Physical and Chemical Properties Of Slash Pine Tree Parts

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ABSTRACT. In three 22-year-old slash pines from an unthinned plantation in central Louisiana, stemwood comprised 58.5 percent of total ovendry tree weight. Stumps and main roots made up 16.5 percent, bark 12.5, top of bole 5.0, needles 4.0, and branches 3.5. This material now is largely wasted when a tree is harvested; methods of utilizing it would extend fiber supplies by 70 percent. Stemwood had higher specific gravity (avg. 0.47 ovendry weight, green volume) and higher alpha-cellulose content (51 percent) than any other tree part. All waste portions had greater lignin and extractive contents than stemwood. Generally, however, chemical data for stumps and roots did not differ greatly from that for stemwood. Ash content of all parts was relatively low.

MUCH OF THE TOTAL MASS of a merchantable tree is in portions not utilized — stump, roots, bark, branches, needles, and top — but the suitability of these materials for specific purposes remains relatively unexplored. The search for uses requires knowledge of the properties of each portion and the amounts available. The study reported here was undertaken to compare certain physical and chemical properties of all portions in three pulpwood-size slash pines (*Pinus elliottii* var. *elliottii* Engelm.).

Literature

Literature on complete-tree utilization is comprehensively reviewed by Keays (1971). In the southern pines, weights of various parts have been measured (Smith, et al. 1963; Whittak et al. 1963; Metz and Wells 1965), but analys of complete trees, including foliage and roo seem to be lacking.

Some information is available on pulpi characteristics of southern pine tree portio stumps and roots (Kress and Mosher 1943; Ste art and Diaz 1972); bark and stemwood (Kel 1950; Martin and Brown 1952); stems, to branches, stumps, and roots (Gleaton and Sayd

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1956; Stewart and Diaz 1972). In general, results from pulping experiments indicate that: 1) Wood from the top of the bole should yield pulp similar to that from the stem and be suitable for admixture. 2) Bark in large amounts is detrimental. 3) Branches larger than 1 inch in diameter (without bark) yield less pulp than stemwood; the branchwood pulp has less strength and greater stretch, and requires less beating, than stem pulp. 4) Stumps and roots should yield pulp of good quality with somewhat higher burst and lower tear strength than stem pulp (Keays 1971).

The properties of parts other than stemwood are incompletely known, although considerable work has been done on mineral and moisture content of southern pine needles and some data have been provided on chemistry and specific gravity of southern pine bark (Chang and Mitchell 1955; Renfro 1956, p. 32; Browning and Sell 1957; Hergert 1960; Harkin and Rowe 1969; Martin 1969; Manwiller 1972). Some references on commercial preparation of needle fiber may also be found (Record 1916; Mississippi Forests and Parks 1936).

Table 1. — STEM, ROOT, AND CROWN DATA FOR THREE 22-YEAR-OLD SLASH PINES GROWING IN AN UNTHINNED PLANTATION AT 6- BY 8-FOOT SPACING.

	Tree 1	Tree 2	Tree 3
DBH (in.)	7.9		7.6
Height (ft.)	61.5		62.6
Merchantable stem length (ft.)	41.7	45.8	41.7
Maximum top dia. inside bark (in.)	3.4	3.3	3.3
Live crown width (ft.)	7.7	7.1	7.8
Live crown height (ft.)	16.1	19.5	22.0
Stump dia. outside bark (in.	9.8	10.0	9.5
Stump dia. inside bark (in.)	7.5	7.3	7.0
Taproot max. dia. outside bark (in.)	13.8	12.9	12.1
Taproot length (ft.)	4.2	5.0	4.1
Taproot green wt. (lb.)	105	102	66
Side roots to 3-foot radius green wt. (lb.)	17	36	13

Procedure

Collection

Three codominant 22-year-old slash pines were selected from an unthinned plantation (6- by 8-foot spacing) in central Louisiana. The soil was well-drained to moderately well-drained Ruston, intergrading with Beauregard under two of the trees.

The trees, described in Table 1, were harvested in late May. One tree was felled at a time, and the cut surface of the stump was sealed with paraffin. All portions were bagged immediately in polyethylene, transported to the laboratory, and weighed green. A circular trench 30 inches deep was dug on a 3-foot radius around each stump to delimit the portion of the root system obtained. A steel belt was wrapped around the root system inside the trench, and the stump and roots were pulled out with a tractor. High-pressure hoses were used to remove adhering soil from the roots. The stumps and main root systems are shown in Figure 1.

