MOISTURE CONTENT AND SPECIFIC GRAVITY OF THE FOUR MAJOR SOUTHERN PINES UNDER THE SAME AGE AND SITE CONDITIONS

Mark D. Gibson

Assistant Professor
School of Forestry, Louisiana Tech University
Ruston, LA 71272

Charles W. McMillin and *Eugene Shoulders*

Principal Wood Scientist and Principal Silviculturist
USDA-Forest Service, Southern Forest Experiment Station
2500 Shreveport Highway, Pineville, LA 71360

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ABSTRACT

Slash, loblolly, longleaf, and shortleaf pines in northern Louisiana were examined for differences in moisture content (MC) and basic specific gravity (SG) of wood and bark in the complete tree, root, stem, and branches and differences in diameter at breast height (dbh), total height, and taproot length of trees in even-aged plantations under identical site conditions, planting densities, and management practices. The four species did not differ statistically in stemwood, branchwood, or complete-tree wood SG on any of the three sites examined (wet, intermediate, and dry). Shortleaf had a significantly higher rootwood SG on all sites. The wet site generally produced wood with a lower SG, and the dry site produced wood with a higher SG. Differences among species in MC appeared dependent upon the tree component and site condition, while intersite differences in MC were generally component and species dependent. No significant difference among the four species was detected for dbh, total height, or taproot length on the dry or intermediate site. Shortleaf on the wet site produced a significantly shorter stem and taproot than the other species. Tallest trees grew on the intermediate site.

Keywords: Moisture content, specific gravity, root, stem, branch, southern pine, loblolly pine, slash pine, longleaf pine, shortleaf pine, species comparison, site.

INTRODUCTION

As Cole et al. (1966) and Snyder and Hamaker (1970) indicate, wood and bark properties are undoubtedly affected by site, geographic location, age, and other factors. Removal or reduction of these influences is essential if valid comparisons are to be made between different species. Such comparisons should provide a better baseline from which managers can make decisions regarding stand management and wood utilization strategies.

Reported here are basic specific gravities (oven-dry weight–green volume basis) and moisture contents (oven-dry basis) of wood and bark for three tree components (roots, stems, and branches) and complete-tree averages for the four major species of southern pine, loblolly (*Pinus taeda* L.), longleaf (*Pinus palustris* Mill.), shortleaf (*Pinus echinata* Mill.), and slash (*Pinus elliottii* Engelm. var. *elliottii*), grown to the same age at identical planting densities on each of three sites in northern Louisiana. Also reported are dbh, total height, and taproot length. Comparisons are made among species for each component. Wood properties of each component are compared to those of bark, and stemwood and stembark properties are com-

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TABLE 1 *Sample tree characteristics.*[1]

Species	No. of samples	Age	DBH		Total height[2]		Taproot length[3]	
			Mean	(Range)	Mean	(Range)	Mean	(Range)
					— ft —			
Dry site								
Loblolly	12	26	5.4 a	(2.3–8.1)	46 a	(23–59)	6.4 a	(4.3–9.2)
Slash	12	26	6.0 a	(3.1–8.6)	50 a	(28–65)	5.8 a	(4.7–8.0)
Longleaf	12	26	6.1 a	(3.2–8.8)	51 a	(31–66)	6.7 a	(4.3–10.5)
Shortleaf	12	26	4.9 a	(1.9–8.5)	44 a	(23–62)	6.0 a	(3.4–10.1)
Intermediate site								
Loblolly	12	27	6.7 a	(4.6–8.8)	58 a	(49–64)	4.4 a	(3.1–5.5)
Slash	12	27	7.9 a	(3.0–10.5)	59 a	(37–71)	3.9 a	(2.1–5.3)
Longleaf	12	27	6.3 a	(3.0–8.5)	56 a	(37–68)	3.7 a	(2.7–5.0)
Shortleaf	12	27	6.6 a	(4.9–9.8)	60 a	(55–66)	4.1 a	(3.0–5.4)
Wet site								
Loblolly	12	25	6.4 a	(4.7–8.3)	54 ab	(42–64)	3.7 a	(2.6–4.9)
Slash	12	25	6.5 a	(3.8–9.5)	58 a	(43–70)	3.4 ab	(1.8–4.5)
Longleaf	12	25	5.0 ab	(2.4–7.4)	44 b	(24–63)	2.7 b	(1.6–4.0)
Shortleaf	12	25	4.0 b	(2.3–6.7)	30 c	(17–40)	2.6 b	(1.6–4.2)

