

# A study of lumber use in pallets manufactured in the United States: 1982 and 1985

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Dwight R. McCurdy

James T. Ewers

Fan H. Kung

David B. McKeever

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## Abstract

Large amounts of wood products are used annually by the U.S. pallet industry. Studies were conducted in 1982 and 1985 to collect information on the volumes and types of wood being used by domestic pallet manufacturers. This information may be used to more accurately predict the future lumber demand of this industry. The average volumes of the 921 pallets sampled in 1982 and the 478 pallets sampled during 1985 were 13.43 and 13.89 board feet, respectively. The volumes varied significantly between expendable and reusable pallets and also among the nine Bureau of Census regions. Differences in the species mix were evident between 1982 and 1985, between expendable and reusable pallets, and among the nine regions.

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More than one-half of U.S. annual hardwood lumber production is reportedly used in the manufacturing of wooden pallets (8). Approximately 277 million pallets were manufactured in the United States in 1980 (4). This number rose to 450 million by 1985 (2). Various estimates of the lumber used per pallet have been made in the past ranging from a high of 25 to a low of 18 board feet (BF).

National studies to determine the volume and type of lumber contained in pallets were conducted in 1982 and 1985. The 1982 study objective was to confirm or negate whether the "best guess" estimates of the past were still correct. The refined follow-up study of 1985 was conducted to validate the 1982 data and to note if any trends could be observed.

The data were analyzed both on national and regional levels. The 1985 data are presented first, followed by selected comparisons to the 1982 data.

## Study methodology

A stratified sampling procedure was used in the 1985 study. A state-by-state listing of all known pallet

manufacturers compiled by the USDA Forest Service served as the population base for the study (1). The states were grouped into regional stratum as defined by the U.S. Census Bureau (Fig. 1).

The number of pallets to be sampled in each region was determined according to the following formula:

$$N_i = (t \times CV_i / DSE)^2$$

where:

$N_i$  = the number of pallets to be sampled in the  $i$ th Bureau of Census region

$t$  = the tabulated t-value

$CV_i$  = the coefficient of variation in pallet volume in the  $i$ th Bureau of Census region (expressed as a percentage).

$DSE$  = the desired sampling error (expressed as a percentage)

In practice, two was used as the t-value for a 90 percent confidence level and five was used for the arbitrary desired sampling error. The coefficient of variation for each strata was derived from the results of a similar study conducted in 1982 (3).

Having determined the number of sample pallets required for each region (Table 1), the following procedure was used to identify the plants from which the sample pallets were to be obtained. Pallet manufacturers that either employed more than 50 people, or were members of the National Wooden Pallet and Container Associ-

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The authors are, respectively, Professor, Researcher, and Professor, Dept. of Forestry, Southern Illinois Univ., Carbondale, IL 62901; and Research Forester, Forest Prod. Lab., Madison, WI 53705. Funds for this research were provided by the USDA Forest Serv., Forest Prod. Lab., Madison, WI and the Forestry Sci. Lab., Princeton, WV under Research Agreement FP-81-0315. This paper was received for publication in February 1987.

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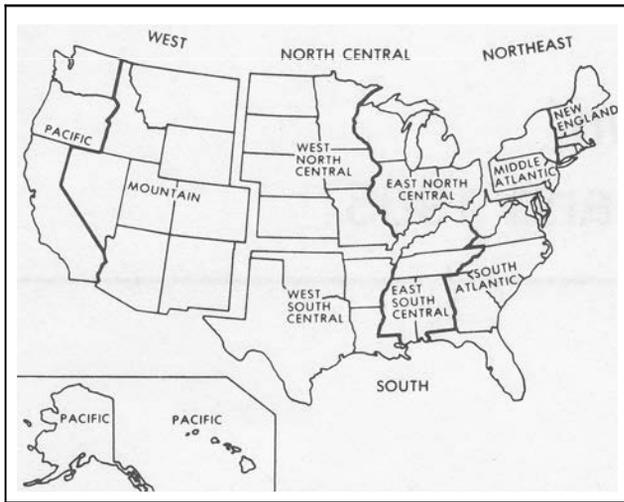


Figure 1. — Regions and census divisions of the United States.

ation were plotted on a regional map. Areas with relatively high concentrations of plotted firms were chosen as target areas for data collection. The reasoning behind this was twofold. First, since the pallet industry is very competitive, it was more likely that larger firms would still be in business. Second, by targeting areas with high concentrations of larger firms, traveling costs would be minimized. It should be noted, however, that once researchers were situated in a particular area, an attempt was made to include all pallet manufacturers in the area, regardless of size.

