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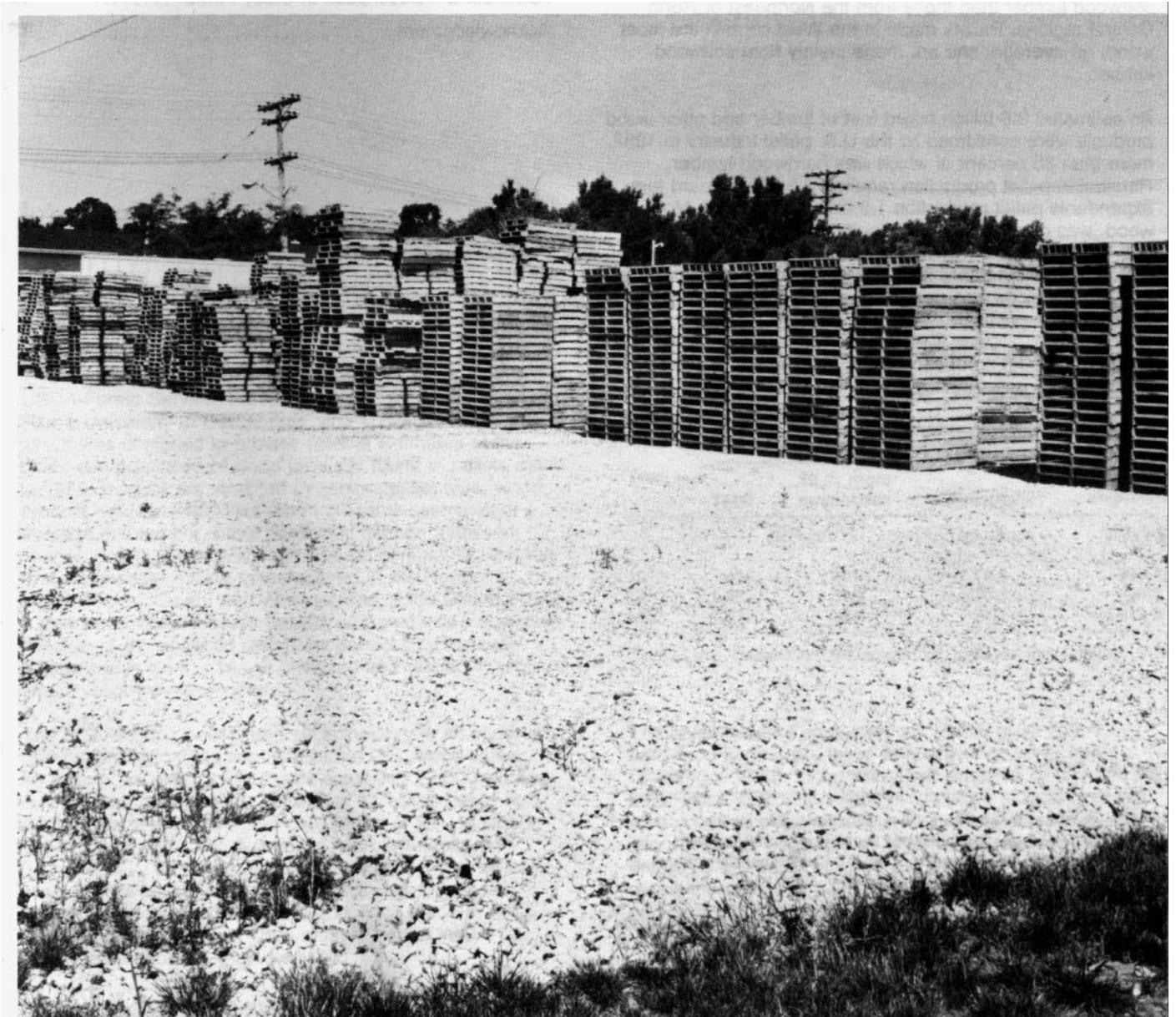
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Wood Used in Pallets Manufactured in the United States, 1982

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Abstract

This paper reports results of a cooperative study by the USDA Forest Service, Southern Illinois University at Carbondale, and Tuskegee Institute. The study was designed to provide statistically reliable information on national and regional use of wood in pallets, by species and pallet type. An estimated 17 fbm of wood was required to produce a finished pallet; the finished pallet contained 12.7 fbm of wood. This is less wood per pallet than had previously been thought.

Significant differences in wood use exist between regions. Pallets from the Northeast and North Central regions contain less wood than those from other regions, and are made almost entirely from hardwood lumber. Southern pallets are intermediate in wood content and are made with more softwood lumber than those from the Northeast or North Central regions. Pallets made in the West contain the most wood, on average, and are made mainly from softwood lumber.

An estimated 3.8 billion board feet of lumber and other wood products were consumed by the U.S. pallet industry in 1982, more than 80 percent of which was hardwood lumber. Reuseable pallet production required 2.3 billion board feet; expendable pallet production 1.5 billion board feet. More wood was consumed in the South than any other region (1.5 billion board feet), followed closely by the North Central region (1.2 billion board feet). Consumption in the Northeast and West regions was nearly equal at 0.8 and 0.5 billion board feet respectively.

Keywords: Pallet production, wood use, lumber consumption, pallet industry

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Wood Used in Pallets Manufactured in the United States, 1982

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Introduction

This paper reports results of a cooperative study by the USDA Forest Service, Forest Products Laboratory, Southern Illinois University at Carbondale, and Tuskegee Institute, which was designed to provide reliable estimates of the types and quantities of wood products found in pallets made in 1982. Results are stratified by region, pallet type, wood product, and species. This report presents estimates of average oak lumber, other hardwood lumber, softwood lumber, and plywood and particleboard content for reusable and expendable pallets manufactured in the Northeast, North Central, South, and West regions of the United States. It also describes the study design, and presents a statistical analysis of the sampled pallets (appendix B). Regional differences in wood use are analyzed and related to regional timber resource differences.

The U.S. wooden pallets and skids industry is an important and rapidly expanding segment of the U.S. wood-using economy.¹ In 1982, 1,677 plants employed 22,000 workers and shipped pallets worth more than \$1 billion (table 1) (U.S. Department of Commerce, Bureau of the Census 1984). Since 1972, the number of establishments has increased by more than 250 percent; employment has increased 50 percent. Pallet manufacturers produced 93 percent of all wooden pallets and skids made in 1982. The remaining 7 percent were made by other industrial firms, presumably for their own use.

