountain pine beetle cost-shares), the Conservation Reserve Program, Environmental Quality Incentives Program, Wildlife Habitat Incentives Program, and Wetlands Reserve Program. Approved state programs also qualify. The excludable amount is the present value of the greater of $2.50 per acre or 10 percent of the average annual income from the property over the last 3 years.

Oklahoma Tax commission in their document, Oklahoma Property Taxes, 2011, Taxpayer's Rights, Remedies and Responsibilities explains how to calculate the Taxes. Taxable Value multiplied by Assessment percent gives the assessed Value. This assessed value minus Exempt Value gives the Net Assessed Value. When the net assessed value is multiplied by Rate per $1000 value (Taxing unit's governing body sets tax rate) gives the tax amount. These taxes are to be paid to the county treasurer. In 2009, Travis Greaves, in his article, "States Use Gentle Hand in Taxing Timberland" explains that in Oklahoma, for the assessment of real property tax, managed timberland used for the cultivation of timber should be classified at its fair cash value for that use.

**Forest tax impact on optimal rotation age**

Earlier, the impact of forest taxation on the optimal rotation age was mentioned without any mathematical proof (e.g., Duerr 1960, Gaffney 1957, 1970; Gregory 1972, Pearse 1967, and Trestrail 1969). These were made under the assumption of full tax capitalization and based on the discrete time version of the land expectation value. Chang, 1982 states that, much remains to be learned about the impact of forest taxation on the optimal rotation under the assumptions of tax capitalization and tax shifting. The profound influence of forest taxation on many state and local economies and on forest productivity necessitated more studies on the impact of the various taxation schemes during the process of revising the forest taxation laws (Chang, (1982)).

Generally, land expectation value after an unmodified property tax is expressed with a formula first advanced by Fairchild (1935)

$$LEV_{upt} = \frac{Vt-C(1+r+x)t}{(1+r+x)t-1}$$

where $LEV_{upt}$ was the Land Expectation Value under unmodified property tax, 't' was the rotation age, C was the regeneration cost, r was the interest rate in decimals, V(t) = P(t) Q(t) the pretax stumpage value of a t year old stand, x was the annual property tax rate (in decimals) on the value of land, y was the annual tax rate (in decimals) on the assessed value of the trees.

The major disadvantage with this method was that there were several assumptions behind the formula that often are not clearly specified. The assumptions include property values are correctly assessed by discounting the value of the forest (land plus trees) at the rotation age to the current age net of the discounted value of all costs during the remainder of the rotation. Another assumption was that the tax base is always the previous year's market value and that the property value is reassessed every year. The assumptions that tax will be fully capitalized into lower land value and the land and the trees are taxed at the same rate were also flawed.

To rectify this, a general formula was derived by Chang, 1982.

$$\mathbf{LEV_{upt}} = \left(\frac{r+y}{r+x}\right)\frac{(1+\alpha)\,Vt-C}{e^{(r+y)t}-1}\ \mathbf{-C}$$

where $LEV_{upt}$ was the Land Expectation Value under unmodified property tax, 't' was the rotation age, C was the regeneration cost, r was the interest rate in decimals, V(t) = P(t) Q(t) the pretax stumpage value of a t year old stand, x was the annual property tax rate (in decimals) on the value of land, y was the annual tax rate (in decimals) on the assessed value of the trees , α was the tax induced percentage increase in stumpage value.

To maximize the land expectation value under the unmodified property tax, this equation is differentiated with respect to t. Since time is an input to the production of timber, at the optimal rotation age the marginal revenue product (MRP) of letting the stand grow one more year must equal the marginal input cost (MIC) of doing so.

Gaffney (1970), opined that the imposition of site value tax would reduce the land value (1970). But there were faults in Gaffneys assumptions as pointed by Chang in 1982. Gaffney overlooked the tax on land as part of the cost of waiting and mistakenly concluded that the imposition of the site value tax would lengthen optimal rotations. The fact is that with no forward shifting of the tax into higher stumpage price; the site value tax will not change the optimal rotation because lower land rent from lower land value is completely offset by the property tax.

Inorder to assess the impact of an unmodified property tax on the optimal rotation age under different assumptions of tax incidence, it is essential to separate the changes in stumpage value from the changes in tax rate. i.e. Net Revenue Increment Rate (NRIR) is equal to the adjusted guiding rate (AGR).

This can be written as $\frac{(1+\alpha)V'(t)}{(1+\alpha)V\ \ (t)-C}$ = (r+y) $\frac{e^{(r+y)t)}}{e^{(r+y)t)}-1}$

Where NRIR = $\frac{\text{Growth in stumpage value}}{\text{net revenue}-\text{stumpage value net regeneration cost}}$

AGR= (Interest rate + tax rate) (correction coefficient)

**a. No tax case**

Before the imposition of an unmodified property tax, $T_{upt}$ (the tax-induced stumpage value increase) equals zero and y also equals zero. As a result, the above equation reduces to

$$\frac{V'(t)}{V\ \ (t)-C} = \frac{re^{rt}}{e^{rt}-1}$$

**b. The impact of unmodified property tax under full tax capitalization**

When the tax is fully capitalized,$\alpha$=0; the NRIR curve remains **V'(t)/[V(t)- C]**, the same as the case without taxes while AGR becomes **$(r + y)e^{(r+y)t}/[e^{(r+y)t} - 1]$.** The effect of the tax imposition on AGR is similar to an increase in the interest rate (Chang, 1982). Consequently, the whole AGR curve moves upward to AGR'. The point where the AGR' curve crosses the solid MRVG curve, t', represents the optimal rotation age for unmodified property tax under full tax capitalization, which is shorter than that of no tax.

**c. The impact of unmodified property tax under forward tax shifting**

When the tax is shifted forward into higher stumpage value AGR becomes **$(r+ y)e^{(r+y)t}/[e^{(r+y)t} -1]$** and the NRIR becomes **$(1+ \alpha)V'(t)/[(l + \alpha)V(t)-C]$** as a result of an $\alpha$ percent increase in the stumpage value. Here also, AGR curve will shift upward and shift will occur in NRIR curve (downward) too (Chang, 1982).

**d. The cases of site value tax and timber tax**

When the tax is capitalized into lower land value, the optimal rotation age is not affected at all. The optimal rotation age after the site value tax is the same as before the site value tax. When the tax is shifted into higher stumpage price, the optimal rotation age will be shorter than when the tax is capitalized into lower land value. On the other hand, shifting tax by lowering the site value tax rate would have no impact on the optimal rotation age (Chang, 1982).

For the timber tax, the relevant AGR and NRIR curves are exactly identical to those for the unmodified property tax. Accordingly, all the conclusions obtained in the case of unmodified property tax also apply to the case of timber tax.

**United States timber markets**

In 2010, total U.S. lumber production equaled 24.909 billion board feet which was 6.4 percent higher than the 2009 total (Western Wood Products Association website). Production in the West showed an increase in 9.2 percent from the 2009 total, while southern production increased by 3.9 percent. Nationwide, production in December totaled 1.981 billion feet, up 17.4per cent compared to the December 2009 total. Even though this can be considered a desired situation, several other factors behind these have to be checked out for the optimal utilization of natural resources with a future perspective. How the production has increased must be studied in detail and if it is desirable to the environment and economy for a longer time period has to be analyzed. Concentration of source of timber to a few species has to be avoided and new species have to be utilized in an environment friendly basis.

Understanding how shocks and the effects of policies are transmitted across space is essential for characterizing how timber markets respond at the relatively fine spatial scales of regional models. Research on spatial price linkages can also be used to evaluate market efficiency.

The model developed by Adams and Haynes (1980) is the centerpiece of national timber market assessments conducted for the RPA (e.g., Adams and Haynes 1996) and has been used to simulate the impacts of various forest sector policies including cost-share programs and international trade scenarios.

**Southern United States timber markets**

The Southern United States, one of the fastest growing regions in the US is also one of the lower median income regions when compared to the nation as a whole. The abundant timber resources of the south have made this part of the United States one of the most important regions with respect to timber markets.

Pine (*Pinus spp.)* plantation silviculture in the Southern United States is one of the major success stories for forestry in the world. The success of pine plantation silviculture has turned the South into the wood basket of the United States (Schultz 1997). Between 1952 and 1996, the South's timber production more than doubled. Its share of U.S.production increased from 41 to 58 percent, and its share of world production increased from 6.3 to 15.8 percent. The region now produces more timber than any other country in the world (Rauscher and Johnson (2004)). Economic factors, including a declining agricultural economy coupled with a rapidly expanding pulp and paper industry based on southern pine, combined to provide the impetus for the large increase in southern pine plantations. The success of this effort was due in large part to the cooperative research and technology transfer efforts of many organizations, including the U.S. Department of Agriculture Forest Service (Forest Service), State forestry agencies, forestry programs at southern universities, and forest industry.

The timber products from the south include softwood saw logs (28 percent of the region's wood output), softwood pulpwood (25 percent), and hardwood pulpwood (16 percent). Since 1952, hardwood pulpwood has experienced the greatest increase in product share, growing from 3 to 16 percent of output (Rauscher and Johnson (2004)).

In 1999 five and a half percent of the total jobs in the South and thirty-nine percent of all wood products jobs in the United States were provided by the successful timber markets of the South. Over the last few years, even when the capacity for lumber production has remained strong, the capacity for paper production has declined to a considerable extent. Timber demand and local economies have been influenced by a variety of factors such as changes in domestic consumption, international trade, closure of older pulp and paper mills and large scale divestiture of forest industry land. These factors are supposed to influence the supply and demand relations in the future too.

The long term forecasts for the timber economy predict an expansion of domestic timber demand in the south. Opportunities for the development of markets for non-timber goods and services, i.e. ecosystem services, may also be emerging and provide additional opportunities for investment. A critical need at the present time is to strengthen the existing markets and develop new markets for forest products and services in this area. This is so important to the nation's economy since it deals with 5 million private forest landowners in the South.

In the analysis done by the Southern Research Station for recent timber market trends in the South, timber supply, demand, prices, imports and exports were evaluated to better understand relationships to future market behavior and timber productivity in the South. The study clearly pointed that softwood pulpwood markets (and prices) declined significantly since the late 1990's due to a variety of reasons such as loss of exports, decreased domestic demand, and loss of pulpmill capacity (16percent) in the South.

Markets for sawtimber (hardwood and softwood) remained relatively steady over the same period. This ultimately resulted in a total decline in timber production by nine percent between 1998 and 2002.

Forest loss due to urbanization and urbanization pressures has influenced the supply of timber in the south. Net loss of timber land was predicted to be as many as 31 million acres over the next 30 years. Afforested agricultural lands also have been on a decline since 1990. Between 1995 and 2005, more than 50percent of industrial forest land had been divested to TIMOs (Timber Investment Management Organizations) and others but its long term timber production potential is unclear.

The changes in the global timber market, including the fast emerging markets for bio-energy and possible new governmental incentives for tree planting, calls for additional plantation establishments. Relatively strong sawtimber prices, stagnated pulpwood prices, and changing landowner objectives could favor longer rotations and larger product sizes. Markets may be flexible on the basis of ecosystem services (water, view-scapes, carbon sequestration etc.) and markets for carbon.

Though there has been a decline in domestic production and per capita consumption of certain timber products as well as a significant reduction in international demand for timber products produced in the United States (including the South), long term demand for lumber and solid wood products is expected to remain strong. Paper production capacity in the South is not expected to recover to the previously high levels in the early 1990's. And forest ownership and owner objectives are changing rapidly in the region.

The demand for southern pine timber products is expected to increase over the next several decades (Prestemon and Abt, 2002) while new and emerging technologies promise further increases in productivity and management efficiency of southern pine plantations (Sedjo, 2001, Rummer, 2002 and Allen et al., 2005). Wear and Greis (2002), concluded in their study that by 2040, the area of plantations in the South was projected to increase by about 67 percent to 22 million ha and provide over 75 percent the annual softwood harvest (Wear and Greis (2002)). Thus, 25 percent of the southern forest lands occupied by intensively managed pine plantations would supply a majority of the nation's need for wood and allow the remaining 75 percent of the South's forest to serve other interests, values, and needs of society.

Since wood costs are usually the single largest cost in pulp, lumber, and engineered wood production, minimizing wood cost through intensive management may be the best way for forest industry in the South to remain competitive in global markets (Rauscher and Johnson, 2004)). If the South is to remain one of diverse, healthy and productive forests, it will be necessary to sustain existing markets and actively pursue new ones.

### Oklahoma timber market

Almost ten million acres (approximately 25 percent of the land area) of Oklahoma is forested. The annual contribution from the forest industry to Oklahoma's economy is more than $2 billion. Oklahoma is the continental crossroads for a variety of forests. The eastern woodland meets the western grassland, mingling with the ponderosa pines of the Rocky Mountains in the far reaches of the Panhandle and the mesquite scrubland of northern Texas. The Ozark hardwoods of oak and hickory finger their way into the pine forests of the Ouachita and the cypress swamps of Louisiana.

The majority of Oklahoma's forests are owned by thousands of private individuals who reside in cities across the state or across the nation. Oklahoma's traditional forest markets are in a state of decline which is threatening landowners and communities who rely on those markets for jobs and economic growth. The major problems facing the market include the lack stability for traditional forest products which causes great uncertainty among landowners and the communities that rely on the industry for jobs and economic growth. Although interest in ecosystem services and non-traditional wood products (carbon, biomass and bio-energy, recreation, water and wildlife) markets are increasing, market mechanisms for these are not well developed. Also, there may be conflicts between new and traditional wood product markets.

The recent downturn in the national economy, and especially the housing market, has seriously affected the state's forest products sector. The number of small sawmills is at its lowest level in recent history.

Between 2002 and 2005, the combined industrial TPO (Timber Products Output) from roundwood and plant byproducts declined 2 percent, from 176 to 173 million cubic feet. TPO from roundwood was down 6.5 million cubic feet, or 5 percent, to 119 million cubic feet, while output of plant byproducts increased 3.6 million cubic feet to 54 million cubic feet. Output of softwood roundwood products declined 3 percent to 95 million cubic feet, while output of hardwood roundwood products declined 15 percent to 24 million cubic feet. Pulpwood and saw logs were the principal roundwood products in 2005. Combined output of these two products totaled 98 million cubic feet and accounted for 83 percent of the State's total round wood output. Total receipts at Oklahoma mills, which included roundwood harvested and retained in the State and roundwood imported from other States, increased 20 percent, from 123 million cubic feet in 2002 to 149 million cubic feet. There were 107 primary round wood-using plants operating in Oklahoma in 2005 (Johnson et al, 2005).

Across all products, 81 percent of roundwood harvested was retained for processing at Oklahoma mills. Exports of roundwood to other States amounted to 23 million cubic feet, while imports of roundwood amounted to 52 million cubic feet making the State a net importer of roundwood (Johnson et al, 2005).

In 2005, Johnson et al reported the sawlog and pulpwood statistics of Oklahoma. Sawlogs accounted for 52 percent of the State's total roundwood products. Output of softwood sawlogs declined 5 percent to 55 million cubic feet (304 million board feet), while that of hardwood sawlogs increased 2 percent to 6.8 million cubic feet (41 million board feet). In 2005, Oklahoma had 95 sawmills. Total softwood sawlog receipts were 56 million cubic feet, while those of hardwoods totaled 8.5 million cubic feet. Of the 19 reporting mills, 7 had receipts <1.0 million board feet, 8 had receipts between 1.0 and 9.99 million board feet, while 4 had receipts >10 million board feet. These four mills accounted for 90 percent of the reported volume. Oklahoma retained 84 percent of its saw-log production for domestic manufacture, with sawlog imports exceeding exports by more than 2.8 million cubic feet in 2005 (Johnson et al. (2005)).

Total pulpwood production, including chipped roundwood, declined 25 percent to 37 million cubic feet (492,000 cords) and accounted for 31 percent of the State's total roundwood TPO. Softwood output was down 29 percent to 20 million cubic feet (270,000 cords), while hardwood output declined 20 percent to 17 million cubic feet (222,000 cords).Two pulpmill facilities were operating and receiving roundwood in Oklahoma in 2005. Total pulpwood receipts for these mills increased 30 percent to 58 million cubic feet, and accounted for 39 percent of total receipts for all mills. Seventy percent of roundwood cut for pulpwood was retained for processing at Oklahoma pulpmills. Roundwood pulpwood accounted for 48 percent of total known exports and 62 percent of total imports. Roundwood pulpwood imports amounted to 33 million cubic feet, while exports totaled 11 million cubic feet, making the State a net importer of pulpwood (Johnson et al, (2005)).

Availability of pine timber depends on the availability of forest resources, (including private sources) recovery limitations imposed by accessibility and environmental concerns, and economic considerations.

Economic factors affecting the supply of timber include production costs, prices of timber and its substitutes, competing uses of forest resources, and policy, among others. First, technologies for forest production, timber harvest and transport, and energy conversion will dictate the production costs of forest products. The costs will also vary with scale of operation, timber spatial density, terrain conditions, average stem diameter, and transport distance, among other things. The most cost-effective production of timber occurs when it is produced simultaneously with other higher valued forest products (biomass for bioenergy, pulping chips).

There must be a demand for (buyers of) pine timber in local markets, which interacts with the supply to determine the market price. Potential buyers include independent developers, utility companies, biorefineries, larger-scale users of sawlog and pulpwood, and the producers of other bio-based products in the future.

Prices of fossil fuels will have an influence on the supply of forest timber. Competing or complementary uses of forest resources for bioenergy and ecological services will also interact with the supply of forest timber. Thinning over-stocked stands, may enhance the production of high quality logs and reduce fire risk whereas there is some concern about the potential loss of soil productivity resulting from excessive removals of biomass. Demand for ecological services such as biodiversity may have a negative or positive impact on the supply of timber from forests (Schaberg and others (2005)). Also, policies pertaining to energy, forest management and utilization, environmental protection, and land use, as well as assistance and incentive programs to forest landowners and timber producers and consumers will also affect the supply of forest timber.

This harvesting and transportation section assumes that a market for pine timber exists and deals primarily with the question of where, when and how to harvest timber that can then be transported to utilization centers some distance from the harvest site. Pine timber products can take on several different forms which each have their own storage and cost considerations.

A long-term stable supply of pine timber is critical to its industrial utilization. The future availability will depend on continued future timber harvests. According to the 2002 Forest and Rangeland Renewable Resources Planning Act (RPA) assessment (Haynes 2003), the projected timber harvests in the U. S. would generally increase during the next 50 years while regional shifts and small harvest reductions in the short run will be likely.

If trees are harvested for bioenergy, pulpwood, and sawlogs, competing or complementary uses of forest resources among these products may exist. A recent study using a dynamic multisector and multiregion model suggests that bioenergy would compete with traditional forest products in the use of forest resources in the short term (before 2030), but they would complement each other in the long term as more lands would be used for forest production that would increase the supply of both timber and feedstock. The short-term effect of bioenergy production on timber output would be moderate (less than 5 percent reduction in timber output) under current market and policy conditions associated with bioenergy and greenhouse gas emissions. Removal of logging residues will reduce site preparation costs (Gan and Smith, 2006) and enhance the survival and growth of seedlings.

# CHAPTER III

# METHODOLOGY

## Study area

This study was conducted in the Ozark and Ouachita National forests, western Arkansas and southern Oklahoma. Oklahoma's forests are more diverse than most states because they grow within a transition zone for climate and vegetative cover within the United States. Elevations run from 287 feet above sea level where the Little River flows in Southeastern Oklahoma to 4973 feet on the Black Mesa near the New Mexico border. The study area is largely in the Ouachita Mountains, where pine-hardwood forests grow. The Ouachita Mountains dominate much of the Southeastern part of Oklahoma, with peaks that rise as much as 2000 feet above the base.

This study area falls under the Ouachita Mountains ecoregion and the Ozark Highlands ecoregion. The 8 million-acre (3,237,600 ha) Ouachita mountain physiographic region is located in west central Arkansas and southeastern Oklahoma. The Ouachita Mountains ecoregion supports oak hickory and pine forests. The drier sites in this ecoregion are dominated by oak, hickory and shortleaf pine. Mean annual rainfall in this humid ecoregion is 43 to 57 inches. The Ozark Highlands Ecoregion is a level to highly dissected plateau composed of flat lying, cherty limestone and dominated by the oak-hickory forest type. This is also a humid region having mean annual rainfall, 41 to 49 inches.

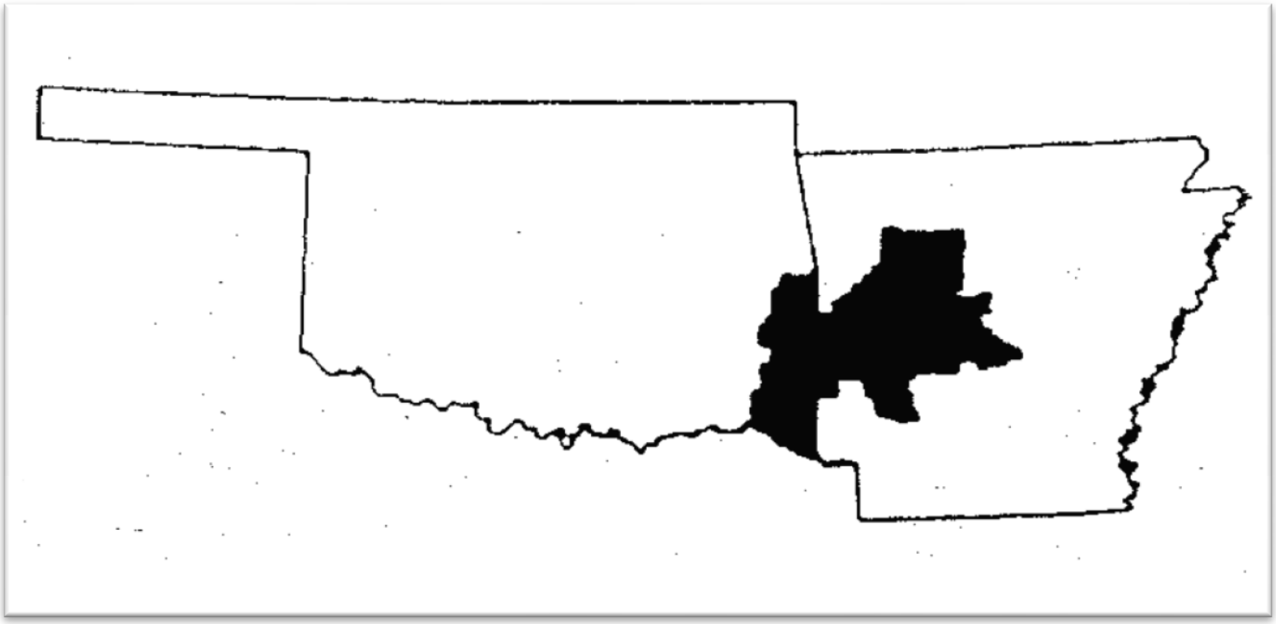

**Fig. 1. Study Area in black within Arkansas and Oklahoma**

**Shortleaf pines**

Shortleaf pine (*Pinus echinata* Mill.), one of the most important southern pine, is also known by the names southern yellow pine, Arkansas soft pine, old field pine or the shortstraw pine. There are no recognized varieties or subspecies for shortleaf pines. Carey (1992), reports that Shortleaf pine hybridizes with loblolly pine (*Pinus taeda)*, pitch pine (*Pinus* rigida), pond pine (*Pinus serotina*), and spruce pine (*Pinus glabra*). The leaves are needle-like, in bundles of two and three mixed together, and from 7-11 cm long. The cones are 4-7 cm long, with thin scales with a transverse keel and a short prickle. They open at maturity but are persistent. The important uses of shortleaf pines include its use as a source of wood pulp, plywood veneer, and lumber for a variety of uses, and as an important food source for birds and small mammals. Seedlings are browsed by deer. Stands of seedlings and saplings provide cover for bobwhite quail and wild turkey. Old-growth shortleaf pine provides habitat for cavity dwellers.

In standing volume, Shortleaf pine *(Pinus echinata* Mill.) is second only to loblolly pine *(Pinus taeda* L.) among the southern pines of the United States. Shortleaf pine amounts to one-quarter of the southern pine volume. The total volume of shortleaf pine is more than the combined volumes of slash *(P. elliottii* Engelm.) and longleaf *(P. pulustris* Mill.) pines. This species has the widest range of the southern pines. It grows in 22 states over more than 1,139,600 $km^2$, ranging from southeastern New York to eastern Texas (Willet, 1986). The greatest concentration of shortleaf pine is found in the Interior Highlands of Arkansas and east Oklahoma (Sternitzke and Nelson, 1970). It is the only naturally occurring pine is seen in the Interior Highlands of this region.

Shortleaf pine represents one of the major constituents of the Southern US timber market. Hence accurate information about the growth and yield aspects of shortleaf pines will be beneficial for industries and the general social welfare. Murphy and Farrar (1985) state that many private nonindustrial timberlands brought under management were understocked. Hence the major difficulty faced by the landowners is to increase stocking while keeping a simultaneous provision of a periodic income under a variety of constraints. To increase stocking, forest managers have adopted various techniques including silvicultural operations such as thinning. Although these techniques have often been employed, how these operations affect the growth of trees and what other variables influence it is still a question. The formulation of an econometric model based on the effect of thinning and understanding the optimal rotation age (economically and biologically) will be helpful in deriving a better management strategy in the case of Shortleaf pines.

**Data**

Until 1985, the major sources of data for the growth and yield of naturally occurring shortleaf pine forests were from fully stocked plots or from unmanaged stands (Lynch et al. 1999). During the period of 1985-1987, the then Department of Forestry (now part of the Department of Natural Resource Ecology and Management) at Oklahoma State University and USDA Forest Service Southern Research Station at Monticello, Arkansas collaboratively established growth and yield plots in even-aged natural shortleaf pine stands that were located in the Ozark and Ouachita National Forests. These plots were selected to represent a range of ages, densities and site qualities. The resulting sample of over 200 plots were permanently established in shortleaf pine natural stands located on the Ozark and Ouachita National Forests and were distributed from areas north of Interstate Highway 40 near Russellville in western Arkansas to near Broken Bow in Southeastern Oklahoma. Measurements of individual shortleaf pine tree total height, crown height, diameter at breast height (DBH) were taken and were used to develop a shortleaf pine survival model, a basal area increment model and a dbh-total height model.

The study plots were circular, 0.2 acres in size with a 52.7 foot radius and surrounded by a 33- foot isolation boundary. The net plot trees (all shortleaf pines) were identified by a tree number painted about six feet up on the tree bole and facing plot centre. Once the trees have been identified, measurements were taken. Plots have been remeasured in every 4 to 6 years and individual tree survival or mortality was recorded at each measurement (Lynch et al. 1999)).

The management of shortleaf pine data from two of the growth studies (studies 48 and 58) were the basis of recent studies conducted in OSU Department of Natural Resource Ecology and Management (including what was formerly the Department of Forestry). These data were for two growth periods (over four or five years). The simulation will be based on one growth period. Data quality checking (consistency of field data recording, quality of plot sheet data and computerized data), intermediate calculations required for statistical analysis and creation of master files for data storage had been done. Possible DBH and total height growth errors were checked and corrected with the help of original plot sheets.

**Optimal rotation age**

Four classes of basal area were established as designed by (Lynch et al. 1999). The ranges and midpoints of these four classes are given in the Table 1. The class midpoints were fixed 30, 60, 90 and 120 for those class ranges (16-45), (46-75), (76-105), and (106-135) square foot per acre respectively.

**Table 1:** Design variables with class midpoints and ranges for plots located in natural, even-aged shortleaf pine forests in western Arkansas and southeastern Oklahoma (Lynch et. al., 1999):

| Design Variable | Class midpoint | Class range |
|---|---|---|
| **Basal area ($ft^2$/ac)** | 30 | 16-45 |
| | 60 | 46-75 |
| | 90 | 76-105 |
| | 120 | 106-135 |

The complete Weibull distribution is used in this study to determine diameter distribution in forest stands. Weibull stand tables were developed for each basal area class viz. 30, 60, 90 and 120. Typical Weibull parameters a, b and c for younger aged stands were computed by Huebschmann (2000) for basal area classes 30, 60, 90 and 120 square feet per acre and these will be used to generate stand tables used for simulation starting values in this study. For each diameter class, the lower dbh limit, the upper dbh limit, Pi (class frequency), class dbh midpoint will be calculated.

Frequency in a dbh class is calculated by multiplying the number of survivors and the Pi value. The Pi value is obtained by the formula

$$Pi = (Exp(-(((L_i-a)/b)^c))-EXP(-(((U_i-a)/b)^c)), \quad a \leq L_i \leq U_i$$

where a, b and c are Weibull parameters, $L_i$ is the lower limit and $U_i$ is the upper limit for class i. $U_i$ limit is obtained when adding 0.5 to the dbh midpoint. $L_i$ is typically found by subtracting 0.5 from the dbh midpoint, but $L_i$ is equated to the Weibull parameter a if it is less than or equal to a.

Basal area will be calculated using the formula,

$$BA = 0.005454*D^2*F$$

where, D is the diameter at breast height and F is the frequency, or number of trees per acre within the desired dbh class.

Simulation is done after entering the frequency and class midpoints in the SLPSS (Shortleaf Pine Stand Simulator). SLPSS simulates the growth and development of naturally-occurring shortleaf pine forest stands. SLPSS is a distance-independent individual tree simulator. A description of the equations upon which SLPSS is based can be found in Lynch et al. (1999). Stand/plot acreage will be taken as 1, beginning year as 2001. Site index will be taken as 70 at the base age 50 years. Stand age values will be entered depending on which age the researcher wants to check. Pulpwood and sawtimber stump height will be taken as 0.5 feet.

Pulpwood top diameter considered in SLPSS will be 3 inches and sawtimber top diameter as 9 inches. Top diameter outside bark was considered for both Pulpwood and sawtimber. Minimum pulp stick length was taken as 5 inches and minimum sawlog length was taken as 8 feet. Minimum pulpwood tree length was taken as 10 feet and minimum saw timber tree length was taken as 8 feet. Bark volume considered was inside bark volume.

Length of the projection period will be changed according to the year the researcher desires to harvest. The simulator will give the green weight of the stem in tons/ acre (total, merchantable and sawtimber). Pulpwood green weight will be found out by subtracting saw timber from merchantable timber green weight.

