To the Graduate Council:

I am submitting herewith a thesis written by Leslie Caroline Ganus entitled "The Tennessee Hardwood Sawmill Profile." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Forestry.

Paul M. Winistorfer, Major Professor

We have read this thesis and recommend its acceptance:

Accepted for the Council:

Associate Vice Chancellor and
Dean of The Graduate School

The Tennessee Hardwood Sawmill Profile

A Thesis
Presented for the
Master of Science Degree
University of Tennessee, Knoxville

Leslie C. Ganus
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Dedication

This thesis is dedicated to my husband and son

Eric Ganus

&

Nick Ganus

whom have shown me immeasurable love and support.

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Abstract

This study is a general profile of the hardwood sawmill industry in Tennessee. Previous industry assessments were not focused specifically on hardwood sawmills and did not include much of the information contained in the Tennessee Hardwood Sawmill Profile. This profile will allow those involved in the production of hardwood lumber to see a broad image of the industry and make adjustments to their individual situations. Data was gathered via a written questionnaire distributed to the majority of sawmills in the state. The survey included questions regarding mill characteristics, production, equipment, residues, external factors, and drying facilities. The survey showed a high level of variation in the all aspects of hardwood lumber production among differing sawmill size classes. Sawmills who produced less than five million board feet of lumber annually, were subject to greater levels of competition and were more likely to go out of business in the next ten years. Larger sawmills with a much larger market share were more likely to have seen growth by their individual firm. The large sawmills were more likely to purchase new equipment and less likely to be forced out of the market.

Preface

The hardwood lumber industry has been of interest to the Tennessee Forest Products Center at the University of Tennessee for many years. Hardwood lumber is the central product for many of the Center's research projects. The limited amount of relevant information currently available regarding the industry led to the interest in a comprehensive survey about the hardwood sawmills in Tennessee.

The introduction states the objectives of the study. The section also gives justification to the need and relevance of the Tennessee Hardwood Sawmill Profile. Finally, the introduction lists the major categories of information sought by the survey.

The literature review gives background information regarding the hardwood lumber industry. This information covers a brief history the forests of Tennessee and includes past harvesting practices. Also included is a characterization of the lumber resource and raw material quality. Produced demand and a description of the lumber market describe the disparity between log and lumber prices. Finally, a brief history of the industry as a whole shows the state's increasing total production and the declining number of sawmills.

The materials and methods describes the details involved in the design and implementation of the Tennessee Hardwood Sawmill Profile. Careful consideration was taken to create an effective tool for data collection. Implementation and subsequent survey response rates are described as well as a discussion of the type of statistical analysis used for categorical survey data.

The results and discussion present the information collected and analyzed from the questionnaire. The data was categorized and presented by regional distributions and annual board foot production classes. Hypotheses offered in the discussion of the data serves to interpret relationships among the categorical variables. These relationships are meant to assist sawmill owners with identifying characteristics relevant to their individual situation.

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Introduction

Tennessee's forest products industry is vital to the state economy. A major component of the industry is the production of hardwood lumber by sawmills. Tennessee consistently ranks as one of the top three hardwood lumber producing states in the nation. In the past twenty years, industrial roundwood output of hardwood sawlogs has increased from 610 million board feet to over 1 billion board feet per year (Stratton and Wright 1998).

Saw logs and pulpwood are the primary roundwood products. Combined output from these products totaled more than three hundred million cubic feet, accounting for ninety-four percent of Tennessee's total industrial roundwood output. Hardwood roundwood product output totaled two hundred thirty-six million cubic feet in 1997 (Stratton and Wright 1998). Saw logs comprised fifty-six percent of Tennessee's total roundwood output in 1997, roughly one hundred eighty million cubic feet. Hardwood saw log output totaled one hundred fifty-nine million cubic feet and accounted for eighty-nine percent of the saw log output (Stratton and Wright 1998).

The number of sawmills in Tennessee declined from six hundred ninety-four in 1979 to four hundred ninety-six in 1997. In 1997, fifty-eight percent of sawmills in Tennessee produced less than one million board

feet per year. Thirty-one percent produced between one and five million board feet annually. Eleven percent produced more than five million board feet annually.

While the hardwood sawmill industry is of economic importance to the state, little is reported that depicts analysis of the industry when compared to similar wood industries in neighboring states. The goal of the Tennessee Hardwood Sawmill Profile was to gather accurate information and to describe in detail, the hardwood sawmill industry in Tennessee. An accurate description of the industry will help producers make better business decisions as we enter the next century.

The objectives of the Tennessee Hardwood Sawmill Profile were: (1) to provide Tennessee's hardwood lumber producers with an industry profile for assistance in decision-making for both short and long-term sustainability and; (2) to evaluate current investment trends in Tennessee's hardwood sawmill industry.

This comprehensive assessment included evaluation of mill characteristics, profiled equipment used and new equipment planned, examined external factors that influence mill productivity, looked at concerns over environmental regulations, explored reoccurring production problems, and allowed mills an opportunity to give insight into the future of the hardwood sawmill industry in Tennessee.

Literature Review

1. The Forests of Tennessee

Ownership

Eighty-four percent of Tennessee's forestland is privately owned. Four hundred seventy thousand individuals own sixty-nine percent of the total forest acreage. Private corporations own seventeen percent of the forests in Tennessee, while only sixteen percent of Tennessee's forests are publicly owned (Tennessee Division of Forestry 1999).

Forest Types

Over seventy percent of Tennessee's forests are of the oak-hickory forest type. This forest type is found throughout the state and supports a variety of both plant and animal species. The oak-hickory forests are present today because of past land use practices, fire protection and the chestnut blight. Heavy logging, grazing and wildfires significantly disturbed the state's forests in the early part of the century. Oaks and hickories gained dominance after the American Chestnut was eradicated by blight in the 1930s. Oaks and hickories, with their dense bark, were able to withstand wildfire damage until the state began an intensive fire

control program in the 1950s. The oaks and hickories have now matured into Tennessee's forests of today (University of Tennessee 1995).

The oak-pine forest covers twelve percent of the state. It is largely a mountain type found from the Cumberland Plateau Eastward. The oak-pine forest type occurs primarily on old field sites but can also be found on upland sites. Site quality is low to moderate ranging from a site index between sixty and seventy (Society of American Foresters 1980). Depending on age, species composition can include loblolly pine (*Pinus taeda*), shortleaf pine (*Pinus echinata*) and virginia pine (*Pinus virginiana*). The principle oak species are white oak (*Quercus alba*), northern red oak (*Quercus rubra*), southern red oak (*Quercus falcata*), black oak (*Quercus velutina*), scarlet oak (*Quercus coccinea*) and chestnut oak (*Quercus prinus*). Associated hardwood species include hickory (*Carya spp.*), yellow-poplar (*Liriodendron tulipifera*), maple (*Acer spp.*) and ash (*Fraxinus spp.*). Much of the understory consists of dogwood (*Cornus florida*), souwood (*Oxydendrun arboreum*) and redbud (*Cercis canadensis*) (Society of American Foresters 1980).

The bottomland hardwood forest type occurs on six percent of the forest area and is found solely in West Tennessee, on alluvial soils, which are prone to flooding. The bottomland hardwood forests are excellent wildlife habitats and produce some of the most valuable veneer and sawlogs in the state. Species occurring in this forest type include

cottonwood (*Populus deltoides*), black willow (*Salix nigra*), sycamore (*Platanus occidentalis*), baldcypress (*Taxodium distichum*), and a variety of red oaks including water oak (*Quercus nigra*), willow oak (*Quercus phellos*), cherrybark oak (*Quercus falcata var. pagodifolia*) and shumard oak (*Quercus shumardii*) (Society of American Foresters 1980).

Pine (*Pinus spp.*) is becoming increasingly important in the state and now occupies twelve percent of the forestland. Grown mostly on plantations by the paper industry, it is also being used for erosion control and mine reclamation. Many landowners are turning to loblolly pine (Pinus taeda) and white pine (Pinus strobus) for planting in old fields, ridgetops and on poor southwest slopes. Pine offers landowners a higher yield on these poorer sites (Society of American Foresters 1980).

2. Resource Characterization

Timber Availability

The supply of hardwood timber in Tennessee seems inexhaustible. Net growth has exceeded removals since the 1950s (May 1991). The U.S. Forest Service completed the sixth forest survey of the state in 1999. Current growth and removal statistics have not been published at this time. Statistics for 1991 show hardwood growth at four hundred ninety-

seven million cubic feet and removals at two hundred seventy-nine million cubic feet, a ratio of 1.7 (Powell 1993). This is a trend seen nationwide (Cubbage, Pacheco, and Abt 1997). However, upon closer examination it becomes evident that hardwood lumber is becoming scarce. Studies suggest that from one-third to one-half of the nominal hardwood timber inventory may not be available for use (Cubbage, Pacheco, and Abt 1997).

There are several reasons for the decline in timber availability. First, hardwood quality has declined as growth has been concentrated in lower grade trees and removals target high grade trees (May 1991). Quality decline has been caused by poor cutting practices such as high-grading, combined with a lack of markets for low quality materials. Secondly, there is an increasing industrial demand for hardwood fiber from the pulp and paper industry due to its substitution for softwood and the increase of paper production in the south (Cubbage and Abt 1998). Finally, over eighty percent of Tennessee's timberland is owned by nonindustrial private landowners (May 1991). Several types of taxation including income taxes, estate and gift taxes and property taxes affect these landowners. Taxation regardless of type, substantially increase the cost of forest management. Hardwoods are particularly affected due to their capital intensive nature and long rotations (Hyldahl, Haney and Bick 1997). As taxes increase, landowners may choose an alternative use for

their land rather than growing timber, thus decreasing the available timber supply in the state.

Timber Quality

The first forest survey for the state of Tennessee was completed in 1950. The survey showed a forest ravaged by decades of extractive uses beginning with large scale clearing of the forest for conversion to agricultural land. Repeated high-grading of the state's remaining forests established and supplied the state's forest products industry. The many years of high-grading, the practice of removing only the best species, grades, and sizes of trees, resulted in a forest filled with small, low quality trees of less desirable species composition. Annual burning of thousands of acres of forest for wildlife and livestock further reduced the quality of Tennessee's timberland.

3. Product Demand

Understanding market demand is essential to the hardwood sawmill industry when making decisions. Forest economists and industry analysts are predicting a dramatic increase in hardwood consumption in the next 20 years (Wiedenbeck and Araman 1993). Hardwoods could

meet a portion of the demand for materials that have been made from softwood lumber in the past. Structural lumber from hardwood species may become a viable alternative to softwood in the market. Hardwoods may be used to produce many secondary products, such as molding and millwork, as well as treated shakes and shingles (Wiedenbeck and Araman 1993).

Lumber Demand

Hardwood lumber demand is greatly affected by forces external to the market, including society, the economy, technological innovations and international trade (Luppold 1991). Many of these factors led to the increased use of hardwood lumber in the 1980s, then caused a recession in the early 1990s. Production increased rapidly between 1986 and 1990 due to a high concentration of flooring plants in the Tennessee-Kentucky region, but then dropped sharply in 1991 resulting from a reduction in domestic furniture production (Luppold and Dempsey 1994). The furniture makers use much of the lumber produced in Tennessee, an industry that has been stagnant in the past few years (Luppold 1991). Unfortunately, little information on demand or material use trends exists, especially for the wood furniture industry. The data that is available is often disputed or outdated by the time it is published (Forbes, Sinclair and Luppold 1993).

Raw material quality is also an issue of demand in the hardwood lumber industry. High-grade lumber can be shipped anywhere, while low and mid-grade lumber tends to be consumed by industries close to the mill. When these "local" markets fluctuate, production of lower lumber grades follows suit (Luppold 1996).

4. Hardwood Sawmill Industry

History

In the late 1800s, the lumber industry entered Tennessee in search of timber to meet the growing demands of a thriving nation. At first, only the highest quality trees were taken. White oak, black walnut, and yellow-poplar were the favored species. As demand increased, loggers returned to Tennessee's forests taking the best of what remained (May 1990). The state's old growth forests continued to be high graded for many years and the industry peaked shortly after the turn of the century. In 1909, annual production was in excess of 1.2 billion board feet (May 1990). Afterward, the industry plummeted, hitting bottom with the rest of the country during the depression of the 1930s.

Current Description

Today, the hardwood lumber industry is very competitive and highly affected by the economy. Several economic factors have major impacts on the industry. Decreased timber availability, species specific demand, and incomplete information make the production of hardwood lumber extremely precarious (Luppold 1991).

The production capacity and location of hardwood sawmills are influenced by the timber supply, raw materials cost, and production processes. When any cost associated with lumber production changes in the industry, sawmill efficiency also changes. These changes are reflected in capital expenditures, expansion of operating hours, and addition of more employees (Luppold 1996).

Eighty-nine percent of Tennessee's sawmills produce less than five million board feet of lumber per mill (Stratton and Wright 1998). The competition among these mills is extremely high. The result is that these firms have no market power, having no influence on log or lumber prices (Luppold 1995). The decreasing margin between log and lumber prices is slowly eroding the profits of these small firms. Many producers are being forced out of business and others are making investments in new technology to stay competitive. Hardwood lumber producers seem to stay

one step behind since they are very seldom in sync with the demands of the secondary markets (Luppold and Baumgrass 1998).

In 1991 over half of the lumber in the Eastern United States was produced at hardwood sawmills, yet little is known about the industry. The lack of information is due to the fragmented and complicated nature of the industry and the fact that there are considerable differences in the hardwood sawmilling industry among states (Luppold 1995). Tennessee consistently ranks as one of the top three hardwood lumber producing states yet there is little information available on its mills (May 1991). An understanding of current business trends better enables a mill to make decisions regarding raw materials use, production plans, and workforce size (Forbes, Sinclair and Luppold 1993). An assessment of the hardwood sawmill industry in Tennessee would help producers better understand the forces that drive competition in the marketplace. An assessment would also focus the interests of those industries supplying equipment to the hardwood mills so that current and future needs of the industry can be met.

Technological Innovation

Tennessee's industrial roundwood output of hardwood sawlogs has steadily increased in the past twenty years. In 1979 roundwood output

was six hundred ten million board feet and had increased to nine hundred eighteen million board feet by 1995 (Johnson and Stratton 1998). In contrast, the number of sawmills decreased from six hundred ninety-four to four hundred ninety-five in the same period of time (Stratton and Wright 1998). During periods of declining prices, less efficient or poorly managed sawmills are forced out of the market (Luppold and Baumgrass 1998). This trend indicates an increase in sawmill efficiency (May 1991). Implementation of emerging technologies can increase a firm's competitive position. Technological innovations have the ability to improve productivity, reduce production costs, and allow a firm to provide better service to their customers (West and Sinclair 1991).

Continuous improvements in processing technologies have increased lumber recovery factors since the 1950s (USDA Forest Service 1990). As new technologies are applied to changing timber resources, the potential for new lumber products increases. For example, the use of hardwoods for structural lumber could challenge the traditional softwood lumber products for a share of the market (USDA Forest Service 1990). However, because of the complexities of the industry in Tennessee such advances have not been explored by the mill owners. Technological change found in the use of the most modern equipment innovations by an industry is primarily responsible for economic growth in other sectors of the forest products market. The impact of technical change on the forest

products sector has been examined by economists using historical, index number, and econometric approaches (Steir and Bengston 1992). A positive relationship has been found between new technology adoption and growth of the firm. Research shows the adoption of new technology has the largest impact upon the market performance of small industrial firms (MacPherson 1994). As firms increase efficiency, they can afford to pay more for hardwood stumpage, thus pressuring inefficient mills that do not have the financial capability to invest in technology or pay the higher prices for raw materials (Bush and Sinclair 1989).

Capital Expenditures

Economic uncertainty has great effect on the way a firm spends money. Much of the economic uncertainty is due to the cyclical nature of lumber prices (Luppold and Baumgrass 1998). When market prices are high, investments in new equipment are feasible; when prices fall, such expenditures of capital become impossible. Such market volatility deters many small firms from investing large amounts of capital in new technology (Luppold 1995).

Historically, the hardwood sawmill business had very few barriers to entry. Very little capital was needed to start a business, this is no longer the case. Building a new stationary sawmill today can cost more than ten

million dollars. In order to amortize the costs of new technology, mills must produce over twenty-five million board feet annually (Barrett 1996). Even small upgrades to enhance lumber recovery can cost over one hundred thousand dollars. Many small firms are unable to make such an investment of capital, become unable to compete, and slowly leave the marketplace.

Materials and Methods

1. SURVEY DESIGN

A mail questionnaire was the source of data collection for the study. Survey design and implementation was based on the Total Design Method (Dillman 1978). The Total Design Method (TDM) describes in detail how to conduct a successful mail survey. The TDM seeks to maximize both the quantity and quality of survey responses. Attention is given to every detail that affects response behavior.

The most difficult part of survey design is writing effective questions. The TDM divided this process into three parts: (1) the kind of information sought; (2) the question structure and; (3) the proper wording. Failure to consider any one of the three divisions can prevent the survey from achieving the study objectives.

Information Being Sought

The identification of exactly what information was desired by the hardwood sawmill profile shaped all other aspects of the study. A brainstorming session was held in January 1999 with the faculty and staff of the University of Tennessee Department of Forestry. This session

resulted in the general categories of information to be gathered in the profile. The major categories included: (1) reoccurring problems in log supply, production and processing, employees, lumber markets, and environmental regulations; (2) external factors that influence the overall mill operations; (3) general mill characteristics; (4) production information; (5) equipment information; (6) investment plans; (7) residue information and; (8) information on lumber drying facilities.

Question Structure

There are four basic types of question structures in the TDM. The distinct difference is the nature of the response behavior asked of the respondent. From these criteria, four categories of questions can be structured; (1) open-ended, (2) close-ended with ordered choices, (3) closed-ended with unordered choices, and (4) partially closed qusetions. Each question type is directed to elicit different types of response behavior from survey respondents.

Open-ended questions rely on survey respondents to "create" their own answers and state them in their own words. This type of question is particularly effective when the purpose is to elicit a particular piece of information that the respondent readily knows and there are a large number of possible answers. This type of question is also used

when respondents are free to express their opinion. Several questions were constructed in the open-ended format. These included describing over all mill problems, reasons for mill shut downs, products exported, equipment purchases, and drying facility energy sources.

Close-ended with ordered choice questions, according to the TDM, have graduated answer choices of a single dimension of some concept. The respondent finds the most appropriate place for his or her response. These questions are narrowly focused and restrict responses to a limited aspect of a particular subject. This type of question is used to determine the extent to which each respondent differs from one another. Close-ended with ordered choice questions were used in the hardwood sawmill profile for determining production levels, number of employees, and the influence of external factors.

Close-ended questions with unordered answer choices have independent alternative responses representing separate concepts. They can be used to collect a variety of information but can be difficult to answer when the respondent must balance several concepts in their minds at the same time. Many of questions in the hardwood sawmill profile were designed in this manor. Careful consideration was taken to design these questions to be relatively simple to answer, with as few answer choices as necessary to keep response choices from being overwhelming to the respondent.

Partially closed questions are a compromise between the three other question types, allowing for variable development without forcing respondents into categories they do not fit. These questions generally have several closed responses and a final open response requiring them to be more specific if chosen. Statistical analysis is often unavailable with respect to data obtained in this format. A sufficient number of additional responses to warrant their inclusion in the analysis are seldom obtained. There are advantages to this type of question format. If a large number of respondents insist that none of the provided categories fit their situation, it can be assumed that other respondents chose a closed response reluctantly suggesting a problem that warrants further examination. There were many questions posed in this format on the profile. It was important that the information gathered from these questions be as precise as possible, therefore response categories had to be flexible enough to encompass all respondents.

Question Wording

The third and often the most difficult part of survey design is wording the questions so that the desired information is collected. Improper wording can create any number of difficulties during analysis.

There are several "rules" outlined in the TDM to aid in effectively wording questions (Table 1).

Table1."Rules" for effective wording of survey questions (Dillman 1978).

• Use simple words	• Do not talk down to respondents
• Do not be vague	• Avoid hypothetical questions
• Keep it short	• Avoid objectionable questions
• Be specific	• Do not be too specific
• Avoid bias	

These rules are a guideline, not an absolute. Many times these rules interfere with one another. It is important to consider each question in the context of the survey as a whole as well as its relationship to the questions that precede it.

Other things considered in question wording include, whether the wording will be uniformly understood, is the question repetitive, are the response choices mutually exclusive, and whether or not too much assumption has been made.

1. Questionnaire Construction

A mail questionnaire requires extreme scrutiny. The absence of an interviewer to answer respondent questions during the survey process makes it necessary to ensure that construction deficiencies are eliminated before the survey is implemented. There are three TDM principles in deciding the order of the questions. Each is designed to maximize overall survey effectiveness.

The first principle is to order questions along a descending social gradient. Those in which a respondent is likely to see as useful come first. Questions that seemingly lack social utility come last. Questions allowing each mill to freely describe the problems they most often encounter were chosen to come first. The respondent profile as well as a place for general comments ended the questionnaire.

The second principle in question ordering is to group similar questions together. All of the questions designed to give a general mill profile were grouped together. Equipment information, residue information, and questions regarding drying facilities were separate sections in the survey.

The third principle is to build a sense of continuity and flow throughout the questionnaire. This is accomplished by using cognitive ties that the respondents are likely to make among the groups of questions.

The Hardwood Sawmill Profile was constructed with the broad, more general questions coming first, followed by the more specific questions.

Pretesting

Pretesting is designed to identify problems in the construction of the questionnaire. Once the questionnaire was drafted, it was reviewed by the faculty and staff of the Tennessee Forest Products Center and several revisions were made. Before pretesting of the hardwood sawmill profile began, a questionnaire was produced that appeared to be in its' final version and was then submitted to three distinct groups for approval. The first group was made up of faculty and staff of the University of Tennessee Department of Forestry faculty and staff; the same group involved in the information brainstorm. The second group included University of Tennessee faculty from the departments of Agricultural Economics, and Statistics, and the United States Department of Agriculture Forest Service. The final group included hardwood sawmill owners and managers. After all pretesting was completed, a final version of the Tennessee Hardwood Sawmill Profile was drafted.

Cover Letter

The cover letter designed for the Tennessee Hardwood Sawmill Profile followed the TDM guidelines. It introduced the study, and sought to motivate the respondents to participate. It was the only opportunity to anticipate and answer respondent questions. The TDM designed cover letter expressed several key concepts to the respondents. It first explained the purpose of the study and its usefulness to the respondent. Establishing usefulness and benefit to the respondent increases the rate of response to the study. The second part of the cover letter was designed to convince the respondent that his or her response was important and that no one else's response can be substituted. This minimized the likelihood that the questionnaire would be passed off to someone else. Finally, the cover letter expressed the confidentially of the questionnaire. Many times there is a fear associated with respondent participation that the responses will be used for purposes other than research and will have negative repercussions in the future. It was important to establish trust with the respondents to overcome this obstacle.

2. Implementation of the Survey

The Tennessee Hardwood Sawmill Profile was mailed on June 28, 1999 to four hundred thirty-five sawmills in Tennessee. The mailing list was obtained from the Tennessee Division of Forestry and included most but not all of the hardwood sawmills in Tennessee. Each survey included an identification number used in recording respondents and non-respondents. Following the TDM guidelines, a follow-up post card was mailed two weeks later thanking respondents for completing and returning the survey and urging non-respondents to participate. A second survey was sent in mid July to non-respondents again urging participation. A copy of the survey, the cover letter, and the follow-up post card are shown in Appendix A.

3. Response Rate

The Tennessee Hardwood Sawmill Profile survey was distributed to hardwood sawmills located in eighty-two of the ninety-six Tennessee counties. Survey responses were obtained from sawmills in sixty counties. For analysis purposes, the state was divided into five geographic designations: East, Plateau, Central, West Central, and West (Figure 1). These are the same regional designations used by the U.S. Forest

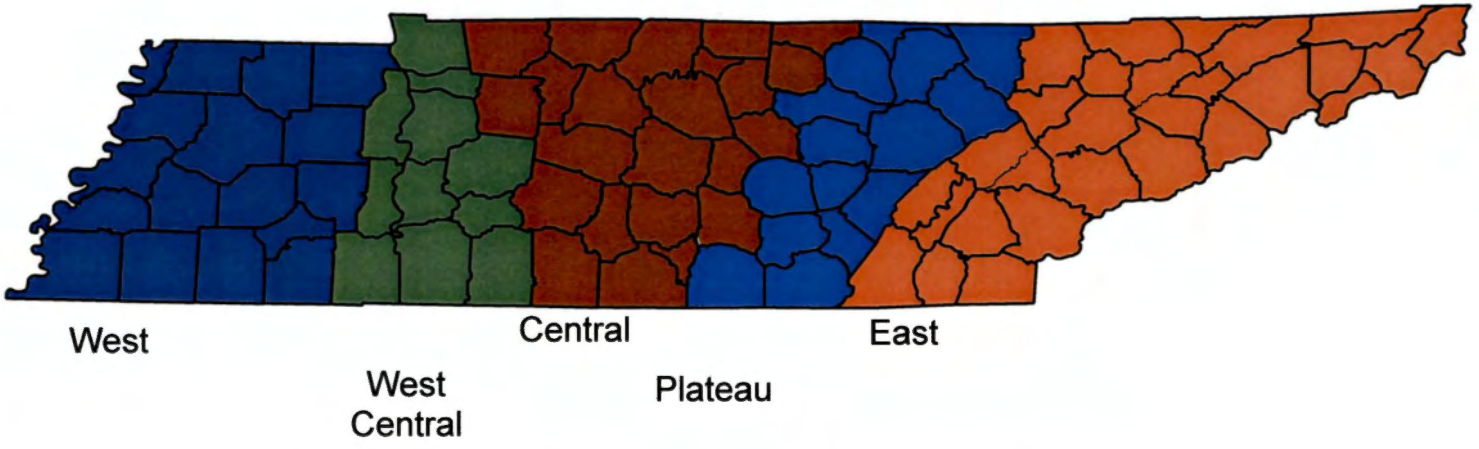


Figure 1. The geographic designations for the Tennessee hardwood Sawmill Profile.

Service in their forest inventory reporting (Rosson 1993). The state-wide survey response rate was twenty-eight percent. Survey response rates ranged from twenty-three to thirty-six percent among the five regions (Figures 2 and 3). There was no difference (P = 0.77) in survey response rate among the five geographical regions.

5. Statistical Analysis

The Tennessee Hardwood Sawmill Profile generated more than one hundred eighty categorical variables and over twenty thousand separate data points. It was infeasible to cross all categories for statistical analysis. Statistical Analysis Systems (SAS 1989) software version 6.12 was used to perform the statistical analysis. The regional distribution and sawmill production size categories best classify the hardwood sawmill industry in Tennessee. Chi-square analysis was performed through crossing other categories by location and production volume to provide a basis for finding relationships among categories. Significance testing was done at the p = 0.05 level (95%).

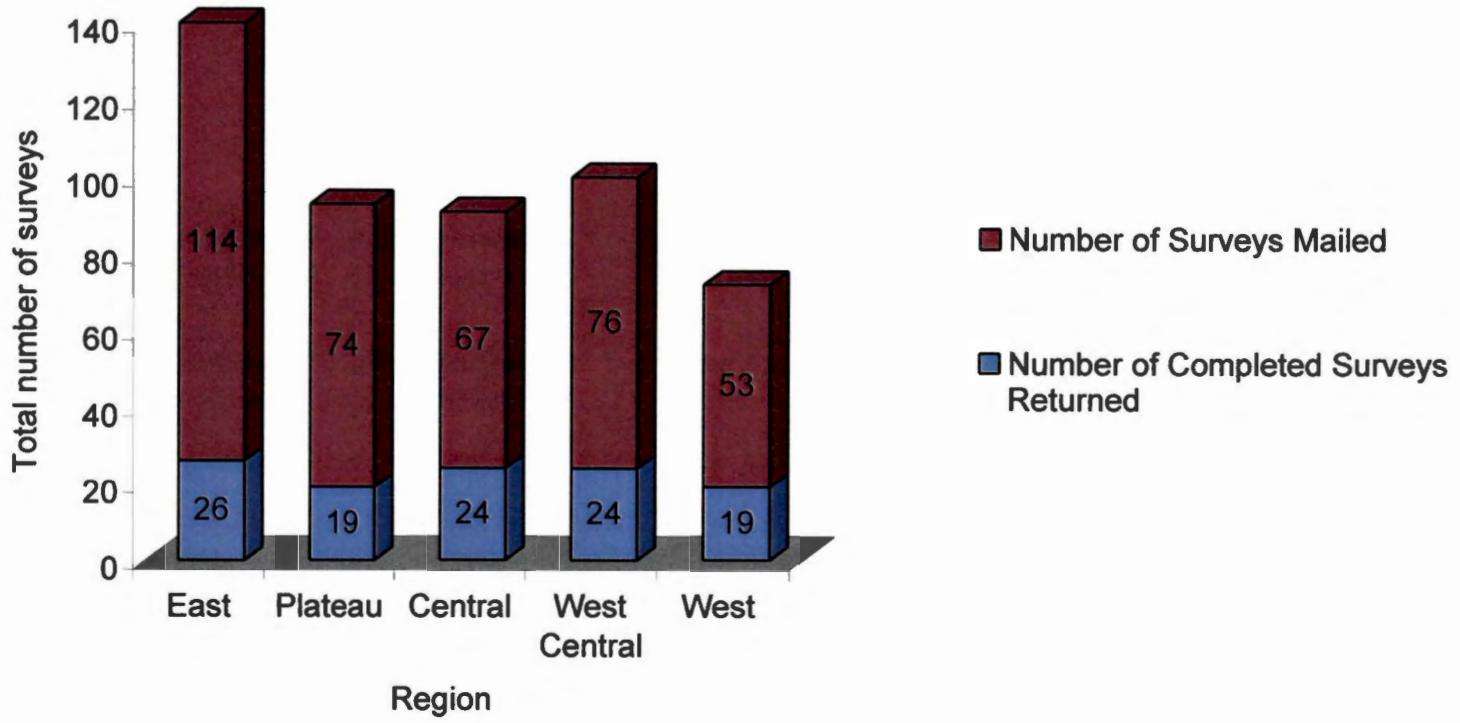


Figure 2. Regional distribution of mailed surveys and and the number of survey respondants.

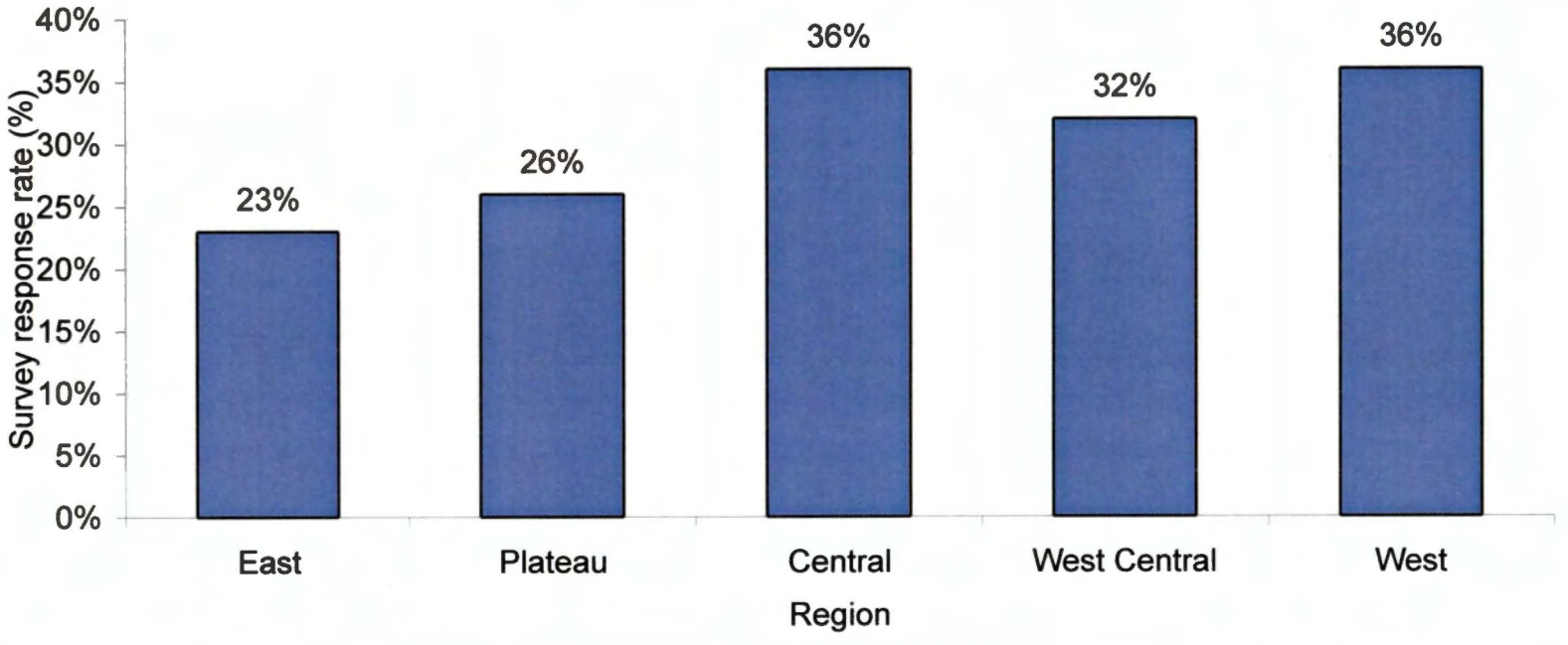


Figure 3. Survey response rate (%) by region.

Categorical Data Analysis

A categorical population is defined as one whose particular associates are characterized as belonging to one of several categories or classes, not necessarily ordered. The model for a categorical population is comprised of the list of possible categories with a population proportion for each category and data is generally presented as a frequency distribution.

The statistical problem to be considered for analysis is testing if the data "fit" a specific model. Comparing observed and theoretical frequencies achieve testing the fit of the data. The theoretical frequencies are determined according to the hypothesis or model being tested. The decision then becomes whether the observed frequencies are analogous to the hypothesis or model.

The statistical method best suited for analysis of categorical data is the chi-square goodness of fit test statistic. The chi-square statistic is a measure of how much the observed frequencies diverge from the expected frequencies (Equation 1).

$$X^2 = ?^{k}_{1} \frac{(y_i - np_i)^2}{np_i} \quad \text{Equation 1.}$$

The product np_i is the expected number of occurrences of a category A_i among n trials, if p_i is the probability. The statistic x^2 will be small if and only if all of the observed frequencies are similar to the expected frequencies. It is also important to determine a critical region for rejecting the model defined by the probabilities. It is generally presented in the form of $x^2 >$ constant.

Although the distribution is generally quite complex and dependent upon the model being tested, such difficulties disappear as the sample size increases. For a large n, the distribution of x^2 under Ho, the null hypothesis, is approximately one of the several predetermined chi-square distributions, depending on the number of categories but otherwise not on the model being tested (Lindgren et al 1978).

The chi-square distributions are indexed by the number of degrees of freedom. For categorical data, the degrees of freedom are equal to the number of categories minus one.

During data analysis, it is also important to consider whether there are relationships between the categorical variables. Since a random variable is defined by its classification into categories it is important to consider whether the categories act independently or interact. In such cases, the chi-square test of independence is appropriate. This procedure tests for independence of classification between two of more variables.

Variable A with categories $A_1,\ldots,A_n$ and variable B with categories $B_1,\ldots,B_n$ are independent if and only if:

$$P(A_i \cap B_j) = P(A_i)P(B_j)$$

for all i, j.

Therefore, a two-way probability can be created by the multiplication of marginal probabilities.