Table 1.—Establishments, employment, and value of industry shipments for SIC Industry 2448—Wood Pallets and Skids, 1972, 1977, and 1982

Year	Establishments		Employment <i>Thousands</i>	Value of industry shipments <i>Million \$</i>
	Total	20 or more employees		
1972	456	271	14.3	295.4
1977	1,290	348	20.3	698.0
1982	1,677	362	22.1	1,012.3

Source: U.S. Department of Commerce, Bureau of the Census (1984).

The pallet industry consumes about half of all U.S. hardwood lumber produced annually (McKeever and Dickerhoof 1980), along with small amounts of plywood and other wood products. Although there are estimates of the overall use of wood in pallets, there is no statistically reliable information on wood use by region, species, and pallet type. Improved estimates of wood use provided by this study help reveal the effects of pallet manufacturing on both national and local timber resources.

¹ SIC Industry 2448. See Office of Management and Budget (1972) for complete industry definition.

Types of Pallets

Wood pallets may be either reusable (also called nonexpendable or permanent) or expendable. Reusable pallets are built for strength and durability and are designed for prolonged use. They are often made from thicker, more durable wood and are frequently purchased for warehouse or factory use (fig. 1). Expendable pallets are generally built from lighter, less expensive wood and are designed for a

limited number of uses. Expendable pallets are generally used in shipping and transportation when the shipper does not expect to have his pallets returned. The 228 million pallets produced in 1982 were nearly evenly divided between reusable and expendable. This is reflected in the distribution of pallet types in this study (fig. 2).

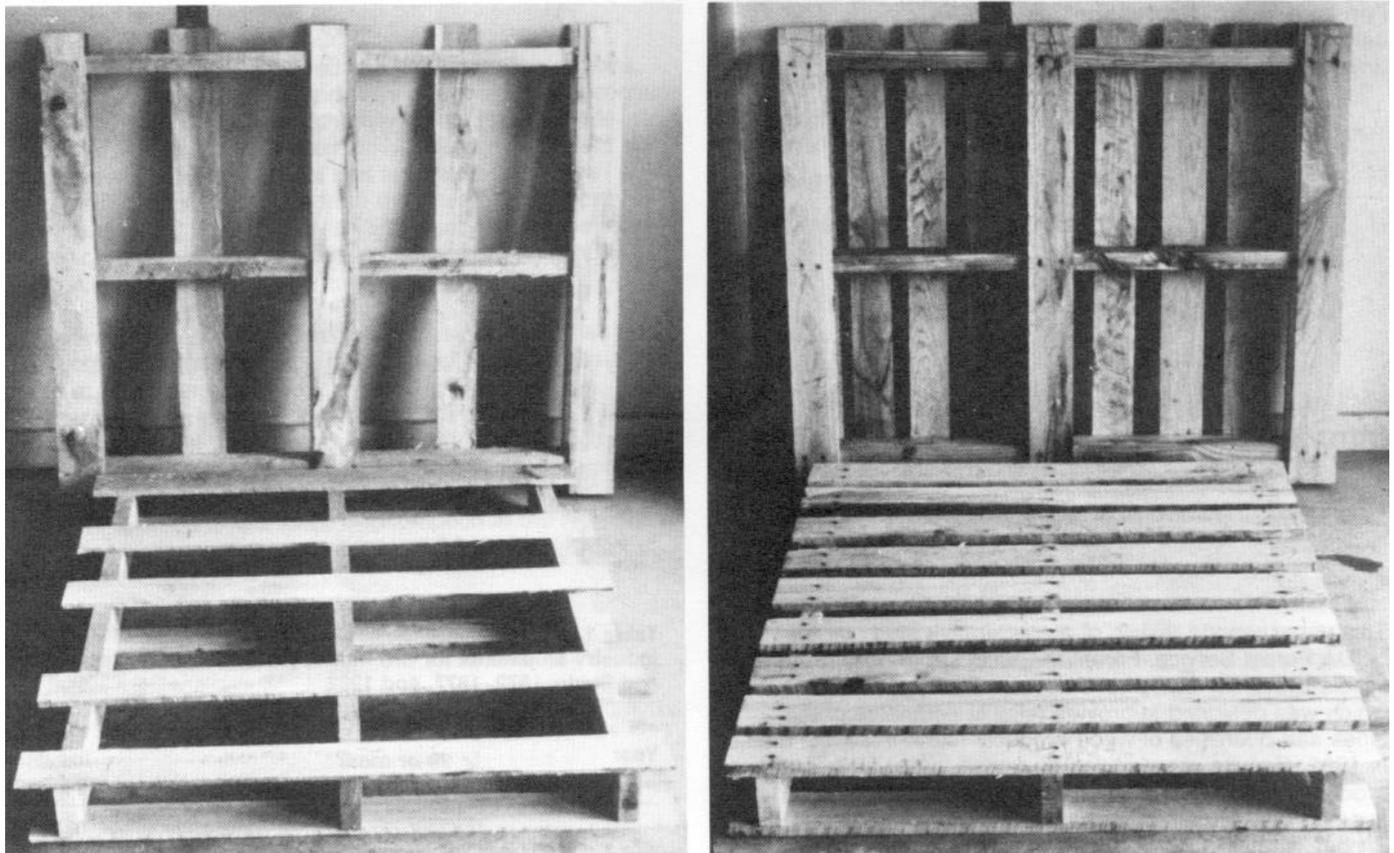


Figure 1.—Double wing, double faced, nonreversible, two-way entry pallets: expendable (left) and permanent (right). (M86 0012-9, M86 0012-7)

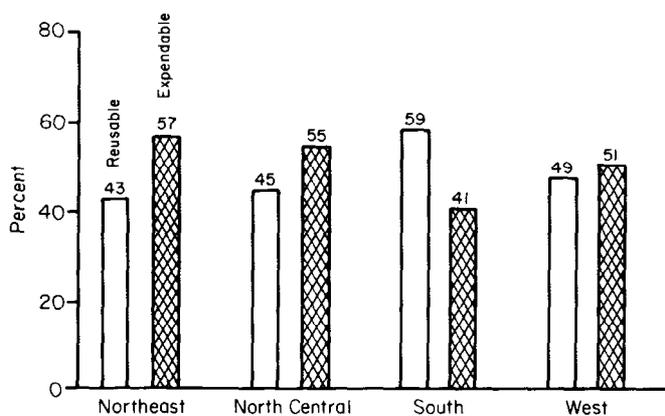


Figure 2.—Distribution of sampled pallets, by region and pallet type, 1982. (ML86 5015)

U.S. Wood Use per Pallet

The average pallet produced by manufacturers in this study contained 12.7 fbm of lumber and other wood products (table 2). One square foot (1-in. basis) of plywood and particleboard = 1 fbm of lumber. Volume used in this report is the actual volume of wood in the finished pallet. The rough volume of wood in pallets (the actual volume plus that removed in notching and chamfering) is reported in appendix table A-1.

