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Held at

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University Park, PA

March 3-6, 1991

Edited by

Larry H. McCormick and Kurt W. Gottschalk

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FOREWORD

This conference is the eighth in a series of biennial meetings that began in 1976 at Southern Illinois University. Other conferences have been hosted by Purdue University, University of Missouri, University of Kentucky, University of Illinois, and University of Tennessee. The purpose of these conferences has remained the same: to provide a forum for the exchange of information concerning the central hardwoods and to engender coordination among forest scientists in the central hardwood region. This purpose is evidently well-served: the last several conferences have each attracted some 45 to 65 program contributions, and the audiences have been correspondingly large.

Previous organizers have refrained from drawing precise boundaries around the "central hardwood region." We prefer to continue that policy on the grounds that to do otherwise might preclude some very worthwhile participation. Thus, while the principal focus has remained on the oak resource for reasons that are obvious, the ecological scope has broadened from oak-hickory (in the early meetings) to Appalachian oak (Knoxville and State College) and mesophytic forests. With a few exceptions, the commercially significant species are similar for all these forest types, and advancements in knowledge are of general interest.

But the central hardwood region is not merely a collection of similar forest types. It also has historical, demographic, political, and economic characteristics that tend to distinguish it from other forest regions of the United States. For example, the population is heavily rural and agricultural, primary wood markets tend to be diffuse and unorganized, wilderness values and endangered species have generally not been overriding issues, and a relatively minor proportion of the forest land is controlled by public agencies or corporate ownerships. These and related conditions play critical roles in the practice of forestry in this region, and in the aggregate they emphasize its distinction from other regions; but no single one is necessarily unique to the central hardwoods. For these reasons, the characteristics of nonindustrial private forest land owners in Massachusetts might be just as relevant to the central hardwood region as regeneration methods for white oak in Indiana.

Since these proceedings are being published in advance, we have no way of judging the ultimate success of the upcoming Eighth Conference. Of course, our earnest hope is that this meeting shall sustain the excellent reputation of the series. We believe this hope is encouraged by the quality of the papers in these proceedings.

REVIEW PROCEDURES

Each manuscript published in these proceedings was critically reviewed by at least two scientists with expertise in disciplines closely aligned to the subject of the manuscript. Reviews were returned to the senior author, who revised the manuscript appropriately and resubmitted it in a diskette format suitable for printing by the Northeastern Forest Experiment Station, USDA Forest Service where they were edited to a uniform format and type style. Manuscript authors are responsible for the accuracy and style of their papers.

TABLE OF CONTENTS

INVITED SPEAKERS

Management of hardwood forests in the mid-atlantic region: past, present and future.
David A. Marquis 1

Central hardwood forest resources: a social science perspective
John F. Dwyer, Herbert W. Schroeder, and Paul H. Gobster 2

ECONOMICS AND FOREST AMENITIES - Moderator: Steven B. Jones

An alternate property tax program requiring a forest management plan and scheduled harvesting
D.F. Dennis and P.E. Sendak 15

Effects of gypsy moth infestation on near-view aesthetic preferences and recreation behavior intentions
S.J. Hollenhorst, S.M. Brock, W.A. Freimund, and M.J. Twery 23

The scenic impact of key forest attributes and long-term management alternatives for hardwood forests
R.G. Ribe 34

HARVESTING AND UTILIZATION - Moderator - Dwight R. McCurdy

Shipping coal to Newcastle: are SRIC *Populus* plantations a viable fiber production option for the central hardwoods region?
C.H. Strauss 55

Harvesting impacts on steep slopes in Virginia
W.B. Stuart and S.L. Carr 67

Impact of timber harvesting on residual trees in a central hardwood forest in Indiana
T.W. Reisinger and P.E. Pope 82

A comparison of small tractors for thinning central hardwoods
N. Huyler and C.B. LeDoux 92

Comparing partial cutting practices in central Appalachian hardwoods
G.W. Miller and H.C. Smith 105

Integrating forest growth and harvesting cost models to improve forest management planning
J.E. Baumgras and C.B. LeDoux 120

Computerized algorithms for partial cuts
R.L. Ernst and S.L. Stout 132

The interactive impact of forest site and stand attributes and logging technology on stand management
C.B. LeDoux and J.E. Baumgras 148

PHYSIOLOGY, GENETICS, AND ECOLOGY - Moderator: Jerome W. Van Sambeek

Effects of drought and shade on growth and water use of *Quercus alba*, *Q. bicolor*, *Q. imbricaria* and *Q. palustris* seedlings
J.J. McCarthy and J.O. Dawson 157

Height and diameter variation in twelve white ash provenance/progeny tests in eastern United States
G. Rink and F.H. Kung 179

Stomatal conductance of seedlings of three oak species subjected to nitrogen fertilization and drought treatments
W.D. Hechler, J.O. Dawson, and E.H. DeLucia 188

Stand density, stand structure, and species composition in transition oak stands of northwestern Pennsylvania
S.L. Stout 194

Composition and structure of an old-growth versus a second-growth white oak forest in southwestern Pennsylvania
J.A. Downs and M.D. Abrams 207

Changes in the relationship between annual tree growth and climatic variables for four hardwood species
E.R. Smith and J.C. Rennie 224

Community and edaphic analysis of mixed oak forests in the ridge and valley province of central Pennsylvania
G.J. Nowacki and M.D. Abrams 247

Extrapolation of forest community types with a geographic information system
W.K. Clatterbuck and J. Gregory 261

REGENERATION - Moderator: Glen R. Stanosz

Insects affecting establishment of northern red oak seedlings in central Pennsylvania
J. Galford, L.R. Auchmoody, H.C. Smith, and R.S. Walters 271

Using Roundup and Oust to control interfering understories in Allegheny hardwood stands
S.B. Horsley 281

Tree shelters increase heights of planted northern red oaks
D.O. Lantagne 291

Mammal caching of oak acorns in a red pine and a mixed oak stand
E.R. Thorn and W.M. Tzilkowski 299

Role of sprouts in regeneration of a whole-tree clearcut in central hardwoods of Connecticut
C.W. Martin and L.M. Tritton 305

Planting stock type x genotype interactions affect early outplanting performance of black walnut seedlings
J.W. Van Sambeek, J.W. Hanover, and R.D. Williams 321

Ten year regeneration of southern Appalachian hardwood clearcuts after controlling residual trees
P.M. Zaldivar-Garcia and D.T. Tew 332

Development of regeneration following gypsy moth defoliation of Appalachian Plateau and Ridge and Valley hardwood stands
D.M. Hix, D.E. Fosbroke, R.R. Hicks, Jr., and K.W. Gottschalk 347

SILVICULTURE, PROTECTION, AND MANAGEMENT - Moderator: Steven B. Horsley

Silvicultural cutting opportunities in oak-hickory forests of West Virginia
S.L. Arner, D.A. Gansner, M.E. Dale, and H.C. Smith 360

Incidence of twolined chestnut borer and *Hypoxylon atropunctatum* on dead oaks along an acidic deposition gradient from Arkansas to Ohio
R.A. Haack and R.W. Blank 373

Black walnut tree growth in a mixed species, upland hardwood stand in southern Indiana
R.K. Myers and B.C. Fischer 388

Effectiveness of electric deer fences to protect planted seedlings in Pennsylvania
D.W. George, T.W. Bowersox, and L.H. McCormick 395

Releasing 75- to 80-year-old Appalachian hardwood sawtimber trees--5-year d.b.h. response
H.C. Smith and G.W. Miller 402

A stand density management diagram for sawtimber-sized mixed upland central hardwoods
J.A. Kershaw, Jr. and B.C. Fischer 414

Evaluation of an approach to improve acorn production during thinning
W.E. Drake 429

Independent effects and interactions of stand diameter, tree diameter, crown class, and age on tree growth in mixed-species, even-aged hardwood stands
D.A. Marquis 442

HYDROLOGY, SOILS, AND NUTRIENT CYCLING - Moderator: James C. Finley

Radial patterns of tree-ring chemical element concentration in two Appalachian hardwood stands
D.R. DeWalle, B.R. Swistock, and W.E. Sharpe 459

Factors affecting temporal and spatial soil moisture variation in and adjacent to group selection openings
W.H. McNab 475

Response of an Appalachian mountain forest soil, soil water, and associated herbaceous vegetation to liming
W.E. Sharpe, B.R. Swistock, and D.R. DeWalle 489

Long-term implications of forest harvesting on nutrient cycling in central hardwood forests
J.A. Lynch and E.S. Corbett 500

HARDWOOD MARKETS - Moderator: Roe S. Cochran

Estimating timber supply from private forests
D.F. Dennis 519

New estimates of hardwood lumber exports from the central hardwood region
W. Luppold and R.E. Thomas 535

Shiitake mushroom production on small diameter oak logs in Ohio
S.M. Bratkovich 543

The pallet industry: a changing hardwood market
G.P. Dempsey and D.G. Martens 550

Factors determining the location of forest products firms
R.F. Fraser and F.M. Goode 556

Are we underestimating the size of our hardwood industries?
S.M. Bratkovich and G.R. Passewitz 569

POSTER SESSION

Pistillate flower abortion in three species of oak
R.A. Cecich, G.L. Brown, and B.K. Piotter 578

Measurement of forest condition and response along the Pennsylvania atmospheric deposition gradient
D.D. Davis, J.M. Skelly, J.A. Lynch, L.H. McCormick, B.L. Nash, M. Simini, E.A. Cameron, J.R. McClenahen, and R.P. Long 579

Impact of small mammals on regeneration of northern red oak
C.A. DeLong and R.H. Yahner 581

Hardwood stumpage price trends in New England
D.F. Dennis and P.E. Sendak 582

Predicting tree mortality following gypsy moth defoliation
D.E. Fosbroke, R.R. Hicks, Jr., and K.W. Gottschalk 583

Invasion of a partially cut oak stand by hayscented fern
J.W. Groninger and L.H. McCormick 585

Microcoppice: a new strategy for red oak clonal propagation
D.E. Harper and B.H. McCown 586

Field testing a soil site field guide from Allegheny hardwoods
S.B. Jones 587

Comparison of northern goshawk nesting habitat in Appalachian oak and northern hardwood forests of Pennsylvania
J.T. Kimmel and R.H. Yahner 588

Response of chestnut oak and red oak to drought and fertilization: growth and physiology
K.W. Kleiner, M.D. Abrams, and J.C. Schultz 589

Physiological and structural foliar characteristics of four central Pennsylvania barrens species in contrasting light regimes
B.D. Kloeppel, M.E. Kubiske, and M.D. Abrams 590

Effect of stand age and soils on forest composition of Spotsylvania Battlefield, Virginia
D.A. Orwig and M.D. Abrams 591

Field response of red oak, pin cherry and black cherry seedlings to a light gradient
M.R. Roberts 592

Pioneer Mothers' Memorial Forest revisited
R.C. Schlesinger, D.T. Funk, P.L. Roth, and C.C. Myers 594

Survival and growth of direct-seeded and natural northern red oak after clearcutting a mature red pine plantation
R.D. Shipman and D.B. Dimarcello 596

TREEGRAD: a grading program for eastern hardwoods
J.W. Stringer and D. W. Cremeans 598

White oak seedling survival and vigor following acorn removal and water stress
E.R. Thorn and W.M. Tzilkowski 600

Understory composition of hardwood stands in north central West Virginia
M.J. Twery 601

Hardwoods are now being harvested at record levels
R.H. Widmann 603

Planting northern red oak: a comparison of stock types
J.J. Zaczek, K.C. Steiner, and T.W. Bowersox 604

ESTIMATING TIMBER SUPPLY FROM PRIVATE FORESTS

Donald F. Dennis[1]

Abstract: Nonindustrial private landowners, who hold a majority of the Nation's commercial forests, own land primarily for reasons other than timber production. The multiple objective and dynamic nature of private ownership make planning and estimation of timber availability from this sector extremely difficult.

Insight into the determinants of timber supply from private forests is provided through development of both theoretical and empirical models of harvest behavior. Tobit and probit models were used to analyze cross-sectional, and pooled time-series and cross-sectional data, respectively. The results highlight the influence of forest characteristics and landowner affluence on the harvest decision. Decomposition of the Tobit coefficients indicates that changes in timber supply are expected to result primarily from changes in the number of acres from which timber is offered for sale and to a much lesser extent from changes in per-acre harvesting intensity.

INTRODUCTION

Almost half of the Nation's hardwoods, approximately 140 million cubic feet of growing stock and 334 million board feet of sawtimber, are contained in the Northeast and North Central regions (USDA Forest Service 1988). For several decades growth has outpaced removals, leading to a doubling of sawtimber volumes since 1952. Increased use of this vast resource could stimulate the regional economy, improve our trade balance, and breathe economic life into rural communities.

An immense population, with a growing appetite for wood products, lives within, or in close proximity to, the region. Demand projections indicate substantial increases in roundwood consumption, well into the future (USDA Forest Service 1982).

There is great potential for increased utilization of the region's hardwoods. Concerns over tropical deforestation and a more competitive dollar may focus attention on eastern hardwoods as a strategic resource in supplying world markets. New and existing technologies for producing composite products from low-quality hardwoods offer numerous opportunities. The political viability of additional nuclear reactors and environmental concerns over increased coal use make wood an attractive alternate energy resource. This is particularly true in the

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energy-dependent Northeast. Traditional sawmilling and manufacturing of specialty products will remain important and are particularly attractive to localities seeking to enhance their economic fortunes.

There is a seemingly abundant resource, sufficient final demand, and some arguably good reasons to use this resource. However, there is apprehension over availability. Seventy percent of the region's hardwood resource occurs on nonindustrial private forests (USDA Forest Service 1988). An additional 21 percent occurs on public lands, where intense recreation pressures often limit timber harvesting. Since forest industry holds only 9 percent of the hardwood growing stock, the key to increased utilization rests with the nonindustrial private landowner.

Surveys reveal that most nonindustrial owners hold land primarily for reasons other than timber production (Widmann and Birch 1988, Birch and Dennis 1980). The multiple objective and dynamic nature of private ownership leads to complex and difficult-to-predict supply responses.

Planning and policy development are further hampered by a lack of knowledge of how trends in demographic patterns of landownership and forest characteristics will affect harvest behavior. There are fears that timber availability will be further limited by increased fragmentation of the forest and by an increasingly affluent landowning population, who may be more interested in the nontimber aspects of forest ownership. In addition to the large increases in timber volume, changes in species composition will influence future harvesting. Red maple has increased dramatically across the region and is now the second most abundant species in New Hampshire, the state from which the empirical portion of this study is drawn.

This study provides insight into the determinants of timber supply from private forests through development of both theoretical and empirical models of harvest behavior. Forest, owner, and economic variables are fully integrated into the analyses.

