NORTH CENTRAL FOREST EXPERIMENT STATION

Research Note NC-300

1992 FOLWELL AVE. ST. PAUL, MN 55108 FOREST SERVICE-U.S.D.A.

1983

DIMENSIONAL CHARACTERISTICS OF HARDWOOD TOP AND LIMB RESIDUE

Nels S. Christopherson, *Research Mechanical Engineer, Houghton, Michigan*

ABSTRACT.—Sawtimber harvesting in northern hardwood stands leaves behind a large amount of residue in the form of tops and limbs. This paper presents typical dimensional characteristics of residue for northern hardwood tops including data on lengths, widths, diameters, and complete branch details.

KEY WORDS: Wood energy, delimbing, biomass utilization, harvesting, topwood residue.

The abundant supply of wood in the United States has led to some wasteful practices, especially with respect to sawtimber residue. Developing new technology and markets will help encourage the utilization of these residues and thus reduce the needless waste of a natural resource.

USDA Forest Service scientists have determined that, after northern hardwood sawtimber harvesting, between 40 and 50 percent of a tree's weight above the stump is left as residue (Mattson and Carpenter 1975). For example, the average topwood residue weight from a 21-inch-d.b.h. sugar maple tree is about 2,000 pounds (Steinhilb and Winsauer 1976). If this single top were recovered for energy, it would be equivalent to one 42-gallon barrel of oil. In the Eastern U.S., an estimated 50 million dry tons of hardwood residue in the form of tops and limbs remain each year after harvesting (Carpenter 1980).

What makes topwood residue rather unique is that it becomes "available" for essentially a zero prior investment because current practice in timber harvesting depreciates the whole tree at time of harvest while utilizing only the saw log portion. This practice will eventually change as topwood harvesting becomes commonplace, but it presently provides an economic incentive.

Continuing research studies are investigating methods to recover this topwood residue. A complete recovery system would include schemes for:

1. Removing the residue from the forest to a landing or roadside,
2. transporting it to a location for further processing, or,
3. processing it in the forest or at the landing and then transporting it.

For the key elements—handling, transportation, and processing—certain facts must be known such as volumes per acre, weights, number of pieces per acre, and physical size of the material. Previous research studies have documented the volumes, weights, and densities per acre of residue tops and limbs (Winsauer and Steinhilb 1980, Steinhilb and Dye 1973, Grantham and Howard 1980, Bradley *et al.* 1980).

What has not been documented are the dimensional characteristics of topwood residue. To design both efficient and economical equipment to handle, transport, or process a top, researchers must know the actual diameters of the main stem and branches. Other details such as the number of branches and their angle with the main stem are also necessary, especially to design equipment to remove limbs. The results presented here will help to fill the gap in engineering data by providing the dimensional characteristics of hardwood top and limb residue. No attempt was made to document the density of tops per a given area or estimate weights or board feet, etc.

DESCRIPTION OF SITES

The topwood data presented in this paper came from a sample of 64 tops. To attempt to eliminate any bias due to logging practice or site differences, the tops were selected from three separate sites. All three sites were mixed northern hardwood stands on rolling terrain in the Upper Peninsula of Michigan: one in Houghton County, one in Keweenaw County, and one in Baraga County. The sites in Houghton and Keweenaw Counties, located on land owned by the Copper Range Company, were marked by that company for the sawtimber harvesting that took place approximately 6 months before the topwood measuring. The Baraga County site, owned by Michigan Technological University, was also marked and cut about 6 months earlier. All three sites were logged by different loggers. These sites were managed and marked for a selective sawtimber harvest which precludes the harvesting of trees under a certain minimum d.b.h. (usually 12 inches).

The breakdown of species of tops for each site is:

Baraga County– 13 red maple *(Acer rubrum)*
6 sugar maple *(Acer saccharum)*
1 elm *(Ulmus americana)*

Houghton County– 23 sugar maple *(Acer saccharum)*
1 yellow birch *(Betula alleghaniensis)*

Keweenaw County– 19 sugar maple *(Acer saccharum)*
1 yellow birch *(Betula alleghaniensis)*

PROCEDURE

At least 20 tops at each site were measured to provide representative data for a "typical" hardwood top. For each top measured, the following data were recorded with all diameters "outside bark" (d.o.b.):

1. Species.
2. Stump diameter.
   All stumps were identified for each top, and diameters were measured at approximately 1 foot above the ground.
3. Stump to top butt distance (merchantable length).
   Measured 1 foot from stump to butt of top along ground.
4. Butt diameter of top.
5. Length of top.
   Length from top butt to top of foliage.
6. Crown width (maximum).
7. Branch data for those greater than 4 inches d.o.b.
   The number of branches, the location of their juncture with the main stem, their angle with the main stem, and their length to 4 inches d.o.b.
8. Number of branches less than 4 inches d.o.b.