Results and Discussion

1. General Mill Characteristics

Age

Sawmill age was determined by the year in which the responding sawmill was established. The statewide average age of the sawmills that responded to the survey was twenty-six years. The oldest sawmill that responded to the survey was one hundred twenty-six years old. The youngest sawmill that responded to the survey was two years old. The average sawmill age among geographic regions ranged from twenty to thirty-eight years (Figure 4). The average age of sawmills in the East region was twenty-three years. In the Plateau region, the average age was thirty-eight. In the Central region, the average age was twenty-two. The average age of responding sawmills in the West Central region was twenty. Finally, the average age of sawmills in the West region was thirty.

The average age of responding sawmills among production classes ranged from twenty-two to forty-nine (Figure 5). The average age of responding sawmills in the under five million annual board foot production class was twenty-two years. In the five to ten million annual board foot production class, the average age was thirty-two years. For sawmills in

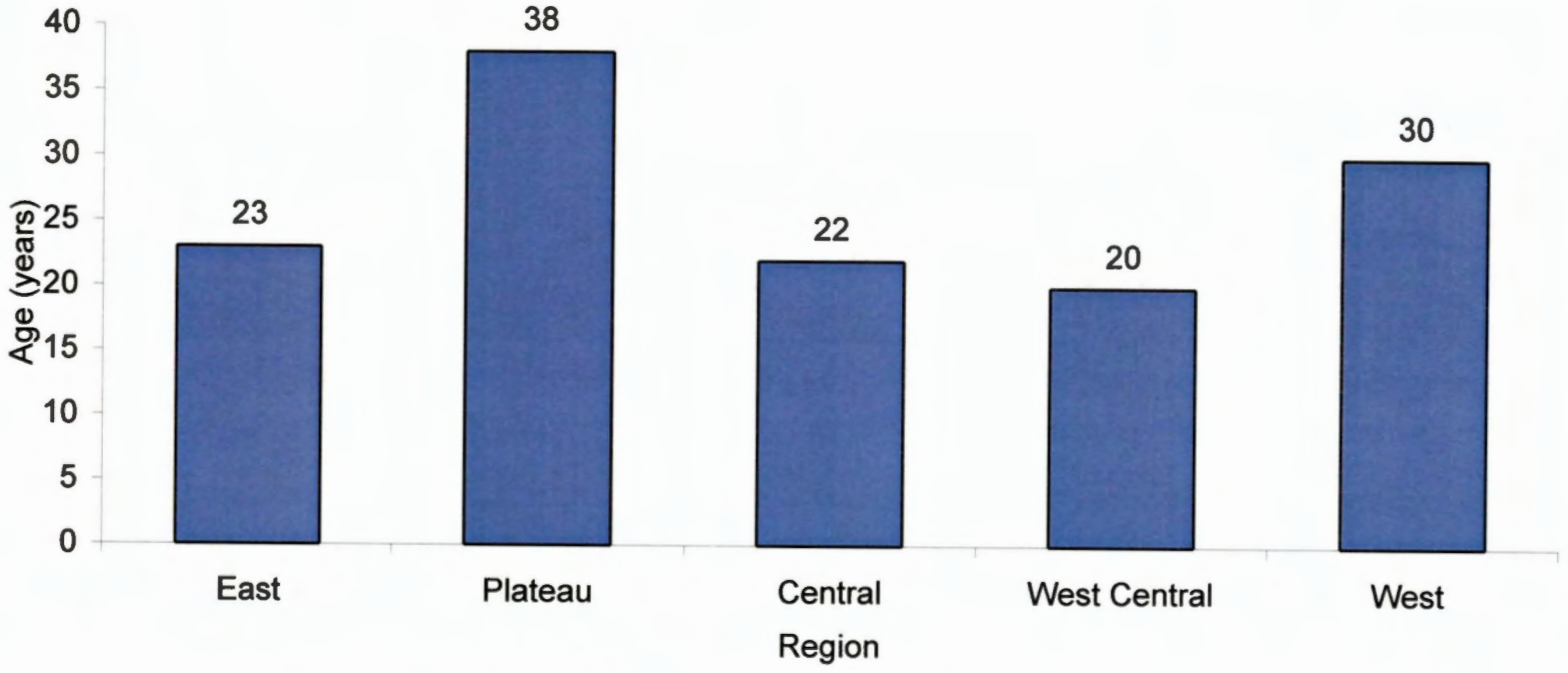


Figure 4.
Average sawmill age in Tennessee among the five geographic regions.

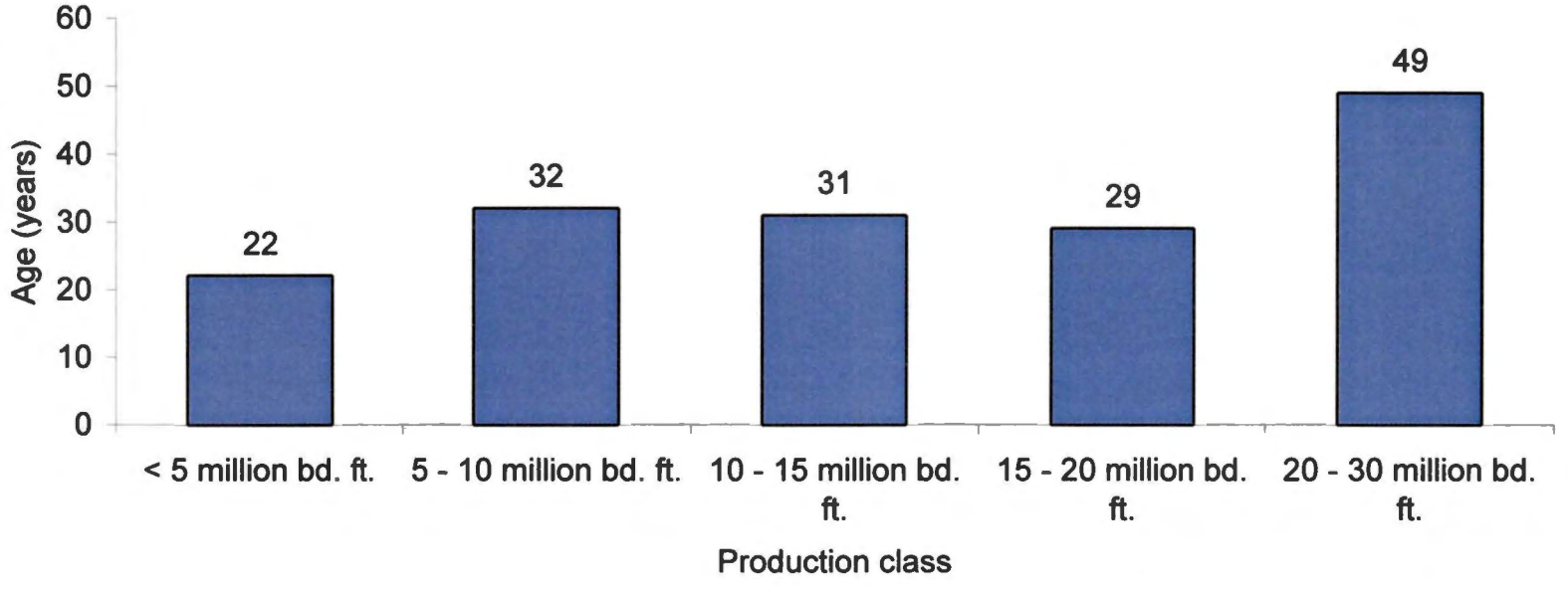


Figure 5. The average age of responding sawmills among production classes.

the ten to fifteen million annual board foot production class, the average was thirty-one. The average age of responding sawmills in the fifteen to twenty million annual board foot production class was twenty-nine. Finally, in the twenty to thirty million annual board foot production class, the average age of responding mills was forty-nine.

Age is a characteristic that may imply industry stability and overall sawmill efficiency. For example, younger sawmills may have more advanced equipment and therefore be more efficient. However, these younger sawmills may not have established reliable, consistent markets for their raw materials supply and for the lumber produced by the sawmill making them more susceptible to fluctuations in those markets. If older sawmills have not upgraded their equipment and facilities, it can be concluded that they would lack the efficiency of the younger sawmills. The older sawmills may have a stronger network of suppliers and have a steady flow of raw materials even if the market is tight. The older mills may have an established sales system as well, allowing them to better withstand market fluctuations.

Current Location

Responding mills reported having been at their current location for an average of twenty-one years, and ranging from fifteen to twenty-six

years among regions (Figure 6). Mills in the East region have been at their current location for an average of twenty years. The mills in the Plateau region have been at their current location for an average of twenty-six years. The sawmills in the Central region average twenty-three years at their current location. The West Central region sawmills average fifteen years at their current location. Finally, sawmills in the West region reported being at their current location for an average of twenty-three years.

Among production classes, mean length of time at the current location ranged from twenty to forty-seven years (Figure 7). The average length of time at the current location of responding sawmills in the under five million annual board foot production class was twenty years. In the five to ten million annual board foot production class, the average length of time at the current location was twenty-three years. For sawmills in the ten to fifteen million annual board foot production class, the average length of time at the current location was twenty-one years. The average length of time at the current location of responding sawmills in the fifteen to twenty million annual board foot production class was twenty. Finally, in the twenty to thirty million annual board foot production class, the average length of time at the current location of responding mills was forty-seven years.

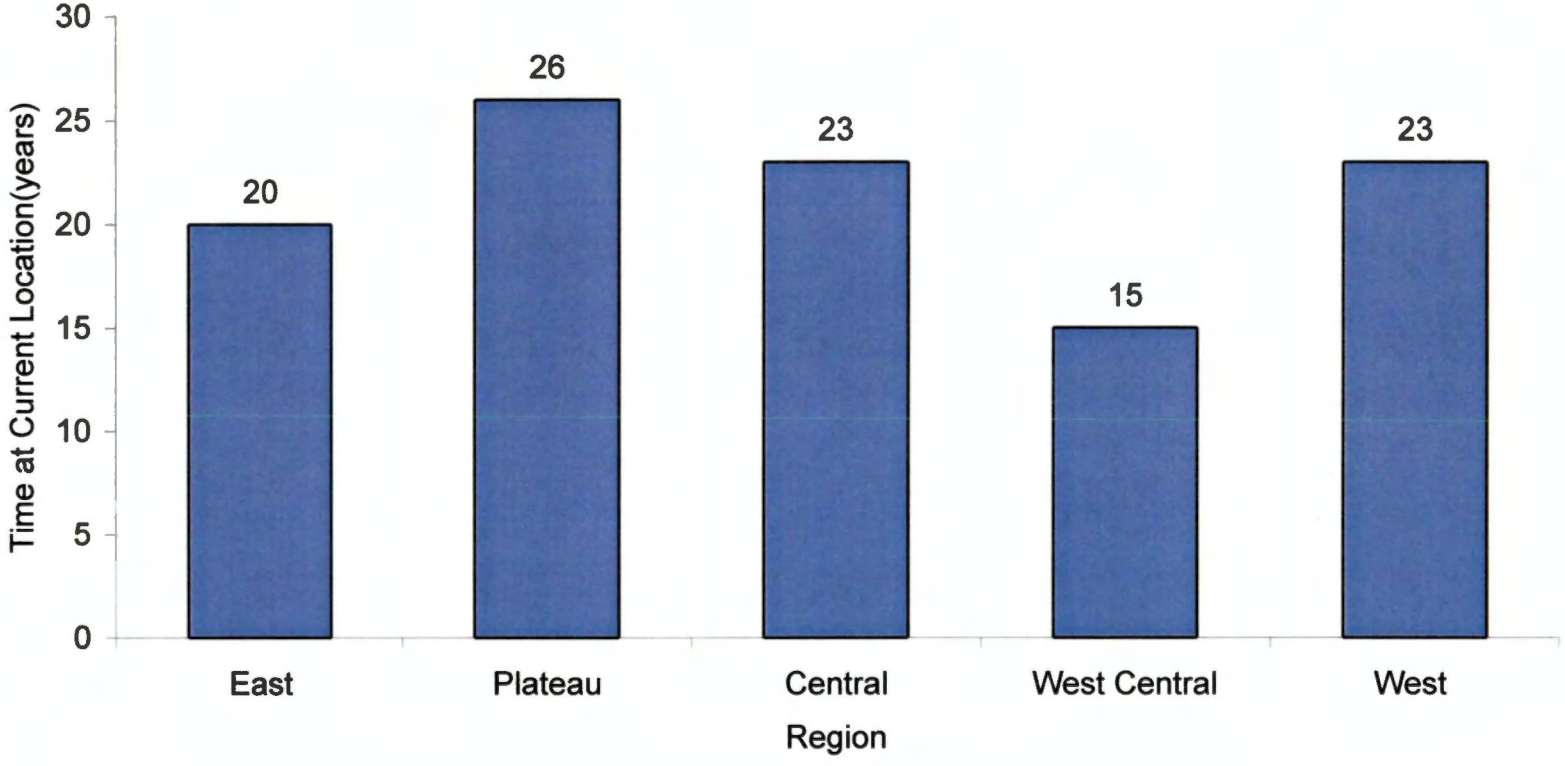


Figure 6. Mean length of time for Tennessee sawmills at their current location.

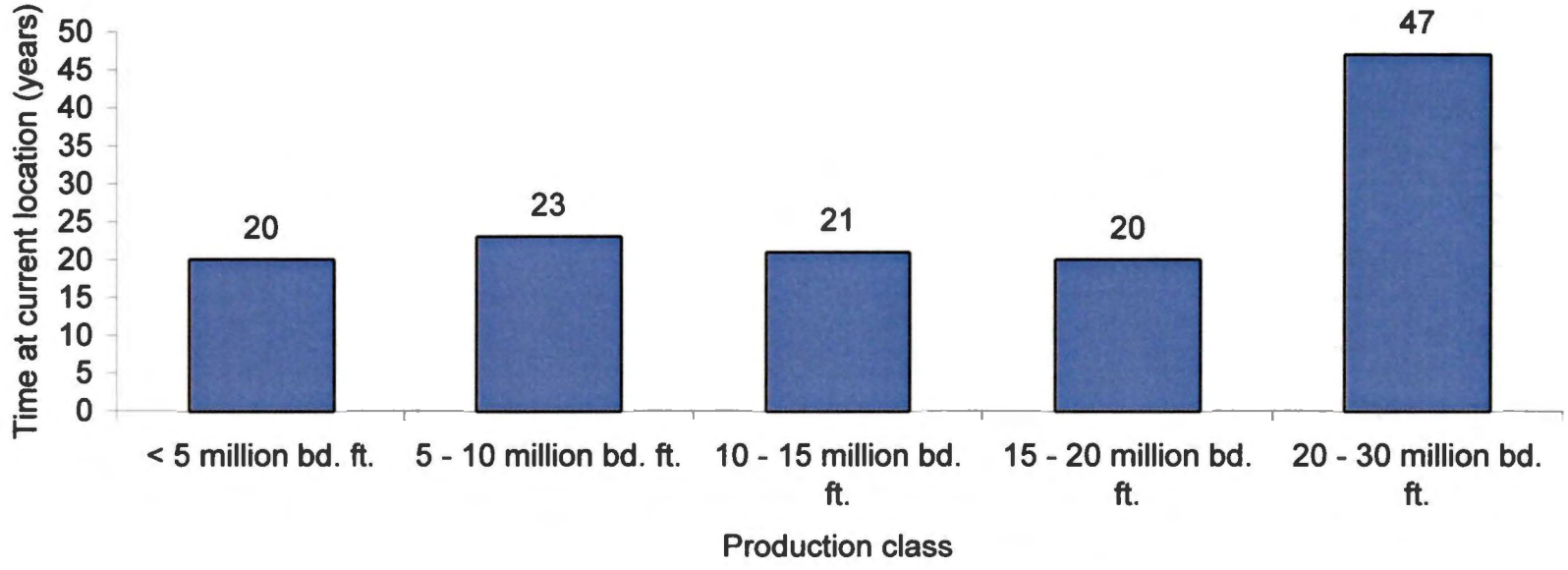


Figure 7. The average length of time at the current location of responding sawmills among production classes.

Fourteen percent of responding sawmills plan to move to a new location in the next ten years. There was no significant difference (P = 0.585) in the number of sawmills that planned to move to a new location in the next ten years among all respondents.

The geographical distribution of responding sawmills that planned to move to a new location ranged from six to fifty percent (Figure 8). There was a significant difference (P = 0.047) in the geographical distribution of sawmills that planned to move to a new location in the next ten years. Fifty percent of sawmills that planned to move to a new location in the next ten years were in the East region. Thirteen percent of responding sawmills who planned to move to a new location were in the Plateau region. Thirteen percent of responding sawmills who planned to move to a new location were in the Central region. Eighteen percent of responding sawmills that planned to move to a new location were in the West Central region. Six percent of responding sawmills who planned to move to a new location were in the West region.

The distribution of sawmills that planned to move to a new location in the next ten years among production classes ranged from zero to seventy-five percent (Figure 9). There was a significant difference (P = 0.046) in the distribution of sawmills that planned to move to a new location in the next ten years among production classes. Seventy-five percent of sawmills that planned to move to a new location were in the

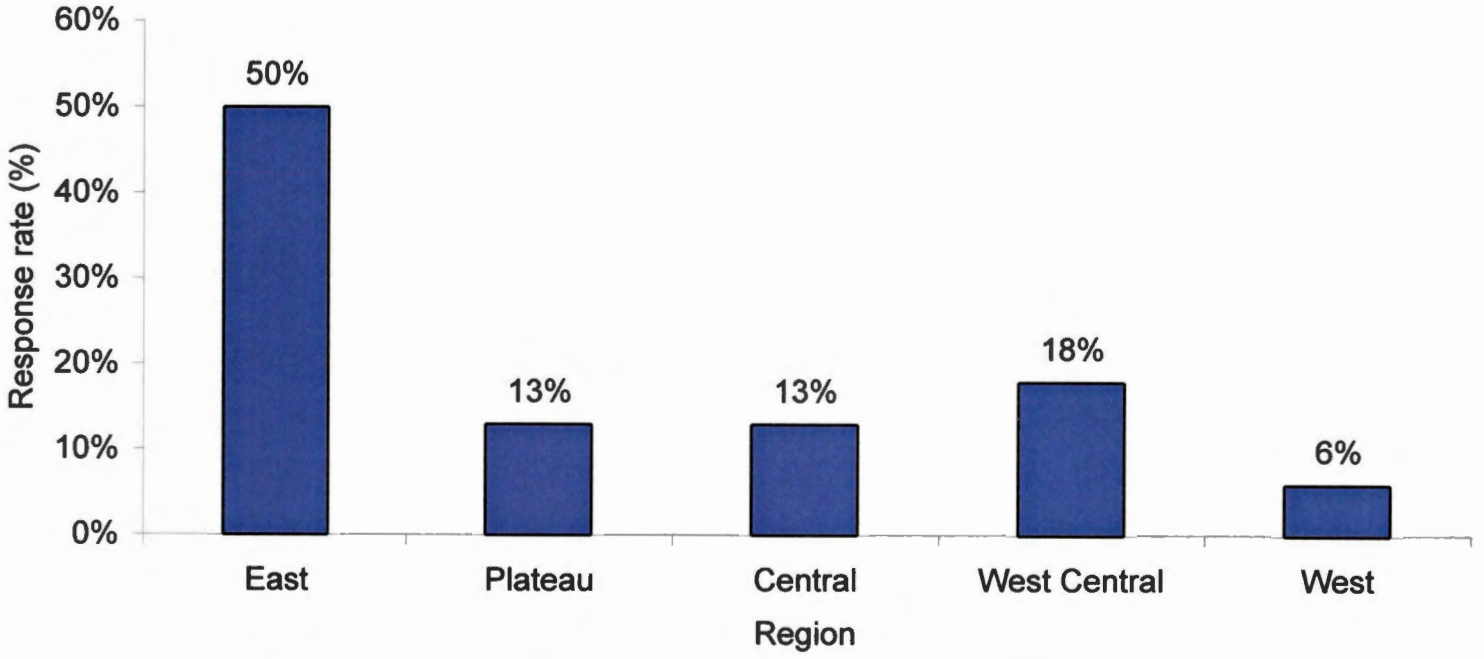


Figure 8. The distribution of sawmills who plan to move to a new location in the next ten years among regions.

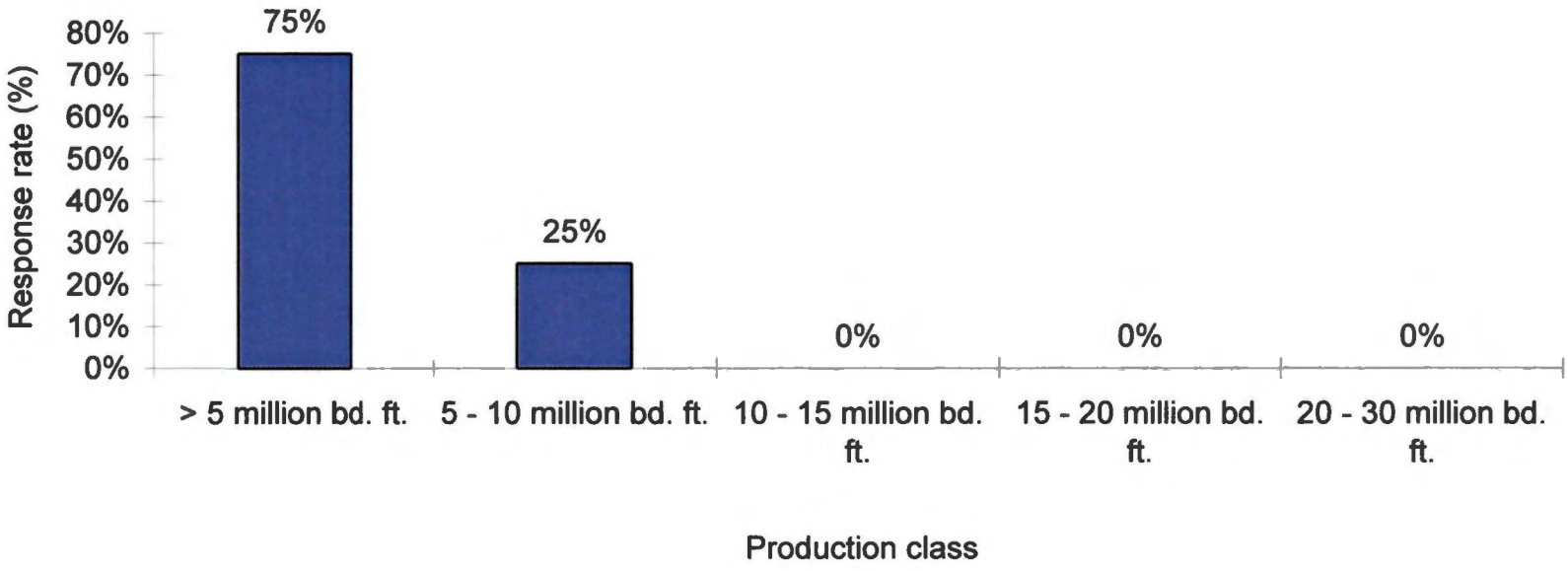


Figure 9. The distribution of responding sawmills who plan to move to a new location in the next ten years among production classes.

less than five million annual board foot production class. Twenty-five percent were in the five to ten million annual board foot production class. There were no sawmills that planned to move to a new location in the next ten years in any other production class.

Twenty-eight percent of responding sawmills planned on closing in the next ten years. There was no significant difference (P = 0.424) in the number of sawmills that planned to close in the next ten years among all respondents.

The geographical distribution of responding sawmills that planned to close ranged from four to thirty-three percent (Figure 10). There was a significant difference (P = 0.035) in the geographical distribution of sawmills that planned to close in the next ten years. Thirty-three percent of sawmills that planned to close in the next ten years were in the East region. Eleven percent of sawmills planning to close were in the Plateau region. Eight percent were in the Central region. Four percent of responding sawmills that planned to close were in the West Central region. Sixteen percent were in the West region.

The distribution of sawmills that planned to close in the next ten years among production classes ranged from zero to seventy-five percent (Figure 11). There was a significant difference (P = 0.001) in the distribution of sawmills that planned to close in the next ten years among production classes. Seventy-five percent of sawmills that planned to

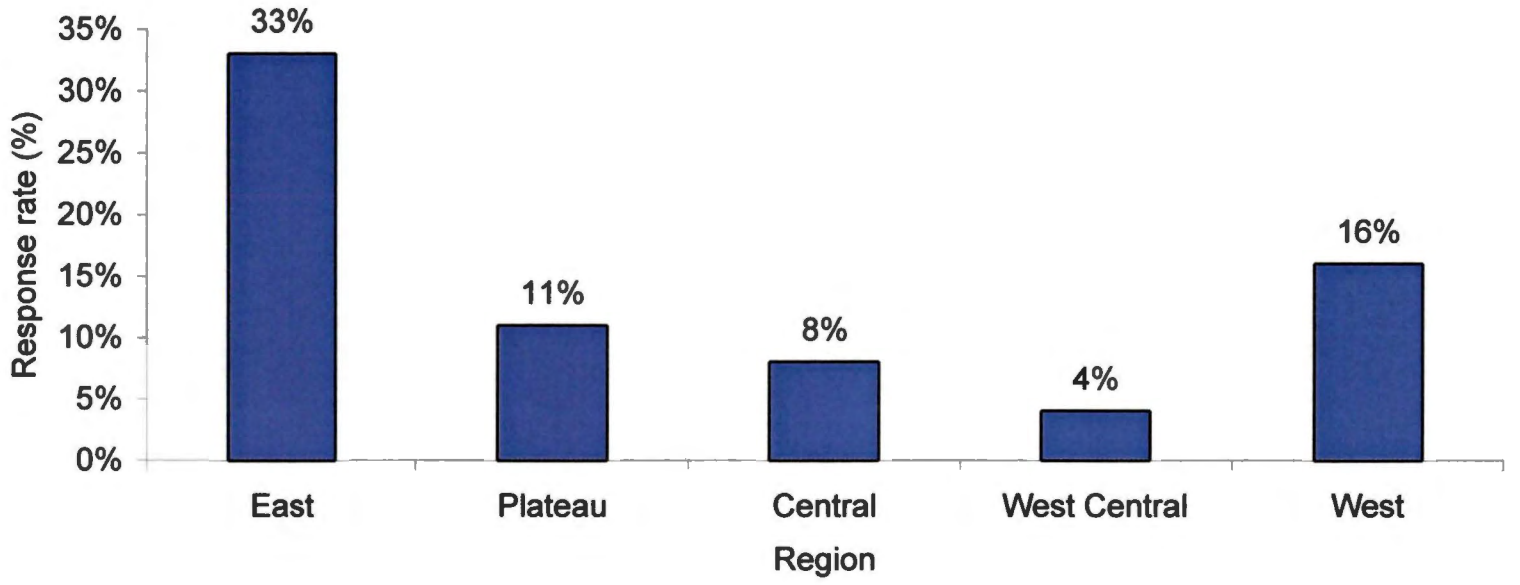


Figure 10. The distribution of responding sawmills who reported planning to close in the next ten years.

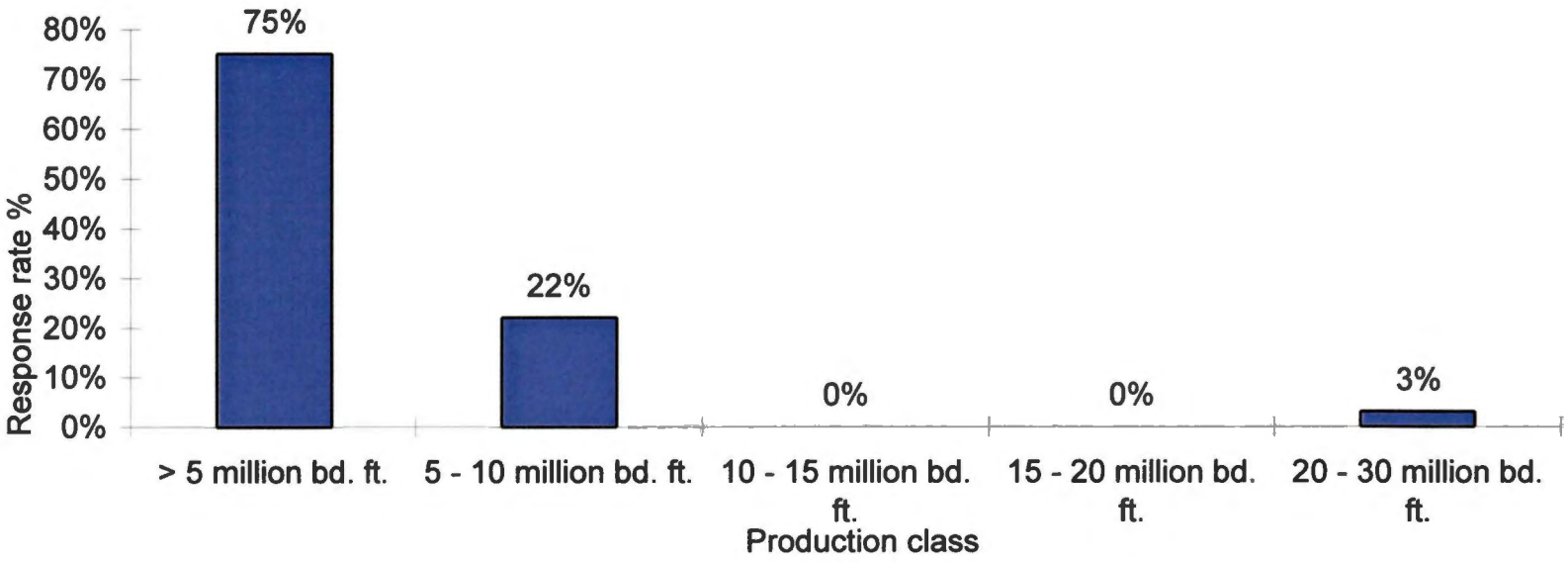


Figure 11. The distribution of responding sawmills that will close in the next ten years among production classes.

close were in the less than five million annual board foot production class. Twenty-two percent were in the five to ten million annual board foot production class. There were no sawmills that planned to close in the next ten years in ten to fifteen and the fifteen to twenty million annual board foot production classes. Three percent of responding sawmills that planned to close in the next ten years were in the twenty to thirty million annual board foot production class.

Combining location information with the average ages in each region, it is possible to make several interpretations about stability within the state's hardwood sawmill industry. Sawmills in the East region are younger than those in the Plateau and West regions and have the second shortest average length of time at their current location. Combining this information with the highest rate of sawmill closure shows that sawmills in the East region are the most unstable in the state. The West Central region appears to be similar to the East region in these areas, however, the West Central region has the lowest reported rate of sawmill closure indicating growth rather than instability. Data did not indicate instability in the Plateau, Central, or West regions.

Type of company

Private corporations comprised forty-six percent of the total number of responding sawmills, and were the most common type of company reported. Both proprietorships and partnerships each totaled twenty-three percent of the total number of responding sawmills. Three percent of responding sawmills classified themselves as public corporations, and five percent classified themselves as other (Figure 12).

Each region had a unique distribution of company types reported by responding sawmills (Table 2). However, there was no significant difference (P = 0.821) in the type of companies reported by responding sawmills across the five geographic regions.

Each of the five production classes had a unique distribution of company types reported by responding sawmills (Table 3). However, there was no significant difference (P = 0.073) in the type of companies reported by responding sawmills across the five production classes.

Sawmill type

Eighty-one percent of sawmills that responded to the Tennessee Hardwood sawmill profile were stationary sawmills and nineteen percent

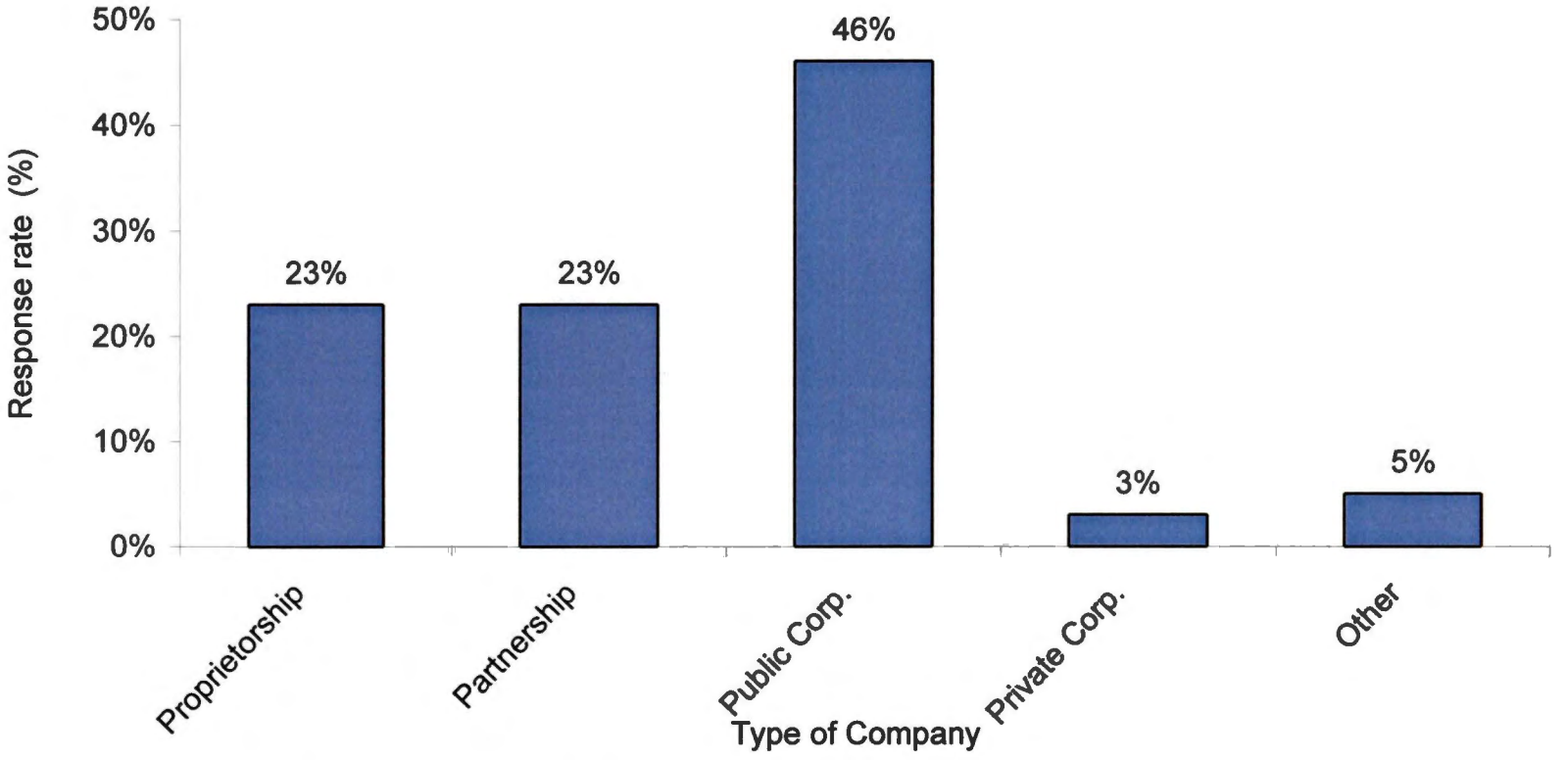


Figure 12. The distribution of responding sawmills among company type.

Table 2. The regional distribution of company types.

			Region			
Type of Company	**East**	**Plateau**	**Central**	**West Central**	**West**	**Total**
Proprietorship	7%	3%	6%	6%	1%	23%
Partnership	7%	2%	4%	5%	5%	23%
Public Corporation	0%	1%	1%	1%	0%	3%
Private Corporation	7%	10%	9%	8%	12%	46%
Other	0%	2%	2%	1%	0%	5%
Total	21%	18%	22%	21%	18%	100%

Table 3. The distribution of company types among production classes.