At each plant, up to five pallets of different types and/or sizes were chosen to be included in the study. Since most producers manufacture pallets to meet specific orders, the variety of sizes or types was limited, and often less than five pallets were available at many plants.

The sampled pallets were not random samples from each firm, but were representative samples because they usually represented the most frequently produced type, or the modes of the individual firm's production. However, when viewed on a regional level, the sample pallets can be considered random samples because the most frequently produced type for one firm may be different from another firm, and no selection restriction on sampling had been imposed relative to size or type of pallet. Statistically, this mode form of sampling should be more precise than random sampling. If the population is normally distributed, the mode, median, and mean should be the same. If the population is not normal, variance of the mode is smaller than the variance of individual observations. Therefore, the mode sampling should give an accurate and precise estimate of wood used per pallet.

<sup>1</sup>Nonexpendable pallets, also called permanent or reusable, are built with thicker (and often more durable) wood than expendable pallets and therefore can be used longer. Expendable pallets are more likely used for shipping; nonexpendable pallets are used for warehouse applications.

TABLE 1. — Study sample, 1982 and 1985.

Region	1982		1985	
	Firms	Pallets	Firms	Pallets
New England	15	46	11	43
Mid-Atlantic	45	139	20	72
East North Central	95	253	13	61
West North Central	25	47	8	29
South Atlantic	35	146	16	72
East South Central	30	97	12	48
West South Central	25	96	12	56
Mountain	5	22	11	49
Pacific	25	75	10	48
	300	921	113	478

TABLE 2. —Daily production data by region.<sup>a</sup>

Region	Number of firms	Average daily production per firm	Average daily production per region (thousands)	Weighting ratio
New England	156	502	78	78/1,948
Mid-Atlantic	294	619	182	182/1,948
East North Central	702	685	481	481/1,948
West North Central	181	720	130	130/1,948
South Atlantic	333	902	300	300/1,948
East South Central	267	747	199	199/1,948
West South Central	176	1,272	224	224/1,948
Mountain	52	695	36	36/1,948
Pacific	179	1,777	318	318/1,948

<sup>a</sup>Source: McCurdy and Ewers, 1986.

For each pallet in the study sample, a rough volume was measured and calculated. The rough volume was obtained via tapes with measurements made to the nearest 1/8 inch. No deductions were made for notching or chamfering. Each board in the pallet was measured and the board volumes added to estimate the pallet's rough volume. Rough volumes were used to compute the percentage of total pallet volume by wood species type. The rough volume measurements were made at the manufacturing facility.

Regional means were calculated as a simple arithmetic mean; the national mean was computed as a weighted average. The stratum weight was calculated by dividing the daily production of pallets in the region by the total daily production in the United States. Daily production data by region are presented in Table 2.

## Findings

### Volume of wood used nationally

The average volume of lumber used per pallet in the United States during 1985 was 13.89 BF (Table 3). When the sample is divided into expendable and nonexpendable pallets, the average volumes were 11.23 and 16.24 BF, respectively.<sup>1</sup> These figures are weighted estimates based on the total average daily production within each region. It should be pointed out that all volume figures included in this report do not include wood residue resulting from the manufacturing process.

### Species of wood used nationally

Nationwide, 73 percent of the lumber used in pallet production was from hardwoods (Table 4). Thirty-four percent was oak; 39 percent was from other hardwoods. Softwoods totaled 25 percent, and the remaining 2 percent was plywood/particleboard. The percentage of soft-

wood was greater in nonexpendable pallets (27%) than in expendable (24%). The percentage of other hardwoods was greater in expendable (41%) than in nonexpendable (37%). The oak component was relatively stable, comprising 34 percent of the wood used in expendable pallets and 33 percent in nonexpendable pallets.