The procedure is done without thinning and with thinning.. Thinning at different periods may give different merchantable volume of wood at different ages The sawtimber tons and pulpwood tons obtained from the simulation (with and without thinning) will be used for further economic analysis. From the price data for Southeastern Oklahoma Timber, Stumpage value in dollars per ton for pine saw timber was estimated $22 per ton and for Pine pulpwood $10per ton. Various discount rates on age will be used and the total price obtained will be calculated.

Various ages will be checked and all the individual tree growth data will be analyzed. The various merchantable volumes obtained from different initial densities, with thinning and without thinning will be compared and the effect is concluded. Furthermore, a glance into the factors that have contributed to an effect of thinning (if any) will be done using simple regression models.

Economically optimum rotation age and biologically optimum rotation age will be calculated separately. Economically optimum rotation age is that age of rotation when the harvest of stumpage will generate the maximum revenue or economic yield. Revenue and cost will be calculated based on the volume and price at a particular age. Profit will be calculated as the difference between revenue and cost. Net present value will be calculated as the difference between present value of revenue and present value of cost. Maximum sustainable yield or mean annual increment will be used to determine the biologically optimal harvest age of timber. This is based on the concept that the largest yield that can be harvested which does not deplete the resource (timber) irreparably and which leaves the resource in good shape for future uses. The optimum rotation age in biological terms will be taken as the point where the slope of Mean Annual Increment is equal to zero, which is also equivalent to the intersection of the MAI and the periodic annual increment (PAI).

**Future value of a single sum**

To find the future value of a single sum, the formula used by Klemperer (2003) will be employed.

$$\mathbf{V_n = V_0 (1+r)^n}$$

Where $V_n$ is the future value (value in year n), $V_0$ is the initial investment, r is the percent interest, n is the number of years.

Klemperer's (2003) assumption that inflation or the general rise in prices will be zero will be used here inorder to calculate the value obtained at various ages.

**Holding value vs. Liquidation value**

The net present value of holding the forest and selling land and timber at the optimal rotation age t is known as holding value. At an age y, the present value of all Revenues Rq minus the present value of all costsCq occurring from age y through t is the holding value.

Holding value at age y= $\sum_{q=0}^{t-y}[\frac{Rq}{(\mathbf{1+r})\text{^}\mathbf{q}} - \frac{Cq}{(1+r)\text{^}q}]$

**Mean Annual Increment Vs Periodic Annual Increment**

Mean annual Increment, MAI= $Y_t/t$

Where $Y_t$ is the yield at time t

Periodic Annual Increment, PAI = $\frac{Y2-Y1}{T2-T1}$

Where Y2 and Y1 are the yields at times 1 and 2 and T1 is the starting year and T2, the ending year.

**Thinning regimes**

Three thinning regimes will be tested for shortleaf pines to determine whether there is any considerable effect on the growth and yield and economic variables. The method adopted here include

For basal area class 30, three different regimes will be tested.

i. One thinning at age 40, followed by 2 growth period of 5 years
ii. One thinning at age 40, another at 45, followed by a growth period of 5 years
iii. Thinning at ages 37, 42 and 47 followed by a growth period of 3 years for basal area class 30.

For basal area class 60, three different regimes will be tested.

iv. One thinning at age 40, followed by 2 growth period of 5 years

v. One thinning at age 40, another at 45, followed by a growth period of 5 years

vi. Thinning at ages 37, 42 and 47 followed by a growth period of 3 years for basal area class 60.

For basal area class 90, three different regimes will be tested.

vii. One thinning at age 30, followed by 2 growth periods of 5 years

viii. One thinning at age 30, another at 35, followed by a growth period of 5 years

ix. Thinning at ages 37, 42 and 47 followed by a growth period of 3 years for basal area class 90.

For basal area class 120, three different regimes will be tested.

x. One thinning at age 30, followed by 2 growth period of 5 years

xi. One thinning at age 30, another at 35, followed by a growth period of 5 years

xii. Thinning at three different ages for basal area class 120.

Thus three thinning regimes will be tested for each basal area class. The three cases include one thinning, two thinning and three thinnings respectively.

CHAPTER IV

# FINDINGS

## Analysis of the data

A detailed analysis of the growth data was done. After reviewing much literature, the variables found to be relevant in testing the effect of thinning were basal area growth, diameter increment, site index, crown ratio and height. The analysis of these variables gave the following results. For convenience the entire plots grouped and named study plot 1 and study plot 2.

### Meaurement 1

In study plot 1 from the first measurement, the values of Crown ratio ranged from 0 to 0.8, whereas in study plot 2 the minimum crown ratio value was 0.12 and the maximum, 0.54. The minimum value showed for the variable basal area in plot 1 was 0.006 and the maximum, 3.25. Study plot 2 showed a basal area range of 0.17 to 1.73.

Diameter values showed a wide range in plot 1 from 1.1 to 24.4, whereas study plot 2 also showed a reasonably wide range but less than the first study plot, 5.6 to 17.8. Minimum Height observed from plot 1, was 10.00 whereas from study 2, the value was much higher, 54. Site index ranged from 9.00 to 78.00 in plot 1, whereas the range was from 56.00 to 78.00 in plot 2.

### Measurement 2

Diameter values showed a wide range in plot 1 from 1.2 to 25.4, whereas study plot 2 also showed a reasonably wide range but less than the first study plot, 5.8 to 18.6. Minimum Height observed from plot one, was 10.00 whereas from study 2, the value was much higher, 55.00. Maximum height reported from plot one was 113.00 and in plot two, it was 96.00.

Site index ranged from 13.00 to 73 in plot 1, whereas the range was from 61.00 to 83.00 in plot 2. In study plot 1 from the first measurement, the values of Crown ratio ranged from 0.025 to 0.8, whereas in study plot 2 the minimum crown ratio value was 0.13 and the maximum, 0.48. The minimum value showed for the variable basal area in plot 1 was 0.008 and the maximum, 3.52. Study plot 2 showed a basal area range of 0.18 to 1.89.

**Optimal rotation age**

Weibull parameters were used to generate shortleaf pine diameter distributions by stand age and shortleaf basal area class combinations. These values were developed by Huebschmann (2000) for the 20-year old age class in the natural even-aged shortleaf pine dataset used to fit parameters to SLPSS (Lynch et al. 1999). The basal area classes were 30, 60, 90 and 120 and the age class was 20. The parameter b had the maximum value in all basal area classes. "a" was the lowest in value for basal area classes, 60, 90 and 120. For basal area class 30, the lowest parameter value was reported by "c", a value reported as 1.76. The maximum parameter value reported among all the basal area classes was 3.74 shown by parameter b for basal area class 90. The parameters obtained are given in table 2.

**Table 2. Weibull parameters used to generate shortleaf pine diameter distributions by stand age and shortleaf basal area class combinations**

| Age class (Years) | Weibull Parameters | | | |
|---|---|---|---|---|
| | Pine BA class (square feet per acre) | a | b | c |
| 20 | 30 | 2.1 | 2.92 | 1.76 |
| | 60 | 1.1 | 3.73 | 2.45 |
| | 90 | 1.1 | 3.74 | 2.06 |
| | 120 | 1.2 | 3.32 | 1.93 |

For basal area class 30, the lower limit, upper limit, basal area, class height, vol/tree and vol/class were obtained for various dbh classes. Pi value was maximum at the diameter class 4, with a reported value of 0.26758. The basal area was maximum at the diameter class 5 with a value of 6.81036. The details are given in table 3.

**Table 3. Stand parameters for various dbh classes in the basal area class 30**

| Dbh | Lower limit | Upper limit | Pi | Basal Area |
|---|---|---|---|---|
| 1 | 2.10000 | 1.50000 | 0.00000 | 0.00000 |
| 2 | 2.10000 | 2.50000 | 0.02979 | 0.14620 |
| 3 | 2.50000 | 3.50000 | 0.21006 | 2.31993 |
| 4 | 3.50000 | 4.50000 | 0.26758 | 5.25382 |
| 5 | 4.50000 | 5.50000 | 0.22199 | 6.81036 |
| 6 | 5.50000 | 6.50000 | 0.14285 | 6.31084 |
| 7 | 6.50000 | 7.50000 | 0.07544 | 4.53604 |
| 8 | 7.50000 | 8.50000 | 0.03360 | 2.63876 |
| 9 | 8.50000 | 9.50000 | 0.01283 | 1.27515 |
| 10 | 9.50000 | 10.50000 | 0.00425 | 0.52094 |
| 11 | 10.50000 | 11.50000 | 0.00123 | 0.24139 |
| 12 | 11.50000 | 12.50000 | 0.00031 | 0.00000 |

For basal area class 60, the lower limit, upper limit, Pi, basal area, class height, vol/tree and vol/class were obtained for various dbh classes. Pi value was maximum at the diameter class 4, with a reported value of 0.26143.The basal area was maximum at the diameter class 5 with a value of 15.80756. The details are given in table 4.

**Table 4. Stand parameters for various dbh classes in the basal area class 60**

| Dbh | Lower limit | Upper limit | Pi | Basal Area |
|---|---|---|---|---|
| 1 | 1.10000 | 1.50000 | 0.00420 | 0.01169 |
| 2 | 1.50000 | 2.50000 | 0.08245 | 0.91739 |
| 3 | 2.50000 | 3.50000 | 0.20121 | 5.03716 |
| 4 | 3.50000 | 4.50000 | 0.26143 | 11.63504 |
| 5 | 4.50000 | 5.50000 | 0.22732 | 15.80756 |
| 6 | 5.50000 | 6.50000 | 0.13926 | 13.94509 |
| 7 | 6.50000 | 7.50000 | 0.06068 | 8.27064 |
| 8 | 7.50000 | 8.50000 | 0.01872 | 3.33206 |
| 9 | 8.50000 | 9.50000 | 0.00404 | 0.91120 |
| 10 | 9.50000 | 10.50000 | 0.00060 | 0.16807 |
| 11 | 10.50000 | 11.50000 | 0.00006 | 0.02220 |
| 12 | 11.50000 | 12.50000 | 0.00000 | 0.00000 |

For basal area class 90, the lower limit, upper limit, Pi, basal area, class height, vol/tree and vol/class were obtained for various dbh classes. Pi value was maximum at the diameter class 4, with a reported value of 0.23000.The basal area was maximum at the diameter class 5 with a value of 19.34336. The details are given in table 5.

**Table 5.Stand parameters for various dbh classes in the basal area class 90**

| Dbh | Lower limit | Upper limit | Pi | Basal Area |
|---|---|---|---|---|
| 1 | 1.10000 | 1.50000 | 0.00995 | 0.04001 |
| 2 | 1.50000 | 2.50000 | 0.11379 | 1.82964 |
| 3 | 2.50000 | 3.50000 | 0.20659 | 7.47355 |
| 4 | 3.50000 | 4.50000 | 0.23000 | 14.79190 |
| 5 | 4.50000 | 5.50000 | 0.19249 | 19.34336 |
| 6 | 5.50000 | 6.50000 | 0.12848 | 18.59155 |
| 7 | 6.50000 | 7.50000 | 0.07010 | 13.80784 |
| 8 | 7.50000 | 8.50000 | 0.03166 | 8.14530 |
| 9 | 8.50000 | 9.50000 | 0.01192 | 3.88038 |
| 10 | 9.50000 | 10.50000 | 0.00375 | 1.50894 |
| 11 | 10.50000 | 11.50000 | 0.00099 | 0.61311 |
| 12 | 11.50000 | 12.50000 | 0.00022 | 0.00000 |

For basal area class 120, the lower limit, upper limit, pi, basal area, class height, vol/tree and vol/class were obtained for various dbh classes. Pi value was maximum at the diameter class 4, with a reported value of 0.23897.The basal area was maximum at the diameter class 5 with a value of 27.23397. The details are given in table 6.

**Table 6. Stand parameters for various dbh classes in the basal area class 120**

| Dbh | Lower limit | Upper limit | Pi | Basal Area |
|---|---|---|---|---|
| 1 | 1.20000 | 1.50000 | 0.00962 | 0.05831 |
| 2 | 1.50000 | 2.50000 | 0.14141 | 3.43050 |
| 3 | 2.50000 | 3.50000 | 0.23783 | 12.98173 |
| 4 | 3.50000 | 4.50000 | 0.23897 | 23.18950 |
| 5 | 4.50000 | 5.50000 | 0.17962 | 27.23397 |
| 6 | 5.50000 | 6.50000 | 0.10766 | 23.50532 |
| 7 | 6.50000 | 7.50000 | 0.05292 | 15.72763 |
| 8 | 7.50000 | 8.50000 | 0.02167 | 8.40993 |
| 9 | 8.50000 | 9.50000 | 0.00746 | 3.66335 |
| 10 | 9.50000 | 10.50000 | 0.00217 | 1.31694 |
| 11 | 10.50000 | 11.50000 | 0.00054 | 0.49530 |
| 12 | 11.50000 | 12.50000 | 0.00011 | 0.00000 |

Frequency distributions and class mid points were found out for each basal area class separately. These values are important since this is being input to the SLPSS (Shortleaf Pine Stand Simulator).

For all basal area classes (30, 60, 90 and 120), the maximum number of trees was reported for diameter class 4. In basal area class 30, the maximum reported numbers of trees were 60.20603. In basal area class 60, the maximum reported numbers of trees were

133.33154. In basal area class 90, the maximum reported numbers of trees were 169.50748. In basal area class 120, the maximum reported numbers of trees were 265.73958. The details are given in table 7.

**Table 7. Frequency distributions at pine basal area classes, 30, 60, 90 and 120**

| Dbh | Basal Area 30 | Basal Area 60 | Basal Area 90 | Basal Area 120 |
|---|---|---|---|---|
| | Frequency (trees per acre) | Frequency (trees per acre) | Frequency (trees per acre) | Frequency (trees per acre) |
| 1 | 0.00000 | 2.14297 | 7.33542 | 10.69193 |
| 2 | 6.70170 | 42.05103 | 83.86691 | 157.24707 |
| 3 | 47.26256 | 102.61907 | 152.25431 | 264.46902 |
| 4 | 60.20603 | 133.33154 | 169.50748 | 265.73958 |
| 5 | 49.94760 | 115.93367 | 141.86549 | 199.73576 |
| 6 | 32.14177 | 71.02376 | 94.68866 | 119.71500 |
| 7 | 16.97328 | 30.94767 | 51.66715 | 58.85076 |
| 8 | 7.55971 | 9.54591 | 23.33523 | 24.09336 |
| 9 | 2.88642 | 2.06260 | 8.78363 | 8.29235 |
| 10 | 0.95515 | 0.30815 | 2.76667 | 2.41464 |
| 11 | 0.36578 | 0.03363 | 0.92905 | 0.75053 |
| 12 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |

**Table 8. Class mid points at pine basal area classes, 30, 60, 90 and 120**

| Dbh | Basal Area 30 | Basal Area 60 | Basal Area 90 | Basal Area 120 |
|---|---|---|---|---|
| | Class mid. (inches) | Class mid. (inches) | Class mid. (inches) | Class mid. (inches) |
| 1 | 1.80000 | 1.30000 | 1.30000 | 1.35000 |
| 2 | 2.30000 | 2.00000 | 2.00000 | 2.00000 |
| 3 | 3.00000 | 3.00000 | 3.00000 | 3.00000 |
| 4 | 4.00000 | 4.00000 | 4.00000 | 4.00000 |
| 5 | 5.00000 | 5.00000 | 5.00000 | 5.00000 |
| 6 | 6.00000 | 6.00000 | 6.00000 | 6.00000 |
| 7 | 7.00000 | 7.00000 | 7.00000 | 7.00000 |
| 8 | 8.00000 | 8.00000 | 8.00000 | 8.00000 |
| 9 | 9.00000 | 9.00000 | 9.00000 | 9.00000 |
| 10 | 10.00000 | 10.00000 | 10.00000 | 10.00000 |
| 11 | 11.00000 | 11.00000 | 11.00000 | 11.00000 |
| 12 | 12.00000 | 12.00000 | 12.00000 | 12.00000 |

For all basal area classes (30, 60, 90 and 120), the class midpoints were calculated. The maximum value of class midpoint for all basal area classes were shown by diameter class 12. The details are given in table 8.

The current stumpage value of sawtimber is 22 dollars per ton and the current stumpage value of pulpwood is 10 dollars per ton. Rate of interest was taken as 4 percent, which is the rate of return assumed.

The future value of sawtimber and pulpwood are calculated using the formula given by Klemperer (2003). The stand age is 20, in the year 2001. As this is 2011 (10 years have passed) since the measurement, future value has to be calculated based on this.

### I. Quantity obtained (No thinning)

For basal area classes 30, 60, 90 and 120, the SLPSS gave the values of the green weight of the stem in tons/ acre (total, merchantable and sawtimber) which are given in the Tables. Pulpwood green weight was found out by subtracting sawtimber from total merchantable timber green weight.

For basal area class 30, several projected lengths have been tested. Rotation ages, 35, 40, 45, 50 and 55 years were tested. A reported value of 104.5 tons was the maximum quantity of sawtons obtained at the rotation age 55. The maximum pulp tons was shown by rotation age 40, with a reported value of 53.8 tons. The details are given in table 9.

**Table 9. Total merchantable tons, saw tons and pulp tons obtained at different ages at basal area class 30 without thinning**

| | Age (Yrs) | Total quantity (tons) | Sawtimber (tons) | Pulpwood (tons) |
|---|---|---|---|---|
| **BA 30** **($ft^2$/ac)** | 35 | 70.6 | 20 | 50.6 |
| | 40 | 93.5 | 39.7 | 53.8 |
| | 45 | 115.3 | 61.9 | 53.4 |
| | 50 | 135.1 | 84 | 51.1 |
| | 55 | 152.7 | 104.5 | 48.2 |

For basal area class 60, the projected lengths tested include rotation ages 35, 40, 45 and 50 years. At the rotation age 50, the quantity of sawtimber in tons was maximum with a reported value of 63.1 tons. The maximum pulp tons was shown by rotation age 45, with a reported value of 103.3tons. The details are given in table 10**.**

**Table 10. Total merchantable tons, saw tons and pulp tons obtained at different ages at basal area class 60 without thinning**

| | Age (Yrs) | Total quantity (tons) | Sawtimber (tons) | Pulpwood (tons) |
|---|---|---|---|---|
| **BA 60** **($ft^2$/ac)** | 35 | 105.4 | 15.4 | 90 |
| | 40 | 129.6 | 30 | 99.6 |
| | 45 | 149.8 | 46.5 | 103.3 |
| | 50 | 166.1 | 63.1 | 103 |

For basal area class 90, several projected lengths have been tested. Rotation ages, 35, 40, 45 and 50 years were tested. Maximum quantity of sawtimber (in tons) was reported at the rotation age 50, with a value of 63.6 tons. The maximum pulp tons was reported at the rotation age 45, with a value of 111.8 tons. The details are given in table 11.

**Table 11. Total merchantable tons, saw tons and pulp tons obtained at different ages at basal area class 90 without thinning**

| BA 90 ($ft^2$/ac) | Age (Yrs) | Total quantity (tons) | Sawtimber (tons) | Pulpwood (tons) |
|---|---|---|---|---|
| | 35 | 121.4 | 21.1 | 100.3 |
| | 40 | 143.3 | 34.4 | 108.9 |
| | 45 | 160.9 | 49.1 | 111.8 |
| | 50 | 174.5 | 63.6 | 110.9 |

For basal area class 120, several projected lengths have been tested. Rotation ages, 35, 40, 45 and 50 years were tested. Maximum saw tons was reported at the rotation age 50, with a value of 42.1 tons. The maximum pulp tons was reported at the rotation age 45, a value of 132.4 tons. The details are given in table 12.

**Table 12. Total merchantable tons, saw tons and pulp tons obtained at different ages at basal area 120 without thinning**

| BA 120 ($ft^2$/ac) | Age (Yrs) | Total quantity (tons) | Sawtimber (tons) | Pulpwood (tons) |
|---|---|---|---|---|
| | 35 | 126.8 | 13.5 | 113.3 |
| | 40 | 146.7 | 22.2 | 124.5 |
| | 45 | 162.5 | 31.7 | 130.8 |
| | 50 | 174.5 | 42.1 | 132.4 |

### II. Value obtained (No thinning)

Assuming that inflation or the general rise in prices is zero, the values at different ages are obtained which are given in the tables below. The value obtained for sawtimber is calculated by multiplying the saw tons/acre obtained from the simulator and stumpage value of sawtimber which is 22 dollars, obtained from the ODAFF (Oklahoma Department of Agriculture Food and Forestry) latest report (personal communication).

In basal area class 30, the maximum value obtained with the discount percent of 4 was at the rotation age of 50, with a reported value of $332. The total value obtained was maximum at the rotation age of 45, reported value being $1896. The value obtained for sawtimber was maximum at the rotation age 55, with a reported value of $2299. The value obtained for pulpwood was maximum at the rotation age 40, with a value of $538. The details are given in table 13.

**Table 13. Value of sawtimber, pulpwood, total value (with and without discounting) for basal area class 30 without thinning**

| | Age (Yrs) | Value obtained for Sawtimber (Dollars/acre) | Value obtained for Pulpwood (Dollars/acre) | Total value obtained (Dollars/acre) | Present Value (Dollars/acre) |
|---|---|---|---|---|---|
| BA 30 ($ft^2/ac$) | 35 | 440 | 506 | 946 | 240 |
| | 40 | 873 | 538 | 1411 | 294 |
| | 45 | 1362 | 534 | 1896 | 325 |
| | 50 | 1848 | 511 | 2359 | 332 |
| | 55 | 2299 | 482 | 2781 | 322 |

For basal area class 60, maximum value obtained with the discount percent of 4 was at the rotation age of 45, with a reported value of $352. The total value obtained was maximum at the rotation age 50, with a value of $2418.2. The value obtained for sawtimber was maximum at the age 50, with a value of $1388. The value obtained for pulpwood was maximum at the age 45, with a reported value of $1033. The details are given in table 14.

**Table 14. Value of saw timber, pulpwood, total value (with and without discounting) for basal area class 60 without thinning**

| | Age (Yrs) | Value obtained for Sawtimber (Dollars/acre) | Value obtained for Pulpwood (Dollars/acre) | Total value obtained (Dollars/acre) | Present Value (Dollars/acre) |
|---|---|---|---|---|---|
| **BA 60 ($ft^2$/ac)** | **35** | 339 | 900 | 1239 | 314 |
| | **40** | 660 | 996 | 1656 | 345 |
| | **45** | 1023 | 1033 | 2056 | 352 |
| | **50** | 1388 | 1030 | 2418 | 340 |

For basal area class 90, maximum value obtained with the discount percent of 4 was at the age of 40, with a reported value of $385.The total value obtained was maximum at the rotation age 50, with a value of $2508. The value obtained for sawtimber was maximum at the age 50, with a value of $1399. The value obtained for pulpwood was maximum at the age 45, with a value of $1118. The details are given in table 15.

**Table 15. Value of saw timber, pulpwood, total value (with and without discounting) for basal area 90 without thinning**

| | Age (Yrs) | Value obtained for Sawtimber (Dollars/acre) | Value obtained for Pulpwood (Dollars/acre) | Total value obtained (Dollars/acre) | Present Value (Dollars/acre) |
|---|---|---|---|---|---|
| **BA 90 ($ft^2$/ac)** | **35** | 464 | 1003 | 1467 | 372 |
| | **40** | 757 | 1089 | 1846 | 385 |
| | **45** | 1080 | 1118 | 2198 | 376 |
| | **50** | 1399.2 | 1109 | 2508 | 353 |

For basal area class 120, maximum value obtained with the discount percent of 4 was at the age of 35, with a reported value of $362. The total value obtained was maximum at the rotation age 50, with a value of $2005. The value obtained for sawtimber was maximum at the age 45, with a value of $697. The value obtained for pulpwood was maximum at the age 45, with a value of $1308. The details are given in the table 16.

**Table 16. Value of saw timber, pulpwood, total value (with and without discounting) for basal area 120 without thinning**

| | Age (Yrs) | Value obtained for Saw timber (Dollars/acre) | Value obtained for Pulpwood (Dollars/acre) | Total value obtained (Dollars/acre) | Present Value (Dollars/acre) |
|---|---|---|---|---|---|
| **BA120 ($ft^2$/ac)** | **30** | 150 | 953 | 1103 | 340 |
| | **35** | 297 | 1133 | 1430 | 362 |
| | **40** | 488 | 1245 | 1733 | 361 |
| | **45** | 697 | 1308 | 2005 | 343 |
| | **50** | 926 | 1324 | 2250 | 317 |

### III. Optimal Rotation age (No thinning)

The optimal rotation age at basal area 30, 60, 90 and 120 are given in the table below. When discounted using the rate 4 per cent the value was maximum at the age 50 for basal area class 30. For basal area class 60, the value was maximum at the age 45. For basal area class 90, the value was maximum at the age 40. For basal area class 120, the value was maximum at the age 35. The details are given in table 17.

**Table 17. Optimal rotation at various basal area classes without thinning**

| Basal area class ($ft^2$/ac) | Optimal Rotation age (Years) |
|---|---|
| 30 | 50 |
| 60 | 45 |
| 90 | 40 |
| 120 | 35 |

## IV. Bare Land Value (No thinning)

BLV at different ages were calculated using the formula, BLV = $NR/((1 + r)^n-1)$. The results obtained from various basal area classes are given below. Higher Bare Land value means better the investment.

For Basal area class 30, highest bare land value was obtained at the age 50 with the reported value of 331dollars per acre, consistent with the optimal rotation age. Bare land value was found to be decreased after age 50. When age 55 was tested the value was 321 dollars per acre. The Net Present value at age 50 was not the highest among the ages tested. Net Present Value was highest at age 55. The details are given in table 18.

**Table 18. Bare Land Value without thinning for basal area 30**

| Age (Yrs) | NPV ($ per acre) | BLV($ per acre) |
|---|---|---|
| **35** | 946 | 239 |
| **40** | 1411 | 293 |
| **45** | 1896 | 324 |
| **50** | 2359 | 331 |
| **55** | 2781 | 321 |

For basal area class 60, the highest Bare Land Value was obtained at the age 45, with a reported value of 351 dollars per acre, which is consistent with the optimal rotation age. Bare land value was found to be decreased after age 45. When age 50 was tested the value was 339 dollars per acre. The Net Present Value at age 45 was not the highest among the ages tested. The Net Present Value was highest at the rotation age 50. The details are given in table 19.

**Table 19. Bare Land Value without thinning for basal area class 60**

| Age (Yrs) | NPV ($ per acre) | BLV($ per acre) |
|---|---|---|
| 35 | 1239 | 313 |
| 40 | 1656 | 344 |
| 45 | 2056 | 351 |
| 50 | 2418 | 339 |

For basal area class 90, the highest Bare Land Value was obtained at the rotation age 40, with a reported value of 384 dollars per acre, consistent with the optimal rotation age. Bare Land Value was found to be decreased after age 40. When age 45 was tested the value was 375 dollars per acre. The Net Present value at age 40 was not the highest among the ages tested. Net Present Value was highest at age 55. The details are given in table 20.

**Table 20. Bare Land Value without thinning for basal area class 90**

| Age (Yrs) | NPV ($ per acre) | BLV($ per acre) |
|---|---|---|
| 35 | 1467 | 371 |
| 40 | 1846 | 384 |
| 45 | 2198 | 375 |
| 50 | 2508.2 | 351.9354 |

For basal area 120, highest Bare Land Value was obtained at the rotation age of 35 years with a reported value of 361 dollars per acre consistent with the optimal rotation age. Bare Land Value was found to be decreased after age 35. When age 40 was tested the value was 360 dollars per acre. The Net Present value at age 35 was not the highest among the ages tested. Net Present Value was highest at age 50. The details are given in table 21.

**Table 21. Bare Land Value without thinning for basal area class 120**

| Age (Yrs) | NPV ($ per acre) | BLV($ per acre) |
|---|---|---|
| **30** | 1103 | 339 |
| **35** | 1430 | 361 |
| **40** | 1733 | 360 |
| **45** | 2005 | 342 |
| **50** | 2250 | 316 |

## V. Holding Value (No thinning)

For basal area class 30, highest holding value was obtained at the age 50, with a reported value, 1858 dollars per acre, consistent with the optimal rotation age. Holding value was found to be decreased after age 50. The Net Present Value at age 50 was not the highest among the ages tested. Net Present Value was highest at age 55. The details are given in table 22.

**Table 22. Holding value at basal area class 30 without thinning**

| Age (Yrs) | NPV ($ per acre) | Holding Value ($ per acre) |
|---|---|---|
| **35** | 946 | 247 |
| **40** | 1411 | 615 |
| **45** | 1896 | 1146 |
| **50** | 2359 | 1858 |
| **55** | 2781 | |

For basal area class 60, highest holding value was obtained at the rotation age 45 with a reported value of 1555 dollars per acre, consistent with the optimal rotation age. Holding value was found to be decreased after age 45. The Net Present value at age 45 was not the highest among the ages tested. NPV was highest at age 50. The details are given in table 23.

**Table 23. Holding value at basal area class 60 without thinning**

| Age (Yrs) | NPV ($ per acre) | Holding Value ($ per acre) |
|---|---|---|
| **35** | 1239 | 498 |
| **40** | 1656 | 949 |
| **45** | 2056 | 1555 |
| **50** | 2418 | |

For basal area class 90, highest holding value was obtained at the age of 40 with a reported value of 1345 dollars per acre, consistent with the optimal rotation age. Holding value was found to be decreased after age 40. The Net Present value at age 40 was not the highest among the ages tested. The Net Present value was highest at the age 50. The details are given in table 24.

**Table 24. Holding value at basal area class 90 without thinning**

| Age (Yrs) | NPV ($ per acre) | Holding Value ($ per acre) |
|---|---|---|
| **35** | 1467 | 794 |
| **40** | 1846 | 1345 |
| **45** | 2198 | |
| **50** | 2508 | |

For basal area class 120, highest holding value was obtained at the age 35 with a reported value of 929 dollars per acre, consistent with the optimal rotation age. Holding value was found to be decreased after age 35. The Net Present value at age 35 was not the highest among the ages tested. NPV was highest at age 50. The details are given in table 25.

**Table 25. Holding Value at basal area class 120 without thinning**

| Age | NPV ($ per acre) | Holding Value ($ per acre) |
|---|---|---|
| **30** | 1103 | 494 |
| **35** | 1430 | 929 |
| **40** | 1733 | |
| **45** | 2005 | |
| **50** | 2250 | |

.

## Thinning Effects

Thinning was done in all basal area classes. The 30 and 60 basal area classes were thinned to 60 square feet per acre at the age of 40. The basal area classes 90 and 120 were thinned to 60 square feet per acre at the age of 30. The frequencies and class mid points were fed into the Shortleaf pine stand simulator.