			Region			
Type of Company	**<5 million bd. ft**	**5 - 10 million bd. ft.**	**10 - 15 million bd. ft.**	**15 – 20 million bd. ft.**	**20 – 30 million bd. ft.**	**Total**
Proprietorship	19%	4%	0%	0%	0%	23%
Partnership	17%	4%	1%	1%	0%	23%
Public Corporation	3%	0%	0%	0%	0%	3%
Private Corporation	23%	12%	5%	3%	3%	46%
Other	5%	0%	0%	0%	0%	5%
Total	67%	20%	6%	4%	3%	100%

were portable sawmills (Figure 13). There was a significant difference (P = 0.001) in the type of sawmill reported by all respondents.

Figure 14 shows the regional distribution of sawmill type among responding sawmills. There was no significant difference (P = 0.821) in the regional distribution of sawmill type.

Figure 15 shows the distribution of sawmill type among production classes for all responding sawmills. There was no significant difference (P = 0.821) in the distribution of sawmill type by annual board foot production categories.

Portable sawmills have minimal influence on the state's total board foot production. These sawmills are usually run by an individual as a hobby or secondary income source.

Access to information

It is very important for sawmills to have access to the current information and technical assistance. It was not surprising to find that the greatest number of sawmills turned to each other and equipment manufactures for assistance. These firms are best suited to put leading information into practical industry applications. The other agencies listed in the survey are government and trade organizations more apt to provide research and service oriented materials.

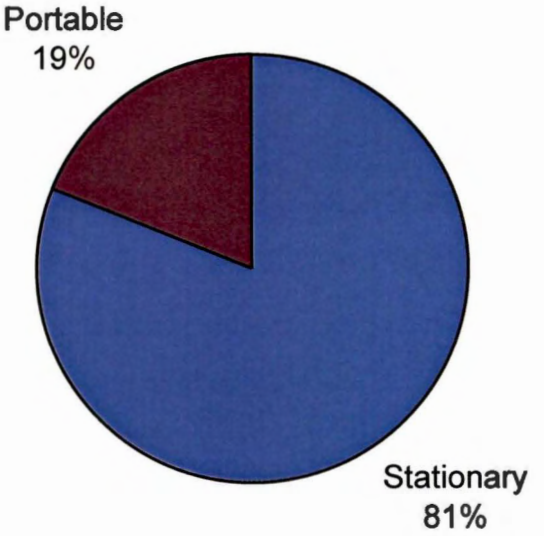


Figure 13. The distribution of the sawmill type among all responding sawmills.

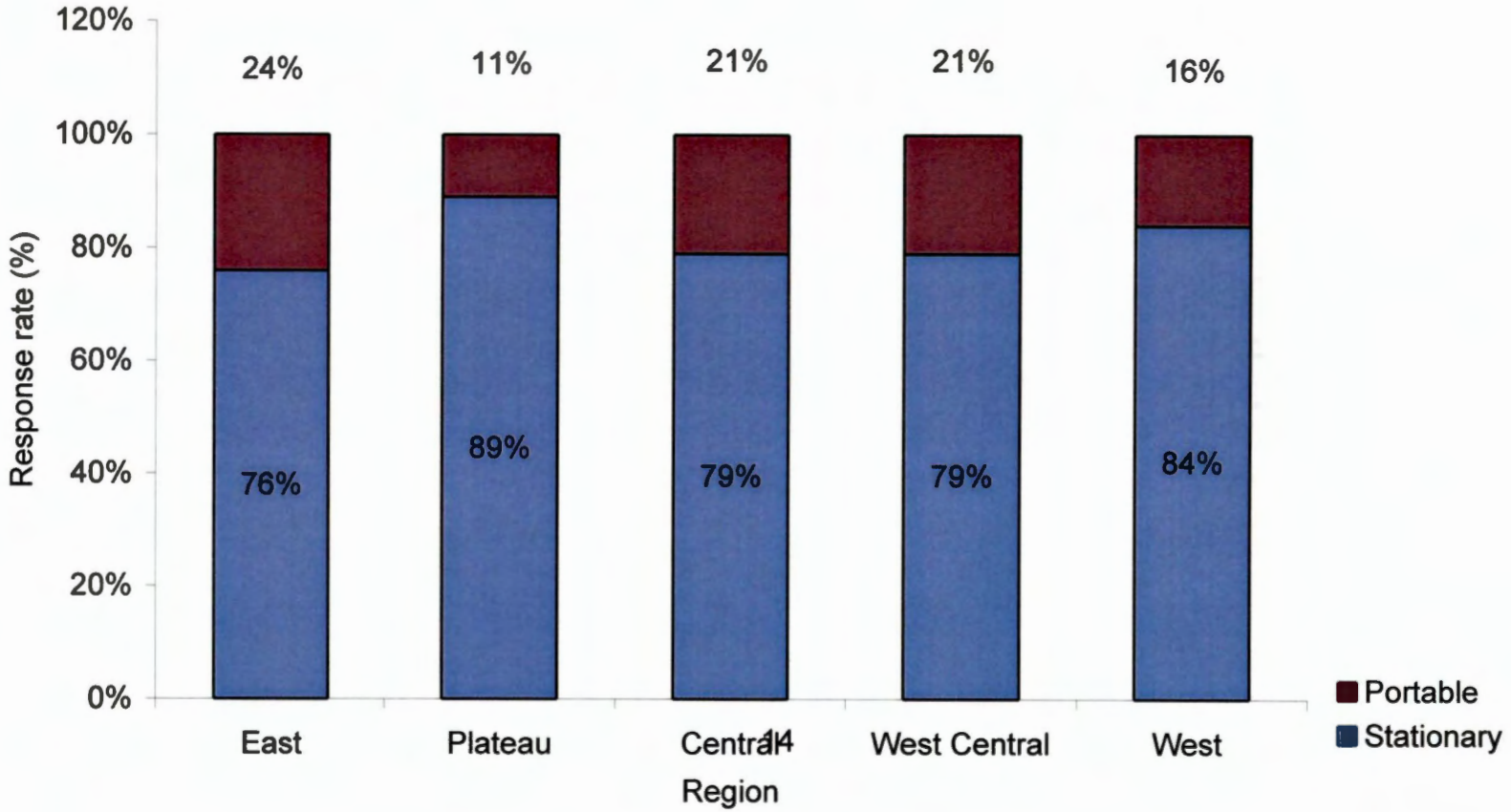


Figure 14. Mill classification as either portable or stationary.

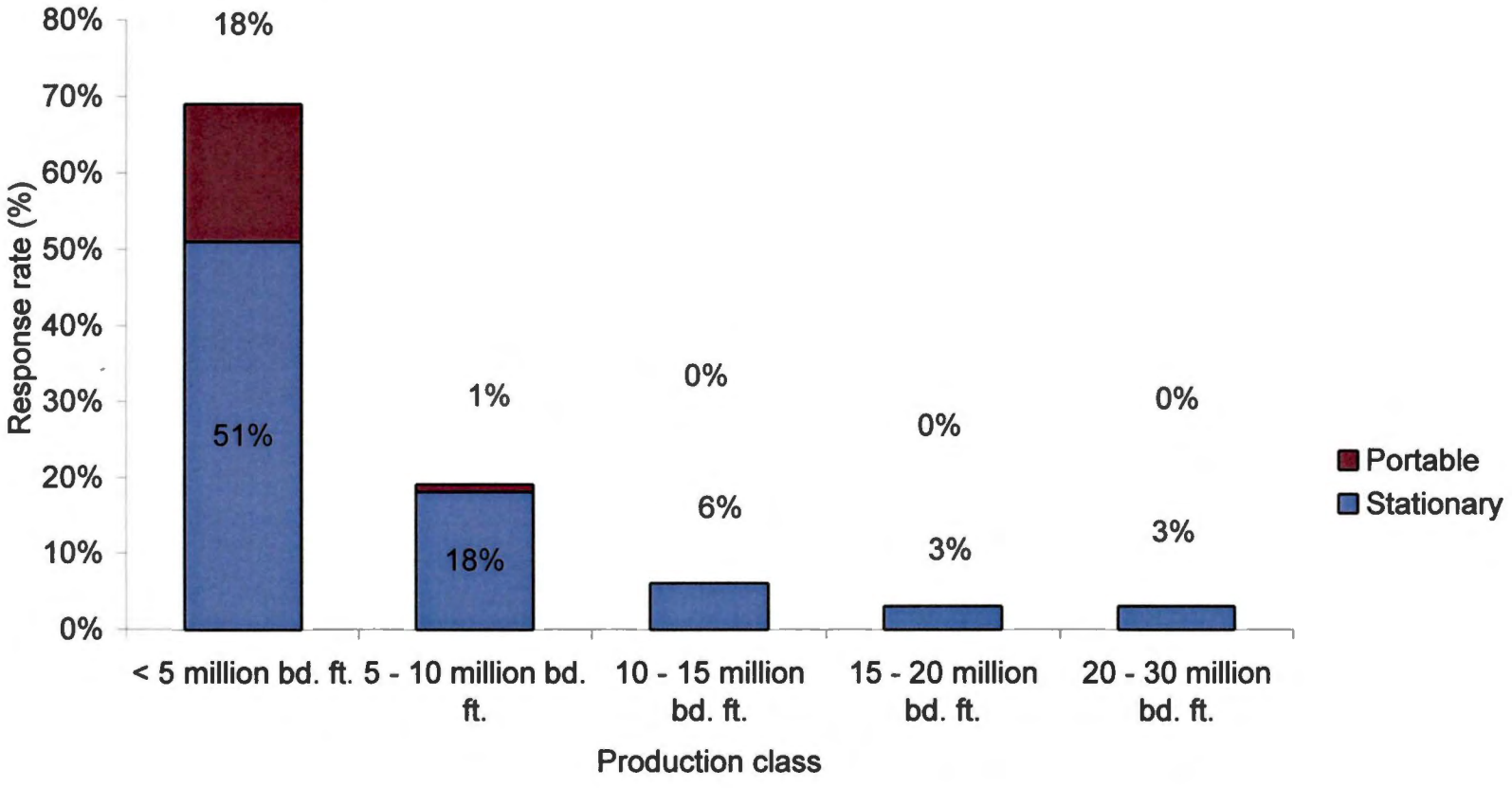


Figure 15. The distribution of sawmill type by production classes.

There were several questions in the Tennessee Hardwood Sawmill Profile designed to gather information about how mills access information and whom they contact for solutions when problems arise. Fifty percent of all responding sawmills reported contacting other mills to help solve problems. Fifty percent of sawmills reported contacting equipment manufactures for assistance. Sixteen percent of responding sawmills contacted someone other than those specified in the Tennessee Hardwood Sawmill Profile. Fourteen percent of responding sawmills contacted consultants. Ten percent contacted the National Hardwood Lumber Association. Ten percent contacted the Tennessee Forestry Association for assistance in solving problems. Ten percent contacted the Tennessee Division of Forestry. Two percent contacted The Tennessee Forest Products Center. Two percent of responding sawmills contacted the USDA Forest Products Laboratory for assistance. One percent of responding sawmills reported contacting The University of Tennessee for assistance (Figure 16).

As the internet continues to expand into the hardwood sawmill industry, sawmills will have easier access to all types of information needed to make a variety of decisions regarding their business. Websites can give them a direct link to their customers and may open up new markets for products and enhance material exchanges.

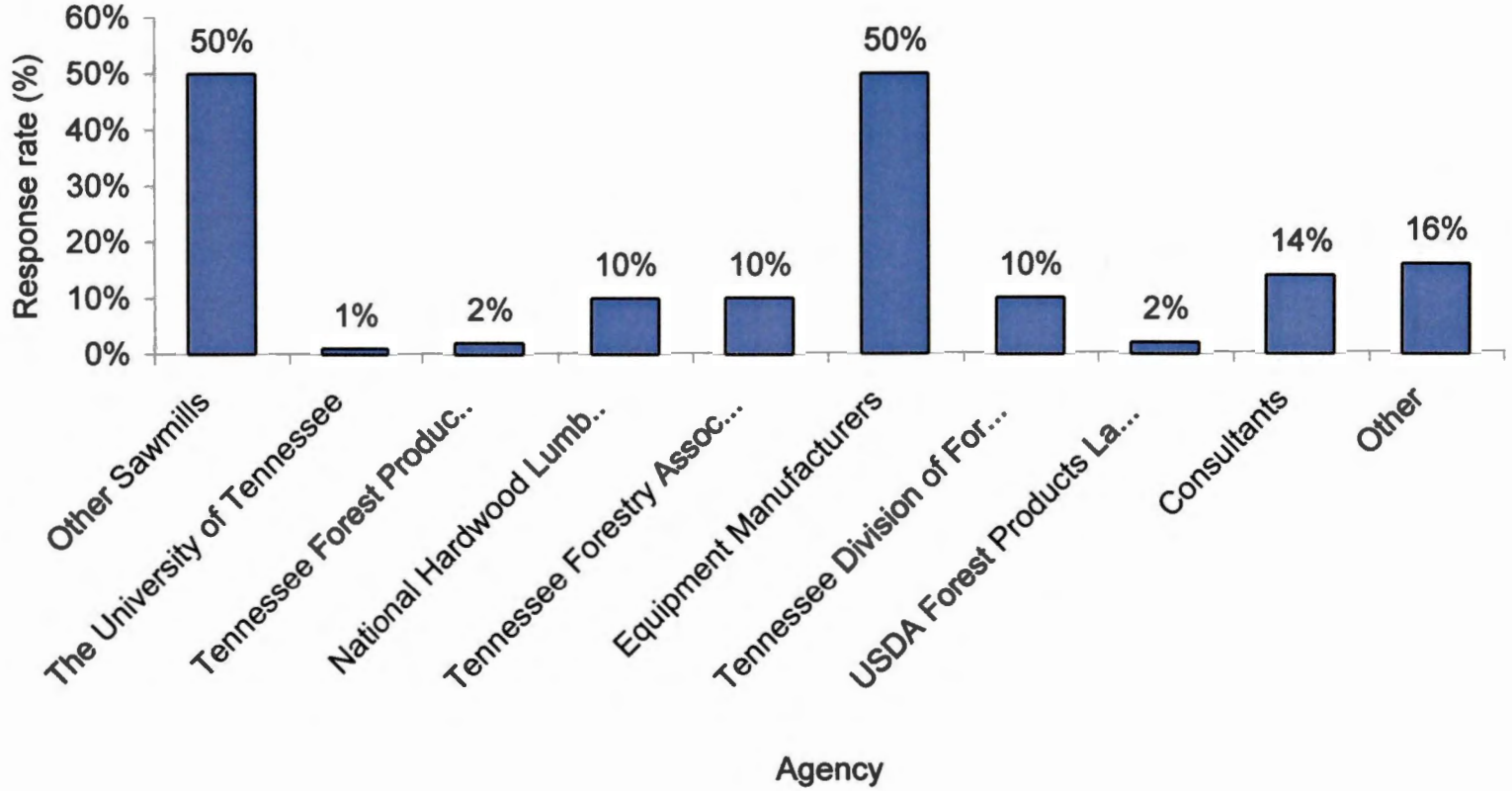


Figure 16. The distribution of who responding mills contact for assistance.

Thirty percent of the total number of responding sawmills reported to have access to the internet. Regionally, the number of sawmills that had access to the internet ranged from sixteen to forty-six percent (Figure 17). There was no significant difference (P = 0.182) in the regional distribution of sawmills with internet access. Sixteen percent of responding sawmills in the Eastern region had internet access. Twenty-one percent of sawmills in the Plateau region had internet access Thirty-eight percent of responding sawmills in the Central region had access to the internet. Forty-six percent of the sawmills in the West Central region had internet access. Finally, of the responding sawmills in the West, twenty-six percent had internet access.

Among the five production classes, the number of responding sawmills that reported having internet access ranged from twenty-nine to seventy-five percent (Figure 18). There was a significant difference (P = 0.001) in whether responding sawmills had access to the internet among production classes; the sawmills with greater annual levels of production had a proportionally greater number of mills with internet access. Twenty-nine percent of sawmills that produced less than five million board feet of lumber annually had access to the internet. In the five to ten million annual board foot production class, twenty-nine percent had access to the internet. Twenty-nine percent of sawmills in the ten to fifteen million annual board foot production class had internet access.

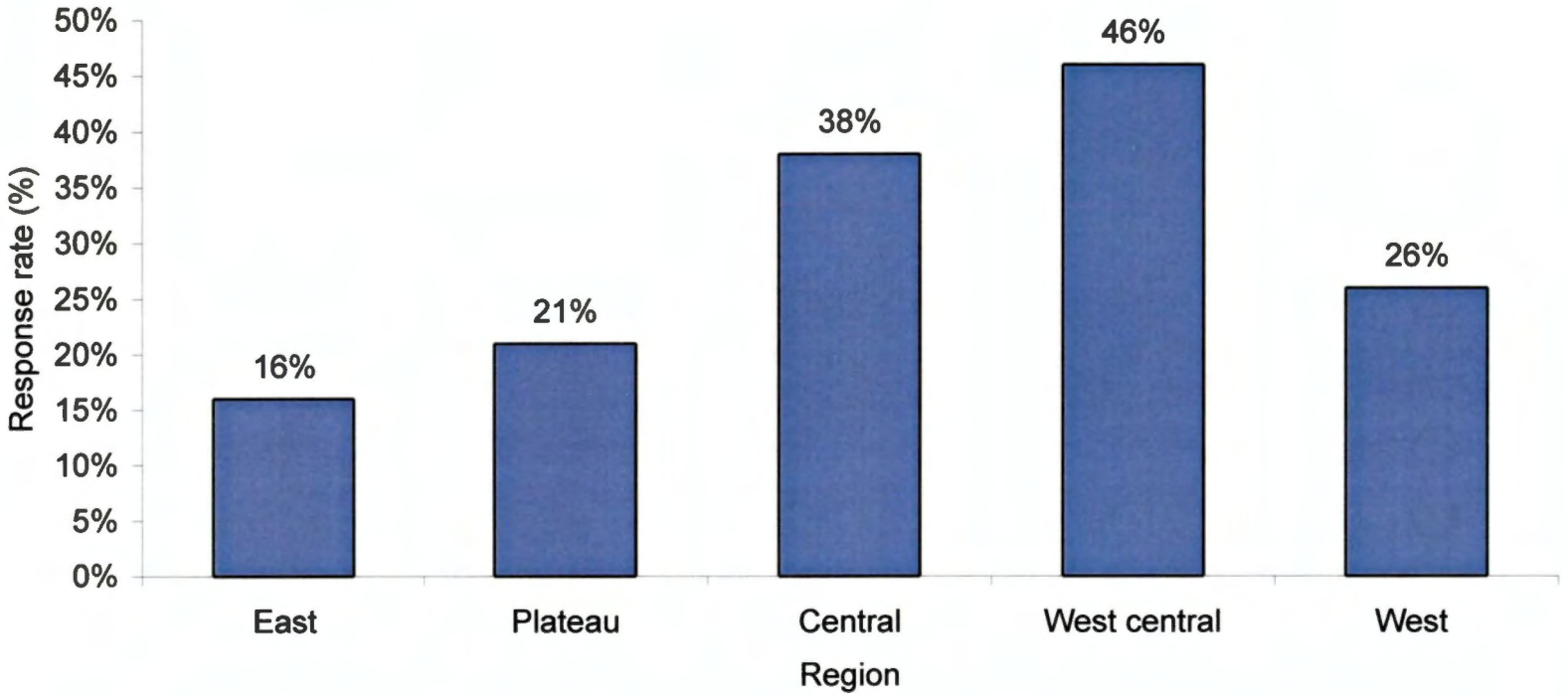


Figure 17. The distribution of responding sawmills with internet access among regions.

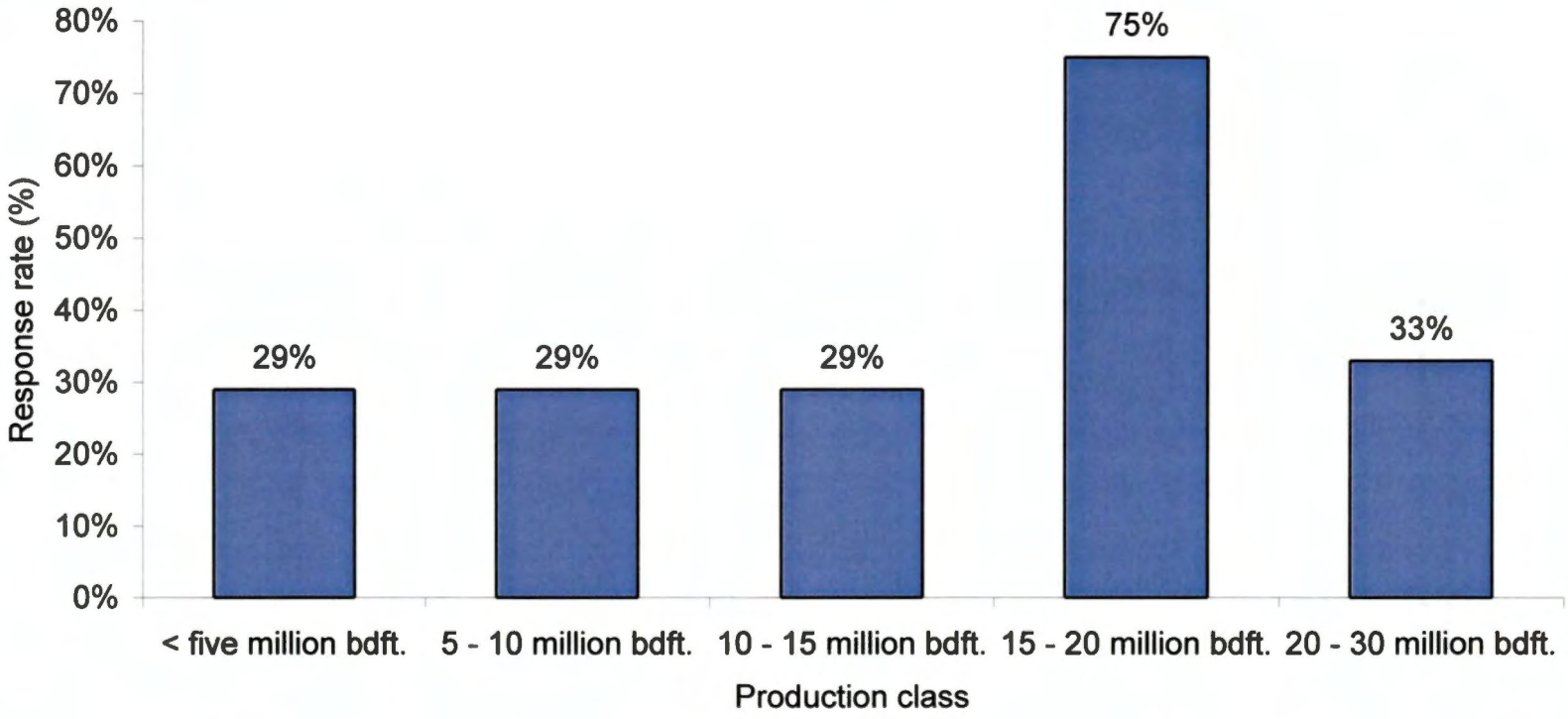


Figure 18. The distribution of responding sawmills with internet access among production classes.

Seventy-five percent of responding sawmills in the fifteen to twenty million annual board foot production class had access to the internet. Finally, thirty-three percent of sawmills in the twenty to thirty million annual board foot production class had internet access. A much larger portion of sawmills in the fifteen to twenty million annual board foot production class reported having internet access than in the other four production classes.

Ten percent of sawmills who responded to the survey have a website. The regional distribution of the number of responding sawmills with a website ranged from zero to sixteen percent (Figure 19). There were no responding sawmills in the East region with a website. In the Plateau region, eleven percent of responding sawmills had a website. Seventeen percent of sawmills who responded in the Central region had a website. In the West Central region, eight percent of responding sawmills had a website. Sixteen percent of sawmills in the West region had a website. There was no significant difference ($P = 0.801$) among regions of responding sawmills with a website.

The number of responding sawmills with a website among production classes ranged from zero to twenty-five percent (Figure 20). There was no significant difference ($P = 0.200$) in whether a responding sawmill had a website among production classes. Six percent of sawmills who produced less than five million board feet of lumber annually had a website. In the five to ten million annual board foot production class, nineteen percent

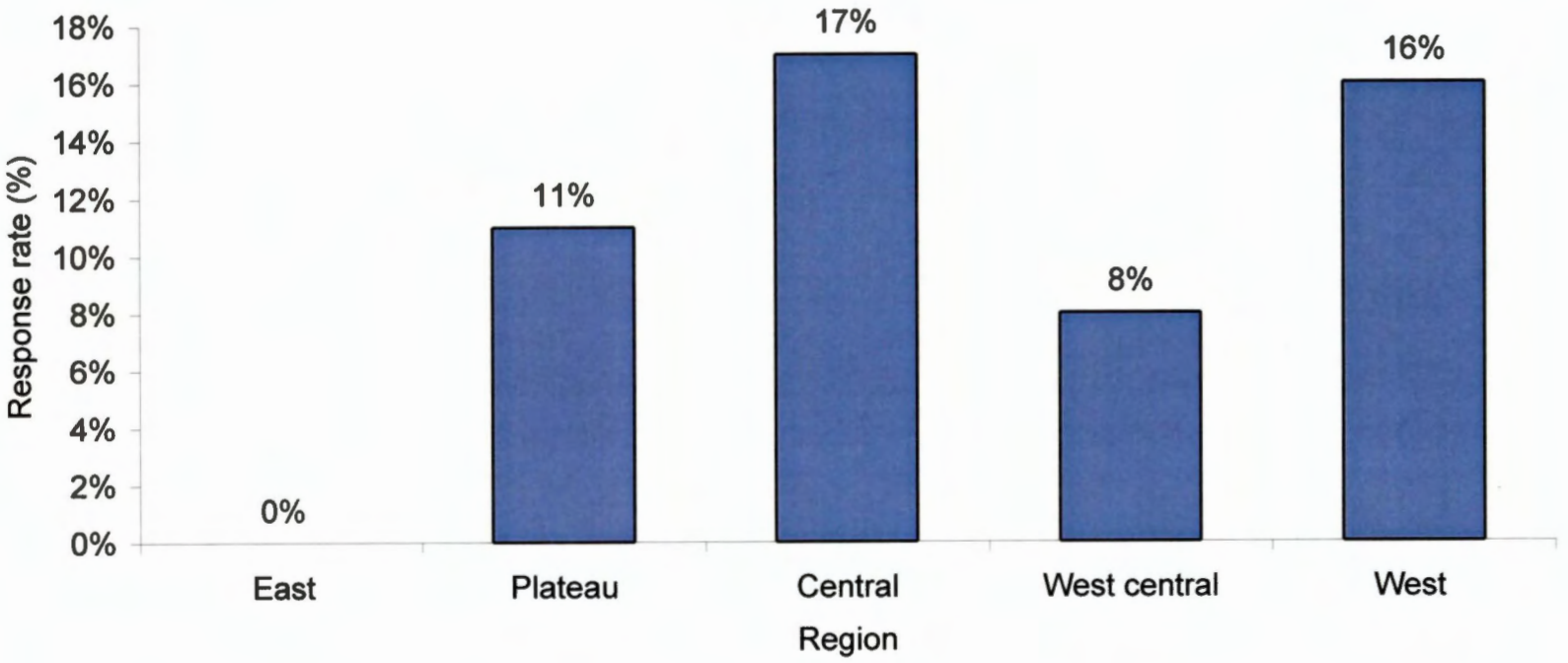


Figure 19. The distribution of responding sawmills with a website among regions.

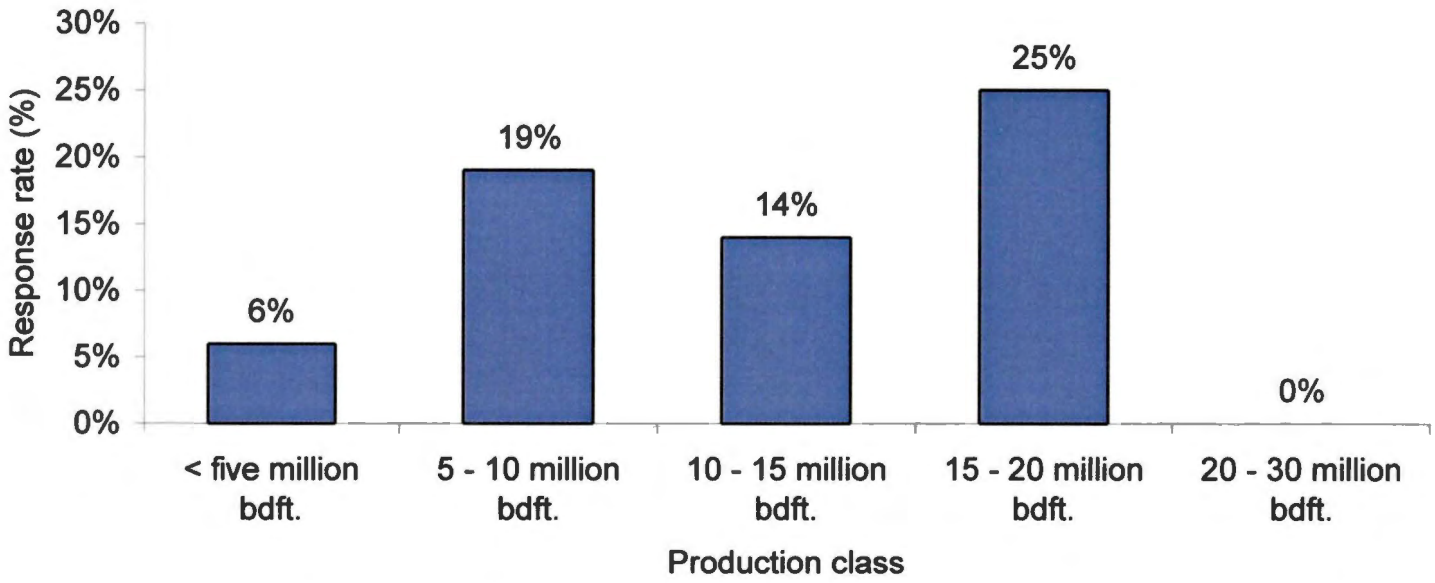


Figure 20. The distribution of responding sawmills with a website among production classes.

had a website. Fourteen percent of sawmills in the ten to fifteen million annual board foot production class had a website. Twenty-five percent of responding sawmills in the fifteen to twenty million annual board foot production class had a website. Finally, no sawmill in the twenty to thirty million annual board foot production class had a website.

Vertical integration

Defined as the move into new functions by a business, vertical integration can be very important to many mills. By having control of the price and supply of raw materials, mills create a more stable flow of capital, and have greater awareness of market fluctuation.

Vertical integration can help mills control their raw materials supply. During times when the log market is tight, those firms who own timberland can use these lands to supplement their flow of incoming logs ensuring a constant supply. Forty-five percent of responding sawmills reported owning timberland in Tennessee and were relatively evenly distributed (P = 0.493) among the five geographic regions (Figure 21).

There was a statistical difference (P = 0.001) in sawmills that owned timberland among production volume classes. A proportionately larger number of sawmills in the highest volume production class, those sawmills who produce between twenty and thirty million board feet per year, reported owning timberland (Figure 22).

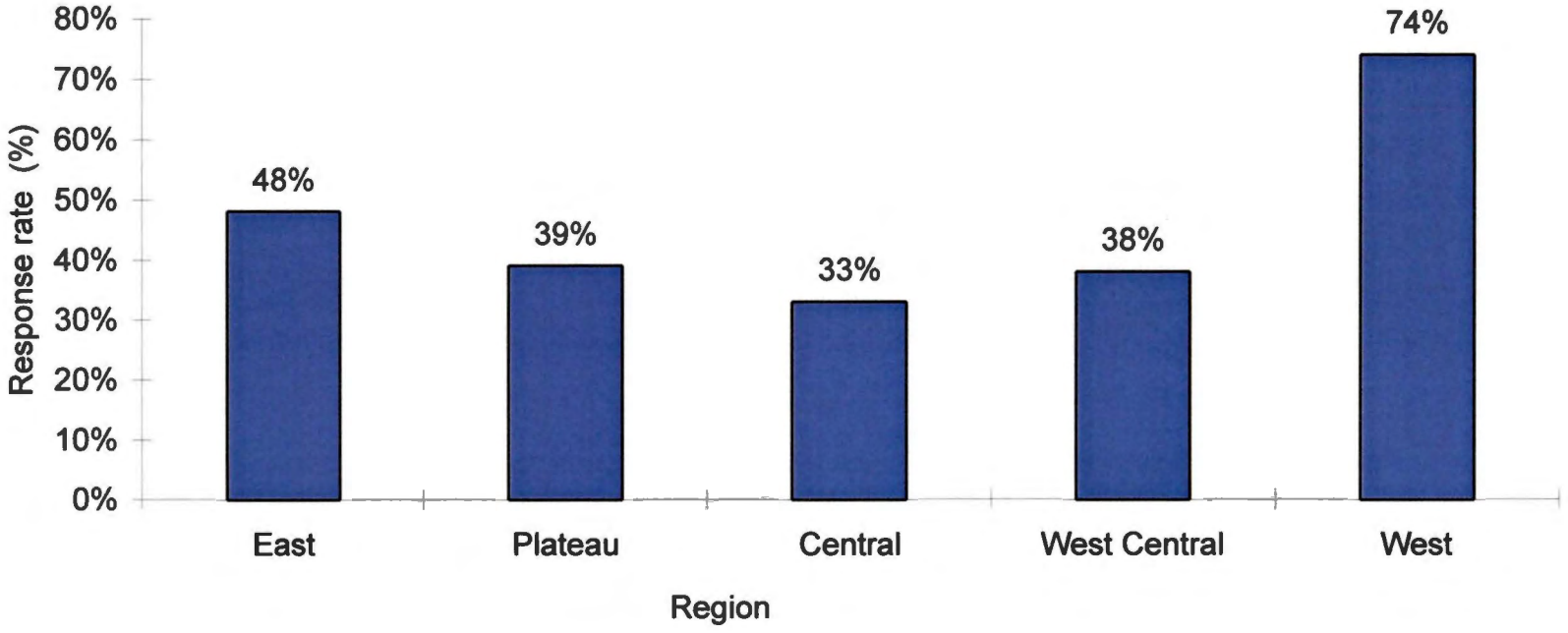


Figure 21. The distribution of responding sawmills that own timberland among regions.