Viewing the data solely on a national basis can be misleading, especially when interpreting species mix between expendable and nonexpendable pallets. Even though the percentage of softwoods was greater for nonexpendable pallets nationwide, seven of the nine Bureau of Census regions individually reported expendable pallets containing a higher percentage of softwood on the average (Table 4). The reasoning for this paradoxical situation is due to the weighting factors involved in calculating the national averages. The two regions using the greatest percentage of softwood (Pacific and Mountain) were also found to be producing a disproportionately large number of nonexpendable pallets. This resulted in inflating the percentage of softwood in nonexpendable pallets for the nation as a whole. The same reasoning can be used for other hardwoods. Seven of the nine regions reported nonexpendable pallets averaging a higher percentage of other hardwoods with the remaining two regions using equal amounts of other hardwoods in both their expendable and reusable pallets. Here again, if this is expanded to a national average, the result is a greater percentage of other hardwoods in expendable pallets. The regions primarily responsible for this discrepancy are the East North Central and Mid-Atlantic. These regions primarily use

other hardwoods and also produce a disproportionate amount of expendable pallets.

#### Comparisons to the 1982 data

Since the study methodologies differed for the 1985 and 1982 studies, it is necessary to first present the methodology by which the 1982 data were collected before making comparisons.

#### 1982 study methodology

A stratified cluster sample procedure was used to select the firms from which 921 pallets were purchased. Stratification was based on the nine Bureau of Census regions (Fig. 1). In each region, the number of firms from which pallets were obtained was approximately proportional to the total number of firms. The firms within each region were clustered in groups of five plants. There were 60 clusters. The firms within each cluster were located as close as possible to each other to minimize travel cost. Only plants with pallets in inventory were included in the study. At each plant, up to five pallets of different type and size were purchased from the existing inventory of pallets manufactured during 1982. A comparison of the study samples is shown in Table 1.

Volume per pallet was calculated by two separate methods in 1982. Exact volume estimates were obtained using the water displacement method (5). Rough volume estimates were calculated by tape measurements to the nearest 1/16 inch, similar to the method used in the 1985 study. Again, no deductions were made for notching or chamfering. The 1985 volume data are compared to these rough volume estimates (6).

#### Confirmation of volume estimates

Since the sampling technique differed for each of the two studies, they can be considered to be mutually independent. Therefore, the 1982 estimates can be confirmed by the 1985 survey and the 1985 estimates can be confirmed by the 1982 survey. For example, to confirm the national average BF volume per pallet, confidence intervals were calculated about each survey's mean. The estimate of the average volume per pallet obtained in 1985 is compared to the confidence interval derived from the 1982 study and the 1982 mean is compared to the 1985 confidence interval. If both estimates are confirmed, i.e. fall within each other's range, we will have greater faith in the estimates. If only one of the

TABLE 3. —Average volume of lumber per pallet and sample size by region, 1985.

Region	Board foot volume (sample size)		
	All pallets	Expendable	Nonexpendable
New England	11.17 (43)	10.45 (27)	12.38 (16)
Mid-Atlantic	13.72 (72)	10.66 (44)	18.35 (28)
East North Central	11.83 (61)	10.37 (39)	14.42 (22)
West North Central	13.22 (29)	10.76 (12)	14.96 (17)
South Atlantic	14.46 (72)	11.88 (23)	15.67 (49)
East South Central	13.57 (48)	10.16 (21)	16.22 (27)
West South Central	14.76 (56)	13.04 (27)	16.36 (29)
Mountain	16.29 (49)	11.89 (12)	17.71 (37)
Pacific	16.80 (48)	13.60 (14)	18.11 (34)
Total United States	13.89 (478)	11.23 (219)	16.24 (259)

TABLE 4 — Species of wood in pallets by region, 1985.

Region	All				Expendable				Nonexpendable			
	Oak	Other hardwood	Soft	Other <sup>a</sup>	Oak	Other hardwood	Soft	Other	Oak	Other hardwood	Soft	Other
	----- (% of pallet volume) -----											
New England	44	36	20	0	47	32	21	0	38	43	19	0
Mid-Atlantic	42	53	5	0	41	53	6	0	44	53	3	0
East North Central	29	61	10	0	30	55	15	0	28	72	0	0
West North Central	83	12	5	0	90	5	5	0	78	16	6	0
South Atlantic	46	46	8	0	31	44	25	0	54	46	0	0
East South Central	39	60	0	1	41	59	0	0	37	61	1	1
West South Central	41	31	27	1	35	30	35	0	47	31	21	1
Mountain	0	6	92	2	0	0	100	0	0	8	89	3
Pacific	1	0	88	11	0	0	94	6	1	0	86	13
Total United States	34	39	25	2	34	41	24	1	33	37	27	3

<sup>a</sup>Includes plywood and particleboard.