1. **Basal area class 30**

Stand size was given 1 acre, beginning year as 2001, stand age, 20 and site index 70. Three cases were tested for finding the effect of thinning,

a. **One thinning at age 40, followed by 2 growth periods of 5 years**

At age, 40 (i. e. the projection length used 20), without thinning, the green weight of total merchantable stem/acre was 93.4 tons per acre and sawtimber was 39.7 tons per acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 53.7.

Free Thinning was done at the $40^{th}$ year (i.e. year 2021) and the target residual pine basal area was set to 60 square feet. The stand was allowed to grow for 5 more years. At the end of the 5 year period, in 2026, the green weight of merchantable stem/acre was 70.7 tons per acre and sawtimber was 38.4 tons per acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 32.3.

The stand was allowed to grow again for 5 years and in 2031, the green weight of merchantable stem/acre was 88.7 and sawtimber was 57.7. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/ acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 31.0. The details are presented in table 26.

**Table 26. Quantity (in tons/acre) and value (in dollars) obtained after one thinning at age 40**

| Thinning | saw timber (tons/acre) | Pulpwood (tons/acre) | Value of saw timber ($) | value of pulp wood ($) | NPV ($ per acre) |
|---|---|---|---|---|---|
| 5 yr after thinning | 38.4 | 32.3 | 845 | 323 | 1168 |
| 10 yr after thinning | 57.7 | 31 | 1269 | 310 | 1579 |

**b. One thinning at age 40, another at 45, followed by a growth period of 5 years**

At age, 40 (i.e. the projection length used 20), without thinning, the green weight of total merchantable stem/acre was 93.4 tons/acre and sawtimber was 39.7 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/ acre. The pulpwood tons/acre thus obtained was 53.7.

Free Thinning was done at the 40$^{th}$ year (i.e. year 2021) and the target residual pine basal area was set to 60 square feet. In 2021, after the thinning the green weight of merchantable stem/acre was 53.5 tons/acre and sawtimber was 22.7 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 30.8.

The stand was allowed to grow again for 5 years and in 2026, free thinning was done again. The green weight of merchantable stem/acre was 58.7 tons/acre and sawtimber was 33.2 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 25.5

The stand was allowed to grow again for 5 years and in 2031, the green weight of merchantable stem/acre was 74.6 tons/acre and sawtimber was 50.9 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 23.7.The details are presented in table 27.

**Table 27. Quantity (in tons/acre) and value (in dollars) obtained after one thinning at age 40 and another at 45**

| Thinning | Sawtimber (tons/acre) | Pulpwood (tons/acre) | Value of sawtimber ($) | Value of pulpwood ($) | NPV ($ per acre) |
|---|---|---|---|---|---|
| **5 yr after first thinning** | 33.2 | 25.5 | 730 | 255 | 985 |
| **5 yr after second thinning** | 50.9 | 23.7 | 1120 | 237 | 1357 |

c. **Thinning at ages 37, 42 and 47 followed by a growth periods of 3 years for basal area class 30**

Free thinning was done at the 37th year (i.e. year 2018) and the target residual pine basal area was set to 60 square feet. In 2018, after the thinning the green weight of merchantable stem/acre was 50.4 tons/acre and sawtimber was 17.6 tons/acre. The pulp wood tons/acre was obtained by subtracting the green weight of sawtimber in tons/ acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/ acre thus obtained was 32.8.

The stand was allowed to grow again for 5 years and in 2023, free thinning was done again. The green weight of merchantable stem/acre was 55.9 tons/acre and sawtimber was 28 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/ acre. The pulpwood tons/acre thus obtained was 27.9.

The stand was allowed to grow again for 5 years and in 2028, the green weight of merchantable stem/acre was 60.9 tons/acre and sawtimber was 38.6 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 22.3.

The stand was allowed to grow again for 3 more years. Thus during the year 2031, the green weight of merchantable stem/ acre was 70.0 tons/acre and sawtimber was 48.8 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 21.2.

2. **Basal area class 60**

Stand size was given 1 acre, beginning year as 2001, stand age, 20 and site index 70. Three cases were tested for finding the effect of thinning,

a. **One thinning at age 40, followed by 2 growth periods of 5 years**

At age, 40 (i.e. the projection length used 20), year 2021, without thinning, the green weight of total merchantable stem/acre was 129.5 tons/acre and sawtimber was 30.0 tons/acre. The pulp wood tons/acre was obtained by subtracting the green weight of saw timber in tons/acre from green weight of total merchantable stem in tons/acre. The pulp wood tons/ acre thus obtained was 99.5. Free Thinning was done at the $40^{th}$ year (i.e. year 2021) and the target residual pine basal area was set to 60 square feet. In 2021, after the thinning the green weight of merchantable stem/acre was 60.4 tons/acre and saw timber was 13.7 tons/acre. The pulp wood tons/acre was obtained by subtracting the green weight of saw timber in tons/acre from green weight of total merchantable stem in tons/ acre. The pulp wood tons/acre thus obtained was 46.7.

The stand was allowed to grow again for 5 years and in 2026, the green weight of merchantable stem/acre was 81.7 tons/acre and sawtimber was 30.7 tons/acre. The pulp wood tons/acre was obtained by subtracting the green weight of saw timber in tons/ acre from green weight of total merchantable stem in tons/ acre. The pulp wood tons/acre thus obtained was 51.0.

The stand was allowed to grow again for 5 years and in 2031, the green weight of merchantable stem/acre was 102.2 and sawtimber was 51.9. The pulp wood tons/acre was obtained by subtracting the green weight of saw timber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 50.3.The details are presented in table 28.

**Table 28. Quantity (in tons/acre) and value (in dollars) obtained after one thinning at age 40**

| Thinning | saw timber (tons/acre) | Pulpwood (tons/acre) | Value of saw timber ($) | value of pulp wood ($) | NPV($ per acre) |
|---|---|---|---|---|---|
| 5 yr after thinning | 30.7 | 51 | 675 | 510 | 1185 |
| 10 yr after thinning | 51.9 | 50.3 | 1142 | 503 | 1645 |

**b. One thinning at age 40, another at 45, followed by a growth periods of 5 years**

At age, 40 (i.e. the projection length used 20), year 2021, without thinning, the green weight of total merchantable stem/acre was 129.5 tons/acre and saw timber was 30.0 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulp wood tons/acre thus obtained was 99.5.

Free Thinning was done at the $40^{th}$ year (i.e. year 2021) and the target residual pine basal area was set to 60 square feet. In 2021, after the thinning the green weight of merchantable stem/acre was 66.6 tons/acre and sawtimber was 15.1 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of saw timber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 51.5.

The stand was allowed to grow again for 5 years and in 2026, free thinning was done again. The green weight of merchantable stem/acre was 56.0 tons/acre and sawtimber was 21.4 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons acre thus obtained was 34.6.

The stand was allowed to grow again for 5 years and in 2031, the green weight of merchantable stem/acre harvested was 73.2 tons/acre and sawtimber was 39.4 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/ acre. The pulpwood tons/acre thus obtained was 33.8.

The stand was allowed to grow again for 5 years and in 2036, the green weight of merchantable stem/acre harvested was 90.5 and sawtimber was 58.6. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/ acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 31.9.

**Table 29. Quantity (in tons/acre) and value (in dollars) obtained after one thinning at age 40 and another at 45**

| Thinning | saw timber (tons/acre) | Pulpwood (tons/acre) | Value of saw timber ($) | value of pulp wood ($) | NPV ($ per acre) |
|---|---|---|---|---|---|
| **5 yr after first thinning** | 21.4 | 34.6 | 471 | 346 | 817 |
| **5 yr after second thinning** | 39.4 | 33.8 | 867 | 338 | 1205 |

**c. Thinning at ages 37, 42 and 47 followed by a growth periods of 3 years for Basal area class 60**

Free thinning was done at the 37$^{th}$ year (i.e. year 2018) and the target residual pine basal area was set to 60 square feet. In 2018, after the thinning the green weight of merchantable stem/acre was 49.7 tons/acre and sawtimber was 11.8 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 37.9.

The stand was allowed to grow again for 5 years and in 2023, free thinning was done again. The green weight of merchantable stem/acre was 53.6 tons/acre and saw timber was 20.7 tons/acre. The pulp wood tons/acre was obtained by subtracting the green weight of sawtimber in tons/ acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 32.9.

The stand was allowed to grow again for 5 years and in 2028, the green weight of merchantable stem/acre harvested was 59.0 tons/acre and sawtimber was 31.3 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 27.7.

The stand was allowed to grow again for 3 more years. Thus during the year 2031, the green weight of merchantable stem/acre was 68.7 tons/acre and sawtimber was 41 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/ acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 27.7.

3. **Basal area class 90**

Stand size was given 1 acre, beginning year as 2001, stand age, 20 and site index 70. Three cases were tested for finding the effect of thinning.

a. **One thinning at age 30, followed by 2 growth periods of 5 years**

At age 30, we used the projection length 10 and year 2011 in the simulation model SLPSS, without thinning, the green weight of total merchantable stem/ acre was 95.4 tons/acre and sawtimber was 10.1 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/ acre. The pulpwood tons/acre thus obtained was 85.3.

Free Thinning was done at the $30^{th}$ year (i.e. year 2011) and the target residual pine basal area was set to 60 square feet. In 2011, after the thinning the green weight of merchantable stem/acre was 48.2 tons/acre and saw timber was 5.0 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 43.2.

The stand was allowed to grow again for 5 years and in 2016, the green weight of merchantable stem/acre was 73.5 tons/acre and saw timber was 17.0 tons/acre. The pulp wood tons/acre was obtained by subtracting the green weight of sawtimber in tons/ acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/ acre thus obtained was 56.5.

The stand was allowed to grow again for 5 years and in 2021, the green weight of merchantable stem/acre was 98.3 tons/acre and sawtimber was 33.0 tons/acre. The pulp wood tons/acre was obtained by subtracting the green weight of saw timber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 65.3.The details are presented in table 30.

**Table 30. Quantity (in tons/acre) and value (in dollars) obtained after one thinning at age 30**

| Thinning | Sawtimber (tons/acre) | Pulpwood (tons/acre) | Value of sawtimber ($) | Value of pulpwood ($) | NPV ($ per acre) |
|---|---|---|---|---|---|
| **5 yr after thinning** | 17 | 56.5 | 374 | 565 | 939 |
| **10 yr after thinning** | 33 | 65.3 | 726 | 653 | 1379 |

### b. One thinning at age 30, another at 35, followed by a growth periods of 5 years

At age, 30 (i.e. the projection length used 10), year 2011, without thinning, the green weight of total merchantable stem/acre was 95.4 tons/acre and saw timber was 10.1 tons/acre. The pulp wood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 85.3.

Free Thinning was done at the 30$^{th}$ year (i.e. year 2011) and the target residual pine basal area was set to 60 square feet. In 2011, after the thinning the green weight of merchantable stem/acre was 55.4 tons/acre and sawtimber was 5.2 tons/acre. The pulp wood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/ acre thus obtained was 50.2.

The stand was allowed to grow again for 5 years and in 2016, free thinning was done again. The green weight of merchantable stem/acre was 45.4 tons/acre and sawtimber was 9.2 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/ acre. The pulpwood tons/acre thus obtained was 36.2.

The stand was allowed to grow again for 5 years and in 2021, the green weight of merchantable stem/acre was 65.5 tons/acre and sawtimber was 24.0 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of saw timber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 41.5.

The stand was allowed to grow again for 5 years and in 2026, the green weight of merchantable stem/acre was 86.1 tons/acre and sawtimber was 42.9 tons/acre. The pulp wood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 43.2.The details are presented in table 31.

**Table 31. Quantity (in tons/acre) and value (in dollars) obtained after one thinning at age 30 and another at 35**

| Thinning | Sawtimber (tons/acre) | Pulpwood (tons/acre) | Value of saw timber ($) | Value of pulp wood ($) | NPV ($ per acre) |
|---|---|---|---|---|---|
| 5 yr after first thinning | 9.2 | 36.2 | 202 | 362 | 564.4 |
| 5 yr after second thinning | 24.0 | 41.5 | 528 | 415 | 943 |

c. **Thinning at ages 37, 42 and 47 followed by a growth periods of 3 years for Basal area class 90**

Free Thinning was done at the 37$^{th}$ year (i.e. year 2018) and the target residual pine basal area was set to 60 square feet. In 2018, after the thinning the green weight of merchantable stem/acre was 64.3 tons/acre and sawtimber was 14.0 tons/acre. The pulp wood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/ acre. The pulpwood tons/acre thus obtained was 50.3.

The stand was allowed to grow again for 5 years and in 2023, free thinning was done again. The green weight of merchantable stem/acre was 53.0 tons/acre and sawtimber was 19.1 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/ acre. The pulpwood tons/acre thus obtained was 33.9.

The stand was allowed to grow again for 5 years and in 2028, the green weight of merchantable stem/acre was 58.4 tons/acre and sawtimber was 30.1 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 28.3.

The stand was allowed to grow again for 3 more years. Thus during the year 2031, the green weight of merchantable stem/acre was 68.1 tons/acre and sawtimber was 39.8 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of saw timber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/ acre thus obtained was 28.3.

4. **Basal area class 120**

Stand size was given 1 acre, beginning year as 2001, stand age, 20 and site index 70. Three cases were tested for finding the effect of thinning,

a. **One thinning at age 30, followed by 2 growth periods of 5 years**

At age 30 (i.e. the projection length used 10), year 2011, without thinning, the green weight of total merchantable stem/acre was 102.1 tons/acre and sawtimber was 6.8 tons/acre. The pulp wood tons/acre was obtained by subtracting the green weight of saw timber in tons/acre from green weight of total merchantable stem in tons/ acre. The pulp wood tons/acre thus obtained was 95.3.

Free thinning was done at the 30$^{th}$ year (i.e. year 2011) and the target residual pine basal area was set to 60 square feet. In 2011, after the thinning the green weight of merchantable stem/acre was 48.7 tons/acre and sawtimber was 2.8 tons/acre. The pulp wood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 45.9.

The stand was allowed to grow again for 5 years and in 2016, the green weight of merchantable stem/acre was 78.4 tons/acre and sawtimber was 9.2 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/

acre from green weight of total merchantable stem in tons/ acre. The pulpwood tons/ acre thus obtained was 69.2.

The stand was allowed to grow again for 5 years and in 2021, the green weight of merchantable stem/acre was 104.9 tons/acre and saw timber was 21.6 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 83.3. The details are presented in table 32.

**Table 32. Quantity (in tons/acre) and value (in dollars) obtained after one thinning at age 30**

| Thinning | Sawtimber (tons/acre) | Pulpwood (tons/acre) | Value of sawtimber ($) | Value of pulpwood ($) | NPV ($ per acre) |
|---|---|---|---|---|---|
| **5 yr after thinning** | 9.2 | 69.2 | 202 | 692 | 894 |
| **10 yr after thinning** | 21.6 | 83.3 | 475 | 833 | 1308 |

**b. One thinning at age 30, another at 35, followed by a growth period of 5 years**

At age, 30 (i.e. the projection length used 10), year 2011, without thinning, the green weight of total merchantable stem/acre was 102.1 tons/acre and sawtimber was 6.8 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of saw timber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 95.3.

Free thinning was done at the 30$^{th}$ year (i.e. year 2011) and the target residual pine basal area was set to 60 square feet. In 2011, after the thinning the green weight of merchantable stem/acre was 50.1 tons/acre and sawtimber was 3.4 tons/acre. The pulp wood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 46.7.

The stand was allowed to grow again for 5 years and in 2016, free thinning was done again. The green weight of merchantable stem/acre was 41.7 tons/acre and sawtimber was 4.9 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/ acre. The pulpwood tons/ acre thus obtained was 36.8.

The stand was allowed to grow again for 5 years and in 2021, the green weight of merchantable stem/acre was 63.4 tons/acre and sawtimber was 13.1 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of saw timber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 50.3.

The stand was allowed to grow again for 5 years and in 2026, the green weight of merchantable stem/acre was 86.2 tons/acre and saw timber was 28.2 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of saw timber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 58.0.The details are presented in table 33.

**Table 33. Quantity (in tons/acre) and value (in dollars) obtained after one thinning at age 30 and another at 35**

| Thinning | Sawtimber (tons/acre) | Pulpwood (tons/acre) | Value of sawtimber ($) | Value of pulpwood ($) | NPV ($ per acre) |
|---|---|---|---|---|---|
| **5 yr after first thinning** | 4.9 | 36.8 | 108 | 368 | 476 |
| **5 yr after second thinning** | 13.1 | 50.3 | 288 | 503 | 791 |

### a. Thinning at three different ages for basal area class 120

Free thinning was done at the 32nd$^{th}$ year (i.e. year 2013) and the target residual pine basal area was set to 60 square feet. In 2013, after the thinning the green weight of merchantable stem/acre was 45.9 tons/acre and sawtimber was 4.6 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 41.3.

The stand was allowed to grow again for 3 years and in 2016, free thinning was done again. The green weight of merchantable stem/acre was 41.9 tons/acre and sawtimber was 6.7 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 35.2.

The stand was allowed to grow again for 5 years and in 2021, the green weight of merchantable stem/acre was 49.5 tons/acre and sawtimber was 15.0 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 34.5.

The stand was allowed to grow again for 5 more years. Thus during the year 2026, the green weight of merchantable stem/acre was 55.4 tons/acre and sawtimber was 22.6 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/ acre. The pulpwood tons/acre thus obtained was 32.8.

The stand was allowed to grow again for 5 more years. Thus during the year 2031, the green weight of merchantable stem/acre was 72.8 tons/acre and saw timber was 38.3 tons/acre. The pulpwood tons/acre was obtained by subtracting the green weight of sawtimber in tons/acre from green weight of total merchantable stem in tons/acre. The pulpwood tons/acre thus obtained was 34.5.The details of 3 thinnings are given in the table 34.

**Table 34. Quantity (in tons/acre) and value (in dollars) obtained after thinning at ages 37, 42 and 47 followed by a growth periods of 3 years for various basal area classes**

| Basal area class | Sawtimber (tons/acre) | Pulpwood (tons/acre) | Value of sawtimber ($) | Value of pulpwood ($) | NPV ($ per acre) |
|---|---|---|---|---|---|
| 30 | 48.8 | 21.2 | 1074 | 212 | 181 |
| 60 | 41.0 | 27.7 | 902 | 277 | 166 |
| 90 | 39.8 | 28.3 | 876 | 283 | 163 |
| 120 | 38.3 | 34.5 | 843 | 345 | 167 |

## Bare Land Value after thinning

### Basal area class 30

For basal area class 30, after one thinning, Bare Land Value was highest at the rotation age 50. The reported value at age 50 was 221.2415 dollars per acre. Net Present Value was highest at this age, a reported value of 1579.4 dollars per acre. The details are given in table 35.

**Table 35. Bare Land Value with one thinning for basal area 30**

| | Age | NPV ($ per acre | BLV ($ per acre) |
|---|---|---|---|
| BA 30 | 45 | 1168 | 199 |
| | 50 | 1579 | 221 |

For basal area class 30, after two thinnings, Bare Land Value was highest at the rotation age 50. The reported value at age 50 was 190 dollars per acre. Net Present Value was highest at this age, a reported value of 1356.8 dollars per acre. The details are given in table 36.

**Table 36. Bare Land Value with two thinnings for basal area class 30**

| | Age | NPV ($ per acre) | BLV ($ per acre) |
|---|---|---|---|
| BA 30 | 45 | 985 | 168 |
| | 50 | 1357 | 190 |

### Basal area class 60

For basal area class 60, after one thinning, Bare Land Value was highest at the rotation age 50. The reported value at age 50 was 230 dollars per acre. Net Present Value was highest at this age, a reported value of 1645 dollars per acre. The details are given in table 37**.**

**Table 37. Bare Land Value with one thinning for basal area class 60**

| | Age | NPV ($ per acre) | BLV ($ per acre) |
|---|---|---|---|
| **BA 60** | 45 | 1185 | 202 |
| | 50 | 1645 | 230 |

For basal area 60, after two thinnings, Bare Land Value was highest at the rotation age 50. The reported value at age 50 was 169dollars per acre. Net Present Value was highest at this age, a reported value of 1205 dollars per acre. The details are given in table 38.

**Table 38. Bare Land Value with two thinnings for basal area class 60**

| | Age | NPV ($ per acre) | BLV ($ per acre) |
|---|---|---|---|
| **BA 60** | 45 | 816.8 | 139 |
| | 50 | 1204.8 | 169 |

**Basal area class 90**

For basal area class 90, after one thinning, Bare Land Value was highest at the rotation age 40. The reported value at age 40 was 286.2306 dollars per acre. Net Present Value was highest at this age, a reported value of 1379 dollars per acre. The details are given in table 39.

**Table 39. Bare Land Value with one thinning for basal area class 90**

| | Age | NPV ($ per acre) | BLV ($ per acre) |
|---|---|---|---|
| **BA 90** | 35 | 939 | 237 |
| | 40 | 1379 | 286 |

For basal area 90, after two thinnings, Bare Land Value was highest at the rotation age 40. The reported value at age 40 was 195.4166 dollars per acre. Net Present Value was highest at this age, a reported value of 943 dollars per acre. The details are given in table 40**.**

**Table 40. Bare Land Value with two thinnings for basal area class 90**

| | Age | NPV ($ per acre) | BLV ($ per acre) |
|---|---|---|---|
| **BA 90** | 35 | 564 | 142 |
| | 40 | 943 | 195 |

**Basal area class 120**

For basal area 120, after one thinning, Bare Land Value was highest at the rotation age 40. The reported value at age 40 was 271.4837 dollars per acre. Net Present Value was highest at this age, a reported value of 1308.2 dollars per acre. The details are given in table 41.

**Table 41. Bare Land Value with one thinning for basal area class 120**

| | Age | NPV ($ per acre) | BLV ($ per acre) |
|---|---|---|---|
| **BA 120** | 35 | 894 | 226 |
| | 40 | 1308 | 271 |

For basal area 120, after two thinnings, Bare Land Value was highest at the rotation age 40. The reported value at age 40 was 163.7983 dollars per acre. Net Present Value was highest at this age, a reported value of 791.2 dollars per acre. The details are given in table 42.

**Table 42. Bare Land Value with two thinnings for basal area class 120**

| | Age | NPV ($ per acre) | BLV ($ per acre) |
|---|---|---|---|
| **BA 120** | 35 | 476 | 120 |
| | 40 | 791 | 164 |

## Holding Values after Thinning

### Basal area class 30

For basal area class 30, after one thinning, Holding Value was highest at the rotation age 50. The reported value at age 50 was 1078.4 dollars per acre. Net Present Value was highest at this age, a reported value of 1579.4 dollars per acre. The details are given in table 43.

**Table 43. Holding Value with one thinning for basal area class 30**

| | Age | NPV ($ per acre) | Holding Value($ per acre) |
|---|---|---|---|
| **BA 30** | 45 | 1168 | 548 |
| | 50 | 1579 | 1078 |

For basal area class 30, after two thinnings, Holding Value was highest at the rotation age 50. The reported value at age 50 was 855.8 dollars per acre. Net Present Value was highest at this age, a reported value of 1356.8 dollars per acre. The details are given in table 44.

**Table 44. Holding Value with two thinnings for basal area class 30**

| | Age | NPV ($ per acre) | Holding Value($ per acre) |
|---|---|---|---|
| **BA 30** | 45 | 985 | 398 |
| | 50 | 1357 | 856 |

**Basal area class 60**

For basal area class 60, after one thinning, Holding Value was highest at the rotation age 50. The reported value at age 50 was 1143.8 dollars per acre. Net Present Value was highest at this age, a reported value of 1644.8 dollars per acre. The details are given in table 45.

**Table 45. Holding Value with one thinning for basal area class 60**

| | Age | NPV ($ per acre) | Holding Value($ per acre) |
|---|---|---|---|
| **BA 60** | 45 | 1185 | 562 |
| | 50 | 1645 | 1144 |

For basal area class 60, after two thinnings, Holding Value was highest at the rotation age 50. The reported value at age 50 was 703.8 dollars per acre. Net Present Value was highest at this age, a reported value of 1204.8 dollars per acre. The details are given in table 46.

**Table 46. Holding Value with two thinnings for basal area class 60**

| | Age | NPV ($ per acre) | Holding Value($ per acre) |
|---|---|---|---|
| **BA 60** | 45 | 817 | 260 |
| | 50 | 1205 | 703.8 |

**Mean Annual Increment Vs Periodic Annual Increment**

Mean annual increment and Periodic annual increment for each basal area class without thinning has been calculated and the graphs were plotted to find the inflection point.

For basal area class 30, MAI vs PAI graph is given in Fig 2.

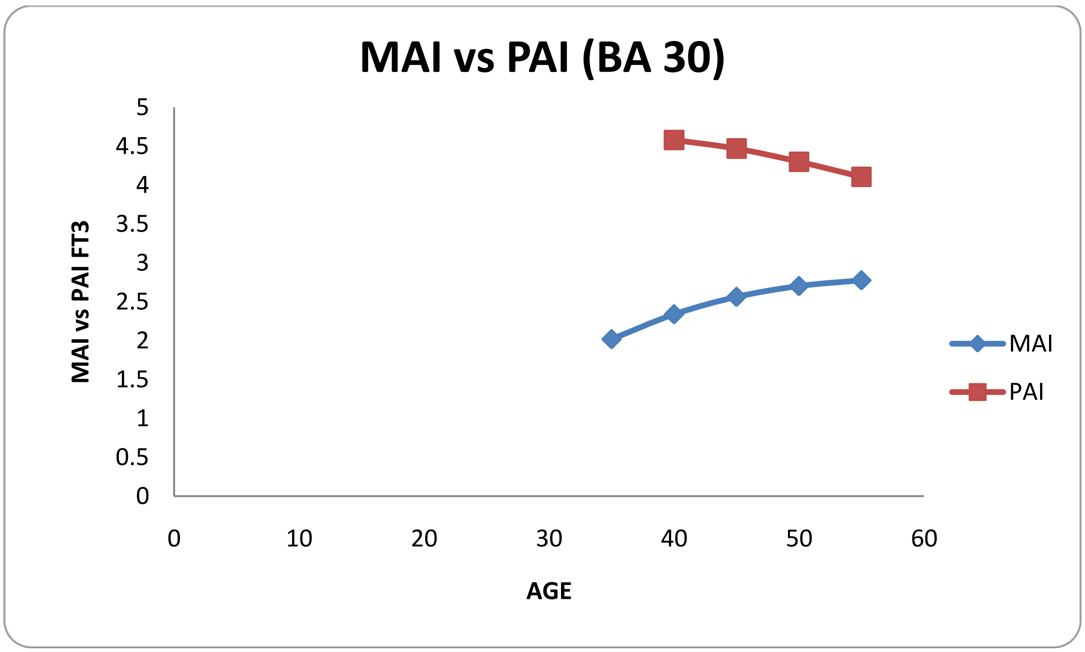


**Fig. 2. MAI Vs PAI ($ft^3$) for Basal area class 30**

For basal area class 60, MAI vs PAI graph is given in Fig 3.

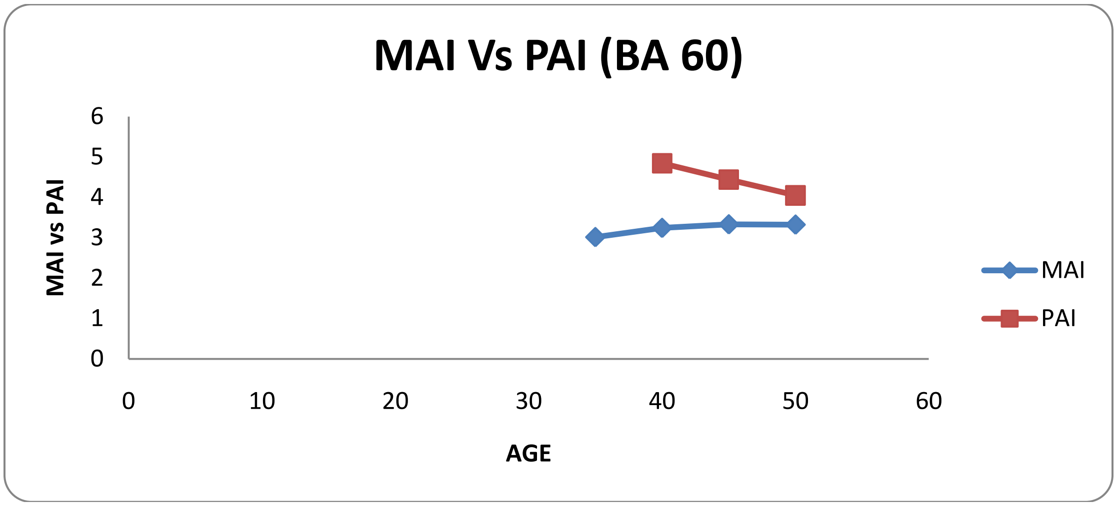


**Fig. 3. MAI Vs PAI ($ft^3$) for basal area class 60**

For basal area class 90, MAI vs PAI graph is given in Fig 4**.** Mean Annual Increment meets Periodic Annual Increment at the age 50 here. This is the biological rotation age.

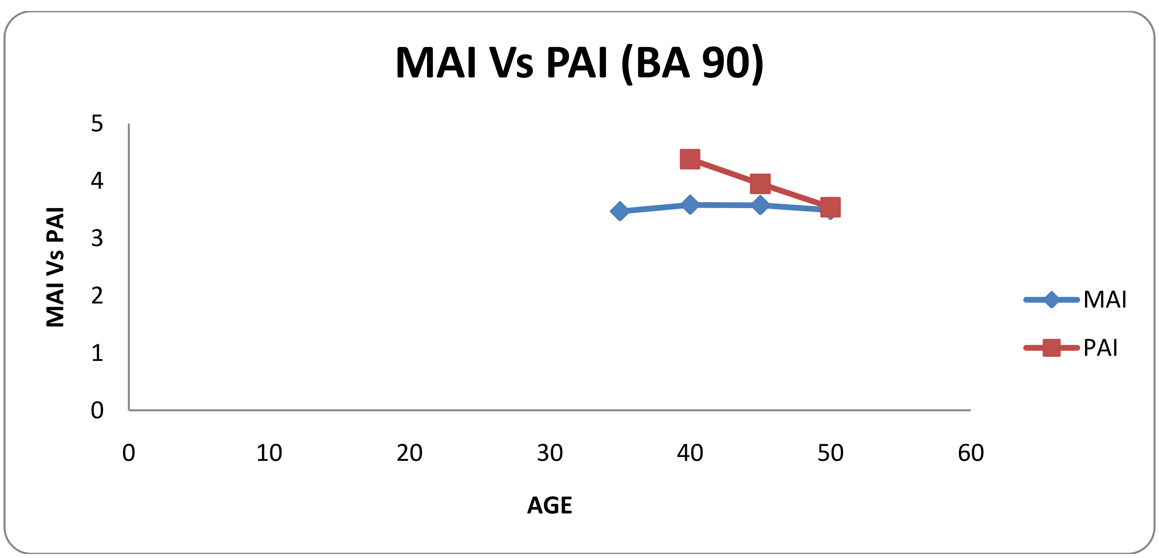


**Fig. 4. MAI Vs PAI ($ft^3$) for basal area class 90**

For basal area class 120, MAI vs. PAI graph is given in Fig 5**.** Mean Annual Increment meets Periodic Annual Increment at the age 45 here. This is the biological rotation age.