DATA ANALYSIS

The first step in the analysis was to establish whether any site or species differences existed. The data were grouped into the following variables by site: Species; stump to top butt distance; stump diameter; top butt diameter; crown width; top length; number of branches in each of six branch classes by diameter in inches, 0-3.9, 4-5.9, 6-7.9, 8-9.9, 10-11.9, 12-15; and branch angle with the main stem of 0-29, 30-59, or 60-90 degrees. From an engineering viewpoint, there are no major site differences as evidenced by means and corresponding standard deviations of the variables. By comparing the results of Houghton and Keweenaw Counties (predominately sugar maple) to those of Baraga County (predominately red maple), there again proved to be no major species differences. Based on these results, all further analysis was done using all 64 residue tops treated as one group.

RESULTS AND CONCLUSIONS

Figure 1 shows a typical northern hardwoods residue top with mean dimensions and their corresponding standard deviations. In addition, the histograms in figures 2 through 6 give a more detailed breakdown of the dimensions.

Topwood is available, but it cannot be just skidded out intact. Because of the average length (36 feet) and width (25 feet) of a top, skidding would seriously damage the residual stand. Reducing the top by manual chain sawing is both costly and unsafe. What looks most promising is a mechanized scheme in which the tops are first reduced and then transported to a landing for further processing.

The details of branch sizes and lengths are shown in table 1 and in figures 7 and 8. Table 1 and figure 7 include only data on the branches themselves, not on the main stems. Figure 8, which presents information on the lengths of roundwood greater than 4 inches d.o.b., includes data on both branches and main stems. The data presented in figure 8 strongly suggest that this material could be utilized for higher value solid wood products rather than simply for chips for fiber and/or fuel.

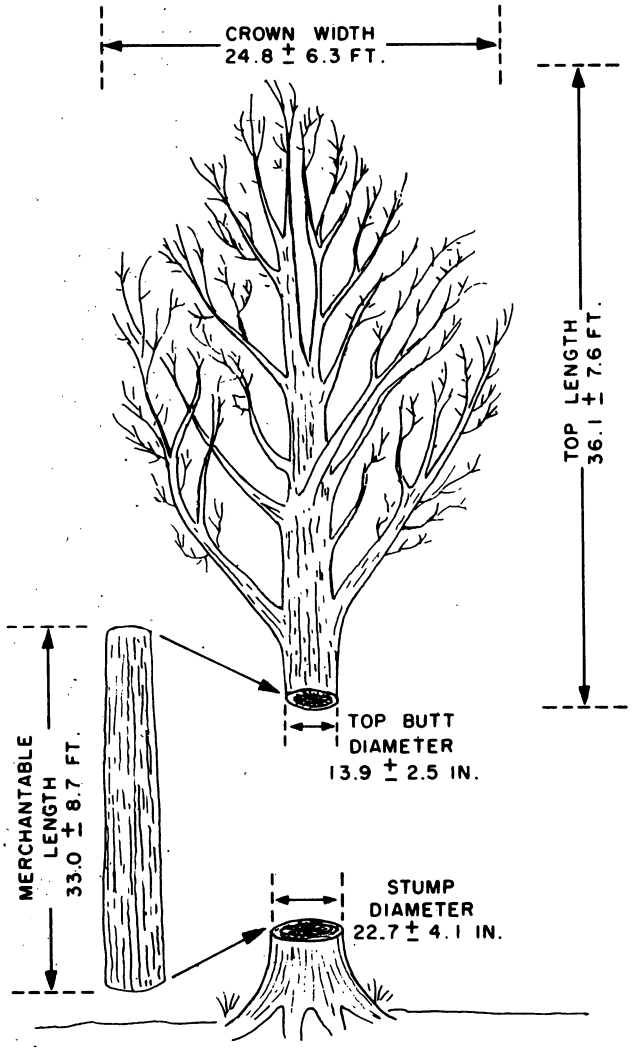

Figure 1.—*Descriptive measures (means and standard deviations) of topwood residue in a mixed northern hardwood stand. Sample size is 64 tops.*