A MICROECONOMIC MODEL OF HARVEST BEHAVIOR

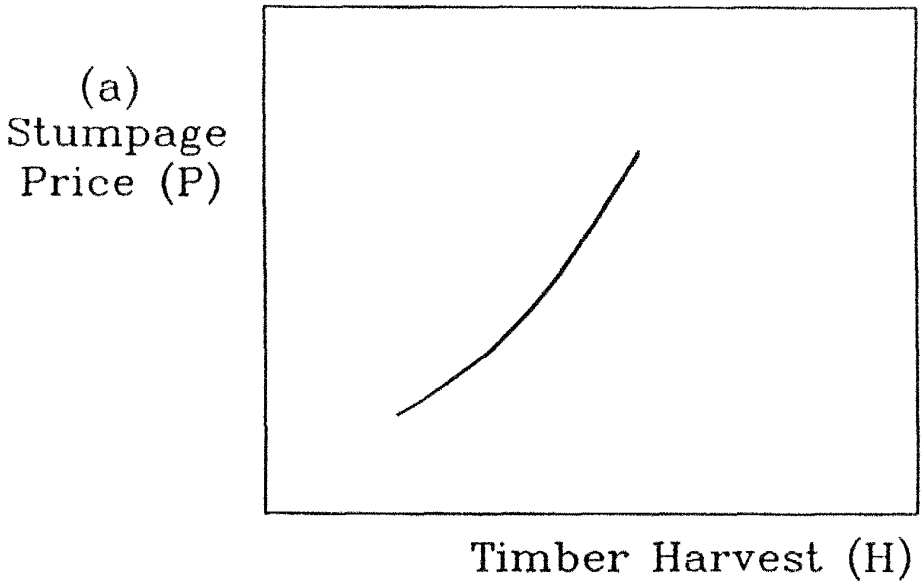
This model was adapted from an approach originally developed by Becker (1965) to analyze an individual's choice in allocating time between work and leisure. Each landowner seeks to maximize utility (satisfaction) from nontimber or forest-related amenities and from the generalized purchasing power of income, subject to two constraints:

$$\max\ U(A,I) \tag{1}$$

subject to

$$I=PH+E \text{ and } A=V-H \tag{2}$$

where



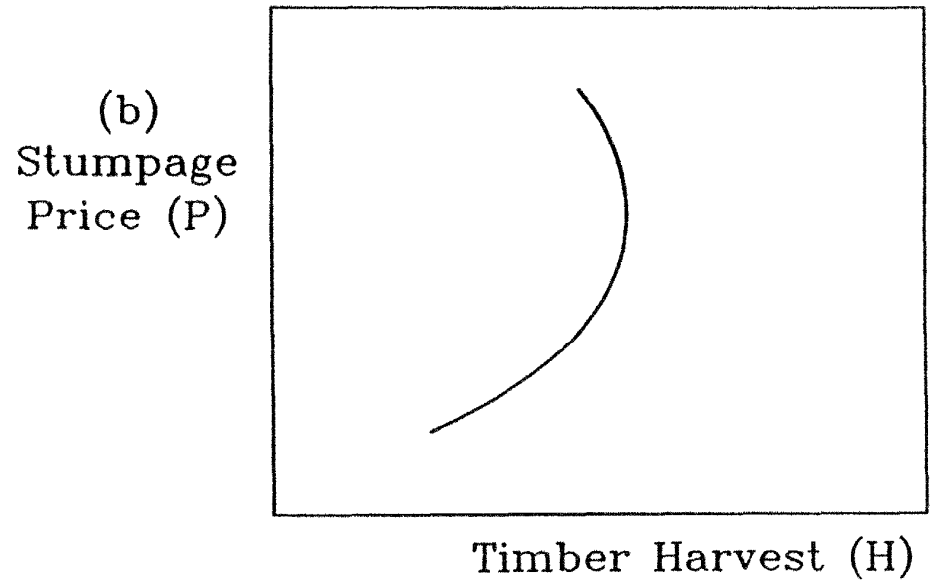


Figure 1. Two possible shapes for an individual landowner's supply curve for timber.

question.

Although theoretical models provide insight into harvest behavior, usefulness is limited by the simplifying assumptions required to make the model tractable. Additional insight can be provided empirically.

U(A,I) = utility defined over A and I,
A = quantity of timber reserved for amenities,
I = total income,
P = stumpage price,
H = quantity of timber harvested,
E = exogenous income,

and

V = initial timber inventory.

The first constraint defines total income as the sum of income from the sale of timber and all income from other sources, and the second defines the amount of timber retained for amenities as the initial timber inventory less the amount harvested.

The first-order conditions of the Lagrangian solution for utility maximization indicate that the landowner will maximize total satisfaction when the following condition is met:

$$P\frac{\partial U}{\partial I} = -\frac{\partial U}{\partial A}\frac{\partial A}{\partial H} \qquad (3)$$

At the optimal mix of amenities and income, the satisfaction gained from increased timber income just equals the satisfaction foregone from amenities to obtain that income.

Further analysis of the first-order condition, called comparative statics, indicates how changes in different variables are expected to influence timber supply. Comparative statics analyses are performed by differentiating equation 2 with respect to the variable of interest. Binkley (1981) and Dennis (1989) provide more detailed discussions of the comparative statics results regarding timber supply.

In this simple model, changes in most of the variables have the expected effect. An increase in the initial timber inventory (V) has a positive effect on harvesting. More timber is available for both amenities and harvest. Increased exogenous income (I) has a negative effect on harvesting. Greater wealth reduces the relative value of additional income and makes harvesting less desirable.

Comparative statics results are not always so obvious. Differentiating with respect to stumpage price (P) yields an ambiguous result. This ambiguity arises from the interaction of two opposing effects. As prices rise we expect landowners to harvest more timber because the relative price of timber is higher. This is called the substitution effect; timber income is substituted for amenities. However, there is an opposing income effect. Swedish economists have called it the Volvo effect (Johansson and Lofgren 1985). Landowners harvest enough timber to buy a new Volvo and then stop; so, increasing the price of timber could actually reduce the harvest.

Normally we expect the substitution effect to dominate and the supply curve to be upward sloping (Figure 1a). However, if the income effect is dominant, the supply curve could be backward bending as shown in Figure 1b. Which effect dominates is an important empirical

DATA SOURCES AND CHARACTERISTICS

Forest data were obtained from 68 fixed-radius (1/5 acre) sample plots measured by the USDA Forest Service, during its periodic statewide survey of New Hampshire. Frieswyk and Malley (1985) provide a thorough discussion of survey procedures. Each sample plot was measured in 1973 and again in 1983, with all trees either measured or accounted for (e.g. harvest or mortality). Species composition and a variety of other forest characteristics were recorded.

A questionnaire, sent to each landowner in conjunction with the forest survey, provided data on ownership (Birch 1988). This included information on size of holding, tenure of ownership, education, age, occupation, whether the owner was raised in an urban or rural environment, and several other owner characteristics. Descriptive statistics for selected forest and owner variables are provided in Table 1.

The exact offer price that each landowner faced was unknown, so price indices, representing sawlogs, pulpwood, and fuelwood, were constructed to proxy for offer prices. The prices were taken from the New Hampshire Forest Market Reports, published annually by the New Hampshire Cooperative Extension Service. Sawtimber prices were available by county and species, pulpwood prices were reported by region (north and south), and statewide prices were reported for fuelwood. The indices were weighted by the relative proportion of removals for each product during 1983, as reported by Frieswyk and Malley (1985) and Nevel, Engalichev, and Gove (1986).

METHODS

The data available for estimating harvest behavior may be examined in several ways. Two dependent variables were considered: (1) a dichotomous variable indicating whether timber was harvested, and (2) the quantity of timber harvested. In addition, an estimation strategy may be employed that accounts for only cross-sectional effects or a combination of cross-sectional and time-series effects.

A binary choice (probit) model was used to analyze the landowner's decision of whether to harvest timber from a particular parcel. Detailed general discussions of probit analysis may be found in most textbooks on econometrics (e.g. Judge et al. 1982). Dennis (1990) provides a thorough discussion of the application of probit analysis to timber harvesting data, which is outlined below.

Probit analysis was used to estimate the relationship between a dichotomous dependent variable (Y_i), coded 1 if timber was harvested from the sample plot, and 0 if no harvesting occurred, and selected explanatory variables (X_i). It is assumed that a landowner's propensity to harvest timber from a particular parcel is represented by an unobservable random index (Y_i^*), which is defined as a function of observable characteristics ($X_i'B$) and a random

Table 1.--Descriptive Statistics[a]

Variable[b]	Units	Mean	Std. dev.	Harvested mean	Non harvested mean
Timber harvest	bd ft/ac	111	332	628	0
Timber volume	bd ft/ac	961	949	1,597	824
Volume (white pine)	bd ft/ac	477	934	1,275	306
Ratio (white pine)	proportion	0.41	0.42	0.73	0.34
Volume (red oak)	bd ft/ac	79	197	136	67
Ratio (red oak)	proportion	0.10	0.24	0.15	0.08
Ownership size	acres	425	1434	917	320
Education	years	15.9	3.8	13.7	16.4
Landowner age	years	59	12	60	58
Tenure	years	23	13	23	23
Coded variables:					
Professional	proportion	0.44	0.50	0.33	0.46
New Hampshire resident	proportion	0.72	0.45	0.75	0.71

[a]N = 68.
[b]See Table 2 for definitions.

disturbance (e_i). If the observed choice (Y_i) equals one when $Y_i^* > 0$ and zero when $Y_i^* < 0$, then :

$$P(Y_i=1)=P(Y_i^*>0)=P(e_i<X_i'B)=F(X_i'B)=\int_{-\infty}^{XB} f(e)de \qquad (4)$$

where F( ) is the cumulative distribution function and f( ) is the probability density function of e_i. Normal specifications are assumed for these functions in the probit model.

Since the model is nonlinear, the estimated coefficients do not represent the change in the probability of timber harvest (P_i) resulting from a unit change in an explanatory variable. Since:

$$P_i=F(X_i'B) \text{ and } X_i'B=F^{-1}(P_i), \qquad (5)$$

the coefficients estimate the effect of a change in an explanatory variable on $F^{-1}(P_i)$. The magnitude of the change in harvest probability depends on the original probability as

determined by the initial values of all the variables and coefficients:

$$\frac{\partial P_i}{\partial X_{ik}} = f(X_i'B)B_k \qquad (6)$$

where k indexes the explanatory variables. The estimated sign shows the direction of change, but the magnitude is influenced by the steepness of the cumulative distribution function at X_i'B.

Additional insight into harvesting behavior may be obtained through analysis of a model that includes the quantity of timber harvested. We assume that landowner's harvest timber when their desire to do so reaches a certain level and the observed harvest provides a measure of that desire. However, because no measure of the relative desire is obtained when there is no harvest the sample is said to be censored at zero. Judge et al. (1985) defines a censored sample as one in which some observations on the dependent variable, corresponding to known sets of independent variables, are not observable. Least-squares estimation procedures produce biased and inconsistent estimates for censored samples because the conditional expectation of the error term is not zero.

Tobin's (1958) pioneering analyses of censored samples, with respect to consumer durables, has led to these models being termed "Tobit models". Amemiya (1984) provides a thorough survey of censored regression models.

As with the probit model, coefficients obtained from Tobit analysis must be interpreted with care. McDonald and Moffitt (1980) offer an innovative procedure for interpreting these coefficients. They show how Tobit analysis can be used to determine both changes in the probability of being above the limit, zero in the case at hand, and changes in the dependent variable if it is already above the limit. Thus, estimated timber supply responses resulting from marginal changes in an explanatory variable may be decomposed into changes in harvesting intensity on lands already being harvested and changes in the number of acres harvested. A more detailed discussion of analytical procedures for analyzing censored samples, with specific reference to timber harvesting, is provided by Dennis (1989).

Both probit and Tobit models may be estimated from cross-sectional or pooled time-series and cross-sectional data. The cross-sectional approach has the advantage of yielding unbiased estimates with minimum variance. Its main disadvantage is that it ignores information on variation over time. A pooled time-series and cross-sectional approach may be used to examine the influence of both annual and cross-sectional variation in the explanatory variables on the harvest decision. This procedure permits the introduction of variables, such as interest rates, that only vary over time, and also allows for annual, as well as cross-sectional, variation in stumpage prices. Although the presence of autocorrelation will cause the variance to be larger than if the same number of independent observations were used, this approach has the advantage of using more information to yield unbiased estimates.

RESULTS AND DISCUSSION

Two models were used to analyze harvesting behavior. Tobit analysis was performed on cross-sectional data, where the dependent variable measured the quantity of timber harvested during the period between surveys (1973 to 1983). A probit model was used to analyze pooled cross-section and time-series data. In this situation the dependent variable was dichotomous, indicating whether timber was harvested from a sample plot during a particular year.

For the pooled sample, the exact year of harvest was obtained from a questionnaire sent to each landowner or by personal contact if there was any ambiguity. Linear interpolation was used to calculate timber volumes for the years between surveys. Harvested trees were removed from plot totals and species composition was adjusted accordingly for years subsequent to harvest.

Table 2 provides a list of acronyms and a brief description for the explanatory variables, and Table 3 shows the regression results. The results are discussed first with respect to the estimated signs and statistical significance of the selected explanatory variables and then with respect to overall inferences concerning timber supply.

Signs and Significance of the Coefficients

Economies of scale in timber harvesting and the assumption of decreasing marginal utility of timber reserved for amenities led us to anticipate a positive relationship between harvesting and both size of forest ownership and timber inventory. The estimated coefficients (probit model) for the natural logarithm of ownership size and for per-acre timber volume were positive, but not statistically significant at the 10-percent level. Tobit analysis yielded a positive correlation between harvesting and timber inventory that was significant at the 5-percent level. Mean per-acre timber volumes were 1.6 mbf for plots that were subsequently harvested, compared to 0.9 mbf for plots that were not harvested.

The presence of commercially valuable species, such as white pine and red oak, were expected to enhance the probability of harvest. The empirical results support this hypothesis. Statistically significant coefficients were obtained for variables measuring the proportion of total timber volumes represented by these species, for both the probit and Tobit models. On average, stands that were subsequently harvested contained about double the percentage of white pine and red oak than those that were not harvested.

Positive coefficients were obtained for the price variables but neither were significant at the 10-percent level. The income and substitution effects, discussed earlier, effectively may be canceling one another. However, before accepting this conclusion there are several other possible reasons for the apparent lack of price responsiveness to consider.

Table 2.--Variable Summary

Variable	Definition (unit)
ACRES	Total woodland acres owned.
MBF	Timber volume (Mbf/acre).
PINE	Proportion of white pine; ratio = [volume of white pine (Mbf/acre)/MBF].
OAK	Proportion of oak[a]; ratio = [volume of oak (Mbf/acre)/MBF].
PI	Composite price index [real (1983) dollars, weighted by state level production]; includes stumpage prices for sawlogs, pulpwood and fuelwood.
SPI	Sawlog price index; sawlog portion of PI.
PICHG	Change in PI between current and previous year.
R	Yields for 3-year Treasury bills (percent).
ED	Years of formal education.
PRO	Coded variable equal, to 1 if owner was employed in a white collar occupation, and 0 otherwise.

[a]Includes red, white, and black oaks.

Since price indices do not generally measure the exact price that a landowner was offered, an "error in variables" problem is suspected. If the price index measures the true offer price with a random error, then the statistical significance of the price coefficient will be biased toward zero. Therefore, the probability of incorrectly rejecting the hypothesis that the coefficient is not zero is greater than the indicated level of significance. This potential problem is particularly troublesome when analyzing the cross-sectional sample, because the price variable is an average of annual prices for the period between surveys. Although pooling the time-series and cross-sectional data provides an improvement by including annual as well as cross-sectional price variation, the results were still not significant.

Multicollinearity is also of concern when analyzing the pooled sample. Correlations are expected between stumpage prices and variables, such as interest rates, that measure or are correlated with timber demand (see below). A potential consequence is that the precision of estimation is reduced, but more importantly, it becomes difficult to disentangle the relative influences of the correlated explanatory variables.

Table 3.--Results

Explanatory variables	Tobit[a] coefficient	Std. error	Probit[b] coefficient	Std. error
Constant	-2.765	2.319	-1.804	1.305
Log_e (ACRES)			0.127	0.101
MBF	0.320**	0.119	0.167	0.131
PINE	1.810**	0.693	1.057**	0.431
OAK	1.432*	0.764		
PI			0.043	0.036
SPI	0.040	0.036		
PICHG			-0.016	0.011
R			-0.126*	0.074
ED	-0.127**	0.053	-0.145**	0.054
PRO	0.585	0.381	0.638*	0.372

**Significant at 5% level.
*Significant at 10% level.
[a]Cross-sectional sample (N = 68); dependent variable equals quantity of timber harvested between surveys (1973-1983).
[b]Pooled cross-sectional and time-series sample (N = 706); dependent variable coded 1 if harvest occurred in a particular year and 0 otherwise.

Price responsiveness may be further obscured by the possibility that landowners are not responding to current price increases because they anticipate higher prices in the future. The most recent price change was used as an indication of price expectation in the pooled sample. Although not significant at the 10-percent level, the estimated coefficient had the anticipated negative sign, providing weak evidence that expectations of future prices affect current decisions.

The expected influence of interest rates on timber harvesting is ambiguous. Higher interest rates effectively increase the opportunity cost of growing timber, making current harvesting more desirable. However, changes in interest rates affect exogenous income, which influences harvest behavior. Interest rates are also correlated with the demand for timber. Housing starts and the demand for consumer goods, such as furniture, are sensitive to mortgage rates and rates charged on consumer credit. Changes in timber demand influence harvest decisions by affecting stumpage prices and by causing timber buyers to adjust their efforts at securing stumpage. Examples of buyer effort that are expected to influence harvesting decisions are advertising and number of landowner contacts.

To examine the influence of interest rates on harvesting decisions, the yield on 3-year Treasury bills, a readily available form of alternate investment and general indicator of interest rates across the economy, was introduced as an explanatory variable in the probit analysis of the pooled sample. A negative relationship was estimated between interest rates and timber harvesting, which suggests that the positive influence expected from an increase in the opportunity cost of growing timber was outweighed by other factors. Since no direct measure of buyer effort was available, the number of housing starts and an index of lumber and wood products manufacturing were used as proxies in an effort to disentangle these effects. The coefficients for these variables, whether introduced singly or in combination, were not significantly different from zero at even the 20-percent level, and the interest rate coefficient remained negative. The problem of multicollinearity may be obscuring the relative influences of the correlated variables, namely stumpage price, interest rate, and buyer effort.