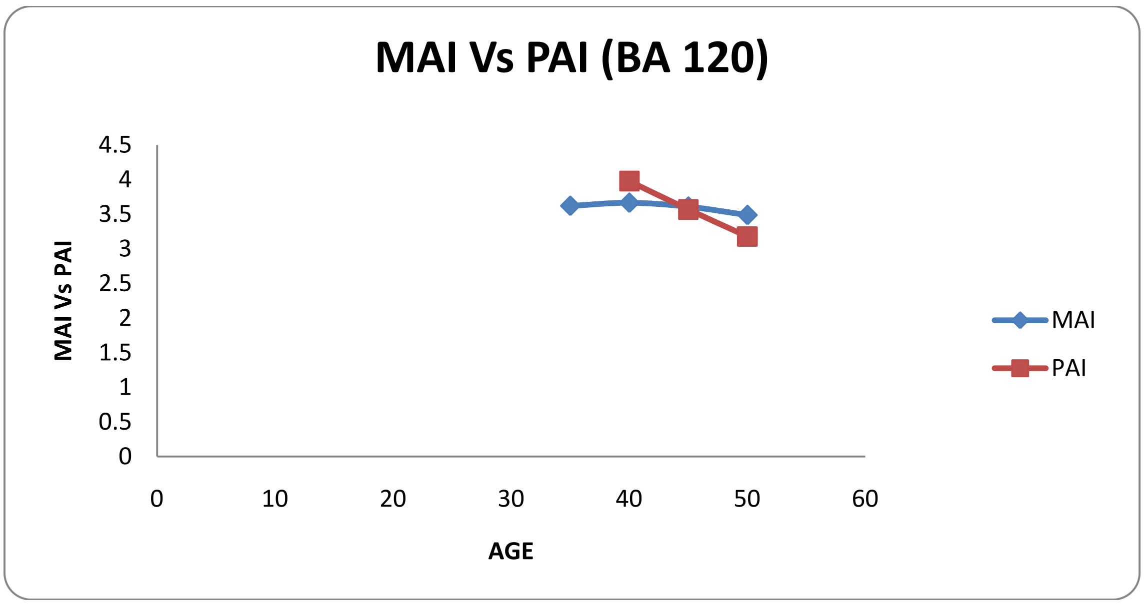


**Fig. 5. MAI Vs PAI ($ft^3$) for basal area class 120**

Biological rotation age is the point at which the PAI and MAI meet. In the Case of basal area class 120, rotation age 45 was found to be biologically optimal. In the basal area class 60 analysis it was found that at rotation age 50 Periodic Annual Increment met Mean Annual Increment, which means that biologically optimal rotation age for BA 60 was 50 years.

**Tax Impact**

Forest landowner's guide to the Federal Income Tax published by United States Department of Agriculture, Forest Service clearly depicts an idea about the property taxes. For one acre it was found that a beginning investment in land at 500 dollars (year 0), plus site preparation at $125 and planting at $75, were the initial investment. i.e. a total of 700 dollars. From literature it was clear that for timber sold after May 5, 2003, and before 2009 and held for more than 12 months, the capital gains tax rate is 5 percent for income that would otherwise be taxed at the 15 percent or lower ordinary income tax rates, and 15 percent for that which would be taxed at the 25 percent or higher rates. Capital gains are the net income from the sale of assets, which usually include timber.

Land Expectation value for various cases have been tested using Fairchild's (1935) formula,

$$LEV_{upt} = \frac{Vt - C(1+r+x)^\wedge t}{(1+r+x)^\wedge t - 1}$$

where $LEV_{upt}$ was the Land Expectation Value under property tax,'t' was the rotation age, C was the regeneration cost, r was the interest rate in decimals, V(t) = P(t) Q(t) the pretax stumpage value of a t year old stand, x was the annual property tax rate (in decimals) on the value of land, y was the annual tax rate (in decimals) on the assessed value of the trees.

The annual tax rate on the assessed value of trees and land was taken as 5 percent. V (t) = P (t) Q (t) the pretax stumpage value of a t year old stand was calculated at the rotation age. The regeneration cost was taken into account.

**No thinning**

For basal area class 30, total value for sawtimber and pulpwood obtained at the optimal rotation age (age 50) for basal area 30 was 2359 $/acre. Total cost at age with herbicide release at age 15 was taken as 80$/acre When the formula was applied, the Land Expectation Value under unmodified property tax was 169$/acre.

The total value for sawtimber and pulpwood obtained at the optimal rotation age (age 45) for basal area 60 was 2056$/acre. Total cost at age with herbicide release at age 15 was taken as 80$/acre. When the formula was applied, the Land Expectation Value under unmodified property tax was 144$/acre.

The total value for sawtimber and pulpwood obtained at the optimal rotation age (age 40) for basal area 90 was 1845.8$/acre. Total cost at age with herbicide release at age 15 was taken as 80 $/acre. When the formula was applied, the Land Expectation Value under unmodified property tax was 127$/acre.

The total value for sawtimber and pulpwood obtained at the optimal rotation age (age 35) for basal area 120 was 1430$/acre. Total cost at age with herbicide release at age 15 was taken as 80$/acre. When the formula was applied, the Land Expectation Value under unmodified property tax was 93$/acre.

**Thinning Effects**

**One thinning**

For basal area 30, total value for saw timber and pulpwood obtained at the optimal rotation age (age 50) for basal area 30 was 1579.4$/acre. When the formula was applied, the Land Expectation Value under unmodified property tax was 22$/acre.

The total value for saw timber and pulpwood obtained at the optimal rotation age (age 45) for basal area 60 was 1644.8 $/acre. When the formula was applied, the Land Expectation Value under unmodified property tax was 35$/acre.

The total value for saw timber and pulpwood obtained at the optimal rotation age (age 40) for basal area 90 was 1379$/acre. When the formula was applied, the Land Expectation Value under unmodified property tax was 45$/acre.

The total value for saw timber and pulpwood obtained at the optimal rotation age (age 40) for basal area 120 was 1308.2$/acre. When the formula was applied, the Land Expectation Value under unmodified property tax was 43$/acre.

**Two thinnings**

For basal area class 30, total value for saw timber and pulpwood obtained at the optimal rotation age (age 50) for basal area 30 was 1356.8$/acre. When the formula was applied, the Land Expectation Value under unmodified property tax was 19$/acre.

The total value for saw timber and pulpwood obtained at the optimal rotation age (age 45) for basal area 60 was 1204.8$/acre. When the formula was applied, the Land Expectation Value under unmodified property tax was 26$/acre.

The total value for saw timber and pulpwood obtained at the optimal rotation age (age 45) for basal area 90 was 943$/acre. When the formula was applied, the Land Expectation Value under unmodified property tax was 20$/acre.

The total value for saw timber and pulpwood obtained at the optimal rotation age (age 45) for basal area 120 was 791.2$/acre. When the formula was applied, the Land Expectation Value under unmodified property tax was 17$/acre.

### Three thinnings

For basal area class 30, total value for saw timber and pulpwood obtained at the optimal rotation age (age 50) for basal area 30 was 1285.6$/acre. When the formula was applied, the Land Expectation Value under unmodified property tax was 18$/acre.

The total value for saw timber and pulpwood obtained at the optimal rotation age (age 50) for basal area 60 was 1179$/acre. When the formula was applied, the Land Expectation Value under unmodified property tax was 16$/acre.

The total value for saw timber and pulpwood obtained at the optimal rotation age (age 50) for basal area 90 was 1158.6$/acre. When the formula was applied, the Land Expectation Value under unmodified property tax was 16$/acre.

The total value for saw timber and pulpwood obtained at the optimal rotation age (age 50) for basal area 120 was 1187.6$/acre.When the formula was applied, the Land Expectation Value under unmodified property tax was 16$/acre.

As we can see from the above results, thinning reduced Land Expectation Value under unmodified property tax. When the thinning regime increased from one thinning through three thinnings it was found that at a tax rate 5 percent and interest rate 4 percent, intense thinning regimes reduced the Land expectation value under modified tax compared to the treatment without thinning.

# CHAPTER V

## Conclusion

Optimal rotation age for shortleaf pines was found out for basal area classes 30, 60, 90 and 120. Weibull distribution was made use of, in order to find the diameter classes. Weibull parameters were calculated. Class midpoints and frequency distributions were found out using the Weibull distribution.

Simulation was done after entering the frequency and class midpoints in the SLPSS (Shortleaf Pine Stand Simulator). Stand/plot acreage was taken as 1 and beginning year as 2001. Site index taken was 70. Stand age values were entered depending on which age this study wanted to check. Pulpwood and sawtimber stump height were taken as 0.5.

Length of the projection period was changed according to the year the researcher wanted to cut the tree. The simulator gave the green weight of the stem in tons/acre (Total, merchantable and sawtimber). Pulpwood green weight was found out by subtracting sawtimber from merchantable timber green weight.

The procedure was done without thinning and with thinning. Thinning at different periods gave different merchantable volume of wood at different ages The sawtimber tons and pulpwood tons obtained from the simulation (with and without thinning) were used for further economic analysis. From the price data for Southeastern Oklahoma timber, stumpage value in dollars per ton for pine saw timber was estimated $22 per ton and for Pine pulpwood $10per ton. The discount rate taken was 4 percent and the values were calculated.

Without thinning, optimal rotation age for basal area class 30 was 50 years and for basal area class 60, the optimal rotation age was 45 years. Optimal rotation age for basal area class 90 was 40 years and optimal rotation age for basal area class 120 was 35 years.

Due to the Limitation of the thinning regimes practiced, Bare Land value and Holding values were found to decrease at the rotation age with thinning. Furthermore, the thinning regimes practiced by James M. Guldin, with a slight modification, have been utilized in this economic analysis and the Bare Land value and Holding Values were smaller in Guldin's thinning regimes compared with others. Before thinning, Bare Land Value and Holding values were maximized at different rotation ages. After thinning, Net Present Value, Bare Land Value and Holding value were maximized at the same rotation ages in all these thinning regimes as presented.

After thinning, mean annual increment equals periodic annual increment at the optimum biological rotation age of 45 years for basal area class 120. For basal area class 60, we found that at rotation age 50, periodic annual increment equals mean annual increment. The optimum biological rotation age is bigger than the optimum economic rotation age, with five years difference for basal area class 60 and with ten years difference for basal area class 120. The BLV, NPV and holding vales are bigger at the economic rotation age.

From the elasticity analysis, it was found that the timber demand is inelastic in US Market. Since the price elasticity of demand for timber is relatively inelastic ($-1 < E_d < 0$), the percentage change in quantity demanded of the timber is smaller than that in price. This results in a total revenue rise with the price increase and vice versa.

As the thinning regime increased from one thinning through three thinnings it was found that at a tax rate 5 percent and interest rate 4 percent, intense thinning regimes reduced the Land expectation value under modified tax compared to the treatment without thinning.

Oklahoma's traditional Timber markets are in a state of decline. The recession and the low in the housing market affected the market adversely. So in this situation it is necessary to give tax incentives to landowners in order to prevent them from converting forest land to other purposes. Optimal rotation age found out in this study will be useful, as this will help the owners to know when they can avail the maximum from a particular investment. This will encourage them to retain the forests.

REFERENCES


Abt, R.C., F.W. Cubbage, and G. Pacheco, 2000. Southern forest resource assessment using the Subregional Timber Supply (SRTS) model. Forest Products Journal 50(4):25–33.

Adams, D. and R.W. Haynes. 1980. The 1980 softwood timber assessment market model: structure, projections, and policy simulations. Forest Science Monograph Vol.22, pp:1-64.

Adams, D. and R.W. Haynes. 1996. The 1993 timber assessment market model: Structure, projections and policy. United States Dept. of Agriculture, Forest Service, Pacific Northwest Station (Portland, Or.)pp. 58.

Adams, D. M., R. W. Haynes, G. F. Dutrow [and others], 1982. Private investment in forest management and the long-term supply of timber. American Journal of Agricultural Economics, Vol. 64, pp: 232-241.

Allen, H.L., T.R. Fox and R.G. Campbell, 2005. What is ahead for intensive pine plantation silviculture in the South?. S. J. Appl. For. Vol. 29 (2), pp. 62–69.

Angelstam, P., G. Mikusinski and M. Breuss, 2002. Biodiversity and forest habitats. In: j. Richardson, R. Bjorheden, P. Hakkila, A.T. Lowe and C.T. Smith, “Bioenergy from Sustainable Forestry: Guiding Principles and Practice” Dordrecht, The Netherlands: Kluwer Academic Publishers, 2002, p. 216-243.

Asche, G., H. Bremnes, and C. R. Wessells 1999. Product aggregation, market integration and relationships between prices: An application to world salmon markets. American Journal of Agricultural Economics, Vol.81, pp: 568-81.

Baker, J.B., J.M. Guldin and R.W. Guldin, 1991. Natural regeneration methods for loblolly and shortleaf pines. For. Farmer, Vol. 50(3), 1991, pp. 59–63.

Baker, J.B., M.D.Cain, J.M.Guldin, P.A. Murphy and M.G.Shelton, 1996. Uneven-aged silviculture for the loblolly and shortleaf pine forest cover types. GTR SO-118. USDA For. Serv., Southern Res. Stn., Asheville, NC. Pp. 65.

Bentley, W.R. and R.D. Fight, 1966. A zero interest comparison of forest rent and soil rent. Forest. Science 12 (1966), p. 460.

Bingham, M., J. Prestemon, D. MacNair and R. Abt, 2003. Market structure in U.S. southern pine roundwood, *Journal of Forest Economics Vol.* **9** (2003), pp. 97–117.

Blatner, K.A. and J.L. Greene. 1989. Woodland owner attitudes toward timber production and management. Resource Management and Optimization. Vol. 6, pp: 205–223.

Bliss, J.C., and A.J. Martin, 1990. How tree farmers view management incentives. Journal of Forestry. Vol. 88(8), pp: 23–29, 42.

Bowes, M. D. and J.V. Krutilla, 1985. Multiple use management of public forestlands. In: Kneese, A.V. and Sweeney, J.L., Editors, Handbook of Natural Resource and Energy Economics Vol II**,** North-Holland, Amsterdam, 1985.

Brockett, C.D. and L. Gerhard, 1999. NIPF tax incentives: Do they make a difference? Journal of Forestry. Vol. 97(4), pp: 16–21.

Budhathoki, C.B., T.B. Lynch and J.M. Guldin, 2008. A mixed effects model for Dbh-height relationship of shortleaf pine *(*Pinus echinata Mill.). Southern Journal of Applied Forestry, Vol. 32, No.1, Feb. 2008, pp: 5-11.
*dr.nal.usda.gov/bitstream/10113/13411/1/IND44041516.pdf*

Burger, J.A. 2002. Soil and Long-Term Site Productivity Values. In: Richardson, J.; Bjorheden, R.; Hakkila, P.; Lowe, A. T.; and Smith, C. T. Bioenergy from Sustainable Forestry: Guiding Principles and Practice. Dordrecht, the Netherlands: Kluwer Academic Publishers, pp: 165-189

Cain, M. D., 1996. Growth expectations from alternative thinning regimes and prescribed burning in naturally regenerated loblolly-shortleaf pine stands through age 20. *Forest Ecology and Management,* Vol. 81, Issues 1-3, February 1996, pp. 227-241, doi**:** 10.1016/0378-1127(95)03605-9.

Cao, Q.V., 2004. Predicting Parameters of a Weibull Function for Modeling Diameter Distribution. Forest Science, Volume 50, Number 5, October 2004, pp. 682-685(4).

Carey, J. H.. 1992. Pinus echinata. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer).

Carter, M.C. and C.D. Foster, 2006, "Milestones and millstones: A retrospective on 50 years of research to improve productivity in loblolly pine plantations", *Forest Ecology and Management,* Vol.227, pp: 137-144.

Chang, S. J., 1982. An Economic Analysis of Forest Taxation's Impact on Optimal Rotation Age. Land Economics, Vol. 58, No. 3, pp. 310-323.

Chang, S. J., 1983. Rotation age, management intensity, and the economic factors of timber production: do changes in stumpage price, interest rate, regeneration cost, and forest taxation matter?, Forest Science Vol. **29,** 1983, pp: 267-277.

Chapman, H.H., 1931. Forest Management. Lyon Company, Albany, NY (1931), p. 544.

Clark, C.W., 1990. Mathematical Bioeconomics, John Wiley and Sons, Inc., New York, 1990.

Clutter, J. L., 1963. Compatible growth and yield models for loblolly pine. Forest Science, Vol.9, No.3, Sep. 1963, pp: 354-371, *ww.ingentaconnect.com/content/saf/fs/1963/00000009/.../art00022*

Conner, R.C. and A.J. Hartsell, 2002. Forest area and conditions. In: Wear, David N.; Greis, John G., eds. , eds. Southern forest resource assessment. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station.

Daniels, B. J. and W.F. Hyde, 1986. Estimation of supply and demand for North Carolina's timber. Forest ecology and management, Vol.14, pp: 59-67.

Duerr, W. A. 1960. Fundamentals of Forestry Economics. New York: McGraw-Hill.

Englin, J. and M. Klan, 1989. Optimal taxation: timber and externalities. *J. Environ. Econom. Management* 18 (1989), pp. 263–275.

Fairchild, F. R, 1935. Forest Taxation in the United States. U.S.D.A. Misc. Publ. 218. Washington, D.C.: U.S.D.A. Forest Service.

Farnden, A. and L. Herring, 2002. Severely repressed lodgepole pine responds to thinning and fertilization: 19-year results. *The Forest Chronicle,* Vol.78, No.3, May-Jun 2002, pp: 404- 414, pubs.nrc-cnrc.gc.ca/journals.old/tfc/tfc78/tfc78404-3.pdf

Faustmann, M., 1849. On the determination of the value which forest land and immature stands possess for forestry. In: Gane, M., Editor,, *Martin Faustmann and the Evolution of Discounted Cash Flow*, Institute Paper of the Commonwealth Forestry Institute, 1849, p. 42.

Fecso, R.S., H.F. Kaiser, J.P.Royer, [and others], 1982. Management practices and reforestation decisions for harvested southern pinelands. Staff Rep. AGES821230. Washington, DC: U.S. Department of Agriculture, Statistical Reporting Service. pp:74.

Fisher, I. 1930. The Theory of Interest. MacMillan, New York, NY (1930), p. 566.

Floyd, D., 2002. Forest sustainability: the history, the challenge, the promise. Durham, NC: The Forest History Society, p.83.

Folweiler A.D. and H.J. Vaux, 1944. Private forest land ownership and management in the loblolly-shortleaf type of Louisiana. *Journal of Forestry,* Vol. 42(11), pp:783-790.

Frechet, M. 1927. Sur la loi de probabilite de lecart maximum. Annales de la Societe Polonaise de Mathematique, Cracovie Vol.6, pp: 93-116.

Gaffney, M, 1957. Concepts of Financial Maturity of Timber and Other Assets. A.E.Information Series No. 62. Dept. of Agricultural Economics, N.C. State University, Raleigh,N.C.

Gaffney, M, 1970. Tax-Induced Slow Turnover of Capital, IV. American Journal of Economics and Sociology, Vol. 29, pp:411-24.

Gan, J. and C.T. Smith, 2006. Availability of logging residues and potential for electricity production and carbon displacement in the U.S. Biomass and Bioenergy. Vol. 30(12), pp: 1011-1020.

Greaves, T, 2009. States Use Gentle Hand in Taxing Timberland. FISCAL FACTS.

Greber, B. J. and H.W. Wisdom, 1985. A timber market model for analyzing roundwood product interdependencies. Forest Science, Vol.31 (1), pp: 164 -179.

Greene, J.L. 1998. The economic effect of federal income tax incentives in southern timber types. Pages 231–241 *in* Meeting in the Middle: Proceedings of the 1997 Society of American Foresters National Convention, Memphis, Tennessee. Society of American Foresters, Bethesda, Maryland.

Greene, J.L. and K.A. Blatner, 1986. Identifying woodland owner characteristics associated with timber management. Forest Science. Vol. 32, pp: 135–146.

Greene, J.L., T.J. Straka, and R.J. Dee, 2004. Nonindustrial private forest owner use of federal income tax provisions. Forest Products Journal. Vol. 54(12), pp: 59–66.

Greene, J.L., T.J. Straka, S. Daniels, M. Jacobson and M. Kilgore, 2005. Existing and Potential Incentives for Practicing Sustainable Forestry on Non-industrial Private Forest Lands, NCSSF Research Project C2, Final Report to the National Commission on Science for Sustainable Forestry, p.33.

Gregory, G.R., 1972. Forest resource economics. Ronald Press, New York, NY (1972), p. 548.

Guldin, J.M. and R.W. Guldin. Economic assessments of even-aged and uneven-aged loblolly-shortleaf pine stands. *In: Hickman, C.A. (Ed.), Proc. of the Southern Forest Economics Workshop on Evaluating Even- and All-Aged Timber Management Options for Southern Forest Lands,* March 29–30, 1990, Monroe, LA. GTR SO-79. USDA For. Serv., Southern Exp. Stn., New Orleans, LA., pp. 55–64.

Hahn, J.T. and R.A. Leary, 1979. Potential diameter growth function. In: A Generalized Forest Growth Projection System Applied to the Lake State Region, USDA For. Serv. Gen. Tech. Rep. NC-49, 1979, pp. 22-26.

Hardie, I.W. and P.J. Parks, 1991. Acreage response to cost sharing in the south, 1981-1991: Integrating individual choice and regional acreage response, Forest Science, Vol. 37(1), pp: 175-190.

Hasenauer, H., 1994. Ein Einzelbaumwachstumssimulator für ungleichaltrige Fichten-Kiefern und Buchen-Fichtenmischbestände. In: *Forstliche Schriftenreihe, Univ. f. Bodenkultur* Vol. 8**,** Waldökosystemforschung und experimentelle Baumforschung an der Universität für Bodenkultur, Wien, p. 152 Österr. Ges.

Haynes, R.W., tech. coord., 2003. An analysis of the timber situation in the United States: 1952 to 2050: a technical document supporting the 2000 USDA Forest Service RPA Assessment. Gen. Tech. Rep. PNW-GTR-560. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. p.254.

Helms, J.A. 1998. The dictionary of forestry. Bethesda, MD: The Society of American Foresters, p. 210.

Hibbard, C.M., M.A. Kilgore and P.V. Ellefson, 2003. Property taxation of private forests in the United States: A national review. Journal of Forestry. Vol. 101(3), pp: 44–49.

Hilt, D.E., 1979. Diameter growth of upland oaks after thinning. Res. Pap. NE-437. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, 1979, 12 p.

Holsoe, T., 1951. Yellow-poplar: reaction to crown release and other factors affecting growth", *Bull. W. Va. agric. Exp. Station*., Vol. No. 344T, 1951, pp. 83.

Hotvedt, J.E. and C.E. Thomas, 1986. Impacts of changes in the commercial forest land base on long-term pine timber supply potential in Louisiana. US Forest Service Research Paper SO-230, Southern For. Exp. Stn, New Orleans, Louisiana (1986).

http://frwebgate.access.gpo.gov/cgiin/getdoc.cgi?dbname=110_cong_bills&docid=f:h6enr.txt.pdf

http://www2.wwpa.org/

Huebschmamnn, M., T.B. Lynch and P .A. Murphy, 2000. Shortleaf pine stand simulator: an even-aged natural shortleaf pine growth and yield model user's manual. Res. Rep. P-967, Okla. State Univ. Agric. Exp. Sta. p.25.

Hyde, W. F., 1980. Timber Supply, Land Allocation and Economic Efficiency. Baltimore: The Johns Hopkins University Press for Resources for the Future.

Jackson, D. H., 1980. The Microeconomics of the Timber Industry. *Boulder, Colo.: Westview Press.*

Johnson, T.G., M. Howell, J.W. Bentley, 2005. Oklahoma's timber industry—an assessment of timber product output and use, 2002. Resour. Bull. SRS–100. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. p.34. [2002].

Johnson, T.G., M. Howell, J.W. Bentley, 2005. Oklahoma's timber industry—an assessment of timber product output and use, 2005. Resource Bulletin, SRS–136, United States Department of Agriculture Forest Service, 2005.

Jung, C. and K. Doroodian, 1994. The law of one price for U.S. softwood lumber: a multivariate cointegration test. *Forest Sci.* Vol. 40, No. 4, pp. 595–600.

Kenneth, B. and K. Judd, 1983. Equilibrium price dispersion. Econometrica 51 (4), pp. 955-69.

Klemperer, W. D., 2003. Forest Resource Economics and Finance. McGraw-Hill (first publ.1996), 2003, p. 549.

Klosowski, R., T. Stevens, D. Kittredge and D. Dennis, 2001. Economic incentives for coordinated management of forestland: A case study of southern New England. *Forest Policy and Economics*. Vol. 2(1), pp: 29–38.

Lamson, N.I., H. C. Smith, A. W. Perkey, W. Arlyn and S. M. Brock, 1990. Crown release increases growth of crop trees. Res. Pap. NE-635, Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, 1990, 8 p.

Lawson, A. R., 1990. Silvics of North America, *Pinus echinata* Mill. shortleaf pine, *In: Burns, Russell M.; Honkala, Barbara H., technical coordinators,* Conifers, Agric. Handb. 654., Vol. 1. Washington, DC: U.S. Department of Agriculture, Forest Service, pp: 316-326. [13394], 1990.

Leary, R. A. and M. R. Holdaway, 1979. Modifier function. In: A Generalized Forest Growth Projection System Applied to the Lake States region, USDA For. Serv. Gen. Tech. Rep. NC-49, North Cent. Exp. Stat., Minnesota, 1979, pp. 31–38.

Lynch, T .B., M.M. Huebschmanann and P .A. Murphy. A survival model for individual shortleaf pine trees in even-aged natural stands pp: 533-538 in Proc. Conf. on Integrated

Tools for Natural Resource Inventories in the 21st Century USDA Forest Service North Central Research Station Gen. Tech. Report, NC- 212.

Lynch, T.B., L.R. Gering, M.M. Huebschmann and P.A Murphy, 1999. An individual-tree growth and yield prediction system for even-aged natural shortleaf pine forest. Southern Journal of Applied Forestry, Vol.23, No.4, 1999, pp. 203–211.

Markus, R., 1967. Ostwald's Relative Forest Rent Theory. *Satz and Druck*, Munich (1967), p. 128.

McKillop, W.L. 1967. Supply and demand for forest products: an econometric study, Hilgardia **38** (1967), p. 132.

McKinley, C. R. and D. Zhang, 2011. Economics for Forest Landowners, Oklahoma Cooperative Extension Service, NREM -5050.
http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-7508/NREM-5050web.pdf

McLemore, B.F., 1981. Minimum stocking levels required for successful management of unevenaged loblolly-shortleaf pine stands. Proceedings first biennial southern Silvicultural Research conference, Atlanta, GA., Nov 6-7, 1980. Gen. Tech Report. SO-34. USDA-FS-SFES. Edited by James P. Barnett, p.292-293.

Meadows, J.S. and J.C.G. Goelz, 2002. Fourth-Year Effects of Thinning on Growth and Epicormic Branching in a Red Oak-Sweetgum Stand on a Minor Stream bottom Site in West-Central Alabama" *Gen. Tech. Rep. SRS48*, Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station, 2002, pp. 201-208.

Meadows, J.S. , 1996. Thinning guidelines for southern bottomland hardwood forests. In: Flynn, Kathryn M., ed. Proceedings of the southern forested wetlands ecology and management conference; Clemson, SC, Consortium for Research on Southern Forested Wetlands, Clemson University, March 1996, pp: 98-101.

Moller, C. Mar:, 1946. Untersuchungen fiber Laubmenge, Stoffverlust und Stoffproduktion des Waldes. Det. forst. Fors6gsvasen, i Danmark, Vol.17, 1946, pp: 1-287.

Moller, C. Mar:, 1947. The effect of thinning, age, and site on foliage, increment, and loss of dry matter. *Journal of Forestry*, Vol. 45, No. 6, June 1947, pp: 393-404, www.ingentaconnect.com/content/saf/jof/1947/00000045/.../art00004

Monserud, R. A. and H. Sterba, 1996. A basal area increment model for individual trees growing in even- and uneven-aged forest stands in Austria. *Forest Ecology and Management,* Vol.80, Issues 1-3, Jan.1996, pp: 57-80, doi:10.1016/0378-1127(95)03638-5

Montgomery, A. A., V. L. Robinson and J.D. Strange, 1975. An economic model of Georgia's long run timber market. Georgia Forest Research Council Report no.34, pp. 21.

Murphy, P. A. J. B. Baker and E. R. Lawson, 1991. Selection Management of Shortleaf pine in the Ouachita mountains. *Southern Journal of Applied Forestry*, Vol. 15, Issue: 1, Feb. 1991, pp: 61-67.
www.ingentaconnect.com/content/saf/sjaf/1991/00000015/.../art00013.

Murphy, P. A. and R.M. Farrar,1982. Interim models for basal area and volume projection of uneven-aged loblolly-shortleaf pine stands. *Southern Journal of Applied Forestry*, Vol. 6, No. 2, May 1982, pp: 115-119, ISSN: 01484419.

Murphy, P. A. and R.M. Farrar, 1985. Growth and yield of unevenaged shortleaf pine stands in the interior highlands. *Res.Paper SO-218,* New Orleans, LA: US Dept. of Agriculture, Forest Service, Southern Forest Experiment Station, Nov. 1985, Govt. doc. No. A 13.78:SO-218.

