STRUCTURAL CHANGES IN THE CENTRAL APPALACHIAN HARDWOOD SAWMILLING INDUSTRY

William Luppold

Project Leader
USDA Forest Service
Forestry Sciences Laboratory
241 Mercer Springs Rd.
Princeton, WV 24740

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ABSTRACT

The Central Appalachian hardwood sawmilling industry has undergone considerable change over the past two decades. Production, average sawmill capacity, and sawmill concentration have increased while the number of sawmills has decreased. However, these changes have not been uniform across states. The largest increases in production capacity occurred in Kentucky, Tennessee, and Pennsylvania, while the largest increases in average mill capacity occurred in Ohio, North Carolina, and Virginia. Changes in sawmill concentration were examined using estimated cumulative concentration curves. This analysis found that average mill capacity and the proportion of production capacity in large sawmills are not necessarily indicative of the degree of sawmill concentration. The increase in sawmill concentration is also correlated with increasing stumpage and log prices.

Keywords: Hardwood, sawmills, sawmill concentration.

INTRODUCTION

The Central Appalachian region (Fig. 1) contains 45% of eastern hardwood sawtimber inventories (Powell et al. 1993). The hardwood sawmills in this region produced approximately 50% of eastern hardwood lumber (5.7 billion board feet) in 1991 (Luppold and Dempsey 1994). Although there has been an increased demand for hardwood timber by the pulp and composite industries, the hardwood lumber industry is still the dominant user of hardwood timber in every state in this region except in North Carolina (Hutchins 1992; Johnson 1994; Wharton and Bearer 1994; Wharton, et al. 1992; Wharton and Martin [in press]; Widman and Long 1992; Widman and Murriner 1990).

It is estimated that in 1992 there were more than 2,400 commercial hardwood sawmills in this region (Luppold 1995). However, since the mid-1970s, the number of sawmills in this region has decreased, while hardwood lumber production has increased by more than 40%. Because changes in this industry can affect local, regional, and national timber markets, research is needed to understand what changes have occurred, what has caused these changes, and if there have been structural changes that could affect stumpage and log timber markets.

The objective of this paper is to examine changes in the hardwood sawmilling industry in the Central Appalachian region. The specific questions to be examined are: (1) Has the hardwood sawmill industry changed in the same manner across all states in the Central Appalachian region? (2) Why have these changes occurred? (3) Has the industry become more concentrated? and (4) Is there any evidence that these changes have affected hardwood log and stumpage markets?

LITERATURE REVIEW

The capacity and location of hardwood sawmills are influenced by the costs of log procurement, manufacturing, and distribution and the size and quality of the local timber resource. When any cost associated with lumber production changes industrywide, the efficient

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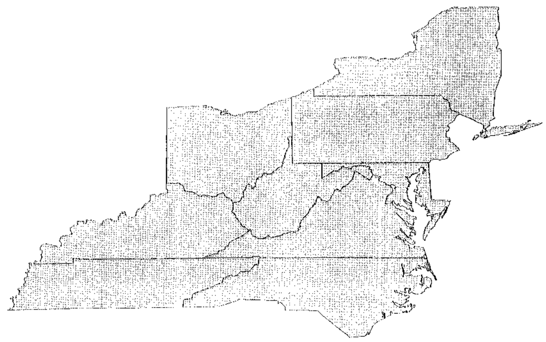

FIG. 1. Central Appalachian hardwood production region.

capacity of sawmills also changes. These changes can be reflected by the purchase of new equipment or the expansion of operating hours or work shifts. There are several studies that address changes in forest product plant capacities and production levels that are relevant to the current analysis.

Granskog (1978, 1989) examined the southern forest products industry and found that minimum efficient plant size had continued to increase in southern pulpmills, softwood plywood plants, and pine sawmills between 1966 and 1986. These studies indicate that economies of scale resulting from capital investment in improved production technology were major factors in increasing the minimum efficient plant size.