Our theoretical model indicated that the harvest decision is influenced by exogenous income and by the relative value landowners place on amenities and consumption. Concerns have arisen that demographic changes in landownership, particularly with respect to increasing affluence, may adversely affect timber supply. Several explanatory variables that measure a landowner's education, age, occupation, early life environment, and state residency were examined to provide insight into the merit of these concerns.

Education and income levels were used to examine the affect of affluence on timber harvesting. Coefficients were negative, but not significant at the 5-percent level, when both variables were included in the model. The low significance levels probably were due to the high collinearity between the two variables. The significance level for each variable improved beyond the 5-percent level when the other was removed from the model. I chose to retain education in the model because 15-percent of the landowners did not respond to the income question. Deletion of this many observations weakened the overall model.

Both analyses yielded a strong negative correlation between education and timber harvesting. There are several plausible explanations for this correlation. Education may directly influence the way landowners value amenities and income or it may proxy for social background or other factors that influence attitudes toward timber harvesting. Also, more highly educated individuals generally have larger incomes, which our theoretical analyses suggest reduce the marginal utility of timber income. It appears that affluence, whether measured by income or education, has a negative effect on timber harvesting.

The influence of occupation on the propensity to harvest timber was examined using two coded variables that indicated whether the owner was a professional or was retired. Probit analysis yielded a positive coefficient for the variable indicating professional status. There is no clear intuitive interpretation for this result. Perhaps professionals have a greater tendency to view their woodlands as an income-producing asset or are more aware of market opportunities than others. No relationship was established between retirement status and timber harvesting.

Several other ownership variables were examined but no significant correlations were found. These included the landowner's age, whether he or she was raised in a rural or urban

environment, in-state residency, tenure of ownership, and whether the owner was involved in the purchase or sale of forest land within the previous 10 years.

Inferences About Timber Supply

Further analysis of the Tobit model, using the procedures of McDonald and Moffitt (1980), provides insight into timber supply from private forests. The signs of the coefficients indicate the direction of change but the magnitude of the marginal responses is determined by the values for all the independent variables and coefficients. Figure 2 shows the X_iB distribution. The results were interpreted at three values for the explanatory variables (X_iB): (1) -1.75, arbitrarily chosen to represent the lower portion of the distribution; (2) -1.098, computed using the mean values for the explanatory variables for the entire sample; and (3) 0.038, computed using the mean values for the harvested plots (see Table 4). Because the dependent variable measured harvest activity over the period 1973 to 1983, the estimates are per-acre values for an 11-year interval.

The first row of Table 4 gives the expected harvest, which may be obtained by multiplying the probability of harvest by the conditional harvest, shown in the second and third rows, respectively. The expected per-acre harvest varied considerably depending on the values of explanatory variables. The probability of harvest was miniscule when computed for the lower third of the distribution and this led to a very small expected harvest. Furthermore, estimated marginal responses were very small for these observations. Directing efforts to increase timber supply at more responsive portions of the population appears more fruitful.

The expected harvest was approximately 18 times larger when computed at values equivalent to the mean values of the plots that were subsequently harvested than for the sample mean. The estimated marginal responses were also considerably higher for these observations. Decomposition of the results indicates that the marginal responses are expected to occur primarily from changes in per-acre harvesting intensity and, to a lesser extent, from changes in the number of acres harvested.

Elasticities measure the estimated response resulting from a 1 percent increase in an explanatory variable. A supply elasticity of 1.06 was estimated for the inventory variable (MBF), which corroborates the inventory elasticity assumed in several aggregate supply models (e.g. Adams and Haynes 1980, Cardellichio and Veltkamp 1981, and Binkley and Cardellichio 1986).

An estimated supply elasticity of approximately -7.0 for the education variable provides credence to concerns that increased affluence may adversely affect timber availability. A 1 year increase in education level reduced the expected harvest by 36 percent when evaluated at the sample mean.

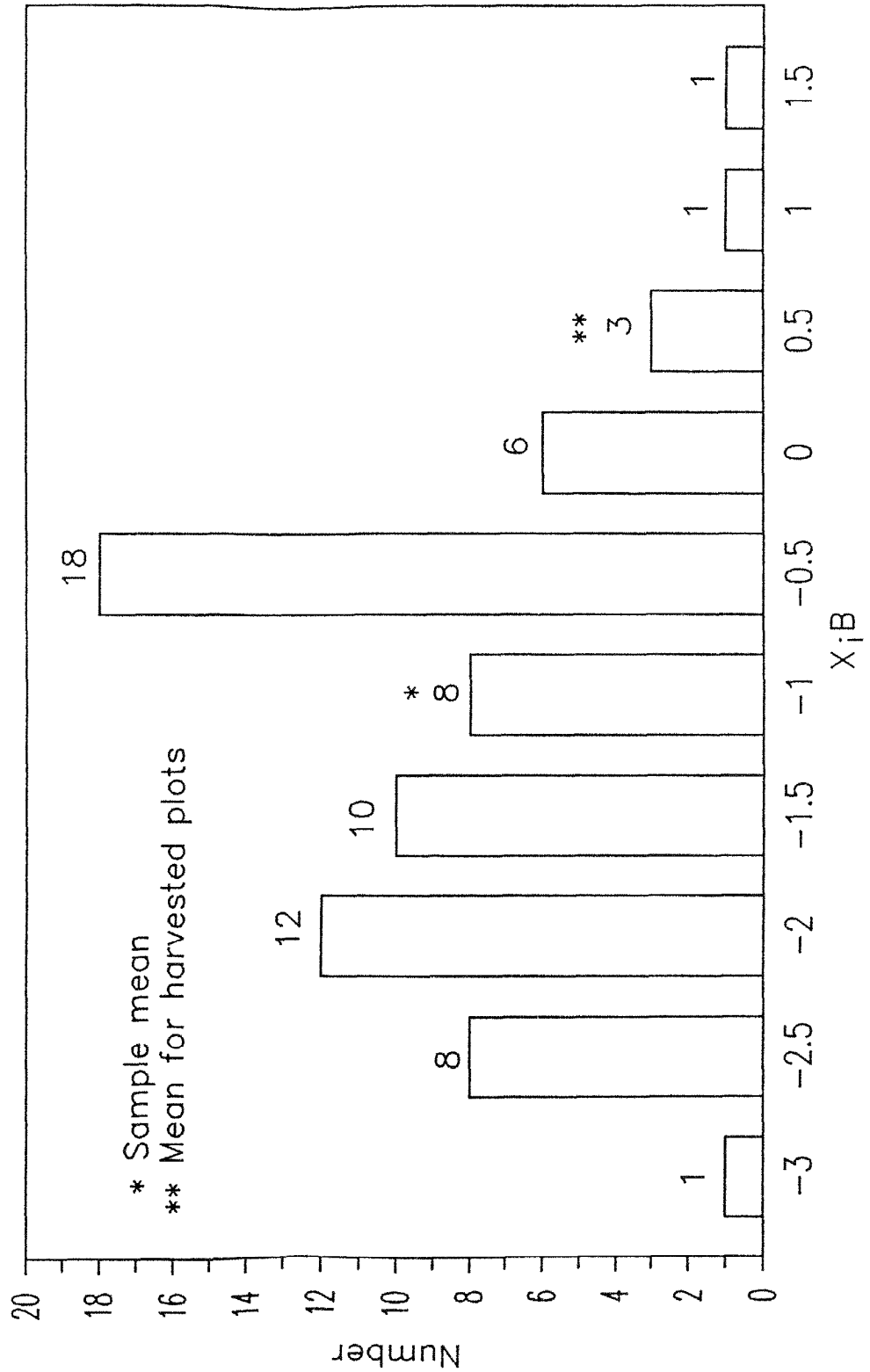


Figure 2. The X_iB distribution for the cross-sectional sample.

Table 4.--Decomposition of Tobit Results

	31st Percentile	Sample mean	Harvested plot mean
	$X_iB = -1.750$	$X_iB = -1.098$	$X_iB = 0.038$
Harvest[a] (Mbf)	.001	.016	.293
Probability of harvest (proportion)	.005	.054	.522
Conditional harvest[b] (Mbf)	.219	.290	.561
Marginal harvest response	$.005B_k$	$.055B_k$	$.522B_k$
Portion of marginal response resulting from:			
Per-acre harvest	8%	14%	38%
Probability of harvest	92%	86%	62%

[a]Estimated per-acre harvest across all plots at this point in the X_iB distribution.
[b]Estimated per-acre harvest for plots at this point in the distribution that are actually harvested.

Using the model to simulate the effect of a continuation of past trends in the explanatory variables can provide additional insight. Northeastern forests are maturing; sawtimber volumes in New Hampshire have increased 26 percent since 1973 (Frieswyk and Malley 1985). Timber quality has also improved, with grade 1 and 2 sawlogs comprising 27 percent of the pine sawtimber and 36 percent of the hardwood sawtimber in 1983. However, species composition is also changing. Red maple growing stock has increased by 137 percent since 1960 and is now the most abundant hardwood in New Hampshire. The affluence levels of landowners has increased. In 1983, almost three-quarters of New Hampshire's individually owned forest land was held by owners who completed education beyond high school.

The assumptions for the simulation were: average sawtimber volumes will be 15 percent higher over the next decade, the proportions of white pine and red oak will decrease by 10 percent, average education levels will increase by 0.25 years, and the proportions of "professionally" employed owners and real stumpage prices will remain constant. The simulations and comparisons were computed at the sample mean and measure harvest behavior for an 11-year interval.

The expected harvest dropped 22 percent, to 12.3 board feet per acre; the expected probability of harvest was reduced from 5.5 to 4.4 percent; and the conditional harvest declined from 290 to 283 board feet per acre. Additional analyses indicate that a 3 percent increase in real stumpage prices would be required to maintain harvests at current levels, under these assumptions. Of course, other options, such as programs designed to enhance growth or improve species composition, might be used to avert the need for increased stumpage prices.

SUMMARY

Forest characteristics, which generally were lacking in previous empirical work, were important determinants of harvest behavior. High per-acre volumes and the presence of commercially valuable species were positively correlated with timber harvesting. Concerns that an increasingly affluent population of landowners may be less likely to harvest timber were supported. Timber harvesting was negatively correlated with both income and education. Several other owner characteristics, such as, age, retirement status, tenure of ownership, whether the owner was raised in a rural or urban environment, and in-state residency, were not significantly correlated with timber harvesting.

Interest rates were negatively correlated with the propensity to harvest timber. This suggests that the positive influence expected from an increase in the opportunity cost of growing timber was out-weighed by other factors. Since interest rates are negatively correlated with housing starts and consumption of other wood products, they may proxy for the effort buyers exert at securing stumpage.

Positive coefficients and relatively high elasticities were estimated for the effect of stumpage prices. However, these results were not statistically significant at the 10-percent level. The opposing income and substitution effects may be canceling one another or the true effect may be obscured by problems of measurement and multicollinearity, inherent in these types of analysis.

Although prospects for timber harvesting should be enhanced as timber volumes increase, a net reduction in availability is anticipated due to changes in species composition, and the expectation that an increasingly affluent landowning population will be less interested in timber harvesting. Any changes in timber availability are expected to result primarily from a decrease in the number of acres from which timber is offered for sale and to a much lesser extent from changes in per-acre harvesting intensity.

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NEW ESTIMATES OF HARDWOOD LUMBER EXPORTS FROM THE CENTRAL HARDWOOD REGION

William Luppold and Edward Thomas[1]

Abstract: Exports have become an increasingly important part of the overall hardwood lumber market. However, recent findings indicate that much of the reported growth of hardwood lumber exports in the 1980's was based on inflated volume data. This paper presents new estimates of hardwood lumber exports to Asia and Europe with emphasis on the central hardwood region of the United States. The major finding is that, although the central region has become a major source of hardwood lumber, exporters in the eastern and western regions have a much larger share of the European and Asian markets.

INTRODUCTION

Exports have been one of the most visible components of the hardwood lumber market over the last decade. Statistics released by the U.S. Department of Commerce, Bureau of the Census (1989) indicate that lumber exports increased by 809 million board feet (or 327 percent) between 1980 and 1988 (Nolley 1990). These statistics report that exports to Asia and Europe increased by 388 million board feet and 249 million board feet, respectively. However, recent findings indicate that volume statistics reported by the Bureau of the Census for hardwood products have been greatly overstated (Luppold and Hansen 1989). This paper presents revised estimates of hardwood lumber exports to Asia and Europe with special emphasis on exports from the north and south-central hardwood regions.

The errors in statistics on hardwood lumber export volumes resulted from errors in the computer program that screens individual export declarations for accuracy, combined with an increasing number of incorrect export declarations. When the volume indicated on an export declaration was incorrect, the program developed a new volume estimate by dividing the declared value by a default price. Different default prices were used for each lumber product; however, most of the default prices had not been changed since the late 1970's. Since May 1989, new screening and default prices have been installed in the computer program, resulting in considerably better estimates of export volumes.

In addition to being historically inaccurate, official estimates of hardwood lumber export volumes are reported only by custom district from which lumber exits the United States and

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not the actual point of origin. This type of reporting does not allow for regional analyses of hardwood lumber exports. However, alternative information on hardwood lumber exports from seaports is available from the Port Import Export Reporting Service (PIERS) (Journal of Commerce 1989-90). This service provides information from individual shipping manifests, including product, weight, selling agent or company, and foreign destination.

Although the data provided by PIERS are extremely detailed, there are certain limitations in developing regional exports volumes. One difficulty with PIERS data is that they do not include material transshipped through Canada. Nearly 20 percent of the lumber exports to Europe travels through Canada via inland custom districts primarily in the northeast. Since dollar-volume figures by custom district are known to be fairly accurate, estimates of total export volumes can be obtained by combining both information obtained from PIERS and the Department of Commerce. However, there is no method for determining the origin of shipments leaving from inland exit points. Another problem in determining the regional impact of lumber exports is that lumber can be sold across regions and then exported. Still, with these limitations, PIERS data can provide the information needed for a rough analysis of hardwood lumber exports on a regional basis.

All non-Census data reported in this paper are derived from PIERS. The validity of these procedures is discussed in Luppold and Thomas (1990). The basic steps used in developing the data were: (1) Classify all observations into the specific 10-digit codes used by the Bureau of the Census; (2) Place all observations not designated by species in a NES (not elsewhere classified) category; (3) Develop export volumes on a shipment-by-shipment basis by using volume information listed on the manifest, or by estimating volume from weight or other information provided on the manifest;[2] and (4) Summarize volumes on a year-by-year, country-by-country basis for all known species and NES categories.

NATIONAL EXPORT TRENDS

In Figure 1, Census estimates of hardwood lumber exports to Asia are compared to estimates developed from PIERS data. Since value information also developed by the Bureau of the Census indicates that nearly all hardwood lumber exports to Asia go through U.S. seaports, the PIERS estimates represent the actual volume exported. The sharp decline in Census estimates between 1988 and 1989 resulted from changes made in the computer program used to compile official export statistics. Since these changes were not used in developing export data for January through April, 1989 Census estimates remain slightly inflated.

Even after discounting the volume inflation in the official hardwood export statistics, exports to Asia increased by nearly 1,000 percent (240 million board feet) between 1981 and 1989

[2]A detailed description of the procedures used to estimate volume from ship manifests, and the validity of these procedures, is discussed by the authors in "A Revised Examination of Hardwood Products Exports to the Pacific Rim (in preparation).