Murray, B.C., 1995. Oligopsony, vertical integration, and output substitution: welfare effects in U, S. pulpwood markets. Land Economics, Vol. 71 (1995) (2), pp. 193–206.

Murray, B. C. and D. N. Wear, 1998. Federal Timber Restrictions and Interregional Arbitrage in U.S. Lumber. Land Economics , Vol. 74, No. 1, Feb., 1998, pp.76-91.

Nagubadi, R.V., D. Zhang, J.P. Prestemon, and D.N. Wear. 2004. Softwood lumber products in the United States: Substitutes, complements, or unrelated? For. Sci., Vol. 50(4), pp: 416–426.

Neary, D.G., 2002. Hydrologic values. In: Richardson, J.; Bjorheden, R.; Hakkila, P.; Lowe, A.T.; and Smith, C.T. Bioenergy from Sustainable Forestry: Guiding Principles and Practice. Dordrecht, The Netherlands: Kluwer Academic Publishers, 2002, pp: 190-215.

Newman, D. H., 1987. An Econometric Analysis of the Southern Softwood Stumpage Market: 1950-1980. Forest Science, Vol. 33, No. 4, 1 December 1987, pp. 932-945(14).

Newman, D. and D.Wear, 1993. Production economics of private forestry: a comparison of industrial and non-industrial forest owners. *American Journal of Agricultural Economics* Vol. **75**, pp. 674–684.

Nyland, R. D., 1996. *Silviculture: Concepts and applications* New York, USA: McGraw-Hill. XXII + 1996, p.633.

Pattanayak, S., B. Murray and R. Abt, 2002. How joint is joint forest production? An econometric analysis of timber supply conditional on endogenous amenity values. *Forest Science* Vol.47, No. 3, pp. 479–491.

Pearse, P. H, 1967. The Optimum Forest Rotation. Forestry Chronicle. Vol. 43, pp:178-95.

Pearson, H.A., 1967. Phenology of Arizona fescue and mountain muhly in the northern Arizona ponderosa pine type. In: USDA For. Serv. Res. Note RM-99, Rocky Mountain For. Range Exp. Stn., Fort Collins, CO,1967, p. 4.

Peterson, J.A., J.R. Seiler, J. Nowak, S.E. Ginn, and R.E. Kreh, 1997. Growth and physiological responses of young loblolly pine stands to thinning. *Forest Science,* Vol. 43, No. 4, Nov. 1997, pp: 529-534, www.ingentaconnect.com/content/saf/fs/1997/00000043/.../art00010

Phillips, D.R. and J.A. Abercrombie Jr., 1987. Pine-hardwood mixtures: A new concept in regeneration. *South. J. Appl. For.*, Vol. 11, No. 4, pp. 192–197.

Pindyck, R. S., 1988. Irreversible investment, capacity choice, and the value of the firm. American Economic Review **78**, 1988. pp. 969–985.

Prestemon, J.P., and D.N. Wear, 2000. Linking harvest choices to timber supply. Forest Science Vol.46 (3), pp: 377–389.

Prestemon, J.P. and R. C. Abt, 2002. TIMBR-1:Timber Products Supply and Demand. Southern Forest Resource assessment draft report.

Prestemon, J.P., and T.P. Holmes, 2000. Timber price dynamics following a natural catastrophe. Am. J. Agric. Econ. Vol. 82, pp: 145–160.

Rauscher, H.M. and K. Johnson, 2004. Southern Forest Science: Past, Present, and Future. Gen. Tech. Report SRS-75. Asheville, NC: USDA Forest Service, Southern Research Station, 2004, p.394.

Reynolds, R.R., J.B. Baker and T.T. Ku,1984. Four decades of selection management on the Crossett Farms Forestry Forties. Bull. 872. Univ. of Ark., Div. of Ag., Ag. Exp. Stn., Fayetteville, AR. pp.43.

Robinson, V. L. 1974. An econometric model of softwood lumber and stumpage markets, 1949-1967. Forest Science, Vol. 20, pp:171-179.

Rosin, P. and E. Rammler, 1933, "The Laws Governing the Fineness of Powdered Coal", *Journal of the Institute of Fuel*, Vol. 7, pp: 29–36.

Royer, J. P. 1987. Determinants of reforestation behavior among Southern landowners. *Forest Science*. Vol. 33(3), pp: 654–667.

Rummer, R., 2002. Forest operations technology. In: Wear, D.N., Greis, J.G. (Eds.), Southern Forest Resource Assessment. USDA For. Serv. Gen. Tech. Rep. GTR-SRS-53, pp. 341–353 (Chapter 15).

Sallnas, O. and Eriksson, L.O. 1989. Management variation and price expectations in an intertemporal forest sector model. Natural Resource Modeling, Vol 3, pp. 385-398.

Samuelson, P.A., 1952. Spatial price equilibrium and linear programming. American Economic Review. Vol. 42, pp: 283-303.

Samuelson, P.A., 1976. Economics of forestry in an evolving society. Economic *Inquiry*, Vol. 14, 1976, pp. 466–492.

Schaberg, R.H., P.B. Aruna, F.W. Cubbage, [and others], 2005. Economic and ecological impacts of wood chip production in North Carolina: an integrated assessment and subsequent applications. Journal of Forest Policy and Economics. Vol. 7(2), pp: 157–174.

Schulte, B.J. and J. Buongiorno, 2004. A growth and yield model for naturally regenerated mixed shortleaf pine forests in the southern USA. International For. Rev., Vol. 6, pp: 19 – 29.

Schulte, B. J. and J. Buongiorno, 1998. Effects of uneven-aged silviculture on the stand structure, species composition, and economic returns of loblolly pine stands. Forest Ecology and Management, Vol. 111, Issue 1, 2 Nov. 1998, pp 83-101.

Schutz, J.P., 1997. La gestion des forêts irrégulières et mélanges. *Sylviculture 2,* Presses Polytechniques et Universitaires Romandes, Lauzane, 1997.

Sedjo, R., 2001. Biotechnology's potential contribution to global wood supply and forest conservation. Resources for the Future Disc. Pap. 01-51. Washington, DC, pp: 37.

Shepard, J. P., 2006. Water quality protection in bioenergy production: the US system of forestry Best Management Practices. Biomass and Bioenergy, Vol. 30(4), 2006, pp: 378-384.

Shifley, S. R. 2006. Sustainable Forestry in the Balance. Journal of Forestry. Vol.104 (4), pp: 187-195.

Skovsgaard, J.P., 2009. Analysing effect**s** of thinning on stand volume growth in relation to site conditions: A case study for even-aged Sitka spruce (*Picea sitchensis* (Bong.) Carr.). *Forestry,* Vol: 82, No.1, 2009, pp:87-104; doi:10.1093/forestry/cpn047.

Smith, W. B., J. L. Vissage, D. R. Darr, and R. M. Scheffield, 2001," Forest resources of the United States, 1997", USDA *For. Serv. Gen. Tech. Rep. NC-219*, Aug. 2001, p.190.

Sternitzke, H. S., and T. C. Nelson, 1970. The southern pines of the United States. Econ. Bot. Vol. 24, pp: 142-150.

Stoddard, C.H. 1961. The Small Private Forest in the United States. Resources for the Future, Inc., Washington, D.C. 171 pages.

Stogsdill, W. R., R.F. Wittwer, T.C. Hennessey and P. M. Dougherty, 1992. Water use in thinned loblolly pine plantations. *For. Ecol. Manag.,*Vol. 50, Issues 3-4, Jul.1992, pp: 233- 245, doi:10.1016/0378-1127(92)90338-A

Tan, X., S. X. Chang, P. G. Comeau and Y. Wang, 2008. Thinning Effects on Microbial Biomass, N Mineralization, and Tree Growth in a Mid-Rotation Fire-Origin Lodgepole Pine Stand in the Lower Foothills of Alberta, Canada. *Forest Science,* Vol. 54, No. 4, Aug. 2008, pp. 465 – 474,
*www.ingentaconnect.com/content/saf/fs/2008/00000054/.../art00008*

Trestrail, R. W., 1969. Forest and the Property Tax-Unsound Accepted Theory. National Tax Journal, Vol.22, pp: 347-56.

Uri, N.D., and R .G. Boyd, 1990. Considerations on modeling the market for softwood lumber in the United States. For. Sc. Vol. 36, pp: 680-692.

US Forest Service, 1929 (rev. 1976), "Volume, yield and stand tables for second-growth southern pines", *US Misc. PubI. 50*, p. 202.

Vaux, H.J., 1954. Economics of young growth sugar pine resources. Univ. Of California, Berkeley, Div. of Ag. Sci. Bull., 78.

Vesterdal, L., M. Dalsgaard, C. Felby, K. Raulund-Rasmussen and B.B. Jorgensen, 1995. Effects of thinning and soil properties on accumulation of carbon, nitrogen and phosphorus in the forest floor of Norway spruce stands, For. Ecol. Manage. Vol. 77, pp. 1–10.

Wakeley, P.C., 1954. Plants in the southern pines. Washington, DC: U.S. Department of Agriculture, Forest Service, pp. 233.

Wakeley, P.C. and J.P. Barnett (In press). "Early forestry research in the South: a personal history", Asheville, NC. U.S.Department of Agriculture, Forest Service, Southern Research Station.

Walsh, T.A.C., 2002. Diameter/basal area increment equations for loblolly pine trees in cutover, site-prepared plantations. Virginінia tech, 2002.

Wear, D. N., 2003. Public timber supply under multiple-use management. In E. O. Sills, & K. L. Abt (Eds.) Forests in a market economy. Dordrecht; Boston: Kluwer Academic Publishers.

Wear, D. N. and J.G. Greis, 2002. Southern Forest Resource Assessment. *Gen. Tech. Rep. SRS-53,* Asheville, NC: USDA Forest Service, Southern Research Station, 2002, p. 635.

Weetman, G.F., M.R. Roberge and C. H. Meng, 1980. Black spruce: 15-year growth and microbiological responses to thinning and fertilization. *Can. J. Forest Res.* Vol. **10**, No.4, 1980, pp. 502–509, doi:10.1139/x80-082

Weibull, W., 1951. A statistical distribution function of wide applicability., J. Appl. Mech.-Trans. ASME , Vol. 18 (3), pp: 293–297.

Willet, R. L., 1986. Foreword. In Proc. of symp. on the Shortleaf pine ecosystem, Murphy, P.A. (ed.). Mar. 31-Apr. 2, 1986, Little Rock, AR, p. 272.

Yang, R .C. 1998. Foliage and stand growth responses of semi mature lodgepole pine to thinning and fertilization. *Can. J. For. Res,* Vol. 28, Sep.1998, pp: 1794- 1804, ISSN: 1208-6037.

Yoho, J.G. and L.M. James, 1958. Influence of some public assistance programs on forest landowners in Northern Michigan. *Land Economics*. 34(4), pp: 357–364.

Yoshimoto, A. and I. Shoji, 1998. Searching for an optimal rotation age for forest stand management under stochastic log prices. European Journal of Operational Research, Vol. 105, Issue 1, 16 pp:100-112.

APPPENDICES

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: SHORT Stand size: 1 ac

Year: 2001 Iteration 0 of 15

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

=============================================================================

| Diam. | | Basal | Cubic-foot Volume/Acre* | | | | | |
|---|---|---|---|---|---|---|---|---|
| Class | Trees/ | Area/ | | Merch- | Saw- | Board-foot Volume/Acre | | |
| Midpt | Acre | Acre | Total | antable | timber | Doyle | Scribner | Int. ¬ |

------------------------------------------------------------------------------

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2 | 6.7 | 0.2 | 1.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 47.3 | 2.4 | 22.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 60.2 | 5.4 | 61.4 | 23.7 | 0.0 | 0 | 0 | 0 |
| 5 | 49.9 | 7.0 | 92.3 | 78.2 | 0.0 | 0 | 0 | 0 |
| 6 | 32.1 | 6.4 | 95.1 | 86.3 | 0.0 | 0 | 0 | 0 |
| 7 | 17.0 | 4.6 | 68.3 | 62.9 | 0.0 | 0 | 0 | 0 |
| 8 | 7.6 | 2.7 | 42.6 | 39.7 | 0.0 | 0 | 0 | 0 |
| 9 | 2.9 | 1.3 | 22.0 | 20.8 | 0.0 | 0 | 0 | 0 |
| 10 | 1.0 | 0.5 | 9.5 | 9.0 | 3.8 | 8 | 15 | 18 |
| 11 | 0.4 | 0.2 | 4.6 | 4.4 | 3.0 | 7 | 12 | 14 |
| Total | 225.0 | 30.7 | 419.0 | 325.0 | 6.7 | 15 | 27 | 32 |

*Inside bark

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch- antable | Saw- timber |
|---|---|---|---|---|---|---|
| 2 | 6.7 | 0.2 | 18 | 0.0 | 0.0 | 0.0 |
| 3 | 47.3 | 2.4 | 25 | 0.0 | 0.0 | 0.0 |
| 4 | 60.2 | 5.4 | 29 | 0.0 | 0.0 | 0.0 |
| 5 | 49.9 | 7.0 | 33 | 3.5 | 3.0 | 0.0 |
| 6 | 32.1 | 6.4 | 35 | 3.5 | 3.1 | 0.0 |
| 7 | 17.0 | 4.6 | 37 | 2.4 | 2.3 | 0.0 |
| 8 | 7.6 | 2.7 | 39 | 1.5 | 1.4 | 0.0 |
| 9 | 2.9 | 1.3 | 40 | 0.8 | 0.7 | 0.0 |
| 10 | 1.0 | 0.5 | 41 | 0.3 | 0.3 | 0.1 |
| 11 | 0.4 | 0.2 | 42 | 0.2 | 0.2 | 0.1 |
| Total | 225.0 | 30.7 | | 12.2 | 11.0 | 0.2 |

=================================================================
======

05-02-2011 14:35:15

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: SHORT Stand size: 1 ac

Year: 2016 Iteration 15 of 15

Stand Age: 35 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

=================================================================
===============

| Diam. | | Basal | Cubic-foot Volume/Acre* | | | | | |
|---|---|---|---|---|---|---|---|---|
| Class | Trees/ | Area/ | | Merch- | Saw- | Board-foot Volume/Acre | | |
| Midpt | Acre | Acre | Total | antable | timber | Doyle | Scribner | Int. ¬ |

--------------------------------------------------------------------------------

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2 | 0.7 | 0.0 | 0.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 1.2 | 0.1 | 0.6 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 2.0 | 0.2 | 2.4 | 0.4 | 0.0 | 0 | 0 | 0 |
| 5 | 12.5 | 1.8 | 32.2 | 27.9 | 0.0 | 0 | 0 | 0 |
| 6 | 21.2 | 4.2 | 83.9 | 77.1 | 0.0 | 0 | 0 | 0 |
| 7 | 31.4 | 8.5 | 181.0 | 169.8 | 0.0 | 0 | 0 | 0 |
| 8 | 39.5 | 13.7 | 306.1 | 290.3 | 0.0 | 0 | 0 | 0 |
| 9 | 39.1 | 17.2 | 405.9 | 387.8 | 0.0 | 0 | 0 | 0 |
| 10 | 30.4 | 16.4 | 406.8 | 390.3 | 117.7 | 263 | 477 | 555 |
| 11 | 18.2 | 11.8 | 303.8 | 292.4 | 170.0 | 414 | 729 | 838 |
| 12 | 10.3 | 8.0 | 210.6 | 203.1 | 149.6 | 424 | 701 | 751 |
| 13 | 4.3 | 3.9 | 105.3 | 101.7 | 84.2 | 256 | 403 | 442 |
| 14 | 1.6 | 1.7 | 48.2 | 46.6 | 41.2 | 138 | 203 | 224 |
| 15 | 0.5 | 0.6 | 17.0 | 16.5 | 15.1 | 56 | 79 | 83 |
| 16 | 0.1 | 0.1 | 2.8 | 2.8 | 2.6 | 10 | 14 | 14 |
| Total | 213.1 | 88.1 | 2,106.7 | 2,006.6 | 580.3 | 1,561 | 2,604 | 2,906 |

=================================================================================

*Inside bark

==========================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch- antable | Saw- timber |
|---|---|---|---|---|---|---|
| 2 | 0.7 | 0.0 | 25 | 0.0 | 0.0 | 0.0 |
| 3 | 1.2 | 0.1 | 32 | 0.0 | 0.0 | 0.0 |
| 4 | 2.0 | 0.2 | 40 | 0.0 | 0.0 | 0.0 |
| 5 | 12.5 | 1.8 | 45 | 1.2 | 1.0 | 0.0 |
| 6 | 21.2 | 4.2 | 49 | 3.0 | 2.8 | 0.0 |
| 7 | 31.4 | 8.5 | 51 | 6.4 | 6.0 | 0.0 |
| 8 | 39.5 | 13.7 | 54 | 10.8 | 10.2 | 0.0 |
| 9 | 39.1 | 17.2 | 55 | 14.3 | 13.6 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10 | 30.4 | 16.4 | 57 | 14.3 | 13.7 | 4.1 |
| 11 | 18.2 | 11.8 | 58 | 10.6 | 10.2 | 5.9 |
| 12 | 10.3 | 8.0 | 59 | 7.4 | 7.1 | 5.1 |
| 13 | 4.3 | 3.9 | 60 | 3.7 | 3.6 | 2.9 |
| 14 | 1.6 | 1.7 | 61 | 1.7 | 1.6 | 1.4 |
| 15 | 0.5 | 0.6 | 62 | 0.6 | 0.6 | 0.5 |
| 16 | 0.1 | 0.1 | 62 | 0.1 | 0.1 | 0.1 |
| Total | 213.1 | 88.1 | | 74.0 | 70.6 | 20.0 |

==============================================================
======

05-02-2011 14:36:08

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: SHORT Stand size: 1 ac

Year: 2001 Iteration 0 of 20

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

==========================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch- antable | Saw- timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 2 | 6.7 | 0.2 | 1.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 47.3 | 2.4 | 22.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 60.2 | 5.4 | 61.4 | 23.7 | 0.0 | 0 | 0 | 0 |
| 5 | 49.9 | 7.0 | 92.3 | 78.2 | 0.0 | 0 | 0 | 0 |
| 6 | 32.1 | 6.4 | 95.1 | 86.3 | 0.0 | 0 | 0 | 0 |
| 7 | 17.0 | 4.6 | 68.3 | 62.9 | 0.0 | 0 | 0 | 0 |
| 8 | 7.6 | 2.7 | 42.6 | 39.7 | 0.0 | 0 | 0 | 0 |
| 9 | 2.9 | 1.3 | 22.0 | 20.8 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10 | 1.0 | 0.5 | 9.5 | 9.0 | 3.8 | 8 | 15 | 18 |
| 11 | 0.4 | 0.2 | 4.6 | 4.4 | 3.0 | 7 | 12 | 14 |
| Total | 225.0 | 30.7 | 419.0 | 325.0 | 6.7 | 15 | 27 | 32 |

===============================================================================

*Inside bark

========================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|
| 2 | 6.7 | 0.2 | 18 | 0.0 | 0.0 | 0.0 |
| 3 | 47.3 | 2.4 | 25 | 0.0 | 0.0 | 0.0 |
| 4 | 60.2 | 5.4 | 29 | 0.0 | 0.0 | 0.0 |
| 5 | 49.9 | 7.0 | 33 | 3.5 | 3.0 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 6 | 32.1 | 6.4 | 35 | 3.5 | 3.1 | 0.0 |
| 7 | 17.0 | 4.6 | 37 | 2.4 | 2.3 | 0.0 |
| 8 | 7.6 | 2.7 | 39 | 1.5 | 1.4 | 0.0 |
| 9 | 2.9 | 1.3 | 40 | 0.8 | 0.7 | 0.0 |
| 10 | 1.0 | 0.5 | 41 | 0.3 | 0.3 | 0.1 |
| 11 | 0.4 | 0.2 | 42 | 0.2 | 0.2 | 0.1 |
| Total | 225.0 | 30.7 | | 12.2 | 11.0 | 0.2 |

======================================================================

05-02-2011 14:57:10

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: SHORT Stand size: 1 ac

Year: 2021 Iteration 20 of 20

Stand Age: 40 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

==========================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch-antable | Saw-timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 2 | 0.4 | 0.0 | 0.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 0.9 | 0.0 | 0.5 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 1.2 | 0.1 | 1.6 | 0.4 | 0.0 | 0 | 0 | 0 |
| 5 | 4.4 | 0.7 | 12.5 | 10.9 | 0.0 | 0 | 0 | 0 |
| 6 | 15.1 | 3.0 | 63.2 | 58.1 | 0.0 | 0 | 0 | 0 |
| 7 | 20.4 | 5.6 | 129.9 | 122.3 | 0.0 | 0 | 0 | 0 |
| 8 | 33.2 | 11.8 | 289.9 | 275.9 | 0.0 | 0 | 0 | 0 |
| 9 | 32.4 | 14.4 | 362.7 | 347.3 | 0.0 | 0 | 0 | 0 |
| 10 | 38.8 | 21.3 | 561.0 | 539.5 | 186.3 | 418 | 759 | 891 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 11 | 25.3 | 16.8 | 460.7 | 444.3 | 266.1 | 678 | 1,176 | 1,314 |
| 12 | 18.1 | 14.2 | 399.7 | 386.3 | 287.1 | 829 | 1,364 | 1,492 |
| 13 | 9.6 | 8.7 | 252.2 | 244.1 | 201.8 | 619 | 970 | 1,062 |
| 14 | 4.7 | 5.0 | 147.3 | 142.7 | 124.8 | 426 | 634 | 672 |
| 15 | 1.7 | 2.1 | 63.6 | 61.7 | 56.1 | 211 | 297 | 309 |
| 16 | 0.6 | 0.9 | 27.6 | 26.8 | 25.0 | 101 | 135 | 141 |
| 17 | 0.1 | 0.2 | 5.3 | 5.2 | 4.9 | 20 | 27 | 28 |
| Total | 206.9 | 104.8 | 2,777.9 | 2,665.5 | 1,152.1 | 3,303 | 5,362 | 5,908 |

*Inside bark

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch- antable | Saw- timber |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | 0.4 | 0.0 | 27 | 0.0 | 0.0 | 0.0 |
| 3 | 0.9 | 0.0 | 35 | 0.0 | 0.0 | 0.0 |
| 4 | 1.2 | 0.1 | 43 | 0.0 | 0.0 | 0.0 |
| 5 | 4.4 | 0.7 | 49 | 0.5 | 0.4 | 0.0 |
| 6 | 15.1 | 3.0 | 52 | 2.3 | 2.1 | 0.0 |
| 7 | 20.4 | 5.6 | 55 | 4.6 | 4.3 | 0.0 |
| 8 | 33.2 | 11.8 | 58 | 10.2 | 9.7 | 0.0 |
| 9 | 32.4 | 14.4 | 59 | 12.7 | 12.2 | 0.0 |
| 10 | 38.8 | 21.3 | 61 | 19.7 | 18.9 | 6.4 |
| 11 | 25.3 | 16.8 | 62 | 16.1 | 15.6 | 9.2 |
| 12 | 18.1 | 14.2 | 64 | 14.0 | 13.5 | 9.9 |
| 13 | 9.6 | 8.7 | 65 | 8.8 | 8.5 | 7.0 |
| 14 | 4.7 | 5.0 | 66 | 5.1 | 5.0 | 4.3 |
| 15 | 1.7 | 2.1 | 66 | 2.2 | 2.2 | 1.9 |
| 16 | 0.6 | 0.9 | 67 | 1.0 | 0.9 | 0.9 |
| 17 | 0.1 | 0.2 | 68 | 0.2 | 0.2 | 0.2 |
| Total | 206.9 | 104.8 | | 97.4 | 93.5 | 39.7 |

==================================================================

======

05-02-2011 14:57:29

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: SHORT Stand size: 1 ac

Year: 2001 Iteration 0 of 25

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

==================================================================

===============

Diam. Basal Cubic-foot Volume/Acre*

Class Trees/ Area/ Merch- Saw- Board-foot Volume/Acre

Midpt Acre Acre Total antable timber Doyle Scribner Int. ¬

-----------------------------------------------------------------------------

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2 | 6.7 | 0.2 | 1.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 47.3 | 2.4 | 22.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 60.2 | 5.4 | 61.4 | 23.7 | 0.0 | 0 | 0 | 0 |
| 5 | 49.9 | 7.0 | 92.3 | 78.2 | 0.0 | 0 | 0 | 0 |
| 6 | 32.1 | 6.4 | 95.1 | 86.3 | 0.0 | 0 | 0 | 0 |
| 7 | 17.0 | 4.6 | 68.3 | 62.9 | 0.0 | 0 | 0 | 0 |
| 8 | 7.6 | 2.7 | 42.6 | 39.7 | 0.0 | 0 | 0 | 0 |
| 9 | 2.9 | 1.3 | 22.0 | 20.8 | 0.0 | 0 | 0 | 0 |
| 10 | 1.0 | 0.5 | 9.5 | 9.0 | 3.8 | 8 | 15 | 18 |
| 11 | 0.4 | 0.2 | 4.6 | 4.4 | 3.0 | 7 | 12 | 14 |
| Total | 225.0 | 30.7 | 419.0 | 325.0 | 6.7 | 15 | 27 | 32 |

=============================================================================

*Inside bark

==================================================================
======

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch- antable | Saw- timber |
|---|---|---|---|---|---|---|
| 2 | 6.7 | 0.2 | 18 | 0.0 | 0.0 | 0.0 |
| 3 | 47.3 | 2.4 | 25 | 0.0 | 0.0 | 0.0 |
| 4 | 60.2 | 5.4 | 29 | 0.0 | 0.0 | 0.0 |
| 5 | 49.9 | 7.0 | 33 | 3.5 | 3.0 | 0.0 |
| 6 | 32.1 | 6.4 | 35 | 3.5 | 3.1 | 0.0 |
| 7 | 17.0 | 4.6 | 37 | 2.4 | 2.3 | 0.0 |
| 8 | 7.6 | 2.7 | 39 | 1.5 | 1.4 | 0.0 |
| 9 | 2.9 | 1.3 | 40 | 0.8 | 0.7 | 0.0 |
| 10 | 1.0 | 0.5 | 41 | 0.3 | 0.3 | 0.1 |
| 11 | 0.4 | 0.2 | 42 | 0.2 | 0.2 | 0.1 |

Total 225.0 30.7 12.2 11.0 0.2

=================================================================
======

05-02-2011 15:08:10

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: SHORT Stand size: 1 ac

Year: 2026 Iteration 25 of 25

Stand Age: 45 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

=================================================================
===============

Diam. Basal Cubic-foot Volume/Acre*

Class Trees/ Area/ Merch- Saw- Board-foot Volume/Acre

| Midpt | Acre | Acre | Total | antable | timber | Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 0.5 | 0.0 | 0.3 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 0.5 | 0.0 | 0.7 | 0.2 | 0.0 | 0 | 0 | 0 |
| 5 | 1.1 | 0.2 | 2.8 | 2.2 | 0.0 | 0 | 0 | 0 |
| 6 | 9.4 | 1.8 | 39.8 | 36.6 | 0.0 | 0 | 0 | 0 |
| 7 | 14.4 | 3.8 | 92.2 | 86.8 | 0.0 | 0 | 0 | 0 |
| 8 | 22.1 | 7.8 | 205.4 | 195.8 | 0.0 | 0 | 0 | 0 |
| 9 | 32.5 | 14.6 | 393.7 | 377.6 | 0.0 | 0 | 0 | 0 |
| 10 | 30.0 | 16.5 | 457.7 | 440.9 | 162.5 | 370 | 675 | 765 |
| 11 | 31.9 | 21.0 | 606.0 | 585.3 | 342.3 | 884 | 1,532 | 1,726 |
| 12 | 25.0 | 19.8 | 587.9 | 569.0 | 425.2 | 1,240 | 2,035 | 2,202 |
| 13 | 14.9 | 13.7 | 416.6 | 403.8 | 334.3 | 1,061 | 1,647 | 1,780 |
| 14 | 9.5 | 10.1 | 312.9 | 303.6 | 265.4 | 924 | 1,370 | 1,441 |
| 15 | 4.7 | 5.7 | 181.4 | 176.1 | 159.5 | 593 | 841 | 881 |
| 16 | 1.7 | 2.4 | 76.9 | 74.8 | 69.4 | 273 | 371 | 396 |
| 17 | 0.6 | 0.9 | 31.7 | 30.8 | 29.2 | 123 | 159 | 168 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 18 | 0.1 | 0.2 | 8.5 | 8.3 | 7.9 | 34 | 43 | 47 |
| Total | 199.3 | 118.6 | 3,414.6 | 3,291.8 | 1,795.6 | 5,502 | 8,674 | 9,406 |

=============================================================================

*Inside bark

====================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch- antable | Saw- timber |
|---|---|---|---|---|---|---|
| 2 | 0.2 | 0.0 | 29 | 0.0 | 0.0 | 0.0 |
| 3 | 0.5 | 0.0 | 38 | 0.0 | 0.0 | 0.0 |
| 4 | 0.5 | 0.0 | 45 | 0.0 | 0.0 | 0.0 |
| 5 | 1.1 | 0.2 | 51 | 0.1 | 0.1 | 0.0 |
| 6 | 9.4 | 1.8 | 55 | 1.4 | 1.3 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 7 | 14.4 | 3.8 | 58 | 3.3 | 3.1 | 0.0 |
| 8 | 22.1 | 7.8 | 61 | 7.2 | 6.9 | 0.0 |
| 9 | 32.5 | 14.6 | 63 | 13.8 | 13.3 | 0.0 |
| 10 | 30.0 | 16.5 | 65 | 16.0 | 15.4 | 5.6 |
| 11 | 31.9 | 21.0 | 66 | 21.2 | 20.5 | 11.8 |
| 12 | 25.0 | 19.8 | 67 | 20.6 | 19.9 | 14.6 |
| 13 | 14.9 | 13.7 | 68 | 14.6 | 14.1 | 11.5 |
| 14 | 9.5 | 10.1 | 69 | 10.9 | 10.6 | 9.2 |
| 15 | 4.7 | 5.7 | 70 | 6.3 | 6.1 | 5.5 |
| 16 | 1.7 | 2.4 | 71 | 2.7 | 2.6 | 2.4 |
| 17 | 0.6 | 0.9 | 72 | 1.1 | 1.1 | 1.0 |
| 18 | 0.1 | 0.2 | 72 | 0.3 | 0.3 | 0.3 |
| Total | 199.3 | 118.6 | | 119.5 | 115.3 | 61.9 |

==================================================================

05-02-2011 15:08:29

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: SHORT Stand size: 1 ac

Year: 2001 Iteration 0 of 30

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

=============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch-antable | Saw-timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 2 | 6.7 | 0.2 | 1.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 47.3 | 2.4 | 22.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 60.2 | 5.4 | 61.4 | 23.7 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5 | 49.9 | 7.0 | 92.3 | 78.2 | 0.0 | 0 | 0 | 0 |
| 6 | 32.1 | 6.4 | 95.1 | 86.3 | 0.0 | 0 | 0 | 0 |
| 7 | 17.0 | 4.6 | 68.3 | 62.9 | 0.0 | 0 | 0 | 0 |
| 8 | 7.6 | 2.7 | 42.6 | 39.7 | 0.0 | 0 | 0 | 0 |
| 9 | 2.9 | 1.3 | 22.0 | 20.8 | 0.0 | 0 | 0 | 0 |
| 10 | 1.0 | 0.5 | 9.5 | 9.0 | 3.8 | 8 | 15 | 18 |
| 11 | 0.4 | 0.2 | 4.6 | 4.4 | 3.0 | 7 | 12 | 14 |
| Total | 225.0 | 30.7 | 419.0 | 325.0 | 6.7 | 15 | 27 | 32 |

=============================================================================

*Inside bark

=================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | 6.7 | 0.2 | 18 | 0.0 | 0.0 | 0.0 |
| 3 | 47.3 | 2.4 | 25 | 0.0 | 0.0 | 0.0 |
| 4 | 60.2 | 5.4 | 29 | 0.0 | 0.0 | 0.0 |
| 5 | 49.9 | 7.0 | 33 | 3.5 | 3.0 | 0.0 |
| 6 | 32.1 | 6.4 | 35 | 3.5 | 3.1 | 0.0 |
| 7 | 17.0 | 4.6 | 37 | 2.4 | 2.3 | 0.0 |
| 8 | 7.6 | 2.7 | 39 | 1.5 | 1.4 | 0.0 |
| 9 | 2.9 | 1.3 | 40 | 0.8 | 0.7 | 0.0 |
| 10 | 1.0 | 0.5 | 41 | 0.3 | 0.3 | 0.1 |
| 11 | 0.4 | 0.2 | 42 | 0.2 | 0.2 | 0.1 |
| Total | 225.0 | 30.7 | | 12.2 | 11.0 | 0.2 |

==============================================================

05-02-2011 15:17:18

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: SHORT    Stand size: 1 ac

Year: 2031    Iteration 30 of 30

Stand Age: 50    Site Index: 70

Pulpwood top diameter: 3 in. o.b.    Sawtimber top diameter: 9 in. o.b.