Bush et al. (1987) found that large eastern sawmilling firms purchased more sophisticated and efficient equipment. This finding implies that the large firms can continue to become larger and more efficient, while the smaller firms that do not or cannot purchase more efficient equipment eventually are forced out of business. The ability of large firms to increase efficiency also may affect the stumpage market. As larger sawmills become increasingly efficient, these firms can pay more for hardwood stumpage, thus squeezing smaller mills that do not have the money to buy the highly demanded higher priced logs.

Although Granskog (1978, 1989) and Bush et al. (1987) indicated increasing economies of scale in the southern pine and eastern sawmilling industry, Bush and Sinclair (1989) found no correlation between labor efficiency and mill capacity in the hardwood industry. However, the sample frame for the Bush and Sinclair (1989) study was developed from the 1982 "Directory of the Forest Products Industry" (Miller Freeman 1982). This directory lists only a fraction of the larger hardwood sawmills. Since the sample frame was biased toward large mills, the necessary range of mill capacities to test for economies of scale in the hardwood industry did not exist.

Hammett et al. (1992) found that larger mills have larger sales staffs and a greater tendency to sell hardwood lumber on the export market. Larger mills have the ability to accumulate enough exportable material and normally have the dry kiln needed to manufacture products for international customers.

Luppold and Dempsey (1994) examined trends in lumber production for eight eastern subregions. This study found large differences in lumber production resulting from differences in local (within region) demand and proportion of timber resource in more desired species. Although high-grade lumber can be shipped virtually anywhere in the world, lower and mid-grade lumber tends to be consumed by industries proximate to sawmills. When these "local" markets expand or contract, lumber production in that region follows the same trend. Areas with a higher proportion of the more desired species (select red and white oak, black cherry, black walnut, and ash) also have seen larger increases in lumber production than regions with lower proportions of these species.

DATA DEVELOPMENT

Although hardwood lumber is manufactured in all states in the Central Appalachian region, eight of the nine states account for over 95% of the region's lumber production. An effort was made to develop information on sawmilling industries in these states by collecting all available directories of primary wood processors published between mid-1970s and early 1990s. Usable directories for this period were obtained for West Virginia, Tennessee, Kentucky, Pennsylvania, and New York. The earliest usable directory obtained for Ohio was 1980. The specific directories used are listed in the reference section under the specific state and agency name.

The directories published by North Carolina and Virginia reported mill information in a format unusable in this study; however, frequent timber output studies for these states provided detailed sawlog consumption by individual mills every 2 to 3 years (USDA 1994). Therefore, log consumption data were used instead of sawmill directory information. The combination of directories and log consumption information allowed for historic sawmill industry data bases to be compiled for all eight states.

Although primary product directories collected for this study provide detailed information on the sawmill industry, most are published on an irregular basis. After examination of the directories, it was decided to begin the analysis for years on the closest year near 1975. Additional information was collected from directories every 3 to 5 years from the initial year.

The format used to report mill capacity differs among states and has changed over time within most states. Although many recent directories of primary wood processors provide actual production data for the larger sawmills, the capacities of most mills are provided in 5 to 10 range classifications. Estimates of hardwood lumber production capacity for specific production ranges were developed by summing the number of hardwood sawmills in each range and multiplying this sum by the range's midpoint. Information on the production capacity of larger sawmills was provided by forest product utilization specialists in individual states. The state estimates shown in Table 1 were developed by summing production estimates for each range group. Table 1 also lists the number of mills, average production capacity per mill, and the proportion of the capacity in mills that produce at least 5 million board feet (mmbf) annually.

Table 1 does not include mills that produce less than 100 thousand bf (mbf) annually. The format of the 1976 and 1980 New York directories made it difficult to separate mills that produced less than 100 mbf from mills that produced between 100 and 500 mbf. Therefore, the information for New York excludes mills that produce less than 500 mbf annually. Because of this accounting difference, the reported number of mills in New York is relatively lower and average production capacity relatively higher than for other states.

