

Factors affecting regional changes in hardwood lumber production

William G. Luppold
Gilbert P. Dempsey

Abstract

Hardwood lumber production increased by nearly 1.8 billion board feet between 1986 and 1990 and decreased sharply in 1991. However, not all areas of the country experienced the same growth in hardwood lumber production during the 1980s. While lumber production in inland regions of the eastern United States and the west increased during the 1980s, lumber output in regions adjacent to the Atlantic and Gulf Coasts remained steady or declined. This paper examines changes in hardwood lumber production and the impact of changing domestic and international demands on these changes.

The late 1980s was a period of continual change in the hardwood lumber market. Between 1986 and 1988, nearly all domestic secondary hardwood processing industries increased their use of hardwood lumber (4). By 1990, hardwood lumber use in the wood household furniture market declined by nearly 9 percent while lumber use by millwork manufacturers decreased by 5 percent over their 1988 high point (4). Overall, however, hardwood lumber consumption increased because of increased exports combined with stable production of wood cabinets, hardwood flooring, and dimension (4). Then the 1991 recession caused large declines in the volume of lumber used by domestic secondary processors. Even so, exports continued to increase in 1991 because of an increased Asian and European demand (16).

The hardwood lumber industry responded to the changes in demand by increasing the quantity of lumber produced. Unfortunately, the magnitude of this increase is difficult to assess because of continual underestimation of hardwood lumber production (2.12). The estimates of hardwood lumber production reported in the Current Industrial Reports (CIR) of the U.S. Department of

Commerce (USDC) indicate virtually no growth in hardwood lumber production during the 1980s (17). However, estimates of U.S. lumber use developed by Dempsey and Luppold (4) indicate a strong growth in domestic and export demand. The assertion that Census estimates are lower than actual hardwood lumber production is further supported by the fact that the 1991 CIR estimate is 150 million board feet (MMBF) less than the estimated lumber use by the furniture and pallet industry plus net exports (3.6.16). This means that lumber use by kitchen cabinet, flooring, millwork, railroad tie, and structural member users, and all other users of hardwood lumber, would have to be zero for Census estimates of hardwood lumber production to be close to actual production.

In this study, we first present new estimates of hardwood production on a regional basis and then examine changes in hardwood lumber production among these regions. Changes in regional lumber production then are related to changes in hardwood lumber demand, the nature of the hardwood resource, and other market considerations.

Selection of regions

In a study completed by Luppold and Dempsey (13), hardwood lumber production was calculated for the North-Central, South-Central, Northeast, and Southeast regions (Fig. 1). However, these regions seem to be too aggregated. For example, the species mix in Vermont is different from the species mix in West Virginia even though both states are in the northeast region. Also, Kentucky and Tennessee have similar forests even though one is located in the North-Central region and the other is in the South Central region.

The authors are, respectively, Project Leader and Economist, USDA Forest Service, Rt. 2, Box 562-B, Princeton, WV 24740. This paper was received for publication in January 1993.
© Forest Products Society 1994.
Forest Prod. J. 44(6):8-14.

For the purposes of this study, hardwood lumber production was viewed in a much smaller regional context and was not influenced by current USDA Forest Service Forest Inventory and Analysis boundaries (Table 1 and Fig. 2). These regions were selected on the basis of the proximity of states to one another, similarities in their species mix, and the proportional sawtimber volume of higher value "select species." The select species group originally was developed by Araman (1) and includes select red and white oaks, hard maple, black cherry, ash, and black walnut. The last line of Table 1 indicates the proportion of select species in a specific region on a national basis.

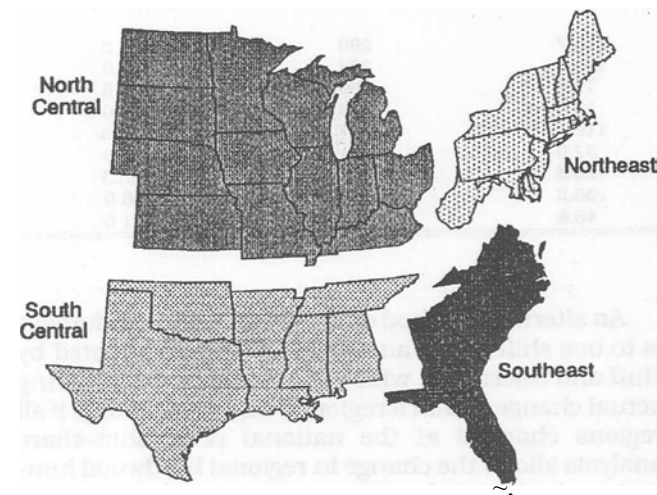


Figure 1. - Hardwood production regions used in a previous study by Luppold and Dempsey (13).