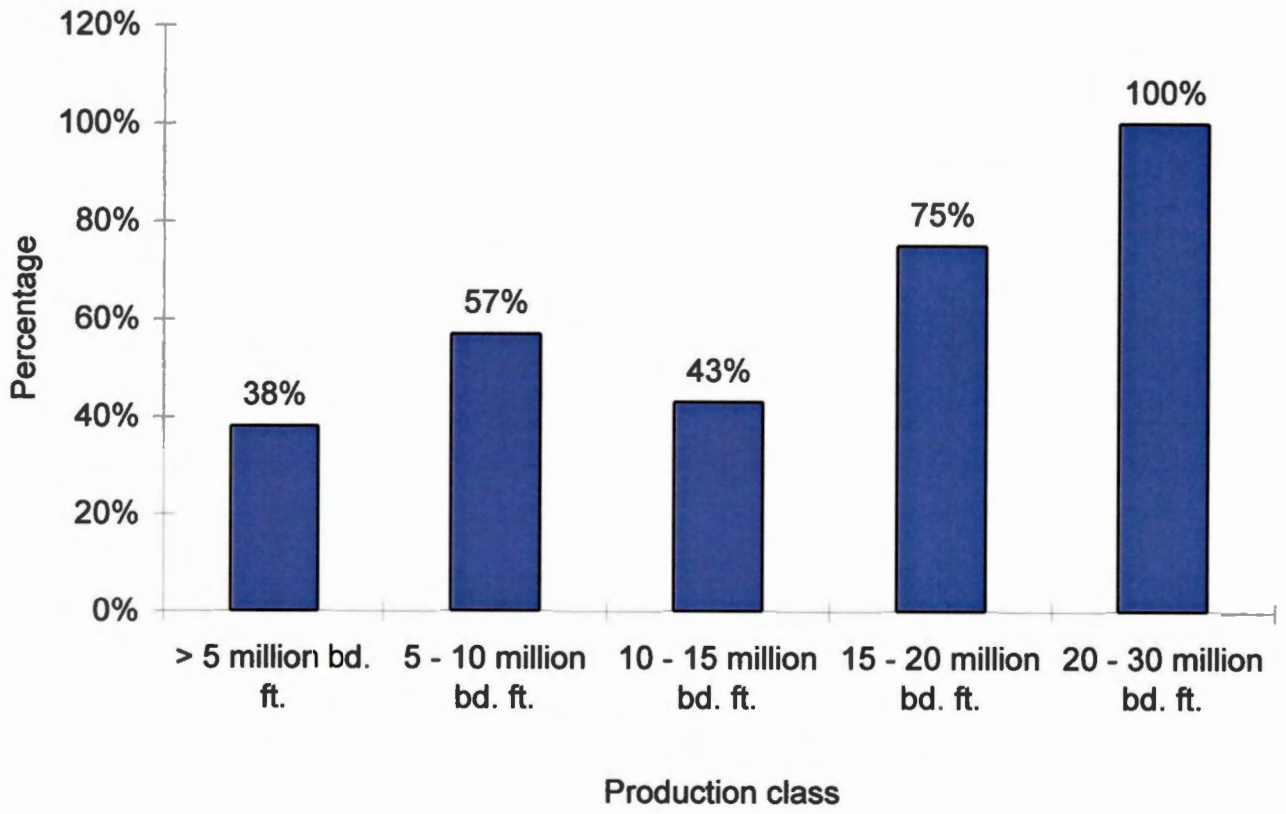


Figure 22. The disrtibution of responding sawmills that own timberland among production classes.

A second type of vertical integration addressed in the Tennessee Hardwood Sawmill Profile was logging operation ownership. The stabilization of log prices can occur through ownership of a logging operation. Twenty-six percent of the responding sawmills reported owning a logging operation. As with timberland ownership, the ownership of a logging operation was relatively evenly distributed among the five geographic regions (Figure 23). A proportionately larger number of sawmills in the higher volume production classes reported owning a logging operation (Figure 24).

1. EMPLOYMENT

Full-time Employment

The analysis of statewide employment distribution of responding hardwood sawmills shows eleven percent had no full-time employees. Forty-six percent of responding sawmills had one to ten full-time employees. Nineteen percent of responding sawmills had eleven to twenty full-time employees. Seven percent of responding sawmills had twenty-one to thirty full-time employees. Four percent of responding

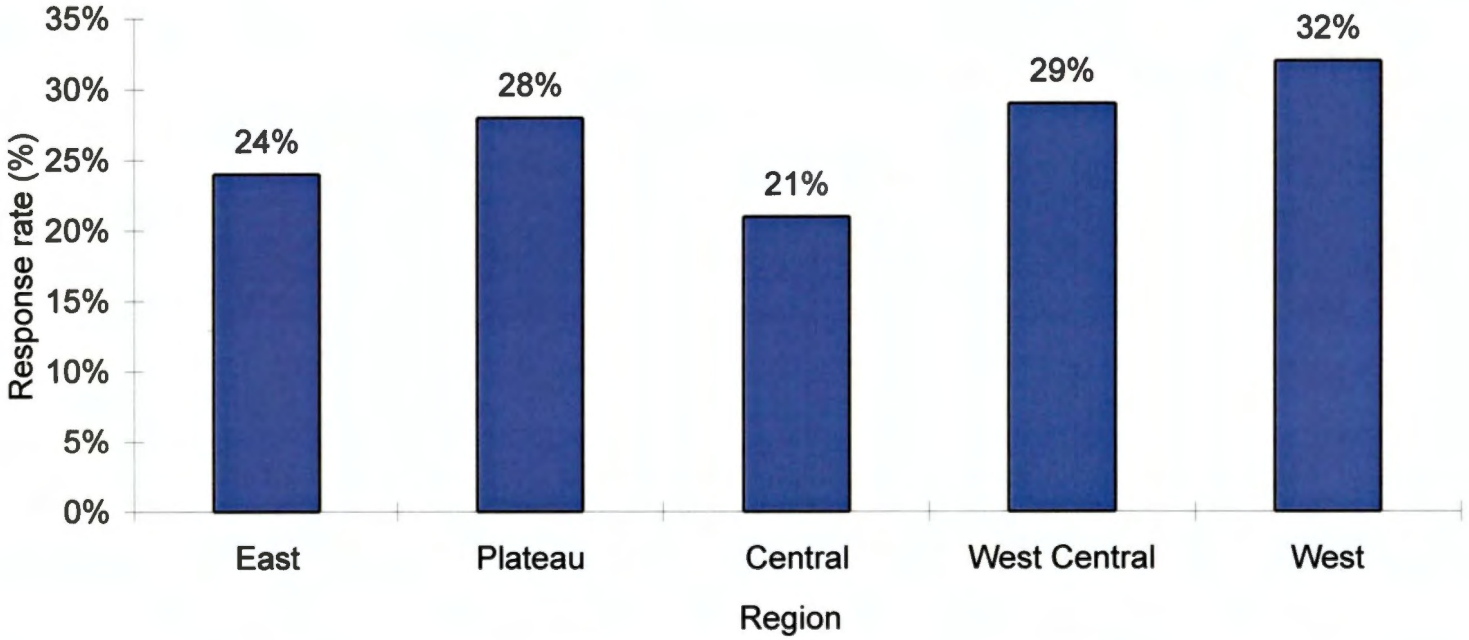


Figure 23. The distribution of responding sawmills who own a logging operation among regions.

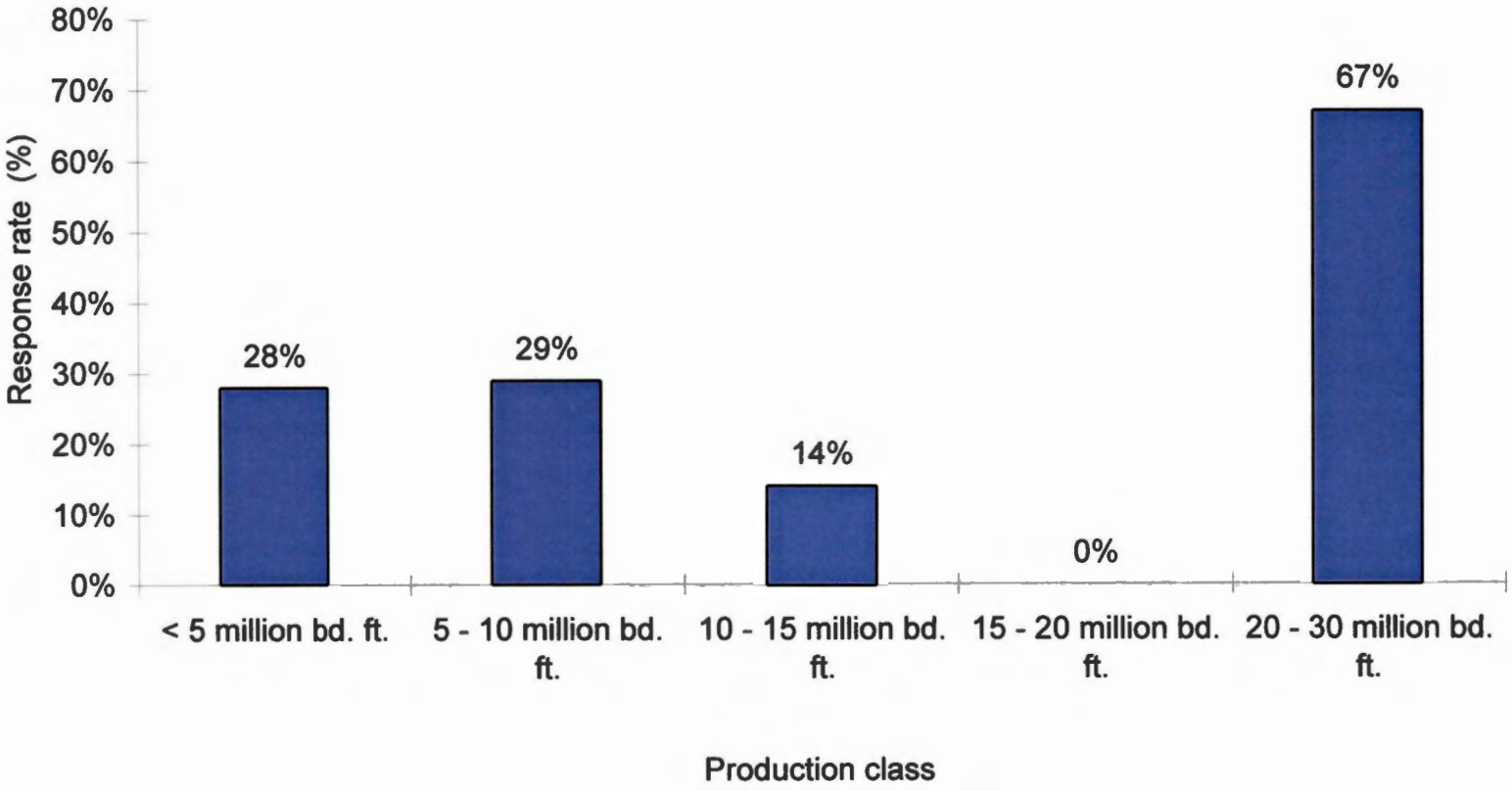


Figure 24. The distribution of responding sawmills that own a logging operation among production classes.

sawmills had thirty-one to forty full-time employees. Five percent of responding sawmills had forty-one to fifty full-time employees. Four percent of responding sawmills reported fifty-one to sixty full-time employees. Four percent of responding sawmills have greater than sixty full-time employees. The distribution of responding sawmills by employment categories is shown in Figure 25. There was a significant difference (P = 0.001) in the number of employees reported by responding sawmills.

The number of full-time employees ranged from zero to ten percent (Table 4). There was no significant difference (P = 0.237) in the number of full-time employees among regions. The number of full-time employees among the five production categories ranged from zero to thirty percent (Table 5). There was a significant difference (P = 0.001) in the number of employees reported by responding sawmills among the five production categories.

The variation in the number of the full-time employees among the five production classes is an indication of efficiency. Among individual production classes, the sawmills with fewer employees should be the most efficient, with the ability to produce the same approximate amount of lumber with a much lower labor cost.

When production levels and employment statistics were crossed with the number of shifts a sawmills runs, data showed that as the number

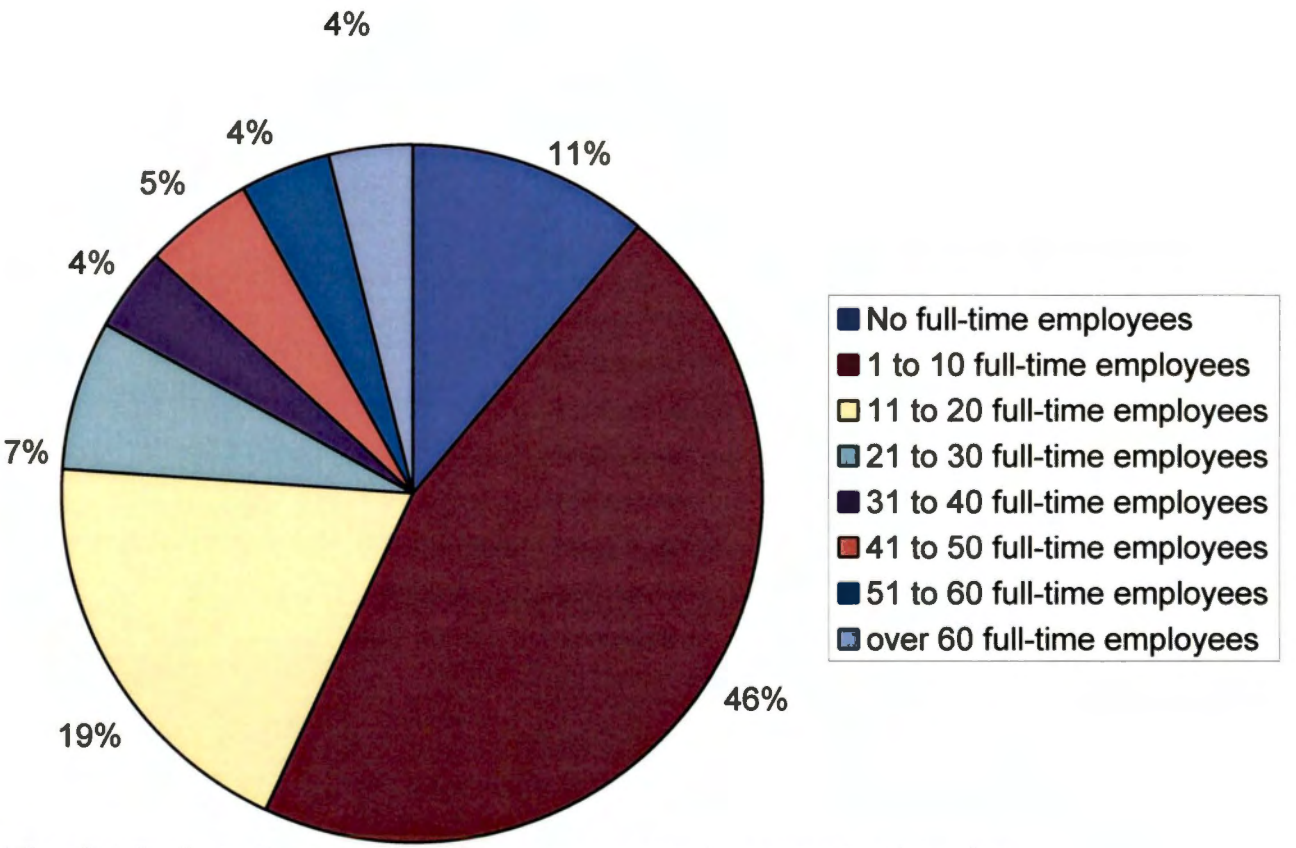


Figure 25. The distribution of survey responses among employeement categories.

Table 4. The regional distribution of responding sawmills by employment categories.

			Region			
Number of employees	**East**	**Plateau**	**Central**	**West Central**	**West**	**Total**
0	2%	4%	0%	1%	4%	11%
1 to 10	11%	11%	7%	6%	11%	46%
11 to 20	3%	3%	4%	3%	5%	18%
21 to 30	2%	0%	3%	1%	1%	7%
31 to 40	1%	1%	1%	1%	1%	5%
41 to 50	1%	1%	1%	2%	0%	5%
51 to 60	1%	2%	0%	1%	0%	4%
over 60	0%	1%	1%	1%	1%	4%
Total	21%	23%	17%	16%	23%	100%

Table 5. The regional distribution of responding sawmills by production classes.

			Region			
Number of employees	**< 5 million bd. ft.**	**5 - 10 million bd. ft.**	**10 - 15 million bd. ft.**	**15 - 20 million bd. ft.**	**20 - 30 million bd. ft.**	**Total**
0	11%	0%	0%	0%	0%	11%
1 to 10	40%	3%	2%	0%	1%	46%
11 to 20	12%	6%	0%	0%	0%	18%
21 to 30	3%	4%	0%	0%	0%	7%
31 to 40	0%	2%	3%	0%	0%	5%
41 to 50	1%	2%	0%	1%	1%	5%
51 to 60	0%	1%	1%	2%	0%	4%
over 60	0%	1%	1%	1%	1%	4%
Total	67%	19%	7%	4%	3%	100%

of employees increased, the number of sawmills that ran two shifts also increased. Sawmills that produced between ten and twenty million board feet of lumber annually were also more likely to run two production shifts than sawmills in the other production classes. It can be concluded that the larger sawmills who ran two production shifts function much like the sawmills in the lower production classes with half the number of full-time employees.

According to responding sawmills, twenty-seven percent had an increase in the number of full-time employees over the past ten years. Twenty-five percent of responding sawmills had a decrease in the number of full-time employees over the past ten years. Forty-eight percent of responding sawmills reported no change in the number of full-time employees (Figure 26). There was a significant difference (P = 0.001) in the change in the number of full-time employees over the past ten years reported by sawmills that responded to the survey.

Part-time Employment

Thirty-four percent of the sawmills that responded to the Tennessee Hardwood Sawmill Profile reported hiring part-time employees. Sixty-six percent of responding sawmills did not have part-

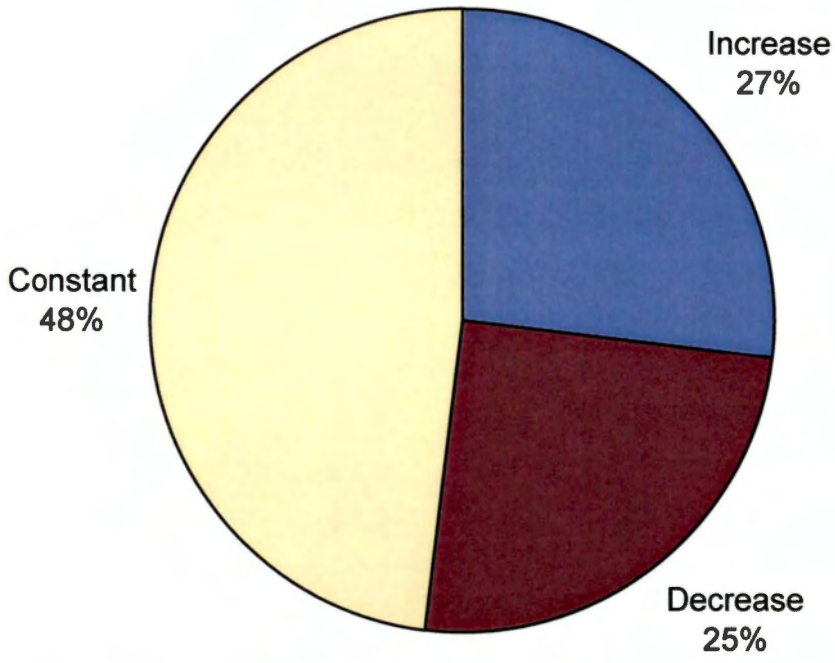


Figure26. The distribution of the change in levels of employment of responding sawmills.

time employees. There is a significant difference (P = 0.001) in whether or not responding sawmills had part-time employees.

The distribution of responding sawmills with part-time employees ranged from twenty-five to forty-seven percent (Figure 27). Thirty-two percent of responding sawmills in the East region had part-time employees. Thirty-three percent of responding sawmills in the Plateau region had part-time employees. Thirty percent of responding sawmills in the Central region had part-time employees. Twenty-five percent of responding sawmills in the West Central region reported hiring part-time employees. Forty-seven percent of the sawmills in the West region reported having part-time employees. There was no significant difference (P = 0.675) in whether or not responding sawmills had part-time employees among regions.

The distribution of responding sawmills with part-time employees among production classes ranged from zero to sixty-seven percent (Figure 28). There was a significant difference (P = 0.001) in the distribution of responding sawmills reporting part-time employees among the five production classes. Thirty-seven percent of responding sawmills that produced less than five million board feet of lumber annually had part-time employees. In the five to ten million annual board foot production class, twenty-nine percent had part-time employees. Fourteen

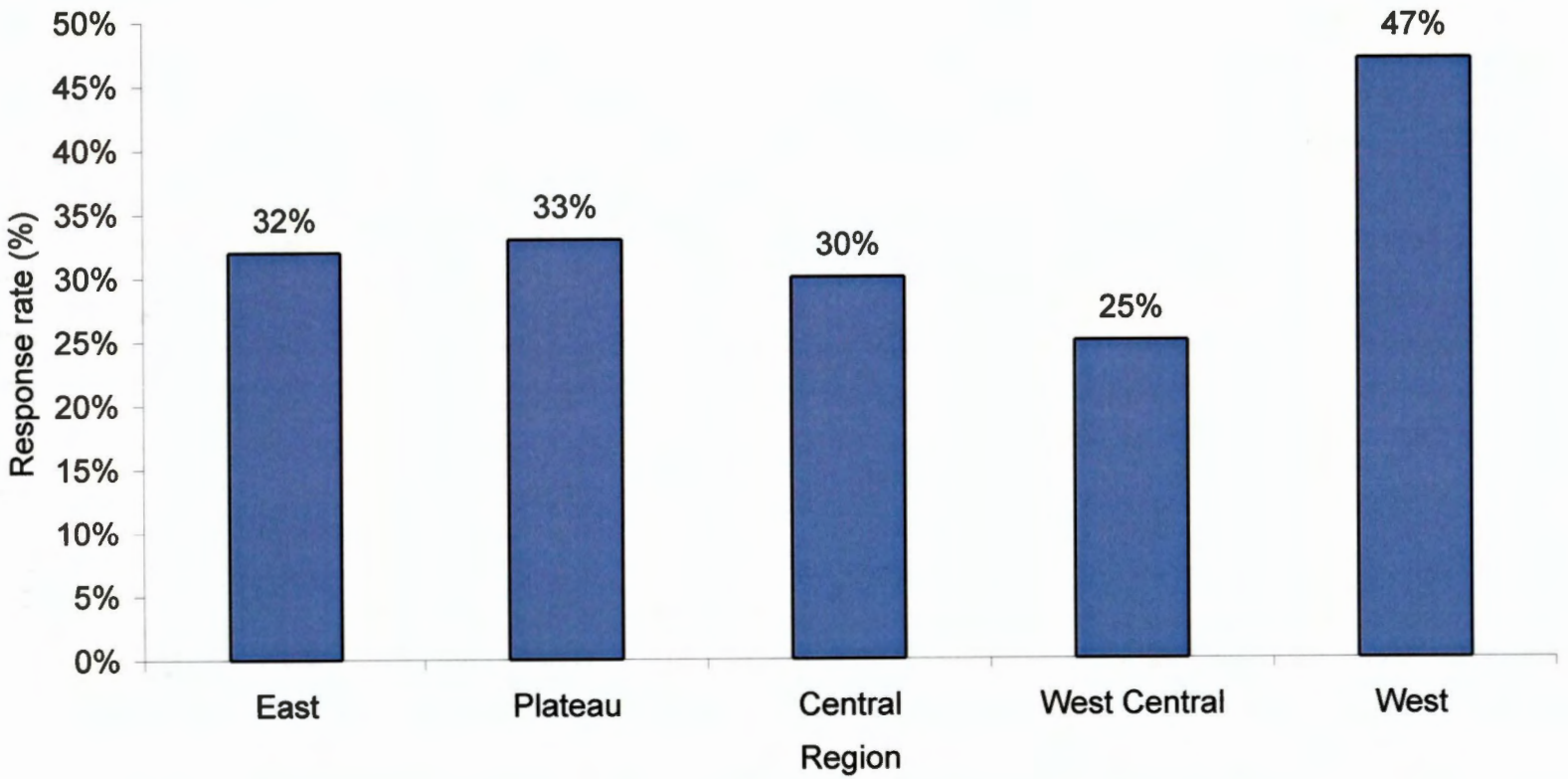


Figure 27. Distribution of responding sawmills with part-time employees among geographical regions.

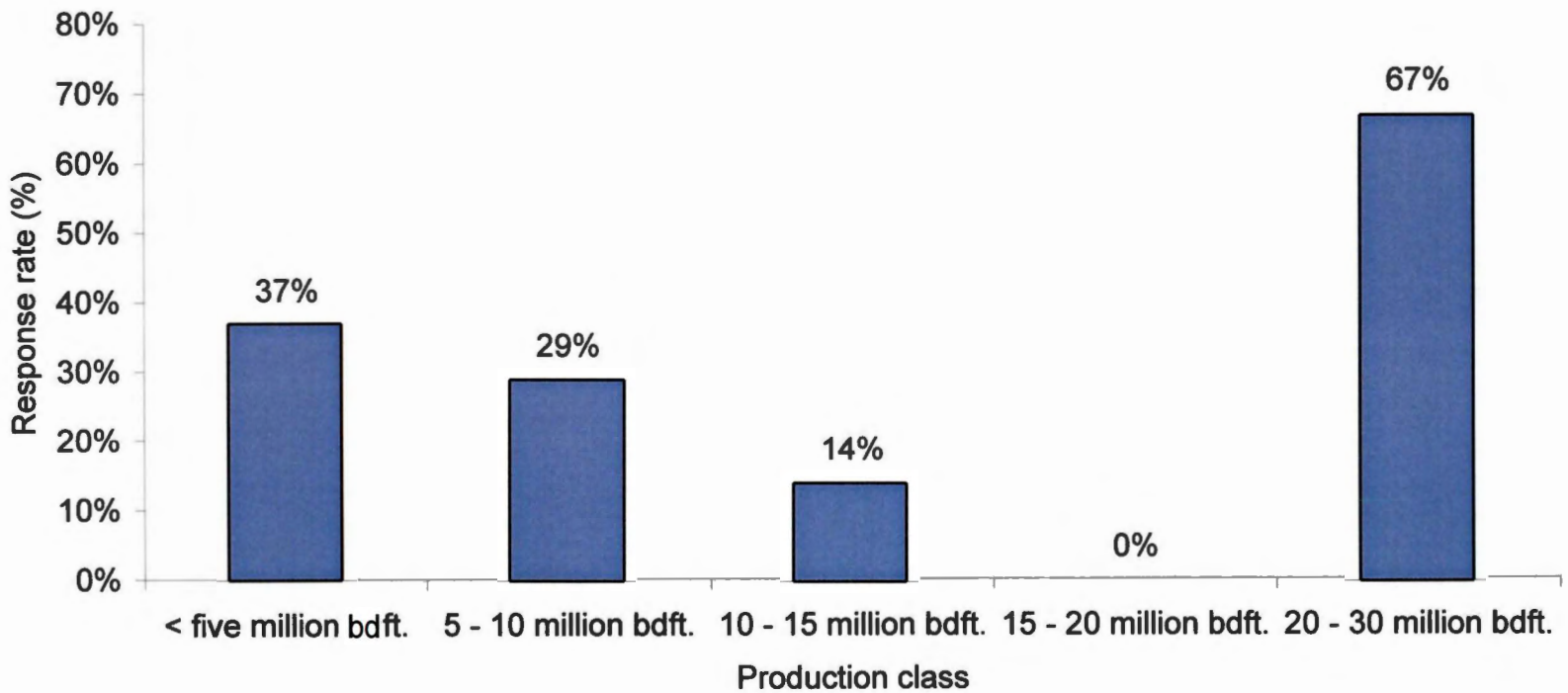


Figure 28. Distribution of responding sawmills with part-time employees among production classes.

percent of sawmills in the ten to fifteen million annual board foot production class had part-time employees. No responding sawmills in the fifteen to twenty million annual board foot production class had part-time employees. Finally, Sixty-seven percent of sawmills in the twenty to thirty million annual board foot production class had part-time employees. The sawmills in the largest annual board foot production class had the greatest percentage of sawmills employing workers on a part-time basis.

1. Production By Total Annual Board Foot Volume Class

Levels of production

The total annual board foot production of responding sawmills was approximately five hundred eighty-four million board feet of lumber, over one half of the state's reported total. Total annual board foot production was calculated by using the mean value for each production class and multiplying by the number of responses in the category. Sixty-nine percent of responding sawmills reported producing less than five million board feet of lumber per year. An additional 19 percent of responding sawmills reported producing between five and ten million board feet of lumber on an annual basis. Less than twelve percent of sawmills reported producing greater than ten million board feet of lumber per year (Figure

29). There was a significant (P = 0.001) difference in the number of responding sawmills in relation to production values.

Changes In Production

An increase in the board foot production over the last decade was reported by thirty-nine percent of sawmills. A decrease in production during the past ten years was reported by twenty-three percent of responding sawmills. Production in the last decade remained constant in thirty-eight percent of responding sawmills. There was not a significant difference (P = 0.087) in changes in production level by the total annual board foot production classes (Figure 30).

In mills that produce less than five million board feet annually, twenty-nine percent responded that their production level had increased over the last ten years, accounting for fifty-one percent of the total number of mills that had an increase in production. Thirty-two percent of the mills reported a decrease in production encompassing ninety-two percent of the mills reporting a decrease. Thirty-nine percent of the sawmills in the less than five million annual board foot production class reported no change in their production level, accounting for seventy-one percent of total number of sawmills that reported production being constant. Figure

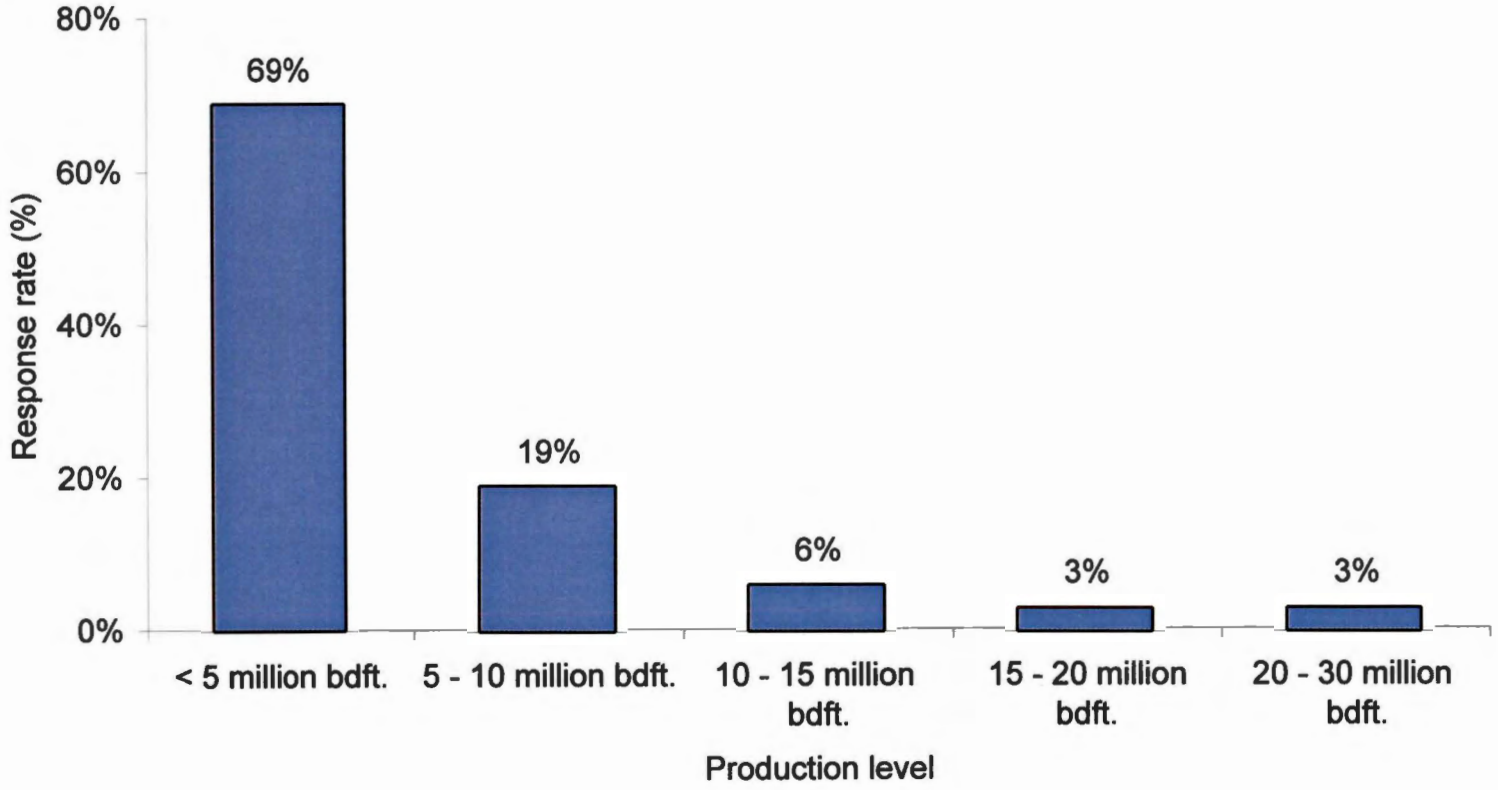


Figure 29. Survey responses among production categories.

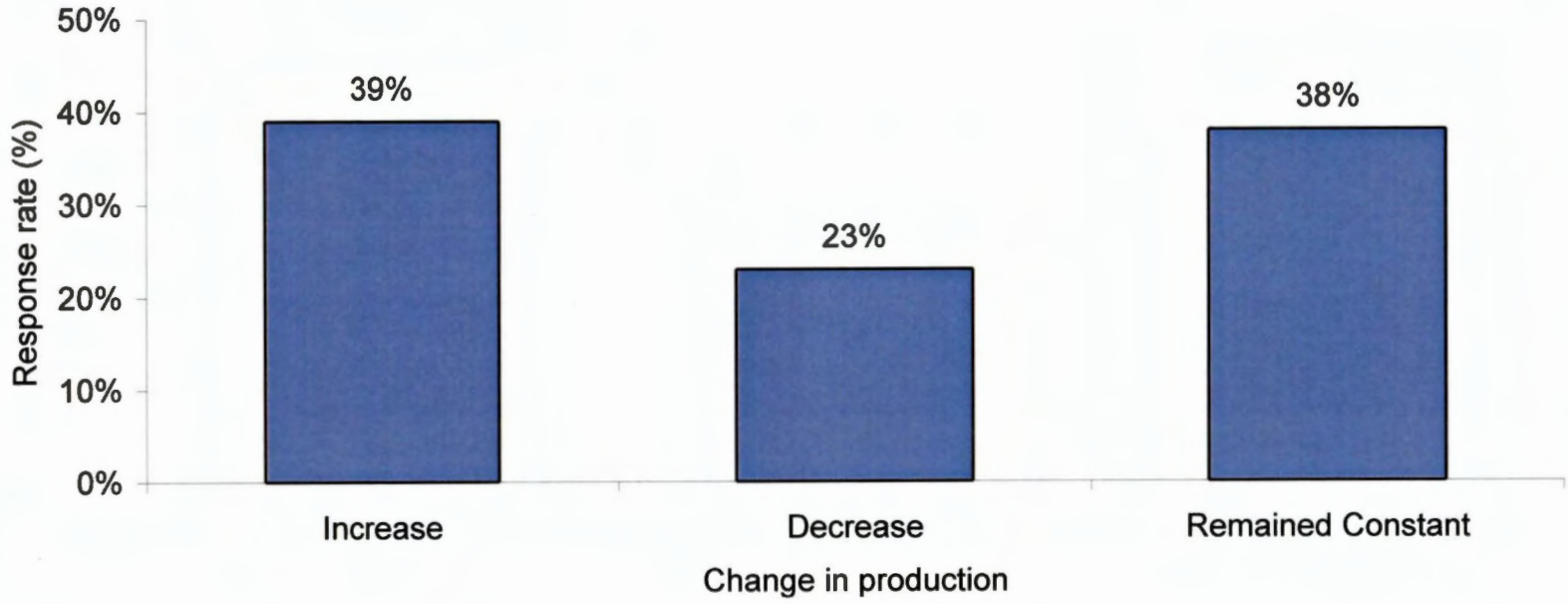


Figure 30. Total response rate of changes in production among all levels of production.

31 shows the distribution of responses to the change in production for sawmills in the less than five million annual board foot production class.

Sixty-two percent of respondents reported an increase in production over the last ten years for sawmills in the five to ten million annual board foot production class, accounting for thirty percent of the total number of sawmills reporting an increase. Five percent of sawmills in the five to ten million annual board foot production class reported a decrease in production, accounting for only four percent of the total number of mills reporting a decrease. Thirty-three percent of sawmills in the five to ten million annual board foot production class reported no change in their production level over the last decade, totaling seventeen percent of all sawmills who reported a constant level of production. Figure 32 shows the distribution of responses to the change in production for sawmills in the five to ten million annual board foot production class.