CHANGES IN THE CENTRAL APPALACHIAN SAWMILLING INDUSTRY

The information in Table 1 indicates that since the mid-to late 1970s, the average capacity of hardwood sawmills has increased as hardwood lumber production has increased. The number of sawmills in six of the eight states peaked in the early to mid-1980s. One problem with the information in Table 1 is that the observations were collected at different points in time. This makes it difficult to directly compare whether annual changes in defining characteristics have been uniform across states. To overcome this problem, average annual change coefficients for capacity, number of mills, average mill capacity, and the proportion of capacity in larger mills were estimated using the following general equation:

$$Ch_{ij} = B_{0i} + B_{1i}(Time) + \Sigma B_{ij}D_{ij} \quad (1)$$

where:

Ch_{ij} = characteristic i, i = 1 to 4 (production capacity, number of mills, average capacity, and proportion of production in larger mills) for state j

Time = year − 73 (year ranges 74 through 92)

D_{ij} = Zero-one dummy variable that allows individual states or groups of

TABLE 1. *Total and annual changes in production capacity, number of mills, average capacity, and proportion of capacity in large mills for states in the Central Appalachian region between the mid 1970s and early 1990s.*[a]

State	Year	Production capacity (mmbf)	Number of mills	Average capacity	Percentage of total capacity in large mills[b]
W. Virginia	76	458	284	1.61	34.4
	80	471	281	1.67	39.0
	86	501	227	2.21	43.3
	92	580	227	2.55	63.3
Annual change (%)		7.6[c]	−2.69	0.059[c]	1.8
Tennessee	74	510	309	1.65	24.4
	79	741	475	1.56	25.9
	84	666	387	1.72	25.9
	89	890	343	2.60	46.3
Annual change (%)		25.3[d]	2.27[d]	0.063	1.5
Kentucky	77	611	365	1.67	20.9
	82	821	433	1.89	27.7
	86	900	398	2.26	36.8
	90	936	395	2.37	43.6
Annual change (%)		25.0[d]	2.31[d]	0.054[c]	1.7
Virginia	78	569	310	1.84	25.4
	84	705	348	2.03	40.5
	87	680	304	2.24	40.3
	92	717	241	2.98	55.7
Annual change (%)		10.6	−4.93[c]	0.081[d]	2.2[d]
N. Carolina	76	456	290	1.57	35.8
	83	601	302	1.99	43.9
	87	759	269	2.82	56.5
	92	616	208	2.96	62.6
Annual change (%)		10.0[c]	−5.13[c]	0.087[d]	1.7
New York[d]	76	279	116	2.40	27.6
	80	423	167	2.54	30.1
	85	447	164	2.73	28.5
	91	491	155	3.17	50.4
Annual change (%)		14.1	−2.60	0.051[c]	1.5
Pennsylvania	75	697	582	1.20	16.1
	82	943	673	1.40	40.0
	86	978	574	1.70	37.9
	91	1,029	578	1.78	42.7
Annual change (%)		20.1[d]	−0.25[d]	0.036[c]	1.7
Ohio	80	465	326	1.43	23.6
	84	456	281	1.62	37.7
	88	515	251	2.07	43.2
	92	416	171	2.44	54.0
Annual change (%)		−4.1[c]	−12.92[c]	0.084[d]	2.5[d]

[a] Average change for inidividual states were compared against average change for all states plus or minus 1.703 standard deviations.
[b] Mill with annual production capacity equal to or exceeding 5 million board feet.
[c] Significantly lower than average.
[d] Significantly higher than average.