Data development

Because USDC Census estimates have been demonstrated to underestimate hardwood lumber production, we looked for alternative data. Unfortunately, there is no single source of accurate hardwood lumber production estimates that exists for all hardwood lumber producing states. Therefore, data from several different sources were combined to form a consistent set of production estimates on each state or regional basis. The specific procedures used to develop estimates of hardwood lumber production are covered in detail in Appendix 1.

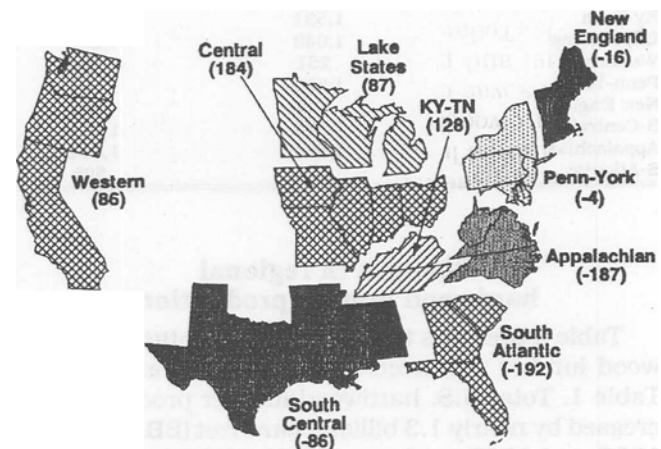


Figure 2. - New hardwood production regions with relative shift-share change between 1986 and 1991.

TABLE 1. - Major hardwood timber regions, by states, predominant species, and proportion of select species (19).

Region and included states								
New England	Penn-York	Central	Lake States	Appalachian	Ky-Tenn	S-Atlantic	S-Central	Western
Maine	New York	Ohio	Michigan	W. Virginia	Tennessee	S. Carolina	Alabama	California
N. Hampshire	Pennsylvania	Indiana	Minnesota	Virginia	Kentucky	Florida	Mississippi	Oregon
Vermont	New Jersey	Illinois	Wisconsin	N. Carolina		Georgia	Louisiana	Washington
Massachusetts	Delaware	Missouri					Arkansas	
Rhode Island	Maryland	Iowa					Texas	
Connecticut								
Predominant species								
(In descending order by sawtimber volume)								
Hard maple	Red oak	White oak	Cottonwood-	Red oak	Red oak	Red oak	Red oak	Red alder
Soft maple	White oak	Red oak	aspen	White oak	White oak	Tup.-blk. gum	White oak	Maple
Red oak	Soft maple	Hickory	Hard maple	Y-poplar	Hickory	Sweetgum	Sweetgum	
Birch	Hard maple	Y-poplar	Red oak	Tup.-blk. gum	Y-poplar	White oak	Hickory	
Beech	Blk. cherry	Soft maple	Soft maple	Sweetgum	Beech	Y-poplar	Tup.-blk. gum	
Cottonwood-aspen	Ash	Ash	White oak	Hickory	Soft maple	Soft maple	Y-poplar	
Ash	Beech	Hard maple	Basswood	Soft maple	Hard maple	Ash	Ash	
Blk. cherry	Y-poplar	Cottonwood-	Ash	Beech	Ash	Hickory	Cottonwood	
	Hickory	aspen	Blk. cherry	Ash	Sweetgum		Beech	
	Basswood	Blk. walnut		Hard maple	Tup.-blk. gum			
		Blk. cherry		Blk. cherry	Blk. walnut			
Select species								
(proportion of sawtimber volume within area, in percent)								
Region: 40	46	40	40	26	29	12	19	NA
Nation: 8	21	15	15	16	9	2	11	NA

TABLE 2. - Estimates of U.S. hardwood lumber production, by region, 1986 to 1991 (in million board feet).