Of sawmills in the ten to fifteen million annual board foot production class, fifty-seven percent of respondents reported an increase in production over the last ten years, accounting for nine percent of the total number of sawmills reporting an increase. Fourteen percent of sawmills in the ten to fifteen million annual board foot production class reported a decrease in production, accounting for only four percent of the total number of mills reporting a decrease. Twenty-nine percent of sawmills in the ten to fifteen million annual board foot production class

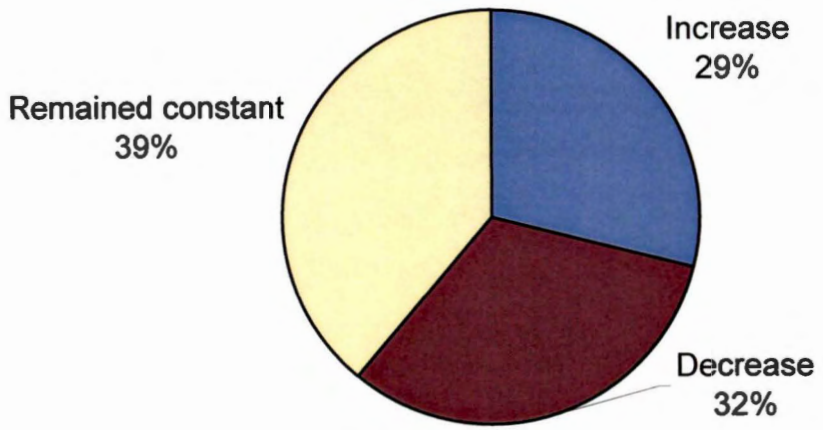


Figure 31. Changes in production over the past ten years for mills who produce less than five million board feet annually.

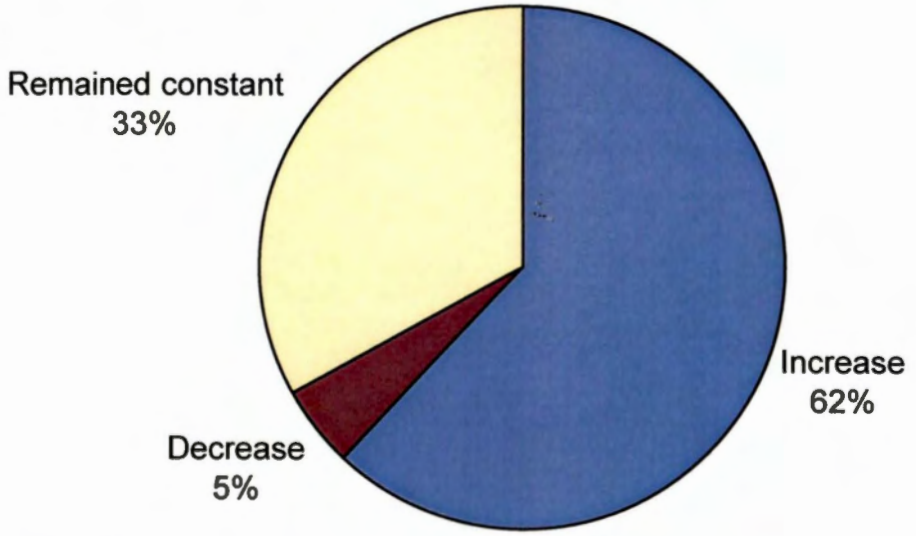


Figure 32. Changes in production over the past ten years for mills who produce five to ten million board feet of lumber annually.

reported no change in their production level over the last decade, totaling five percent of all sawmills who reported a constant level of production. Figure 33 shows the distribution of responses to the change in production for sawmills in the ten to fifteen million annual board foot production class.

In mills that produce fifteen to twenty million board feet annually, fifty percent responded that their production level had increased over the last ten years, accounting for five percent of the total number of mills that had an increase in production. No sawmill in the fifteen to twenty million board feet annual board foot production class reported a decrease in production. Fifty percent of the sawmills in the fifteen to twenty million annual board foot production class reported no change in their production level, accounting for five percent of total number of sawmills who reported production being constant. Figure 34 shows the distribution of responses to the change in production for sawmills in the fifteen to twenty million board feet annual board foot production class.

Sixty-seven percent of respondents reported an increase in production over the last ten years for sawmills in the twenty to thirty million annual board foot production class, accounting for nine percent of the total number of sawmills reporting an increase. No sawmill in the twenty to thirty million board feet annual board foot production class reported a decrease in production. Thirty-three percent of sawmills in the twenty to thirty million annual board foot production class reported no change in

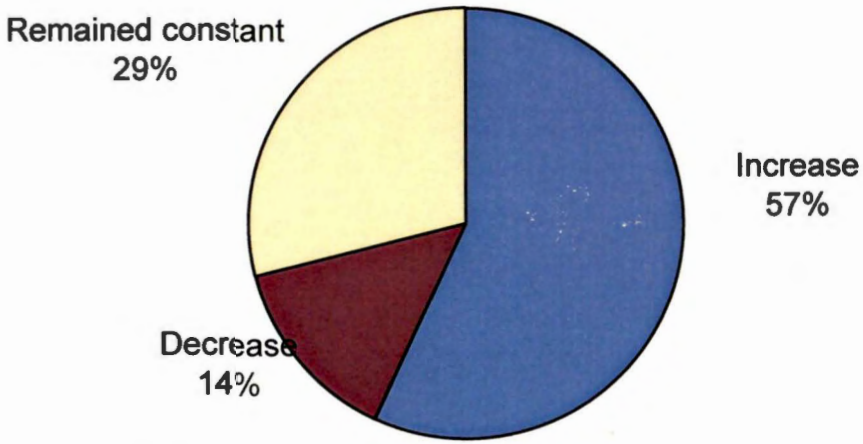


Figure 33. Changes in production over the past ten years for mills who produce between ten and fifteen million board feet of lumber annually.

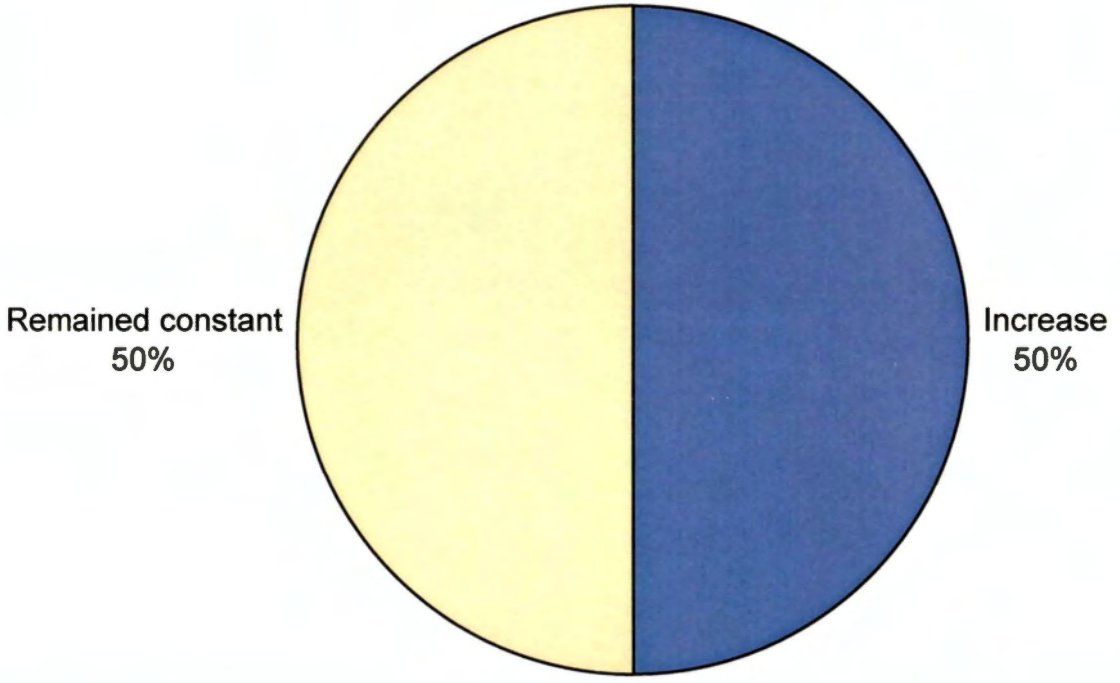


Figure 34. Changes in production over the past ten years for mills who produce between fifteen to twenty million board feet of lumber per year.

their production level, accounting for two percent of the total number of responding sawmills with no change in their production level. Figure 35 shows the distribution of responses to the change in production for sawmills in the twenty to thirty million board feet annual board foot production class.

Hardwood lumber production in Tennessee is very strong. Over three quarters of the responding sawmills reported annual production having remained constant or having increased in the last ten years. There is however, a disparity between sawmills in the less than five million annual board foot production class and the four other classes of production. Sawmills in the less than five million annual board foot production class had the largest portion of responding sawmills whose production had decreased and the smallest portion of sawmills that reported an increase in production. Further analysis indicates that the sawmills in the less than five million annual board foot production class who reported that production had decreased are also those sawmills who responded that they will close in the next ten years.

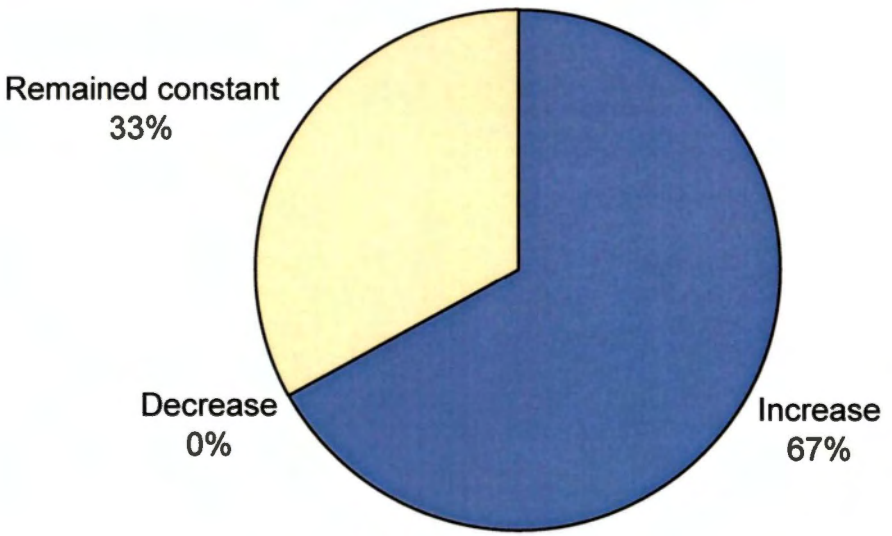


Figure 35. Changes in production over the past ten years for mills who produce twenty to thirty million board feet of lumber annually.

Softwood

Softwood is not used by forty-seven percent of responding sawmills. Average percentage of total production of softwood in mills is twenty-six percent. Production percentages of softwood by region are presented in Table 6.

Raw material imports

Twenty-seven percent of responding sawmills import logs from other states. There is a significant difference (P = 0.001) in whether or not a responding sawmill imports logs from other states. The states from which logs are imported include, Alabama, Georgia, Illinois, Kentucky, Mississippi, Missouri, North Carolina, and Virginia. Twenty-eight percent of the total volume of logs is imported from these states.

The regional distribution of responding sawmills that import logs from other states ranged from thirteen percent to thirty percent (Figure 36). There was no significant difference (P = 0.787) in the regional distribution of responding sawmills that import logs from other states.

The distribution of responding sawmills that import logs from other states by production levels ranges from three to forty-three percent (Figure 37). There was a significant difference (P = 0.001) in the

Table 6. Regional Distribution of Softwood Production

			Region		
Percentage	**East**	**Plateau**	**Central**	**West Central**	**West**
0%	33	39	52	38	74
1-10%	17	33	18	46	0
11-20%	4	0	4	8	21
21-30%	0	17	9	0	0
31-40%	8	11	4	4	5
41-51%	13	0	3	4	0
51-60%	4	0	0	0	0
61-70%	13	0	0	0	0
71-80%	4	0	0	0	0
81-90%	0	0	0	0	0
91%+	4	0	10	0	0
Total	100	100	100	100	100

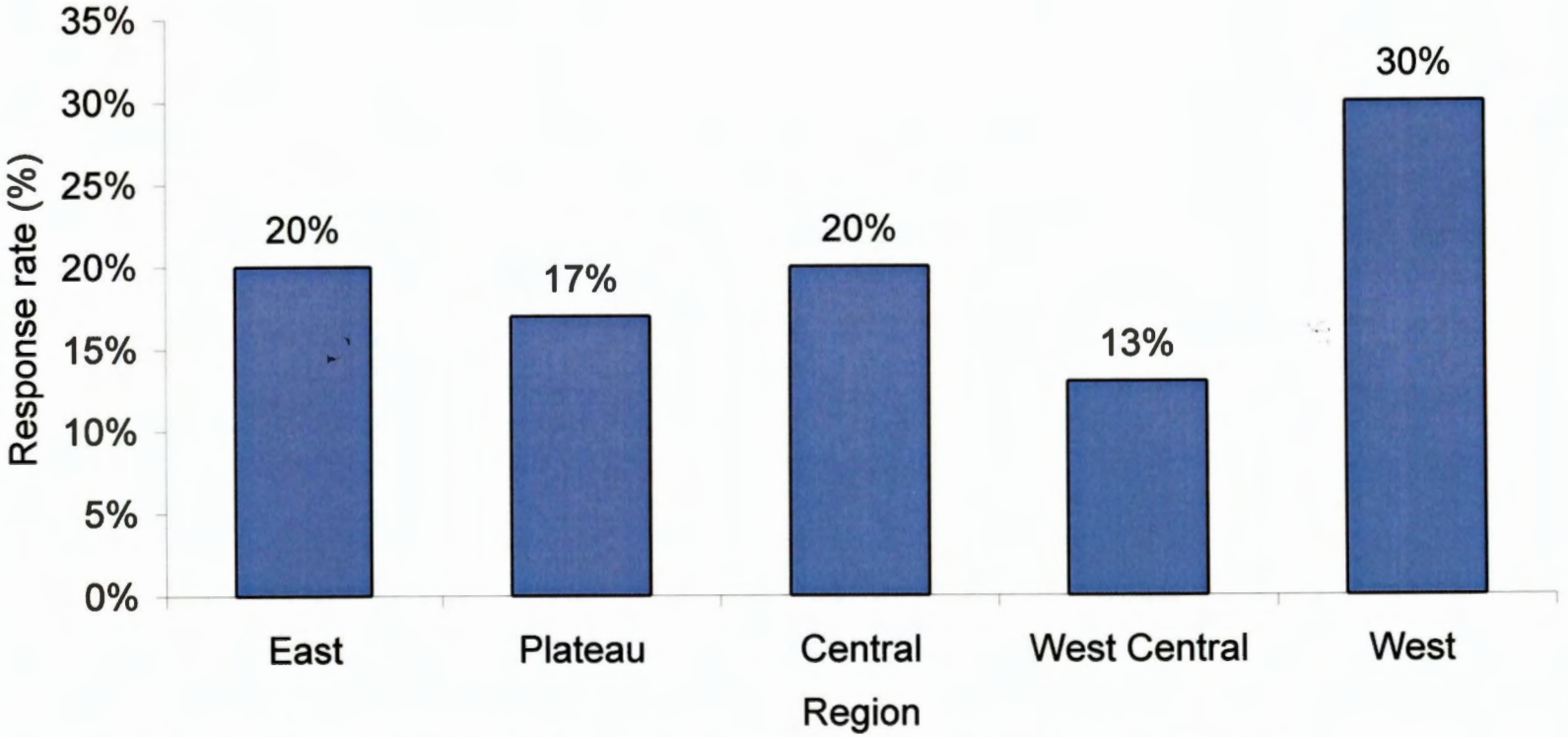


Figure 36. The distribution of responding sawmills who import logs from other states among regions.

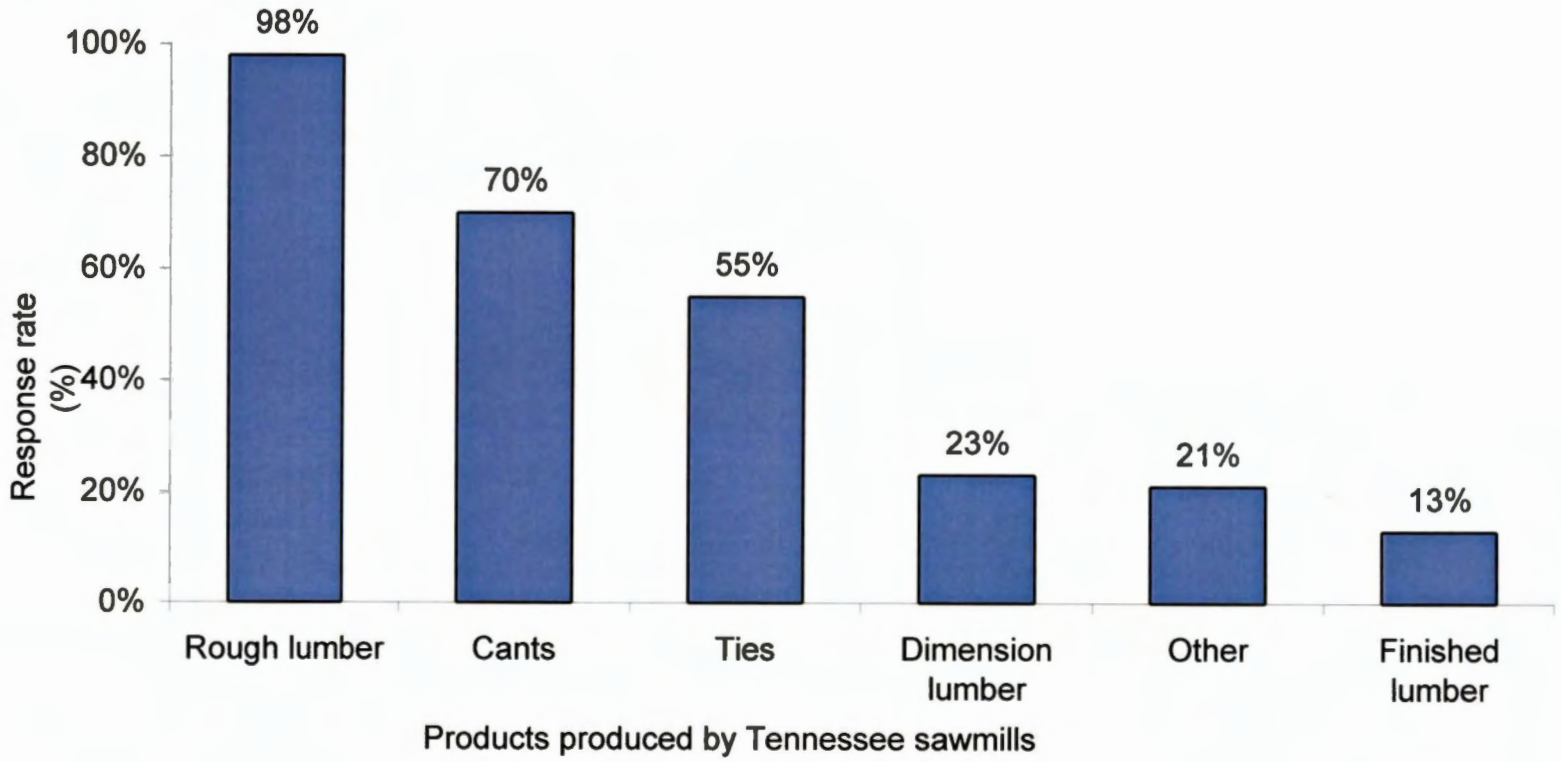


Figure 38. Products produced by responding mills.

distribution of sawmills that import logs from other states by production classes.

The West region had the largest number of sawmills who import logs from other states. It is logical to assume that this is due to the West region's border with the Mississippi river. The river is heavily used for commercial shipping along all of the states it borders. Since greater amounts of raw materials can be shipped by barge than through trucking, transportation costs would be lower for sawmills in close proximity to a port. The Plateau and West Central regions share borders with the fewest number of neighboring states giving them less opportunity for importing logs.

Since all of the responding sawmills in the twenty to thirty million annual board foot production class own timberland and a very small percentage import logs, it can be assumed that these mills have a steady supply of logs from their own land and rarely need to buy raw materials from outside sources.

1. Products Produced

Rough lumber is produced by ninety-eight percent of the mills that responded to the profile. Cants are produced at seventy percent of the sawmills, and fifty-five percent of mills produce ties. Dimension lumber is

produced by twenty-three percent of the responding mills. Finished lumber is produced by thirteen percent of the sawmills. Twenty-one percent of the sawmills produce products other than those specified by the survey (Figure 38).

Rough Lumber

Ninety-seven percent of responding sawmills in the less than five million annual board foot production class produce rough lumber, accounting for sixty-eight percent of the total number of responding sawmills who reported the production of rough lumber. All of the responding sawmills in each of the other production classes produce rough lumber, accounting for thirty-two percent of the total number of responding sawmills who reported the production of finished lumber. Figure 39 shows the distribution of the total number of sawmills who report producing rough lumber for each production class. There is no difference ($P = 0.109$) in the production of rough lumber for different levels of production.

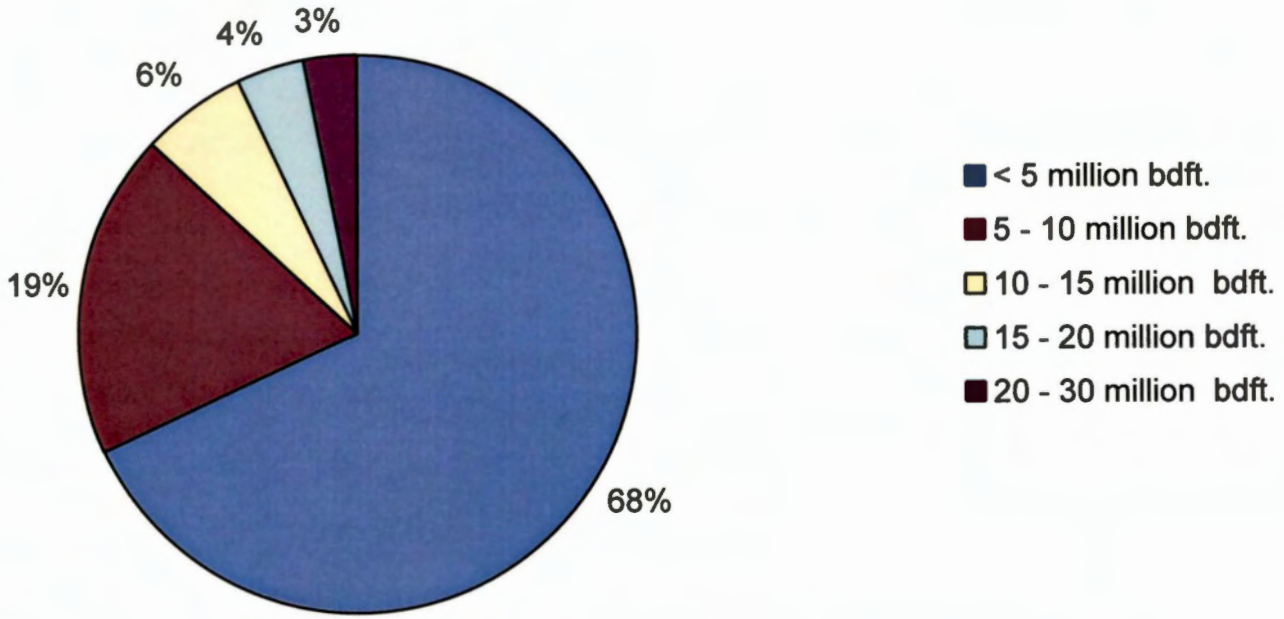


Figure 39. Distribution of responding sawmills producing rough lumber by production class.

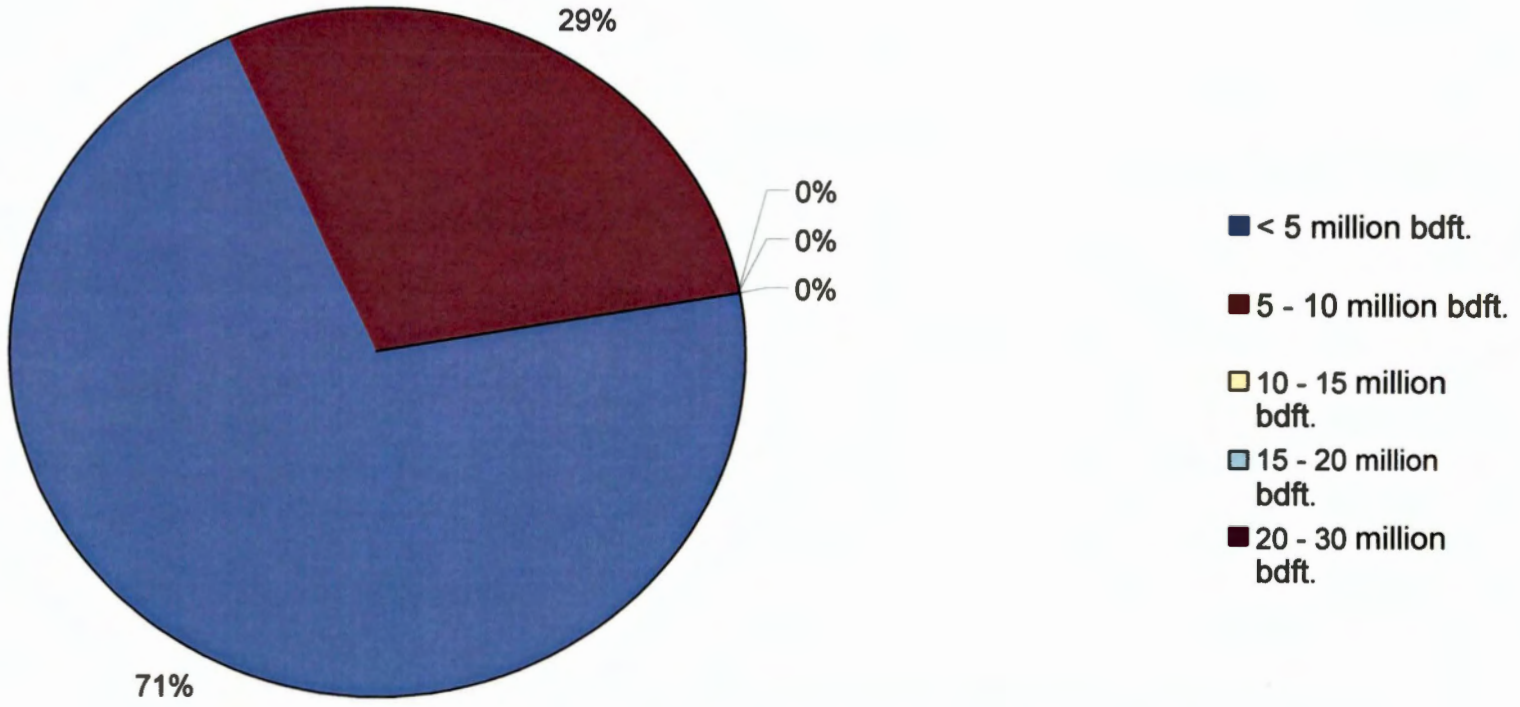


Figure 40. Distribution of responding sawmills reporting the production of finished lumber.

Finished Lumber

Thirteen percent of responding mills in the lowest production class, less than five million board feet annually, produce finished lumber, representing seventy-one percent of the total number of responding sawmills which reported the production of finished lumber. Nineteen percent of the responding sawmills in the five to ten million annual board foot production class produce finished lumber, comprising twenty-nine percent of the total number of responding sawmills that produce finished lumber (Figure 40). The production of finished lumber by level of annual board foot production was not significantly different (P = 0.587).

Dimension Lumber

Dimension lumber is produced by twenty-four percent of responding mills in the less than five million annual board foot production class, accounting for seventy-two percent of the total number of sawmills who reported producing dimension lumber. Twenty-four percent of responding sawmills in the five to ten million annual board foot production class, accounting for twenty percent of the total number of responding sawmills who reported the production of dimension lumber. None of the responding sawmills in the ten to fifteen million annual board foot

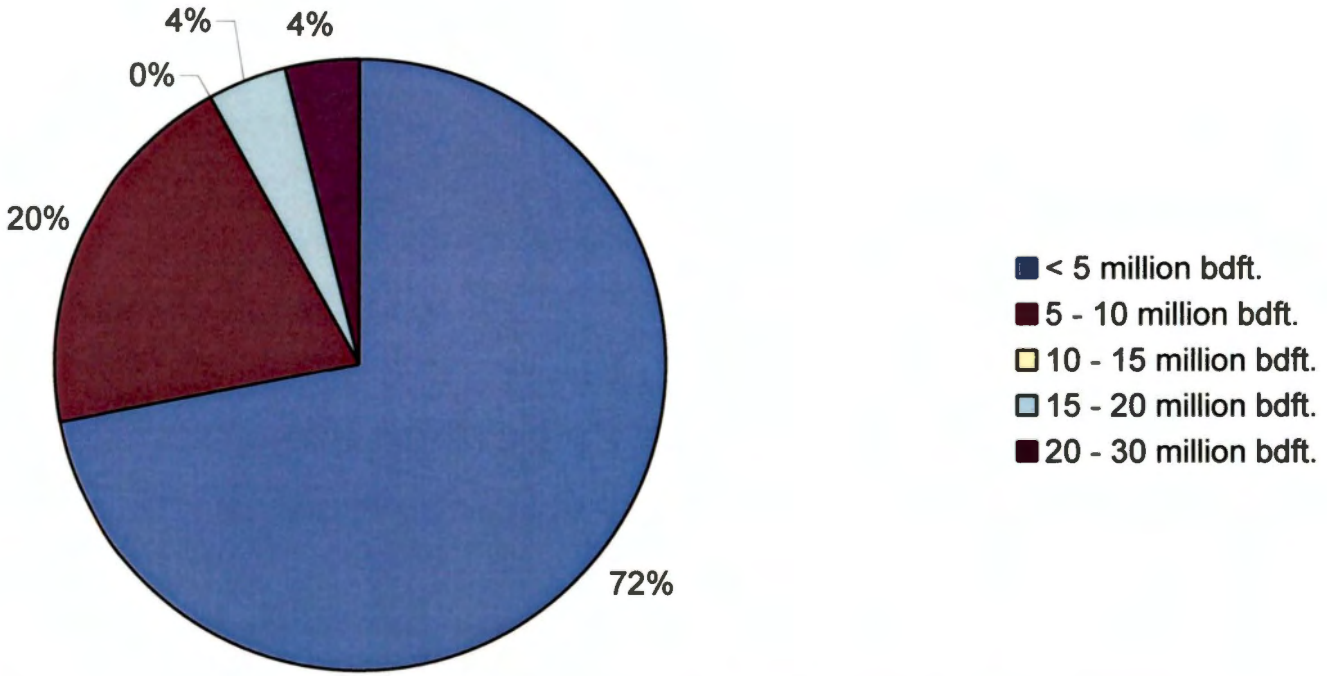


Figure 41. Distribution of responding sawmills producing dimension lumber by production class.

production class reported producing dimension lumber. Of the responding sawmills in the fifteen million annual board foot production class, twenty-five percent reported producing dimension lumber. These sawmills account for four percent of the total number of sawmills producing dimension lumber. Finally, in the twenty to thirty million annual board foot production class, thirty-three percent of the responding sawmills reported producing dimension lumber, contributing four percent of the total number of responding sawmills who reported producing dimension lumber (Figure 41). There was no difference (P = 0.676) in the production of dimension lumber by production classes.

Ties

Fifty-seven percent of responding mills in the lowest production class (less than five million board feet annually) produced ties, representing seventy percent of the total number of responding sawmills that reported the production of ties. Seventy-one percent of the responding sawmills in the five to ten million annual board foot production class produced ties, comprising twenty-five percent of the total number of responding sawmills that produced ties. Forty-three of the responding sawmills in the ten to fifteen million annual board foot production class that reported producing ties account for five percent of the total number of

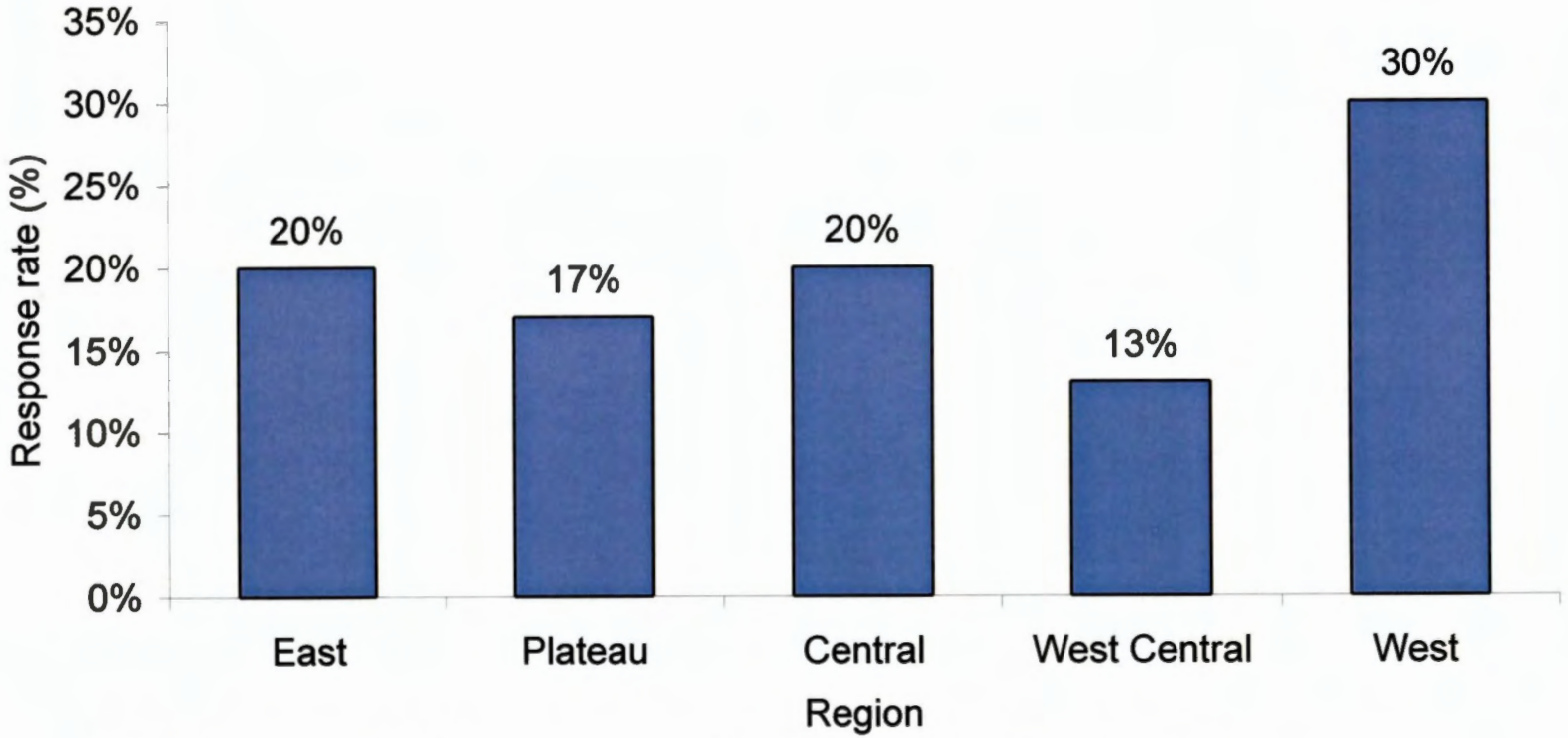


Figure 41. The distribution of responding sawmills who import logs from other states among regions.

sawmills that produced ties. Of the responding sawmills in the fifteen million annual board foot production class, none reported the production of ties. Finally, in the twenty to thirty million annual board foot production class, no responding sawmills reported producing ties (Figure 42.). There was a significant difference (P = 0.02) in the production of ties by production classes.