TABLE 2. *Ordinary least-squares estimates of the relationship among hardwood lumber capacity, number of hardwood sawmills, and average sawmill capacity and time for states in the Central Appalachian region. States included in intercept shifter are in parentheses.*

Equation[a] (characteristic)	Explanatory variable	Regression coefficient	Standard error	Student's "t"[b]
(1) Capacity of sawmilling industry	Intercept	300.67	34.81	8.64
	Time	14.20	2.43	5.83
	D_1 (PN)	462.10	44.02	10.50
	D_2 (TN, KY)	320.39	34.94	9.17
	D_3 (VA, NC)	168.68	34.84	4.82
Adjusted $R^2 = 0.845$				
(2) Number of sawmills	Intercept	416.64	21.00	19.84
	Time	−2.36	1.43	1.65
	D_1 (WV, OH, NC)	−129.55	20.48	6.33
	D_2 (PA)	209.90	27.27	7.70
	D_3 (VA)	−86.97	27.48	3.16
	D_4 (NY)	−242.53	27.25	8.90
Adjusted $R^2 = 0.893$				
(3) Average capacity of sawmills	Intercept	2.091	0.1195	17.49
	Time	0.062	0.0064	9.62
	D_1 (WV, TN, KY, OH)	−0.807	0.1129	7.15
	D_2 (PA)	−1.218	0.1426	8.54
	D_3 (VA, NC)	−0.521	0.1241	4.20
Adjusted $R^2 = 0.850$				
(4) Average capacity of sawmills	Intercept	0.163	0.0185	8.79
	Time	0.017	0.0015	11.88
	D_1 (VA, NC)	0.121	0.0189	6.41
Adjusted $R^2 = 0.853$				

[a] Equations described in text.
[b] Critical "t" value for P level of 0.05 1.703 for Eqs. 1 and 3, 1.706 for Eq. 2, and 1.699 for Eq. 4.

states (j's) to have different intercepts. Each characteristic i has a different set of $D_{j's}$

B_{0i} = Intercept coefficient for equation representing characteristic i

B_{1i} = Slope coefficient that represents average yearly change of characteristic i

B_{ij} = Set of coefficients corresponding to zero-one dummy variables (D_{ij}'s)

The ordinary least-squares results for the four equations described above are presented in Table 2. The ($B_{1i's}$) coefficients and corresponding standard errors shown in Table 2 were used to develop ranges to test whether annual changes shown in Table 1 were significantly different from the eight-state average. The composition of the zero-one dummy variable for the four equations was developed by a two-step method. The first step was to estimate zero-one dummy variables for each state and equation. The resulting coefficients were clustered into ranges based on the value of these coefficients plus or minus the standard error times 1.72 (0.05 t value @ 22 df).

Actual annual changes in production capacity in Tennessee, Kentucky, and Pennsylvania were significantly higher than average, while annual changes in West Virginia, North Carolina, and Ohio were below average. These changes are consistent with those of Luppold and Dempsey (1994), who found that recent growth in lumber production was high in Kentucky and Tennessee, moderate in New York and Pennsylvania, and relatively low in West Virginia, Virginia, and North Carolina. The changes were caused by changing demands of hardwood using industries found in these regions (Luppold and Dempsey 1994). The decrease in North Carolina also has been affected by reduced availability of National Forest timber in the western part of the state.

Ohio had the largest relative decrease in the number of sawmills. This drop was caused by reduced sawtimber availability. A recent study of the Ohio timber resource showed sawtimber removals of select and other red and white oaks exceeding or nearly equaling growth (Ervin et al. 1994). The reduced availability of sawtimber has caused Ohio sawmills to import a large portion of the logs they consume from neighboring states (Widman and Long 1992).

Virginia and North Carolina also had greater than average decreases in the number of sawmills. Again, this decrease is correlated to lumber production. In both states, lumber production increased sharply between the mid-1970s and early 1980s but was nearly the same in 1992 as in the early 1980s. The lack of a large increase in lumber production since 1980 in Virginia and North Carolina is correlated with the decreased lumber demand by wood furniture factories located in these states (Luppold and Dempsey 1994). Tennessee and Kentucky had more mills in the early 1990s than in the mid-1970s, while the number of mills in Pennsylvania was virtually the same in 1991 as in 1975. All three states had significantly higher than average annual increases in lumber production capacity due to increased domestic and international demands for lumber (Luppold and Dempsey 1994).