[1] Under each site, numbers in the same column followed by the same lower case letter(s) are not significantly different at the 0.05 level according to Scheffe's multiple-comparison procedure. Numbers represent the average of 12 trees per species.
[2] Figures represent the mean heights from groundline to apical tip.
[3] Figures represent the mean lengths from groundline to taproot tip.

pared to those of branchwood and branchbark and rootwood and rootbark for each species.

MATERIALS AND METHODS

Trees were selected from three relatively uniform sites in northern Louisiana. Three distinctly different soil types were represented: a wet site (poorly drained Caddo series), an intermediate site (well-drained Shubuta series), and a dry site (Alaga series). All sites contained three plots of loblolly, longleaf, slash, and shortleaf pine in a randomized complete block design. The between-tree and between-row spacing in each plot was 6 feet. Four trees were selected from each plot by ranking all tree dbh's, dividing the ranking into quarters, and selecting the midpoint of each quarter as a sample tree. Means and ranges of sample tree characteristics are presented in Table 1 by site and species.

Sample trees were measured for dbh and total height, then felled and limbed. Branches were segregated into four categories: (1) dead, (2) live pieces 2.0 inch dob and larger, (3) live pieces 0.25 to 2 inches dob, and (4) live pieces 0.25 inch dob and smaller including needles. Stems were bucked at 8.5-foot intervals from the base to just below the 4-inch dob height, the 4-inch dob height, and the 2-inch dob height. The top of each stump was sealed with a waxy end-coating to reduce moisture loss prior to excavation. Stump-taproots were excavated within 2 weeks of felling and stored under a water spray until they could be cleaned, measured for length, and bucked at 5 positions along their length: first, 2 inches below the stump top, then at the base of the major laterals, and finally at three equidistant points between the base of the major laterals and the taproot tip.

Disks for moisture content (MC) and basic specific gravity (SG) determination of wood and bark were removed at the time of felling from each stem bucking

point, and from two randomly selected branches within each branch category. Stump-taproot disks were obtained after excavation and cleaning from each bucking point. All disks were marked, placed in plastic bags, and stored at 2 C prior to laboratory analysis. All sampling was completed between August and November 1982.

The green weight of each sample disk was measured with and without bark, and bark percentage was determined from the disk sample on a green-weight basis. Disk green volumes were determined by water immersion following saturation of the specimens under vacuum. Moisture content was determined on an oven-dry basis after drying to a constant weight at 103 C. Specific gravity of wood and bark was computed on an oven-dry weight–green volume basis. Weighted values for MC and SG of wood and bark in the stump-taproot, stem, branches, and complete tree were calculated by weighting sample disk values for each component in proportion to the total volume of the component in the tree.

The data were analyzed using an analysis of variance ($P \leq 0.05$) for a randomized complete block design. Moisture content and SG data were examined for heterogeneity of variance and transformed logarithmically when necessary to correct for this condition. Data are presented here as untransformed values for ease of interpretation. Species differences were compared using Scheffe's multiple comparison procedure at the 0.05 level of significance (Steel and Torrie 1980). Statistical analyses for differences among sites were not performed because of the small sample size.

RESULTS AND DISCUSSION

Tree characteristics

The average dbh, total height, and taproot length for the four species on each site are shown in Table 1. There was no significant difference ($P = 0.05$) among the four species for these characteristics on either the dry or the intermediate sites. The wet site, however, showed significant differences among the species in all variables.

On the wet site, the dbh of slash and loblolly pines was significantly larger than that of shortleaf. Total height in shortleaf was significantly less than in the other three species, and longleaf was significantly shorter than slash. Taproot length was significantly greater in loblolly than in longleaf or shortleaf, yet slash did not differ significantly from the other three species. These findings probably reflect inherent differences between species in nutrient requirements and tolerance to poor soil aeration (U.S. Division of Timber Management Research 1965, pp. 360–372, 384–389, 451–463).

