Effects of Stand and Site Variables on the Lumber Value of Uneven-aged Loblolly Pine Stands

David W. Patterson, *School of Forest Resources, Arkansas Forest Resources Center, University of Arkansas at Monticello, and* **Paul A. Murphy** *(deceased) and* **Michael G. Shelton,** *USDA Forest Service, Southern Research Station, Monticello, AR.*

ABSTRACT: *Uneven-aged silviculture using single-tree selection provides the landowner with periodic income from a continuous forest which has a varied canopy. Data were collected from 24 plots of a larger study to determine if site index, basal area, and maximum dbh affected volume and value of lumber from loblolly pine* (Pinus taeda *L.) trees in uneven-aged stands. Tree grades and lumber yield equations were used to determine the volume of lumber by grade for each tree. Market prices from May 1997 and May 1998 were used to estimate lumber value. Analysis of variance showed that study variables significantly affected lumber volume, lumber value/mbf, and stand value/ac. With 1997 prices, increases in site index and maximum dbh significantly increased lumber value/mbf, but only maximum dbh was significant with 1998 prices. Stand values ranged from $4,100 to $12,350/ac and were significantly higher for the higher site index, basal area, and maximum dbh. South. J. Appl. For. 24(4):202–206.*

Forest landowners are feeling more and more pressure to increase biodiversity and wildlife habitats and decrease the number of clearcuts. Uneven-aged silviculture provides some benefits that are especially appealing to nonindustrial private landowners and users of public lands (Guldin and Baker 1998, Stout 1998). Well-established silvicultural techniques exist for creating and sustaining uneven-aged stands of loblolly (*Pinus taeda* L.) and shortleaf (*P. echinata* Mill.) pines, and they provide landowners with broader options to attain management objectives than previously existed (Baker et al. 1996). However, the value of timber products yielded by uneven-aged pine stands is still poorly understood. In 1983–1985, a study was initiated to determine how different stand and site variables affected the growth and development of loblolly pine stands that were under uneven-aged silviculture using single-tree selection (Murphy and Shelton 1994). The study included three site index classes, three basal areas, and three maximum dbhs. This overall study was expanded in 1997 to include an evaluation of lumber volume, quality, and value in a subset of plots. Because of other silvicultural objectives of the study, our approach was to estimate the lumber volume and quality without cutting the trees.

NOTE: The corresponding author is David Patterson, who can be reached at the University of Arkansas at Monticello, Monticello, AR 71656-3468—Phone: (870) 460-1652; Fax: (870) 460-1092; E-mail: pattersond@uamont.edu. This study was partially funded by a cooperative agreement through the USDA, Forest Service, Southern Research Station, Monticello, AR. It has been approved for publication by the Director, Arkansas Agricultural Experiment Station as manuscript #98093. Manuscript received November 30, accepted March 9, 2000. Copyright © 2000 by the Society of American Foresters.

Methods

Study Design and Treatments

Detailed descriptions of the overall study are provided by Murphy and Shelton (1994) and Shelton and Murphy (1995), and only a brief overview will be provided here. The study was located in southern Arkansas and northern Louisiana. This study employed a subset of the treatments of the overall study. Plots were selected that had: (1) site indexes (50 yr basis for loblolly pine) of either less than 81 ft (poor site) or more than 91 ft (good site); (2) after-harvest basal areas of either 60 or 80 ft^2/ac; and (3) maximum dbh after harvest of either 16 in. or 20 in. Thus, this study is a $2 \times 2 \times 2$ factorial in a completely random design with 3 replicates, which provided a total of 24 observations. The square 1.6 ac treatment plots included an interior square 0.5 ac net plot, where detailed measurements were obtained.

