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Harvesting Southern Pine With Taproots Can Extend Pulpwood Resource Significantly

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ABSTRACT—If lateral roots are first severed, southern pines can be pulled from the soil like carrots, thereby adding 20 percent to the merchantable weight of each stem harvested. Morphology and chemical constituents of the taproots indicate their suitability for kraft pulping. Prototype harvesting equipment is being designed.

Pulpwood harvesting of taproots from plantation-grown southern pine is an idea whose time has come.

With some variation as to site, southern pines typically develop a root system consisting of a large carrot-shaped taproot and some shallow laterals. In pulpwood-size trees, the complete system to a 3-foot radius contains about 28 percent as much wood (dry-weight basis) as in the so-called merchantable stem (Table 1, Figure 1).

Table 1. Weight distribution (ovendry basis) of above- and below-ground parts of three 22-year-old, 7.7-inch, unthinned, plantation-grown slash pine trees cut in central Louisiana.¹

| Portion of tree | Total tree | Weight fraction of— | |
|------------------------------|------------|---------------------|------------------------------------|
| | | Above-ground parts | Bark-free stem to 4-inch top (DOB) |
| | | — Percent — | |
| Bark-free stem | | 70.2 | 100.0 |
| Roots and stump ² | | 19.8 | 28.2 |
| Stem bark to 4-inch top | 12.5 | 15.0 | 21.4 |
| Top (with bark) | 5.0 | 6.0 | 8.5 |
| Needles | 4.0 | 4.7 | 6.7 |
| Branches (with bark) | 3.5 | 4.2 | 5.9 |
| Total | 100.0 | | |

¹ Adapted from Howard (2); see also Koch (3), p. 1541.

² Roots to a 3-foot radius; see Figure 1, left.

The laterals pose severe problems of retrieval, transport and use. With them pruned away, the taproot of a 15- to 30-year-old slash pine weighs about 20 percent as much as the merchantable stem. Maximum diameter occurs a few inches below ground level and is 1.5 to 2 times stem diameter at breast height. Length is commonly 3 to 5 feet.

Rootwood Suitability for Kraft Pulp

In a sample of 20 southern pines aged 12 to 89 years, Manwiller (4) found that rootwood tracheids were one-third longer and one-third larger in diameter than stemwood tracheids measured at stump height; rootwood cell walls were 18 percent thinner and lumens

almost two-thirds larger (Table 2). In observations on the taproot of a single tree, Manwiller found that all cell dimensions increased to a maximum at a point about 1-½ feet below ground level and then diminished.

Table 2. Mean tracheid dimensions in root and stumpwood of 20 southern pines.¹

| Dimension | Stumpwood ² | | Rootwood ³ | |
|---------------------|------------------------|--------------------|-----------------------|--------------------|
| | Mean | Standard deviation | Mean | Standard deviation |
| Length (mm) | 2.97 | 0.64 | 3.99 | 0.89 |
| Cell diameter (μm) | 38.76 | 9.39 | 52.48 | 12.21 |
| Lumen diameter (μm) | 25.66 | 11.06 | 41.69 | 13.08 |
| Wall thickness (μm) | 6.55 | 2.15 | 5.40 | 1.67 |

¹ Data from Manwiller (4).

² Stumpwood sampled from two opposed 20-degree wedges (1-inch-thick) removed 18 to 24 inches above ground level.

³ Sampled from disks taken along the taproot beginning at the point where major laterals were attached.