Each tree was divided into six parts (sampling for chemical analysis and specific gravity determinations is described in parentheses):

Stemwood — the merchantable stem, up to a 4-inch top, barkfree (4-inch disks taken at 100-inch intervals).

Bark — inner and outer bark from the merchantable stem (horizontal strips taken at 48-inch intervals).

Roots — wood and bark from the main root system, including the 6-inch stump (1-inch disks, the first taken at 1 inch below the top of the stump and all others at 8-inch intervals along the length of the tap and side roots).

Top — wood and bark of the bole above the merchantable stem (1/2-inch disks every 3 feet).

Branches — wood and bark, including twigs but excluding dead limbs (1-inch disks taken every 3 feet).

Foliage — all needles, including immature new growth (samples from each foot of branch length).

Green weights of all samples were recorded; all other portions of the trees were weighed and

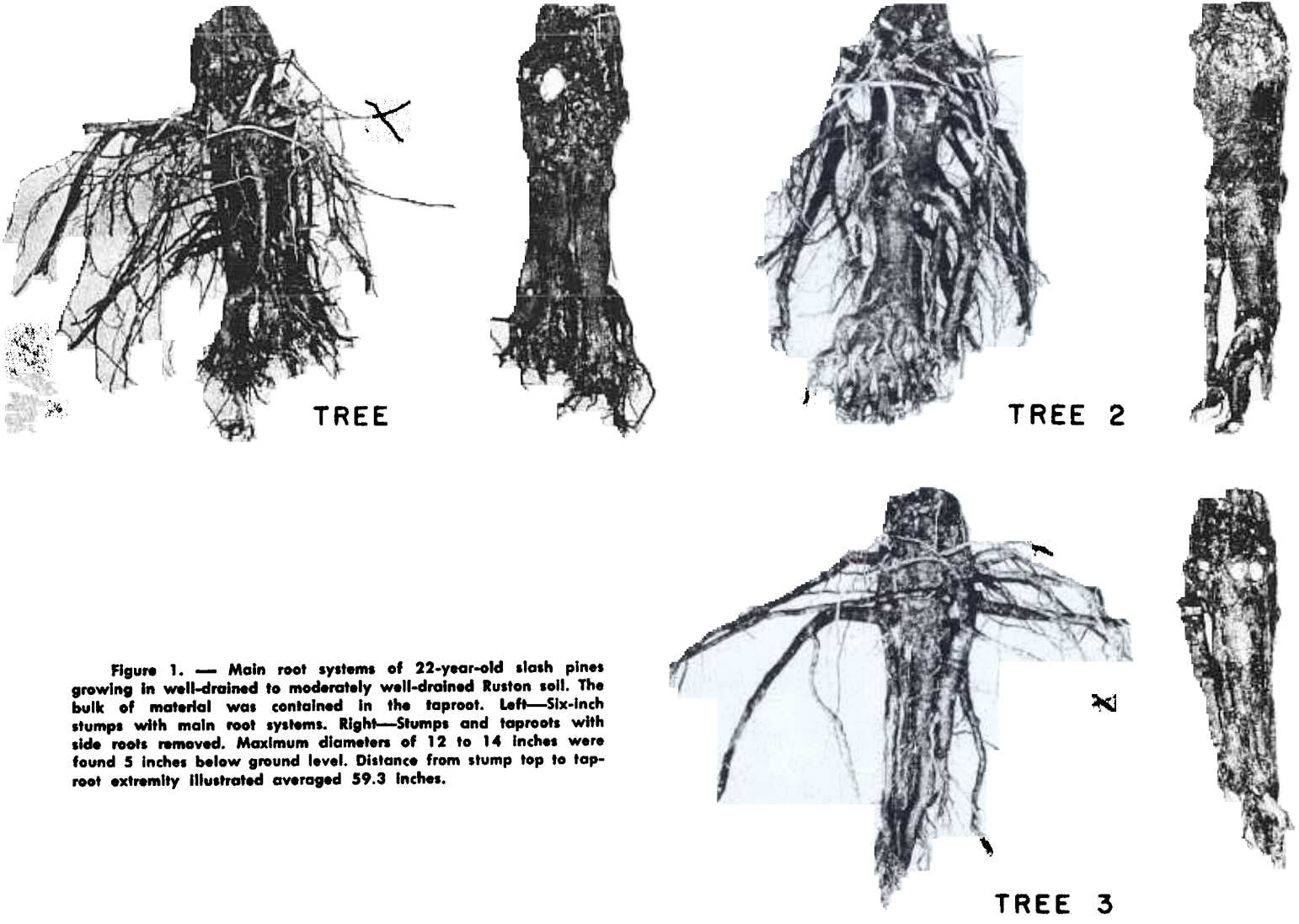

Figure 1. — Main root systems of 22-year-old slash pines growing in well-drained to moderately well-drained Ruston soil. The bulk of material was contained in the taproot. Left—Six-inch stumps with main root systems. Right—Stumps and taproots with side roots removed. Maximum diameters of 12 to 14 inches were found 5 inches below ground level. Distance from stump top to taproot extremity illustrated averaged 59.3 inches.

ovendried for determinations of dry weight and green moisture content.

Measurements

All specific gravity determinations were based on green volume and ovendry weight. For calculation of extracted specific gravity, ovendry weight was reduced by the amount of extractives present. A pycnometer was used to measure green volume of needles.