Region	1986	1987	1988	1989	1990	1991
----- (MMBF) -----						
Appalachian	1,964	2,077	2,212	2,179	2,050	1,914
S-Central	1,774	2,101	1,928	1,991	2,197	1,811
Central	1,521	1,646	1,773	1,848	1,892	1,811
Ky-Tenn	1,531	1,702	1,848	1,916	1,921	1,765
Penn-York	1,590	1,619	1,723	1,738	1,743	1,697
Lake States	1,043	1,113	1,242	1,235	1,261	1,202
New England	533	525	533	555	592	554
S-Atlantic	670	647	621	625	627	525
Western	251	265	290	328	377	354
Total U.S.	10,877	11,695	12,170	12,415	12,660	11,633

TABLE 3. -Relative change in U.S. hardwood lumber production, by region, 1986 to 1991

Region	Lumber production		Expected change (EC)	Actual change (AC)	Difference (AC-EC)
	1986	1991			
----- (MMBF) -----					
Central	1,521	1,811	105.7	290	184.3
Ky-Tenn	1,531	1,765	106.4	234	127.6
Lake States	1,043	1,202	72.5	159	86.5
Western	251	354	17.4	103	85.6
Penn-York	1,590	1,697	110.5	107	-3.5
New England	533	554	37.0	21	-16.0
S-Central	1,774	1,811	123.3	37	-86.3
Appalachian	1,964	1,914	136.5	-50	-186.5
S-Atlantic	670	525	46.6	-145	-191.6

Changes in regional hardwood lumber production

Table 2 presents the estimated quantities of hardwood lumber produced in the nine regions listed in Table 1. Total U.S. hardwood lumber production increased by nearly 1.3 billion board feet (BBF) between 1986 and 1988, and nearly 1/2 BBF between 1988 and 1990. The 1 BBF decrease in production in 1991 appears to be related directly to reduced demand in the U.S. market as a result of the 1990 to 1991 recession. Even with this severe drop, U.S. production increased by 764 MMBF between 1986 and 1991.

The estimates presented in Table 2 are generally very different from Census estimates, but these differences varied considerably among states. While Census estimates and Forest Service timber product output studies for Florida and South Carolina were virtually identical, Census estimates for Maine accounted for only one-sixth of the volume estimated by a 1991 state mill survey. The probable cause for the low Census estimates is that Census concentrates only on 3,000 mills with more than 20 employees (17). It is believed by the authors that the bulk of the 2,600 remaining mills were hardwood mills.

Although production increased between 1986 and 1991, it did not increase uniformly across all regions. The greatest increases in production were in the Central, Kentucky-Tennessee, Western, Lake States, and Penn-York regions (Table 2). Minor increases also occurred in the South-Central, and New England regions. Hardwood production decreased slightly in the Appalachian region and dropped by 21 percent in the South-Atlantic region.

An alternate method of examining regional changes is to use shift-share analysis [table 3) as adapted by Huff and Sherr (10), which is a method of comparing actual change within a region to expected change if all regions changed at the national rate. Shift-share analysis allows the change in regional hardwood lumber production to be examined on a relative versus actual basis. Herrick (9) applied this method in determining changes and shifts in regional forest industries. Hammett and McNamara (7) used shift-share to measure the relative competitiveness of regions in wood products export markets.

The result of the shift-share analysis shows a large difference between expected growth in production and actual growth (Table 3). When the difference between the actual versus expected change is examined geographically (Fig. 2), a pattern that runs from east to west and south to north seems evident. Excluding the western region, the positive differences were confined to the inland regions (Central, Kentucky-Tennessee, and Lake States) while the largest negative differences seem confined to the South-Atlantic, Appalachian, and South-Central regions.

Even though the shift-share analysis was useful in highlighting the changes in hardwood lumber production between 1986 and 1991, it did not tell the whole story. Closer examination of Table 2 indicates that hardwood lumber production in each region seemed to follow a somewhat different path between 1986 and 1991. These differences appear directly linked to changes in hardwood product demand during this period. Changes in production in specific regions will be analyzed in the following section in the order of appearance in Table 3.

TABLE 4. - Regional distribution of secondary hardwood lumber manufacturers in 1990, based on regional employment (in percent of national) (18).