=============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch- antable | Saw- timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 0.3 | 0.0 | 0.2 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 0.4 | 0.0 | 0.5 | 0.2 | 0.0 | 0 | 0 | 0 |
| 5 | 0.9 | 0.1 | 2.5 | 2.0 | 0.0 | 0 | 0 | 0 |
| 6 | 5.0 | 1.0 | 22.6 | 20.9 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7 | 12.3 | 3.3 | 83.1 | 78.4 | 0.0 | 0 | 0 | 0 |
| 8 | 14.2 | 5.0 | 138.8 | 132.5 | 0.0 | 0 | 0 | 0 |
| 9 | 24.9 | 11.2 | 328.5 | 315.5 | 0.0 | 0 | 0 | 0 |
| 10 | 26.5 | 14.6 | 428.3 | 413.0 | 148.4 | 341 | 621 | 739 |
| 11 | 27.6 | 18.2 | 546.7 | 528.7 | 306.0 | 806 | 1,395 | 1,509 |
| 12 | 28.1 | 21.9 | 679.2 | 658.1 | 483.7 | 1,410 | 2,319 | 2,502 |
| 13 | 21.8 | 20.1 | 638.8 | 619.9 | 513.0 | 1,674 | 2,593 | 2,724 |
| 14 | 13.3 | 14.1 | 459.3 | 446.2 | 390.8 | 1,382 | 2,038 | 2,134 |
| 15 | 8.6 | 10.4 | 343.3 | 333.8 | 302.1 | 1,128 | 1,599 | 1,684 |
| 16 | 4.0 | 5.5 | 183.6 | 178.7 | 165.4 | 646 | 883 | 935 |
| 17 | 1.7 | 2.7 | 90.5 | 88.1 | 82.8 | 341 | 449 | 482 |
| 18 | 0.6 | 1.1 | 39.7 | 38.6 | 36.9 | 167 | 210 | 219 |
| 19 | 0.1 | 0.2 | 7.6 | 7.4 | 7.1 | 34 | 41 | 43 |
| Total | 190.2 | 129.6 | 3,993.2 | 3,862.0 | 2,436.2 | 7,928 | 12,148 | 12,970 |

=============================================================================

*Inside bark

=============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|
| 2 | 0.1 | 0.0 | 31 | 0.0 | 0.0 | 0.0 |
| 3 | 0.3 | 0.0 | 40 | 0.0 | 0.0 | 0.0 |
| 4 | 0.4 | 0.0 | 48 | 0.0 | 0.0 | 0.0 |
| 5 | 0.9 | 0.1 | 54 | 0.1 | 0.1 | 0.0 |
| 6 | 5.0 | 1.0 | 58 | 0.8 | 0.7 | 0.0 |
| 7 | 12.3 | 3.3 | 61 | 2.9 | 2.8 | 0.0 |
| 8 | 14.2 | 5.0 | 64 | 4.9 | 4.7 | 0.0 |
| 9 | 24.9 | 11.2 | 66 | 11.5 | 11.1 | 0.0 |
| 10 | 26.5 | 14.6 | 68 | 15.0 | 14.5 | 5.1 |
| 11 | 27.6 | 18.2 | 69 | 19.1 | 18.5 | 10.5 |
| 12 | 28.1 | 21.9 | 71 | 23.7 | 23.0 | 16.6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 13 | 21.8 | 20.1 | 72 | 22.3 | 21.7 | 17.7 |
| 14 | 13.3 | 14.1 | 73 | 16.0 | 15.6 | 13.5 |
| 15 | 8.6 | 10.4 | 74 | 12.0 | 11.6 | 10.4 |
| 16 | 4.0 | 5.5 | 74 | 6.4 | 6.2 | 5.7 |
| 17 | 1.7 | 2.7 | 75 | 3.2 | 3.1 | 2.9 |
| 18 | 0.6 | 1.1 | 76 | 1.4 | 1.3 | 1.3 |
| 19 | 0.1 | 0.2 | 76 | 0.3 | 0.3 | 0.2 |
| Total | 190.2 | 129.6 | | 139.7 | 135.1 | 84.0 |

=================================================================
======

05-02-2011 15:17:38

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: SHORT Stand size: 1 ac

Year: 2001 Iteration 0 of 15

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

===========================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch-antable | Saw-timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 1 | 2.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 42.1 | 1.0 | 7.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 102.6 | 5.3 | 47.8 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 133.3 | 12.0 | 136.1 | 52.4 | 0.0 | 0 | 0 | 0 |
| 5 | 115.9 | 16.2 | 214.1 | 181.5 | 0.0 | 0 | 0 | 0 |
| 6 | 71.0 | 14.2 | 210.2 | 190.8 | 0.0 | 0 | 0 | 0 |
| 7 | 30.9 | 8.4 | 124.6 | 114.7 | 0.0 | 0 | 0 | 0 |
| 8 | 9.5 | 3.4 | 53.8 | 50.2 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | 2.1 | 0.9 | 15.7 | 14.8 | 0.0 | 0 | 0 | 0 |
| 10 | 0.3 | 0.2 | 3.1 | 2.9 | 1.2 | 3 | 5 | 6 |
| 11 | 0.0 | 0.0 | 0.4 | 0.4 | 0.3 | 1 | 1 | 1 |
| Total | 510.0 | 61.5 | 812.9 | 607.7 | 1.5 | 3 | 6 | 7 |

=============================================================================

*Inside bark

====================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|
| 1 | 2.1 | 0.0 | 9 | 0.0 | 0.0 | 0.0 |
| 2 | 42.1 | 1.0 | 18 | 0.0 | 0.0 | 0.0 |
| 3 | 102.6 | 5.3 | 25 | 0.0 | 0.0 | 0.0 |
| 4 | 133.3 | 12.0 | 29 | 0.0 | 0.0 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | 115.9 | 16.2 | 33 | 8.2 | 6.9 | 0.0 |
| 6 | 71.0 | 14.2 | 35 | 7.7 | 6.9 | 0.0 |
| 7 | 30.9 | 8.4 | 37 | 4.5 | 4.1 | 0.0 |
| 8 | 9.5 | 3.4 | 39 | 1.9 | 1.8 | 0.0 |
| 9 | 2.1 | 0.9 | 40 | 0.6 | 0.5 | 0.0 |
| 10 | 0.3 | 0.2 | 41 | 0.1 | 0.1 | 0.0 |
| 11 | 0.0 | 0.0 | 42 | 0.0 | 0.0 | 0.0 |
| Total | 510.0 | 61.5 | | 22.9 | 20.4 | 0.1 |

==============================================================
======

05-02-2011 15:44:10

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: SHORT Stand size: 1 ac

Year: 2016 Iteration 15 of 15

Stand Age: 35 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

=============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch-antable | Saw-timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 5.3 | 0.1 | 1.2 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 8.4 | 0.4 | 4.8 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 26.5 | 2.5 | 37.1 | 11.7 | 0.0 | 0 | 0 | 0 |
| 5 | 40.7 | 5.7 | 98.8 | 83.1 | 0.0 | 0 | 0 | 0 |
| 6 | 65.3 | 12.9 | 257.6 | 236.6 | 0.0 | 0 | 0 | 0 |
| 7 | 85.5 | 22.8 | 482.8 | 452.6 | 0.0 | 0 | 0 | 0 |
| 8 | 89.5 | 31.5 | 705.9 | 669.9 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | 60.2 | 26.7 | 634.5 | 606.3 | 0.0 | 0 | 0 | 0 |
| 10 | 36.4 | 19.6 | 483.8 | 464.2 | 143.7 | 317 | 576 | 664 |
| 11 | 19.2 | 12.4 | 317.7 | 305.7 | 175.3 | 423 | 747 | 856 |
| 12 | 6.3 | 4.9 | 129.2 | 124.6 | 92.0 | 261 | 432 | 469 |
| 13 | 1.5 | 1.4 | 37.9 | 36.6 | 30.4 | 93 | 146 | 159 |
| 14 | 0.2 | 0.2 | 6.6 | 6.4 | 5.7 | 19 | 28 | 31 |
| 15 | 0.0 | 0.0 | 0.8 | 0.8 | 0.7 | 3 | 4 | 4 |
| Total | 445.2 | 141.2 | 3,198.8 | 2,998.5 | 447.9 | 1,115 | 1,932 | 2,183 |

=========================================================================================

*Inside bark

=========================================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 0.1 | 0.0 | 11 | 0.0 | 0.0 | 0.0 |
| 2 | 5.3 | 0.1 | 26 | 0.0 | 0.0 | 0.0 |
| 3 | 8.4 | 0.4 | 34 | 0.0 | 0.0 | 0.0 |
| 4 | 26.5 | 2.5 | 41 | 0.0 | 0.0 | 0.0 |
| 5 | 40.7 | 5.7 | 45 | 3.6 | 3.1 | 0.0 |
| 6 | 65.3 | 12.9 | 49 | 9.2 | 8.5 | 0.0 |
| 7 | 85.5 | 22.8 | 51 | 17.1 | 16.1 | 0.0 |
| 8 | 89.5 | 31.5 | 54 | 24.9 | 23.6 | 0.0 |
| 9 | 60.2 | 26.7 | 55 | 22.3 | 21.3 | 0.0 |
| 10 | 36.4 | 19.6 | 57 | 17.0 | 16.3 | 5.0 |
| 11 | 19.2 | 12.4 | 58 | 11.1 | 10.7 | 6.0 |
| 12 | 6.3 | 4.9 | 59 | 4.5 | 4.4 | 3.2 |
| 13 | 1.5 | 1.4 | 60 | 1.3 | 1.3 | 1.0 |
| 14 | 0.2 | 0.2 | 61 | 0.2 | 0.2 | 0.2 |
| 15 | 0.0 | 0.0 | 62 | 0.0 | 0.0 | 0.0 |
| Total | 445.2 | 141.2 | | 111.4 | 105.4 | 15.4 |

==================================================================
======

05-02-2011 15:44:26

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: SH Stand size: 1 ac

Year: 2001 Iteration 0 of 20

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

==================================================================
===============

| Diam. | | Basal | Cubic-foot Volume/Acre* | | | | | |
|---|---|---|---|---|---|---|---|---|
| Class | Trees/ | Area/ | | Merch- | Saw- | Board-foot Volume/Acre | | |
| Midpt | Acre | Acre | Total | antable | timber | Doyle | Scribner | Int. ¬ |

-----------------------------------------------------------------------------

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 2.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 42.1 | 1.0 | 7.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 102.6 | 5.3 | 47.8 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 133.3 | 12.0 | 136.1 | 52.4 | 0.0 | 0 | 0 | 0 |
| 5 | 115.9 | 16.2 | 214.1 | 181.5 | 0.0 | 0 | 0 | 0 |
| 6 | 71.0 | 14.2 | 210.2 | 190.8 | 0.0 | 0 | 0 | 0 |
| 7 | 30.9 | 8.4 | 124.6 | 114.7 | 0.0 | 0 | 0 | 0 |
| 8 | 9.5 | 3.4 | 53.8 | 50.2 | 0.0 | 0 | 0 | 0 |
| 9 | 2.1 | 0.9 | 15.7 | 14.8 | 0.0 | 0 | 0 | 0 |
| 10 | 0.3 | 0.2 | 3.1 | 2.9 | 1.2 | 3 | 5 | 6 |
| 11 | 0.0 | 0.0 | 0.4 | 0.4 | 0.3 | 1 | 1 | 1 |
| Total | 510.0 | 61.5 | 812.9 | 607.8 | 1.5 | 3 | 6 | 7 |

==============================================================================

*Inside bark

======================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|
| 1 | 2.1 | 0.0 | 9 | 0.0 | 0.0 | 0.0 |
| 2 | 42.1 | 1.0 | 18 | 0.0 | 0.0 | 0.0 |
| 3 | 102.6 | 5.3 | 25 | 0.0 | 0.0 | 0.0 |
| 4 | 133.3 | 12.0 | 29 | 0.0 | 0.0 | 0.0 |
| 5 | 115.9 | 16.2 | 33 | 8.2 | 6.9 | 0.0 |
| 6 | 71.0 | 14.2 | 35 | 7.7 | 6.9 | 0.0 |
| 7 | 30.9 | 8.4 | 37 | 4.5 | 4.1 | 0.0 |
| 8 | 9.5 | 3.4 | 39 | 1.9 | 1.8 | 0.0 |
| 9 | 2.1 | 0.9 | 40 | 0.6 | 0.5 | 0.0 |
| 10 | 0.3 | 0.2 | 41 | 0.1 | 0.1 | 0.0 |
| 11 | 0.0 | 0.0 | 42 | 0.0 | 0.0 | 0.0 |

Total 510.0 61.5 22.9 20.4 0.1

=============================================================
======

05-02-2011 15:54:00

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: SH Stand size: 1 ac

Year: 2021 Iteration 20 of 20

Stand Age: 40 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

=============================================================
===============

Diam. Basal Cubic-foot Volume/Acre*

| Class | Trees/ | Area/ | | Merch- | Saw- | Board-foot Volume/Acre | | |
|---|---|---|---|---|---|---|---|---|
| Midpt | Acre | Acre | Total | antable | timber | Doyle | Scribner | Int. ¬ |
| 1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 1.5 | 0.0 | 0.3 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 4.1 | 0.2 | 2.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 15.6 | 1.5 | 22.9 | 8.3 | 0.0 | 0 | 0 | 0 |
| 5 | 25.8 | 3.6 | 64.6 | 52.8 | 0.0 | 0 | 0 | 0 |
| 6 | 51.9 | 10.4 | 218.1 | 200.6 | 0.0 | 0 | 0 | 0 |
| 7 | 69.0 | 18.8 | 437.7 | 412.1 | 0.0 | 0 | 0 | 0 |
| 8 | 67.2 | 23.4 | 568.8 | 540.8 | 0.0 | 0 | 0 | 0 |
| 9 | 79.8 | 35.0 | 878.4 | 840.7 | 0.0 | 0 | 0 | 0 |
| 10 | 48.5 | 26.6 | 700.7 | 673.9 | 226.0 | 508 | 922 | 1,087 |
| 11 | 28.4 | 18.5 | 503.6 | 485.6 | 278.6 | 704 | 1,234 | 1,371 |
| 12 | 14.9 | 11.4 | 321.5 | 310.7 | 226.9 | 650 | 1,075 | 1,161 |
| 13 | 4.6 | 4.2 | 120.3 | 116.4 | 95.8 | 291 | 458 | 504 |
| 14 | 1.3 | 1.4 | 40.8 | 39.5 | 34.5 | 117 | 175 | 186 |
| 15 | 0.2 | 0.3 | 8.3 | 8.0 | 7.3 | 27 | 39 | 40 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 16 | 0.0 | 0.0 | 0.9 | 0.9 | 0.8 | 3 | 4 | 5 |
| Total | 413.0 | 155.1 | 3,889.0 | 3,690.4 | 869.8 | 2,300 | 3,907 | 4,353 |

=============================================================================

*Inside bark

======================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.0 | 13 | 0.0 | 0.0 | 0.0 |
| 2 | 1.5 | 0.0 | 27 | 0.0 | 0.0 | 0.0 |
| 3 | 4.1 | 0.2 | 35 | 0.0 | 0.0 | 0.0 |
| 4 | 15.6 | 1.5 | 44 | 0.0 | 0.0 | 0.0 |
| 5 | 25.8 | 3.6 | 48 | 2.4 | 1.9 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 6 | 51.9 | 10.4 | 52 | 7.8 | 7.2 | 0.0 |
| 7 | 69.0 | 18.8 | 55 | 15.5 | 14.6 | 0.0 |
| 8 | 67.2 | 23.4 | 57 | 20.0 | 19.1 | 0.0 |
| 9 | 79.8 | 35.0 | 59 | 30.9 | 29.5 | 0.0 |
| 10 | 48.5 | 26.6 | 61 | 24.6 | 23.6 | 7.8 |
| 11 | 28.4 | 18.5 | 62 | 17.6 | 17.0 | 9.6 |
| 12 | 14.9 | 11.4 | 63 | 11.2 | 10.9 | 7.8 |
| 13 | 4.6 | 4.2 | 65 | 4.2 | 4.1 | 3.3 |
| 14 | 1.3 | 1.4 | 65 | 1.4 | 1.4 | 1.2 |
| 15 | 0.2 | 0.3 | 66 | 0.3 | 0.3 | 0.3 |
| 16 | 0.0 | 0.0 | 67 | 0.0 | 0.0 | 0.0 |
| Total | 413.0 | 155.1 | | 136.0 | 129.6 | 30.0 |

==================================================================

05-02-2011 15:54:23

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: HH Stand size: 1 ac

Year: 2001 Iteration 0 of 25

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

===============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch-antable | Saw-timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 1 | 2.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 42.1 | 1.0 | 7.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 102.6 | 5.3 | 47.8 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 133.3 | 12.0 | 136.1 | 52.4 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5 | 115.9 | 16.2 | 214.1 | 181.5 | 0.0 | 0 | 0 | 0 |
| 6 | 71.0 | 14.2 | 210.2 | 190.8 | 0.0 | 0 | 0 | 0 |
| 7 | 30.9 | 8.4 | 124.6 | 114.7 | 0.0 | 0 | 0 | 0 |
| 8 | 9.5 | 3.4 | 53.8 | 50.2 | 0.0 | 0 | 0 | 0 |
| 9 | 2.1 | 0.9 | 15.7 | 14.8 | 0.0 | 0 | 0 | 0 |
| 10 | 0.3 | 0.2 | 3.1 | 2.9 | 1.2 | 3 | 5 | 6 |
| 11 | 0.0 | 0.0 | 0.4 | 0.4 | 0.3 | 1 | 1 | 1 |
| Total | 510.0 | 61.5 | 812.9 | 607.7 | 1.5 | 3 | 6 | 7 |

==============================================================================

*Inside bark

=====================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch- antable | Saw- timber |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2.1 | 0.0 | 9 | 0.0 | 0.0 | 0.0 |
| 2 | 42.1 | 1.0 | 18 | 0.0 | 0.0 | 0.0 |
| 3 | 102.6 | 5.3 | 25 | 0.0 | 0.0 | 0.0 |
| 4 | 133.3 | 12.0 | 29 | 0.0 | 0.0 | 0.0 |
| 5 | 115.9 | 16.2 | 33 | 8.2 | 6.9 | 0.0 |
| 6 | 71.0 | 14.2 | 35 | 7.7 | 6.9 | 0.0 |
| 7 | 30.9 | 8.4 | 37 | 4.5 | 4.1 | 0.0 |
| 8 | 9.5 | 3.4 | 39 | 1.9 | 1.8 | 0.0 |
| 9 | 2.1 | 0.9 | 40 | 0.6 | 0.5 | 0.0 |
| 10 | 0.3 | 0.2 | 41 | 0.1 | 0.1 | 0.0 |
| 11 | 0.0 | 0.0 | 42 | 0.0 | 0.0 | 0.0 |
| Total | 510.0 | 61.5 | | 22.9 | 20.4 | 0.1 |

==================================================================

======

05-02-2011 16:06:43

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: HH Stand size: 1 ac

Year: 2026 Iteration 25 of 25

Stand Age: 45 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

=============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch- antable | Saw- timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 0.4 | 0.0 | 0.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 1.8 | 0.1 | 1.0 | 0.0 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | 6.4 | 0.6 | 9.4 | 2.7 | 0.0 | 0 | 0 | 0 |
| 5 | 18.3 | 2.5 | 46.3 | 36.9 | 0.0 | 0 | 0 | 0 |
| 6 | 31.2 | 6.1 | 131.6 | 120.8 | 0.0 | 0 | 0 | 0 |
| 7 | 60.6 | 16.3 | 398.1 | 375.2 | 0.0 | 0 | 0 | 0 |
| 8 | 65.4 | 23.1 | 611.3 | 582.6 | 0.0 | 0 | 0 | 0 |
| 9 | 63.3 | 28.1 | 764.2 | 732.8 | 0.0 | 0 | 0 | 0 |
| 10 | 55.5 | 29.9 | 826.4 | 795.7 | 239.0 | 536 | 975 | 1,184 |
| 11 | 40.3 | 26.2 | 751.4 | 725.6 | 410.3 | 1,043 | 1,821 | 2,023 |
| 12 | 24.3 | 19.1 | 565.9 | 547.8 | 405.9 | 1,181 | 1,944 | 2,092 |
| 13 | 7.5 | 7.0 | 212.5 | 206.0 | 170.9 | 545 | 845 | 910 |
| 14 | 3.1 | 3.3 | 100.9 | 97.9 | 85.2 | 295 | 439 | 461 |
| 15 | 1.0 | 1.2 | 36.7 | 35.7 | 32.2 | 119 | 169 | 178 |
| 16 | 0.2 | 0.2 | 7.3 | 7.1 | 6.6 | 26 | 35 | 38 |
| 17 | 0.0 | 0.0 | 0.9 | 0.9 | 0.9 | 4 | 5 | 5 |
| Total | 379.3 | 163.6 | 4,464.1 | 4,267.5 | 1,350.9 | 3,748 | 6,234 | 6,890 |

==============================================================
==============

*Inside bark

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.0 | 15 | 0.0 | 0.0 | 0.0 |
| 2 | 0.4 | 0.0 | 28 | 0.0 | 0.0 | 0.0 |
| 3 | 1.8 | 0.1 | 38 | 0.0 | 0.0 | 0.0 |
| 4 | 6.4 | 0.6 | 46 | 0.0 | 0.0 | 0.0 |
| 5 | 18.3 | 2.5 | 51 | 1.7 | 1.3 | 0.0 |
| 6 | 31.2 | 6.1 | 55 | 4.7 | 4.3 | 0.0 |
| 7 | 60.6 | 16.3 | 58 | 14.1 | 13.3 | 0.0 |
| 8 | 65.4 | 23.1 | 61 | 21.5 | 20.5 | 0.0 |
| 9 | 63.3 | 28.1 | 63 | 26.8 | 25.7 | 0.0 |
| 10 | 55.5 | 29.9 | 64 | 29.0 | 27.9 | 8.3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 11 | 40.3 | 26.2 | 66 | 26.3 | 25.4 | 14.1 |
| 12 | 24.3 | 19.1 | 67 | 19.8 | 19.2 | 14.0 |
| 13 | 7.5 | 7.0 | 68 | 7.4 | 7.2 | 5.9 |
| 14 | 3.1 | 3.3 | 69 | 3.5 | 3.4 | 2.9 |
| 15 | 1.0 | 1.2 | 70 | 1.3 | 1.2 | 1.1 |
| 16 | 0.2 | 0.2 | 71 | 0.3 | 0.2 | 0.2 |
| 17 | 0.0 | 0.0 | 72 | 0.0 | 0.0 | 0.0 |
| Total | 379.3 | 163.6 | | 156.4 | 149.8 | 46.5 |

================================================================
======

05-02-2011 16:07:04

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: DD Stand size: 1 ac

Year: 2001 Iteration 0 of 30

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

==============================================================================

| Diam. | | Basal | Cubic-foot Volume/Acre* | | | | | |
|---|---|---|---|---|---|---|---|---|
| Class | Trees/ | Area/ | | Merch- | Saw- | Board-foot Volume/Acre | | |
| Midpt | Acre | Acre | Total | antable | timber | Doyle | Scribner | Int. ¬ |
| 1 | 2.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 42.1 | 1.0 | 7.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 102.6 | 5.3 | 47.8 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 133.3 | 12.0 | 136.1 | 52.4 | 0.0 | 0 | 0 | 0 |
| 5 | 115.9 | 16.2 | 214.1 | 181.5 | 0.0 | 0 | 0 | 0 |
| 6 | 71.0 | 14.2 | 210.2 | 190.8 | 0.0 | 0 | 0 | 0 |
| 7 | 30.9 | 8.4 | 124.6 | 114.7 | 0.0 | 0 | 0 | 0 |
| 8 | 9.5 | 3.4 | 53.8 | 50.2 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | 2.1 | 0.9 | 15.7 | 14.8 | 0.0 | 0 | 0 | 0 |
| 10 | 0.3 | 0.2 | 3.1 | 2.9 | 1.2 | 3 | 5 | 6 |
| 11 | 0.0 | 0.0 | 0.4 | 0.4 | 0.3 | 1 | 1 | 1 |
| Total | 510.0 | 61.5 | 812.9 | 607.7 | 1.5 | 3 | 6 | 7 |

==============================================================================

*Inside bark

=====================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch- antable | Saw- timber |
|---|---|---|---|---|---|---|
| 1 | 2.1 | 0.0 | 9 | 0.0 | 0.0 | 0.0 |
| 2 | 42.1 | 1.0 | 18 | 0.0 | 0.0 | 0.0 |
| 3 | 102.6 | 5.3 | 25 | 0.0 | 0.0 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | 133.3 | 12.0 | 29 | 0.0 | 0.0 | 0.0 |
| 5 | 115.9 | 16.2 | 33 | 8.2 | 6.9 | 0.0 |
| 6 | 71.0 | 14.2 | 35 | 7.7 | 6.9 | 0.0 |
| 7 | 30.9 | 8.4 | 37 | 4.5 | 4.1 | 0.0 |
| 8 | 9.5 | 3.4 | 39 | 1.9 | 1.8 | 0.0 |
| 9 | 2.1 | 0.9 | 40 | 0.6 | 0.5 | 0.0 |
| 10 | 0.3 | 0.2 | 41 | 0.1 | 0.1 | 0.0 |
| 11 | 0.0 | 0.0 | 42 | 0.0 | 0.0 | 0.0 |
| Total | 510.0 | 61.5 | | 22.9 | 20.4 | 0.1 |

================================================================
======

05-02-2011 16:13:32

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: DD Stand size: 1 ac

Year: 2031 Iteration 30 of 30

Stand Age: 50 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

=============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch- antable | Saw- timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 0.7 | 0.0 | 0.4 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 3.7 | 0.4 | 5.9 | 2.3 | 0.0 | 0 | 0 | 0 |
| 5 | 12.6 | 1.8 | 35.6 | 29.2 | 0.0 | 0 | 0 | 0 |
| 6 | 19.5 | 3.9 | 87.8 | 80.9 | 0.0 | 0 | 0 | 0 |
| 7 | 40.1 | 10.7 | 270.2 | 254.8 | 0.0 | 0 | 0 | 0 |
| 8 | 60.7 | 21.3 | 584.1 | 557.3 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | 59.3 | 26.5 | 776.5 | 745.6 | 0.0 | 0 | 0 | 0 |
| 10 | 54.8 | 29.8 | 878.3 | 846.7 | 249.3 | 570 | 1,038 | 1,186 |
| 11 | 46.9 | 31.1 | 935.8 | 905.0 | 528.1 | 1,385 | 2,390 | 2,669 |
| 12 | 24.8 | 19.4 | 600.6 | 582.0 | 429.2 | 1,251 | 2,052 | 2,233 |
| 13 | 14.9 | 13.5 | 429.3 | 416.6 | 342.2 | 1,106 | 1,722 | 1,830 |
| 14 | 6.8 | 7.2 | 235.2 | 228.5 | 200.2 | 708 | 1,044 | 1,099 |
| 15 | 1.6 | 2.0 | 66.9 | 65.1 | 59.1 | 222 | 313 | 331 |
| 16 | 0.4 | 0.6 | 19.4 | 18.9 | 17.5 | 68 | 93 | 99 |
| 17 | 0.1 | 0.2 | 5.7 | 5.5 | 5.2 | 21 | 28 | 30 |
| 18 | 0.0 | 0.0 | 0.7 | 0.7 | 0.6 | 3 | 4 | 4 |
| Total | 347.1 | 168.5 | 4,932.4 | 4,738.9 | 1,831.3 | 5,334 | 8,685 | 9,481 |