Samples for chemical analysis were ground to pass a 40-mesh screen. A portion of the material was extracted successively with alcohol-benzene, alcohol, and hot water for use in lignin, holocellulose, and alpha-cellulose determinations. Lignin analysis was by the Forest Products Laboratory's modified hydrolysis procedure (Moore and Johnson 1967). Holocellulose and alpha-cellulose were determined by the method of Erickson (1962) with seven treatment cycles at 30-minute intervals. Hemicellulose values were obtained by subtraction of alpha-cellulose from holocellulose percentages. Alcohol-benzene extractive content was determined by TAPPI Standard T6os-59. For total ash content, samples were oxidized with concentrated HNO_3, then ignited in a 480°C muffle furnace for 6 hours. Four replications per sample were made for each analysis.

Results for the various tree parts were compared by analysis of variance.

Results

Stem and root dry weights showed large between-tree differences (Table 2). Only about 59 percent of total tree dry weight was merchantable stemwood. The other portions, currently unutilized, represent about 70 percent of the merchantable bark-free stem weight (ovendry):

Tree part	Percent of merchantable stemwood	Percent of total tree weight
Stemwood	100.0	58.5
Roots	28.2	16.5
Bark	21.4	12.5
Top	8.5	5.0
Needles	6.7	4.0
Branches	5.9	3.5

Moisture content of the various portions differed greatly between trees (Fig. 2). Considerable fluctuations of these values can be expected with changes in local moisture conditions. Bark contained much less moisture than other tree portions, even though the inner bark was included.

Table 2. — DRY WEIGHTS OF VARIOUS TREE PARTS FROM 21-YEAR-OLD SLASH PINES.

Tree part	Tree 1	Tree 2	Tree 3
		(lb.)	
Stem	191	203	163
Roots	54	65	38
Bark	41	36	42
Top	18	14	15
Needles	12	12	13
Branches	11	10	12
Total	327	340	283

Unextracted specific gravities of the stems averaged 0.46 to 0.48 (Table 3). Needles had slightly lower values; specific gravities of roots, tops, and branches did not differ significantly at the 0.05 level. Bark was about two-thirds as dense as stemwood.

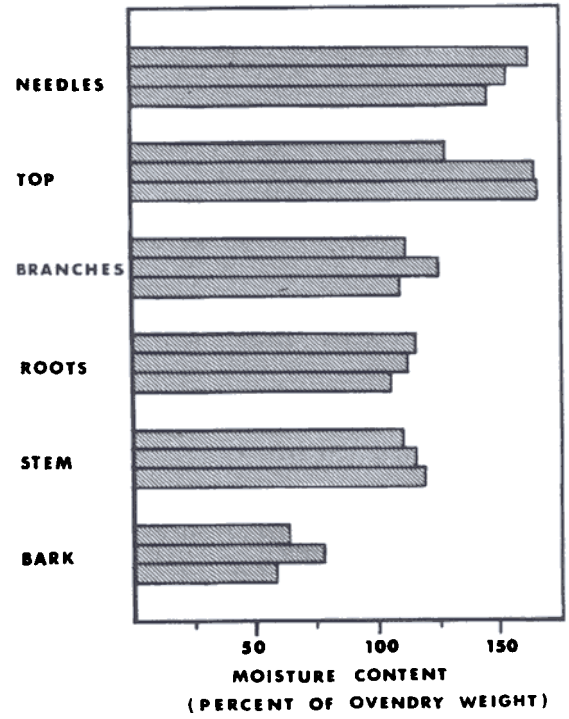

Figure 2. — Moisture content of the various tree portions, shown by individual tree.