Before harvest, all loblolly pine trees greater than 3.5 in. were inventoried by 1 in. dbh classes separately for the measurement plot and isolation strip. Then plots were marked for harvest to attain their randomly assigned residual structures. Plots were initially harvested as part of the study in 1983 to 1985, harvesting approximately one-third of the plots each year. Harvesting was repeated on a 5 yr cutting cycle; so plots had been harvested three times as part of the overall study before the present investigation. Trees were selected

for harvest using the basal area–maximum dbh–quotient method of uneven-aged regulation (Baker et al. 1996). This objective method of regulation specifies after-cut targets, and the elements are listed in order of their priority. A uniform quotient of 1.2 for 1 in. dbh classes was maintained as uniformly as possible in all treatments. Maximum dbh and quotient define the shape of the residual dbh distribution, and Shelton and Murphy (1995) provide a description of the distribution of tree numbers by product class after the first 5 yr of the overall study. Competing vegetation was controlled using herbicides after the first harvest and before the third.

Measurements and Calculations

During the first 4 months of 1998, the dbh and height of each tree (5 in. dbh and greater) were recorded for each 0.5 ac plot. Each tree with dbh of 9 in. or greater was graded according to the visual grading rules of Clark and McAlister (1998) for southern pine trees in natural stands which are based on the number and size of limbs in the first 32 ft of height. A subset of trees, each selected from a different direction from the center of the plot, were bored, and their average growth rate (rings per inch for the last 3 in. of growth) determined. Then the age of each tree in the plot was estimated by using half of the dbh minus the bark thickness times the average growth rate for the plot. Bark thickness was estimated according to Farrar and Murphy (1988). Trees with dbh of less than 5 in. were not considered in the study.

The grading rules of Clark and McAlister (1998) include a series of equations for estimating the lumber volume that should be recovered at the sawmill for each tree grade. The proportion of the lumber volume grading No. 1 and better, No. 2 , and No. 3 and poorer was also estimated using equations based on dbh, total height, and age. For example, the equations for Grade 1 trees follow:

$$Vol = -42.419 + 0.01683\, D^2H \quad (1)$$

$$No.1 = 0.36133 - 0.00000239\, D^2H + 0.00325\, Age \quad (2)$$

$$No.2 = 0.51919 + 0.00000198\, D^2H - 0.00269\, Age \quad (3)$$

$$No.3 = 0.11948 + 0.000000212\, D^2H - 0.000562\, Age \quad (4)$$

where:

Vol = board feet of lumber in the tree,

D = dbh in inches,

H = total height of tree in feet,

$No.1$ = proportion of lumber volume that is grade No.1 or better,

$No.2$ = proportion of lumber volume that is grade No.2,

$No.3$ = proportion of lumber volume that is grade No.3 or lower, and

Age = age of tree at 4.5 ft in years.

Multiplying the result of Equation (2) times the results of Equation (1) gives the volume No. 1 or better lumber recovered from that tree.

The value of a piece of lumber depends on its size and grade. To use an average price per mbf for all lumber in a grade would penalize the value of larger trees over smaller trees. To correct for this bias, data from an unpublished study (Patterson, undated) of 50 loblolly pine trees harvested in East Texas (10 trees for each of five 2 in. dbh classes) were used. The data set contained the size and grade for each piece of lumber recovered from each tree. This actual lumber recovery data and market values for each size and grade of lumber from Random Lengths (1997, 1998) were used to develop weighted averages for each tree size, lumber grade, and market conditions (Table 1). For each tree in the current study, the data were substituted into the appropriate equations to arrive at the volume of lumber in each lumber grade. These values were multiplied by the appropriate weighted dollar values and added to produce the total tree value for a given market condition.

The following dependent variables were used for statistical analysis: (1) lumber volume per acre, (2) lumber quality in the terms of dollars per mbf, and(3) stand value per acre. Analysis of variance was used to determine if the tested stand and site variables had a significant effect on dependent variables. Significance was accepted at $P \leq 0.05$.

Results

Lumber volume ranged from 9.3 mbf/ac for poor sites with 60 ft^2/ac of basal area and 16 in. maximum dbh to 21.1 mbf/ac for the good sites with 80 ft^2/ac of basal area and 20 in. maximum dbh (Figure 1). This was a difference of 2.3-fold. Analysis of variance indicated that site index, basal area, and maximum dbh all significantly affected lumber volume per acre (Table 2). Increases in each treatment variable resulted in increases in lumber volume.