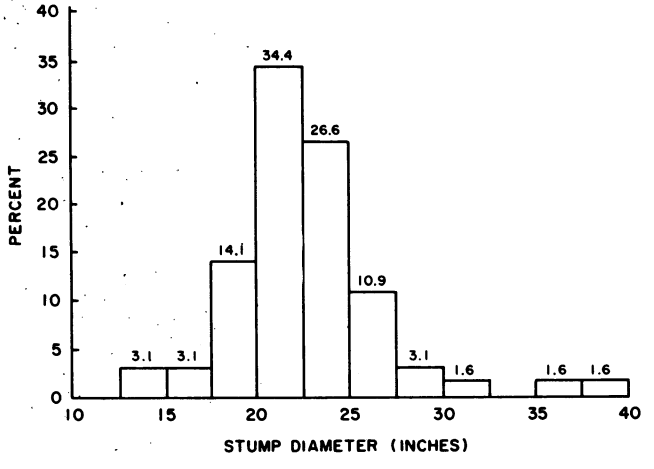

Figure 2.—*Distribution of stump diameters for 64 stumps.*

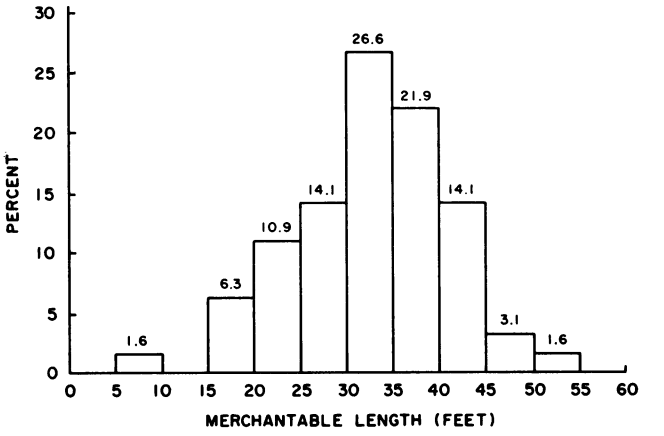

Figure 3.—*Distribution of merchantable lengths for 64 trees (stump to top butt distances).*