Nearly 40 percent of all pallets studied were made entirely from a single material, either lumber, hardwood lumber, or softwood lumber. Nearly 80 percent were made from either all hardwood lumber or all softwood lumber.

Differences Between Pallet Types

The need for greater strength and durability in reusable pallets, compared to expendable pallets, is reflected in the types and quantities of wood products used for each. Reusable pallets contain over 50 percent more wood than expendable pallets: 15.4 fbm per reusable pallet, versus 10.1 fbm per expendable pallet (table 2). Of the wood used in reusable pallets, 87 percent is hardwood lumber; in expendable pallets, 73 percent is hardwood lumber. Conversely expendable pallets use more than twice as much softwood lumber than reusable pallets. Only small amounts of plywood are used in either reusable or expendable pallets. Standard errors for these wood use estimates are shown in table 2.

Average wood content per pallet varies considerably by pallet style and size. Wood use estimates for selected pallet styles are presented in appendix table A-2; estimates for pallet sizes are shown in appendix table A-3.

Regional Variation in Wood Use per Pallet

There are important regional differences in (1) the quantities and types of wood used per pallet and (2) the types of pallets produced. These differences are caused by such factors as the types of industries being supplied and the distance from pallet producer to consumer. But differences largely reflect regional differences in timber characteristics and availability. Pallets made in the Northeast and North Central regions are almost exclusively oak and other hardwood lumber, because of the abundance and low cost of lower grade hardwood timber. Pallets produced in the South, although made mostly of hardwood lumber, contain more softwood lumber and plywood than those in the Northeast and North Central regions. The abundance of softwood timber in the West is responsible for the predominance of softwood lumber used in western pallets.

Table 2.—Average wood content (\pm standard error) of pallets manufactured in the United States, by type of pallet, wood product, species group, and region, 1982

Pallet type/ wood product	Northeast	North Central	South	West	United States
	----- Fbm -----				
Reusable					
Hardwood lumber	14.3 \pm 0.5	14.2 \pm 0.4	15.1 \pm 0.4	2.3 \pm 0.8	13.3 \pm 0.3
Oak	7.0 \pm .6	8.1 \pm .5	8.8 \pm .4	.6 \pm .4	7.4 \pm .3
Other hardwoods	7.3 \pm .6	6.0 \pm .5	6.3 \pm .4	1.8 \pm .7	5.9 \pm .3
Softwood lumber	.0 \pm .0	.2 \pm .1	.4 \pm .2	14.7 \pm 1.1	1.8 \pm .2
Plywood ¹	.0 \pm .0	.1 \pm .1	.3 \pm .1	.6 \pm .4	.2 \pm .1
Total, all wood ²	14.3 \pm .5	14.5 \pm .4	15.8 \pm .4	17.6 \pm .7	15.4 \pm .2
Expendable					
Hardwood lumber	8.1 \pm .3	7.9 \pm .3	8.6 \pm .4	.5 \pm .3	7.4 \pm .2
Oak	3.6 \pm .3	3.1 \pm .3	3.8 \pm .4	.1 \pm .1	3.1 \pm .2
Other hardwoods	4.5 \pm .4	4.9 \pm .3	4.7 \pm .4	.4 \pm .3	4.3 \pm .2
Softwood lumber	.4 \pm .2	1.4 \pm .3	2.4 \pm .4	12.4 \pm .7	2.7 \pm .2
Plywood ¹	.0 \pm .0	.0 \pm .0	.0 \pm .0	.2 \pm .2	³ .0 \pm .0
Total, all wood ²	8.6 \pm .2	9.4 \pm .2	11.0 \pm .3	13.1 \pm .7	10.1 \pm .2
Total, all pallets					
Hardwood lumber	10.8 \pm .4	10.7 \pm .3	12.4 \pm .3	1.4 \pm .5	10.4 \pm .2
Oak	5.1 \pm .3	5.4 \pm .3	6.7 \pm .3	.3 \pm .2	5.3 \pm .2
Other hardwoods	5.7 \pm .3	5.4 \pm .3	5.7 \pm .3	1.1 \pm .4	5.1 \pm .2
Softwood lumber	.3 \pm .1	.9 \pm .2	1.3 \pm .2	13.5 \pm .7	2.2 \pm .2
Plywood ¹	.0 \pm .0	.1 \pm .1	.2 \pm .1	.4 \pm .2	.1 \pm .0
Total, all wood ²	11.1 \pm .3	11.7 \pm .3	13.8 \pm .3	15.3 \pm .5	12.7 \pm .2

¹ Includes small amounts of particleboard.

² Totals may not add due to rounding.

³ Less than 0.05 fbm.

Pallets made in the Northeast and North Central regions contain nearly equal amounts of wood, but less than pallets made in other regions. In the Northeast, the average pallet contained 11.1 fbm of wood (table 2). Slightly lesser amounts of oak were used than other hardwood species. Pallets made in the North Central region contained more wood at 11.7 fbm but contained less hardwood lumber. Hardwood lumber was equally divided between oaks and other species. Pallets produced in the South and West regions contained significantly more wood, 13.8 fbm and 15.3 fbm respectively, than those produced in the Northeast and North Central regions. Pallets produced in the West were larger, on the average, than those produced in any other region and contained mostly softwood lumber. The larger average wood use in the West is caused by the lower strength-to-volume ratios for softwood lumber compared to hardwood lumber. Estimates of wood use by pallet type, region, and wood product, and their associated standard errors are shown in table 2; estimates by geographic division are shown in table A-4.

Regional differences in average wood content for all pallets, as described above, are similar to the regional differences in reusable pallets and regional differences in expendable pallets. The ratio of wood in expendable pallets to reusable pallets increases from East to West and from North to South. Thus, the greatest relative difference in wood use between reusable and expendable pallets exists in the Northeast.

There are significant regional differences in the frequency of pallet types produced. More than half of all pallets sampled from the Northeast and North Central regions are expendable, whereas more than half of the pallets sampled from the South are reusable (table 3). Pallets from the West were nearly equally divided between reusable and expendable pallets.