==============================================================================

*Inside bark

=======================================================================

Diam. Basal Avg. Green Weight of Stem (Tons/Acre)

| Class Midpt | Trees/ Acre | Area/ Acre | T. Ht. (ft) | Total | Merch- antable | Saw- timber |
|---|---|---|---|---|---|---|
| 2 | 0.1 | 0.0 | 30 | 0.0 | 0.0 | 0.0 |
| 3 | 0.7 | 0.0 | 40 | 0.0 | 0.0 | 0.0 |
| 4 | 3.7 | 0.4 | 49 | 0.0 | 0.0 | 0.0 |
| 5 | 12.6 | 1.8 | 54 | 1.3 | 1.1 | 0.0 |
| 6 | 19.5 | 3.9 | 58 | 3.1 | 2.9 | 0.0 |
| 7 | 40.1 | 10.7 | 61 | 9.6 | 9.0 | 0.0 |
| 8 | 60.7 | 21.3 | 64 | 20.6 | 19.6 | 0.0 |
| 9 | 59.3 | 26.5 | 66 | 27.3 | 26.2 | 0.0 |
| 10 | 54.8 | 29.8 | 68 | 30.8 | 29.7 | 8.6 |
| 11 | 46.9 | 31.1 | 69 | 32.7 | 31.7 | 18.1 |
| 12 | 24.8 | 19.4 | 71 | 21.0 | 20.3 | 14.8 |
| 13 | 14.9 | 13.5 | 72 | 15.0 | 14.6 | 11.8 |
| 14 | 6.8 | 7.2 | 73 | 8.2 | 8.0 | 6.9 |
| 15 | 1.6 | 2.0 | 74 | 2.3 | 2.3 | 2.0 |
| 16 | 0.4 | 0.6 | 74 | 0.7 | 0.7 | 0.6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 17 | 0.1 | 0.2 | 75 | 0.2 | 0.2 | 0.2 |
| 18 | 0.0 | 0.0 | 76 | 0.0 | 0.0 | 0.0 |
| Total | 347.1 | 168.5 | | 172.7 | 166.1 | 63.1 |

================================================================
======

05-02-2011 16:17:18

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: SS Stand size: 1 ac

Year: 2001 Iteration 0 of 15

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

================================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch- antable | Saw- timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 1 | 7.3 | 0.0 | 0.2 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 83.9 | 2.0 | 14.2 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 152.3 | 7.8 | 70.9 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 169.5 | 15.2 | 173.0 | 66.6 | 0.0 | 0 | 0 | 0 |
| 5 | 141.9 | 19.8 | 262.0 | 222.1 | 0.0 | 0 | 0 | 0 |
| 6 | 94.7 | 18.9 | 280.2 | 254.3 | 0.0 | 0 | 0 | 0 |
| 7 | 51.7 | 14.0 | 208.0 | 191.6 | 0.0 | 0 | 0 | 0 |
| 8 | 23.3 | 8.3 | 131.4 | 122.7 | 0.0 | 0 | 0 | 0 |
| 9 | 8.8 | 3.9 | 67.1 | 63.2 | 0.0 | 0 | 0 | 0 |
| 10 | 2.8 | 1.5 | 27.5 | 26.1 | 10.9 | 24 | 44 | 51 |
| 11 | 0.9 | 0.6 | 11.7 | 11.1 | 7.5 | 17 | 30 | 36 |

Total 737.0 92.1 1,246.1 957.7 18.4 41 74 87

=================================================================================

*Inside bark

========================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|
| 1 | 7.3 | 0.0 | 9 | 0.0 | 0.0 | 0.0 |
| 2 | 83.9 | 2.0 | 18 | 0.0 | 0.0 | 0.0 |
| 3 | 152.3 | 7.8 | 25 | 0.0 | 0.0 | 0.0 |
| 4 | 169.5 | 15.2 | 29 | 0.0 | 0.0 | 0.0 |
| 5 | 141.9 | 19.8 | 33 | 10.0 | 8.5 | 0.0 |
| 6 | 94.7 | 18.9 | 35 | 10.2 | 9.3 | 0.0 |
| 7 | 51.7 | 14.0 | 37 | 7.4 | 6.9 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 8 | 23.3 | 8.3 | 39 | 4.7 | 4.4 | 0.0 |
| 9 | 8.8 | 3.9 | 40 | 2.4 | 2.2 | 0.0 |
| 10 | 2.8 | 1.5 | 41 | 1.0 | 0.9 | 0.4 |
| 11 | 0.9 | 0.6 | 42 | 0.4 | 0.4 | 0.3 |
| Total | 737.0 | 92.1 | | 36.1 | 32.5 | 0.6 |

=================================================================
======

05-02-2011 16:35:10

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: SS Stand size: 1 ac

Year: 2016 Iteration 15 of 15

Stand Age: 35 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch- antable | Saw- timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 7.1 | 0.2 | 1.4 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 21.6 | 1.2 | 13.3 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 44.0 | 3.9 | 55.8 | 13.5 | 0.0 | 0 | 0 | 0 |
| 5 | 83.3 | 11.6 | 202.1 | 167.5 | 0.0 | 0 | 0 | 0 |
| 6 | 87.1 | 17.2 | 342.4 | 314.4 | 0.0 | 0 | 0 | 0 |
| 7 | 107.1 | 28.6 | 610.6 | 572.7 | 0.0 | 0 | 0 | 0 |
| 8 | 77.1 | 26.7 | 595.3 | 564.6 | 0.0 | 0 | 0 | 0 |
| 9 | 65.7 | 28.5 | 672.0 | 641.8 | 0.0 | 0 | 0 | 0 |
| 10 | 43.2 | 23.4 | 580.9 | 557.5 | 173.7 | 387 | 703 | 795 |
| 11 | 18.6 | 12.3 | 316.4 | 304.6 | 182.7 | 452 | 791 | 909 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 12 | 9.3 | 7.2 | 191.6 | 184.8 | 136.9 | 389 | 642 | 697 |
| 13 | 3.7 | 3.3 | 90.7 | 87.6 | 72.6 | 221 | 347 | 381 |
| 14 | 1.4 | 1.5 | 40.8 | 39.5 | 34.9 | 117 | 172 | 189 |
| 15 | 0.4 | 0.4 | 12.5 | 12.1 | 11.0 | 40 | 57 | 61 |
| Total | 569.8 | 166.0 | 3,725.7 | 3,460.4 | 611.8 | 1,607 | 2,713 | 3,032 |

==============================================================================

*Inside bark

======================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|
| 1 | 0.2 | 0.0 | 13 | 0.0 | 0.0 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | 7.1 | 0.2 | 25 | 0.0 | 0.0 | 0.0 |
| 3 | 21.6 | 1.2 | 34 | 0.0 | 0.0 | 0.0 |
| 4 | 44.0 | 3.9 | 40 | 0.0 | 0.0 | 0.0 |
| 5 | 83.3 | 11.6 | 45 | 6.7 | 5.8 | 0.0 |
| 6 | 87.1 | 17.2 | 49 | 12.3 | 11.3 | 0.0 |
| 7 | 107.1 | 28.6 | 51 | 21.7 | 20.3 | 0.0 |
| 8 | 77.1 | 26.7 | 54 | 21.0 | 19.9 | 0.0 |
| 9 | 65.7 | 28.5 | 55 | 23.6 | 22.6 | 0.0 |
| 10 | 43.2 | 23.4 | 57 | 20.4 | 19.6 | 6.0 |
| 11 | 18.6 | 12.3 | 58 | 11.1 | 10.7 | 6.3 |
| 12 | 9.3 | 7.2 | 59 | 6.7 | 6.5 | 4.7 |
| 13 | 3.7 | 3.3 | 60 | 3.2 | 3.1 | 2.5 |
| 14 | 1.4 | 1.5 | 61 | 1.4 | 1.4 | 1.2 |
| 15 | 0.4 | 0.4 | 62 | 0.4 | 0.4 | 0.4 |
| Total | 569.8 | 166.0 | | 128.5 | 121.4 | 21.1 |

=================================================================
======

05-02-2011 16:36:04

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: EE Stand size: 1 ac

Year: 2001 Iteration 0 of 20

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

=============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch-antable | Saw-timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 1 | 7.3 | 0.0 | 0.2 | 0.0 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2 | 83.9 | 2.0 | 14.2 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 152.3 | 7.8 | 70.9 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 169.5 | 15.2 | 173.0 | 66.6 | 0.0 | 0 | 0 | 0 |
| 5 | 141.9 | 19.8 | 262.0 | 222.1 | 0.0 | 0 | 0 | 0 |
| 6 | 94.7 | 18.9 | 280.2 | 254.3 | 0.0 | 0 | 0 | 0 |
| 7 | 51.7 | 14.0 | 208.0 | 191.6 | 0.0 | 0 | 0 | 0 |
| 8 | 23.3 | 8.3 | 131.4 | 122.7 | 0.0 | 0 | 0 | 0 |
| 9 | 8.8 | 3.9 | 67.1 | 63.2 | 0.0 | 0 | 0 | 0 |
| 10 | 2.8 | 1.5 | 27.5 | 26.1 | 10.9 | 24 | 44 | 51 |
| 11 | 0.9 | 0.6 | 11.7 | 11.1 | 7.5 | 17 | 30 | 36 |
| Total | 737.0 | 92.1 | 1,246.1 | 957.7 | 18.4 | 41 | 74 | 87 |

=============================================================================

*Inside bark

====================================================================

Diam. Basal Avg. Green Weight of Stem (Tons/Acre)

| Class Midpt | Trees/ Acre | Area/ Acre | T. Ht. (ft) | Total | Merch- antable | Saw- timber |
|---|---|---|---|---|---|---|
| 1 | 7.3 | 0.0 | 9 | 0.0 | 0.0 | 0.0 |
| 2 | 83.9 | 2.0 | 18 | 0.0 | 0.0 | 0.0 |
| 3 | 152.3 | 7.8 | 25 | 0.0 | 0.0 | 0.0 |
| 4 | 169.5 | 15.2 | 29 | 0.0 | 0.0 | 0.0 |
| 5 | 141.9 | 19.8 | 33 | 10.0 | 8.5 | 0.0 |
| 6 | 94.7 | 18.9 | 35 | 10.2 | 9.3 | 0.0 |
| 7 | 51.7 | 14.0 | 37 | 7.4 | 6.9 | 0.0 |
| 8 | 23.3 | 8.3 | 39 | 4.7 | 4.4 | 0.0 |
| 9 | 8.8 | 3.9 | 40 | 2.4 | 2.2 | 0.0 |
| 10 | 2.8 | 1.5 | 41 | 1.0 | 0.9 | 0.4 |
| 11 | 0.9 | 0.6 | 42 | 0.4 | 0.4 | 0.3 |
| Total | 737.0 | 92.1 | | 36.1 | 32.5 | 0.6 |

===================================================================
======

05-02-2011 16:48:41

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: EE Stand size: 1 ac

Year: 2021 Iteration 20 of 20

Stand Age: 40 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

===================================================================
================

Diam. Basal Cubic-foot Volume/Acre*

Class Trees/ Area/ Merch- Saw- Board-foot Volume/Acre

Midpt Acre Acre Total antable timber Doyle Scribner Int. ¬

--------------------------------------------------------------------------------

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 2.1 | 0.1 | 0.4 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 6.9 | 0.4 | 4.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 27.0 | 2.4 | 34.8 | 5.1 | 0.0 | 0 | 0 | 0 |
| 5 | 52.2 | 7.1 | 129.3 | 103.9 | 0.0 | 0 | 0 | 0 |
| 6 | 73.9 | 14.5 | 302.6 | 277.8 | 0.0 | 0 | 0 | 0 |
| 7 | 90.3 | 24.0 | 556.9 | 523.7 | 0.0 | 0 | 0 | 0 |
| 8 | 86.2 | 30.1 | 738.0 | 701.8 | 0.0 | 0 | 0 | 0 |
| 9 | 63.1 | 27.8 | 699.6 | 669.7 | 0.0 | 0 | 0 | 0 |
| 10 | 48.5 | 26.1 | 685.3 | 658.8 | 202.4 | 451 | 819 | 987 |
| 11 | 29.6 | 19.3 | 525.9 | 507.1 | 291.4 | 725 | 1,269 | 1,413 |
| 12 | 15.6 | 12.2 | 343.4 | 331.9 | 245.9 | 709 | 1,169 | 1,285 |
| 13 | 7.0 | 6.4 | 186.3 | 180.3 | 149.7 | 461 | 719 | 785 |
| 14 | 2.5 | 2.7 | 78.5 | 76.1 | 66.8 | 230 | 340 | 361 |
| 15 | 1.0 | 1.2 | 37.9 | 36.8 | 33.5 | 127 | 178 | 185 |
| 16 | 0.2 | 0.2 | 7.7 | 7.5 | 7.0 | 28 | 38 | 40 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Total | 506.2 | 174.5 | 4,330.7 | 4,080.5 | 996.7 | 2,729 | 4,532 | 5,055 |

==============================================================================

*Inside bark

=====================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch- antable | Saw- timber |
|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.0 | 17 | 0.0 | 0.0 | 0.0 |
| 2 | 2.1 | 0.1 | 27 | 0.0 | 0.0 | 0.0 |
| 3 | 6.9 | 0.4 | 36 | 0.0 | 0.0 | 0.0 |
| 4 | 27.0 | 2.4 | 43 | 0.0 | 0.0 | 0.0 |
| 5 | 52.2 | 7.1 | 48 | 4.2 | 3.5 | 0.0 |
| 6 | 73.9 | 14.5 | 52 | 10.8 | 9.9 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 7 | 90.3 | 24.0 | 55 | 19.7 | 18.6 | 0.0 |
| 8 | 86.2 | 30.1 | 57 | 26.0 | 24.7 | 0.0 |
| 9 | 63.1 | 27.8 | 59 | 24.6 | 23.5 | 0.0 |
| 10 | 48.5 | 26.1 | 61 | 24.0 | 23.1 | 7.0 |
| 11 | 29.6 | 19.3 | 62 | 18.4 | 17.8 | 10.0 |
| 12 | 15.6 | 12.2 | 64 | 12.0 | 11.6 | 8.5 |
| 13 | 7.0 | 6.4 | 65 | 6.5 | 6.3 | 5.2 |
| 14 | 2.5 | 2.7 | 66 | 2.7 | 2.7 | 2.3 |
| 15 | 1.0 | 1.2 | 66 | 1.3 | 1.3 | 1.2 |
| 16 | 0.2 | 0.2 | 67 | 0.3 | 0.3 | 0.2 |
| Total | 506.2 | 174.5 | | 150.7 | 143.3 | 34.4 |

==================================================================

05-02-2011 16:49:05

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: QQ Stand size: 1 ac

Year: 2001 Iteration 0 of 25

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

===============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch- antable | Saw- timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 1 | 7.3 | 0.0 | 0.2 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 83.9 | 2.0 | 14.2 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 152.3 | 7.8 | 70.9 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 169.5 | 15.2 | 173.0 | 66.6 | 0.0 | 0 | 0 | 0 |
| 5 | 141.9 | 19.8 | 262.0 | 222.1 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6 | 94.7 | 18.9 | 280.2 | 254.3 | 0.0 | 0 | 0 | 0 |
| 7 | 51.7 | 14.0 | 208.0 | 191.6 | 0.0 | 0 | 0 | 0 |
| 8 | 23.3 | 8.3 | 131.4 | 122.7 | 0.0 | 0 | 0 | 0 |
| 9 | 8.8 | 3.9 | 67.1 | 63.2 | 0.0 | 0 | 0 | 0 |
| 10 | 2.8 | 1.5 | 27.5 | 26.1 | 10.9 | 24 | 44 | 51 |
| 11 | 0.9 | 0.6 | 11.7 | 11.1 | 7.5 | 17 | 30 | 36 |
| Total | 737.0 | 92.1 | 1,246.1 | 957.7 | 18.4 | 41 | 74 | 87 |

================================================================================

*Inside bark

=====================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch- antable | Saw- timber |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 7.3 | 0.0 | 9 | 0.0 | 0.0 | 0.0 |
| 2 | 83.9 | 2.0 | 18 | 0.0 | 0.0 | 0.0 |
| 3 | 152.3 | 7.8 | 25 | 0.0 | 0.0 | 0.0 |
| 4 | 169.5 | 15.2 | 29 | 0.0 | 0.0 | 0.0 |
| 5 | 141.9 | 19.8 | 33 | 10.0 | 8.5 | 0.0 |
| 6 | 94.7 | 18.9 | 35 | 10.2 | 9.3 | 0.0 |
| 7 | 51.7 | 14.0 | 37 | 7.4 | 6.9 | 0.0 |
| 8 | 23.3 | 8.3 | 39 | 4.7 | 4.4 | 0.0 |
| 9 | 8.8 | 3.9 | 40 | 2.4 | 2.2 | 0.0 |
| 10 | 2.8 | 1.5 | 41 | 1.0 | 0.9 | 0.4 |
| 11 | 0.9 | 0.6 | 42 | 0.4 | 0.4 | 0.3 |
| Total | 737.0 | 92.1 | | 36.1 | 32.5 | 0.6 |

==================================================================

05-02-2011 16:56:01

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: QQ Stand size: 1 ac

Year: 2026 Iteration 25 of 25

Stand Age: 45 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

=============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch- antable | Saw- timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 0.5 | 0.0 | 0.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 2.8 | 0.2 | 1.8 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 15.8 | 1.5 | 22.7 | 6.2 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5 | 29.9 | 4.2 | 78.9 | 64.5 | 0.0 | 0 | 0 | 0 |
| 6 | 59.1 | 11.8 | 258.0 | 237.5 | 0.0 | 0 | 0 | 0 |
| 7 | 70.6 | 19.0 | 461.3 | 434.6 | 0.0 | 0 | 0 | 0 |
| 8 | 83.7 | 29.6 | 783.5 | 746.8 | 0.0 | 0 | 0 | 0 |
| 9 | 55.9 | 24.7 | 671.6 | 644.0 | 0.0 | 0 | 0 | 0 |
| 10 | 54.4 | 29.1 | 803.7 | 773.7 | 232.2 | 518 | 943 | 1,068 |
| 11 | 40.1 | 26.5 | 761.5 | 735.5 | 429.2 | 1,107 | 1,920 | 2,175 |
| 12 | 16.1 | 12.7 | 375.9 | 363.8 | 270.7 | 790 | 1,300 | 1,400 |
| 13 | 11.3 | 10.2 | 309.6 | 300.1 | 246.2 | 770 | 1,204 | 1,316 |
| 14 | 5.2 | 5.5 | 169.9 | 164.9 | 144.1 | 502 | 744 | 778 |
| 15 | 2.0 | 2.5 | 78.2 | 76.0 | 68.9 | 257 | 364 | 380 |
| 16 | 0.8 | 1.2 | 37.9 | 36.9 | 34.3 | 136 | 184 | 196 |
| Total | 448.2 | 178.4 | 4,814.7 | 4,584.4 | 1,425.6 | 4,080 | 6,658 | 7,314 |

=============================================================================

*Inside bark

=======================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch- antable | Saw- timber |
|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.0 | 19 | 0.0 | 0.0 | 0.0 |
| 2 | 0.5 | 0.0 | 29 | 0.0 | 0.0 | 0.0 |
| 3 | 2.8 | 0.2 | 39 | 0.0 | 0.0 | 0.0 |
| 4 | 15.8 | 1.5 | 46 | 0.0 | 0.0 | 0.0 |
| 5 | 29.9 | 4.2 | 51 | 2.9 | 2.3 | 0.0 |
| 6 | 59.1 | 11.8 | 55 | 9.2 | 8.5 | 0.0 |
| 7 | 70.6 | 19.0 | 58 | 16.3 | 15.4 | 0.0 |
| 8 | 83.7 | 29.6 | 61 | 27.6 | 26.3 | 0.0 |
| 9 | 55.9 | 24.7 | 63 | 23.6 | 22.6 | 0.0 |
| 10 | 54.4 | 29.1 | 64 | 28.2 | 27.1 | 8.0 |
| 11 | 40.1 | 26.5 | 66 | 26.7 | 25.7 | 14.8 |
| 12 | 16.1 | 12.7 | 67 | 13.1 | 12.7 | 9.3 |
| 13 | 11.3 | 10.2 | 68 | 10.8 | 10.5 | 8.5 |
| 14 | 5.2 | 5.5 | 69 | 5.9 | 5.8 | 5.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 15 | 2.0 | 2.5 | 70 | 2.7 | 2.7 | 2.4 |
| 16 | 0.8 | 1.2 | 71 | 1.3 | 1.3 | 1.2 |
| Total | 448.2 | 178.4 | | 168.3 | 160.9 | 49.1 |

=================================================================
======

05-02-2011 16:56:30

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: RR Stand size: 1 ac

Year: 2001 Iteration 0 of 30

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

==========================================================================
===============

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch-antable | Saw-timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 1 | 7.3 | 0.0 | 0.2 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 83.9 | 2.0 | 14.2 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 152.3 | 7.8 | 70.9 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 169.5 | 15.2 | 173.0 | 66.6 | 0.0 | 0 | 0 | 0 |
| 5 | 141.9 | 19.8 | 262.0 | 222.1 | 0.0 | 0 | 0 | 0 |
| 6 | 94.7 | 18.9 | 280.2 | 254.3 | 0.0 | 0 | 0 | 0 |
| 7 | 51.7 | 14.0 | 208.0 | 191.6 | 0.0 | 0 | 0 | 0 |
| 8 | 23.3 | 8.3 | 131.4 | 122.7 | 0.0 | 0 | 0 | 0 |
| 9 | 8.8 | 3.9 | 67.1 | 63.2 | 0.0 | 0 | 0 | 0 |
| 10 | 2.8 | 1.5 | 27.5 | 26.1 | 10.9 | 24 | 44 | 51 |
| 11 | 0.9 | 0.6 | 11.7 | 11.1 | 7.5 | 17 | 30 | 36 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Total | 737.0 | 92.1 | 1,246.1 | 957.7 | 18.4 | 41 | 74 | 87 |

==========================================================================

*Inside bark

====================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|
| 1 | 7.3 | 0.0 | 9 | 0.0 | 0.0 | 0.0 |
| 2 | 83.9 | 2.0 | 18 | 0.0 | 0.0 | 0.0 |
| 3 | 152.3 | 7.8 | 25 | 0.0 | 0.0 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | 169.5 | 15.2 | 29 | 0.0 | 0.0 | 0.0 |
| 5 | 141.9 | 19.8 | 33 | 10.0 | 8.5 | 0.0 |
| 6 | 94.7 | 18.9 | 35 | 10.2 | 9.3 | 0.0 |
| 7 | 51.7 | 14.0 | 37 | 7.4 | 6.9 | 0.0 |
| 8 | 23.3 | 8.3 | 39 | 4.7 | 4.4 | 0.0 |
| 9 | 8.8 | 3.9 | 40 | 2.4 | 2.2 | 0.0 |
| 10 | 2.8 | 1.5 | 41 | 1.0 | 0.9 | 0.4 |
| 11 | 0.9 | 0.6 | 42 | 0.4 | 0.4 | 0.3 |
| Total | 737.0 | 92.1 | | 36.1 | 32.5 | 0.6 |

================================================================
======

05-02-2011 17:03:45

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: RR Stand size: 1 ac

Year: 2031 Iteration 30 of 30

Stand Age: 50 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

==============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch-antable | Saw-timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 1.0 | 0.1 | 0.7 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 5.9 | 0.5 | 8.4 | 1.6 | 0.0 | 0 | 0 | 0 |
| 5 | 17.5 | 2.4 | 46.0 | 35.9 | 0.0 | 0 | 0 | 0 |
| 6 | 43.2 | 8.6 | 194.9 | 179.5 | 0.0 | 0 | 0 | 0 |
| 7 | 61.3 | 16.7 | 424.4 | 400.6 | 0.0 | 0 | 0 | 0 |
| 8 | 64.3 | 22.9 | 630.7 | 602.0 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | 60.0 | 26.4 | 769.8 | 739.0 | 0.0 | 0 | 0 | 0 |
| 10 | 60.3 | 33.1 | 971.5 | 936.7 | 302.1 | 692 | 1,258 | 1,443 |
| 11 | 34.3 | 22.9 | 689.1 | 666.5 | 394.4 | 1,049 | 1,807 | 2,000 |
| 12 | 24.0 | 18.8 | 583.1 | 565.0 | 416.8 | 1,220 | 2,003 | 2,170 |
| 13 | 14.6 | 13.5 | 429.4 | 416.7 | 345.4 | 1,129 | 1,747 | 1,846 |
| 14 | 6.1 | 6.5 | 211.9 | 205.9 | 180.7 | 641 | 943 | 990 |
| 15 | 3.4 | 4.1 | 135.5 | 131.8 | 119.2 | 444 | 631 | 661 |
| 16 | 1.5 | 2.0 | 68.5 | 66.6 | 61.7 | 241 | 329 | 349 |
| 17 | 0.6 | 0.9 | 29.6 | 28.8 | 27.1 | 112 | 147 | 158 |
| Total | 398.1 | 179.4 | 5,193.5 | 4,976.5 | 1,847.2 | 5,529 | 8,865 | 9,617 |

==============================================================================

*Inside bark

=====================================================================

| Diam. | | Basal | Avg. | Green Weight of Stem (Tons/Acre) | | |
|---|---|---|---|---|---|---|
| Class | Trees/ | Area/ | T. Ht. | | Merch- | Saw- |

| Midpt | Acre | Acre | (ft) | Total | antable | timber |
|---|---|---|---|---|---|---|
| 2 | 0.1 | 0.0 | 31 | 0.0 | 0.0 | 0.0 |
| 3 | 1.0 | 0.1 | 41 | 0.0 | 0.0 | 0.0 |
| 4 | 5.9 | 0.5 | 48 | 0.0 | 0.0 | 0.0 |
| 5 | 17.5 | 2.4 | 53 | 1.5 | 1.2 | 0.0 |
| 6 | 43.2 | 8.6 | 58 | 6.9 | 6.4 | 0.0 |
| 7 | 61.3 | 16.7 | 61 | 15.0 | 14.2 | 0.0 |
| 8 | 64.3 | 22.9 | 64 | 22.2 | 21.2 | 0.0 |
| 9 | 60.0 | 26.4 | 66 | 27.0 | 25.9 | 0.0 |
| 10 | 60.3 | 33.1 | 68 | 34.0 | 32.8 | 10.4 |
| 11 | 34.3 | 22.9 | 69 | 24.1 | 23.3 | 13.6 |
| 12 | 24.0 | 18.8 | 71 | 20.4 | 19.8 | 14.3 |
| 13 | 14.6 | 13.5 | 72 | 15.0 | 14.6 | 11.9 |
| 14 | 6.1 | 6.5 | 73 | 7.4 | 7.2 | 6.2 |
| 15 | 3.4 | 4.1 | 74 | 4.7 | 4.6 | 4.1 |
| 16 | 1.5 | 2.0 | 74 | 2.4 | 2.3 | 2.1 |
| 17 | 0.6 | 0.9 | 75 | 1.0 | 1.0 | 0.9 |

Total 398.1 179.4 181.7 174.5 63.6

==================================================================
======

05-02-2011 17:04:18

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: WW Stand size: 1 ac

Year: 2001 Iteration 0 of 10

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

==================================================================
===============

Diam. Basal Cubic-foot Volume/Acre*

| Class | Trees/ | Area/ | | Merch- | Saw- | Board-foot Volume/Acre | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Midpt | Acre | Acre | Total | antable | timber | Doyle | Scribner | Int. ¬ |
| 1 | 10.7 | 0.1 | 0.3 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 157.2 | 3.7 | 26.5 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 264.5 | 13.5 | 123.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 265.7 | 23.9 | 271.2 | 104.4 | 0.0 | 0 | 0 | 0 |
| 5 | 199.7 | 27.9 | 368.9 | 312.7 | 0.0 | 0 | 0 | 0 |
| 6 | 119.7 | 24.0 | 354.2 | 321.6 | 0.0 | 0 | 0 | 0 |
| 7 | 58.9 | 16.0 | 237.0 | 218.2 | 0.0 | 0 | 0 | 0 |
| 8 | 24.1 | 8.5 | 135.7 | 126.7 | 0.0 | 0 | 0 | 0 |
| 9 | 8.3 | 3.7 | 63.3 | 59.6 | 0.0 | 0 | 0 | 0 |
| 10 | 2.4 | 1.3 | 24.0 | 22.8 | 9.5 | 21 | 38 | 44 |
| 11 | 0.8 | 0.5 | 9.4 | 9.0 | 6.1 | 14 | 24 | 29 |
| Total | 1,112.0 | 123.0 | 1,613.7 | 1,175.0 | 15.6 | 35 | 62 | 74 |

================================================================================

*Inside bark

==================================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|
| 1 | 10.7 | 0.1 | 9 | 0.0 | 0.0 | 0.0 |
| 2 | 157.2 | 3.7 | 18 | 0.0 | 0.0 | 0.0 |
| 3 | 264.5 | 13.5 | 25 | 0.0 | 0.0 | 0.0 |
| 4 | 265.7 | 23.9 | 29 | 0.0 | 0.0 | 0.0 |
| 5 | 199.7 | 27.9 | 33 | 14.1 | 12.0 | 0.0 |
| 6 | 119.7 | 24.0 | 35 | 12.9 | 11.7 | 0.0 |
| 7 | 58.9 | 16.0 | 37 | 8.5 | 7.8 | 0.0 |
| 8 | 24.1 | 8.5 | 39 | 4.8 | 4.5 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 9 | 8.3 | 3.7 | 40 | 2.2 | 2.1 | 0.0 |
| 10 | 2.4 | 1.3 | 41 | 0.8 | 0.8 | 0.3 |
| 11 | 0.8 | 0.5 | 42 | 0.3 | 0.3 | 0.2 |
| Total | 1,112.0 | 123.0 | | 43.8 | 39.2 | 0.5 |