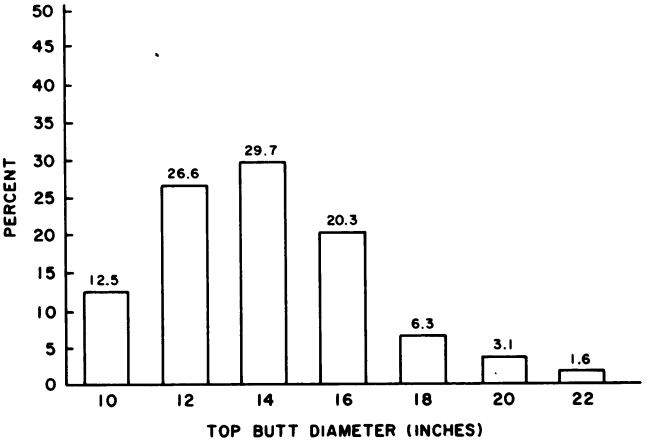

Figure 4.—*Distribution of top butt diameters for 64 tops.*

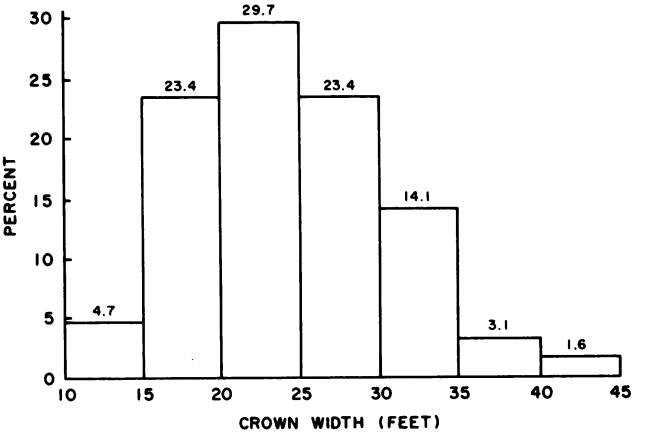

Figure 5.—*Distribution of maximum crown widths for 64 tops.*

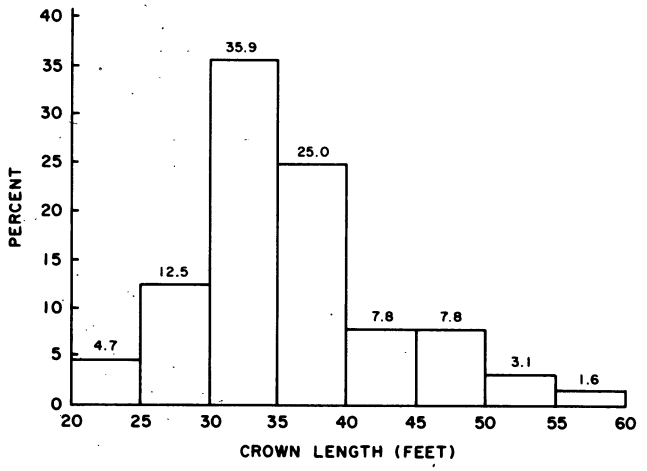

Figure 6.—*Distribution of crown lengths for 64 tops.*

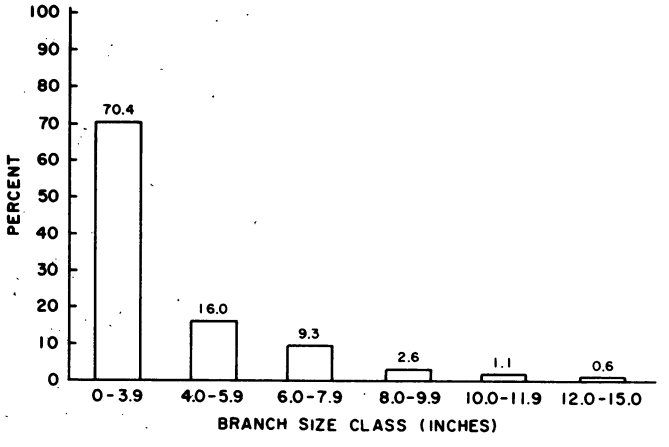

Figure 7.—*Distribution of branch size classes for 64 tops. (Does not include main stem.)*

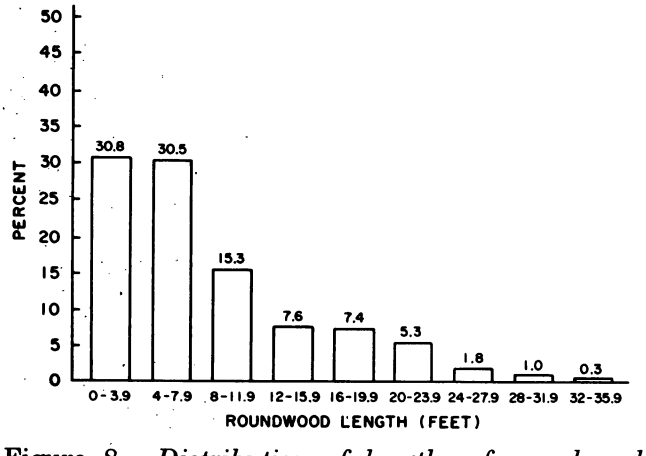

Figure 8.—*Distribution of lengths of roundwood greater than 4 inches d.o.b. for 64 tops. (Includes both main stem and branches.) NOTE: Total number of pieces is 393; mean length is 7.9 feet (std. dev. = 6.7).*

Table 1.—*Branch details*[1]

Branch size class (inches)	Number of branches per top	
	Range	Mean
0– 3.9	2–34	15.3
4– 5.9	0–7	3.3
6– 7.9	0–7	1.9
8– 9.9	0–2	.5
10–11.9	0–2	.2
12–15	0–2	.1

[1]Does not include main stem.

For branches greater than 4 inches d.o.b., the angle with the main stem is distributed as follows:

0–30 degrees	33 percent
30–60 degrees	44 percent
60–90 degrees	23 percent

A correlation matrix was calculated for all variables. There proved to be no relations that would be useful from an engineering viewpoint. The largest correlation is stump diameter versus top butt diameter with an r value of 0.53. The next largest is branch class six versus top butt diameter with an r of 0.51. All other correlations were negligible.

Further research is needed on various schemes and devices to harvest northern hardwood top and limb residue. The results presented here have established a representative set of engineering data to guide this research.

LITERATURE CITED

Bradley, Dennis P.; Carpenter, Eugene M.; Mattson, James A.; Hahn, Jerold T.; Winsauer, Sharon A. The supply and energy potential of forest resources in northern Wisconsin and Michigan's Upper Peninsula. Res. Pap. NC-182. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1980. 21 p.

Carpenter, Eugene M. Wood fuel potential from harvested areas in the eastern United States. Resour. Bull. NC-51. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1980. 14 p.

Grantham, John B.; Howard, Jack James O. Logging residue as an energy source. In: Sarkenen, Kyosti V.; Tillman, David A., eds. Progress in biomass conversion. Vol. 2. New York: Academic Press, Inc.; 1980: 1-35.

Mattson, James A.; Carpenter, Eugene M. Logging residue in a northern hardwood timber sale. North. Logger and Timber Process. 24(7): 16, 17, 29; 1976.

Steinhilb, H. M.; Dye, Glenn W. Harvesting logging residue from a selectively cut northern hardwood stand. North. Logger and Timber Process. 21(11): 12-14, 34, 36-37; 1973.

Steinhilb, H. M.; Winsauer, Sharon A. Sugar maple: tree and bole weights, volumes, centers of gravity, and logging residue. Res. Pap. NC-132. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1976. 7 p.

Winsauer, Sharon A.; Steinhilb, Helmuth M. Summary of green weights and volumes for five tree species in Michigan. Res. Pap. NC-191. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1980. 22 p.

U.S. GOVERNMENT PRINTING OFFICE:1983-666-761/5045