Table 3.—Estimated regional pallet production, by pallet type, 1982

Region	Value added by manufacture ¹	Pallet production*		Estimated pallet production		
		Reusable	Expendable	Reusable	Expendable	Total
		<i>Pct</i>		<i>Million</i>		
Northeast	18.4	43	57	18.1	23.9	42.0
North Central	34.6	45	55	35.5	43.4	78.9
South	36.1	59	41	48.6	33.7	82.3
West	10.9	49	51	12.2	12.6	24.8
United States	100.0	50	50	114.3	113.7	3228.0

¹ Based on data from the U.S. Department of Commerce, Bureau of the Census (1985).

² From figure 2.

³ National Wooden Pallet and Container Association (1984)

Estimated Total Wood Consumption

Because United States pallet producers are the Nation's single largest consumers of hardwood lumber, it is important to develop reliable estimates of timber demand. National and regional estimates of wood consumed by pallet type and wood product type are developed from information in this study and from information developed by the National Wooden Pallet and Container Association and the U.S. Census Bureau.

The estimation procedure was as follows:

First, we took the total number of pallets produced in 1982 (National Wooden Pallet and Container Association 1984) and separated it into regional production. This separation was based on the proportion of value added by manufacturers (table 3) in each region from the 1982 Census of Manufacturers (U.S. Department of Commerce, Bureau of the Census 1985). Second, we separated the number of units produced in each region into the number of reusable and the number of expendable pallets. This separation was based on proportions (fig. 2) from this study. The number of pallets of each type produced in each region is shown in table 3. Third, we multiplied the number of units of each pallet type in each region (table 3) by the average wood content per reusable or expendable pallet (table 2) for each region, wood product, and species group. Finally, we multiplied the wood content by a production waste factor of 1.33. This factor was calculated as the ratio of the pallet plant owners' estimate of 17 fbm of wood consumed per pallet (appendix C) to the average wood content per pallet of 12.7 fbm (table 2). The resulting wood consumption by type of pallet, wood product, and species group, is shown in table 4. The total United States estimates are the sum of regional estimates; estimates for all pallets are the sum of the estimates for reusable and expendable pallets.

The 228 million pallets produced in 1982 required nearly 3.9 billion fbm of wood products to build (table 4, fig. 3). Of this, more than 3.8 billion fbm (99 pct) was lumber. The remaining 1 percent was plywood and particleboard. Hardwood lumber accounted for 81 percent (3.1 billion fbm) of total wood consumption. Hardwood lumber consumption was nearly equally divided between oaks and other hardwoods. Less than 1 billion fbm of softwood lumber was consumed.

More than 1.5 billion fbm of wood was consumed in the South, more than any other region (table 4, fig. 4). Consumption in the North Central region was slightly less at 1.2 billion fbm. The Northeast and West regions consumed less than half as much wood as the North Central and South regions. Reusable pallet production in the South accounted for over 25 percent of all wood consumed in the United States for pallets. Within each region, wood consumption for reusable pallets exceeded that for expendable pallets. More than twice as much wood was used for reusable pallets in the South than for expendable pallets. In all other regions, wood consumption for reusable pallets was approximately 25 percent greater than for expendable pallets.

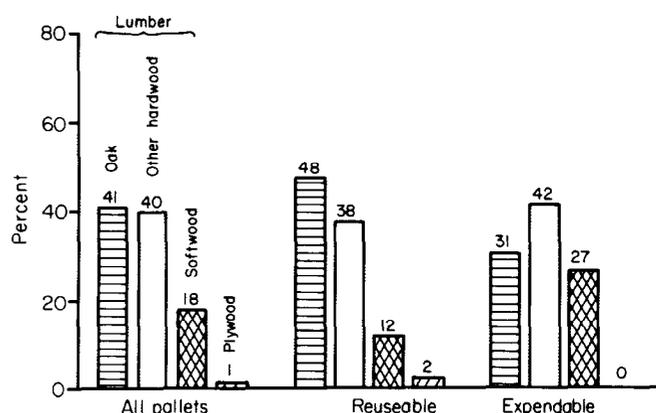


Figure 3.—Percent wood product consumption, by pallet type and wood product type, 1982. (ML86 5014)

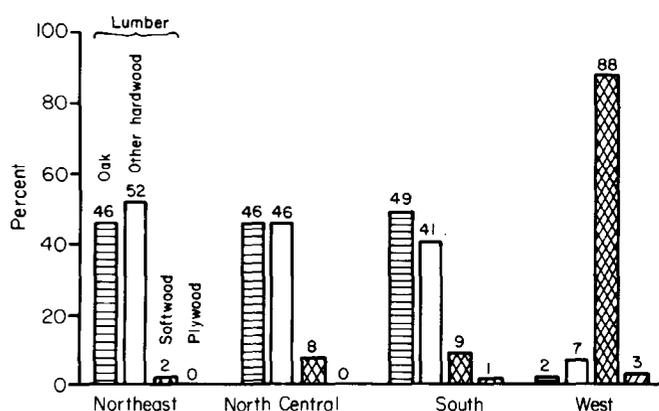


Figure 4.—Percent wood product consumption, by region and wood product type, 1982. (ML86 5013)

Pallet manufacturers obtain their wood raw materials from a variety of sources. McCurdy and Wildermuth (1981) found that in 1980 only 51 percent of all pallet firms purchased lumber. Many firms cut their own lumber from purchased cants, sawlogs, and stumpage. Most relied on a combination of purchased lumber and lumber cut at the pallet plant.

Table 4.—Wood products consumption by the U.S. pallet industry, by pallet type and wood product type, 1982

Pallet type/wood products	Northeast	North Central	South	West	United States
----- <i>Million fbm</i> -----					
Reusable					
Hardwood lumber	344	667	978	39	2,028
Oak	168	383	570	10	1,131
Other hardwoods	176	284	408	29	897
Softwood lumber	0	9	26	238	273
Plywood ¹	0	5	19	10	34
Total, all wood ²	344	681	1,023	287	2,335
Expendable					
Hardwood lumber	259	462	382	9	1,112
Oak	115	179	171	2	467
Other hardwoods	144	283	211	7	645
Softwood lumber	13	81	108	209	411
Plywood ¹	0	0	0	3	3
Total, all wood ²	272	543	490	221	1,526
Total, all pallets					
Hardwood lumber	603	1,129	1,360	48	3,140
Oak	283	562	741	12	1,598
Other hardwoods	320	567	619	36	1,542
Softwood lumber	13	90	134	447	684
Plywood ¹	0	5	19	13	37
Total, all wood ²	616	1,224	1,513	508	3,861

¹ Includes small amounts of particleboard.

² Totals may not add due to rounding.