In structure, rootwood varies considerably from stemwood. Roots make virtually uninterrupted growth throughout all 12 months of the year; although distinct bands of latewood are sometimes found, growth increments are more often distinguished only by several rows of radially flattened cells, whose walls may be no thicker than those of earlywood (Figure 2, left). Frequency, size, and distribution of bordered pits in rootwood tracheid walls are more variable than in stemwood, and fibril angles may be greater. The pit structure is not likely to affect pulping processes greatly, but high fibril angles may lead to inferior paper properties. Except for a greater incidence of ray tracheids elongated perpendicularly to the rays, and virtual absence of thick-walled parenchyma cells, rootwood rays and resin canals resemble those of stemwood.¹

To provide some data on chemical constituents, Howard (2) uprooted three 22-year-old slash pines growing in central Louisiana on well-drained sandy loam soil in an unthinned plantation. Lateral roots were severed at a radius of 3 feet. In comparison with stemwood representative of the portion from 6-inch stump height to a 4-inch top, rootwood had slightly higher content of extractives, lignin, and ash and slightly less cellulose (Table 3). The roots had a moisture content of 111 percent and specific gravity of 0.38 (basis of unextracted ovendry weight and green volume), while stemwood averaged 116 percent in moisture content and 0.47 in specific gravity.

In short, it seems likely that taproots of the southern pines are pulpable by the kraft process. Because of

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¹The text and referenced figure in this paragraph are from work done by E. T. Howard in preparation for her publication (2). See also Koch (3, p. 563).

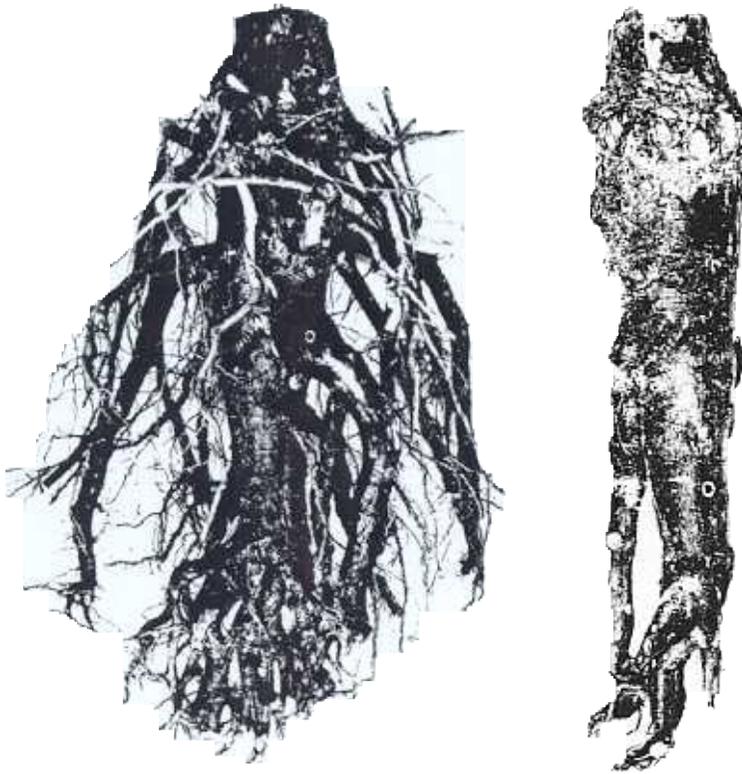


Figure 1. Root from 22-year-old slash pine tree of 7.6 inches d.b.h., harvested in central Louisiana. Oven-dry weight of the root system to a 3-foot radius (left) was 65 pounds—equal to 32.0 percent of the dry weight of the bark-free merchantable stem. When trimmed (right), the root measured about 5 feet in length and 12.9 inches in diameter 3 inches below ground level. In green condition, the trimmed root had 72 percent of the weight of the untrimmed.