As Shoulders (1983) reported for the larger study from which these sites were chosen, our average tree heights were greatest on the intermediate site for all species. The shortest trees, on the average, occurred on the dry site for loblolly and slash, but on the wet site for longleaf and shortleaf. Average taproot length was greatest on the dry site and shortest on the wet site for all species.

Specific gravity

The average specific gravity (SG) of wood and bark in the complete tree, root, stem, and branches for the four species on each site is presented in Table 2.

Dry site.—No significant differences in wood SG were noted among the four species on the dry site for the complete tree and its components, with the exception of rootwood (RW). A comparison of bark SG showed significant differences among the species for complete-tree bark (CTB) and stembark (SB), but no significant differences in rootbark (RB) or branchbark (BB) SG.

Intermediate site.—This site exhibited significant differences among the four species in RW SG with shortleaf significantly higher than the other species. However, there was no statistical difference among species for complete-tree wood (CTW), stemwood (SW), or branchwood (BW) SG. Bark SG was not significantly different among the species for the complete tree and its components, with the exception of SB.

Wet site.—The four species on the wet site did not differ statistically in CTW, SW, nor BW SG, but did show differences in RW SG. No statistical differences among species existed for SB or BB SG, but differences were present for RB and CTB.

Comparison of root, stem, and branch SG.—The following general relationships were discernible when root, stem, and branch SG were compared. Wood SG ranked SW > BW > RW for all species on the wet site; for loblolly, slash, and longleaf on the intermediate site; and for slash and longleaf on the dry site. Loblolly and shortleaf on the dry site and shortleaf on the intermediate site ranked SW > RW > BW. Phillips et al. (1976), comparing the same four species in natural uneven-age stands in Alabama and Mississippi (one species per stand), found, as we did, that SW SG > BW SG in all species. They also showed BB SG > SB SG in shortleaf and slash, but BB SG < SB SG in loblolly and longleaf. In contrast, we found BB SG > RB SG or SB SG for all species on all sites, RB SG > SB SG on the dry and intermediate sites, and SB SG > RB SG for all species on the wet site. One possible explanation for these conflicting results may be stand differences, such as: tree diameter range (5.8–21.0 inches in their study versus 1.9–10.5 inches in ours) and age range (28–110 years versus 25–27 years).

Comparison of wood and bark SG.—The wood SG of the four species on the three sites was greater than the bark SG in the complete tree, stem, and root of all species on all sites. Branchwood versus branchbark demonstrated this same relationship on the dry and intermediate sites for all species; however, wet-site BB SG exceeded BW SG in slash and shortleaf. Our findings for the dry and intermediate sites corresponded to those of Phillips et al. (1976).

Site comparison.—Intersite differences in SG were basically component and species dependent; however, several trends were recognizable. The wet site generally produced wood with the lowest SG, while the dry site generally exhibited the highest wood SG. For example, RW SG was lowest for all species, CTW SG and SW SG were lowest for all species except loblolly, and BW SG was lowest for slash and longleaf when wet-site values were examined. When dry-site values were inspected, CTW and SW exhibited their highest SG for all species and RW had the highest SG in all species except slash. Branchwood was the notable exception to the pattern in that the intermediate site exhibited the highest SG, except for longleaf which had its highest BW SG on the dry site.

The highest bark SG generally occurred on the wet site, but the site with the lowest bark SG was not consistent. For example, CTB and BB SG in all species,

TABLE 2. *Specific gravity of the complete tree and tree components of four southern pine species on three sites.*[1]