Region	Flooring and dimension	Kitchen cabinets	Pallets and containers	Household wood furniture	Household upholstered furniture
----- (% of national) -----					
Central	10.2	16.7	18.6	8.1	9.8
Ky-Tenn	21.0	3.2	8.5	5.1	9.7
Lake States	3.9	7.2	10.5	4.4	2.2
Penn-York	7.5	14.4	9.4	8.6	2.7
New England	2.8	2.9	3.6	3.6	2.6
S-Central	14.8	12.2	14.5	7.0	27.0
Appalachian	20.0	6.5	8.9	44.0	33.0
S-Atlantic	1.6	8.1	8.9	5.5	3.0

TABLE 5. - Index of changes in output of major secondary hardwood manufacturers in 1990, based on regional employment (1986 = 100) (18).

Year	Flooring and dimension	Kitchen cabinets	Pallets and containers	Household wood furniture	Household upholstered furniture
1986	100.0	100.0	100.0	100.0	100.0
1987	104.6	109.7	102.9	104.8	106.5
1988	110.4	111.5	107.8	105.7	108.2
1989	110.5	112.9	110.1	101.0	107.6
1990	109.0	110.4	111.3	98.1	102.3
1991	100.6	100.2	109.3	91.7	95.3

Analyses of regional change

Like most products, the distance hardwood lumber travels from producers to users is related to the value of the lumber. High-grade lumber can be exported profitably overseas while low-grade lumber is more likely to be consumed in close proximity to the sawmills. The following analysis between lumber demand and regional lumber production is based on the assumption that a large percentage of the lower grade and mid -grade lumber is consumed within or near the region where it is produced. Table 4 presents information on the proportion of the nation's secondary hardwood manufacturing employment contained in each of the eight eastern regions. The Western region was excluded from Table 4 because the dominance of the secondary manufacturers using softwood lumber would make employment information difficult to interpret. The information contained in Table 5 approximates demand trends for major secondary hardwood manufacturing industries by indexing changes in national employment within each industry from 1986 to 1991.

In addition to the information contained in Tables 4 and 5, the authors have introduced information from their own knowledge of the hardwood market. This knowledge is especially important in interpreting the statistics concerning the flooring and dimension industries. Although the U.S. Department of Labor combines the flooring and dimension industries under one Standard Industrial Code, flooring and dimension are two distinct industries. In recent years, hardwood flooring production has grown steadily (14). However, the dimension industry is affected by growth and contraction of wood household furniture production.

The Central region experienced the largest regional increase in lumber production between 1986 and 1991 in both a relative and absolute sense. However, it should be noted that some states in this region tend to import logs from

adjoining regions. Forty percent of the sawtimber volume in this region was of select species with select white oak making up the bulk of the volume (19). The increase in production in this region appears related to the 221 percent increase in white oak exports between 1986 and 1991 (11,12). The white oak from this region seems to be preferred by European buyers.

Two other factors that may have affected production in the Central region are the pallet and kitchen cabinet industries. In 1990, 19 percent of the pallet industry employment was located in the Central region (Table 4). Although few sawmills specialize in pallet lumber production, the pallet industry traditionally has provided a market for the low-grade lumber produced from log centers. This region also has a large concentration of kitchen cabinet manufacturers. The increased production of kitchen cabinets in the mid-1980s probably contributed to the increase in lumber demand and production in this region.

Hardwood lumber production in the Kentucky Tennessee region grew rapidly between 1986 and 1990, but dropped sharply in 1991. This region is unique because it contains Appalachian hardwoods in its eastern forests and Central hardwoods in its Central and western woodlands. The 29 percent proportion of select species in this region (Table 1) is somewhat misleading because the large volume of yellow-poplar in the eastern section masks the physical volume of select species in the area. This region also benefited from increased white oak exports. However, the white oak from the Kentucky-Tennessee region is not as preferred as white oak from the Central region.

Another factor that has increased production in the Kentucky-Tennessee region is the high concentration of flooring plants. The drop in lumber production in 1991 seems to be associated with reduced domestic furniture

production. It is suspected that the red oak and poplar lumber produced in the eastern part of this region tends to be used by the North Carolina and Virginia furniture industry.