Summary and Conclusions

Pallets manufactured in the United States in 1982 contained, on the average, 12.7 fbm of wood. Reuseable pallets contained significantly more wood than expendable pallets—15.4 fbm compared to 10.1 fbm. Pallets built in the Northeast and North Central regions were considerably smaller than those built in other regions but contained relatively more hardwood lumber. Pallets built in the West were larger than those from other regions and contained primarily softwood lumber. Southern pallets were intermediate in size and wood products distribution.

Pallet plant owners and operators canvassed in this study indicated that, on the average, 17 fbm of wood was required to build a pallet in 1982. Thus, for each board foot of wood in a finished pallet, 1.33 fbm of wood products was consumed. Using this factor of 1.33 fbm, an estimated 3.9 billion fbm of wood was consumed in 1982. This estimate includes purchased lumber and plywood as well as lumber cut at the pallet plant from purchased cants, sawlogs, and stumpage. Hardwood lumber accounted for 81 percent of all wood products consumed—3.1 billion fbm. Because published hardwood lumber production data do not include the volumes of lumber cut at pallet plants from purchased sawlogs and stumpage, strict comparisons of hardwood lumber consumption by the pallet industry to total U.S. hardwood lumber production are not possible.

Considerably less lumber is being consumed in the United States to produce pallets than had previously been thought. From 1960 through 1978 it was assumed that 25 fbm of lumber was required to construct the average pallet (U.S. Department of Agriculture, Forest Service 1982; National Wooden Pallet and Container Association 1984). Long-term projections made by the USDA Forest Service in 1982 indicated an average 22 fbm of lumber would be required per pallet from 1990 through the year 2030. In 1978 it was recognized that lumber consumption per pallet was overestimated. Between 1978 and 1982 lumber consumption estimates were gradually reduced from 25 to 18 fbm. This study confirms that wood consumption per pallet is indeed lower than had previously been thought. Despite this lower use per pallet, the pallet industry remains the single largest consumer of hardwood lumber, particularly lower quality lumber.

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Appendix A Statistical Tables

Table A-1.—Average rough content (\pm standard error) of wood in pallets manufactured in the United States, by type of pallet, wood product, species group, and region, 1982

Pallet type/wood product	Northeast	North Central	South	West	United States
----- Fbm -----					
Reusable					
Hardwood lumber	15.6 \pm 0.6	14.9 \pm 0.4	16.2 \pm 0.4	2.4 \pm 0.9	14.3 \pm 0.3
Oak	7.7 \pm .7	8.6 \pm .5	9.4 \pm .5	.6 \pm .4	6.0 \pm .3
Other hardwoods	7.9 \pm .6	6.3 \pm .5	6.8 \pm .4	1.9 \pm .8	6.3 \pm .3
Softwood lumber	.0 \pm .0	.2 \pm .1	.5 \pm .2	15.3 \pm 1.2	1.9 \pm .3
Plywood ¹	.0 \pm .0	.1 \pm .1	.4 \pm .2	.6 \pm .5	.3 \pm .1
Total, all wood ²	15.6 \pm .6	15.2 \pm .4	17.1 \pm .4	18.4 \pm .8	16.4 \pm .3
Expendable					
Hardwood lumber	8.5 \pm .3	8.2 \pm .3	9.0 \pm .4	.5 \pm .3	7.7 \pm .2
Oak	3.8 \pm .3	3.2 \pm .3	4.0 \pm .4	.2 \pm .2	3.3 \pm .2
Other hardwoods	4.7 \pm .4	5.0 \pm .3	4.9 \pm .4	.4 \pm .3	4.4 \pm .2
Softwood lumber	.5 \pm .2	1.5 \pm .3	2.5 \pm .4	12.5 \pm .7	2.7 \pm .2
Plywood ¹	.0 \pm .0	.0 \pm .0	.0 \pm .0	.2 \pm .2	.0 \pm .0
Total, all wood ²	9.0 \pm .2	9.6 \pm .2	11.5 \pm .3	13.2 \pm .6	10.4 \pm .2
Total, all pallets					
Hardwood lumber	11.6 \pm .4	11.2 \pm .3	13.2 \pm .4	1.5 \pm .5	11.0 \pm .2
Oak	5.5 \pm .4	5.6 \pm .3	7.2 \pm .3	.4 \pm .2	5.6 \pm .2
Other hardwoods	6.1 \pm .4	5.6 \pm .3	6.0 \pm .3	1.1 \pm .4	5.4 \pm .2
Softwood lumber	.3 \pm .1	.9 \pm .2	1.3 \pm .2	13.9 \pm .7	2.3 \pm .2
Plywood ¹	.0 \pm .0	.1 \pm .1	.2 \pm .1	.4 \pm .2	.1 \pm .0
Total, all wood ²	11.8 \pm .4	12.2 \pm .3	14.7 \pm .3	15.8 \pm .6	13.4 \pm .2

¹ Includes small amounts of particleboard.

² Totals may not add due to rounding.

³ Less than 0.05 fbm.

Table A-2.—Average wood content (\pm standard error) of pallets manufactured in the United States by pallet type and style, 1982

Pallet style	Reusable pallets	Expendable pallets	Total, all pallets
----- Fbm -----			
Single faced, nonreversible, two-way entry	14.6 \pm 1.3	8.2 \pm 0.7	10.9 \pm 0.8
Flush stringers, double faced, nonreversible, two-way entry	15.4 \pm .5	10.7 \pm .4	13.2 \pm .3
Flush stringers, double faced, nonreversible, four-way entry	14.6 \pm .2	9.9 \pm .2	12.7 \pm .2
Block, double faced, nonreversible, four-way entry	17.0 \pm 2.2	9.9 \pm .7	11.2 \pm .8
Flush stringers, double faced, reversible, two-way entry	21.2 \pm 1.4	11.5 \pm 2.0	19.8 \pm 1.4
Flush stringers, double faced, reversible, four-way entry	17.0 \pm .8	9.3 \pm 3.1	15.7 \pm 1.2
Single wing, single faced, nonreversible, two-way entry	14.8 \pm 1.5	8.8 \pm .5	11.1 \pm .8
Single wing, double faced, nonreversible, two-way entry	13.9 \pm 1.1	10.3 \pm .4	11.3 \pm .5
Single wing, double faced, nonreversible, four-way entry	13.2 \pm .7	9.9 \pm .6	11.8 \pm .6
Double wing, double faced, nonreversible, two-way entry	14.9 \pm 1.1	9.7 \pm .5	11.6 \pm .6
Double wing, double faced, nonreversible, four-way entry	15.3 \pm 1.1	11.1 \pm .6	12.9 \pm .7