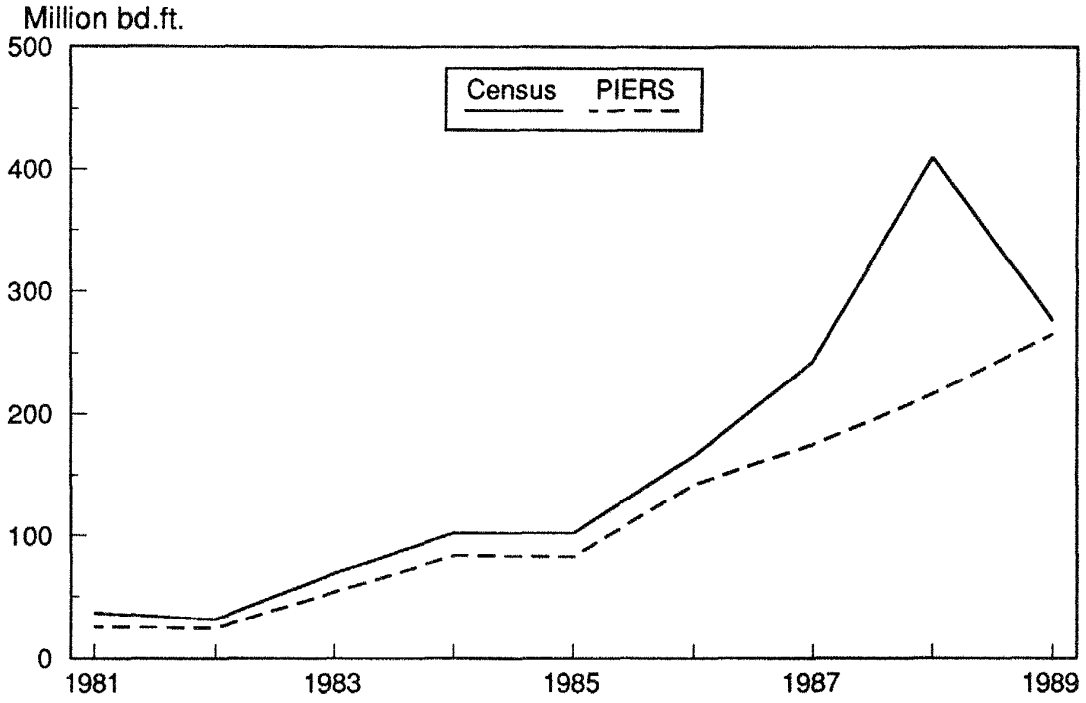

Figure 1. Estimates of hardwood lumber exports to Asia as reported by USDC Bureau of Census and developed from PIERS data.

(Fig. 1). The rapid growth in Asian exports emanated primarily from increased demand by Japan and Taiwan. These two countries accounted for nearly 90 percent of all hardwood lumber exports to Asia in 1989. Although the growth in these two markets occurred almost simultaneously, the demands by Japan and Taiwan are considerably different.

The Japanese use U.S. hardwood lumber for production of furniture, millwork, and fixtures that are consumed in the Japanese market. Red alder was the primary hardwood lumber species exported to Japan in 1989. Also shipped were large amounts of ash, yellow-poplar, white oak, and red oak. Exports to Taiwan were manufactured into furniture and other products that were exported primarily back to the U.S. market. Red oak was the primary species exported to Taiwan in 1989, with significant amounts of white oak also shipped.

Estimates of hardwood lumber exported to Europe as developed by the Bureau of the Census and from PIERS data are shown in Figure 2. Since a significant portion of European exports from the United States go through Canada, a third line representing adjusted PIERS estimates is shown. The adjusted PIERS estimates were developed by multiplying the PIERS estimate by the ratio of total value of exports to Europe over the value of European exports leaving primarily seaport custom districts. Again, the sharp decline in Census estimates between 1988 and 1989 resulted from changes made in the computer programs used to compile official export statistics.

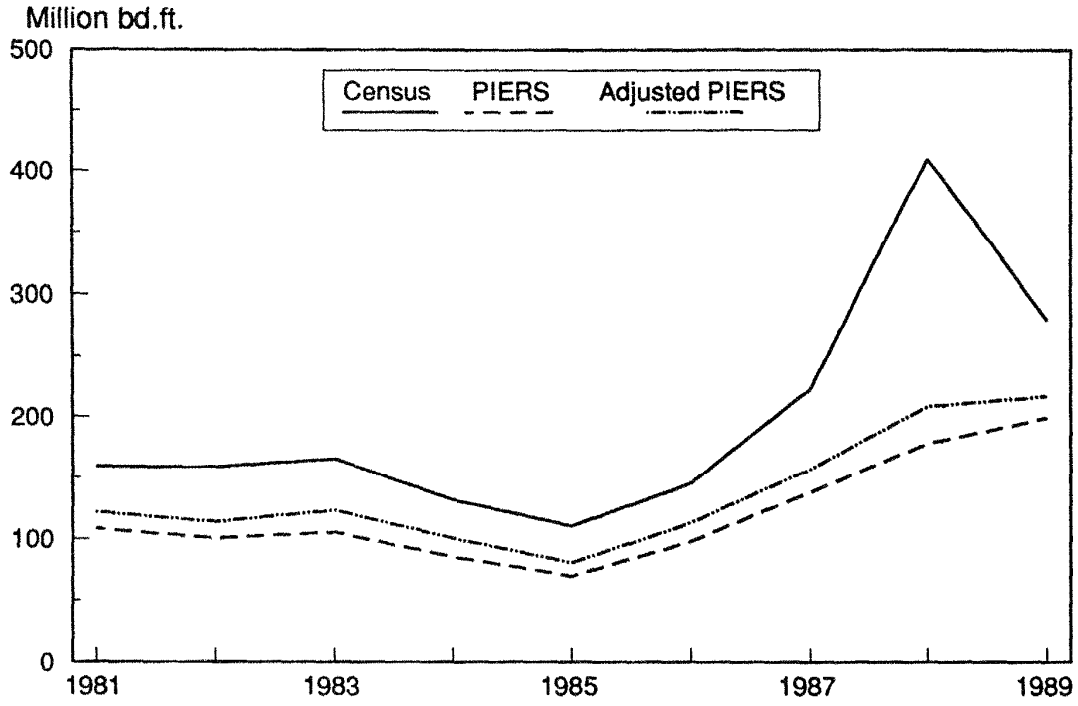

Figure 2. Estimates of hardwood lumber exports to Europe as reported by USDC Bureau of Census and developed from PIERS data.

Hardwood lumber exports to Europe nearly doubled in the 1980's from an already high base in the late 1970's. By the end of the decade, exports to Asia were higher than exports to Europe. The European market differed sharply when compared to the Asian market in that no single country or set of countries continued to be a dominant user of U.S. hardwood lumber. In the early 1980's, West Germany, the Netherlands, and Belgium were the primary markets for U.S. lumber. In the mid-1980's, Italian demand for U.S. lumber increased sharply while the traditional northern European market either remained static or declined. In the late 1980's, nearly all European markets increased; however, exports to the United Kingdom, Spain, and Italy increased at faster rates.

White oak was the major species exported to Europe in the 1980's. Significant quantities of red oak also were exported to Europe, with Belgium and France the major users. Ash and yellow-poplar also were exported to Europe in increasing volumes in the late 1980's. Yellow-poplar currently is the major species exported to Italy.

REGIONAL EXPORT TRENDS

The north and south-central regions produce well over 50 percent of the 11 billion board feet of hardwood lumber manufactured in the United States (Luppold and Dempsey 1989). At first analysis, this level of regional production indicates that these regions are the major suppliers of exported lumber. Surprisingly, the central region is a minor force in the Asian market when examining regional export information developed from PIERS data (Fig. 3). In 1989, only 17 percent of Asian exports originated directly from firms located in the central hardwood region.

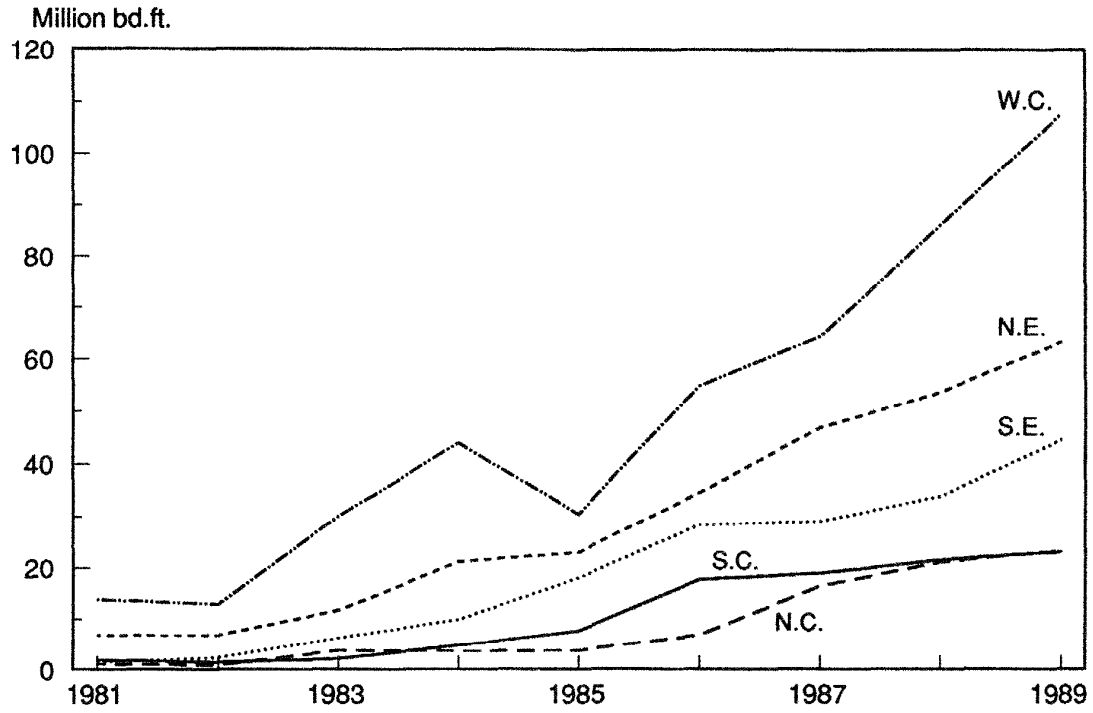

Figure 3. Regional estimates of hardwood lumber exports to Asia as developed from PIERS data.

Part of the reason why the central region appears less important in the Asian market is that nearly 40 percent of the nearly 250 million board feet of hardwood lumber going to Asia in 1989 was shipped by West Coast firms. A significant but unmeasurable amount of lumber shipped by West Coast exporters is eastern species such as red oak, white oak, ash, maple, and poplar. The closer proximity of the central region to the West Coast would suggest that a high proportion of this lumber is from the central region. Although this situation highlights the weakness of using PIERS data for U.S. regional analyses, some interesting trends can be drawn from the limited information at hand.

The first notable trend is that growth in exports to Asia from all regions has grown over time in a similar pattern. Until recently, exports to Asia from the south-central region have slightly exceeded exports from the north-central region. The recent slight increase in strength of the north-central market can be explained by examining the major Asian markets served by these regions.

Throughout the 1980's, Taiwan was the major market for south-central lumber exports, with red oak the major species. Ash, the only other significant export from the south-central region, was shipped in increasing amounts to Japan through the mid-1980's. Exports to Asia from the north-central region tended to vacillate between white oak shipments to Japan in the early 1980's, to red oak shipments to Taiwan in mid-1980, back to white oak shipments to Japan in the late 1980's. Today, Japan is the primary market for the north-central region. In the late 1980's, the Japanese market grew faster than the Taiwanese market; the result was that north-central exports to the Asian market increased at a faster rate than south-central exports.

Exports to Europe, by region, for 1981 to 1989 are shown in Figure 4. Exporters from the central hardwood region account for a much greater share of the European market than the Asian market. The northeast region, however, appears to be the largest source of exports to Europe. Some of the material shipped by northeastern and southeastern firms could have emanated from the central region, but there is no accurate information on these interregional transfers.

One interesting aspect of Figure 4 is that exports from the north-central region increased at a much faster rate in the 1980's than exports from the northeastern region. In 1981, 49 percent (52.6 million board feet) of the exports to Europe originated from the northeast while only 8 percent (8.5 million board feet) originated from the north-central region. By 1989, exports shipped from the northeast increased to 69.5 million board feet while exports from the north-central region increased to 30.6 million board feet. Alder exports from the West Coast to Europe also increased sharply in the 1980's. Exports from the southeast and south-central regions increased at about the same rate as total exports during the 1980's.

The primary European markets served from the north-central region changed as the overall European market changed. Germany and Belgium were the primary European markets for north-central lumber through the mid-1980's. In the late 1980's, Italy, the United Kingdom, and Spain became increasingly important markets for north-central hardwood lumber. White oak has been and remains the primary species shipped to Europe from this region regardless of country of destination.

In the early 1980's, Germany and the Netherlands were the most important export markets for the south-central region. In the mid-1980's, Italy rivaled Germany as the most important market. By the late 1980's, Italy, Spain, Belgium, and the United Kingdom were more important markets for south-central hardwood lumber than Germany. As in the case of the north-central region, white oak was the most important species exported to Europe from the south-central region.

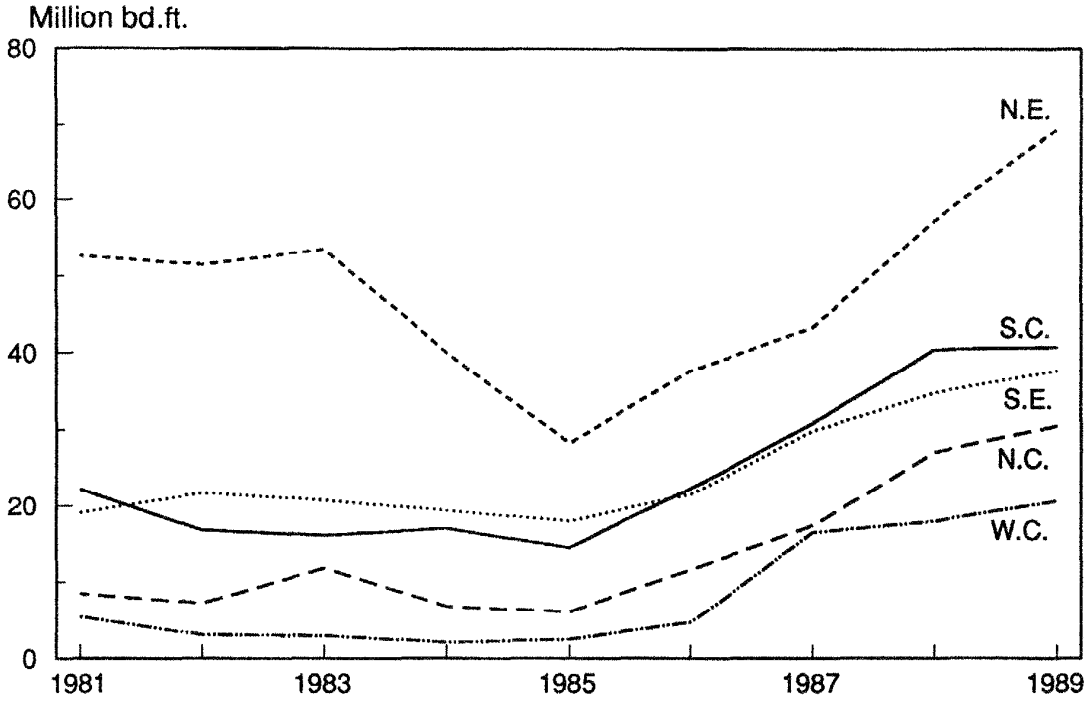

Figure 4. Regional estimates of hardwood lumber exports to Europe as developed from PIERS data.

SUMMARY AND CONCLUSION

Although the central hardwood region manufactures more than 50 percent of the hardwood lumber produced in the United States, the amount of lumber directly exported from this region is substantially less. Part of this apparent discrepancy can be attributed to shipments of exportable lumber from the central to coastal regions. However, the cost of transporting products to international markets is increased because many of the states in the central region are landlocked. Still, the north-central region has increased its share of exports to Europe relative to all other eastern regions. As the export markets in both Asia and Europe continue to expand, it is almost certain that the vast production and timber resources of the central hardwood region will be increasingly required to serve the growing international demand for U.S. hardwood lumber.

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SHIITAKE MUSHROOM PRODUCTION ON SMALL DIAMETER OAK LOGS IN OHIO

Stephen M. Bratkovich[1]

Abstract: Yields of different strains of shiitake mushrooms (*Lentinus edodes*) were evaluated when produced on small diameter oak logs in Ohio. Logs averaging between 3-4 inches in diameter were inoculated with four spawn strains in 1985. After 3-1/2 years, strain *S-1* produced a total of 432 lbs. of fresh shiitake per cord when log management included forced fruiting by soaking in water for 24 hours. Additional strain and fresh lbs. per cord results were *FWF*, 291 lbs.; *82A*, 120 lbs.; and *RA 3-2-E*, 39 lbs. For all spawn strains, forced fruiting increased shiitake mushroom yield when compared to a control. Foresters need to be aware of the dependency of shiitake mushroom yields on spawn strain and management practices when making recommendations to landowners on the utilization of small diameter oak logs. Foresters also can use shiitake mushroom production as another tool in stimulating private non-industrial forestland management.