Cants

Cants were produced by sixty percent of responding mills in the less than five million annual board foot production class, accounting for fifty-nine percent of the total number of sawmills who reported producing cants. Eighty-six percent of responding sawmills in the five to ten million annual board foot production class produced cants, accounting for twenty-three percent of the total number of responding sawmills who reported the production of cants. All of the responding sawmills in the ten to fifteen million annual board foot production class reported producing cants accounting for nine percent of the total number of sawmills who reported producing cants. Of the responding sawmills in the fifteen million annual board foot production class, all reported producing cants. These sawmills accounted for five percent of the total number of sawmills producing cants. Finally, in the twenty to thirty million annual board foot production

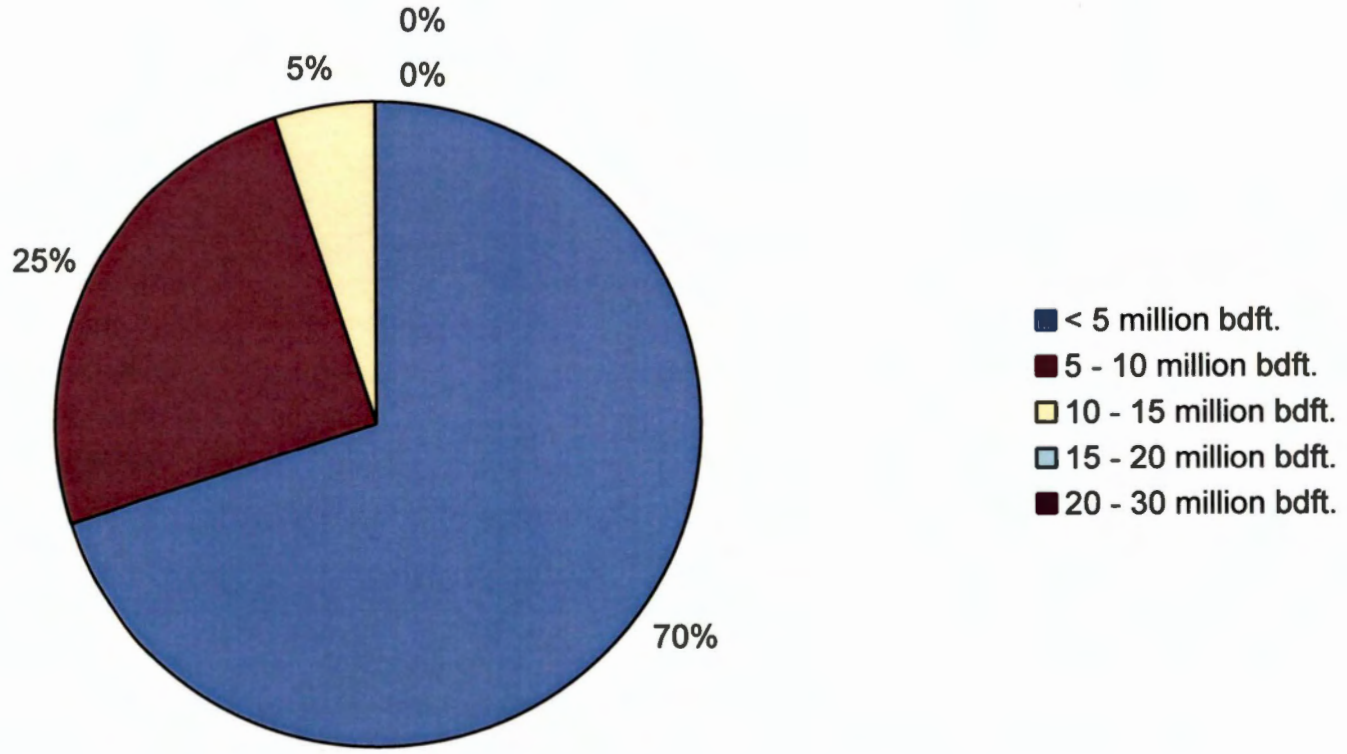


Figure 42. Distribution of responding sawmills producing ties by production class.

class, all of the responding sawmills reported producing cants, contributing four percent of the total number of responding sawmills who reported producing cants (Figure 43). There was a significant difference (P = 0.020) in the production of cants by production classes.

Other Products

Other products were produced by sixteen percent of responding mills in the less than five million annual board foot production class, accounting for fifty-two percent of the total number of sawmills who reported producing other products. Thirty-three percent of responding sawmills in the five to ten million annual board foot production class produced other products, accounting for thirty percent of the total number of responding sawmills who reported the production of other products. Twenty-nine of the responding sawmills in the ten to fifteen million annual board foot production class reported producing other products, accounting for nine percent of the total number of responding sawmills who reported the production of other products. Of the responding sawmills in the fifteen million annual board foot production class, twenty-five percent reported producing other products. These sawmills account for four percent of the total number of sawmills producing other products. Finally, in the twenty to thirty million annual board foot production class, thirty-three percent of

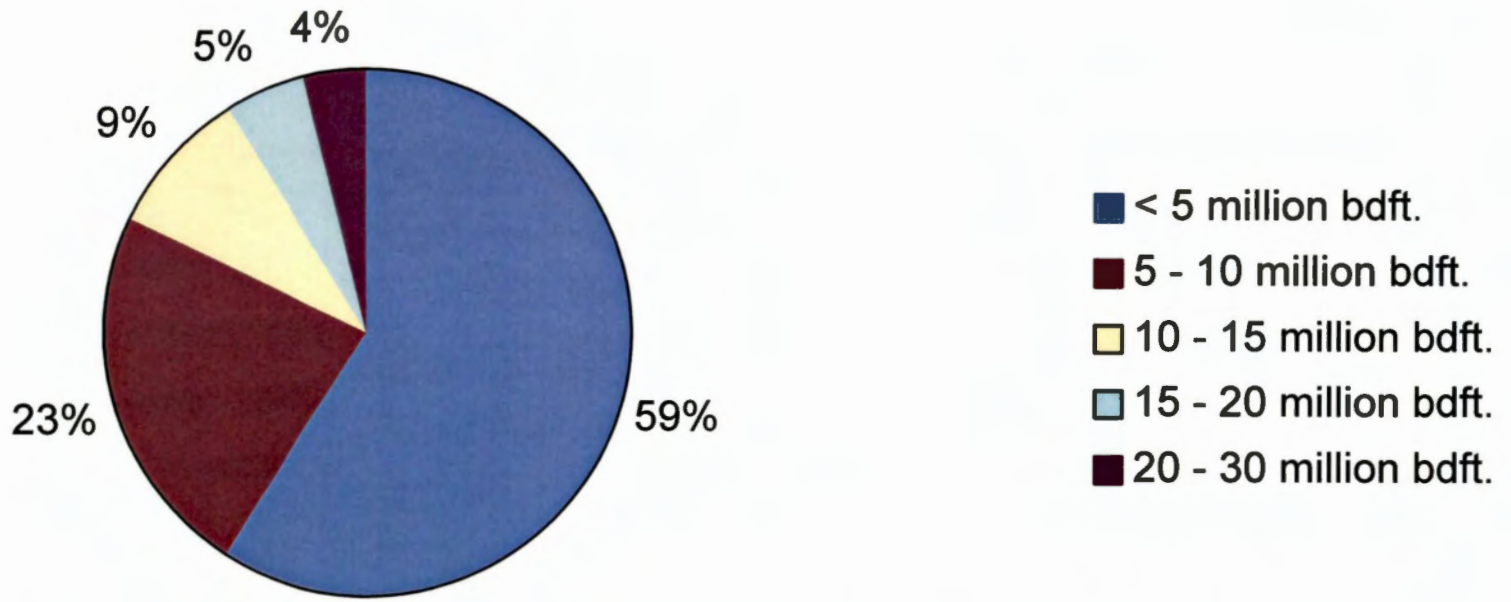


Figure 43. Distribution of responding sawmills producing cants by production class.

the responding sawmills reported producing other products, contributing five percent of the total number of responding sawmills who reported producing other products (Figure 44). There was no statistical difference (P = 0.440) in the production of other products by production classes.

Sawmills in the lowest production class produced the greatest percentage of products other than those specified on the survey. These may be specialty products in which their producers have identified niche markets. It is also important to note that close to three-quarters of the finished lumber was produced by sawmills in the less than five million annual board foot production class. This is another indication of niche markets and the development of specialty products.

2. Regional Production

The number of responding sawmills in each production class varies among regions (Table 7). There is a difference (P = 0.031) in the number of sawmills in each production class for each of the five geographical regions.

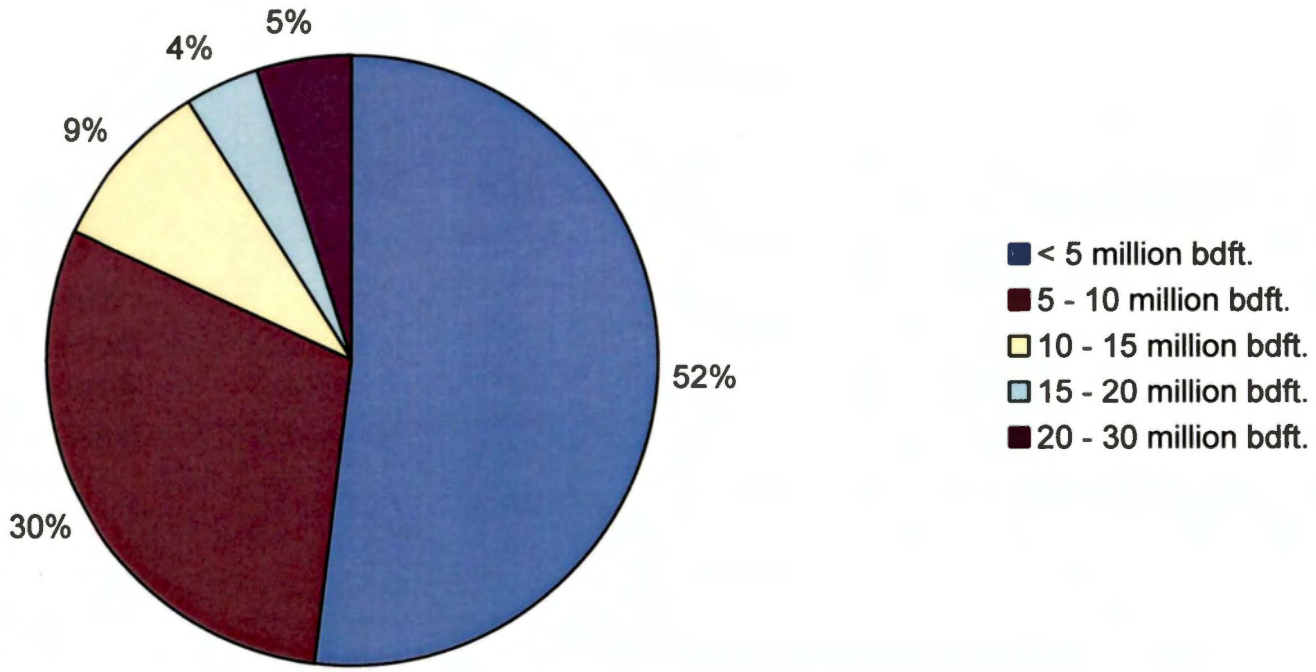


Figure 44. Distribution of responding sawmills producing other products by production class.

Table 7. Regional distribution of responding sawmills among production volume classes.

			Region		
Production Class	East	Plateau	Central	West Central	West
< 5 million bdft.	18%	9%	18%	16%	16%
5 - 10 million bdft.	2%	5%	1%	4%	4%
10 - 15 million bdft.	3%	1%	1%	2%	2%
15 - 20 million bdft.	1%	0%	1%	0%	0%
20 - 30 million bdft.	0%	2%	1%	0%	0%

East

Responding sawmills in the East produced approximately one hundred twenty million board feet of lumber per year. This accounts for twenty-one percent of the total board foot production reported by responding sawmills. The majority of responding sawmills in the Eastern region, seventy-seven percent, produce less than five million board feet of lumber annually. Eight percent of mills produce between five and ten million board feet of lumber per year. An additional eleven percent produce between ten and fifteen million board feet of lumber per year. Finally, four percent produce between fifteen and twenty million board feet of lumber per year.

Red oak, white oak, and yellow-poplar are the top three species cut at mills in the East region. Other species commonly reported being cut at responding mills include ash, black walnut, cherry, and both soft and hard maple.

All responding mills in the Eastern region report producing rough lumber. Cants are produced at fifty-two percent of mills. Dimension lumber is produced at thirty-two percent of the responding mills, which is the highest percentage among all five regions. Ties are produced at twenty-four percent of the mills. Twelve percent of the sawmills produce finished lumber, and eight percent produce other products.

Plateau

Responding sawmills in the East produced approximately one hundred thirty-three million board feet of lumber per year. This accounts for twenty-three percent of the total board foot production reported by responding sawmills. Sawmills in the state's Plateau region report that fifty-three percent produce less than five million board feet of lumber per year. Thirty-two percent report producing five to ten million board feet annually. Five percent produce ten to fifteen million board feet of lumber per year. Finally, ten percent of sawmills produce between twenty and thirty million board feet of lumber, the highest number of mills of this size class reported by any region in the state.

The species most often cut in the Plateau region is red oak, white oak, and yellow-poplar. Ninety-four percent of mills report cutting hard maple, soft maple, ash, beech, and cherry. Other common species cut include hickory, sweetgum, and black walnut.

Every sawmill that responded to the profile from the Plateau region reported producing rough lumber. Cants are produced at seventy-eight percent of the sawmills. Ties are produced by fifty-six percent of mills in the Plateau region. Dimension lumber is produced by twenty-eight percent of mills. Finished lumber is produced by eleven percent of mills.

Thirty-three percent of mills produce other products, the highest percentage among the five geographic regions.

Central

Responding sawmills in the East produced approximately one hundred thirteen million board feet of lumber per year. This accounts for nineteen percent of the total board foot production reported by responding sawmills. Eighty-four percent of sawmills in the Central region of the state report producing less than five million board feet of lumber per year. Each of the other four categories of production classes had a four percent response rates.

The three most common species cut by sawmills in the Central region are red oak, white oak, and yellow-poplar. Other common species cut are hard maple, ash, cherry, and black walnut.

Rough lumber is produced by ninety-two percent of the sawmills in the Central region of the state. Cants are produced at fifty-four percent of mills. Ties are produced at thirty-three percent of mills. Thirteen percent produce dimension lumber. Eight percent produce finished lumber. Seventeen percent of responding mills produce other products.

West Central

Responding sawmills in the East produced approximately one hundred million board feet of lumber per year. This accounts for seventeen percent of the total board foot production reported by responding sawmills. In the West Central region, seventy-five percent of the sawmills that responded to the survey report producing less than five million board feet of lumber per year. Seventeen percent produce five to ten million board feet annually, and eight percent produce between ten and fifteen million board feet of lumber.

There are five species most commonly cut in the West Central region: red oak, white oak, yellow-poplar, ash, and hickory. Other commonly cut species are hard maple, sweetgum, beech, and cherry.

All West Central region mills produce rough lumber. Ninety-two percent produce ties. Cants are produced at eighty-eight percent of the sawmills. The percentage of the mills producing both cants and ties in the West Central region are the highest among the five regions. Seventeen percent produce dimension lumber. Finished lumber is produced at thirteen percent of mills, and twenty-five percent of mills produce other products.

West

Responding sawmills in the East produced approximately one hundred eighteen million board feet of lumber per year. This accounts for twenty percent of the total board foot production reported by responding sawmills. In the Western region of Tennessee, forty-seven percent of the responding sawmills produce less than five million board feet of lumber per year. Forty-two percent produce five to ten million board feet of lumber. Eleven percent produce fifteen to twenty million board feet of lumber per year.

The most common species cut by mills in the West region is white oak, closely followed by red oak, and yellow-poplar. Other species cut include elm, hickory, ash, and cherry.

All of the responding mills in the West region produce rough lumber. Eighty-four percent produce cants. Ties are produced by seventy-four percent of the sawmills. Dimension lumber is produced by twenty-six percent of mills. Twenty-one percent of sawmills produce finished lumber, the highest among all regions. Twenty-six percent of West region sawmills produce other products.

Hardwood lumber production is evenly distributed among the five geographical regions. It is important to note that the East and Plateau regions had the highest percentages of the total board foot production of

responding sawmills. These two regions had the lowest overall survey response rate.

1. Equipment Information

Headrig

A circular headrig is used by seventy-one percent of responding sawmills. A band headrig is used by twenty-nine percent of responding sawmills (Figure 45). There is a significant difference (P = 0.001) in the type of headrig used by sawmills that responded to the Tennessee Hardwood Sawmill Profile.

The regional distribution of the type of headrig in use at responding sawmills among the five geographical regions ranged from four to eighteen percent (Table 8). There was no significant difference (P = 0.461) in the regional distribution of the type of headrig in use at responding sawmills among the five geographical regions.

The distribution of the type of headrig in use at responding sawmills among the five classes of annual board foot production ranged from zero to fifty percent (Table 9). There were no band headrigs reported in the twenty to thirty million annual board foot production class. There was a

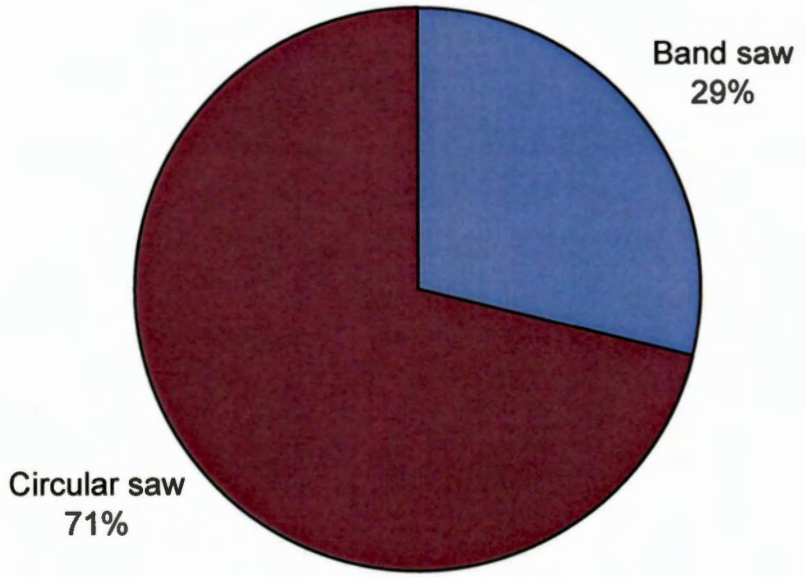


Figure 45. The type of headrigs used by responding sawmills.

Table 8. The distribution of headrig types among regions.

	Region					
Headrig type	**East**	**Plateau**	**Central**	**West Central**	**West**	**Total**
Circular	13%	12%	16%	17%	13%	71%
Band	9%	6%	6%	4%	4%	29%
Total	22%	18%	22%	21%	17%	100%

Table 9. The distribution of headrig types among production classes.

	Production class					
Headrig type	**< 5 million bd. ft.**	**5 – 10 million bd. ft.**	**10 – 15 million bd. ft**	**15 – 20 million bd. ft.**	**20 – 30 million bd. ft.**	**Total**
Circular	50%	13%	3%	2%	3%	71%
Band	18%	6%	3%	2%	0%	29%
Total	68%	19%	6%	4%	3%	100 %

significant difference (P = 0.053) in the distribution of the type of headrig in use at responding sawmills among the five production classes.

The average age of a headrig in use reported by responding sawmills was fifteen years. The average age of a circular headrig in use reported by responding sawmills was thirty-five years. The average age of a band headrig in use reported by responding sawmills was nine years.

A second headrig was reported by nineteen percent of responding sawmills. Of the sawmills that reported a second headrig in use, nineteen percent were circular headrigs and eighty-one percent were band headrigs. There was a significant difference (P = 0.001) in the type of second headrig in use at responding sawmills. The average age of the second headrig reported by responding sawmills was seven years. Seventeen percent of responding sawmills have plans to change or upgrade their headrig. There is a significant difference (P = 0.001) in whether or not responding sawmills planned to change or upgrade their headrig.

The regional distribution in the number of responding sawmills that planned to change or upgrade their headrig ranged from eleven to thirty-three percent (Figure 46). There was no significant difference (P = 0.608) in the number of responding sawmills who planned to change or upgrade their headrig. Fourteen percent of responding sawmills in the East region planned to change or upgrade their headrig. Eleven percent of responding

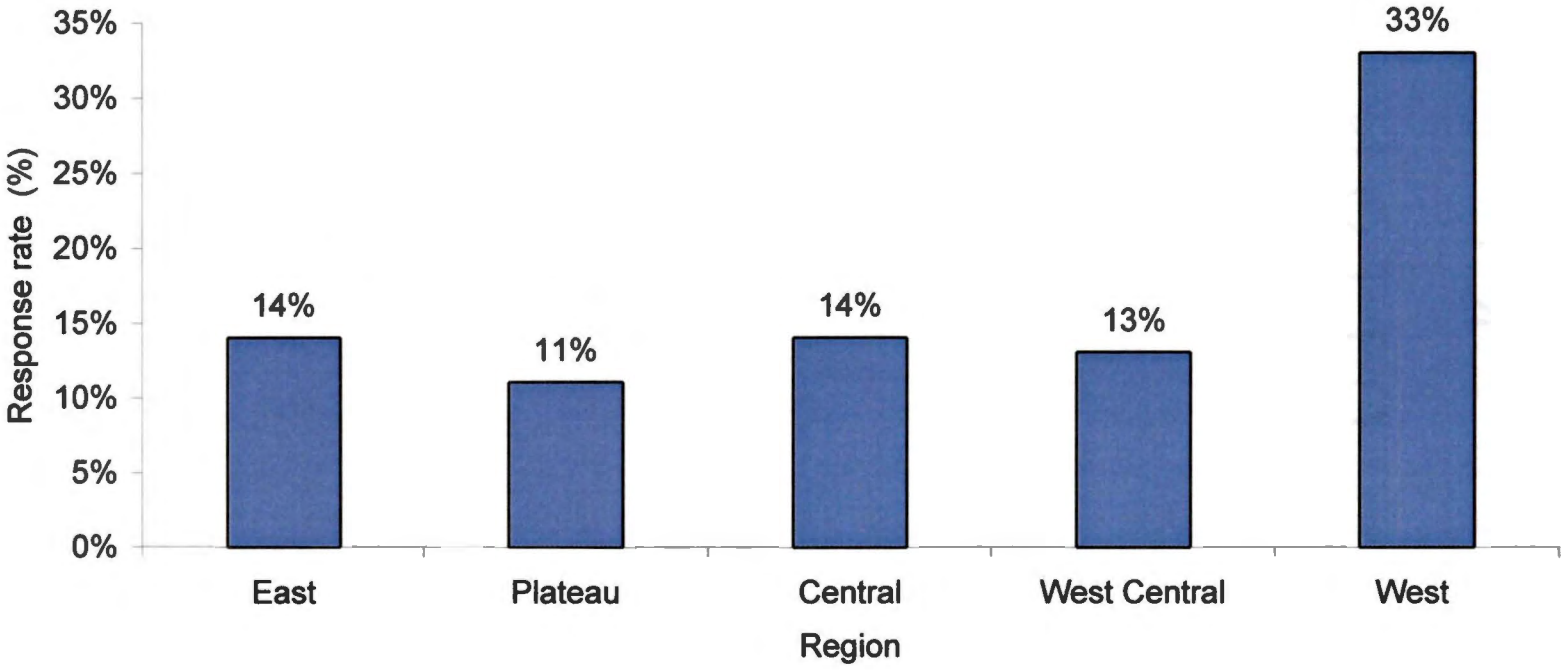


Figure 46. The distribution of responding sawmills who planned to change or upgrade their headrig among geographic regions.

sawmills in the Plateau region planned to change or upgrade their headrig. Fourteen percent of responding sawmills in the Central region planned to change or upgrade their headrig. Thirteen percent of responding sawmills in the West Central region planned to change or upgrade their headrig. Thirty-three percent of responding sawmills in the West region planned to change or upgrade their headrig.

The distribution in the number of responding sawmills that planned to change or upgrade their headrig among the five production classes ranged from zero to seventy-five percent (Figure 47). There was a significant difference (P = 0.001) in the number of responding sawmills who planned to change or upgrade their headrig among the five annual board foot production classes. Nine percent of responding sawmills in the less than five million annual board foot production class planned to change or upgrade their headrig. Thirty-three percent of responding sawmills in the five to ten million annual board foot production class planned to change or upgrade their headrig. Seventeen percent of responding sawmills in the ten to fifteen million annual board foot production class planned to change or upgrade their headrig. Seventy-five percent of responding sawmills in the fifteen to twenty million annual board foot production class region planned to change or upgrade their headrig. None of responding sawmills in the twenty to thirty million annual board foot production class planned to change or upgrade their headrig.

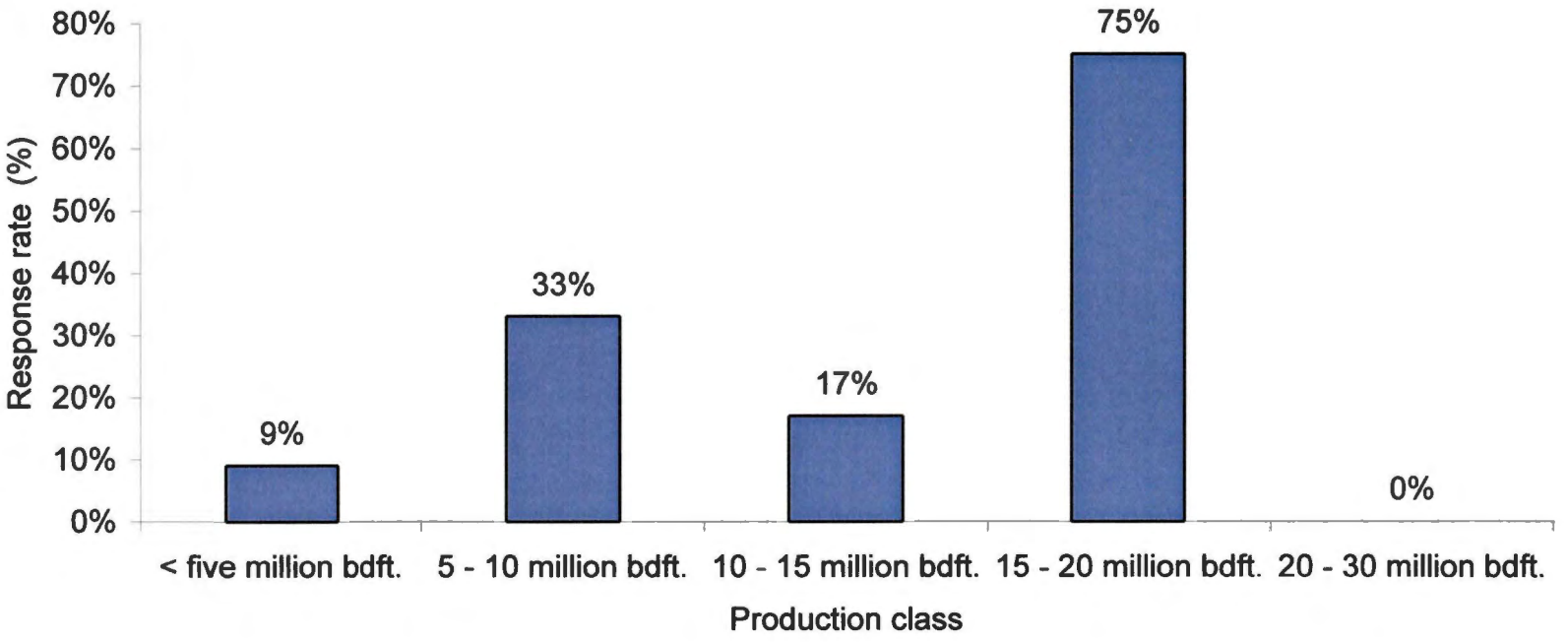


Figure 47. The distribution of responding sawmills who planned to change or upgrade to their headrig among production classes.

Twenty-seven percent of sawmills that planned to change or upgrade their headrig will purchase a circular headrig. Sixty-four percent of sawmills that planned to change or upgrade their headrig will purchase a band headrig. Nine percent of sawmills that planned to change or upgrade their headrig will purchase a chipping saw. Figure 48 shows the distribution in the type of change or upgrade in the headrig. There is a significant difference (P = 0.001) in the type of headrig planned for purchase. The average expected cost of the change or upgrade of the headrig is four hundred ninety thousand dollars.

There is a shift in purchase trends from circular headrigs to more efficient band headrigs. In the past five years the majority of new headrigs purchased were band headrigs. Two-thirds of those sawmills that plan to change or upgrade their headrig will purchase a band headrig.

Value-added equipment

Thirty percent of responding sawmills have surfacing or planing equipment. There is a significant difference (P = 0.001) in whether or not responding sawmills had surfacing or planing equipment.

Value-added processing once found only in the secondary wood products processing sector has become more prevalent in the hardwood lumber industry. The secondary markets are increasingly requesting

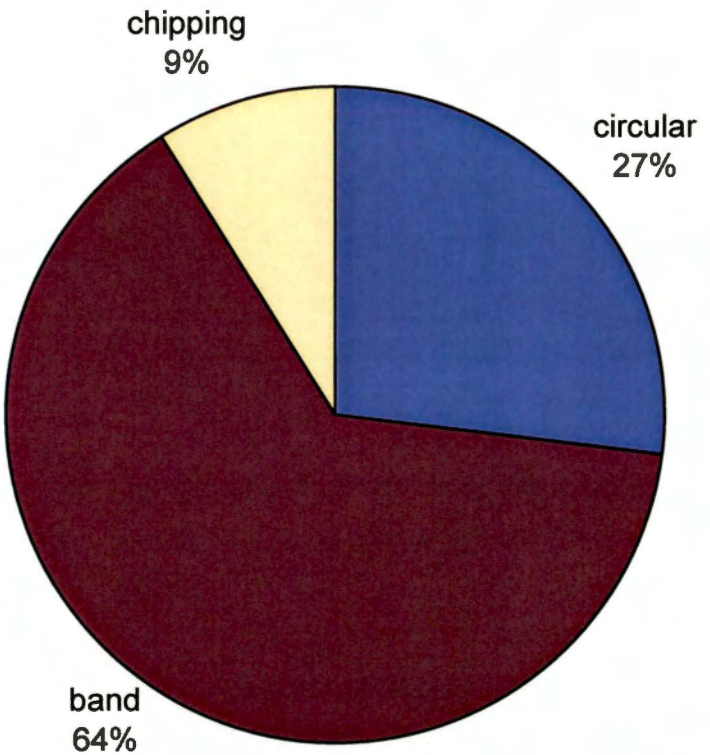


Figure 48. The distrubution of the types of headrigs planned for purchase.

lumber be surfaced and planed by the primary producer. Value-added processing at the primary production stage lessens the production cost and manufacturing time of the secondary processors. The secondary forest products industry is clustered around the four cities of Memphis, Nashville, Morristown, and Chattanooga. These areas show the highest need for value-added lumber. The regional distribution in the number of responding sawmills with surfacing or planing equipment ranged from twenty-two to forty-four percent (Figure 49). There was no significant difference (P = 0.507) in the number of responding sawmills who had surfacing or planing equipment among regions. Thirty-one percent of responding sawmills in the East region had surfacing or planing equipment. Twenty-two percent of responding sawmills in the Plateau region had surfacing or planing equipment. Forty-four percent of responding sawmills in the Central region had surfacing or planing equipment. Twenty-two percent of responding sawmills in the West Central region had surfacing or planing equipment. Thirty-two percent of responding sawmills in the West region had surfacing or planing equipment.

- The distribution in the number of responding sawmills that had surfacing or planing equipment among the five production classes ranged from twenty-seven to fifty percent (Figure 50). There was a significant difference (P = 0.001) in the number of responding sawmills who had

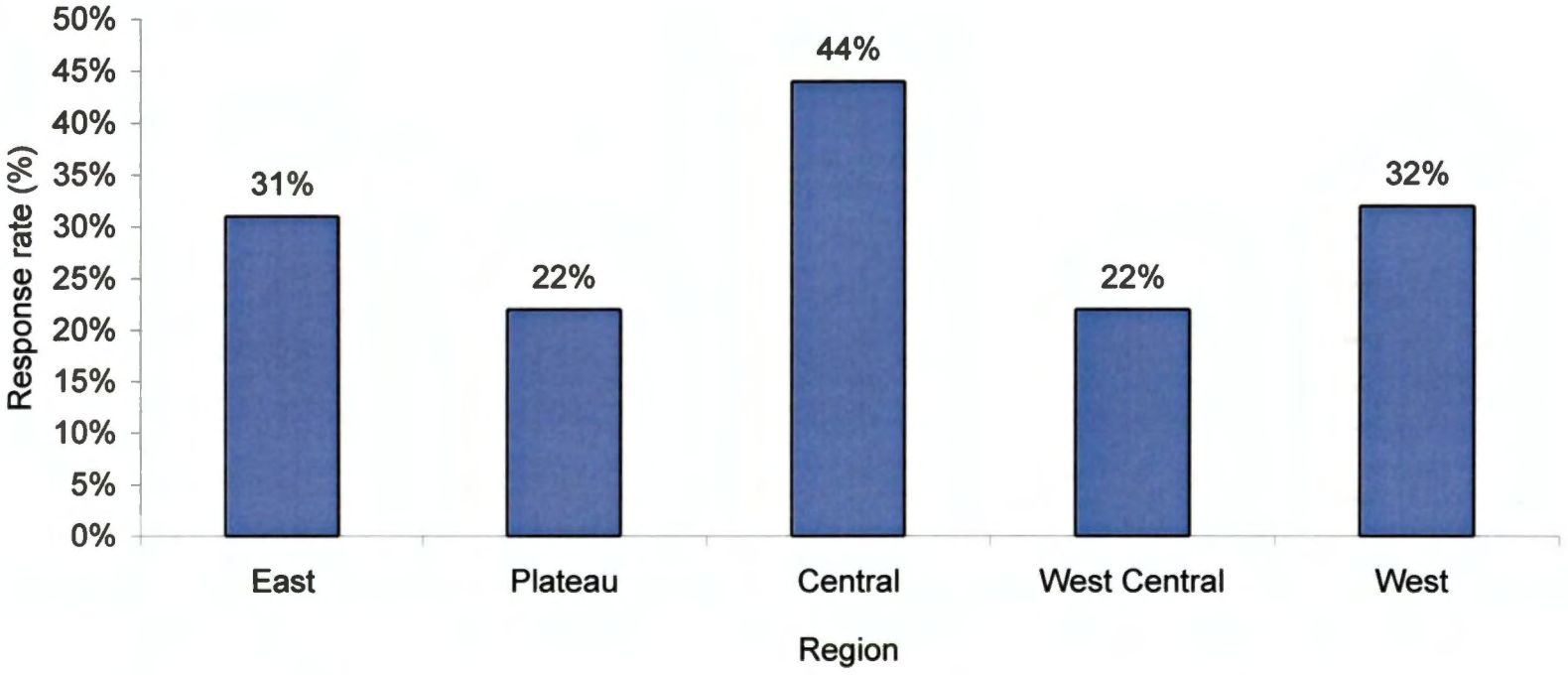


Figure 49. The distribution of responding sawmills with surfacing or planing equipment among regions.