TABLE 5. — Regional range and 95 percent confidence interval for the average volume of wood per pallet, 1982 and 1985.

Region	Sample size	Average volume	Range		Confidence interval	
			Lower limit	Upper limit	Lower limit	Upper limit
----- (BF) -----						
New England						
1982	46	10.19*	4.42	20.99	9.08	11.31
1985	43	11.17*	4.36	19.45	10.01	12.33
Mid-Atlantic						
1982	139	12.38*	3.03	29.76	11.49	13.27
1985	72	13.72	5.01	38.38	12.12	15.33
E. N. Central						
1982	253	11.58*	2.93	39.58	11.02	12.15
1985	61	11.84*	4.50	31.08	10.67	13.00
W. N. Central						
1982	47	15.26	7.85	31.06	14.13	16.39
1985	29	13.22	4.25	21.35	11.52	14.93
South Atlantic						
1982	146	14.35*	1.27	44.65	13.34	15.36
1985	72	14.46*	4.90	34.50	13.13	15.89
E. S. Central						
1982	97	14.51*	2.84	32.20	13.51	15.52
1985	48	13.57*	4.42	35.68	12.04	15.10
W. S. Central						
1982	96	15.58*	5.20	38.61	14.39	16.77
1985	56	14.76*	6.00	26.95	13.49	16.03
Mountain						
1982	22	15.48*	4.92	37.58	14.62	17.15
1985	49	16.29*	4.87	57.30	13.85	18.72
Pacific						
1982	75	15.89*	4.92	37.58	14.62	17.15
1995	48	16.80*	4.36	60.30	14.14	19.45
Total United States						
1982	921	13.43*	1.27	44.65	13.08	13.78
1985	478	13.89	4.25	60.30	13.28	14.50

\* = Estimate confirmed by the other confidence interval.

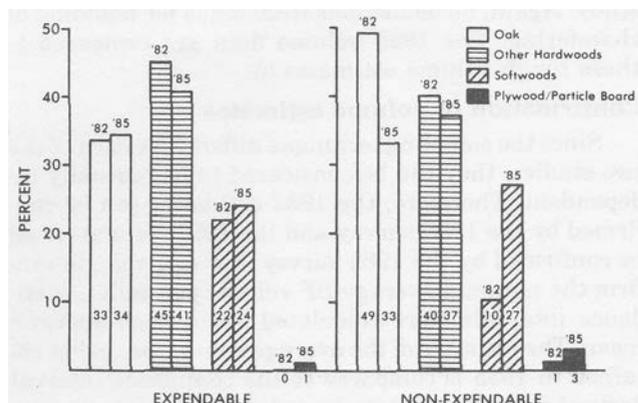


Figure 2. — Percent of wood species used per pallet, 1982 and 1985.

two are confirmed, we will trust the confirmed estimate more than the unconfirmed one. If both means are out of the other's confidence interval, we should reexamine the study methodology and possibly investigate further.

Looking at the pallet sample as a whole and basing the comparison on the 1982 methodology, Table 5 indicates that the 1985 national average of 13.89 BF is significantly greater than the 1982 average of 13.43 BF ( $\alpha = .05$ ). However, based on the 1985 methodology, the two national averages are statistically the same. Since the 1982 estimate was confirmed and the 1985 estimate was not, we should consider the national average of 13.43 BF to be the more trustworthy estimate. The reasoning for this is based on the following expla-

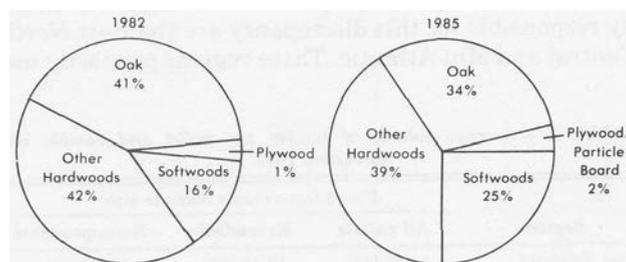


Figure 3. — Percent of wood species used per pallet by classification. 1982 and 1985.

nations: 1) the sample size in 1982 ( $N = 921$ ) was almost twice as large as in 1985 ( $N = 478$ ); and 2) the root mean square error in the analysis of variance table for testing regional differences in 1985 (6.2892) was greater than the error in 1982 (0.4247).