INTRODUCTION

Foresters working in the hardwood regions of the U.S. are continually searching for methods to increase management on non-industrial private forestland. An accompanying goal, which often is a pre-requisite to management, is increased utilization of low quality tree species. Leatham (1982) presented documentation on how shiitake mushrooms (*Lentinus edodes* [Berk.] Sing.) could be grown on underutilized wood harvested from low-grade hardwood trees, particularly oak. With a 1988-89 wholesale price of $4.70 per lb. (USDA 1989), it is not surprising that foresters are eager to learn if shiitake mushroom production can be used as a tool to stimulate forest management.

Shiitake mushrooms can be cultivated on either intact hardwood logs or wood particles (Royse, Schisler and Diehle 1985). Relatively little scientific information has been published in the U.S. on cultivating shiitake mushrooms on logs (Leatham 1982, San Antonio 1981, San Antonio and Hanners 1983). Published information is also scanty on the potential yields and economic returns from shiitake cultivation on logs (Anon. 1989, Baughman 1989, Haney 1989, San Antonio 1981).

This paper compares shiitake mushroom production on mixed oak logs using a combination of different mushroom strains and management practices (soaking versus non-soaking of logs). Results are useful for making recommendations to foresters and forestland owners.

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MATERIALS AND METHODS

Spawn Selection

During January 1985, four spawn strains from three commercial U.S. spawn suppliers were purchased. The specific strains obtained were: *S-1* from Elix Corporation, Arvonia, VA, *82A* and *RA 3-2-E* from Mushroompeople, Inverness, CA, and *V3A*, *V3B*, *R56B*, and *R569* from Far West Fungi, South San Francisco, CA. Since it was not known that four, rather than one strain from Far West Fungi would be received, the four strains (after being mixed uniformly) were grouped together for testing purposes and named "FWF" strain. Therefore, the experiment was designed to test differences between the following strains: *S-1*, *82A*, *RA 3-2-E* and *FWF*. Strains *S-1* and *RA 3-2-E* were on a sawdust medium and *82A* and *FWF* were on wood dowels. All spawn was refrigerated until inoculation.

Obtaining the Logs

Two and one-half cords of wood, which came from tree tops and branches of harvested sawlogs and pulpwood, was cut in late February 1985. The unsplit logs consisted of 50 percent oak (*Quercus* spp.) and 50 percent American beech (*Fagus grandifolia*). Log diameters ranged from two to eight inches with lengths up to 12 feet. The average log diameter was slightly over three inches.

The harvested logs were taken to the Elizabeth L. Evans Outdoor Education Center in Jackson county, Ohio, site of the experiment. In early March 1985, logs were cut into four foot lengths and stacked firewood style until inoculation. A total of 801 logs, 386 oak and 415 beech, comprised the two and one-half cord sample. Spawn strain and management practice were randomly assigned to the logs. An aluminum tag was stapled on the ends of each log for coding purposes.

Inoculation Procedure

Approximately 90 percent of the logs were inoculated between March 25 and April 4, 1985. The remainder of the logs were inoculated May 3, 1985. The number of inoculation sites per four foot log was determined by log diameter with the log diameter in inches translating to the number of rows drilled in the log lengthwise. For example, a log with a diameter of four inches had four lengthwise rows of inoculation sites. Inoculation sites were spaced six inches apart within rows with each inoculation site offset three inches from the neighboring row. Regardless of the number of rows per log, rows of inoculation sites were spaced approximately three inches apart.

The wood dowel inoculation sites were drilled 5/16 inch in diameter and to a depth of approximately 3/4 inch. After drilling, the logs were moved to a work table where the dowels were tapped into the holes with a hammer. The inoculation sites were then painted with a hot, melted cheese wax.

Inoculation sites for the sawdust spawn were drilled 12mm (approximately 1/2 inch) in diameter and 3/4 inch deep. A sawdust spawn inoculation gun was used with the *S-1* spawn. The consistency of the *RA 3-2-E* spawn required the spawn to be placed by hand into the inoculation holes. Fifty percent of the sawdust spawn inoculation sites (*S-1* and *RA 3-2-E*) were randomly treated with melted cheese wax. The remaining fifty percent had a styrofoam plug placed into the hole on top of the sawdust.

Log Stacking

Following inoculation, all logs were restacked firewood style and covered with black plastic for one week and then with burlap. This log stacking pattern, known as a temporary laying position, was selected to conserve log moisture. The site for the temporary laying was the same site used for all other phases of the experiment (inoculation, permanent laying, soaking and raising). The location is a bottomland near the mouth of a large hollow or ravine. Air movement is good and the site is densely shaded by a stand of mature sugar maple. A small stream flows past the site.

In late May 1985, surface molds (*Trichoderma* spp. and *Daldinia concentrica*) appeared on the logs so the burlap was removed. One week following burlap removal, the logs were restacked into a cross-hatch or crib pattern. (Example: the first row of five to six logs were placed in a north-south direction, the second row in an east-west direction, etc., with the height of the stack approximately four feet). This stacking arrangement permitted better air movement around the logs in an attempt to control the surface molds. The cross hatch pattern was the chosen permanent laying position. The logs were restacked in late June 1985 in a more widely spaced cross-hatch of three to four logs per row in a successful effort to eliminate the surface molds.

The logs remained in the permanent laying cross-hatch pattern until October 1985 when mushrooms started to appear on a few oak logs. At this time, all oak logs were raised by leaning them against the fence which encircled the experiment. The beech remained in the cross-hatch pattern.

Log Irrigation and Soaking

During the summer of 1985, all logs were irrigated twice with a garden sprinkler. Since the effect of the irrigation was judged to be beneficial only to the surface molds, irrigation was

discontinued for the remainder of the experiment. During October and November 1985, 12.5 inches of rainfall (an unusually high amount) were recorded at the experimental site.

During 1986 and 1987 logs randomly selected for soaking were completely immersed in water for 24 hours. A total of four soakings were administered. All logs in the experiment were managed according to recommended shiitake management practices depending on whether or not they had been soaked. For example, soaked logs were placed in the upright fruiting position (leaned against a fence) immediately following a water soak while non-soaked logs remained in the cross-hatch pattern until fruiting occurred at which time they were placed in the upright fruiting postion.

RESULTS

Beech Logs

The beech logs in 1985 yielded one lb. of fresh shiitake per cord for both the *S-1* and *FWF* strains; there was no fruiting on the *82A* or *RA 3-2-E* logs. The beech logs were eliminated from the experiment during 1986 due to poor fruiting, low log moisture content, and splitting/sloughing bark.

Oak Logs

During the fall of 1985, which was prior to the water soaking treament initiated in 1986, the combination of logs designated for soaking and control yielded the following average fresh shiitake per cord: *S-1* strain, 38 lbs.; *FWF* strain, eight lbs. There was no activity on the *82A* or *RA 3-2-E* inoculated oak logs in 1985.

During 1986-88 mushrooms were produced during the period from April/May to November/December. Table 1 presents fresh shiitake yield in lbs. per cord for all four strains from 1986 through 1988.

The more prolific strains, *S-1* and *FWF* (as measured by total fresh lbs. per cord), had peaks in yield the first full year of production (1986) while strains *RA 3-2-E* and *82A* peaked during the last year of data collection (1988). All spawn strains showed mushroom yields to be greatest for the three-year period when log soaking was utilized as a management practice.

It is interesting to consider seasonal fruiting/harvest trends in addition to annual yields. For example, 78 percent of the 1987 *82A* yield occurred **after** October 14 while 98 percent of the 1987 *S-1* yield occurred **before** October 14 (on soaked logs). Even though the '87 *S-1* yield was nearly double the *82A* yield (79 to 40 lbs. per cord), the combinaton of the two strains would have extended the marketing season for a commercial grower.

Table 1.--Per cord 1986-88 shiitake yield on 1985 inoculated oak logs.*

Spawn Strain**	Treatment***	1986	1987	1988	Total
		---------- Fresh lbs./Cord**** ----------			
RA 3-2-E	Soak	0	13	26	39
RA 3-2-E	No Soak	0	7	3	10
S-1	Soak	350	79	3	432
S-1	No Soak	287	63	50	400
FWF	Soak	172	104	17	291
FWF	No Soak	149	43	13	205
82A	Soak	7	40	73	120
82A	No Soak	0	7	20	27

*Logs were inoculated at a spacing of approximately 6" by 3".
**RA 3-2-E and S-1 were on a sawdust medium. FWF and 82A were dowels.
***Logs soaked for 24 hrs. twice in 1986 (March/Sept.) and twice in 1987 (May/August).
****Approximately 330 logs/cord. Average log diameter slightly over 3".

Logs that were water soaked not only received additional moisture as compared to the control or non-soaked logs, but the soaking served as a forced fruiting with the peak growth flush occurring approximately seven days following soaking. The non-soaked logs were more dependent on weather conditions with growth flushes occurring in close proximity to natural precipitation.

Table 2 presents the same data as in Table 1 except Table 2 data is on a **per log** basis. The data for Table 2 was compiled for all logs originally inoculated in 1985 and thus represents mean production per log; mean production figures include individual logs which were poor, as well as good, producers.

DISCUSSION

Foresters recognize that landowners are often hesitant to invest in forest management activities when economic returns are in the distant future; timber stand improvement and non-commercial thinnings are two examples. However, if the management practice generates small diameter oak logs, then shiitake production is a potential source of short-term cash flow

Table 2.--Per log 1986-88 shiitake yield on 1985 inoculated oak logs.

Spawn Strain	Treatment	1986	1987	1988	Total
		---------- Fresh lbs./Log* ----------			
RA 3-2-E	Soak	0.00	0.04	0.08	0.12
RA 3-2-E	No Soak	0.00	0.02	0.01	0.03
S-1	Soak	1.06	0.24	0.01	1.31
S-1	No Soak	0.87	0.19	0.15	1.21
FWF	Soak	0.52	0.31	0.05	0.88
FWF	No Soak	0.45	0.13	0.04	0.62
82A	Soak	0.02	0.12	0.22	0.36
82A	No Soak	0.00	0.02	0.06	0.08

*Inoculated logs averaged slightly over 3" in diameter. All other footnotes from Table 1 apply to Table 2.

for the landowner. Foresters should be prepared to present this option to landowners since in certain instances it might be just the incentive needed to stimulate forest management.

Readers should be aware that the results reported in this paper are from an initial testing program. Since 1985 when this study was initiated, improved management practices and more desirable spawn strains have been identified. Experience gained in management technique is critical for optimal success. However, foresters who communicate with landowners about shiitake mushroom cultivation can use the methods and results of this study as general guidelines to move individuals through the process.

It is important to recognize that the optimum combination of host tree species, spawn strain and log management can be specific to a geographical area. For example, Haney (1989), using spawn from a local supplier found sycamore (*Platanus occidentalis*) to outperform other tree species in western North Carolina. The Forest Resource Center in Minnesota recently reported shiitake yields on force-fruited ironwood (*Ostrya virginiana*) to be nearly double red oak, the best species previously identified in the region (Anon. 1989). Based on the North Carolina and Minnesota research as well as the Ohio research presented in this paper, forest landowners interested in shiitake cultivation should be encouraged to experiment on a small-scale. Unfortunately, some individuals have jumped into large-scale shiitake production without understanding that tree species, spawn strain, log management and geographical area have an impact on mushroom production.

Management practices, such as force fruiting the logs by soaking, was shown in this study to increase the rate and amount of mushroom yields and is a management option that foresters can pass on to landowners. Although this article did not focus on economics, landowners need to be encouraged to analyze the economic impact of all management decisions. Landowners without available labor or a nearby source of water may choose not to soak their logs, thus decreasing mushroom yields but perhaps increasing net profit in their particular situation.

Finally, the concept of shiitake mushroom production goes beyond the idea of raising a gourmet mushroom on hardwood logs. Too often landowners and foresters think only in terms of traditional forest products such as pulpwood and sawtimber and overlook opportunities for economic returns from wildlife, recreation and food (Haney, 1989). Shiitake mushrooms could stimulate both foresters and landowners to broadened their vision of possibilities that can enhance both profits and forest management opportunities.

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THE PALLET INDUSTRY: A CHANGING HARDWOOD MARKET

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Abstract: From its inception during World War II, the wooden pallet industry has grown to become the Nation's largest industrial consumer of hardwood lumber products. Since most of the raw material in wooden pallets is lower grade lumber, the pallet industry's growth, efficiency, and changing raw material inputs must be of concern to the grade hardwood lumber industry, the fine-hardwood lumber-using sectors, and hardwood resource investors and managers.

INTRODUCTION

The United States' wooden pallet industry currently provides a viable market for more than 5.1 billion board feet of mostly lower grade hardwood lumber (or lumber equivalent) annually. This represents more than 46 percent of the total U.S. hardwood lumber production. Therefore, significant changes in either pallet output or its manner of production is important to the grade hardwood lumber industry and its prime outlets--the fine-hardwood-using industries, such as manufacturers of wood household and office furniture, cabinets, etc., and, to varying degrees, hardwood resource managers. For example, economic activity in the pallet industry affects both the physical availability and price structure of grade hardwood lumber used by these higher valued domestic product markets, including the export market. Hardwood forest resource managers also would have fewer management options if there were no pallet market to utilize much of the lower grade timber resource.

The pallet industry is currently in a sustained growth mode and has more than doubled its unit product output since the economic recession of 1982. Despite the higher costs of productive inputs, the industry is producing more pallets with less labor and at lower output prices. Industry efficiency, as measured by labor productivity, has increased by more than 83 percent since 1972 (Dempsey 1988). This has been accomplished in the face of more stringent manufacturing standards and higher costs. Contributing to these efficiencies were structural and operational changes that affected the source, quantity, and form of raw materials as well as their in-plant utilization.

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YESTERYEAR

Prior to World War II, the principal means of loading, moving, stacking, and storing industrial products was by hand, coupled with the use of wheeled hand jacks, platform carts, and various kinds of fixed and moveable hoists. Simple wooden platforms were used in these systems primarily for load separation and support. According to Wallin (1986), industrial pallets as we currently know them were introduced as a materials handling tool in the 1930's, though their use was minimal. For example, only 11 million wooden pallets were produced annually in the late 1930's. The early pallets were produced "in house" by the firms using them, or as specialty products by the manufacturers of wooden boxes and other containers.

Pallets were not used extensively in materials handling systems for two reasons. First, the technology to mechanize materials handling was not available until 1937 when the first generation of small, gas-powered forklift trucks was developed (Eichler 1976). Second, given the state of the economy and the surplus of labor during the 1930's, there was little economic incentive among the country's major industries to mechanize their materials handling systems.

During World War II, however, the urgent need for faster and more effective methods of handling vast amounts of materials stimulated the development of a variety of highly maneuverable, motorized forklift "trucks." The use of these vehicles allowed goods to be moved, stacked, and stored with extraordinary speed and versatility, and with a minimum of labor. The primary base structures used for these functions were the two- and four-way-entry wooden pallets. After World War II, the pallet industry continued to grow with the economy. As major industrial segments such as the food, beverage, chemical, metal, automotive, and transport industries expanded and sought more effective means of handling their products, the mechanization and use of wooden pallets became widespread.

TODAY'S INDUSTRY

Since its birth as a manufacturing segment, the United States' pallet industry has evolved from a "cottage" industry to a major supplier of base structures for materials handling. From an annual output of 11 million pallets in the late 1930's, the industry produced about 32 million in 1946 and grew to 505 million in 1989. Today, the wooden pallet industry is still growing. In units produced, the industry has averaged a 17.3-percent annual rate of growth over the past 9 years. In addition to the market's pallet replacement needs and an expanding economy, this growth has been in response to: (1) a broadened market as a larger proportion of industrial firms palletize; and (2) the increased mechanization and automation of materials handling systems by current users of pallets.

In 1989, pallet manufacturers produced more than 505 million new pallets and skids--the most ever according to estimates by the National Wooden Pallet and Container Association (1990). Pallet output in 1989 represented a 121-percent increase in production over that of 1982 (228.3 million) and more than tripled the 1972 output of 155 million. Since 1972, pallet

production has increased with general steadiness except for 1975 and 1982, both economic recession years. Between 1983 and 1989, the industry showed its strongest and most sustained growth since World War II.

The 17-year general expansion in pallet output brought about a corresponding but less than proportional increase in the total value of pallet products sold. This holds true whether shipment values are measured in either current or constant prices. In current dollars, the industry's value of pallet products shipped increased more than sixfold (642 percent), or from $623 million in 1972 to $4 billion in 1989.