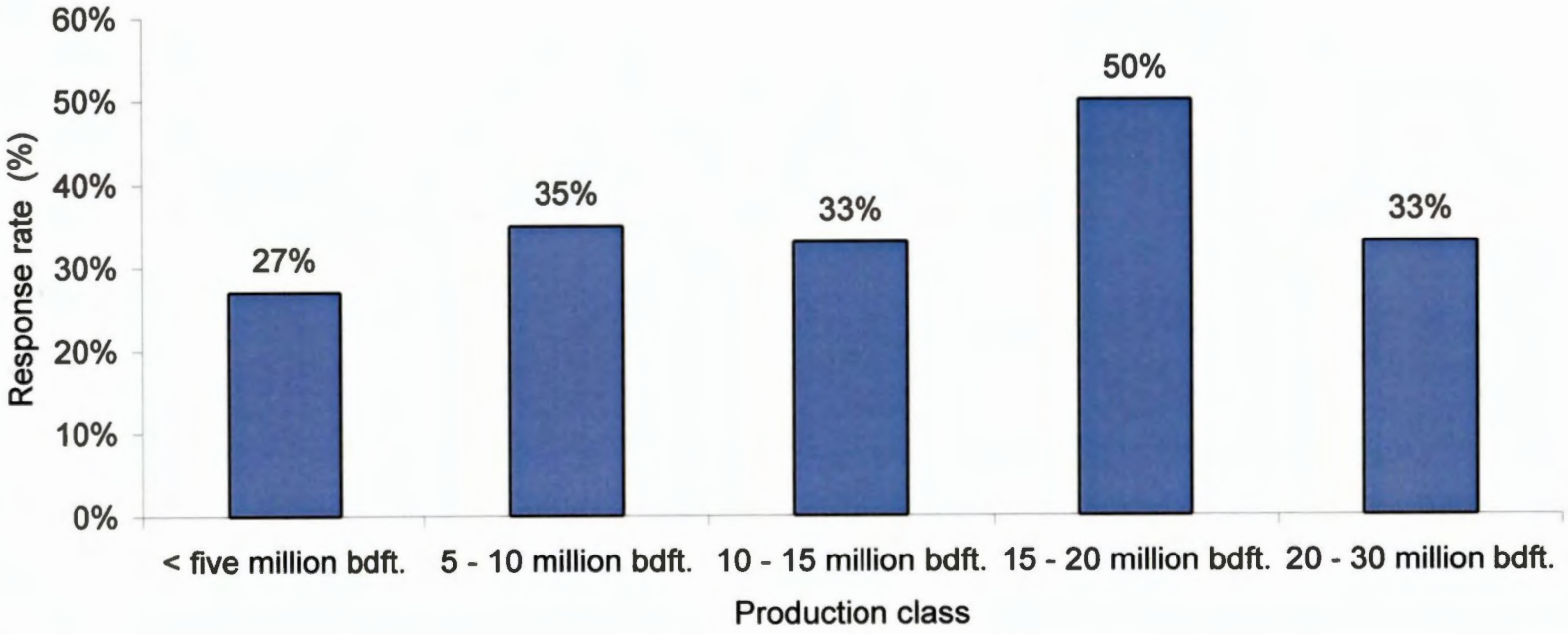


Figure 50. The distribution of responding sawmills with surfacing or planing equipment among production classes.

surfacing or planing equipment among the five annual board foot production classes. Twenty-seven percent of responding sawmills in the less than five million annual board foot production class had surfacing or planing equipment. Thirty-five percent of responding sawmills in the five to ten million annual board foot production class had surfacing or planing equipment. Thirty-three percent of responding sawmills in the ten to fifteen million annual board foot production class had surfacing or planing equipment. Fifty percent of responding sawmills in the fifteen to twenty million annual board foot production class had surfacing or planing equipment. Thirty-three percent of responding sawmills in the twenty to thirty million annual board foot production class had surfacing or planing equipment.

Responding sawmills surfaced or planed an average of twenty-three percent of their total output. The regional averages of the total output surfaced or planed by responding sawmills ranged from thirteen to forty percent (Figure 51) There was a notable difference (P = 0.093) in the distribution of the total output surfaced or planed by responding sawmills among the five geographic regions. An average of fourteen percent of the total output of responding sawmills in the East was surfaced or planed. An average of thirteen percent of the total output of responding sawmills in the Plateau region was surfaced or planed. An average of forty percent of the total output of responding sawmills in the Central region was surfaced

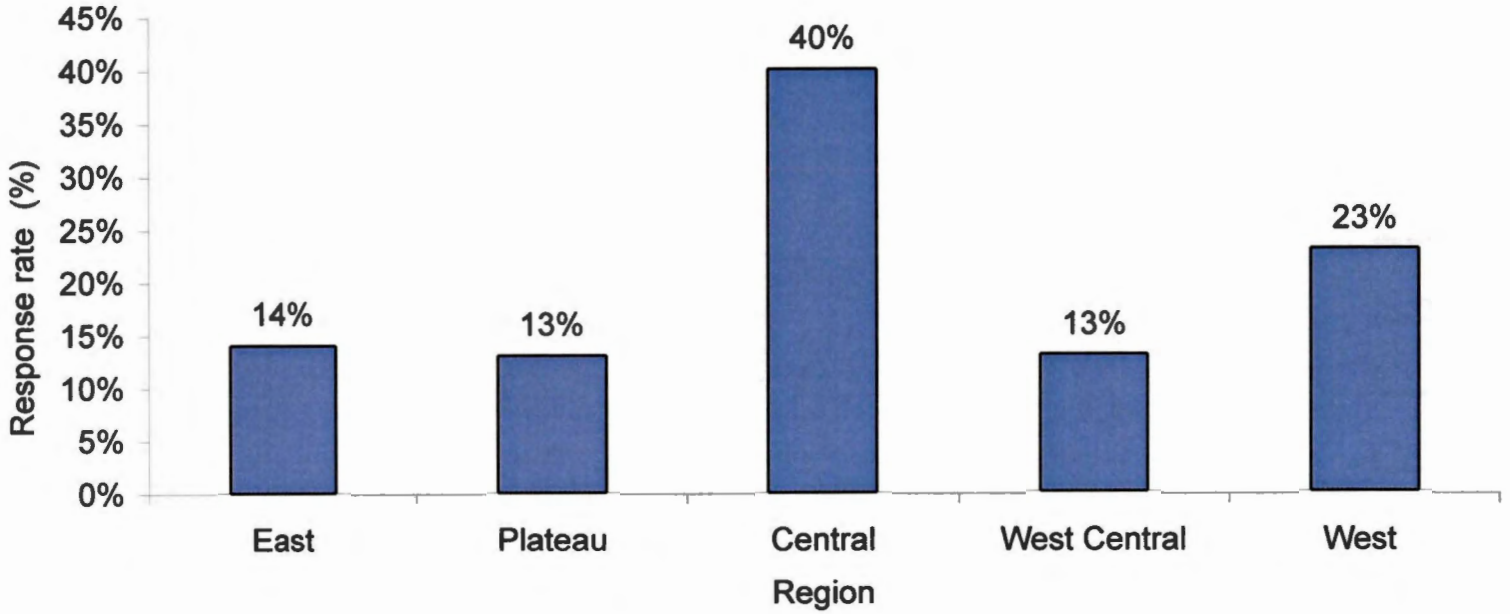


Figure 51. The average volume of production surfaced or planed by responding sawmills by geographic regions.

or planed. An average of thirteen percent of the total output of responding sawmills in the West Central region was surfaced or planed. An average of twenty-three percent of the total output of responding sawmills in the West was surfaced or planed.

The average of the total output surfaced or planed by responding sawmills ranged from zero to twenty-four percent among the five production classes (Figure 52) There was a significant difference (P = 0.019) in the distribution of the total output surfaced or planed by responding sawmills among the five production classes. Twenty-four percent of the total output among responding sawmills in the less than five million annual board foot production class was surfaced or planed. Nineteen percent of the total output among responding sawmills in the five to ten million annual board foot production class was surfaced or planed. Sixteen percent of the total output among responding sawmills in the ten to fifteen million annual board foot production class was surfaced or planed. Twenty-four percent of the total output among responding sawmills in the fifteen to twenty million annual board foot production class was surfaced or planed. None of the total output among responding sawmills in the twenty to thirty million annual board foot production class was surfaced or planed.

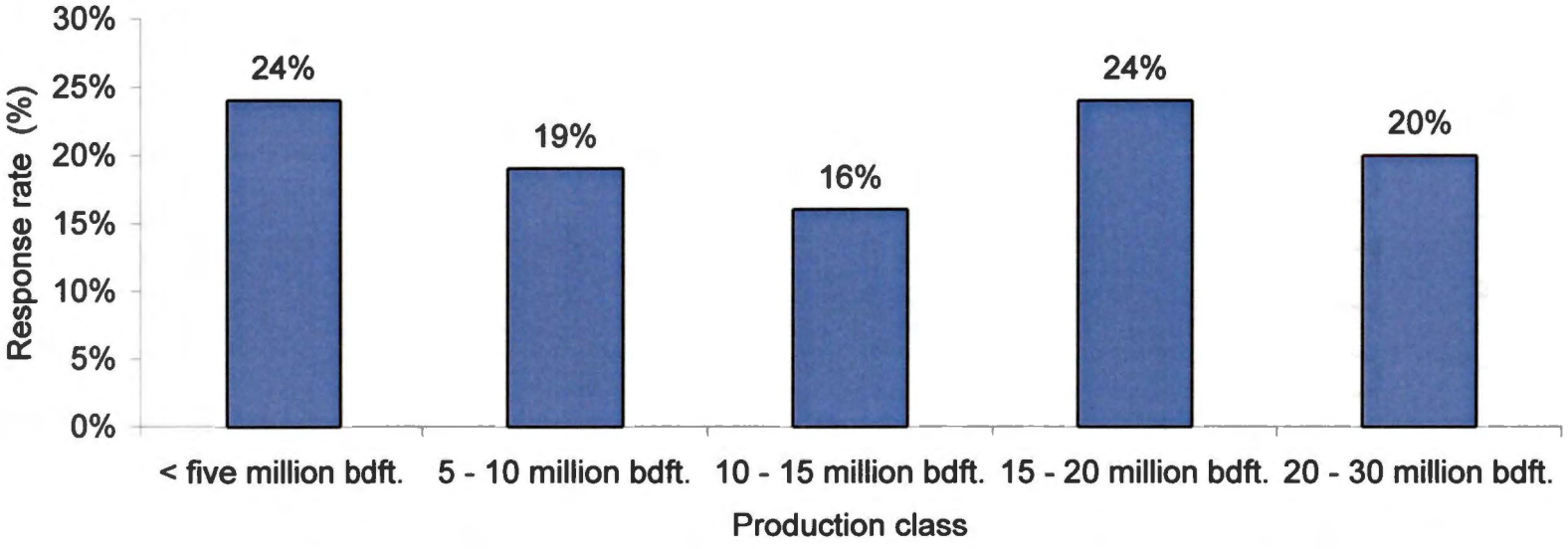


Figure 52. The average volume of production surfaced or planed by responding sawmills among production classes.

Processing equipment

A specific list was generated during the pretesting to identify those sawmills with technologically advanced equipment. The list was not exhaustive but thorough enough to explore trends in the use of technologically advanced equipment among Tennessee sawmills . Three percent of responding sawmills had a ring debarker. Forty-four percent had a Rosser head debarker. Four percent of sawmills had a drum debarker. Standard carriages are in use at sixty percent of responding mills. Ten percent of sawmills had a linear positioning carriage. Nine percent of the responding sawmills had a laser log scanner. Four percent of responding sawmillsuse a light-curtain scanner. One percent of responding sawmills had a camera scanner. Ten percent of sawmills that responded to the profile had a single arbor gang saw in use at their mill. Six percent had a double arbor gang saw. One percent of responding sawmills had a slash gang saw. Forty percent of responding mills use a single arbor edger. Thirteen percent of responding sawmills had a double arbor edger. Seventeen percent of responding sawmills had a vertical edger. Nine percent of responding sawmills use a line bar resaw. Sixteen percent of responding sawmills had a drop saw trimmer.

Thirty-six percent of the responding sawmills plan to purchase new equipment other than a headrig in the next five years. The regional

distribution of responding sawmills with new equipment purchase plans ranged from twenty-two to forty-seven percent (Figure 53). There was no significant difference (P = 0.831) in the number of responding sawmills who planned to purchase new equipment. Thirty-three percent of responding sawmills in the East region planned to purchase new equipment. Forty-seven percent of responding sawmills in the Plateau region planned to purchase new equipment. Thirty-nine percent of responding sawmills in the Central region planned to purchase new equipment. Twenty-two percent of responding sawmills in the West Central region planned to purchase new equipment. Thirty-nine percent of responding sawmills in the West region planned to purchase new equipment.

The regions with the oldest sawmills were also those regions with the highest percentage of new equipment purchase plans. In contrast, the West Central region with the youngest average sawmill age had the lowest percentage of sawmills that planned to purchase new equipment.

The distribution in the number of responding sawmills that planned to purchase new equipment among the five production classes ranged from zero to one hundred percent (Figure 54). There was not a significant difference (P = 0.001) in the number of responding sawmills who planned to purchase new equipment among the five annual board foot production classes. Thirty-two percent of responding sawmills in the less than five

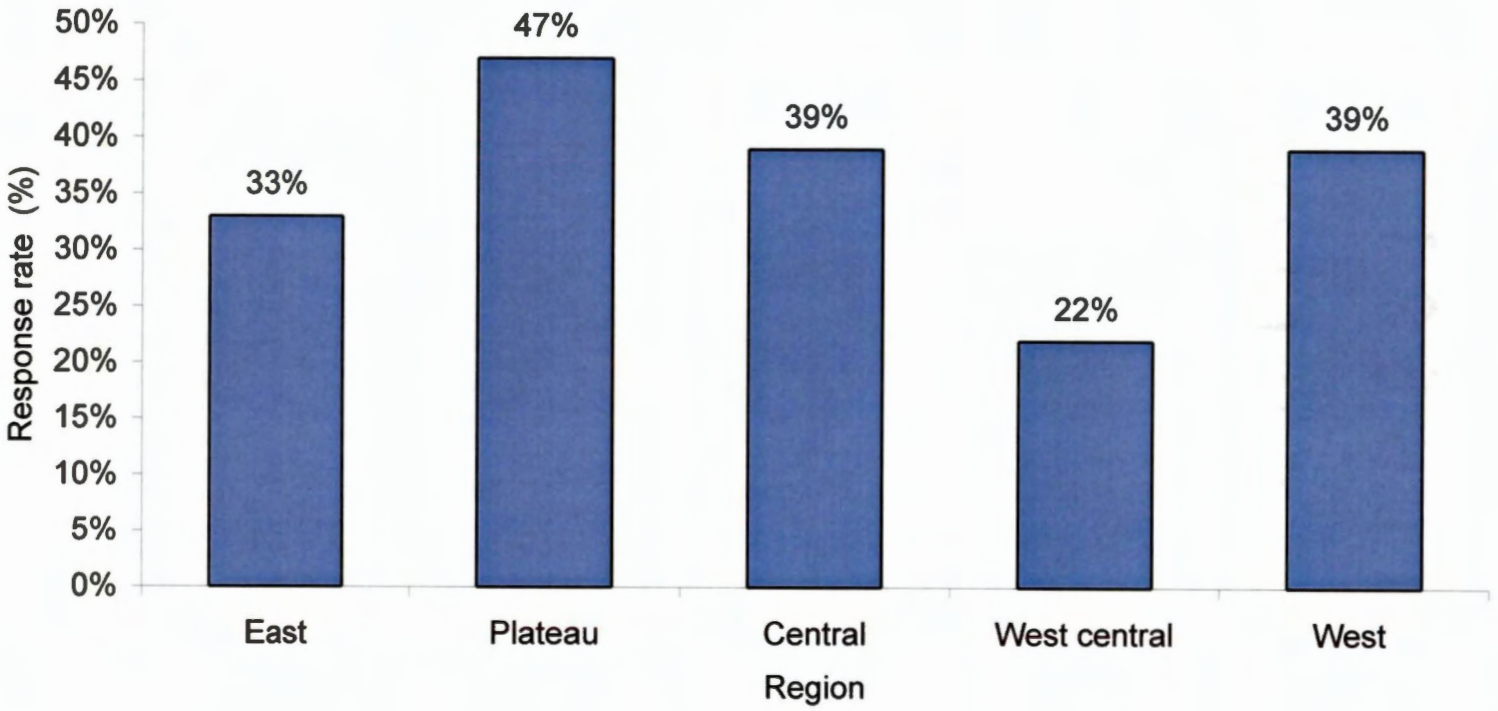


Figure 53. Distribution of sawmills with new equipment purchase plans among regions.

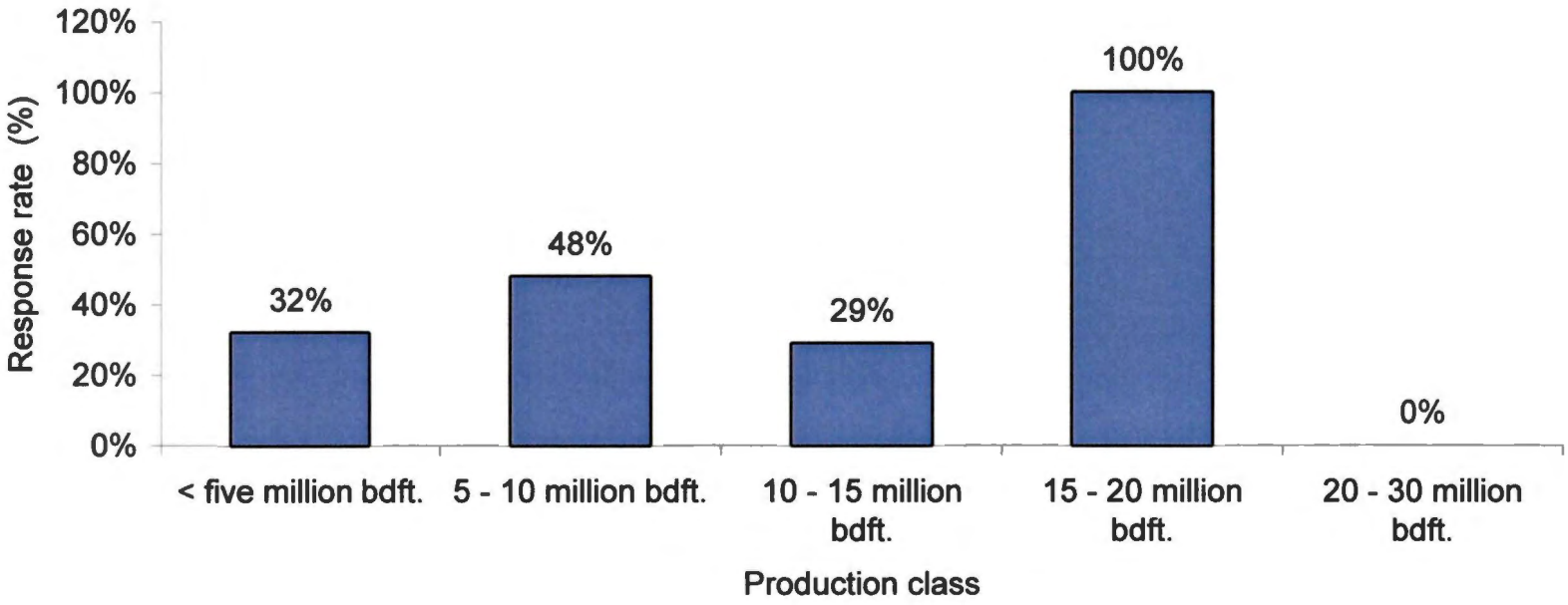


Figure 54. The distribution of sawmills with new equipment purchase plans among production classes.

million annual board foot production class planned to purchase new equipment. Forty-eight percent of responding sawmills in the five to ten million annual board foot production class planned to purchase new equipment. Twenty-nine percent of responding sawmills in the ten to fifteen million annual board foot production class planned to purchase new equipment. All of the responding sawmills in the fifteen to twenty million annual board foot production class region planned to purchase new equipment. None of responding sawmills in the twenty to thirty million annual board foot production class planned to purchase new equipment.

Among responding sawmills with new equipment purchase plans, twenty-one percent planned to buy an edger. Eighteen percent of responding sawmills with new equipment purchase plans reported planning to buy a resaw. Sixteen percent of sawmills with new equipment purchase plans were undecided as to the type of equipment to purchase. Eleven percent of responding sawmills with plans to purchase new equipment reported planning to buy a loader. Eleven percent of responding sawmills with purchase plans for new equipment plan on building a new mill. Other pieces of equipment included in purchase plans by responding sawmills were trimmers (7%), debarkers (7%), carriages (7%), chippers (7%), drop sorters (6%), dry kilns (6%), and planers (5%).

With the addition of the new equipment, responding sawmills expect to increase their production by an average of sixteen percent. The

regional distribution in the percent increase expected in production with the purchase of new equipment ranged from eight to twenty-three percent (Figure 55). There was no significant difference (P = 0.240) in the regional distribution in the percent increase expected in production with the purchase of new equipment. Responding sawmills in the East region expected an increase in production of sixteen percent with the purchase of new equipment. Responding sawmills in the Plateau region expected an increase in production of eight percent with the purchase of new equipment. Responding sawmills in the Central region expected an increase in production of twenty-three percent with the purchase of new equipment. Responding sawmills in the West Central region expected an increase in production of eleven percent with the purchase of new equipment. Responding sawmills in the West region expected an increase in production of thirteen percent with the purchase of new equipment.

The distribution among production classes in the percent increase expected in production with the purchase of new equipment ranged from zero to eighteen percent (Figure 56). There was a significant difference (P = 0.001) in the percent increase expected in production with the purchase of new equipment among production classes. Responding sawmills in the less than five million annual board foot production class expect to increase production by fourteen percent with the purchase of new

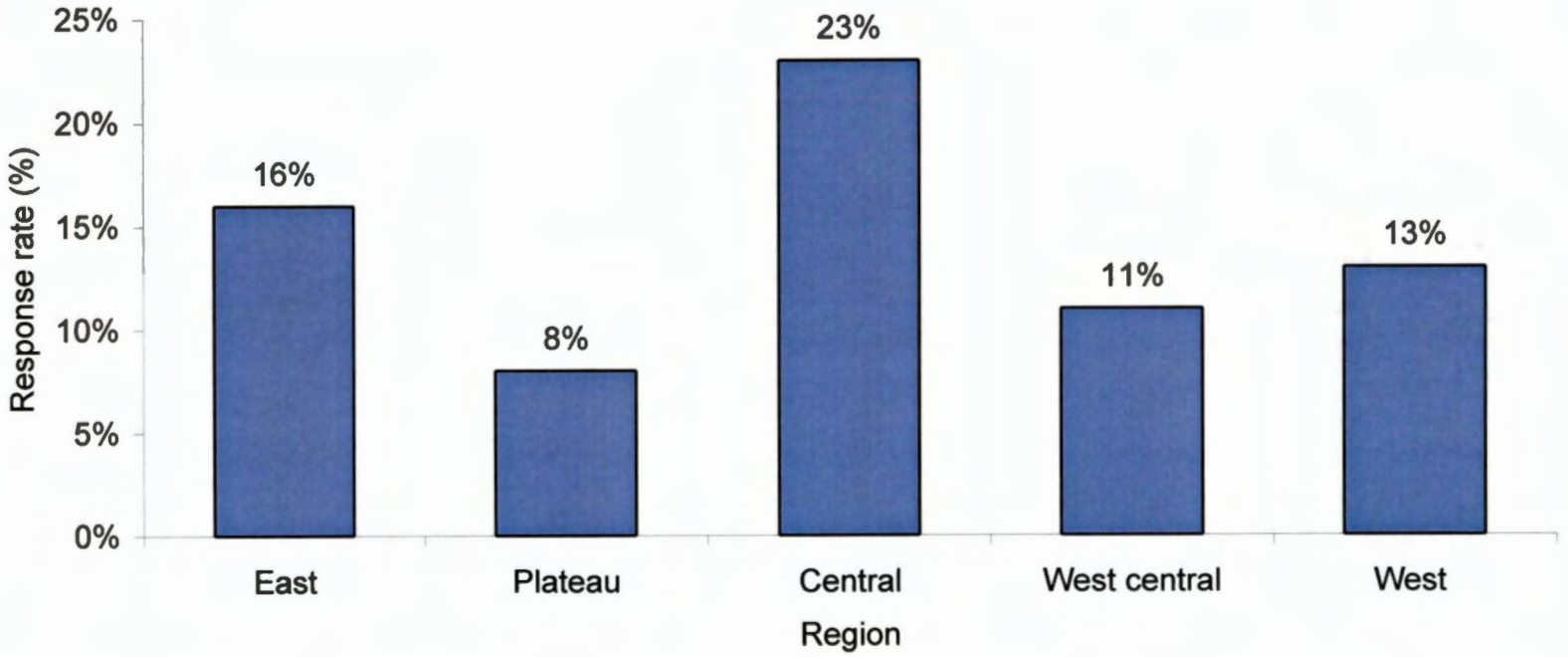


Figure 55. The expected increase in production with new equipment among regions.

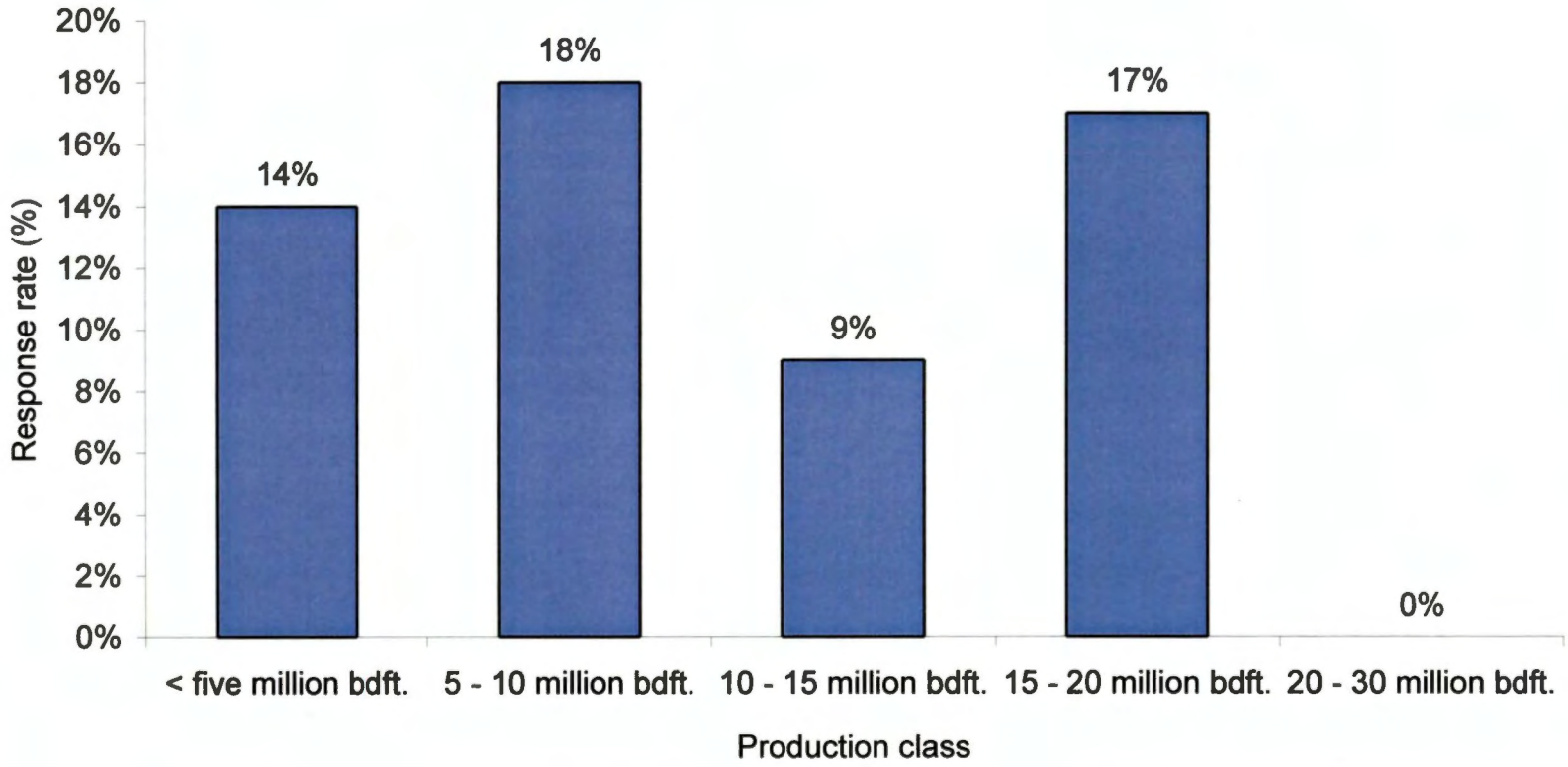


Figure 56. The expected increase in production with new equipment among production classes.

equipment. Responding sawmills in the five to ten million annual board foot production class expect to increase production by eighteen percent with the purchase of new equipment. Responding sawmills in the ten to fifteen million annual board foot production class expect to increase production by nine percent with the purchase of new equipment. Responding sawmills in the fifteen to twenty million annual board foot production class expect to increase production by seventeen percent with the purchase of new equipment. Responding sawmills in the twenty to thirty million annual board foot production class do not expect to increase production with the purchase of new equipment.

Sawmills in the West Central region were on average, the youngest sawmills in the state. These sawmills may not need to replace equipment at this time and may only be purchasing equipment to expand production or increase efficiency. Sawmills in the East region show more instability than other regions and may lack the capital needed for new equipment purchases. However unless sawmills in the East continue to upgrade to newer technologies, the competition will continue to create a difficulties in the production of hardwood lumber. The Plateau, Central, and West regions showed strong growth and development expansion plans.

Among production classes, the fifteen to twenty million annual board foot class showed tremendous growth potential. This production class had the highest capital expenditure rate of all five production

classes. The twenty to thirty million annual board foot production class showed no plans for growth or expansion. This production class may have reached maximum capacity thus new equipment would not have an adequate effect for the sawmill to justify the expense. It may also stand to reason much of the new equipment is not designed to accommodate the amount of lumber produced at these larger facilities.

1. Drying Facilities

Lumber drying can help firms recover profits lost to inefficient production processes since prices for dry lumber have increased substantially in the past ten years. Prices for low grade dry lumber show the most dramatic increase for many species (Figure 57). New processes aimed at reducing drying time, degrade and stain have emerged in the past two years increasing drying efficiency considerably.

A 1998 survey of the hardwood lumber industry by the Weekly Hardwood Review found that seventy-one percent of responding sawmills had a drying facility. Sixty-two percent of the dry kilns had been built since 1993. Sawmills that produce five to ten million board feet per year had built the majority of the dry kilns.

Of the mills that responded to the hardwood sawmill profile, seventeen percent reported having drying facilities. There is a significant

Figure 57. Hard maple dry lumber price index for East Tennessee.

difference (P = 0.001) in whether or not a responding sawmill reported having a drying facility. There was not a significant difference (P = 0.678) in whether or not a responding sawmill had a drying facility among regions. The regional distribution of sawmills with drying facilities show sixteen percent in the East, twenty-one percent in the Plateau, twenty-one percent in the Central, ten percent in the West Central, and thirty-two percent in the West (Figure 58).

There was a significant difference (P = 0.010) in whether or not a responding sawmill had a drying facility among production classes. The distribution of drying facilities among the five production categories ranged from five to forty-seven percent (Figure 59). Forty-seven percent of responding sawmills in the less than five million annual board foot production class had drying facilities. Thirty-two percent of the responding sawmills in the five to ten million annual board foot production class had drying facilities. Five percent of the responding sawmills in the ten to fifteen million annual board foot production class had drying facilities. Eleven percent of the responding sawmills in the fifteen to twenty million annual board foot production class had drying facilities. Five percent of the responding sawmills in the twenty to thirty million annual board foot production class had drying facilities.

The number of kilns reported by these sawmills ranged from one to eight. Fifty-six percent of the mills report an automated kiln control

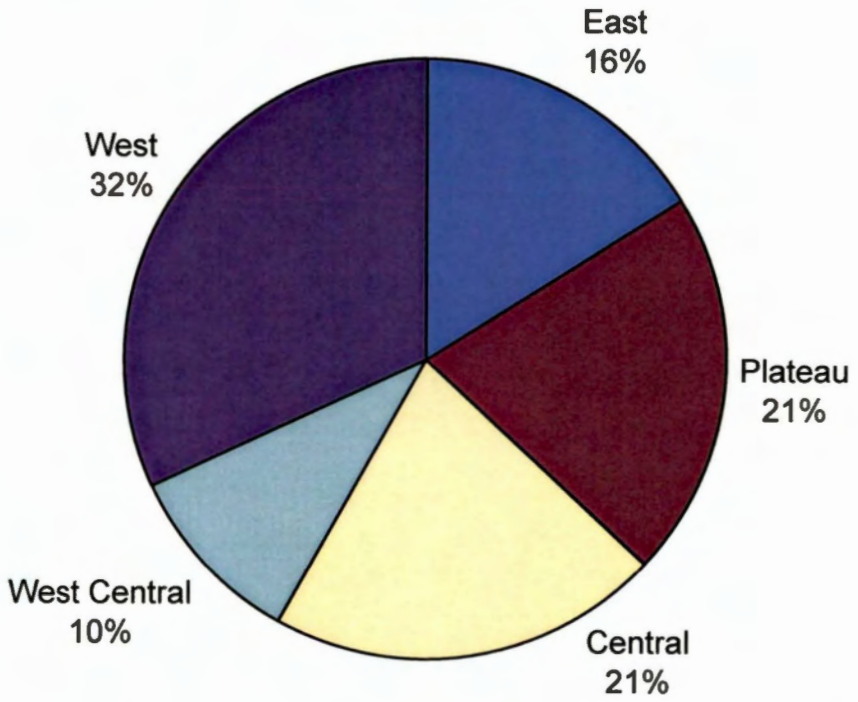


Figure 58. The distribution of sawmills with drying facilities among regions.

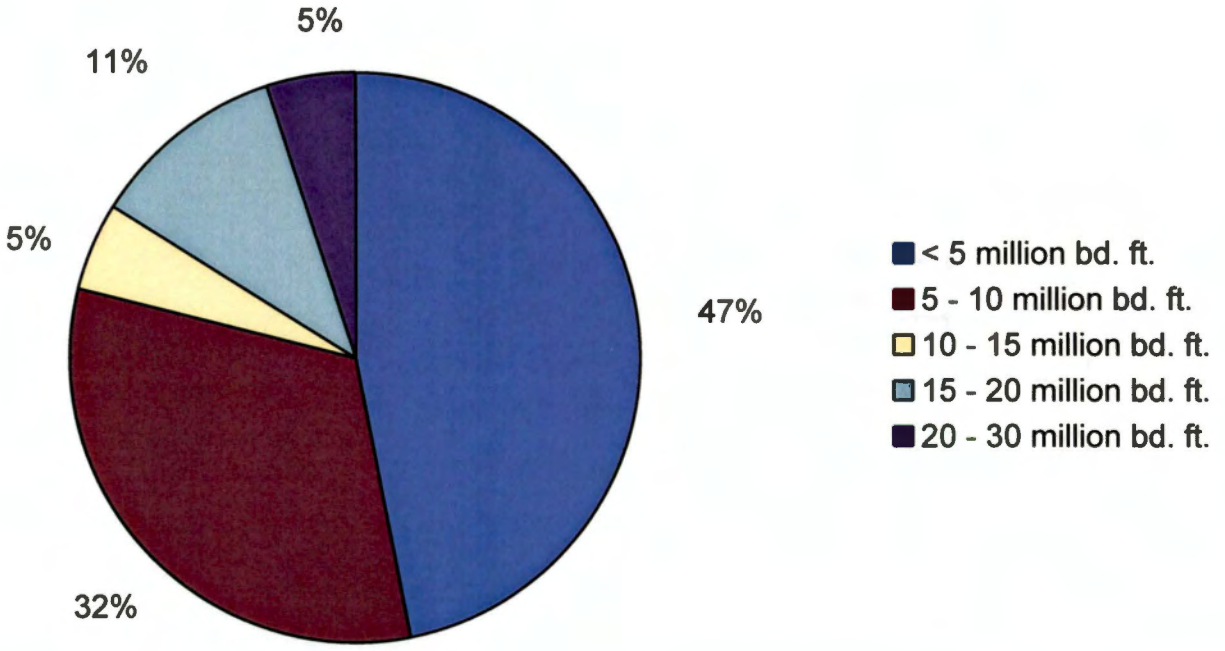


Figure 59. The distribution of sawmills with drying facilities among production classes.

system for their drying process. All of the automated control systems were installed within the past fifteen years.