Lumber value per mbf was used as an indicator of quality. Using May 1997 prices, values ranged from \$533 to \$584/mbf for the extreme combinations of the variables (Figure 2). The highest value was only 10% more than the lowest value. The values for the other combinations did not express a consistent trend. The analysis of variance indicated that only site index and maximum dbh were significant. For May 1998

Table 1. The weighted value of lumber from loblolly pine trees harvested in East Texas by tree dbh and lumber grade in 1997 and 1998.

	Value (\$/mbf) by lumber grade		
Dbh (in.)	No. 1+	No. 2	No. 3–
1997*			
10	557	530	366
12	574	530	366
14	589	549	366
16	613	569	366
18+	670	596	366
1998*			
10	503	428	306
12	510	428	306
14	476	428	306
16	493	428	306
18+	504	441	325

* Prices based on Random Lengths Lumber Market Report for May 9, 1997 and May 15, 1998.

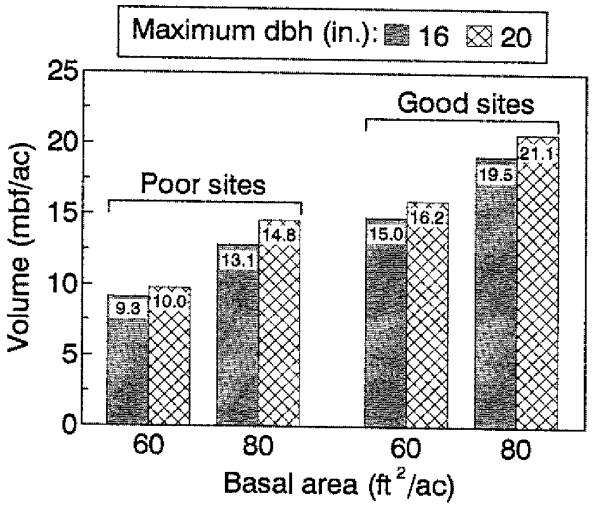

Figure 1. Lumber volume in uneven-aged loblolly pine stands related to site index (poor < 81 ft or good > 91 ft), basal area, and maximum dbh.

prices, values ranged from \$431 to \$453/mbf on poor sites and from \$444 to \$450/mbf on good sites (Figure 2). The highest value was only 5% more than the lowest value. Only maximum dbh had a significant effect in 1998.

The value of the stand's lumber dropped from 1997 to 1998. Based on May 1997 prices, the value of the stand's lumber ranged from \$5,054 to \$12,350/ac for the extreme combination of variables (Figure 3). Increases in site index, basal area, and maximum dbh all significantly increased the stand's lumber value. The stand values based on the May 1998 prices ranged from \$4,101 to \$9,535/ac with a similar trend across the combination of variables; these values were about 20% lower than those in 1997. Again, all three treatment variables were significant and positive in effect.

Discussion

The difference in market prices between May 1997 and May 1998 was considerable. The prices for all grades and sizes had dropped from 1997 to 1998, but the drop in price of No. 2 or better 2 × 10 and 2 × 12 lumber was about double the drop in prices for 2 × 4 and 2 × 6 lumber. In May 1998, 2 × 10 lumber was selling for less than either 2 × 4 or 2 × 6 lumber for all grades but 2 × 12's still were the highest priced. The wider widths were losing their price premium to the narrower widths because of competition from engineered wood products (Random Lengths 1998, World Wood Review 1998). In the past, larger trees had an advantage over smaller trees because wider widths, which had a higher market value, could be produced. Larger trees will lose some of their economic advantage if the wider widths lose their higher value.