Species	Specific gravity							
	Wood				Bark			
	Complete-tree[2]	Root[3]	Stem[4]	Branch[5]	Complete-tree	Root	Stem	Branch
				Dry site				
Loblolly	0.480 a	0.443 b	0.496 a	0.418 a	0.306 b	0.345 a	0.291 b	0.364 a
Slash	0.475 a	0.386 c	0.501 a	0.458 a	0.308 b	0.320 a	0.296 b	0.389 a
Longleaf	0.482 a	0.431 b	0.498 a	0.465 a	0.334 ab	0.354 a	0.320 ab	0.379 a
Shortleaf	0.496 a	0.479 a	0.504 a	0.429 a	0.349 a	0.355 a	0.343 a	0.383 a
				Intermediate site				
Loblolly	0.461 a	0.404 b	0.474 a	0.431 a	0.324 a	0.337 a	0.315 ab	0.377 a
Slash	0.468 a	0.403 b	0.482 a	0.462 a	0.316 a	0.311 a	0.300 b	0.413 a
Longleaf	0.461 a	0.413 b	0.469 a	0.464 a	0.346 a	0.349 a	0.341 a	0.375 a
Shortleaf	0.481 a	0.463 a	0.488 a	0.455 a	0.337 a	0.350 a	0.331 ab	0.362 a
				Wet site				
Loblolly	0.472 a	0.392 a	0.489 a	0.429 a	0.334 b	0.322 ab	0.324 a	0.416 a
Slash	0.454 a	0.342 c	0.473 a	0.448 a	0.347 ab	0.308 b	0.335 a	0.449 a
Longleaf	0.447 a	0.389 b	0.455 a	0.444 a	0.380 a	0.355 a	0.373 a	0.424 a
Shortleaf	0.476 a	0.431 a	0.487 a	0.448 a	0.374 ab	0.364 a	0.368 a	0.450 a

[1] Under each site, numbers in the same column followed by the same lower case letter(s) are not significantly different at the 0.05 level according to Scheffe's multiple-comparison procedure. Numbers represent the average of 12 trees per species.
[2] Complete-tree includes the root, stem, and crown (live and dead branches, excluding foliage).
[3] Root includes all the root system within an 11-inch radius of the pith from the top of a 6-inch stump to the taproot tip.
[4] Stem includes all material from a 6-inch stump to the terminal leader.
[5] Branch includes all branches 0.25-inch dob or larger.

RB SG in longleaf and shortleaf, and SB SG in all species except loblolly were higher on the wet site.

In comparison with the SG values of Phillips et al. (1976), our BW values for slash were slightly higher and those for loblolly and longleaf were slightly lower on all sites than their respective values of 0.434, 0.449, and 0.489. Shortleaf BW SG on the wet and dry sites were slightly lower than, and on the intermediate site slightly higher than their value (0.450). Our SW SG for slash and longleaf on all sites was slightly lower than their respective values of 0.516 and 0.558. Our loblolly and shortleaf SW SG were slightly higher on the dry and wet sites than their values of 0.474 and 0.473, respectively, but loblolly was identical to and shortleaf was slightly higher than their values on the intermediate site.

In comparison with the average SW SG presented by Wahlgren and Schumann (1975) in their wood density survey, our values on all sites for loblolly and shortleaf were slightly higher than their values of 0.47 and 0.46, respectively, while slash and longleaf were slightly lower than their value of 0.53.

Moisture content

The average moisture content (MC) of wood and bark in the complete tree, root, stem, and branches for the four species on each site is presented in Table 3.

Dry site.—Wood MC differed significantly among the four species on the dry site for RW, but showed no statistical difference for CTW, SW, or BW. A com-

TABLE 3. *Moisture content of the complete tree and tree components of four southern pine species on three sites.*[1]

Species	Moisture content (%)							
	Wood				Bark			
	Complete-tree[2]	Root[3]	Stem[4]	Branch[5]	Complete-tree	Root	Stem	Branch
				Dry site				
Loblolly	87 a	126 ab	77 a	70 a	85 a	136 a	75 b	66 a
Slash	82 a	122 ab	72 a	83 a	103 a	162 a	97 ab	66 a
Longleaf	92 a	136 a	81 a	85 a	110 a	165 a	107 a	66 a
Shortleaf	81 a	110 b	75 a	73 a	86 a	143 a	81 ab	54 a
				Intermediate site				
Loblolly	80 b	97 b	77 b	74 ab	88 a	125 b	87 a	76 a
Slash	69 b	84 b	67 b	62 b	99 a	153 ab	104 a	72 a
Longleaf	98 a	124 a	95 a	86 a	103 a	162 a	101 a	75 a
Shortleaf	84 ab	95 b	83 ab	68 b	97 a	133 ab	94 a	92 a
				Wet site				
Loblolly	95 a	106 a	94 a	67 a	80 a	130 ab	75 a	71 a
Slash	93 a	112 a	91 a	68 a	85 a	166 a	82 a	56 a
Longleaf	104 a	112 a	104 a	78 a	80 a	150 a	80 a	53 a
Shortleaf	100 a	93 a	102 a	73 a	71 a	115 b	63 a	68 a