==================================================================

05-03-2011 11:08:29

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: WW Stand size: 1 ac

Year: 2011 Iteration 10 of 10

Stand Age: 30 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

=============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch- antable | Saw- timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 29.3 | 0.7 | 5.5 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 81.3 | 4.3 | 45.9 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 140.4 | 12.3 | 167.4 | 32.6 | 0.0 | 0 | 0 | 0 |
| 5 | 187.0 | 25.6 | 418.9 | 349.6 | 0.0 | 0 | 0 | 0 |
| 6 | 163.5 | 32.0 | 572.4 | 521.8 | 0.0 | 0 | 0 | 0 |
| 7 | 124.5 | 32.6 | 628.8 | 586.9 | 0.0 | 0 | 0 | 0 |
| 8 | 88.5 | 30.2 | 626.8 | 592.8 | 0.0 | 0 | 0 | 0 |
| 9 | 45.8 | 20.0 | 440.8 | 420.0 | 0.0 | 0 | 0 | 0 |
| 10 | 20.1 | 10.9 | 251.7 | 241.0 | 77.5 | 171 | 311 | 362 |
| 11 | 7.5 | 4.9 | 117.7 | 113.0 | 70.5 | 172 | 301 | 345 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 12 | 2.2 | 1.7 | 41.8 | 40.2 | 31.2 | 91 | 148 | 161 |
| 13 | 0.8 | 0.8 | 19.2 | 18.5 | 15.6 | 48 | 75 | 81 |
| 14 | 0.2 | 0.2 | 3.9 | 3.7 | 3.3 | 10 | 16 | 17 |
| Total | 891.8 | 176.2 | 3,340.8 | 2,919.9 | 198.0 | 494 | 851 | 965 |

=============================================================================

*Inside bark

=======================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|
| 1 | 0.8 | 0.0 | 12 | 0.0 | 0.0 | 0.0 |
| 2 | 29.3 | 0.7 | 23 | 0.0 | 0.0 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | 81.3 | 4.3 | 31 | 0.0 | 0.0 | 0.0 |
| 4 | 140.4 | 12.3 | 37 | 0.0 | 0.0 | 0.0 |
| 5 | 187.0 | 25.6 | 41 | 14.1 | 12.1 | 0.0 |
| 6 | 163.5 | 32.0 | 45 | 20.6 | 18.8 | 0.0 |
| 7 | 124.5 | 32.6 | 47 | 22.4 | 20.9 | 0.0 |
| 8 | 88.5 | 30.2 | 49 | 22.2 | 20.9 | 0.0 |
| 9 | 45.8 | 20.0 | 51 | 15.5 | 14.8 | 0.0 |
| 10 | 20.1 | 10.9 | 52 | 8.8 | 8.5 | 2.7 |
| 11 | 7.5 | 4.9 | 54 | 4.1 | 4.0 | 2.4 |
| 12 | 2.2 | 1.7 | 55 | 1.5 | 1.4 | 1.1 |
| 13 | 0.8 | 0.8 | 55 | 0.7 | 0.6 | 0.5 |
| 14 | 0.2 | 0.2 | 56 | 0.1 | 0.1 | 0.1 |
| Total | 891.8 | 176.2 | | 110.0 | 102.1 | 6.8 |

=================================================================
======

05-03-2011 11:11:19

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: YY Stand size: 1 ac

Year: 2001 Iteration 0 of 15

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

=============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch-antable | Saw-timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 1 | 10.7 | 0.1 | 0.3 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 157.2 | 3.7 | 26.5 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 264.5 | 13.5 | 123.1 | 0.0 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | 265.7 | 23.9 | 271.2 | 104.4 | 0.0 | 0 | 0 | 0 |
| 5 | 199.7 | 27.9 | 368.9 | 312.7 | 0.0 | 0 | 0 | 0 |
| 6 | 119.7 | 24.0 | 354.2 | 321.6 | 0.0 | 0 | 0 | 0 |
| 7 | 58.9 | 16.0 | 237.0 | 218.2 | 0.0 | 0 | 0 | 0 |
| 8 | 24.1 | 8.5 | 135.7 | 126.7 | 0.0 | 0 | 0 | 0 |
| 9 | 8.3 | 3.7 | 63.3 | 59.6 | 0.0 | 0 | 0 | 0 |
| 10 | 2.4 | 1.3 | 24.0 | 22.8 | 9.5 | 21 | 38 | 44 |
| 11 | 0.8 | 0.5 | 9.4 | 9.0 | 6.1 | 14 | 24 | 29 |
| Total | 1,112.0 | 123.0 | 1,613.7 | 1,175.0 | 15.6 | 35 | 62 | 74 |

==============================================================================

*Inside bark

=====================================================================

Diam. Basal Avg. Green Weight of Stem (Tons/Acre)

| Class Midpt | Trees/ Acre | Area/ Acre | T. Ht. (ft) | Total | Merch- antable | Saw- timber |
|---|---|---|---|---|---|---|
| 1 | 10.7 | 0.1 | 9 | 0.0 | 0.0 | 0.0 |
| 2 | 157.2 | 3.7 | 18 | 0.0 | 0.0 | 0.0 |
| 3 | 264.5 | 13.5 | 25 | 0.0 | 0.0 | 0.0 |
| 4 | 265.7 | 23.9 | 29 | 0.0 | 0.0 | 0.0 |
| 5 | 199.7 | 27.9 | 33 | 14.1 | 12.0 | 0.0 |
| 6 | 119.7 | 24.0 | 35 | 12.9 | 11.7 | 0.0 |
| 7 | 58.9 | 16.0 | 37 | 8.5 | 7.8 | 0.0 |
| 8 | 24.1 | 8.5 | 39 | 4.8 | 4.5 | 0.0 |
| 9 | 8.3 | 3.7 | 40 | 2.2 | 2.1 | 0.0 |
| 10 | 2.4 | 1.3 | 41 | 0.8 | 0.8 | 0.3 |
| 11 | 0.8 | 0.5 | 42 | 0.3 | 0.3 | 0.2 |
| Total | 1,112.0 | 123.0 | | 43.8 | 39.2 | 0.5 |

======================================================================

05-02-2011 17:10:58

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: YY Stand size: 1 ac

Year: 2016 Iteration 15 of 15

Stand Age: 35 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

===============================================================================

Diam. Basal Cubic-foot Volume/Acre*

Class Trees/ Area/ Merch- Saw- Board-foot Volume/Acre

Midpt Acre Acre Total antable timber Doyle Scribner Int. ¬

--------------------------------------------------------------------------------

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 10.2 | 0.3 | 2.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 36.7 | 2.0 | 22.2 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 101.6 | 9.2 | 132.8 | 27.9 | 0.0 | 0 | 0 | 0 |
| 5 | 139.5 | 19.6 | 343.9 | 289.0 | 0.0 | 0 | 0 | 0 |
| 6 | 143.8 | 28.3 | 563.8 | 517.5 | 0.0 | 0 | 0 | 0 |
| 7 | 141.6 | 37.9 | 804.8 | 754.8 | 0.0 | 0 | 0 | 0 |
| 8 | 92.8 | 32.8 | 736.8 | 699.3 | 0.0 | 0 | 0 | 0 |
| 9 | 52.3 | 23.1 | 546.4 | 522.0 | 0.0 | 0 | 0 | 0 |
| 10 | 29.5 | 15.7 | 389.0 | 373.2 | 113.0 | 248 | 451 | 528 |
| 11 | 15.3 | 9.9 | 253.9 | 244.3 | 140.7 | 341 | 601 | 687 |
| 12 | 5.5 | 4.2 | 112.0 | 108.0 | 80.2 | 228 | 377 | 406 |
| 13 | 2.0 | 1.8 | 49.8 | 48.1 | 40.1 | 123 | 192 | 209 |
| 14 | 0.7 | 0.7 | 20.3 | 19.6 | 17.4 | 60 | 87 | 94 |
| Total | 771.5 | 185.6 | 3,977.5 | 3,603.7 | 391.4 | 999 | 1,709 | 1,925 |

==============================================================================

*Inside bark

==============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|
| 1 | 0.1 | 0.0 | 13 | 0.0 | 0.0 | 0.0 |
| 2 | 10.2 | 0.3 | 26 | 0.0 | 0.0 | 0.0 |
| 3 | 36.7 | 2.0 | 34 | 0.0 | 0.0 | 0.0 |
| 4 | 101.6 | 9.2 | 40 | 0.0 | 0.0 | 0.0 |
| 5 | 139.5 | 19.6 | 45 | 12.6 | 10.6 | 0.0 |
| 6 | 143.8 | 28.3 | 49 | 20.2 | 18.6 | 0.0 |
| 7 | 141.6 | 37.9 | 51 | 28.6 | 26.8 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 8 | 92.8 | 32.8 | 54 | 26.0 | 24.7 | 0.0 |
| 9 | 52.3 | 23.1 | 55 | 19.2 | 18.4 | 0.0 |
| 10 | 29.5 | 15.7 | 57 | 13.6 | 13.1 | 3.9 |
| 11 | 15.3 | 9.9 | 58 | 8.9 | 8.6 | 4.8 |
| 12 | 5.5 | 4.2 | 59 | 3.9 | 3.8 | 2.8 |
| 13 | 2.0 | 1.8 | 60 | 1.7 | 1.7 | 1.4 |
| 14 | 0.7 | 0.7 | 61 | 0.7 | 0.7 | 0.6 |
| Total | 771.5 | 185.6 | | 135.5 | 126.8 | 13.5 |

==============================================================
======

05-02-2011 17:11:26

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: QQ Stand size: 1 ac

Year: 2001 Iteration 0 of 20

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

==============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch- antable | Saw- timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 1 | 10.7 | 0.1 | 0.3 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 157.2 | 3.7 | 26.5 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 264.5 | 13.5 | 123.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 265.7 | 23.9 | 271.2 | 104.4 | 0.0 | 0 | 0 | 0 |
| 5 | 199.7 | 27.9 | 368.9 | 312.7 | 0.0 | 0 | 0 | 0 |
| 6 | 119.7 | 24.0 | 354.2 | 321.6 | 0.0 | 0 | 0 | 0 |
| 7 | 58.9 | 16.0 | 237.0 | 218.2 | 0.0 | 0 | 0 | 0 |
| 8 | 24.1 | 8.5 | 135.7 | 126.7 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | 8.3 | 3.7 | 63.3 | 59.6 | 0.0 | 0 | 0 | 0 |
| 10 | 2.4 | 1.3 | 24.0 | 22.8 | 9.5 | 21 | 38 | 44 |
| 11 | 0.8 | 0.5 | 9.4 | 9.0 | 6.1 | 14 | 24 | 29 |
| Total | 1,112.0 | 123.0 | 1,613.7 | 1,175.0 | 15.6 | 35 | 62 | 74 |

==============================================================================

*Inside bark

=====================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|
| 1 | 10.7 | 0.1 | 9 | 0.0 | 0.0 | 0.0 |
| 2 | 157.2 | 3.7 | 18 | 0.0 | 0.0 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | 264.5 | 13.5 | 25 | 0.0 | 0.0 | 0.0 |
| 4 | 265.7 | 23.9 | 29 | 0.0 | 0.0 | 0.0 |
| 5 | 199.7 | 27.9 | 33 | 14.1 | 12.0 | 0.0 |
| 6 | 119.7 | 24.0 | 35 | 12.9 | 11.7 | 0.0 |
| 7 | 58.9 | 16.0 | 37 | 8.5 | 7.8 | 0.0 |
| 8 | 24.1 | 8.5 | 39 | 4.8 | 4.5 | 0.0 |
| 9 | 8.3 | 3.7 | 40 | 2.2 | 2.1 | 0.0 |
| 10 | 2.4 | 1.3 | 41 | 0.8 | 0.8 | 0.3 |
| 11 | 0.8 | 0.5 | 42 | 0.3 | 0.3 | 0.2 |
| Total | 1,112.0 | 123.0 | | 43.8 | 39.2 | 0.5 |

=================================================================
======

05-02-2011 17:21:59

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: QQ Stand size: 1 ac

Year: 2021 Iteration 20 of 20

Stand Age: 40 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

===========================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch-antable | Saw-timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 2.8 | 0.1 | 0.6 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 18.1 | 1.0 | 12.3 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 56.5 | 5.3 | 79.9 | 19.1 | 0.0 | 0 | 0 | 0 |
| 5 | 91.7 | 12.8 | 233.3 | 193.1 | 0.0 | 0 | 0 | 0 |
| 6 | 134.0 | 26.4 | 551.6 | 506.7 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7 | 121.0 | 32.5 | 754.7 | 710.1 | 0.0 | 0 | 0 | 0 |
| 8 | 103.7 | 36.0 | 878.6 | 835.4 | 0.0 | 0 | 0 | 0 |
| 9 | 63.1 | 27.6 | 692.4 | 662.7 | 0.0 | 0 | 0 | 0 |
| 10 | 42.8 | 23.2 | 609.2 | 585.8 | 191.0 | 426 | 774 | 931 |
| 11 | 19.1 | 12.6 | 345.7 | 333.4 | 197.4 | 503 | 874 | 967 |
| 12 | 8.2 | 6.3 | 178.3 | 172.3 | 127.0 | 366 | 603 | 660 |
| 13 | 3.7 | 3.3 | 95.4 | 92.3 | 75.8 | 231 | 364 | 391 |
| 14 | 1.5 | 1.6 | 46.6 | 45.1 | 39.5 | 134 | 200 | 212 |
| 15 | 0.5 | 0.5 | 16.6 | 16.1 | 14.7 | 55 | 78 | 81 |
| Total | 666.6 | 189.1 | 4,495.4 | 4,172.0 | 645.3 | 1,715 | 2,894 | 3,243 |

==============================================================================

*Inside bark

=====================================================================

Diam. Basal Avg. Green Weight of Stem (Tons/Acre)

Class Trees/ Area/ T. Ht. Merch- Saw-

| Midpt | Acre | Acre | (ft) | Total | antable | timber |
|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.0 | 16 | 0.0 | 0.0 | 0.0 |
| 2 | 2.8 | 0.1 | 28 | 0.0 | 0.0 | 0.0 |
| 3 | 18.1 | 1.0 | 37 | 0.0 | 0.0 | 0.0 |
| 4 | 56.5 | 5.3 | 43 | 0.0 | 0.0 | 0.0 |
| 5 | 91.7 | 12.8 | 48 | 8.5 | 7.1 | 0.0 |
| 6 | 134.0 | 26.4 | 52 | 19.7 | 18.1 | 0.0 |
| 7 | 121.0 | 32.5 | 55 | 26.7 | 25.2 | 0.0 |
| 8 | 103.7 | 36.0 | 57 | 31.0 | 29.4 | 0.0 |
| 9 | 63.1 | 27.6 | 59 | 24.3 | 23.3 | 0.0 |
| 10 | 42.8 | 23.2 | 61 | 21.4 | 20.5 | 6.6 |
| 11 | 19.1 | 12.6 | 62 | 12.1 | 11.7 | 6.8 |
| 12 | 8.2 | 6.3 | 64 | 6.2 | 6.0 | 4.4 |
| 13 | 3.7 | 3.3 | 65 | 3.3 | 3.2 | 2.6 |
| 14 | 1.5 | 1.6 | 65 | 1.6 | 1.6 | 1.4 |
| 15 | 0.5 | 0.5 | 66 | 0.6 | 0.6 | 0.5 |

Total 666.6 189.1 155.5 146.7 22.2

===============================================================
======

05-02-2011 17:23:25

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: TT Stand size: 1 ac

Year: 2001 Iteration 0 of 25

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

===============================================================
=============

Diam. Basal Cubic-foot Volume/Acre*

Class Trees/ Area/ Merch- Saw- Board-foot Volume/Acre

| Midpt | Acre | Acre | Total | antable | timber | Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 1 | 10.7 | 0.1 | 0.3 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 157.2 | 3.7 | 26.5 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 264.5 | 13.5 | 123.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 265.7 | 23.9 | 271.2 | 104.4 | 0.0 | 0 | 0 | 0 |
| 5 | 199.7 | 27.9 | 368.9 | 312.7 | 0.0 | 0 | 0 | 0 |
| 6 | 119.7 | 24.0 | 354.2 | 321.6 | 0.0 | 0 | 0 | 0 |
| 7 | 58.9 | 16.0 | 237.0 | 218.2 | 0.0 | 0 | 0 | 0 |
| 8 | 24.1 | 8.5 | 135.7 | 126.7 | 0.0 | 0 | 0 | 0 |
| 9 | 8.3 | 3.7 | 63.3 | 59.6 | 0.0 | 0 | 0 | 0 |
| 10 | 2.4 | 1.3 | 24.0 | 22.8 | 9.5 | 21 | 38 | 44 |
| 11 | 0.8 | 0.5 | 9.4 | 9.0 | 6.1 | 14 | 24 | 29 |
| Total | 1,112.0 | 123.0 | 1,613.7 | 1,175.0 | 15.6 | 35 | 62 | 74 |

*Inside bark

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch- antable | Saw- timber |
|---|---|---|---|---|---|---|
| 1 | 10.7 | 0.1 | 9 | 0.0 | 0.0 | 0.0 |
| 2 | 157.2 | 3.7 | 18 | 0.0 | 0.0 | 0.0 |
| 3 | 264.5 | 13.5 | 25 | 0.0 | 0.0 | 0.0 |
| 4 | 265.7 | 23.9 | 29 | 0.0 | 0.0 | 0.0 |
| 5 | 199.7 | 27.9 | 33 | 14.1 | 12.0 | 0.0 |
| 6 | 119.7 | 24.0 | 35 | 12.9 | 11.7 | 0.0 |
| 7 | 58.9 | 16.0 | 37 | 8.5 | 7.8 | 0.0 |
| 8 | 24.1 | 8.5 | 39 | 4.8 | 4.5 | 0.0 |
| 9 | 8.3 | 3.7 | 40 | 2.2 | 2.1 | 0.0 |
| 10 | 2.4 | 1.3 | 41 | 0.8 | 0.8 | 0.3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 11 | 0.8 | 0.5 | 42 | 0.3 | 0.3 | 0.2 |
| Total | 1,112.0 | 123.0 | | 43.8 | 39.2 | 0.5 |

==================================================================

05-02-2011 17:29:14

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: TT Stand size: 1 ac

Year: 2026 Iteration 25 of 25

Stand Age: 45 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

===========================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch- antable | Saw- timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 2 | 0.4 | 0.0 | 0.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 5.3 | 0.3 | 3.4 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 29.8 | 2.7 | 42.3 | 10.5 | 0.0 | 0 | 0 | 0 |
| 5 | 64.1 | 8.9 | 169.6 | 138.5 | 0.0 | 0 | 0 | 0 |
| 6 | 97.0 | 19.0 | 414.2 | 380.7 | 0.0 | 0 | 0 | 0 |
| 7 | 112.0 | 29.6 | 715.8 | 673.8 | 0.0 | 0 | 0 | 0 |
| 8 | 100.3 | 34.4 | 901.4 | 858.3 | 0.0 | 0 | 0 | 0 |
| 9 | 77.9 | 34.2 | 932.4 | 893.9 | 0.0 | 0 | 0 | 0 |
| 10 | 45.4 | 24.8 | 687.4 | 662.0 | 221.3 | 504 | 918 | 1,041 |
| 11 | 23.3 | 15.2 | 435.4 | 420.5 | 238.5 | 599 | 1,045 | 1,198 |
| 12 | 14.4 | 11.1 | 329.5 | 318.8 | 233.5 | 676 | 1,116 | 1,203 |
| 13 | 5.8 | 5.3 | 161.9 | 156.9 | 130.1 | 414 | 642 | 695 |
| 14 | 1.9 | 2.0 | 63.5 | 61.7 | 54.0 | 189 | 279 | 293 |
| 15 | 0.9 | 1.1 | 35.3 | 34.3 | 31.0 | 115 | 163 | 171 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 16 | 0.3 | 0.4 | 12.9 | 12.6 | 11.6 | 45 | 62 | 66 |
| Total | 578.8 | 189.2 | 4,905.3 | 4,622.6 | 920.0 | 2,541 | 4,225 | 4,667 |

==============================================================================

*Inside bark

=====================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|
| 2 | 0.4 | 0.0 | 29 | 0.0 | 0.0 | 0.0 |
| 3 | 5.3 | 0.3 | 39 | 0.0 | 0.0 | 0.0 |
| 4 | 29.8 | 2.7 | 46 | 0.0 | 0.0 | 0.0 |
| 5 | 64.1 | 8.9 | 51 | 6.2 | 5.0 | 0.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 6 | 97.0 | 19.0 | 55 | 14.8 | 13.6 | 0.0 |
| 7 | 112.0 | 29.6 | 58 | 25.3 | 23.9 | 0.0 |
| 8 | 100.3 | 34.4 | 61 | 31.8 | 30.2 | 0.0 |
| 9 | 77.9 | 34.2 | 63 | 32.7 | 31.4 | 0.0 |
| 10 | 45.4 | 24.8 | 65 | 24.1 | 23.2 | 7.6 |
| 11 | 23.3 | 15.2 | 66 | 15.2 | 14.7 | 8.2 |
| 12 | 14.4 | 11.1 | 67 | 11.5 | 11.1 | 8.0 |
| 13 | 5.8 | 5.3 | 68 | 5.7 | 5.5 | 4.5 |
| 14 | 1.9 | 2.0 | 69 | 2.2 | 2.2 | 1.9 |
| 15 | 0.9 | 1.1 | 70 | 1.2 | 1.2 | 1.1 |
| 16 | 0.3 | 0.4 | 71 | 0.5 | 0.4 | 0.4 |
| Total | 578.8 | 189.2 | | 171.2 | 162.5 | 31.7 |

======================================================================

05-02-2011 17:29:50

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: AA Stand size: 1 ac

Year: 2001 Iteration 0 of 30

Stand Age: 20 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

==============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch-antable | Saw-timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 1 | 10.7 | 0.1 | 0.3 | 0.0 | 0.0 | 0 | 0 | 0 |
| 2 | 157.2 | 3.7 | 26.5 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 264.5 | 13.5 | 123.1 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 265.7 | 23.9 | 271.2 | 104.4 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5 | 199.7 | 27.9 | 368.9 | 312.7 | 0.0 | 0 | 0 | 0 |
| 6 | 119.7 | 24.0 | 354.2 | 321.6 | 0.0 | 0 | 0 | 0 |
| 7 | 58.9 | 16.0 | 237.0 | 218.2 | 0.0 | 0 | 0 | 0 |
| 8 | 24.1 | 8.5 | 135.7 | 126.7 | 0.0 | 0 | 0 | 0 |
| 9 | 8.3 | 3.7 | 63.3 | 59.6 | 0.0 | 0 | 0 | 0 |
| 10 | 2.4 | 1.3 | 24.0 | 22.8 | 9.5 | 21 | 38 | 44 |
| 11 | 0.8 | 0.5 | 9.4 | 9.0 | 6.1 | 14 | 24 | 29 |
| Total | 1,112.0 | 123.0 | 1,613.7 | 1,175.0 | 15.6 | 35 | 62 | 74 |

================================================================

==============

*Inside bark

================================================================

======

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|

---------------------------------------------------------------------

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 10.7 | 0.1 | 9 | 0.0 | 0.0 | 0.0 |
| 2 | 157.2 | 3.7 | 18 | 0.0 | 0.0 | 0.0 |
| 3 | 264.5 | 13.5 | 25 | 0.0 | 0.0 | 0.0 |
| 4 | 265.7 | 23.9 | 29 | 0.0 | 0.0 | 0.0 |
| 5 | 199.7 | 27.9 | 33 | 14.1 | 12.0 | 0.0 |
| 6 | 119.7 | 24.0 | 35 | 12.9 | 11.7 | 0.0 |
| 7 | 58.9 | 16.0 | 37 | 8.5 | 7.8 | 0.0 |
| 8 | 24.1 | 8.5 | 39 | 4.8 | 4.5 | 0.0 |
| 9 | 8.3 | 3.7 | 40 | 2.2 | 2.1 | 0.0 |
| 10 | 2.4 | 1.3 | 41 | 0.8 | 0.8 | 0.3 |
| 11 | 0.8 | 0.5 | 42 | 0.3 | 0.3 | 0.2 |
| Total | 1,112.0 | 123.0 | | 43.8 | 39.2 | 0.5 |

=================================================================
======

05-02-2011 17:44:15

EVEN-AGED NATURAL SHORTLEAF PINE GROWTH AND YIELD SIMULATOR

Current Stand Conditions

Stand ID: AA Stand size: 1 ac

Year: 2031 Iteration 30 of 30

Stand Age: 50 Site Index: 70

Pulpwood top diameter: 3 in. o.b. Sawtimber top diameter: 9 in. o.b.

=============================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Cubic-foot Volume/Acre* Total | Merch-antable | Saw-timber | Board-foot Volume/Acre Doyle | Scribner | Int. ¬ |
|---|---|---|---|---|---|---|---|---|
| 2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 3 | 2.0 | 0.1 | 1.4 | 0.0 | 0.0 | 0 | 0 | 0 |
| 4 | 12.1 | 1.1 | 17.3 | 4.8 | 0.0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5 | 40.4 | 5.6 | 108.4 | 86.3 | 0.0 | 0 | 0 | 0 |
| 6 | 74.9 | 14.7 | 332.7 | 306.0 | 0.0 | 0 | 0 | 0 |
| 7 | 100.9 | 27.0 | 682.3 | 643.4 | 0.0 | 0 | 0 | 0 |
| 8 | 89.3 | 31.1 | 851.5 | 812.2 | 0.0 | 0 | 0 | 0 |
| 9 | 74.1 | 32.7 | 952.0 | 913.9 | 0.0 | 0 | 0 | 0 |
| 10 | 49.7 | 26.7 | 788.2 | 759.7 | 210.8 | 479 | 872 | 1,011 |
| 11 | 33.0 | 21.5 | 645.1 | 623.7 | 352.3 | 904 | 1,571 | 1,746 |
| 12 | 16.5 | 13.0 | 402.2 | 389.7 | 288.4 | 842 | 1,382 | 1,518 |
| 13 | 7.3 | 6.6 | 209.5 | 203.3 | 166.7 | 538 | 838 | 885 |
| 14 | 4.3 | 4.5 | 144.8 | 140.7 | 122.6 | 430 | 638 | 666 |
| 15 | 1.5 | 1.9 | 61.3 | 59.6 | 54.1 | 203 | 287 | 304 |
| 16 | 0.6 | 0.8 | 28.1 | 27.3 | 25.4 | 100 | 136 | 144 |
| 17 | 0.1 | 0.1 | 3.8 | 3.7 | 3.5 | 14 | 19 | 20 |
| Total | 506.7 | 187.3 | 5,228.8 | 4,974.4 | 1,223.7 | 3,510 | 5,742 | 6,295 |

==============================================================================

*Inside bark

======================================================================

| Diam. Class Midpt | Trees/ Acre | Basal Area/ Acre | Avg. T. Ht. (ft) | Green Weight of Stem (Tons/Acre) Total | Merch-antable | Saw-timber |
|---|---|---|---|---|---|---|
| 2 | 0.1 | 0.0 | 30 | 0.0 | 0.0 | 0.0 |
| 3 | 2.0 | 0.1 | 41 | 0.0 | 0.0 | 0.0 |
| 4 | 12.1 | 1.1 | 48 | 0.0 | 0.0 | 0.0 |
| 5 | 40.4 | 5.6 | 53 | 3.6 | 3.0 | 0.0 |
| 6 | 74.9 | 14.7 | 57 | 11.9 | 10.9 | 0.0 |
| 7 | 100.9 | 27.0 | 61 | 24.1 | 22.8 | 0.0 |
| 8 | 89.3 | 31.1 | 64 | 30.0 | 28.6 | 0.0 |
| 9 | 74.1 | 32.7 | 66 | 33.4 | 32.1 | 0.0 |
| 10 | 49.7 | 26.7 | 68 | 27.6 | 26.6 | 7.3 |
| 11 | 33.0 | 21.5 | 69 | 22.6 | 21.8 | 12.1 |
| 12 | 16.5 | 13.0 | 71 | 14.1 | 13.6 | 9.9 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 13 | 7.3 | 6.6 | 72 | 7.3 | 7.1 | 5.7 |
| 14 | 4.3 | 4.5 | 73 | 5.1 | 4.9 | 4.2 |
| 15 | 1.5 | 1.9 | 74 | 2.1 | 2.1 | 1.9 |
| 16 | 0.6 | 0.8 | 75 | 1.0 | 1.0 | 0.9 |
| 17 | 0.1 | 0.1 | 75 | 0.1 | 0.1 | 0.1 |
| Total | 506.7 | 187.3 | | 182.9 | 174.5 | 42.1 |

=================================================================

05-02-2011 17:45:44

# VITA

Jomals Mathews John

Candidate for the Degree of

Master of Science

Thesis: ECONOMICS OF SFFECTIVE THINNING OF SHORTLEAF PINES IN OUACHITA AND OZARK MOUNTAINS OF OKLAHOMA AND ARKANSAS

Major Field: Natural Resource Ecology and Mangement

Biographical:

Education:

Completed the requirements for the Master of Science in Forest Economics at Oklahoma State University, Stillwater, Oklahoma in December, July, 2011.

Completed the requirements for the Bachelor of Science in Forestry at Kerala Agricultural University/ College of Forestry , Thrissur, Kerala/India in 2007.

Experience: Research assistant at Kerala Agricultural University, India
Graduate Research assistant at Oklahoma State University, USA

Professional Memberships: Omega Chi

Name: Jomals Mathews John Date of Degree: July, 2011

Institution: Oklahoma State University Location: OKC or Stillwater, Oklahoma

Title of Study: ECONOMICS OF SFFECTIVE THINNING OF SHORTLEAF PINES IN OUACHITA AND OZARK MOUNTAINS OF OKLAHOMA AND ARKANSAS

Pages in Study: 117 Candidate for the Degree of Master of Science

Major Field: Natural Resource Ecology and Management

Scope and Method of Study: We used Weibull distribution to find the diameter classes and conducted Weibull parameters calculations. Simulation was done after entering the frequency and class midpoints in the SLPSS (Shortleaf Pine Stand Simulator). We conducted SLPSS simulations and NPV/BLV calculations to find optimal rotation age and best stocking. This will help the forest landowners to know when they can avail the maximum from a particular investment. Tax impact study will help the government in determining tax incentives.

Findings and Conclusions: Optimal rotation age for shortleaf pines was achieved for basal area classes 30, 60, 90 and 120. Oklahoma's traditional timber market is in a state of decline. The recession and the low demand in the housing market affected the market adversely. It is necessary to give tax incentives to landowners to prevent them from converting too much forest land to other purposes. As the thinning regime increased from one thinning through three thinnings, at a tax rate of 5% and an interest rate of 4%, intense thinning regimes reduced the land expectation value under modified tax compared to the treatment without thinning. Before thinning, Bare Land Value and Holding values were maximized at different rotation ages. After thinning, Net Present Value, Bare Land Value and Holding value were maximized at the same rotation ages in all these thinning regimes as presented.

ADVISER'S APPROVAL: ______________________________