Quality in sawtimber is usually a function of size and freedom from limbs. Different silvicultural practices result in different degrees of self-pruning and growth rates. Lumber value is also related to size and freedom of knots (limb segments). Therefore, we felt that lumber value per mbf would be a good indicator of tree quality for a given stand. This appears true for May 1997 market prices. The larger trees from good sites and from stands with maximum dbh of 20 in. had a higher lumber value per mbf. Therefore, site index and maximum dbh were significant variables in determining value. The effects of basal area on lumber value were not significant, suggesting that the 60 ft²/ac treatment of this study was not associated with a decrease in quality. In even-aged stands, lower basal areas are generally associated with increased diameter growth but less self-pruning, while higher basal areas result in less diameter growth but increased self-pruning. Perhaps the irregular and clustered spatial arrangement of trees in uneven-aged stands lessens the influence of basal area on tree quality. With the May 1998 market prices, only those trees large enough to produce 2 × 12's had a value per mbf higher than the rest. Therefore, maximum dbh was the only significant variable because only trees between 16 and 20 in. could produce 2 × 12's and those under 16 in. could not.

Large differences in lumber volume per acre occurred for each combination of variables. Site index affects lumber volume by affecting merchantable height, while basal area affects the number of trees present, and maximum dbh affects their size. This difference in volume was great enough to make the stand values different regardless of which market price was used. Because the lumber prices in 1998 were lower, the stands had a marked reduction in value. This study was a snapshot of stand conditions and lumber values at given points in time. Lumber markets are dynamic, and values will vary through time and at both local and regional scales.

Conclusions

Uneven-aged silviculture using single-tree selection is a viable option for loblolly pine that may appeal to many forest landowners. Results of this study indicate that uneven-aged

Table 2. Results of the analysis of variance for timber volume and value in uneven-aged loblolly pine stands with different site index, basal area, and maximum dbh.

	Site index		Basal area		Maximum dbh	
Property*	MSE	*P*	MSE	*P*	MSE	*P*
Volume (mbf/ac)	2.28E2	<0.01	1.20E2	<0.01	1.03E1	0.04
1997 lumber value† (\$/mbf)	2.86E3	<0.01	8.82E1	0.47	2.44E3	<0.01
1998 lumber value (\$/mbf)	2.16E2	0.11	8.07E1	0.31	4.17E2	0.03
1997 stand value (\$/ac)	8.71E7	<0.01	4.01E7	<0.01	5.91E6	0.02
1998 stand value (\$/ac)	4.79E7	<0.01	2.47E7	<0.01	2.86E6	0.01

* There was one degree of freedom for each treatment and one for each treatment interaction (not shown); the error term had 16 degrees of freedom.

† For the 1997 lumber value, the interaction of site index and maximum dbh was significant (MSE = 1.66E2; $P < 0.01$); no other interaction was significant at $P < 0.05$ for this or other properties.

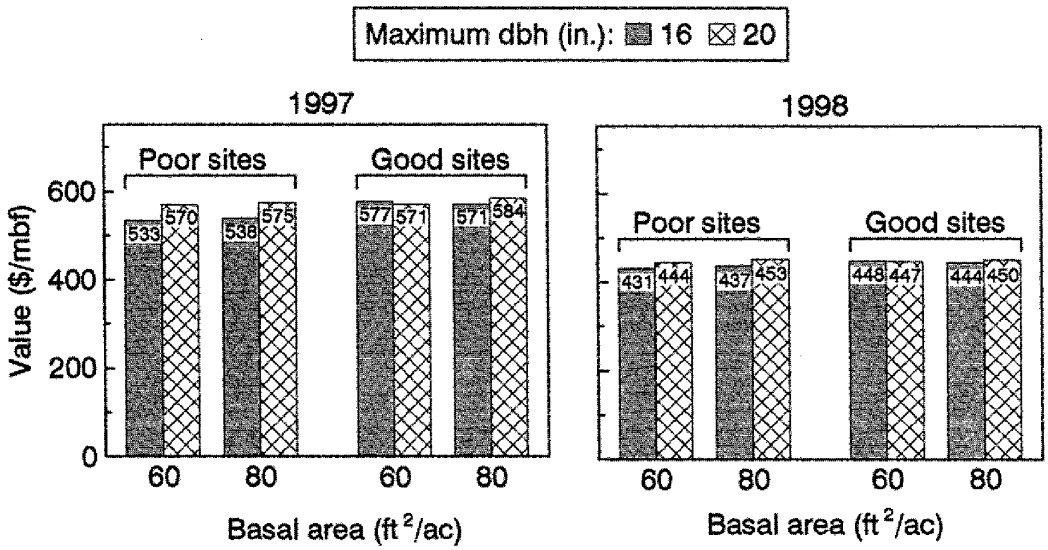

Figure 2. Lumber value per mbf in uneven-aged loblolly pine stands in May 1997 and 1998 related to site index (poor < 81 ft or good > 91 ft), basal area, and maximum dbh.