Hardwood lumber production in the western region also increased each year between 1986 and 1990 before decreasing in 1991. The major species produced in western hardwood sawmills is red alder. Red alder lumber production increased in the 1980s as producers developed products for Japanese and domestic (mainly West Coast) users. The western pallet industry also used the low quality alder. The drop in western production in 1991 seems to be related to the 10 percent drop in alder exports to Japan combined with a recession-triggered decline in West Coast demand (11,12).

The timber resource of the Lake States is unique because the three dominant species are cottonwood-aspens, hard maple, and red oak. Although red oak is the third most abundant species on a resource volume basis, it is the number one species on a lumber production basis. Production in this region increased between 1986 and 1988 but started to decrease in 1989. Although this would indicate a strong relationship to changes in overall domestic demand, the decrease in exports of basswood to Japan may have contributed to reduced production in this region (11). Lake States red oak is considered by many secondary processors to be a superior product and commands a 10 to 20 percent price premium over red oak lumber from other regions (8). However, there is increasing evidence that the oak resource in this region is being cut faster than it is growing (15).

After a sharp increase between 1986 and 1988, hardwood lumber production in the Penn-York region remained relatively stable. This region has the highest concentration of select species among all regions. Much of the quality timber in this region is concentrated in northwestern Pennsylvania and southwestern New York. The region appears to have been a major source of material for the northeast millwork industry, which in the mid 1980s was a major user of high grade red oak lumber (5). However, the demand by the millwork industry dropped sharply after 1987. Apparently, a combination of international and domestic demands for higher grade lumber and dimension and local demands by the kitchen cabinet industry (Table 4) have caused production in this region to stay relatively stable.

The New England region contains a high proportion of select species, but hardwood lumber production in this region has been erratic. The most important species in this region is hard maple. The decrease in lumber production between 1987 and 1989 appears to have been the result of a decrease in domestic demand. The increased production since 1989 appears to be the result of an increase in domestic and international demand for hard maple.

Hardwood lumber production in the South-Central region increased between 1986 and 1987, but then remained steady for 3 years. After spiking in 1990, production dropped sharply in 1991. Although the timber in this region is mainly

of the nonselect species, the flat terrain, selective cutting methods, and ample supplies have allowed sawmills to produce large volumes of hardwood lumber. The major export market for this region is Taiwan, while the domestic users include the upholstered furniture and flooring industries. The regional and international demand base for lumber from this region allowed production to remain stable in the mid-1980s. However, the authors have yet to find any explanation for the large increase in production between 1989 and 1990. The sharp drop in production between 1990 and 1991 appears to be recession related but also may be related to increased timber demands by the pulp industry in this region.

The Appalachian region is the largest hardwood lumber production region, but has a relatively low proportion of select species. This low proportion is the result of yellow-poplar being the dominant species in much of this region. Appalachian lumber production grew steadily between 1986 and 1989. The drop since 1989 appears to be related to the decrease in demand by the North Carolina and Virginia furniture industries. Dimension plants associated with the wood furniture industry make up a large part of the dimension and flooring industries located in this region. The large shift-share decrease shown in Table 3 is in part the result of the large size of this region.

The South-Atlantic region contains the lowest volume of select species of the nine eastern regions. The low volume of better quality timber and the lack of a market for the gum species in the 1980s probably have been the major reasons for the almost continuous decline in lumber production in this region.

Summary and conclusion

In the mid-to-late 1980s, U.S. hardwood lumber production grew steadily. Although the 1991 recession caused a significant decline in hardwood lumber output, total production grew by 764 MMBF between 1986 and 1991. During this period, however, there was a shift in hardwood lumber production on a regional basis. In 1986, 60 percent of the nation's hardwood lumber was produced in regions that bordered the Atlantic Ocean or the Gulf of Mexico. By 1991, hardwood lumber output in these regions represented only 56 percent of U.S. production. Excluding the South-Atlantic region, the decline in hardwood lumber production of the coastal regions relative to the U.S. total was not due to general decreases in production, but to strong increases in output by the interior regions of the East and the West Coast.

The largest increase in hardwood lumber production during the period occurred in the Central and Kentucky-Tennessee regions. Although the export of white oak lumber has been a major force in this increase, hardwood lumber demand by secondary wood processors located within the region contributed significantly to the region's growth in lumber output. Increases in flooring production between 1986 and 1991 provided local markets for nonexport-grade

lumber in both the South-Central and Kentucky-Tennessee regions.