In recent years, while both the total output and shipment values of new pallets have increased, the price per unit in terms of 1982 dollars decreased and then stabilized. Between 1972 and 1979, the inflation-adjusted average price of new pallets increased, reaching a peak in 1979 at $9.99 per unit. After 1979, the price of pallets decreased and then became relatively stable at a lower level. The real price of pallets sold between 1972 and 1982 averaged $8.83 per unit (1982 dollars). Similarly, adjusted prices averaged $7.66 per pallet from 1982 through 1989--with average annual prices ranging from $7.42 to $7.92 per unit.

Such patterns in production and prices show that the industry's recent 7-year growth in value of shipments was due to increased quantity and quality of pallet production rather than to increases in unit price. This efficiency has allowed the wooden pallet industry to grow despite counteracting forces such as increased competition from alternate materials; steadily rising costs of raw material, energy, transportation services, and other production items; and adverse changes in the automotive and defense materials handling markets.

CAPITAL/LABOR SUBSTITUTION

A major reason for the improved competitive position of the pallet industry is the substitution of capital for labor (Dempsey 1988). This trend has been most obvious since 1977 and particularly in the more repetitive, labor-intensive operations. In 1985, the last year for which complete data are available--the pallet industry invested more than $46 million in capital assets, 86 percent in new production items, and 14 percent in used assets. This investment was 8 percent higher than the annual average ($42.9 million) for the previous 4 years and nearly double that invested by the industry in 1977 ($24.1 million).

The industry's largest expenditures, $39.7 million, were for "new" capital assets in the form of machinery and equipment, plants, facilities, and other production structures. Within this category, new machinery and equipment for mechanizing and automating production were the capital goods purchased most heavily, totaling 85 percent of investments. The balance of expenditures, 15 percent, was for new plants, facilities, and other structures.

A break with the practice of relying on labor to sustain increases in output first became evident in the late 1970's. Innovative new machinery and equipment were coming onto the market, and capital investments increased to $1,418 per production worker. By 1979, there

was both a surge in capital investments and a leveling in employment of production workers. This production year represented a turning point in the pallet industry's capital and labor investment mix. And the manner in which these productive factors were used was changing. The developing trend emphasized the substitution of capital for labor in the production of pallets.

Capital investments continued strong from 1979 through 1985, and most likely to the present. Annual investments per worker nearly doubled (up 91 percent) from 1977 through 1985, increasing from $1,190 to $2,282 per production worker and continuing the trend toward a lessening dependence on labor to sustain output.

CHANGE IN RAW MATERIAL USE

Beginning in its formative years--in the late 1930's and early 1940's--and lasting over 2 decades, the pallet industry obtained its raw material almost exclusively from the lower grades of random-width, random-length lumber generated as a byproduct of the grade hardwood sawmills (Martens 1989a). The predominant grades used were No. 2 and No. 3 Common. Softwood lumber was substituted in some areas where hardwoods were difficult to obtain. In such cases, the softwoods used were primarily from the economy and utility grades of West Coast lumber and in the No. 3 and No. 4 southern pine structural grades.

As the pallet industry became a more consistent market for lumber, the hardwood sawmill industry began manufacturing a sound grade of lumber in 4-, 6-, and 8-inch widths commonly referred to as "pallet grade." The use of pallet grade lumber not only reduced the waste incurred by the industry's use of random-width lumber, but also assured the sawmill industry a steadily growing market for the difficult-to-move, lower furniture grades.

By the 1960's, the demand for the lower grades of hardwood lumber began to exceed the supply generated by the grade lumber mills in many areas. It was during this period that vertical integration began within both the sawmill and pallet plant sectors. Most of the integrated sawmills, however, still operated as traditional hardwood grade mills with high-value lumber going to the furniture industry and lower grade lumber going to the pallet industry. It also was about this time that we saw the advent of 4-, 6-, and 8-inch cants.

The cant concept quickly became popular because its use was advantageous to both the sawmill and the pallet mill. In the sawmill, the time that each log spent at the headsaw was shortened. This increased both the total volume of lumber produced and the volume of lumber in the higher valued grades. In the pallet plant, the use of cants eliminated the waste generated from random-width lumber and allowed greater flexibility in the variety of pallet part sizes that could be produced.

Cants, particularly the 4- by 6-inch size, provided maximum versatility in the production of pallet parts with minimum waste; they also could be handled and stored efficiently and breakdown could be automated, allowing increased production while minimizing labor costs.

The production of 1-5/8-inch thickness of lumber from cants also appears to be gaining in popularity for many of the same reasons--high flexibility, minimum waste, high production, and ease of handling. Full thickness is used for stringers, the lumber resawn once for 3/4-inch deckboards or twice for 1/2-inch deckboards. Many pallet plants with roundwood sawing facilities are cutting to 1-5/8 inch for internal storage and use.

In the 1970's, as raw material supplies tightened, more and more bolter mills and scragg mills were being used to produce pallet parts from pulpwood bolts. Also, in the captive sawmills there was less emphasis placed on producing grade lumber. The concept of going directly from roundwood to pallet parts became common. In the 1980's, a considerable portion of the pallet industry took this practice one step farther by shifting to tree-length material, thus eliminating the log step. With tree-length material, the stems are crosscut to the length, or multiples of the length, of the pallet parts to be produced. This virtually eliminates end trim waste, increases volume yield, and facilitates handling through multiple scragg saws, gang ripsaws, or other multiple sawing operations.

By 1986, according to McCurdy and Ewers (1987), the raw material used for pallet production in the predominately hardwood regions consisted of 24.4 percent logs, 36.7 percent cants, and 38.9 percent lumber. The lumber category also included 6/4 lumber that was resawn and precut pallet shook. Of the 24.4 percent in logs, 5.8 percent was purchased as stumpage, almost one-fourth of the total logs category.

THE FUTURE?

One of the more significant changes within the pallet industry has been the amount of raw material used in the manufacture of wooden pallets. In the last 20 years, the average volume of lumber contained in a pallet has decreased from 20 board feet to about 13 (McKeever 1987). Unpublished data from a 1985 survey conducted by Dwight R. McCurdy and James T. Ewers at Southern Illinois University showed that pallet part sizes had decreased. Where the deckboard thickness for nonexpendable hardwood pallets was 1 inch 20 years ago, more than one-half of these pallets now have deckboards that are 3/4-inch or less. Further, well over 50 percent of the expendable hardwood pallets produced had deckboards of 1/2-inch in thickness (Martens 1989a).

This trend in the reduction of raw material used per unit is expected to continue as the Nation's pallet-using industries progress toward faster, more automated materials handling systems to provide a more competitive service and reduce costs in the process. The demand is expected to increase for lighter, more versatile base structures of equal or better strength to complement such systems. In such a market, the challenge for the wooden pallet industry will be to produce a more tailored and better engineered product while maintaining tight controls over pallet manufacturing costs.

The trend away from the purchase of 1-inch lumber by the pallet industry will likely continue because of its comparatively high handling cost, limited flexibility, and lower efficiency. By

contrast, the use of sawn cants and 1-5/8 inch thick boards will likely remain strong because of their high versatility and low waste factors. The latter also can be used to supplement the raw material supply of pallet plants that maintain roundwood sawing facilities. Consequently, grade hardwood lumber mills producing these products should continue to have a steady market for them.

In recent years there have been considerable efforts to develop and market pallets produced from more energy intensive materials such as plastic, metal, corrugated paper, and reconstituted wood. Some have found their way into specialized use markets. To date, however, about 97 percent of all pallets are still made of wood. This probably will remain true for the foreseeable future. Wood is versatile, less energy intensive, and generally a less costly material to use for pallets.

In sum, the United States' wooden pallet industry has proven itself to be strongly competitive, both internally and externally. To meet the challenges cited, the industry is expected to continue its advancements in mechanization, automation, and communication processes as a means of improving quality and reducing costs in the more labor-intensive, production-flow processes, and provide better service in product marketing activities. In doing so, the wooden pallet industry may become even more aggressive in lowering the relative cost of raw materials and become less labor dependent and more capital intensive.

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FACTORS DETERMINING THE LOCATION OF FOREST PRODUCTS FIRMS

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Abstract: In the past decade there has been an increase in the number of intrastate, state and regional programs aimed at encouraging forest resource based economic development in northeastern USA. These programs were aimed at deriving economic benefits from the large volume of mature forest resources in the region. The improvement of rural communities by creating job opportunities was seen as one of the primary benefits of the development programs, and they therefore focused attention on attracting firms and new manufacturing facilities. Most of these programs set the location of forest products firms as their target and seem to operate on the hypothesis that all forest products firms have the same general requirement when choosing a new location. The purpose of this study was twofold: first to test the hypothesis that different types of forest products firms have the same location requirements and second to test the hypothesis that location determinants within communities are the same irrespective of their size. Statistical analysis of 30 independent variables representing the economic, infrastructural, geographic and social conditions of 1098 northeastern communities indicate that each of the three types of forest industry subsectors studied had a unique combination of location determinants. In addition, each subsector had location determinants in metropolitan communities which were significantly different from the location determinants of non-metropolitan communities. These results suggest that programs aimed at attracting forest products firms may derive greater benefit from matching firms and communities rather than following the common practice of going after whole industries.

INTRODUCTION

In the past decade there has been a significant increase in the number of intrastate, state and regional programs aimed at encouraging forest resources based economic development in northeastern USA (Jones and Koester 1989). These programs are usually geared to deriving economic benefits from the large volume of mature forest resources in the region (State Foresters 1984). Improving the economies of rural communities by creating job opportunities is seen as one of the primary benefits of developmental programs which focus on attracting new manufacturing facilities. Most programs attempt to promote their state\region by advertising the positive aspects of their area. The promotional activities are typically general with respect to content and audience. A possible explanation for this situation, in a marketing analogy, is that the programs (sales departments) have not identified target

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industries (the consumers) to whom they make their 'sales pitch', neither have they identified target communities (the products) they plan to 'sell' to the industries. A possible reason for this may be that implicit in these programs are two very important assumptions: first, firms in all forest products industries have the same requirements and second, these firms have the same requirements irrespective of the size of the community in which they choose to set up new businesses. These assumptions contradict industrial location theory. Since various wood product industries have different input requirements and markets, location theory would suggest that a community which is a good site for plants in one industry might be a poor site for plants in another wood products industry. Further, location theory suggest that plants in a given industry may have different orientations. For example, a furniture factory may locate in a metropolitan area solely because of the market in that area. Another furniture plant may locate in a rural area to take advantage of cheap inputs and plan to serve regional or national markets. Thus, location theory provides the conceptual base for two hypotheses: that is, (i) the location requirement of forest products firms are invariant with respect to industry type; and (ii) the location requirements of forest products firms are invariant with respect to community size.

METHODS

Conceptual Issues And Hypotheses

Types of Forest Products Firms: Conventional wisdom suggests that, in the aggregate, forest product firms would have a set of location requirements that are very different to firms in the broadcasting industry. Firms planning to locate forest products manufacturing plants would be concerned with the availability and cost of raw material, labor and utilities; the location of markets; and the transport linkages. On the other hand, firms planning to set up a new broadcasting facility would be primarily concerned with the size of their broadcast service niche/market and be little concerned about transport facilities or energy costs.

Empirical industrial location studies support this hypothesis. In fact, recent studies have looked at the factors influencing the choice of a geographic area as the site for a new facility. Coughlin's *et al.* (1989) study of foreign direct investment in the USA is an example of such a study. These researchers were able to determine those factors which are important in the site choices of aggregate (2 digit SIC) industries. The fundamental hypothesis of this study was that two digit SIC industries have different location determinants. The empirical analysis supported this analysis. Implicit in this analysis, however, was the hypothesis that the location requirements of sawmills (SIC 2421) and wood kitchen cabinet manufacturers (SIC 2434) are exactly the same. The same, as all other firms in the aggregate Lumber and Wood Products Manufacturing industry (SIC 24).

An alternative hypothesis suggests that, in spite of wood being a common component in the production process, there may be enough differences in the location requirements that a sawmiller would choose an entirely different location from the location chosen by a kitchen

cabinet manufacturer. A sawmiller, for example, would be concerned about the supply of sawlogs in a chosen locality, whereas, the kitchen cabinet manufacturer would be concerned about access to markets in a chosen locality.

Types of Communities: Most economic development programs are based on the conventional wisdom that firms in a given industry would choose similar types of communities to set up businesses. Most industrial location analyses are based on this assumption. Smith, et al, (1978) for example conducted a study of southern communities and found that seven factors (site quality, site ownership, access to interstate highways, availability of bond finance, fire protection, presence of a college, and educational expenditure) were important in explaining why firms chose to locate in these communities.

An alternative hypothesis suggests that the size of the community would affect what factors become important in making location choices. Two possible scenarios are presented to suggest why this hypothesis may have validity. First, large communities, that is metropolitan areas, may have most of the prerequisites to attract most types of firms. In contrast, smaller communities may be limited to meeting only some of the location requirements of some types of firms. In the small cities and towns therefore, there may be many different features of the location, economic base, or labor force which may have significant statistical importance. In larger cities so many important features may be common that only a few differences are statistically significant. Second, and more important, some firms may deliberately choose a larger city because they plan to satisfy a particular market niche within that city. Another firm may be less concerned about such a narrow market and choose, instead, a non-metropolitan community with a low tax rate. Population size and/or population density have been included in industrial location models as a control variable, but, there has never been an explicit test of the differences in the location determinants in metropolitan and non-metropolitan communities. That is, the interaction between community size and other location determinants has not been explored.

The following section contains a discussion of the models that were developed to test two hypotheses:

(i) different types of forest products firms have the same location requirements, and

(ii) location determinants for metropolitan communities are the same as the location determinants for non-metropolitan communities.

Models To Test The Hypotheses

To test these hypotheses it was neccessary to develop a model that contained a set of explanatory variables which would reflect the unique socioeconomic and place-specific attributes of communities. The Northeast Industrial Targeting and Economic Development Database (NIT & EDD) System developed by Goode and Hastings (1989) was the source of the 31 independent variables used in the analysis. These variables were (acronyms in capital letters):

i) Potential Market Access. This variable (MARKET), conceptualized and made operational by Goode (1986), reflects if there is an excess quantity demanded for the industry's product in the market area surrounding the community.

ii) Potential Net Input Availability (PNIA) of Intermediate Manufactured Inputs. There are three (INPUT1, INPUT2, INPUT3) of these intermediate manufactured input variables (operationalized by Goode and Hastings 1988) for each of the three wood processing industries. The input variables are different for each of the wood processing industries. These input variables were selected on the basis of the magnitude of their input coefficient in the national Input/Output model. Positive values of these variables reflect whether the community is located in an area where there is an excess quantity of the inputs.

iii) Potential Net Input Availability of Forest Resources. This variable (FOREST, estimated in the same way as the input variables) reflect whether the community is located in an area where there is an excess quantity of forest resources supplied.

iv) Taxes

Per-Capita State Taxes (STATE)
Per-Capita County + Local Taxes (LOCAL+CNTY)
Source: 1970 Revenue Sharing File - US Department of Treasury

v) Transportation

Number of Railroads (RAILROADS)
Number of Airlines (AIRLINES)
Distance to Interstate Highway (HIWAY)
Distance to Primary Highway (ROAD)
Source: 1970 Rand-McNally Atlas

vi) Labor Force Characteristics

% with College Education (EDUCATED)
Male Labor Force Participation (MALELABOR)
Female Labor Force Participation (LADYLABOR)
% Males Working More Than 27 Weeks (MALEFULL)
% Female Working More Than 27 Weeks (LADYFULL)
Source: 1970 Census of Population

vii) Community Services

% Houses with Sewer (SEWERS)
Number of Hospital Beds (HBEDS)
Source: American Directory of Health Care Providers

viii) Colleges in the Community

viii) Colleges in the Community
% Population in College (COEDS)
Source: Directory of America Colleges and Universities

ix) Level of Development
Per-Capita Income (INCOME)
% Employed in Manufacturing (MFTLABOR)
% Houses Vacant (VACANT)
Source: 1970 Census of Population

x) Community Attributes
Distance to Metropolitan Statistical Area
Source: 1970 Rand McNally Atlas (PROXIMITY)
Population size (POPULATION)
Complexity of Service Sector
SERVICES - developed service sector
BSERVICES - basic service sector
Source: 1970 Duns Market Indicators File

xi) Demographic Characteristics
% Living in Same County for 5 years (RESIDENTS)
% Population that is nonwhite (NONWHITES)
% Population older than 65 years (RETIREES)
Source: 1970 Census of Population
Region - NEWENGLAND
- MIDATLANTIC

The dependent variable in the models was a dichotomous variable with a one (1) indicating that the community had a new plant start in the industry during the period 1970-1980, a zero (0) indicated that the community did not have a start.