stands have a substantial value that will be sustained through time. The landowner will receive periodic income if the stand is maintained at acceptable basal areas and maximum dbhs by timber harvesting and competing vegetation is periodically controlled. The 80 ft^2/ac treatment of this study was higher than is normally recommended for sustaining uneven-aged stands of loblolly pine because regeneration processes are adversely affected. Comparison of the lumber quality of the 80 ft^2/ac treatment to more acceptable residual basal areas in uneven-aged stands (i.e., the 60ft^2/ac treatment) suggests that the lower stocking levels will not significantly reduce lumber value. The 20 in. maximum dbh may be an advantage to landowners in markets that provide a premium value for lumber of the wider widths, but when such markets do not exist (local mills have modern technology that can handle only diameters of 18 in. and less), the 16 in. maximum dbh would probably be preferable for achieving the landowner's timber goals. Results of this study show that fluctuations in market prices have a pronounced affect on lumber value. The flexibility in cutting cycles, stocking levels, and structures in uneven-aged stands allows capturing value during periods of good markets. However, the inflexibility of the upper stocking threshold in uneven-aged stands may be a disadvantage during periods of poor markets; uneven- aged stands may have to be cut during poor markets to prevent overstocking from adversely affecting regeneration. Although uneven-aged silviculture maintain stands with a high value, most of the true value of the stand will not be realized by nonindustrial private landowners because they receive payment based on stumpage and not lumber recovery. However, landowners may capture some on the true value of the stand through higher competitive bids for stands with high quality lumber.

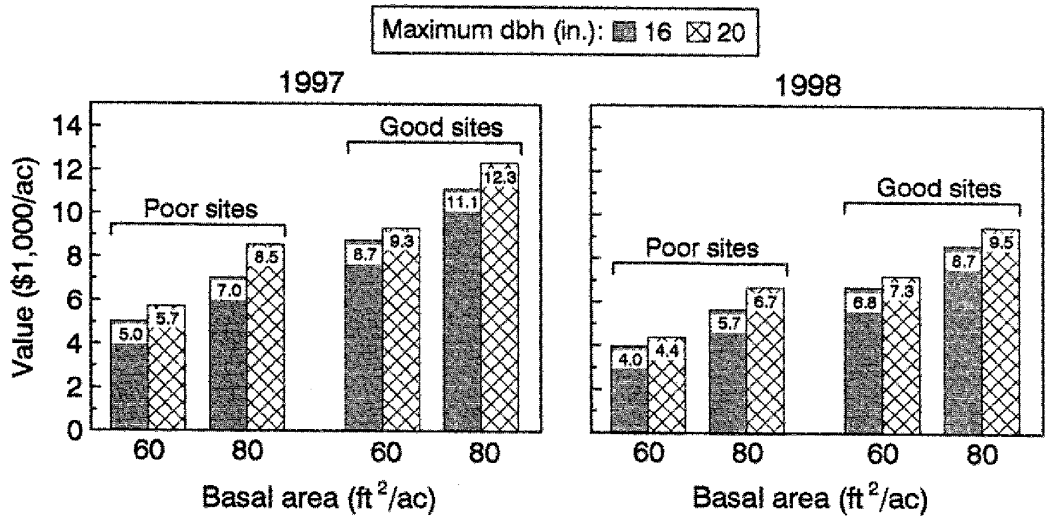

Figure 3. Lumber value per ac in uneven-aged loblolly pine stands in May 1997 and 1998 related to site index (poor < 81 ft or good > 91 ft), basal area, and maximum dbh.

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