As the number of sawmills declined in Virginia, North Carolina, and Ohio, the average capacity of the remaining sawmills increased significantly faster than the eight-state average. All of these states have experienced either reduced log supplies (Ohio and North Carolina) or reduced demand by the furniture industry (Virginia and North Carolina). These market conditions have caused small firms to exit the market and remaining firms to increase in capacity, indicating that there are economies of scale or size in hardwood lumber production.

Tennessee was the only state where the change in average capacity was statistically equal to the eight-state average of 6.2% per year. West Virginia, Kentucky, and New York had increases in average capacity slightly lower than the eight-state average, while Pennsylvania showed the lowest increase in average capacity. However, all of these states had increases in hardwood lumber production and production capacity between the early 1980s and early 1990s.

The proportion of production capacity in large sawmills (equal to or exceeding 5 million board feet annually) increased dramatically in all eight states between the late 1970s and early 1990s. This change is the result of small sawmills closing and increased capacity of remaining mills. For instance, one Ohio mill with a production capacity of 4 million board feet per year in 1980 produced more than 25 million board feet in 1992 (Ohio Dep. Nat. Resour. 1980, 1992). Again, the increased dominance of the large mills indicates economies of scale or size.

CHANGES IN SAWMILL CONCENTRATION

The increasing average capacities of hardwood sawmills and the increasing proportion of lumber production capacity at larger mills indicate that the hardwood sawmilling industry is becoming more concentrated. Unfortunately, data collected from directories of primary wood processors cannot be directly compared for changes in sawmill concentration within and among states. However, if it is assumed that the observations for proportional production volumes and proportional number of firms for each state and year lie on cumulative concentration curves, such curves could be estimated from these observations. Changes in concentration could then be developed from the information provided by these curves.

The cumulative concentration curve, as defined by Kluender et al. (1993), ranks firms from largest to smallest and plots the cumulative proportion of the industry production against the firm rank. In a perfectly competitive industry where all firms have the same capacity, the cumulative concentration curve would be a straight diagonal line. The cumulative concentration curve (CC curve), as defined in this study, differs from Kluender et al. (1993) in that cumulative proportion of the industry production is plotted against cumulative proportion of firms for a specific state and year.

Estimation of CC curves for most states and years listed in Table 1 required the development of a function form that could predict an entire curve given five or six observations. The selection of a CC curve functional form began by examining the actual CC curve for Virginia in 1992. This examination led to four criteria that a usable function would have to meet:

1. The limits of the function's range and domain should be equal to or asymptotically approach 0 and 1 with the range equal to 0 when the domain is 0 and 1 when the domain is 1.
2. The function must rise rapidly and increase at a decreasing rate in the relevant range of the equation.
3. It was more important that the function have predictive power at the low end of its range. These criteria were included because the most relevant portion of the CC curve is in the earlier portions.
4. Because of limited observations, the function must be estimated linearly using only one independent variable and, if necessary, an intercept term.

Several commonly used logarithmic and multiplicative functional forms were examined using these criteria. Although it was relatively easy to obtain a high R^2 using many of these forms, none could satisfy all criteria. However, the transcendental form presented in Eq. 2 provided excellent results in predicting the Virginia CC curve (Fig. 2):

$$Ln(CPP_{ij}) = B_{0ij} + B_{1ij}(Ln(CPS_{ij}) - CPS_{ij}) \quad (2)$$
$$\text{Subject to } B_{0ij} = B_{1ji}$$

Given that $B_{0ij} = B_{1ji} = B$ Eq. 2 can be written as:

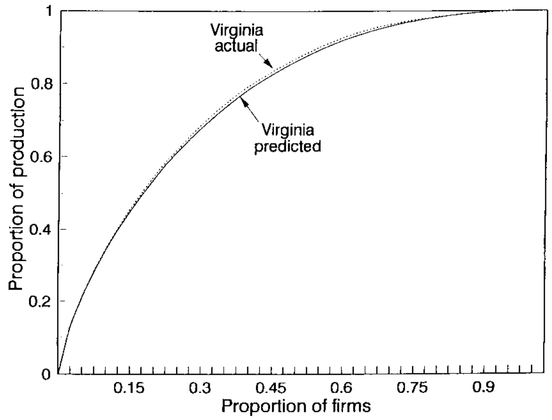

FIG. 2. Actual and predicted cumulative concentration curves for Virginia's hardwood sawmilling industry in 1992.

$$CPP = CPS^B e^{(B - B(CPS))} \quad (2a)$$

where:

CPP_{ij} = Cumulative proportion of production capacity in state i, i = 1 to 8 in year j (range of CPP is 0 to 1)

CPS_{ij} = Cumulative proportion of sawmills in state i, in year j (range of CPS is 0 to 1)

B_{0ij} = Intercept coefficient for equation representing state i in year j

B_{1ij} = Slope coefficient for equation representing state i in year j

The restriction forcing the intercept and slope coefficient to be equal ensures that the range and domain properties of criteria 1 are met. This restriction also provided a single coefficient (B) that provides a relative measure of concentration across all states and years. The higher the value of B, the lower the degree of concentration (Fig. 3). Although the slope/intercept restriction marginally reduced statistical fit in some instances, excluding this restriction produced slope and intercept coefficients that were difficult to interpret.

Estimated CC curves in the form of Eq. 2 in Table 3 are for the states and years included in this study. The CC curves were estimated in four equation systems (one system for each

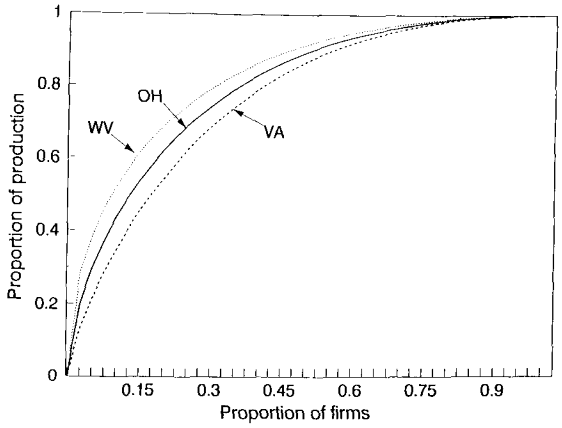

FIG. 3. Predicted cumulative concentration curves for West Virginia, Virginia, and Ohio sawmilling industries in 1992.

TABLE 3. *Estimates of the cumulative concentration curve B coefficients for states in the Central Appalachian region between 1974 and 1992. Equation estimated using seemingly unrelated regression.*