There were five sources of energy used to operate the drying facilities. Wood waste is used by thirty-nine percent of mills to power their drying facilities. Natural gas accounts for twenty-six percent of the energy source used. Eighteen percent of the drying facilities use electric power. Steam power is used by thirteen percent of sawmills with drying facilities. Solar power is used by four percent of sawmills to run their lumber drying operation.

Average total capacity of the dry kilns was reported as one hundred sixty-eight thousand board feet of lumber. Total capacity of the kiln drying facilities ranged from seventy thousand board feet to three hundred five thousand board feet of lumber among regions. Sawmills reported drying red oak, white oak, yellow-poplar, black walnut, cherry, ash, and cottonwood.

Predrying facilities were reported by twenty-seven percent of mills with drying capability. Average capacity of the predrying facilities is five hundred sixty thousand board feet.

Dry lumber storage was reported by ninety-four percent of the sawmills with drying facilities. Average capacity of the dry lumber storage is one million two hundred forty thousand board feet.

2. RESIDUES

Between twenty and thirty-five percent of the responding sawmills did not adequately complete the residues section of the Tennessee Hardwood Sawmill Profile. Therefore, a statistical analysis of the residue data was not justified. There was, however, some general information that can be reported from the data collected.

The average volume of bark produced by responding sawmills was fifteen thousand eight hundred seventy-seven yards per year. The average volume of chips, slabs, and edgings produced by responding sawmills was fifty-one thousand three hundred seventy tons per year. On average, twenty-six thousand nine hundred tons of sawdust is produced each year by responding sawmills. Less than one percent of the residue produced by responding sawmills is used to generate heat or electricity, sent to a landfill, or given away at no cost each year.

Responding sawmills reported selling more residues than they reported producing. This error, combined with the lack of responses to the survey in the residues section may be an indication that sawmills in Tennessee do not have accurate information on the waste stream produced by their sawmill.

If responses to the residues section of the Tennessee Hardwood Sawmill Profile had been completed, it would have been of interest to

cross sawmill and headrig age, production class, and region with the residue responses. These comparisons may have shown a correlation between mill efficiency and wood waste generated by the sawmills. Further research of residue production in Tennessee's hardwoods sawmills is suggested.

3. External Factors

External factors are those factors over which a sawmill has no control. These factors can have influence over many areas of hardwood lumber production including raw material supply, production, capital, operating expenses, and total profit. It is important to consider how much these factor can influence an individual sawmill as well as the industry as a whole.

Responses to the Tennessee Hardwood Sawmill Profile showed that all of the external factors listed in the survey had a moderate influence on responding sawmills. There was no significant difference ($P = 0.582$) in the responses for all external factors. There was no significant difference in the distribution of the responses for the five geographical regions or the five production classes.

Sawmills in lower production classes had a greater perception that the external factors had less of an effect on their business. They feel that

because they are small they are less susceptible to outside influences. External factors may have a greater effect on these smaller sawmills given the fact that they have no market power or price influences.

Table 10.The distribution of responses to a decrease in the supply of raw materials among regions.

			Region			
Response	East	Plateau	Central	West Central	West	Total
No Influence	2%	2%	4%	2%	2%	12%
Little Influence	3%	1%	3%	2%	3%	12%
Moderate Influence	2%	3%	5%	5%	5%	20%
Significant Influence	10%	8%	5%	9%	7%	39%
Do Not Know	7%	3%	4%	3%	0%	17%
Total	24%	17%	21%	21%	17%	100%

Table 11. The distribution of responses to a change in the quality of raw materials among regions.

			Region			
Response	East	Plateau	Central	West Central	West	Total
No Influence	2%	2%	3%	2%	2%	11%
Little Influence	0%	4%	4%	2%	3%	13%
Moderate Influence	6%	4%	3%	5%	6%	24%
Significant Influence	8%	5%	8%	10%	6%	37%
Do Not Know	8%	2%	3%	2%	0%	15%
Total	24%	17%	21%	21%	17%	100%

Table 12. The distribution of responses to a change in the cost of raw materials among regions.

			Region			
Response	East	Plateau	Central	West Central	West	Total
No Influence	1%	2%	2%	1%	0%	6%
Little Influence	0%	1%	2%	2%	0%	5%
Moderate Influence	3%	2%	3%	2%	4%	14%
Significant Influence	12%	10%	12%	14%	13%	61%
Do Not Know	8%	2%	2%	2%	0%	14%
Total	24%	17%	21%	21%	17%	100%

Table 13. The distribution of responses to an increase in the minimum wage among regions.

			Region			
Response	East	Plateau	Central	West Central	West	Total
No Influence	8%	4%	8%	9%	3%	32%
Little Influence	3%	4%	6%	6%	6%	25%
Moderate Influence	1%	4%	3%	2%	4%	14%
Significant Influence	3%	3%	1%	4%	4%	15%
Do Not Know	9%	2%	3%	0%	0%	14%
Total	24%	17%	21%	21%	17%	100%

Table 14. The distribution of responses to the rate of inflation among regions.

			Region			
Response	East	Plateau	Central	West Central	West	Total
No Influence	2%	2%	3%	4%	0%	11%
Little Influence	3%	4%	6%	4%	2%	19%
Moderate Influence	6%	4%	6%	5%	8%	29%
Significant Influence	4%	4%	3%	6%	5%	22%
Do Not Know	9%	3%	3%	2%	2%	19%
Total	24%	17%	21%	21%	17%	100%

Table 15. The distribution of responses to interest rates among regions.

			Region			
Response	East	Plateau	Central	West Central	West	Total
No Influence	2%	1%	2%	4%	1%	10%
Little Influence	3%	3%	5%	2%	1%	14%
Moderate Influence	2%	6%	6%	7%	6%	27%
Significant Influence	8%	4%	4%	7%	8%	31%
Do Not Know	9%	3%	4%	1%	1%	18%
Total	24%	17%	21%	21%	17%	100%

Table 16. The distribution of responses to energy prices among regions.

			Region			
Response	East	Plateau	Central	West Central	West	Total
No Influence	3%	0%	2%	3%	1%	9%
Little Influence	1%	3%	3%	4%	4%	15%
Moderate Influence	5%	4%	8%	4%	4%	25%
Significant Influence	6%	7%	5%	8%	7%	33%
Do Not Know	9%	3%	3%	2%	1%	18%
Total	24%	17%	21%	21%	17%	100%

Table 17. The distribution of responses to business cycles among regions.

			Region			
Response	East	Plateau	Central	West Central	West	Total
No Influence	3%	0%	5%	1%	0%	9%
Little Influence	2%	3%	2%	4%	3%	14%
Moderate Influence	3%	5%	6%	2%	4%	20%
Significant Influence	7%	7%	4%	10%	8%	36%
Do Not Know	9%	2%	4%	4%	2%	21%
Total	24%	17%	21%	21%	17%	100%

Table 18. The distribution of responses to market competition among regions.

			Region			
Response	East	Plateau	Central	West Central	West	Total
No Influence	0%	1%	3%	0%	1%	5%
Little Influence	3%	2%	5%	1%	4%	15%
Moderate Influence	6%	6%	5%	8%	4%	29%
Significant Influence	6%	6%	5%	10%	7%	34%
Do Not Know	9%	2%	3%	2%	1%	17%
Total	24%	17%	21%	21%	17%	100%

Table 19. The distribution of responses to market uncertainty among regions.

			Region			
Response	East	Plateau	Central	West Central	West	Total
No Influence	3%	1%	3%	0%	0%	7%
Little Influence	1%	1%	5%	2%	2%	11%
Moderate Influence	3%	4%	7%	4%	5%	23%
Significant Influence	7%	9%	3%	13%	9%	41%
Do Not Know	10%	2%	3%	2%	1%	18%
Total	24%	17%	21%	21%	17%	100%

Table 20. The distribution of responses to secondary markets among regions.

			Region			
Response	East	Plateau	Central	West Central	West	Total
No Influence	3%	1%	4%	1%	2%	11%
Little Influence	3%	3%	5%	5%	4%	20%
Moderate Influence	4%	6%	6%	6%	5%	27%
Significant Influence	3%	4%	2%	6%	4%	19%
Do Not Know	11%	3%	4%	3%	2%	23%
Total	24%	17%	21%	21%	17%	100%

Table 21. The distribution of responses to weather among regions.

			Region			
Response	East	Plateau	Central	West Central	West	Total
No Influence	0%	0%	1%	3%	3%	7%
Little Influence	4%	2%	4%	2%	1%	13%
Moderate Influence	7%	4%	4%	6%	3%	24%
Significant Influence	4%	9%	11%	10%	8%	42%
Do Not Know	9%	2%	1%	0%	2%	14%
Total	24%	17%	21%	21%	17%	100%

Table 22. The distribution of responses to state and federal regulations among regions.

			Region			
Response	East	Plateau	Central	West Central	West	Total
No Influence	3%	0%	3%	1%	2%	9%
Little Influence	6%	3%	5%	4%	2%	20%
Moderate Influence	2%	4%	4%	6%	6%	22%
Significant Influence	4%	7%	4%	8%	6%	29%
Do Not Know	9%	3%	5%	2%	1%	20%
Total	24%	17%	21%	21%	17%	100%

Table 23. The distribution of responses to export markets among regions.

			Region			
Response	East	Plateau	Central	West Central	West	Total
No Influence	3%	3%	8%	4%	4%	22%
Little Influence	1%	3%	4%	2%	1%	11%
Moderate Influence	2%	2%	4%	2%	5%	15%
Significant Influence	7%	6%	2%	12%	6%	33%
Do Not Know	11%	3%	3%	1%	1%	19%
Total	24%	17%	21%	21%	17%	100%

Table 24.The distribution of responses to a decrease in the supply of raw materials among production classes.

Response	< 5 million bd. ft.	5 - 10 million bd. ft.	10 - 15 million bd. ft.	15 - 20 million bd. ft.	20 - 30 million bd. ft.	Total
No Influence	10%	2%	0%	0%	0%	12%
Little Influence	9%	1%	1%	0%	0%	11%
Moderate Influence	12%	6%	0%	2%	1%	21%
Significant Influence	24%	8%	4%	2%	2%	40%
Do Not Know	14%	1%	1%	0%	0%	16%
Total	69%	18%	6%	4%	3%	100%

Table 25. The distribution of responses to a change in the quality of raw materials among production classes.

Response	< 5 million bd. ft.	5 - 10 million bd. ft.	10 - 15 million bd. ft.	15 - 20 million bd. ft.	20 - 30 million bd. ft.	Total
No Influence	10%	1%	0%	0%	0%	11%
Little Influence	10%	1%	0%	1%	1%	13%
Moderate Influence	14%	8%	2%	1%	0%	25%
Significant Influence	23%	7%	3%	2%	2%	37%
Do Not Know	12%	1%	1%	0%	0%	14%
Total	69%	18%	6%	4%	3%	100%

Table 26. The distribution of responses to a change in the cost of raw materials among production classes.

Response	< 5 million bd. ft.	5 - 10 million bd. ft.	10 - 15 million bd. ft.	15 - 20 million bd. ft.	20 - 30 million bd. ft.	Total
No Influence	6%	0%	0%	0%	0%	6%
Little Influence	6%	0%	0%	0%	0%	6%
Moderate Influence	11%	2%	1%	0%	0%	14%
Significant Influence	34%	15%	4%	4%	3%	60%
Do Not Know	12%	1%	1%	0%	0%	14%
Total	69%	18%	6%	4%	3%	100%

Table 27. The distribution of responses to an increase in the minimum wage among production classes.

Response	< 5 million bd. ft.	5 - 10 million bd. ft.	10 - 15 million bd. ft.	15 - 20 million bd. ft.	20 - 30 million bd. ft.	Total
No Influence	25%	7%	0%	1%	0%	33%
Little Influence	16%	3%	3%	1%	2%	25%
Moderate Influence	6%	5%	1%	1%	0%	13%
Significant Influence	11%	2%	1%	1%	1%	16%
Do Not Know	11%	1%	1%	0%	0%	13%
Total	69%	18%	6%	4%	3%	100%

Table 28. The distribution of responses to the rate of inflation among production classes.

Response	< 5 million bd. ft.	5 - 10 million bd. ft.	10 - 15 million bd. ft.	15 - 20 million bd. ft.	20 - 30 million bd. ft.	Total
No Influence	10%	0%	0%	0%	0%	10%
Little Influence	14%	2%	1%	0%	3%	20%
Moderate Influence	14%	10%	3%	3%	0%	30%
Significant Influence	16%	4%	1%	1%	0%	22%
Do Not Know	15%	2%	1%	0%	0%	18%
Total	69%	18%	6%	4%	3%	100%

Table 29. The distribution of responses to interest rates among production classes.

Response	< 5 million bd. ft.	5 - 10 million bd. ft.	10 - 15 million bd. ft.	15 - 20 million bd. ft.	20 - 30 million bd. ft.	Total
No Influence	8%	0%	1%	0%	1%	10%
Little Influence	11%	2%	0%	0%	0%	13%
Moderate Influence	17%	5%	2%	1%	2%	27%
Significant Influence	18%	9%	2%	3%	0%	32%
Do Not Know	15%	2%	1%	0%	0%	18%
Total	69%	18%	6%	4%	3%	100%

Table 30. The distribution of responses to energy prices among production classes.

Response	< 5 million bd. ft.	5 - 10 million bd. ft.	10 - 15 million bd. ft.	15 - 20 million bd. ft.	20 - 30 million bd. ft.	Total
No Influence	6%	1%	1%	0%	0%	8%
Little Influence	13%	2%	0%	1%	0%	16%
Moderate Influence	15%	6%	2%	1%	2%	26%
Significant Influence	21%	7%	2%	2%	1%	33%
Do Not Know	14%	2%	1%	0%	0%	17%
Total	69%	18%	6%	4%	3%	100%

Table 31. The distribution of responses to business cycles among production classes.

Response	< 5 million bd. ft.	5 - 10 million bd. ft.	10 - 15 million bd. ft.	15 - 20 million bd. ft.	20 - 30 million bd. ft.	Total
No Influence	8%	0%	1%	0%	0%	9%
Little Influence	11%	1%	0%	0%	1%	13%
Moderate Influence	11%	6%	1%	2%	2%	22%
Significant Influence	21%	9%	3%	2%	0%	35%
Do Not Know	18%	2%	1%	0%	0%	21%
Total	69%	18%	6%	4%	3%	100%

Table 32. The distribution of responses to market competition among production classes.

Response	< 5 million bd. ft.	5 - 10 million bd. ft.	10 - 15 million bd. ft.	15 - 20 million bd. ft.	20 - 30 million bd. ft.	Total
No Influence	4%	0%	0%	0%	0%	4%
Little Influence	10%	4%	0%	2%	0%	16%
Moderate Influence	20%	5%	2%	1%	3%	31%
Significant Influence	21%	7%	3%	1%	0%	32%
Do Not Know	14%	2%	1%	0%	0%	17%
Total	69%	18%	6%	4%	3%	100%

Table 33. The distribution of responses to market uncertainty among production classes.

Response	< 5 million bd. ft.	5 - 10 million bd. ft.	10 - 15 million bd. ft.	15 - 20 million bd. ft.	20 - 30 million bd. ft.	Total
No Influence	6%	0%	0%	0%	0%	6%
Little Influence	7%	2%	1%	2%	0%	12%
Moderate Influence	13%	4%	2%	2%	2%	23%
Significant Influence	28%	10%	2%	0%	1%	41%
Do Not Know	15%	2%	1%	0%	0%	18%
Total	69%	18%	6%	4%	3%	100%

Table 34. The distribution of responses to secondary markets among production classes.

Response	< 5 million bd. ft.	5 - 10 million bd. ft.	10 - 15 million bd. ft.	15 - 20 million bd. ft.	20 - 30 million bd. ft.	Total
No Influence	7%	1%	0%	1%	1%	10%
Little Influence	15%	5%	1%	1%	0%	22%
Moderate Influence	16%	5%	3%	2%	2%	28%
Significant Influence	12%	4%	1%	0%	0%	17%
Do Not Know	19%	3%	1%	0%	0%	23%

Table 35. The distribution of responses to weather among production classes.

Response	< 5 million bd. ft.	5 - 10 million bd. ft.	10 - 15 million bd. ft.	15 - 20 million bd. ft.	20 - 30 million bd. ft.	Total
No Influence	21%	0%	0%	1%	0%	22%
Little Influence	10%	3%	1%	0%	0%	14%
Moderate Influence	18%	3%	2%	1%	2%	26%
Significant Influence	26%	10%	2%	2%	1%	41%
Do Not Know	11%	2%	1%	0%	0%	14%
Total	86%	18%	6%	4%	3%	117%

Table 36. The distribution of responses to state and federal regulations among production classes.

Response	< 5 million bd. ft.	5 - 10 million bd. ft.	10 - 15 million bd. ft.	15 - 20 million bd. ft.	20 - 30 million bd. ft.	Total
No Influence	7%	1%	0%	0%	0%	8%
Little Influence	15%	1%	2%	2%	1%	21%
Moderate Influence	11%	7%	2%	2%	0%	22%
Significant Influence	19%	7%	1%	0%	2%	29%
Do Not Know	17%	2%	1%	0%	0%	20%

Table 37. The distribution of responses to export markets among production classes.

Response	< 5 million bd. ft.	5 - 10 million bd. ft.	10 - 15 million bd. ft.	15 - 20 million bd. ft.	20 - 30 million bd. ft.	Total
No Influence	19%	2%	0%	1%	0%	22%
Little Influence	4%	3%	0%	2%	2%	11%
Moderate Influence	9%	4%	2%	0%	0%	15%
Significant Influence	21%	7%	3%	1%	1%	33%
Do Not Know	16%	2%	1%	0%	0%	19%
Total	69%	18%	6%	4%	3%	100%

1. PROBLEMS

An important element of the Tennessee Hardwood Sawmill Profile was to allow responding sawmill the opportunity to give open responses to the types of problems they encounter as part of their industry. Problems were addressed in the beginning of the survey to reassure respondents of their opportunity to freely express their perspective on the hardwood sawmill industry in the state. Responding sawmills were asked to list their top problem in several categories. Responses varied independently, with no significant difference among regions (P = 0.643) and production classes (P = 0.433).

Log Supply

Thirty-six percent of responding sawmills had no major problems with log supply. Twenty-percent of responding sawmills reported that log quality was the problem of greatest concern with regard to log supply. Sixteen percent reported that prices for logs were too high. Thirteen percent reported that acquiring logs for processing was the major problem in the log supply category. Seven percent reported that the weather made the acquisition difficult. Eight percent reported a variety of problems in

their log supply including difficulty with logging operations, lack of logs from the National Forests and inadequate log size.

Production and Processing

Fifty-seven percent of responding sawmills reported no reoccurring problems in production and processing. Sixteen percent of responding sawmills reported that equipment maintenance and repair was the largest problem with production and processing. Fourteen percent of responding sawmills reported labor was the largest problem in production and processing. Eight percent of responding sawmills reported that the continual upgrading of equipment was the most burdensome problem with production and processing. One percent of sawmills reported other problems that included the lack of capital and the lack of financing for the purchase of new equipment.

Employees

Thirty-eight percent of responding sawmills reported having no reoccurring problems with employees. Thirty-eight percent of sawmills reported having problems with employee turnover. Fourteen percent reported that attendance was the greatest problem with employees. Eight

percent of responding sawmills reported that low pay was the greatest problem with employees. Four percent reported that the greatest problem with employees was the request for more benefits. Thirteen percent reported other problems with employees including lack of qualified applicants for open positions, a lack of education for positions that require training above a high school diploma, low morale, and a high rate of absenteeism.

Lumber Market

Forty-four percent of sawmills report no problems with the lumber market. Thirty-six percent of sawmills reported that the market for the products they produce is unstable. Eighteen percent of sawmills report the price of lumber is too low. Two percent reported a variety of problems with the lumber market including a lack of local markets, a lack of a market for low quality lumber, and the purchase limits from quotas set by secondary industries.

Environmental Regulations

Sixty-seven percent of responding sawmills had no problems with environmental regulations. Nine percent reported that there were too

many environmental regulations in place. Five percent felt the current environmental policies were hard too comply with. Four percent of sawmills felt the environmental regulations were politically driven. Six percent of responding sawmills reported a variety of problems with environmental regulations including too much paperwork associated with compliance, current regulations were unfair to smaller sawmills, and the regulations are too costly to comply with.

Other

Fourteen percent of responding sawmills included problems that did not fit into the categories specified on the survey. In each instance, these responses accounted for a response rate of less than two percent of responding sawmills. Other problems included problems with the media, public perception of the industry, taxes, safety, clearcutting, immigrant workers, striplogging, paperwork, and the condition of incoming logs.

2. RESPONDENT PROFILE

Sawmill owners completed sixty-seven percent of the surveys. Sawmill presidents completed twelve percent of the surveys.

Twelve percent of the surveys were completed by mill managers. Production managers completed two percent of the surveys. Seven percent of the surveys were completed by someone other than specified in the questionnaire. Tennessee Hardwood Sawmill Profile respondents had been in their current position an average of fourteen years.

Thirty-six percent of survey respondents were members of the Tennessee Forestry Association. Twenty-one percent of survey respondents were members of the National Hardwood Lumber Association. Eight percent of survey respondents were members of the Hardwood Manufacturers Association. Six percent of survey respondents were members of the Appalachian Hardwood Manufacturers Inc. Two percent of survey respondents were members of a trade association not specifically listed in the questionnaire.

Conclusion

The purpose of the Tennessee Hardwood Sawmill Profile was to create a broad-based description of the hardwood sawmill industry in Tennessee. The profile was designed to provide the industry with information that would aid sawmills with capital expenditure decisions. Many aspects of hardwood lumber production were encompassed by the survey to ensure representation of all types and sizes of hardwood sawmills.

Sawmills in Tennessee do not show distinct variation among regions. However much variation is seen in all aspects of hardwood lumber production when survey data is compared among the five classes of annual board foot production. Sawmills in the two largest production classes are stable, more efficient, and able to maintain market power. Overall the large sawmills have shown growth and expansion in the industry. Sawmills in the twenty to thirty million board foot production class appear to have reached production capacity with no plans for further modernization. Sawmills in the fifteen to twenty million board foot production class will continue to develop and are more likely to purchase new equipment.

Sawmills in the smallest annual levels of production are more volatile. These mills are more likely to have seen a decline in production

and have a greater proportion of sawmills that will be forced out of the market. This process will lessen the competitive burden on small, but efficient, sawmills that can withstand market fluctuations.

Interpretation of the results would be unique to the situation of an individual sawmill. Specific regional and annual board foot production information can be used to derive purchase plans to maximize productive efficiency and allocative efficiency.

Given the breadth of the information collected, many relationships in the data have yet to be explored. Supplementary, more detailed analysis of the data collected from the survey will be completed by the Tennessee Forest Products Center. The Tennessee Hardwood Sawmill Profile should be implemented every five to seven years to ensure data is current. Revisions to the questionnaire should be made to the residue section so that more comprehensive information will be collected about the generation of wood waste by Tennessee sawmills. Other revisions to the survey could include more specific questions regarding equipment types, foreign exports, and more specific board foot production values.

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Appendix A

Dear Tennessee Hardwood Sawmill Owner/Producer:

The mission of the Tennessee Forest Products Center is to help Tennessee wood products producers solve problems. The goal of this survey is to profile changing technology in the hardwood industry as well as address the problems and concerns facing hardwood lumber producers today. Our hope is to aid Tennessee producers in their decision making process by providing an assessment of the hardwood sawmill industry in the state. It is important for us to identify the issues you are faced with. In order to truly characterize an industry as complex as yours, it is important that each questionairre be completed and returned.

As a hardwood sawmiller, no one knows the industry better. Your input into this research is vital. It allows you to voice your concerns about where the hardwood sawmill industry is headed. It is an opportunity for you to get involved and help ensure the success of the industry.

The confidentiality of your survey responses is guaranteed. The results of this survey will never be presented in a way that will allow the identification of your mill. The survey has an identification number for mailing purposes only, so we may check your name off the mailing list when the questionnaire is returned. Your name will never be placed on the questionnaire.

The results of this research will be made available to the hardwood sawmill industry, forestry professionals, equipment manufacturers, and be used guide our research at the Tennessee Forest Products Center. You may receive a summary of the results by checking the appropriate box at the end of the questionnaire.

We would be happy to answer any questions you have about this survey. Please call (423) 974-7994 or e-mail lganus@utk.edu.

Thank you for your assistance.

Sincerely,

Dr. Paul M. Winistorfer
Director

Leslie C. Ganus
Graduate Research Assistant

The Tennessee Hardwood Sawmill Profile
Tennessee Forest Products Center

Q-1 Please describe the top problem encountered by your mill in all of the following categories.

1 Log supply _____

_____

_____

_____

_____

_____

2 Production/ Processing _____

_____

_____

_____

_____

_____

3 Employees _____

4 Lumber market

5 Environmental regulation

_____

_____

6 Other _____

_____

_____

_____

_____

_____

Q-2 How much does each of the following external factors influence your mill?

	No Influence	Little Influence	Moderate Influence	Significant Influence	Do Not Know
Decrease In The Supply Of Raw Materials	1	2	3	4	5
Change In The Quality Of Raw Materials	1	2	3	4	5
Change In The Cost Of Raw Materials	1	2	3	4	5
Increase In Minimum Wage	1	2	3	4	5
Rate Of Inflation	1	2	3	4	5
Interest Rates	1	2	3	4	5
Energy Prices	1	2	3	4	5
Business Cycles	1	2	3	4	5

Market Competition	1	2	3	4	5
Market Uncertainty	1	2	3	4	5
Secondary Markets	1	2	3	4	5
Weather	1	2	3	4	5
State And Federal Regulations	1	2	3	4	5
Export Markets	1	2	3	4	5

Q-3 Who do you most often contact to help solve problems at your mill? (circle all that apply)

1 Other mills
2 The University of Tennessee
3 Tennessee Forest Products Center
4 National Hardwood Lumber Association
5 Tennessee Forestry Association
6 Equipment Manufactures
7 Tennessee Division of Forestry
8 USDA Forest Products Laboratory
9 Consultants

10 Other (specify) _____

Q-4 Does your mill have access to the Internet? (circle one)

1 Yes
2 No

Q-5 Does your mill have its own web site (Internet homepage)? (circle one)

1 Yes
2 No

Q-6 Which of the following items best describe your company? (circle one)

1 Proprietorship
2 Partnership

3 Public corporation
4 Private corporation
5 Other (specify) _____

Q-7 Is your mill portable or stationary? (circle one)

1 Portable
2 Stationary

Q-8 In what year was your business established? (specify)
_____(year)

Q-9 How long has your mill been in its current location? (specify)
_____(years)

Q-10 Do you plan to move to a new location in the next 10 years? (circle one)

1 Yes
2 No
If yes, why? _____

Q-11 Do you plan on closing your mill in the next 10 years? (circle one)

1 Yes
2 No
If yes, why? _____

Q-12 Does your mill own timberland in Tennessee? (circle one)

1 Yes
2 No

Q-13 Does your mill own a logging operation in Tennessee? (circle one)

1 Yes
2 No

Q-14 How many full time employees do you have at the mill? (circle one)

1	1 - 10	7	61 - 70
2	11 - 20	8	71 - 80
3	21 - 30	9	81 - 90
4	31 - 40	10	91 - 100
5	41 - 50	11	100+
6	51 - 60	12	No full-time employees

Q-15 In the past ten years, has the number of full time employees changed? (circle one)

1 increased
2 decreased
3 remained constant

By what percent, if any, has the number changed?
_____%

Q-16 Do you have any part time employees at the mill? (circle one)

1 Yes
2 No

Q-17 Which of the following values best describe the yearly level of production?

1 <5 million bdft	5 20-30 million bdft
2 5-10 million bdft	6 30-40 million bdft
3 10-15 million bdft	7 40-50 million bdft
4 15-20 million bdft	8 >50 million bdft

Q-18 In the last 10 years, has the production level of your mill changed? (circle one)

1 Increased
2 Decreased
3 Remained constant

By what percent, if any, has the production level changed?
_____%

Q-19 How many shifts do you run? (circle number)

1
2
3

Q-20 How many days per year does your mill operate? (specify)
_____Days

Q-21 How many hours per week are you shut down for equipment repairs? (specify)
_____Hours

Q-22 For what reasons, other than equipment repair, has your mill been shut down in the past year? (specify)

_____

_____

_____

_____

_____

_____

Q-23 What products are produced at your mill? (circle all that apply)

1 Rough lumber
2 Finished lumber
3 Dimension lumber
4 Ties
5 Cants
6 Other (specify)

_____

Q-24 What hardwood species are cut at your sawmill? (circle all that apply)

1 Red oak
2 White oak
3 Yellow-poplar
4 Hickory
5 Elm
6 Hard maple
7 Soft maple
8 Hackberry
9 Ash
10 Beech
11 Cherry
12 Cypress
13 Black walnut
14 Sweetgum
15 Cottonwood
16 Other (specify) _____

Q-25 What are the top 3 species by percent of production?

1 _____(species) _____%

2 _____(species) _____%

3 _____(species) _____%

Q-26 What percent of your production, if any, is softwood? (specify)

_____%

Q-27 Does your mill *import* logs from other states? (circle one)

1 Yes
2 No

If yes, which state(s)? (specify)

_____

If yes, what percent of the total volume is imported?

_____%

Q-28 What percent of the total lumber produced is sold to producers within Tennessee? (specify)

_____%

Please breakdown the percentage by species.

1 _____(species) _____%

2 _____(species) _____%

3 _____(species) _____%

4 _____(species) _____%

5 _____(species) _____%

6 _____(species) _____%

Q-29 What percent of the total lumber produced is sold to producers in other states? (specify)

_____%

Please breakdown the percentage by state.

1 _____(state) _____%

2 _____(state) _____%

3 _____(state) _____%

4 _____(state) _____%

5 _____(state) _____%

6 _____(state) _____%

Q-30 Does your mill *export* lumber to other countries? (circle one)

1 Yes

2 No

If yes, which countries? (specify) _____

What percent of the total lumber produced is exported yearly? (specify)

_____%

What are the species and lumber products exported?

(specify)

_____

_____

_____

Equipment Information

Please answer the following questions regarding equipment in your mill.

Q-31 What type of headrig is used in your mill? (circle one)

1 Circular
2 Band
3 Chipping
4 Multi-band
5 Other (specify) _____

Q-32 How many years has the current headrig been in use at your mill? (specify)

_____Years

Q-33 Do you have a second headrig? (circle one)

1 Yes
2 No

If yes, how many years has the second headrig been in use? (specify)

_____Years

Q-34 Do you have plans to change or upgrade the headrig(s)? (circle one)

1 Yes
2 No

If yes, what do you intend to change or upgrade to? (specify)

_____

How much do you expect the change or upgrade to cost? (specify)

_____

Q-35 Which of the following production equipment is used at your sawmill? (circle all that apply)

1 Ring Debarker
2 Rosser Head Debarker
3 Drum Debarker
4 Standard Carriage
5 Linear Positioning Carriage
9 Single Arbor Gang Saw
10 Double Arbor Gang Saw
11 Slash Gang Saw
12 Single Arbor Edger
13 Double Arbor Edger

6 Laser Log Scanner
7 Light-Curtain Scanner
8 Camera Scanner
14 Vertical Edger
15 Line Bar Resaw
16 Drop Saw Trimmer

Q-36 Do you have surfacing or planing equipment? (circle one)

1 Yes
2 No

If yes, estimate the percent of your production that is surfaced.

_____%

Q-37 Does your mill have plans to purchase new equipment, other than the headrig, in the next five years? (circle one)

1 Yes
2 No

If yes, what type of equipment? (specify)

_____

_____

Q-38 By what percent if any, do you expect production to increase with the addition of the new equipment specified above? (specify)

_____%

Residues

Please answer the following questions about the residues produced by your mill, including bark, chips, sawdust, slabs, and edgings.

Q-39 What is the volume of wood residue produced by your mill each year? (specify)

1 _____Yards of bark
2 _____Tons of chips, slabs, and edgings
3 _____Tons of sawdust

Q-40 What is the volume of residue used for generating heat or electricity for your mill? (specify)

1 _____Yards of bark
2 _____Tons of chips, slabs, and edgings
3 _____Tons of sawdust

Q-41 What is the volume of residue sold by your mill each year? (specify)

1 _____Yards of bark
2 _____Tons of chips, slabs, and edgings
3 _____Tons of sawdust

Q-42 What is the volume of residue you landfill each year? (specify)

1 _____Yards of bark
2 _____Tons of chips, slabs, and edgings
3 _____Tons of sawdust

Q-43 What is the volume of residue given away at no cost each year? (specify)

1 _____Yards of bark
2 _____Tons of chips, slabs, and edgings
3 _____Tons of sawdust

Drying Facilities

Please answer the following questions if your mill has drying or predrying facilities. If your mill does not have drying facilities, skip to the next section on page 10.

Q-44 What is the total capacity of your kiln drying facilities at this location (excluding predryers)?

_____Bdft

Q-45 How many kilns do you operate? (specify)

_____Kiln(s)

Q-46 Does your mill do contract lumber drying for other sawmills? (circle one)

1 Yes
2 No

Q-47 What source(s) of energy does your drying facility use? (specify)

_____
_____

Q-48 Is your kiln control system automated for control of the drying process? (circle one)

1 Yes
2 No

If yes, what year was the automated control system installed? (specify)

_____Year

Q-49 What percent of your total lumber production is kiln dried? (specify)

____%

Q-50 What lumber products/species do you most often dry? (specify)

_____

_____

Q-51 Does your mill have dry lumber storage? (circle one)

1 Yes
2 No

If yes, what is the capacity of your dry lumber storage? (specify)

_____Bdft

Q-52 Do you have predrying facilities at your mill? (circle one)

1 Yes
2 No

If yes, what is the capacity of your predrying facility? (specify)

_____Bdft

Respondent Profile

Please answer the following questions about yourself.

Q-53 What is your position at the mill? (circle one)

1 Owner
2 President
3 Mill manager
4 Production manager
5 Other (specify) _____

Q-54 How many years have you been in your current position at this mill? (specify)

___Years

Q-55 How many total years have you been in the sawmill business? (specify)

____Years

Q-56 Are you a member of any trade associations? (circle all that apply)

1 Appalachian Hardwood Manufacturers Inc.
2 Carolinas-Tennessee Building Materials Association
3 Forest Products Society
4 Hardwood Manufacturers Association
5 National Hardwood Lumber Association
6 Tennessee Forestry Association
7 Other _____

Q-57 Would you like a summary of the results of this survey (available in early 2000)?

1 Yes
2 No

General Comments

_____

_____

_____

_____

_____

_____

_____

Survey no._____

Vita

I was raised in Knoxville, Tennessee. I graduated from Farragut High School in 1990. I entered the Culinary Arts program at Johnson and Wales University for two years. In the spring of 1995, I enrolled at the University of Tennessee in the Forestry, Wildlife, and Fisheries program. I graduated in May of 1998 with my Bachelor's of Science Degree in Forestry, with a resource management concentration and minor in Economics.

During my undergraduate program, I was a teaching assistant for a Forest Resource Analysis class, where I taught the use of forest investment computer programs. I also completed the Forest Management Plan and Environmental Assessment on the Eastern Band of Cherokee Indians Reservation for the Bureau of Indian Affairs.

I received my Master's of Science degree under the direction of Dr. Paul Winistorfer, and I was employed as a graduate research assistant for the Tennessee Forest Products Center.

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