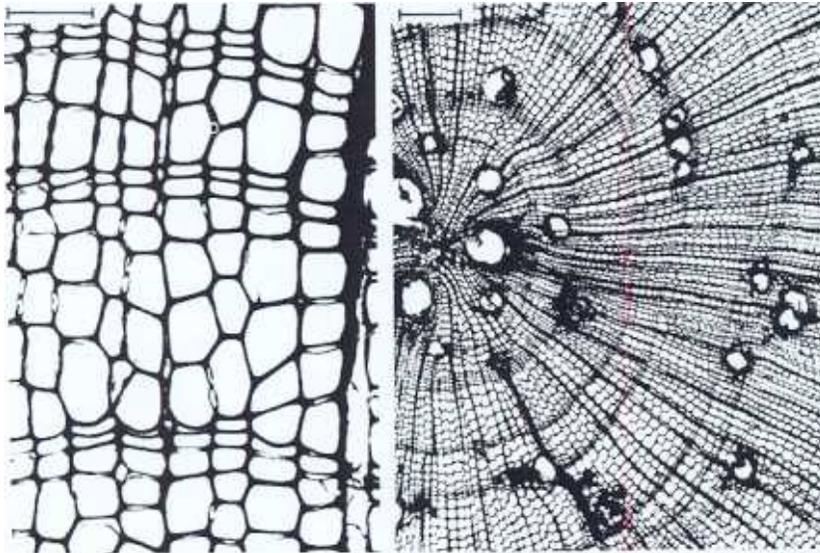


Figure 2. *Left:* Cross-section of large shortleaf pine root. Walls of earlywood and latewood are of equal thickness, and growth increments are marked only by differences in radial dimensions. Scale mark represents 100 μm . *Right:* Cross-section from center of longleaf pine root. Pith is absent. Primary resin canals are grouped at center of the root. Scale shows 0.5 mm.

chemical makeup, slightly lower yields than those obtainable from stemwood can be expected.

Harvesting Technique

Judging from the data in Table 1, pulpwood tonnage from southern pine stands could be considerably increased by harvesting taproots. To this end, I advance the concept of first shearing the lateral roots close to the taproot, and then plucking the entire tree from the ground.

Most laterals on southern pines are within 18 inches of the surface. I visualize that they can be severed with a tubular shear sharpened on its lower edge and hinged like a clamshell to encircle the tree.

To try the idea, an order was placed with Rome

Industries of Cedartown, Ga., to make a prototype tubular shear and to use a JD544A prime mover as a crane to lift the tree.² The prototype (*Figure 3*) was tested during September 1973 with 15-year-old plantation-grown pines on dry, hard Georgia clay.

The concept worked as planned (*Figure 4*, left). During the first stage of harvesting, the tubular shear was driven into the ground to sever the laterals. Then the stem and taproot were lifted through the shear. The hole left by the root was small (*Figure 4*, right) and quickly caved in as the felling machine traveled about the area. Table 4 lists root dimensions and lifting

²Mention of trade names is for information only, and does not imply endorsement by the U.S. Department of Agriculture.

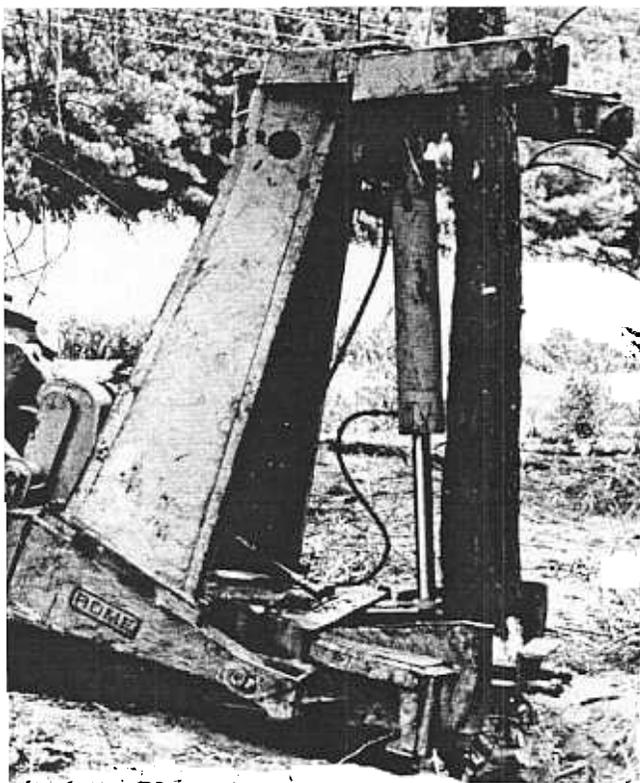


Figure 3. This prototype whole-tree harvester grips a young pine near ground level and lifts it free with taproot attached. To minimize lifting forces, lateral roots must be sheared off first. The harvester is mounted on, and powered by, a rubber-tired prime mover.