The increased demand for hard maple in the late 1980s and early 1990s appears to have affected production in New England and may have stimulated production in the Lake States region. The impact of variations in domestic demand, especially in the furniture market, appears to be most visible in the Appalachian region, and is an important factor affecting hardwood lumber production in the Kentucky-Tennessee region. The high quality of timber in the Penn-York region has contributed to the steady production of hardwood lumber in this area. By contrast, the sharp decline in lumber production in the South Atlantic region appears to be associated with the relatively low availability of the more preferred select species within the region's sawtimber resource base.

Future changes in regional hardwood lumber production will be affected by each region's ability to supply timber in the long run. For example, it is not known if the current mix of species and grades produced in the Lake States region is sustainable at 1990 levels. It also is unclear whether the hardwood timber demands of the pulp and paper industry in the southern regions will cause the volume of hardwood lumber produced in the South to decline in the 1990s. It does appear that there are adequate volumes of hardwood sawtimber in the Appalachian and Kentucky-Tennessee regions to support the increased production of hardwood lumber well above the 1990 level.

Literature cited

1. Araman, P.A. 1987. Eastern United States hardwood sawtimber resources and export potential. *In: Proc. Southern Forest Economics Workers and Mid-West Forest Economists Symp.* Asheville, N.C. pp. 127-134.
2. Cardellichio, P.A. and C.S. Binkley. 1984. Hardwood lumber demand in the United States: 1950 to 1980. *Forest Prod. J.* 34(2): 15-22.
3. Christoforo, J.C., R.J. Bush, and W.G. Luppold. A profile of the U.S. pallet and container industry. *Forest Prod. J.* 44(2): 9-14.
4. Dempsey, G.P. and W.G. Luppold. 1992. The state of hardwood lumber markets. *Northern Logger & Timber Processor* 40(10):22-24.
5. Flowers, J.C., C.C. Hassler, and W.G. Luppold. 1990. Utilization of yellow-poplar in the architectural moulding and millwork industry. *Forest Prod. J.* 40(10): 35-38.
6. Forbes, C.L., S.A. Sinclair, and W.G. Luppold. 1993. Wood material use in the U.S. furniture industry: 1990 to 1992. *Forest Prod. J.* 43(7/8): 59-65.
7. Hammett, AL. and K.T. McNamara. 1991. Shifts in southern wood products exports: 1980 to 1988. *Forest Prod. J.* 41(2):68-72.
8. *Hardwood Market Report*. 1993. Henry Smith, ed. Memphis, Tenn. 71(33):39.
9. Herrtck, O.W. 1976. Structure and change in northern U.S. forest industry: a shift-share analysis. *Forest Prod. J.* 26(8):29-34.
10. Huff, D.L. and L.A. Sherr. 1967. A measure for determining differential growth rates of markets. *J. Market Research* 4(11):391-395.
11. *Journal of Commerce*. Product import export reporting service. New York. (Tape on file at the Forestry Sciences Laboratory, Princeton, W.V.).
12. Luppold, W.G. and G.P. Dempsey. 1989. New estimates of central and eastern U.S. hardwood lumber production. *Northern J. Applied Forestry* 6(3): 120-123.
13. _____ and R.E. Thomas. 1991. New estimates of hardwood lumber exports to Europe and Asia. Res. Pap. NE-652. USDA Forest Serv., Northeast. Forest Expt. Sta., Radnor, Pa. 22 pp.
14. Martens, D. 1992. International market for millwork. *In: Proc. Alternative for the 90's: Wood Products, Technologies and International Markets*. Appalachian Export Center for Hardwoods, Southern Ohio Wood Industry Consortium. Cambridge, Ohio. pp. 44-51.
15. Minnesota Department of Natural Resources. 1993. Minnesota's forest resources. Minnesota Dept. of Natural Resources. Div. of Forestry. St. Paul, Minn.
16. Nolley, J.W. 1993. Bulletin of hardwood market statistics: winter 1992. Res. Note NE-353. USDA Forest Serv., Northeast. Forest Expt. Sta., Radnor, Pa. 43 pp.
17. U.S. Department of Commerce. 1989-90. Lumber production and mill stocks. MA24T(81-91)-1. U.S. Dept. of Commerce. Washington, D.C.
18. U.S. Department of Labor. 1991. Labor employment and wages. (Tape on file at the Forestry Sciences Laboratory, Princeton, W.V.).
19. Waddell, K.L., D.D. Oswald, and D.S. Powell. 1989. Forest statistics of the United States. 1987. Res. Bull. PNW -RB-168. USDA Forest Serv., Pacific Northwest Res. Sta., Portland, Oreg. 106 pp.