Table A-3.—Average wood content (\pm standard error) of pallets manufactured in the United States, by pallet type and size class, 1982

Size class	Reusable pallets	Expendable pallets	Total, all pallets
<i>In.</i>	<i>Fbm</i>		
48 x 40	15.2 \pm 0.2	10.8 \pm 0.3	13.9 \pm 0.2
48 x 48	20.3 \pm .8	12.6 \pm 1.0	18.9 \pm .8
40 x 48	15.9 \pm .5	12.1 \pm 1.1	14.9 \pm .6
42 x 42	15.3 \pm .9	10.4 \pm .6	12.6 \pm .6
48 x 42	17.3 \pm 1.0	10.9 \pm .5	14.7 \pm .9
36 x 36	10.5 \pm .4	8.9 \pm .5	9.7 \pm .3
36 x 48	13.4 \pm 1.1	10.0 \pm .9	11.3 \pm .8
40 x 40	14.7 \pm 1.0	8.9 \pm .5	12.8 \pm .9
44 x 44	14.3 \pm 1.3	11.1 \pm .7	13.0 \pm .9
44 x 40	14.2 \pm 1.2	10.3 \pm .8	12.3 \pm .9
30 x 30	9.1 \pm .0	6.5 \pm .5	6.7 \pm .5

Table A-4.—Average wood content (\pm standard error) of pallets manufactured in the United States, by type of pallet, wood product, species group, and Census Bureau division, 1982

Pallet type/ wood product	Northeast		North Central		South			West	
	New England	Middle Atlantic	East Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific
Reusable									
Hardwood lumber	12.1 \pm 1.1	14.7 \pm 0.6	14.1 \pm 0.4	14.4 \pm 0.5	15.0 \pm 0.6	14.1 \pm 0.6	16.3 \pm 0.9	15.8 \pm 2.8	1.1 \pm 0.6
Oak	7.7 \pm 1.3	6.9 \pm .7	6.4 \pm .5	13.0 \pm .8	8.2 \pm .7	8.3 \pm .7	10.3 \pm .7	1.7 \pm 1.7	.5 \pm .4
Other hardwoods	4.4 \pm 1.3	7.8 \pm .7	7.7 \pm .6	1.4 \pm .6	6.9 \pm .7	5.8 \pm .6	6.0 \pm .7	14.1 \pm 3.4	.7 \pm .5
Softwood lumber	.0 \pm .0	.0 \pm .0	.1 \pm .1	.5 \pm .5	.2 \pm .1	1.0 \pm .4	.2 \pm .2	2.7 \pm 2.7	15.8 \pm 1.1
Plywood ¹	.0 \pm .0	.0 \pm .0	.0 \pm .0	.4 \pm .4	.6 \pm .3	.2 \pm .2	.2 \pm .2	.0 \pm .0	.7 \pm .5
Total, all wood ²	12.1 \pm 1.1	14.7 \pm .6	14.2 \pm .4	15.2 \pm .6	15.8 \pm .6	15.3 \pm .5	16.7 \pm .8	18.5 \pm 4.0	17.5 \pm .7
Expendable									
Hardwood lumber	8.3 \pm .4	6.1 \pm .3	8.0 \pm .3	7.8 \pm 1.7	8.6 \pm .6	9.9 \pm .6	7.5 \pm .9	1.4 \pm .8	.0 \pm .0
Oak	3.3 \pm .5	3.8 \pm .4	2.8 \pm .3	6.8 \pm 1.7	2.5 \pm .5	5.6 \pm .8	4.3 \pm .7	.4 \pm .4	.0 \pm .0
Other hardwoods	5.0 \pm .6	4.2 \pm .4	5.1 \pm .3	1.0 \pm .7	6.1 \pm .6	4.3 \pm .7	3.2 \pm .5	1.0 \pm .7	.0 \pm .0
Softwood lumber	.2 \pm .2	.5 \pm .2	1.3 \pm .3	2.8 \pm 1.5	1.7 \pm .5	.3 \pm .2	5.1 \pm 1.0	13.2 \pm 1.4	11.9 \pm .8
Plywood ¹	.0 \pm .0	.0 \pm .0	.0 \pm .0	.0 \pm .0	.0 \pm .0	.0 \pm .0	.0 \pm .0	.0 \pm .0	.3 \pm .3
Total, all wood ²	8.5 \pm .4	8.6 \pm .3	9.3 \pm .2	10.6 \pm .8	10.3 \pm .4	10.2 \pm .6	12.6 \pm .6	14.6 \pm 1.1	12.2 \pm .8
Total, all pallets									
Hardwood lumber	9.3 \pm .5	11.3 \pm .4	10.4 \pm .3	12.8 \pm .7	12.3 \pm .5	12.6 \pm .5	12.2 \pm .8	4.0 \pm 1.5	.7 \pm .4
Oak	4.4 \pm .6	5.3 \pm .4	4.2 \pm .3	11.5 \pm .6	5.8 \pm .5	7.4 \pm .6	7.5 \pm .6	.6 \pm .4	.3 \pm .2
Other hardwoods	4.9 \pm .6	6.0 \pm .4	6.1 \pm .3	1.3 \pm .5	6.5 \pm .5	5.3 \pm .5	4.7 \pm .4	3.4 \pm 1.4	.4 \pm .3
Softwood lumber	.2 \pm .1	.3 \pm .1	.9 \pm .2	1.0 \pm .5	.8 \pm .2	.8 \pm .3	2.4 \pm .5	11.3 \pm 1.5	14.2 \pm .7
Plywood ¹	.0 \pm .0	.0 \pm .0	.0 \pm .0	.3 \pm .3	.3 \pm .2	.1 \pm .1	.1 \pm .1	.0 \pm .0	.5 \pm .3
Total, all wood ²	9.5 \pm .5	11.6 \pm .4	11.2 \pm .3	14.2 \pm .5	13.5 \pm .5	13.5 \pm .5	14.8 \pm .6	15.3 \pm 1.1	15.3 \pm .6

¹ Includes small amounts of particleboard.

²Totals may not add due to rounding.

Appendix 6 Survey Sample Design and Data Analysis Procedures

This study is based on a stratified cluster sample of U.S. pallet manufacturers. A stratified cluster sampling procedure was used to account for regional differences in wood use and to minimize sampling costs. An explanation of stratified cluster sampling can be found in Cochran (1963).

A complete list of U.S. pallet manufacturing establishments was obtained from Dun and Bradstreet.² The list was stratified by the nine U.S. Department of Commerce, Bureau of the Census geographical divisions (fig. B-1). The number of clusters in a region was proportional to production (table B-1).