Table 3. — SPECIFIC GRAVITY (GREEN VOLUME, OVENDRY WEIGHT) OF VARIOUS TREE PORTIONS FROM 21-YEAR-OLD SLASH PINES.

Tree part	Tree 1	Tree 2	Tree 3
Stem			
Unextracted	0.48	0.46	0.47
Extracted	.44	.42	.42
Needles			
Unextracted	.45	.46	.44
Extracted	.33	.33	.33
Branches			
Unextracted	.38	.41	.42
Extracted	.33	.35	.37
Top			
Unextracted	.39	.34	.42
Extracted	.35	.30	.36
Roots			
Unextracted	.40	.35	.39
Extracted	.35	.31	.35
Bark			
Unextracted	.32	.30	.34
Extracted	.28	.26	.30

All tree parts differed significantly (0.05 level) in lignin, hemicellulose, and ash contents. Lignin contents, expressed as percentages of extractive-free, ovendry weights, were:

	Tree 1	Tree 2	Tree 3
Bark	49.7	48.9	51.4
Needles	37.4	39.4	36.4
Branches	34.8	35.1	35.2
Top	32.1	31.6	33.8
Roots	31.7	29.3	33.0
Stem	27.2	28.2	28.1

As bark was included in branch, top, and root materials, lignin values higher than for stemwood would be expected.

Extractive content (as percentage of ovendry weight) averaged lower in stemwood (9.1 percent) than in any other tree part; roots averaged only 2.7 percentage points higher than stemwood:

	Tree 1	Tree 2	Tree 3
Needles	25.6	26.9	26.1
Branches	14.3	14.4	12.1
Bark	12.8	13.5	12.7
Roots	11.4	11.7	12.1
Top	9.4	10.8	12.9
Stem	8.7	8.6	9.9

Branches and bark did not differ significantly, nor did roots and tops. Needles contained twice the percentage of extractives found in any other tree part; composition of this extract probably differs greatly from that of other tree parts.

The tree portions varied widely in alpha-cellulose content (expressed as percentage of extractive-free ovendry weight):

	Tree 1	Tree 2	Tree 3
Stem	53.1	50.6	49.7
Roots	44.4	46.5	42.9
Needles	42.6	40.0	45.1
Top	41.1	41.8	41.5
Branches	36.9	36.1	37.7
Bark	23.8	23.1	24.1

The largest proportion was found in stemwood (51.1 percent). Roots averaged 44.6 percent; needles 42.5; tops 41.5; and branches 36.9. Bark contained 23.7 percent alpha-cellulose; thus, inclusion of bark with roots, tops, and branches resulted in lower values than for bark-free material. Likewise, material to be pulped would give reduced alpha-cellulose yields if bark were included.

Hemicellulose values (as percentages of extractive-free, ovendry weight) exhibited a much narrower range among the various tree parts, but all parts differed significantly.

	Tree 1	Tree 2	Tree 3
Branches	33.4	33.9	33.7
Top	30.3	32.1	31.2
Stem	27.1	25.2	28.0
Roots	25.4	25.3	26.2
Bark	25.0	24.9	24.7
Needles	23.1	21.7	22.2

Greater amounts of hemicellulose were found in branches (33.7 percent) and tops (31.2) than in stemwood (26.8). Amounts in roots and bark were only slightly less than in stemwood.

All parts were relatively low in ash content (expressed as percentage of unextracted ovendry weight):

	Tree 1	Tree 2	Tree 3
Needles	2.3	2.6	2.3
Roots	1.6	1.0	2.3
Branches	1.4	.9	1.2
Bark	1.0	.8	.8
Top	.8	.7	.8
Stem	.4	.4	.2

Needles contained more ash (2.4 percent) than any other part; stemwood (0.3 percent) was lowest. Ash content for bark averaged 0.9 percent — considerably less than the values reported for barks of other species, particularly hardwoods. The slightly higher ash content of roots may be related to accidental inclusion of small amounts of soil embedded in the root bark.

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