Appendix 1

Development of hardwood lumber production data

Alternative sources of eastern hardwood lumber production are severance tax records of sawlog production, sawlog receipts from USDA Forest Service timber product output studies, and state surveys of hardwood lumber production or sawlog receipts (Table 6). Estimates of western hardwood lumber production were provided by the Western Hardwood Association.

Estimates of sawtimber harvest developed by the Southern Forest Experiment Station's Forest Inventory and Analysis unit primarily are based on severance tax records. Severance taxes are collected in Alabama, Mississippi, Louisiana, Texas, and Arkansas. Estimates of lumber production in Tennessee are developed from surveys conducted by the Tennessee Department of Forestry.

Severance tax records collected in Arkansas are for total tons of hardwood timber cut in the state. Sawtimber volume and pulpwood volume are not separated. However, the USDA Forest Service estimates Arkansas hardwood pulpwood consumption on a yearly basis. Hardwood lumber production (lumber tally) for Arkansas was estimated by subtracting pulpwood consumption from hardwood timber cut and dividing the remaining tonnage by 6. The assumption that it takes 12,000 pounds of logs to yield 1,000 board feet of hardwood lumber green tally is a conservative conversion factor developed in cooperation with the Arkansas state utilization forester.

Although severance tax records on sawtimber production (Doyle scale) or green tally lumber estimates are collected yearly, there are some problems associated with using these records for estimating hardwood lumber production for the remaining four states in the South-Central region. It appears that sawtimber cut in Alabama totals considerably less than the hardwood production capacity. However, it is believed by the authors and the staff at the USDA Forest Service, Southern Research Station's Forest Inventory and Analysis of Midmonth States that most of the logs cut in this five-state region eventually are processed within the region. Therefore, summing sawlog production (multiplied by 1.32 for Doyle overrun) and lumber tally over the five-state area should provide an accurate measure of hardwood lumber production in the South-Central region.

Timber product output (ITPO) studies are conducted by the forest inventory and analysis units in the Northeastern, Southeastern, and North-Central Research Stations of the USDA Forest Service in cooperation with individual state foresters. These studies survey primary forest products

TABLE 6. - Source of data and method used to estimate missing data points.

State	1986	1987	1988	1989	1990	1991
Alabama	TX ^a	TX	TX	TX	TX	TX
Arkansas	TX	TX	TX	TX	TX	TX
Connecticut	ELSS ^b	ELSS	SS ^c	ELSS	ELSS	SS
Delaware	ELFS ^d	ELFS	ELFS	ELFS	ELFS	ELFS
Florida	ECFS	FS ^e	ECFS ^f	FS	ECFS	FS
Georgia	FS	ECFS	ECFS	FS	ECFS	ECFS
Illinois	CIR ^g	CIR	CIR	CIR	CIR	CIR
Indiana	ELFS	ELFS	ELFS	ELFS	FS	ELFS
Iowa	ELFS	ELFS	FS	ELFS	ELFS	ELFS
Kentucky	FS	ELFS	ELFS	ELFS	ELFS	ELFS
Louisiana	TX	TX	TX	TX	TX	TX
Matyland	ELFS	ELFS	ELFS	ELFS	ELFS	ELFS
Maine	SS	SS	SS	ECSS ^h	SS	SS
Massachusetts	ELSS	ELSS	ELSS	SS	ELSS	ELSS
Michigan	FS	ELFS	FS	ELFS	FS	ELFS
Minnesota	ELFS	ELFS	FS	ELFS	FS	ELFS
Missouri	ELFS	FS	ELFS	ELFS	ELFS	FS
Mississippi	TX	TX	TX	TX	TX	TX
New Hampshire	ELSS	ELSS	SS	SS	SS	SS
New Jersey	ELFS	ELFS	ELFS	ELFS	ELFS	ELFS
New York	ELSS	SS	SS	ELSS	SS	ELSS
North Carolina	ECFS	FS	ECFS	ECFS	FS	ECFS
Ohio	ELFS	ELFS	ELFS	FS	ELFS	ELFS
Pennsylvania	ELFS	ELFS	FS	ELFS	ELFS	ELFS
Rhode Island	ELSS	SS	SS	SS	SS	SS
South Carolina	FS	ECFS	ECFS	FS	ECFS	FS
Tennessee	SS	SS	SS	SS	SS	SS
Texas	TX	TX	TX	TX	TX	TX
Vermont	SS	SS	SS	SS	SS	SS
Virginia	TX	TX	TX	TX	TX	TX
West Virginia	SS	SS	SS	SS	SS	SS
Wisconsin	FS	ELFS	FS	ELFS	FS	ELFS