² Dun and Bradstreet, Inc., Marketing Services Division, 99 Church Street, New York, NY 10007.

At each cluster location, five establishments were selected for sampling. These five establishments were located as close together as possible to minimize travel costs. Only establishments with pallet inventories on hand were included in the study. No pallets were made specifically for the study. At each establishment, up to five pallets of different styles and sizes were purchased from existing inventory of pallets manufactured in 1982. Originally, no more than three pallets of any particular type, style, and size class were to be purchased at a single plant cluster. This restriction was later lifted to achieve an adequate sample size. Since most establishments inventory only their most commonly produced pallet types and many establishments produce pallets to meet specific orders, it was not possible to obtain five different pallets at each establishment. The resulting

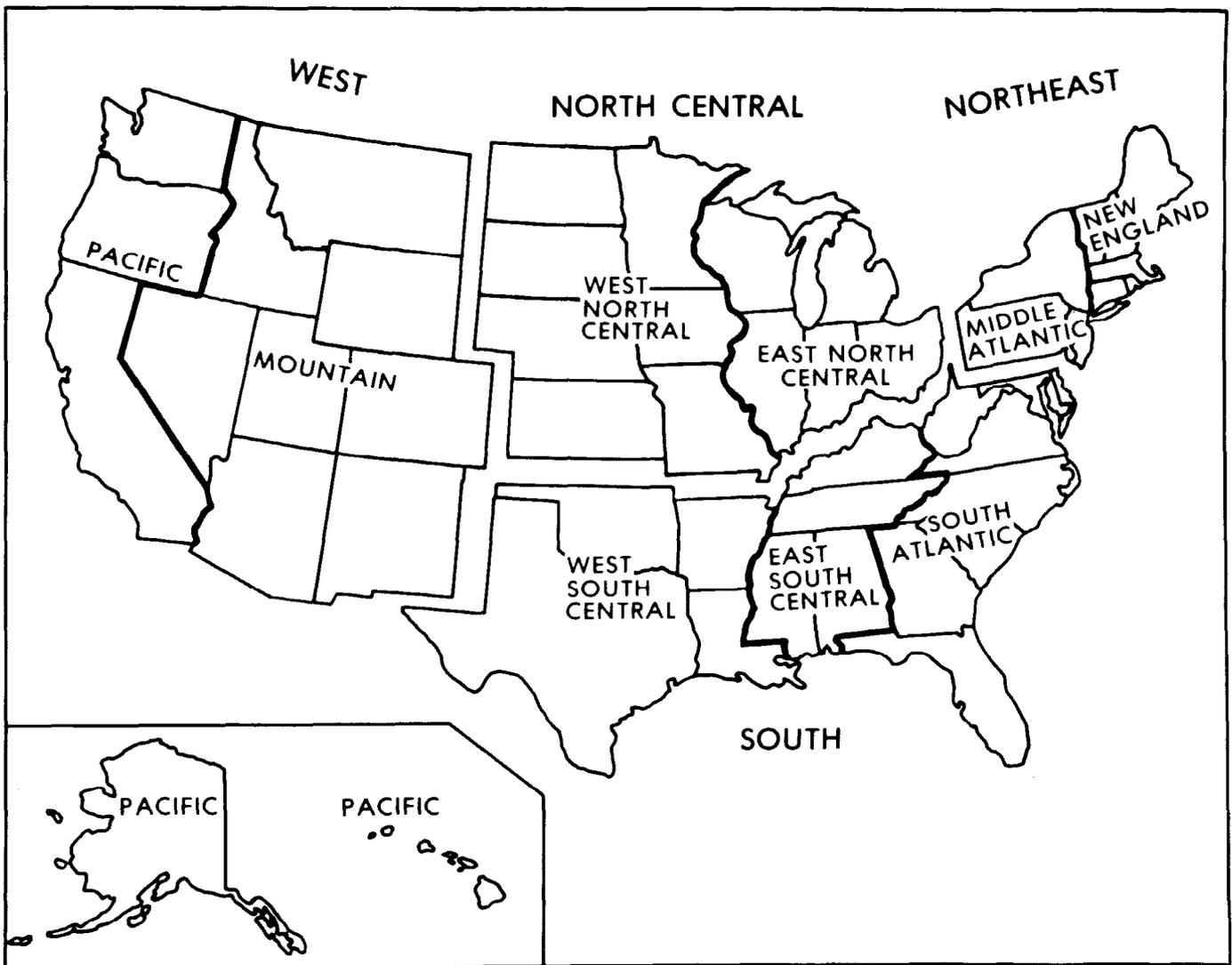


Figure B-1.—U.S. Department of Commerce, Bureau of the Census, regions and geographic divisions of the United States. (M86 5002)

study sample consisted of 921 pallets (table B-2). The sample was originally designed to estimate the amount of wood in the major types, styles, and sizes of pallets produced. It was not specifically designed to estimate frequencies of production. However, during the course of the study, it became apparent that the sampling procedure did in fact estimate both the amount of wood contained in pallets and their frequency of production. Pallets included in the sample were obtained from producer's inventories. Because producers inventory only their most frequently produced pallets and because the restriction of allowing only three pallets of any particular type, style, and size from a single cluster to be included in the sample was lifted, the sample became self-weighting. That is, the types, styles, and sizes most frequently produced appear more frequently in the sample. Thus, the sample can be considered a random sample with probability proportional to frequency. This is confirmed by comparisons of statistics from this study to statistics from a study previously conducted in 1977 by the National Wooden Pallet and Container Association (1979). Both studies indicated that nearly equal numbers of reusable and expendable pallets are produced annually. Pallet distribution by size class are also very similar:

Size class	1977 Survey	Current study
<i>In.</i>	<i>Pct</i>	<i>Pct</i>
48 x 40	27	20
48 x 48	5	5
40 x 48	5	5
42 x 42	3	6
36 x 36	2	4
36 x 48	2	2
48 x 42	3	4
40 x 40	1	2
All other	<u>52</u>	<u>52</u>
Total	100	100

The similar distributions of pallets by type and by size class between these two studies indicate that the pallet sample in this study was representative of total pallet production.

To determine the volume of wood in each pallet by species, each pallet component was measured with a tape to the nearest 1/16 inch and identified by wood product type and species. No deductions were made for chamfering or notching. The wood volume of each piece was calculated, and volumes were summed by type of wood product and species. Percent oak lumber, other hardwood lumber, softwood lumber, softwood plywood, and particleboard were then calculated for the pallet. Other data recorded at the establishment for each pallet included an identification number, cluster code, state code, establishment code, pallet type, style, and size class, stringer length, and deck length.