State	Year	B Coefficient	Standard Error	R^2	Production by top 10 percent of mills (in percent)
West Virginia	1976	0.0624	0.0246	98.6	41.7
West Virginia	1980	0.565	0.0015	99.4	45.3
West Virginia	1986	0.612	0.0011	99.8	42.4
West Virginia	1992	0.466[a]	0.0010	99.6	52.0
Tennessee	1974	0.712	0.0056	99.9	36.8
Tennessee	1979	0.681	0.0029	99.9	38.5
Tennessee	1984	0.660	0.0031	99.9	39.6
Tennessee	1979	0.596[a]	0.114	99.1	43.3
Kentucky	1977	0.740	0.0032	99.9	35.4
Kentucky	1982	0.678	0.0019	99.9	38.7
Kentucky	1986	0.596	0.0014	99.9	43.3
Kentucky	1990	0.608[a]	0.0015	99.9	42.6
Virginia	1978	0.743	0.0055	99.9	35.2
Virginia	1984	0.702	0.0021	99.9	37.4
Virginia	1987	0.748	0.0025	99.9	35.0
Virginia	1992	0.754	0.0019	99.9	34.7
North Carolina	1976	0.584	0.0071	99.7	44.1
North Carolina	1983	0.585	0.0063	99.8	44.0
North Carolina	1987	0.580	0.0040	99.9	44.3
North Carolina	1992	0.658[b]	0.0097	99.7	39.8
New York	1976	0.452	0.0267	91.9	53.0
New York	1980	0.481	0.0243	94.4	50.9
New York	1985	0.570	0.0157	98.4	44.9
New York	1990	0.474	0.0178	97.1	51.4
Pennsylvania	1975	0.679	0.0089	99.9	38.6
Pennsylvania	1982	0.649	0.0121	99.5	40.3
Pennsylvania	1986	0.702	0.0148	99.4	37.4
Pennsylvania	1990	0.584[a]	0.0098	99.6	44.1
Ohio	1980	0.703	0.0050	99.9	37.3
Ohio	1984	0.598	0.0100	99.6	43.2
Ohio	1988	0.587	0.0030	99.9	43.9
Ohio	1992	0.594[a]	0.0112	99.5	43.4

[a] Estimated increases in sawmill concentration over the data period.
[b] Significant decreases in sawmill concentration over the data period.

state) using seemingly unrelated regression techniques developed by Zellner (1962). Estimations were completed using SHAZAM 7.0 econometric computer program (Shazam 1993). The Zellner estimation technique was used because it pooled observations (increasing the degrees of freedom), allowed direct comparison of coefficients in specific states across years, and reduced variance by adjusting estimates for contemporaneously correlated error.

The statistical fits of the estimated CC curves were excellent in most states and years. The R^2 associated with these curves exceeded 0.99 in most cases and was 0.9999 in many of the equations. The exceptions were the equations for New York. Table 3 also includes estimates of hardwood lumber production by the top 10% of mills in the various states and years. The information in this table indicates that the sawmilling industry in West Virginia, Kentucky, Tennessee, Pennsylvania and Ohio has become more concentrated over time.

The prediction resulting from the cumulative concentration curves provided unexpected results. One important finding is that average capacity of sawmill and proportion of production in larger sawmills does not adequately describe sawmill concentration. For example, in 1992 Virginia had a higher average capacity than Ohio or West Virginia. Yet Virginia had the lowest concentration levels while Ohio and West Virginia had two of the highest concentration levels. An examination of the actual cumulative concentration curves for these two states verified this finding (Fig. 3).

DISCUSSION AND CONCLUSIONS

Although the Central Appalachian hardwood industry has shown considerable changes across all states, there is no indication that these changes have occurred in a consistent manner. Most of the divergence in trends is the result of the diverse nature of the hardwood lumber industry; however, some of these differences may be the result of inconsistencies or errors in state directories of primary wood processors.

The industry has become more concentrated over time, though the impact of this change is difficult to assess. One can argue that large hardwood sawmills could be spatial monopsonists and could exercise market power, thus keeping stumpage prices low. This behavior cannot be observed in the marketplace.

An analysis of stumpage and log markets in Ohio (a state with a relatively high degree of concentration) indicated that stumpage prices have increased faster than log prices, and log prices have increased faster than lumber prices (Luppold and Baumgras, 1995). Luppold and Baumgras also found similar trends in Pennsylvania. These trends indicate that increasing capacity is correlated with increased competition in the stumpage market because larger mills must expand their procurement area. Another factor that is allowing both increases in mill capacity and log market competition is improved road conditions in the Appalachian region.

The number of mills in the Central Appalachian hardwood lumber industry is decreasing as hardwood lumber production is increasing. In most states, these changes have coincided with changes in sawmill concentration. These changes are facilitated by reduced production costs (economies of scale), reduced distribution costs, or increased access to lumber markets because of volume of production. The changes have increased returns to the hardwood resource due to increased productive and marketing efficiency resulting from increased economies of scale or size.

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