Data Analysis

Units of Analysis and Study Area: The units of analysis were communities in 13 northeastern states (Virginia, West Virginia, Pennsylvania, New York, New Jersey, Delaware, Maryland, Massachusetts, Rhode Island, Connecticut, New Hampshire, Vermont, and Maine). Communities were defined as a Census Place and surrounding minor civil divisions whose population centroid was within five miles of the population centroid of the Census Place. One hundred and five large metropolitan areas (population greater 100,000 people) were excluded from the 1203 communities in the NIT&EDD. The remaining 1098 communities were divided into two samples containing 368 small metropolitan and 730 non-metropolitan communities. Metropolitan communities were those located in Metropolitan Statistical Areas.

Forest Industries Studied: Three subsectors of the forest products industries were analyzed in this study. An aggregation of 4 digit SIC industries into subsectors was necessary in order to have large enough samples to provide statistically reliable results. Some problems of using aggregate data were reduced by combining only those industries with similar input requirements as determined from the national input-output table. The subsectors analyzed were:

(i) The Furniture Subsector
Comprised of the SIC industries
2431-Millwork,
2434-Wood Kitchen Cabinets,
2511-Wood Household Furniture, and
2517-Wood TV, Radio, and Sewing Cabinets
The three PNIA variables for this subsector were:
(1) Sawmill, (2)Wood Veneer and Containers, and (3) Plastics.

(ii) The Wood Veneer Subsector
Comprised of the SIC industries
2435-Hardwood Veneer and Plywood,
2436-Softwood Veneer and Plywood,
2439-Structural Wood Members,NEC,
2441-Wood Boxes,
2449-Wood Containers,NEC, and
2452-Prefabricated Wood Building and Components
The three PNIA variables for this subsector were:
(1) Logging, (2) Sawmills, and(3) Plastics.

(iii) The Pallet Subsector
Comprised of the SIC industries
2448-Wood Pallets and Skids,
2492-Particleboard, and
2499-Wood Products,NEC
The three PNIA variables for this subsector were:
(1) Sawmills, (2) Plastics, and (3) Logging.

The Models: Nine models were analysed in this study. Six models were estimated by SAS Stepwise Logistic Regression Procedure (SAS, 1985). The first 3 models were used to determine what subset of the 31 independent variables were significant (alpha=.10) in explaining the location of each of the 3 subsectors in the 368 metropolitan communities. The second 3 models were used to determine what subset of the 31 independent variables were significant (alpha=.10) in explaining the location of each of the 3 subsectors in the 730 non-metropolitan communities.

A third set of 3 models contained 62 independent variables, the 31 variables discussed above and another 31 computed by multiplying each (of those 31 variables) by a dichotomous variable, which had a value of one (1) for metropolitan communities and a value of zero (0) for non-metropolitan communities. The latter 31 variables were used to determine which of

the first 31 variables were significantly different (alpha=.10) in metropolitan and non-metropolitan communities.

RESULTS

The Aggregate Industry Effect

We examined the regression results by organizing the significant variables to highlight a comparison of the location determinants of the three subsectors (Table 1) within metropolitan and non-metropolitan communities. In general, the results indicate that the set of industrial location determinants for each of the three subsectors were different in both types of communities.

Metropolitan Community Models: Of the 11 significant variables in the three subsector models for metropolitan communities none were significant in all three models. Two variables BSERVICE, NEWENGLAND) had coefficients with the same sign in the furniture and the pallet subsectors: indicating that these firms chose New England communities with well developed service sectors. The veneer and pallets subsector were both attracted to larger communities. However, firms in the veneer subsector located in communities with higher per-capita incomes, while firms in the pallet industry located in communities with low per-capita incomes. Opposite signs on the coefficients of a significant variable (NONWHITE) was also evident in the furniture and veneer subsectors models. Here, the result suggest that firms in the furniture subsectors located in communities that had higher proportions of nonwhite residents, while, firms in the veneer subsector located in predominantly white communities.

There were 3 unique significant variables (INPUT1, ROAD, EDUCATED) for the furniture subsector, 1 unique variable (LADYLABOR) for the veneer subsector, and 2 unique variables (AIRLINES, MALELABOR) for the pallet subsector. These results suggest that firms in the furniture subsector tended to concentrate in more remote metropolitan communities with a high proportion of college graduates. On the other hand, firms in the veneer subsector tended to locate where there was a high level of female participation in the workforce. Firms in the pallet subsector located in metropolitan communities with good airline connections and a high level of male participation in the labor force. Thus, while there are some common location determinants there are also significant differences across industries.

Non-Metropolitan Community Models: Of the 16 variables significant in the three subsector models only one (POPULATION) was significant in all three models. A result which clearly indicates that larger non-metropolitan communities are most likely to be chosen by the types of firm represented in these subsectors. However, while firms in the furniture and pallet subsectors tended to locate in non-metropolitan communities where similiar firms are already established, there is no such tendency indicated for firms in the veneer subsector. Further, while firms in the furniture subsector and the veneer subsector displayed regional tendencies,

Table 1.-- Location determinants for metropolitan and non-metropolitan communities for the Furniture, Veneer, Pallet and their allied inputs industries subsectors.

	METROPOLITAN			NON-METROPOLITAN			
VARIABLE	FURN	VENR	PALL	FURN	VENR	PALL	
MARKET	.	.	.	(-)	.	(-)	*
INPUT1	(-)	.	.	(-)	.	(-)	*
INPUT2	.	.	.	.	.	(+)	
INPUT3	.	.	.	.	.	.	
FOREST	.	.	.	(-)	.	.	
STATE	.	.	.	.	.	.	
LOCAL+CNTY	.	.	.	.	.	(-)	
AIRLINES	.	.	(+)	.	(+)	(+)	*
RAILROADS	.	.	.	.	.	.	
ROAD	(+)	.	.	(-)	.	.	
HIWAY	.	.	.	.	.	.	
EDUCATED	(+)	.	.	.	.	.	
MALELABOR	.	.	(+)	(+)	.	.	
LADYLABOR	.	(+)	.	.	.	(+)	
MALEFULL	.	.	.	.	.	.	
LADYFULL	.	.	.	.	(+)	.	
SEWERS	.	.	.	.	.	.	
HBEDS	.	.	.	.	.	.	
COEDS	.	.	.	.	.	.	
MFTLABOR	.	.	.	.	.	.	
INCOME	.	(+)	(-)	.	.	.	
VACANT	.	.	.	(+)	.	.	
PROXIMITY	.	.	.	.	.	.	
POPULATION	.	(+)	(+)	(+)	(+)	(+)	*
SERVICES	.	.	.	.	.	.	
BSERVICE	(-)	.	(-)	(-)	(-)	.	*
NONWHITE	(+)	(-)	.	.	.	.	
RETIREES	.	.	.	.	.	.	
NEWENGLAND	(+)	.	(+)	(+)	.	.	*
MIDATLANTIC	.	.	.	(+)	(-)	.	
RESIDENTS	.	.	.	.	.	(-)	
COMMUNITY	368	368	368	730	730	730	
STARTS	120	44	93	145	80	131	
STARTS (%)	33	12	25	20	11	18	
SIGNIFICANT	6	4	6	10	5	8	
COMMON	<- 0 -><- 1 ->			<- 2 -><- 2 ->			
COMMON	<----- 2 ---->			<----- 4 ---->			
OVERALL		11			16		19
COMMON		3			5		6

* Significant variables (with the same sign) common to at least two subsectors in the same community.

no such tendency was displayed by firms in the pallet subsector. Firms in the veneer and pallet subsectors located in non-metropolitan communities with good airline connections while firms in the furniture industry located in non-metropolitan communities close to primary roads. A well developed service sector was important to firms in the furniture and veneer subsectors while low local and county taxes appears to be important to firms in the pallet subsector. Finally, firms in the furniture subsector tended to locate in non-metropolitan communities with high housing vacancy rates and high levels of male participation in the labor force, while, firms in the veneer and pallet subsectors located where there was a large female workforce.

The Community Size Effect

The results of the analysis for the three subsectors are presented in Table 2. Variables with coefficients which were significantly different in metropolitan and non-metropolitan communities are also indicated. In general these results indicate that the location determinants for the metropolitan communities were different from the location determinants for non-metropolitan communities.

The Furniture Subsector: Close examination of Table 2 shows that there are 10 variables which are significant in explaining the location of the furniture subsector in non-metropolitan communities, while there are 6 location determinants for metropolitan communities. There were 4 variables (MARKET, FOREST, ROAD, LADYFULL) with coefficients which were significantly different in metropolitan and non-metropolitan communities. The coefficients for one of these variables (ROAD) had opposite signs in the two models. A result which suggests that non-metropolitan communities close to primary roads are more likely to attract a new firm, while remote metropolitan communities are more attractive. This apparently contradictory result may be explained by the market orientation of the firms. Firms locating in non-metropolitan communities may plan to cater to regional markets, while firms locating in remote metropolitan communities may plan to cater to the local market. Thus, highways are important to non-metropolitan furniture plants and not important to metropolitan furniture plants.

Three of the location determinants (INPUT1, NEWENGLAND, BSERVICE) were common to the two models and had the same sign. A result indicating a preference by firms in this subsector to locate in New England communities with a well developed service sector and a sawmill output deficit (i.e. consumption of sawmill output exceeds local supplies. A phenomena Goode (Goode 1989) associated with agglomeration). The two other variables (NONWHITE, EDUCATED) in the metropolitan model suggest that firms may prefer communities with a high proportion of nonwhite and a high proportion of college educated people. The other 6 variables (MARKET, FOREST, MALELABOR, VACANT, POPULATION, MIDATLANTIC) in the non-metropolitan model suggest that these firms tended to locate in larger communities with excess output (i.e. the output from the subsector exceeds local consumption. A phenomena Goode (Goode 1989) also associated with agglomeration). Non-metropolitan communities in Mid-Atlantic states with vacant housing

Table 2.-- Variables significant (alpha=.10) in the industrial location models for the Furniture, Veneer, Pallet and their allied inputs industries subsector analysed by metropolitan and non-metropolitan communities.

	-FURNITURE-		--VENEER---		---PALLET-----		
VARIABLE	METRO	NONMETRO	METRO	NONMETRO	METRO	NONMETRO	
MARKET	.	(-)**	.	.	.	(-)	
INPUT1	(-)	(-)	.	.	.	(-)	*
INPUT2	.	.	.	.	.	(+)	
INPUT3	.	.	.	.	.	.	
FOREST	.	(-)**	.	.	.	.	
STATE	.	.	.	.	.	.	
LOCAL+CNTY	.	.	.	.	.	(-)**	
AIRLINES	.	.	.	(+)**	(+)	(+)	*
RAILROADS	.	.	.	.	.	.	
ROAD	(+)	(-)**	.	.	.	.	
HIWAY	.	.	.	.	.	.	
EDUCATED	(+)	.	.	.	.	.	
MALELABOR	.	(+)	.	.	(+)	. **	
LADYLABOR	.	.	(+)	.	.	(+)	
MALEFULL	.	.	.	.	.	.	
LADYFULL	.	. **	.	(+)**	.	.	
SEWERS	.	.	.	.	.	.	
HBEDS	.	.	.	.	.	.	
COEDS	.	.	.	.	.	.	
MFTLABOR	.	.	.	.	.	.	
INCOME	.	.	(+)	.	(-)	.	
VACANT	.	(+)	.	.	.	.	
PROXIMITY	.	.	.	.	.	.	
POPULATION	.	(+)	(+)	(+)**	(+)	(+)	*
SERVICES	.	.	.	.	.	.	
BSERVICE	(-)	(-)	.	(-)	(-)	.	*
NONWHITE	(+)	.	(-)	. **	.	.	
RETIREES	.	.	.	.	.	.	
NEWENGLAND	(+)	(+)	.	.	(+)	.	*
MIDATLANTIC	.	(+)	.	(-)	.	.	
RESIDENTS	.	.	.	.	.	(-)	
SIGNIFICANT	6	10	4	5	6	8	
OVERALL	12		8		12		19
COMMON	<- 3 ->		<- 1 ->		<- 2 ->		5

* Significant variables (with the same sign) common to subsector models in the two types of communities.

** Variables with coefficients in metropolitan models which were significantly different (alpha=.10) from coefficients in non-metropolitan models.

and a high level of male labor force participation were also likely to attract firms in this subsector.

The Wood Veneer Subsector: Examination of Table 2 shows that there were four variables (LADYLABOR, INCOME, NONWHITE, POPULATION) which help to explain the location of the wood veneer subsector in metropolitan communities. There were also four location determinants (AIRLINES, LADYFULL, POPULATION, BSERVICE, MIDATLANTIC) for non-metropolitan communities. Of these variables four (AIRLINES, LADYFULL, POPULATION, NONWHITE) had coefficients which were significantly different in metropolitan and non-metropolitan communities. One of these location determinants (POPULATION) was common to the two models. In both models the effect was positive i.e. larger communities were more likely to get a new firm than a small community, but, in the non-metropolitan communities the size effect was more important since the coefficient for this variable was significantly larger in the non-metropolitan model than the coefficient for the variable in the metropolitan model. These results indicate there is a very clear preference by firms in these industries to locate in larger communities whether they were metropolitan or non-metropolitan. However, firms locating in non-metropolitan communities tended to locate in New England and South Atlantic towns with well developed service sectors, good airline connections and high proportions of working women. In metropolitan communities, firms tended to locate in places with predominantly white populations, high female workforce participation rates, and high per capita incomes.

The Pallet Subsector: Examination of Table 2 shows that there are 8 variables (MARKET, INPUT1, INPUT2, LOCAL+CNTY, AIRLINES, LADYLABOR, POPULATION, RESIDENTS) which help to explain the location of wood veneer subsector in non-metropolitan communities, while there are 6 location determinants (AIRLINES, MALELABOR, INCOME, POPULATION, BSERVICE, NEWENGLAND) for metropolitan communities. There were 2 variables (LOCAL&CNTY, MALELABOR) with coefficients which were significantly different in metropolitan and non-metropolitan communities. A result which shows that the effect of local and county taxes were significantly more important to firms locating in non-metropolitan communities, while the male labor force participation rate was significantly more important to firms locating in metropolitan communities. Only 2 of the location determinants (POPULATION, AIRLINES) were common to the two models. A result indicating a preference by firms in this subsector to locate in larger communities served by a number of airlines. However, firms locating in non-metropolitan communities also tended to locate where there was an excess supply of plastics and a high proportion of working women. While, firms locating in metropolitan communities also tended to locate in New England towns where there were high male labor force participation rates, highly developed service sectors, and low per capita income.

In summary, while the models for the three subsectors of the forest products industry had some variables in common, each subsector model had several unique significant explanatory variables. In the metropolitan community models there were 11 significant variables, of these only three had the same sign in at least two of the subsectors. In non-metropolitan community models there were 16 significant variables, of these only five had the same sign in at least two of the subsectors. Overall, there were 19 significant variables, of these only six

had commonality across subsectors within community type. Therefore, less than a third of the determinants were common to two or more of the subsectors. Evidence which suggest that each subsector has a relatively unique set of location determinants.

SUMMARY AND CONCLUSION

This study was designed to test the hypotheses that location determinants within communities are invariant with respect to community size and industry subsector. To test these hypotheses 31 variables reflecting the socioeconomic and space specific characteristics of 1098 northeastern communities were estimated by stepwise logistic regression. The results indicate that each subsector had location determinants which were different in non-metropolitan communities and metropolitan communities. Comparison of the significant variables for the three subsectors indicate that less than a third of the determinants were common to two or more subsectors. This suggests that each subsector has a relatively unique set of location factors whether they were metropolitan or non-metropolitan community models.

The conclusions of this study are twofold. First, non-metropolitan communities have a different set of location determinants for forest products industries than small metropolitan communities in northeastern USA. Second, subsectors of the forest products industry each have a set of location requirement which are different. These results suggest that programs aimed at attracting forest products firms in northeastern USA need to be make a special effort to target the specific type of firm they are interested in while being aware of the socio-economic and space specific characteristic of the communities they are planning to develop.

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ARE WE UNDERESTIMATING THE SIZE OF OUR HARDWOOD INDUSTRIES?