Table B-1.—Sample cluster locations

Region/Division	Cluster	
Northeast		
New England	Newington, CT East Bridgewater, MA	Milton, VT
Middle Atlantic	Jersey City, NJ Essex, NY Herkimer, NY North Tonawanda, NY Carnegie, PA	Clifford, PA Mifflintown, PA Mill Hall, PA Pittsburgh, PA
North Central		
East North Central	Batavia, IL Chicago, IL Joliet, IL Fairmont, IN Middleburg, IN New Palestine, IN Benton Harbor, MI Coleman, MI Mio, MI North Street MI	Vanderbuilt, MI Bainbridge, OH Cleveland OH Newbury, OH Norwalk, OH Portsmouth, OH Antigo, WI Racine, WI Whitewater, WI
West North Central	Iola, KA Minneapolis, MN Marble Hill, MO	Piedmont, MO Springfield, MO
South		
South Atlantic	Fort Pierce, FL Douglasville, GA Locust, NC Spruce Pine, NC	Marietta, SC Ashland, VA Prospect, VA
East South Central	Whistler, AL Eubank, KY Lewisburg, KY	Collins, MS Bolivar, TN Summitville, TN
West South Central	Stephens, AR Lake Charles, LA Guthrie, OK	Dayton, TX Fort Worth, TX
West Mountain	Denver, CO	
Pacific	Los Angeles, CA Napa, CA Wilmington, CA	Portland, OR Camas, WA

The pallets were then transported to Tuskegee Institute, Alabama, where total wood volume was measured using a water displacement volumetric measurement procedure. The procedure was developed at the Forest Products Laboratory and measures wood volume to within 0.1 fbm. Details of this procedure can be found in McKeever, Burns, and Thomas (1985).

Table B-2.—Distribution of sampled pallets by division, region, and pallet type, 1982

Division/region	Clusters	Firms	Pallets		Total
			Reusable	Expendable	
New England	3	15	12	34	46
Middle Atlantic	9	45	68	71	139
Northeast	12	60	80	105	185
East North Central	19	95	99	154	253
West North Central	5	25	36	11	47
North Central	24	120	135	165	300
South Atlantic	7	35	84	62	146
East South Central	6	30	63	34	97
West South Central	5	25	52	44	96
South	18	90	199	140	339
Mountain Pacific	1	5	4	18	22
West	5	25	44	31	75
West	6	30	48	49	97
Total	60	300	462	459	921

Data from the nine Census Bureau geographic divisions were grouped into four Census Bureau regions--Northeast, North Central, South and West--for analysis. Prior to grouping, analysis of variance tests were performed to determine if total average wood content per pallet varied significantly among divisions within each of the four regions. The SAS procedure PROC GLM was used in the analysis (SAS Institute Inc. 1982). Results indicated no significant difference in average wood content per pallet between divisions in each of the four regions for reusable pallets and in three of four regions for expendable pallets:

Pallet type/ region	F-value	Pr>F
Reusable		
Northeast	3.22	0.0767
North Central	1.60	.2082
South	.92	.3994
West	.14	.7120
Expendable		
Northeast	.01	.9069
North Central	1.95	.1642
South	6.27	.0025
West	3.07	.0861

In the South, one division had wood use in expendable pallets which was significantly different from use in the other two divisions. Overall, little information was lost by grouping the data into the four Census Bureau regions.

Wood use per pallet was computed for each pallet type (reusable vs. expendable), and wood product type (oak lumber, other hardwood lumber, softwood lumber, and softwood plywood and particleboard) in each region. These estimates were calculated as simple arithmetic averages or sums of observations divided by numbers of observations. This estimation procedure is appropriate for sampling with probability proportional to frequency. Regional differences in wood use were analyzed using SAS procedures PROC MEANS and PROC GLM. Wood use per pallet differed significantly among regions for both pallet types and for all wood types except plywood at the 1 percent significance level:

Pallet type/wood product	F-value	Pr>F
Reusable		
Hardwood lumber	84.75	0.0001
Oak	34.04	.0001
Other hardwoods	13.70	.0001
Softwood lumber	369.00	.0001
Plywood and particleboard	1.56	.1977
Total	6.36	.0003
Expendable		
Hardwood lumber	73.43	.0001
Oak	17.42	.0001
Other hardwoods	21.92	.0001
Softwood lumber	149.35	.0001
Plywood and particleboard	2.76	.0417
Total	29.09	.0001

Plywood use in expendable pallets differed significantly at the 5 percent level. There were no significant regional differences for plywood use in reusable pallets. The significant variation in regional wood use indicates that regional data more fully explain pallet industry wood use than national data alone. Regional data better reflect the timber resources, and industrial markets available to the pallet producer, than national data alone.

Appendix C Description of Study Firms

Acknowledgment

During the study, certain information was obtained about the pallet plants from which pallets were purchased. In general, these plants produced more pallets than the industry average and consumed a greater volume of wood as compared to industry figures for 1980 (McCurdy and Wildermuth 1980):

The authors thank the owners and operators of the pallet manufacturing firms who provided pallets for this study.

Production class	Plant distribution	
	1982	1980
<i>Number of pallets</i>		
----- Pct -----		
PRODUCTION		
1 to 20,000	12	25
20,001 to 60,000	20	25
60,001 to 140,000	24	24
140,001+	44	25
<i>Thousand fbm</i>		
VOLUME		
0 to 250	12	25
251 to 1,000	22	25
1,001 to 3,000	31	23
3,001+	35	27

Sampled firms produced an average 187,000 pallets during 1982, compared to the industry average of 112,000 pallets in 1980. The higher average production for sampled firms is to be expected because pallets were purchased from plants which maintained pallet inventories. Many smaller firms did not maintain inventories or were temporarily out of production when visited.

Pallet plant owners are very knowledgeable about the types and quantities of wood products used in their pallets. They estimated that 17 fbm of wood was used to produce a pallet in 1982. This is slightly lower than the 20 fbm estimated for 1980 by McCurdy and Wildermuth (1981) and the 18 fbm estimated for 1982 by the National Wooden Pallet and Container Association (1984). The distribution of wood types used in pallets, as estimated by the plant owners, was very similar to findings of this study:

Wood Type	Owner estimate	Study results
	----- Pct -----	
Oak	41	42
Other hardwood	41	40
Softwood	18	17
Plywood	0	1

Based on the owners' apparent knowledge of their operations, the estimated 17 fbm of wood consumed per pallet should be realistic.