Comparing the 1982 and 1985 volume estimates on a regional level shows the West North Central region had a significantly higher volume estimate in 1982 and a significantly lower volume in 1985. The 1985 volume was significantly higher than the 1982 volume in the Mid-Atlantic region.

### Comparison of wood species mix

An overall decline in the use of oak and other hardwoods as raw materials for the pallet industry occurred between 1982 and 1985 (Fig. 2). The decline in hardwood use is being replaced by greater use of softwood lumber. Separating the sample into expendable and nonexpendable pallets also indicated changes in usage patterns (Fig. 3). An increase in the usage of softwood

lumber for nonexpendable pallets, and hardwood lumber for expendable pallets is occurring. We think this apparently illogical shift is due to differing study methodologies, not actual changes occurring in the industry.

In the 1982 study, results were based on the number of pallet-producing firms in each region. This wrongly assumed that for each region the number of pallets produced per firm was the same. Thus, the result underestimated the contribution made by regions that produced relatively large numbers of pallets from relatively few firms, and overemphasized the contribution made by regions producing fewer pallets from a greater number of firms. The 1985 study used a more representative approach of extrapolating figures based on the average number of pallets produced daily by each region.

### Summary and conclusions

To determine the amount of lumber used in pallets manufactured in the United States, 921 pallets manufactured during 1982 and 478 pallets made during 1985 were analyzed. These pallets were obtained from 300 and 113 firms, respectively. An average of 13.89 BF of lumber was used in the pallets analyzed in 1985. The average amounts used in 1985 varied significantly between expendable and nonexpendable pallets, with 11.23 and 16.24 BF, respectively. The 1985 figures are weighted estimates based on the total average daily regional production. In 1985, the average volume of lumber per pallet increased from east to west. The percentage of expendable pallets also increased from east to west.

In 1985, 73 percent of the wood used in the pallets came from hardwood tree species. The oaks accounted for nearly one-half of the hardwood volume. In addition,

the types of wood varied by the region in which the pallets were manufactured. For example, most of the pallets containing softwoods were manufactured in the Mountain and Pacific regions.

In future studies to determine the amount of wood in pallets, the sample of pallets analyzed should be stratified between expendable and nonexpendable pallets within each region. The number of pallets should be correlated with the coefficients of variation found in this study.

### Literature cited

1. Emanuel, D.M. 1985. Wooden Pallet Manufacturers. USDA Forest Serv., Northeastern Forest Expt. Sta., Forestry Sci. Lab., Princeton, W.V.
2. McCurdy, D.R. and J.T. Ewers. 1986. The pallet industry in the United States—1980 and 1985. Dept. of Forestry Publ., Southern Illinois Univ., Carbondale, Ill.
3. \_\_\_\_\_, F.H. Kung, and J.T. Ewers. 1984. A study of wood use in pallets manufactured in the United States—1982. Dept. of Forestry Publ., Southern Illinois Univ., Carbondale, Ill.
4. \_\_\_\_\_ and D.W. Wildermuth. 1981. The pallet industry in the United States—1980. Dept. of Forestry Publ., Southern Illinois Univ., Carbondale, Ill.
5. McKeever, D.B., M. Burns, and J. Thomas. 1985. An improved method for measuring the volume of large wooden objects. *Forest Prod. J.* 33(1):33-35.
6. \_\_\_\_\_, D.R. McCurdy, F.H. Kung, and J.T. Ewers. 1986. Wood use in pallets manufactured in the United States, 1982. Res. Bull. FPL-RB-17. USDA Forest Serv., Forest Prod. Lab., Madison, Wis.
7. SAS. 1982. SAS User's Guide: Statistics, Version 5 Edition. SAS Institute, Inc., Cary, N.C.
8. USDA Forest Service. 1982. An analysis of the timber situation in the United States, 1952-2030. Forest Res. Rept. No. 23, Washington, D.C.