Figure 4. *Top*: Taproot of 15-year-old slash pine as it appeared when lifted free of the ground still attached to the stem. Usual stump line is about where area of skinned bark begins. *Bottom*: Hole left when tree was lifted. Surrounding the hole is slot cut by tubular shear that severed laterals prior to lifting.

Table 3. Chemical composition of rootwood and of other tree parts; average for three 22-year-old slash pine trees (data from Howard (2)).

| Component | Roots | | | | | |
|--------------------------------|---------|----------|------|------|---------|------|
| | Top | Branches | Stem | Bark | Needles | |
| | Percent | | | | | |
| Extractives ^{1,2} | 11.7 | 11.0 | 13.6 | 9.1 | 13.0 | 26.2 |
| Alpha-cellulose ^{3,4} | 44.6 | 41.5 | 36.9 | 51.1 | 23.7 | 42.5 |
| Hemicellulose ^{3,4} | 25.6 | 31.2 | 33.7 | 26.8 | 24.9 | 22.3 |
| Lignin ^{3,5} | 31.3 | 32.5 | 35.1 | 27.8 | 49.9 | 37.7 |
| Ash ^{1,6} | 1.6 | .8 | 1.2 | .3 | .9 | 2.4 |

¹ Percent of unextracted, oven-dry weight.

² TAPPI Standard T6 os-59.

³ Percent of extractive-free oven-dry weight.

⁴ Erickson (1) sodium chlorite method.

⁵ Modified hydrolysis procedure of Moore, W. E., and Johnson, D. B. 1967. Procedures for the chemical analysis of wood and wood products. USDA Forest Serv. Forest Prod. Lab., Madison, Wi. By this method other acid-insoluble substances would also be reported as "lignin."

⁶ Nitrated, then ashed at 480° C. for 6 hours.

Table 4. Taproot dimensions and lifting forces for 15-year-old slash pines in hard clay soil.

| D.b.h. | Taproot diameter at below-ground swell | Taproot length | Lifting force after laterals were sheared |
|--------|--|----------------|---|
| | Inches | | Pounds |
| 5-3/4 | 9 | 54 | 20,000 |
| 6 | 9 | 34 | 16,000 |
| 10 | 20 | 44 | 25,000 |

forces illustrative of the trees harvested. Considerably more force is required to shear the laterals than is needed to lift the tree after the laterals have been severed. With the tubular shear, it is likely that forces

approaching 200,000 pounds will be needed to cut away the laterals of trees 30 years old.

Once lifted free of the ground, stems with taproots attached can probably be yarded in the customary manner, but loaded for transport with root ends alternated for compactness. On arrival at the mill, taproots will probably be severed for special washing and chipping procedures. This special handling appears necessary because considerable dirt remains attached as the taproots come from the ground. Harvesting and handling will remove some bark, and washing will take off more. It is probable, however, that significant quantities will remain on the roots when chipped.

Prompt Application Likely

A second prototype of the tree harvester is being designed. Harvesting rate should average one tree per minute in even-aged stands on soils that are free of boulders. Most southern pine grows on such sites. The concept offers a way of increasing productivity per acre 20 percent at a time when demand for wood is increasing and land for new plantations is limited. Moreover, elimination of stumps would substantially reduce costs of preparing sites for regeneration. For these reasons, several major pulp companies have indicated a desire to make prompt application of the concept should research trials prove successful.

Literature Cited

- Erickson, H. D. 1962. Some aspects of method in determining cellulose in wood. TAPPI 45: 710-719.
- Howard, E. T. 1973. Physical and chemical properties of slash pine tree parts. Wood Sci. 5: 312-317.
- Koch, P. 1972. Utilization of the southern pines. USDA Agric. Handb. 420. 1663 p.
- Manwiller, F. G. 1972. Tracheid dimensions in rootwood of southern pine. Wood Sci. 5: 122-124.