[1] Under each site, numbers in the same column followed by the same lower case letter(s) are not significantly different at the 0.05 level according to Scheffe's multiple-comparison procedure. Numbers represent the average of 12 trees per species.
[2] Complete-tree includes the root, stem, and crown (live and dead branches, excluding foliage).
[3] Root includes all the root system within an 11-inch radius of the pith from the top of a 6-inch stump to the taproot tip.
[4] Stem includes all material from a 6-inch stump to the terminal leader.
[5] Branch includes all branches 0.25-inch dob or larger.

parison of bark MC showed significant differences among species for SB, but none for CTB, RB, or BB.

Intermediate site.—Significant species differences in wood MC on the intermediate site were present for the complete tree and all components. Bark MC was significantly different among the species for RB. However, CTB, SB, and BB MC did not differ significantly among species.

Wet site.—The four species did not differ significantly in wood MC on the wet site. No statistical differences among species existed for CTB, SB, nor BB MC, but differences were present for RB MC.

Comparison of root, stem, and branch MC.—The following general relationships occurred when root, stem, and branch MC were compared. Wood MC ranked RW > SW > BW for all species on all sites with the exception of slash and longleaf on the dry site (RW > BW > SW) and shortleaf on the wet site (SW > RW > BW). Bark MC ranked RB > SB > BB for all species on all sites, except for shortleaf on the wet site (RB > BB > SB).

Phillips et al. (1976) found, as we did, that SW MC exceeded BW MC in loblolly, but found the opposite result for the other three species. In the SB and BB comparison, they found BB > SB, which corresponded only to our wet-site shortleaf. Differences between their study and ours with respect to tree diameter and age may have led to these conflicting results.

Comparison of wood and bark MC.—The comparison of wood and bark revealed CTB MC exceeded CTW MC for all species on the dry and intermediate sites, with the exception of dry-site loblolly. On the wet site, the trend was reversed

for all four species. Rootbark MC exceeded RW MC for all species on all sites. Stembark MC exceeded SW MC for all species on the intermediate site, for all except loblolly on the dry site, and for none of the species on the wet site. Branchwood MC exceeded BB MC except for loblolly on the wet site and loblolly, slash, and shortleaf on the intermediate site. Phillips et al. (1976) found SB MC was lower than SW MC for the four species and BW MC exceeded BB MC except in loblolly.

Site comparison.—Intersite differences in MC were generally component and species dependent; although certain trends were discernible. The highest SW MC and CTW MC occurred on the wet site, while the highest RW MC occurred on the dry site for all species. No single site produced a consistently high MC for BW for all species. Loblolly and slash produced the lowest MC for CTW, RW, and SW on the intermediate site, while longleaf and slash had their lowest MC for these components on the dry site. Branchwood MC was lowest for loblolly and longleaf on the wet site and lowest for slash and shortleaf on the intermediate site.

CTB MC was highest for slash and longleaf on the dry site, highest for loblolly and shortleaf on the intermediate site, and lowest on the wet site for all species. Rootbark MC was highest on the dry site (except in slash). Stembark MC was highest on the intermediate site (except in longleaf) and lowest on the wet site (except in loblolly). Branchbark SG was highest on the intermediate site for all species.

CONCLUSIONS

The four species did not differ significantly in CTW, SW, or BW SG on any site. Rootwood SG was significantly higher in shortleaf than in the other three species on all sites.

Intersite differences in SG were usually component and species dependent, although the wet site generally produced wood with a lower SG and the dry site produced wood with a higher SG.

The average wood MC in the complete tree, root, stem, and branches of longleaf pine was consistently higher than the other three species on all sites. Differences among species in component wood and bark MC were generally component and site dependent, while intersite differences in MC were generally component and species dependent.

Average dbh, total height, and taproot length did not differ significantly among the four species on the dry or the intermediate sites. Wet-site shortleaf produced a significantly shorter stem than the other species and a significantly shorter taproot than loblolly.

On the average, all species grew taller on the intermediate site. The shortest loblolly and slash occurred on the dry site, while the shortest longleaf and shortleaf occurred on the wet site.

Taproots were longer, on the average, on the dry site and shorter on the wet site for all species.

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