^a TX = developed from state severance tax records.

^b ELSS = estimated using changes in employment and state mill surveys.

^c SS = developed from state survey data of lumber production or sawlog receipts.

^d ELFS = estimated using changes in employment and Forest Service TPO studies.

^e FS = developed from log receipt information published in USDA Forest Service TPO studies.

^f ECFS = estimated using changes in Census estimates of lumber production and USDA Forest Service TPO studies.

^g CIR = estimated from Census.

^h ECSS = estimated using changes in Census estimates of lumber production and state mill surveys.

firms in order to obtain timber production and timber receipts information. Timber receipts information was used in the current study since it approximates the volume of hardwood lumber produced. Since the TPO studies estimate receipts in terms of the International 1/4-inch rule log scale, a 5 percent overrun was assumed between log scale going into the mill and green lumber tally. Unfortunately, TPO studies are conducted on an intermittent basis with the intervening periods varying from 2 to 9 years. Therefore, a two-step procedure was used to estimate lumber production during the intervening years.

First, the principal wood utilization foresters in each state were contacted for additional information on hardwood lumber production in their respective states. Several states, including New York, Tennessee, Maine, Vermont, West Virginia, Connecticut, New Hampshire, and Rhode Island, collected hardwood saw log receipts or hardwood lumber production for some, or all, of the years in the study period. Data provided in terms of Doyle or International log scales were converted into board-foot, green tally volume using the conversion factors provided by the supplying agency.

Second, in the cases where data were not available for the interim year(s), hardwood lumber production was estimated in two ways depending on the relative volume of softwood lumber produced in the state. In states that were predominantly hardwood forested, interim estimates of hardwood lumber production were based on changes in sawmill employment. The employment data used were reported individually to the U.S. Department of Labor (USDOL) by state unemployment insurance departments (18).

The specific method used to develop missing observations was first to develop ratios between hardwood lumber production and sawmill employment for all the observations provided by TPO or state surveys. Estimates of hardwood lumber production in the missing years were developed by multiplying this ratio by sawmill employment. The authors also solicited additional comments and verification from state utilization foresters on estimates developed for Maryland, Connecticut, and Indiana.

Because each state's sawmill industry was different, the ratio of hardwood lumber production to sawmill employment varied. However, these ratios were similar for adjoining states within a specific region. Furthermore, the ratios varied only slightly over time and showed no upward or downward trend.

Estimates for lumber production for Illinois were based on information published in the Current Industrial Reports, Census estimates were used for this state because no recent TPO study had been completed for Illinois. The state utilization forester expressed the belief that Census estimates were accurate for this state. Preliminary results of a 1992 Illinois mill survey indicate production at or lower than the volumes developed from Census.

In North Carolina, South Carolina, Florida, and Georgia, significant softwood production exists. This means changes in employment are greatly affected by changes in softwood lumber production. Although Census estimates of hardwood lumber production in South Carolina and Florida are similar to TPO estimates in these states, the authors believe that CIR estimates increasingly have underestimated hardwood lumber production in North Carolina. However, TPO studies normally are developed every 2 or 3 years for these states. Multipliers for the years preceding and after each missing observation were developed by using the percentage difference between TPO estimates and CIR estimates (17). The missing observations were developed by ; multiplying the appropriate CIR estimate for that year and state by the average of the two multipliers on each side of the observation.

Virginia and Maine also produce relatively large volumes of softwood lumber. Virginia production volumes were based on severance tax records. Lumber production in Maine was based on annual sawmill log consumption surveys.