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Abstract: Sawmills and planing mills (SIC code 2421) were analyzed by comparing data from the 1987 County Business Patterns, published by the U. S. Bureau of Census, and research conducted by the Ohio Cooperative Extension Service for the same year. The Ohio study and the Bureau of Census survey were comparable in industry sector definition, data collection unit and survey instrument. The Ohio research included all known sawmills and planing mills in Ohio whereas the Bureau of Census used probability sampling based on firm size with estimates made of establishments with under five employees. The Ohio research found substantial increases in number of establishments (38 percent), number of employees (88 percent) and annual payroll (82 percent) compared to Census Bureau estimates of the Ohio sawmill and planing mill industry. Foresters, forest product specialists, economic developers and others who work with the forest products industry need to be cautious when using published Census Bureau data to describe the industry. Evidence from the Ohio study and other research suggests a substantial Census Bureau underestimation of the true size of the hardwood industry.

INTRODUCTION

The central hardwood forest, which includes parts or all of 24 states, is the largest forest region in the United States. The economic and social importance of this forest region is significant when one considers that with the exception of the Pacific Coast, eastern Canada, and central Mexico, the largest concentration of population and industry in North America is located in this region (Duffield 1982).

Historically, the central hardwood forest region has been a national leader in the production of wood and paper products. Today however many states are viewing their forests from a much broader perspective. Pennsylvania, for example, has targeted the forest products industry as part of an overall statewide economic development effort. Other states such as Ohio have not formally targeted the industry for development but have increased their economic development efforts in the forested regions of the state.

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Statistics published by the U. S. Bureau of Census are frequently used as a starting point for studies involving economic impact and development potential. Economic developers, educators, planners, legislators, researchers and persons involved in the financial sector use Bureau of Census data for needs assessment, program planning and the like. Historically foresters, forest product specialists and forest industry officials have expressed concern that the Bureau of Census underestimates the true size of the forest products industry. Phelps and Smith (1985), in describing a Missouri study, conclude that Census Bureau data may underestimate industries that use wood as a raw material. Jones and Zinn (1986), report the number of establishments, number of employees and annual wages of West Virginia forest product industries to be roughly double those reported by the U.S. Bureau of Census.

Dempsey (1987) states that in 1982 the Census Bureau provided data on 751 commercial lumber producing sawmills and planing mills operating in Pennsylvania, Kentucky and West Virginia; state forest product industry directories, however, reported 1892 operational sawmills located within the tri-state area in 1984. Doud (1990) estimates the number of employees in the Pennsylvania kitchen cabinet industry to be nearly three times the Census Bureau estimate. Additional discrepancies in the area of hardwood lumber production have also been reported (Cardellichio and Binkley 1984, Luppold and Dempsey 1989).

Numerous reasons have been proposed to explain the discrepancies between the findings of statewide or regional studies and Bureau of Census surveys. One explanation is definition. The Census Bureau categorizes industries by the primary product shipped as determined by dollar value. Consequently, a combination logging and sawmill establishment is defined by the Census Bureau as either a logging establishment or a sawmill but not both. Based on definition, some establishments may be counted twice or omitted entirely in statewide and/or regional surveys.

A second possible explanation for the discrepancies between numbers reported by state and/or regional studies and U. S. Bureau of Census estimates could be due to the data collection unit. The Bureau of Census uses the individual establishment as the data collection unit. For example, "Company A" may be the non-manufacturing corporate headquarters for establishments X, Y and Z. The Bureau of Census would survey the X, Y and Z manufacturing establishments but not Company A, the corporate headquarters. However, if Company A mistakenly received, and responded to a survey instrument on "behalf" of the X, Y and Z establishments, then double counting would occur if the individual establishments also were surveyed.

Third, it is not uncommon for statewide and/or regional surveys to contact 100 percent of the known establishments. The Census Bureau, however, uses probability sampling based on firm size with estimates made of establishments with under five employees. Since the hardwood industry is characterized by numerous small firms (Haygreen and Bowyer 1989), the Census Bureau may not be adequately canvassing the entire industry.

Fourth, Census Bureau data is often compared with studies where the survey time period is different. While the time period difference may not always be a problem in itself, when

coupled with one or more of the previous explanations could contribute to the discrepancies between statewide and/or regional and Census Bureau survey estimates.

PURPOSE

The purpose of this study was to: 1) identify the discrepancy (if any) between statistics published by the U. S. Bureau of Census and a statewide study on selected variables for the 1987 Ohio sawmill and planing mill sector (SIC code 2421) and 2) quantify the extent of the discrepancy.

METHODS

Research Design

This study was descriptive in nature and utilized mail questionnaires for data collection. To have a meaningful comparison between Bureau of Census data and the Ohio survey research data, a common definition of the industry sector was used (Anon. 1987). The Bureau of Census defines sawmills and planing mills (SIC code 2421) as: 1) those establishments primarily engaged in sawing rough lumber and timber from logs and bolts, or resawing cants and flitches into lumber, including box lumber and softwood cut stock, 2) planing mills combined with sawmills, and 3) separately operated planing mills which are engaged primarily in producing surfaced lumber and standard workings or patterns of lumber. Dry kilns and mills producing railroad ties, chips and studs are also included in the Bureau of Census definition.

Since many establishments are integrated operations such as logging, sawmilling and secondary manufacturing, the Bureau of Census classification of an establishment is based upon the dollar value of the primary product shipped. As an example, a combination sawmill/pallet mill which annually sells a higher dollar value of pallets than lumber in a given year would fall into the industry sector of "wood pallets and skids" (SIC code 2448) and would not be reported in the results of this study. If the combination mill sold a higher dollar value of lumber as compared to pallets, then the mill would fit the Bureau of Census definition of a sawmill and planing mill.

Sample Population

The sample population consisted of all known Ohio establishments which potentially would fit the Bureau of Census definition of a sawmill and planing mill. The names of the establishments were compiled from a base list published in directory form by the Ohio

Department of Natural Resources, Division of Forestry (Long 1988). This directory was supplemented with additional establishments compiled from lists by the Ohio Forestry Association/Timber Industry Council, Ohio service foresters and Ohio extension agents. These sources represented the best available lists of sawmills and planing mills in the state of Ohio. The sample size, after eliminating known duplications, was 389 establishments.

Survey Instrument

A questionnaire was designed that sought information for 1987 regarding employees, payroll, capital expenditures and the quantity and value of products produced. Value is the dollar amount of products shipped and services performed at the net selling value, f.o.b. plant, to the customer, ie., after discounts and allowances and exclusive of freight charges and excise taxes (U. S. Department of Commerce 1987).

In developing the instrument the authors selected questions from the 1987 Census of Manufactures questionnaire (U. S. Department of Commerce 1987). The instructions, questions and format used in the Ohio survey instrument were as identical as possible to the Bureau of Census instrument.

The Ohio survey omitted some questions included on the Bureau of Census questionnaire. Only those questions relevant to the Ohio study were chosen. In addition, questions that required calculations by respondents were also omitted from the Ohio study, ie., average employment for the year (divide line b by 4; omit fractions). The reason "calculation questions" were omitted was respondent convenience, survey brevity and possible inaccurate calculations by the respondent. In summary, the Ohio survey instrument replicated selected questions and instructions from the Census Bureau questionnaire so as not to misidentify any firms in the sawmill and planing mill sector or inaccurately record data.

Data Collection and Analysis

The questionnaire, along with a cover letter and a postage paid return envelope, was mailed to each of the 389 establishments. Approximately four weeks following the initial mailing, a second letter and questionnaire were sent to those establishments who had not responded. One month following the second mailing there were 102 responses, or a return rate of 25.6 percent. Nine questionnaires were non-deliverable.

Of the 278 non-respondents, 55 or 19.7 percent were contacted by telephone (random sample) as a follow-up with with an additional seven having wrong or changed phone numbers or disconnected phones. A check for non-response bias was conducted by comparing respondents with non-respondents (Miller and Smith 1983). The comparison was done on the key variables of number of employees, annual payroll, capital expenditures and product value. The t-test indicated no significant difference between respondents and non-respondents at the

alpha level of .05. Thus, the results of the study were generalized to the target population under study. The analyses used were frequency distribution and percentages.

For the purpose of this paper, 1987 sawmills and planing mills was the industry sector studied. A sawmill and planing mill is defined as one which was in business during the 1987 year. This definition excludes non-sawmills and out-of-business establishments. Of the 102 mail respondents, 54 (52.9 percent) were current sawmills or planing mills. In the non-respondent follow-up group of 55, there were 28 sawmills and planing mills (50.9 percent). This leads to an estimate that the number of 1987 sawmill and planing mills from the original sampling frame of 389 was actually 200 (54 + .509 x (389 - 102)). Therefore, the response rate for 1987 sawmill and planing mills is 41 percent ((54 + 28)/200).

RESULTS AND DISCUSSION

The Ohio survey, as noted above, estimates the 1987 sawmill and planing mill sector to be comprised of approximately 200 establishments as compared to the Bureau of Census estimate of 145 establishments (U.S. Department of Commerce 1989). A second estimate of Ohio sawmill and planing mill establishments was computed via a "weighting" formula where non-responding establishments randomly selected for telephone follow-ups represented more than their own establishment. For example, a firm selected in a 20 percent random sample is essentially representing 4 firms in addition to itself and carries a "weight" of 5 (100/20 = 5). The weighting method, when applied to the Ohio survey data, resulted in an estimate of 198 sawmill and planing mill establishments. Therefore the authors are confident that 200 is a reliable point estimate of this industry sector in Ohio. This is a 38 percent increase of the figure reported by the Bureau of Census ((200-145)/145).

The Ohio survey estimated nearly double (88 percent) the number of sawmill and planing mill employees compared to the Census Bureau estimate (Figure 1). Regarding annual payroll, a similar increase (82 percent) was found in the Ohio survey (Figure 2). These rather substantial increases of 88 percent for employees and 82 percent for annual payroll clearly depict the Census Bureau underestimate.

The Bureau of Census underestimated the number of establishments in all employee size classes. The Ohio survey found a greater percentage of establishments in the larger employment size classes, especially in the 20-49 employee size class (Table 1). The larger employee size classes had the greatest underestimation. This explains how a 38 percent increase in establishments translates to a 88 and 82 percent increase in employees and payroll.

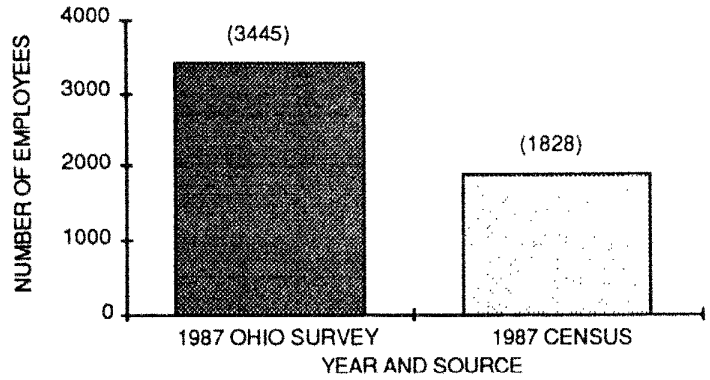

Figure 1. Estimates of sawmill and planing mill employees.

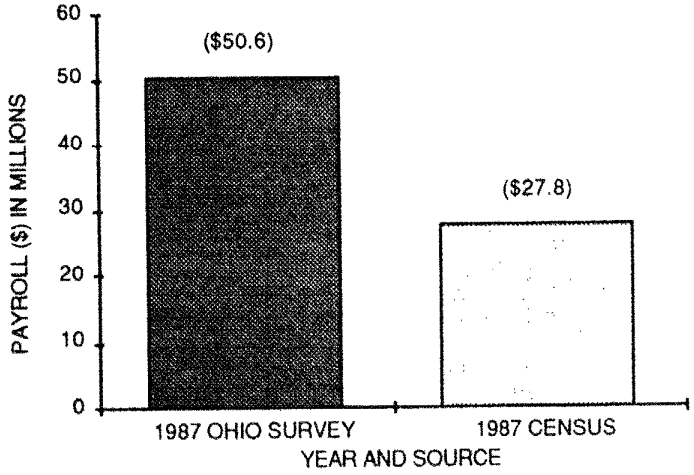

Figure 2. Estimates of sawmill and planing mill annual payroll.

Table 1.--U.S. Bureau of Census and Ohio Survey Estimates of Number of Establishments and Percentage by Employment-Size Class, 1987.

	Employment-size class													
Source	1 to 4		5 to 9		10 to 19		20 to 49		50 to 99		100+		Total	
Census	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Bureau	54	37	29	20	35	24	19	13	7	5	1	1	145	100
Ohio	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Survey	70	35	35	18	40	20	40	20	13	6	2	1	200	100

The Ohio survey documented capital expenditures for new machinery, equipment and buildings of $18.9 million and a 1987 sawmill and planing mill product value of $355 million. As of October 1990 however, 1987 Census Bureau estimates on these two variables were not yet available. While the Census Bureau has published comparison data for 1982, to be consistent in our comparisons, 1987 data must be available. Further analysis will be done at a later date.

Based on number of establishments, number of employees, and annual payroll, the Ohio survey clearly documents a significant difference with the data published by the Census Bureau. The Ohio survey found substantial increases in number of establishments (38 percent), number of employees (88 percent) and annual payroll (82 percent) (Figure 3).

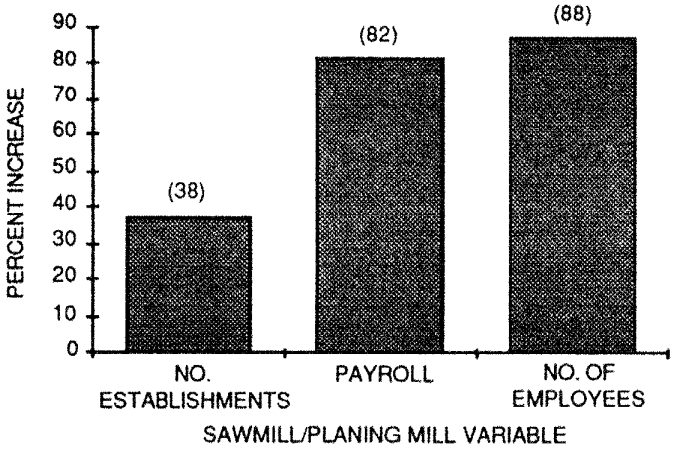

Figure 3. Percent increase of Ohio survey estimates over Census Bureau estimates.

IMPLICATIONS

Foresters, forest product specialists, economic developers and others who work with the forest products industry need to be cautious when using published Census Bureau data to describe the hardwood industry. Results from this research document that a specific industry sector in Ohio, sawmills and planing mills, is substantially larger than published Bureau of Census estimates. Consequently, economic development strategies and economic impact studies could be grossly inaccurate if based on Bureau of Census data.

In certain instances the Census Bureau underestimation could result in specific forest product industry sectors being viewed as "unimportant" from a statewide or regional perspective. Ultimately, this might cause public and private resources (dollars, personnel, etc.) to be allocated to "larger and more important" non-forest industries.

Another implication of underestimation, according to Luppold and Dempsey (1989), is the undervaluation of potential returns from quality northern forest sites. They conclude that an erroneous prediction of lower future hardwood stumpage values would discourage forest investment and ironically, could result in even higher long-term prices.

The results presented in this paper suggest that other central hardwood states could use the Ohio example as a beginning point for more accurately reporting sawmill and planing mill sector Census Bureau data. For example, the Ohio survey estimate of 200 sawmill and planing mill establishments versus the Census Bureau estimate of 145 establishments implies an "expansion factor" of 1.38 (200/145). The expansion factors for number of employees and annual payroll are 1.88 and 1.82, respectively.

While the authors feel the expansion factors might be accurate in Ohio for other primary manufacturing forest industry sectors such as logging camps and logging contractors (SIC code 241), the authors believe the expansion factors would not hold for various secondary manufacturers. In Ohio, for example, there are only three pulp mills. These mills would not "fall through the cracks" in an industry-wide canvass whereas many small sawmills are overlooked in surveys. Likewise, the expansion factors should be used with caution in other states.

The authors are hopeful that researchers in other central hardwood states would replicate the Ohio study. Other primary manufacturing industries, in addition to the sawmill and planing mill sector, need to be studied to determine if the Ohio results hold in other states and for other industry sectors.

A final comment on methodology is appropriate. Even though the results of the Ohio study support the general conclusion that others have made, ie., the Bureau of Census underestimates the size of forest product industries, the Ohio research is different. The Ohio study and the Bureau of Census survey used the same definition of "sawmills and planing mills" (SIC code 2421), surveyed the same data collection unit (individual establishments), used a comparable data collection instrument, and collected data during the same time period (1987). Consequently, the Ohio and Census Bureau data comparison is an "apples to apples" comparison.

In conclusion, no intent to discredit the U.S. Department of Commerce, Bureau of Census, is implied. The authors compliment the Census Bureau for continually providing valuable and useful data in industry sectors where accurate information is difficult to obtain.

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