Wood Density Surveys of the Minor Species of Yellow Pine in the Eastern United States

Part V--Virginia Pine (*Pinus virginiana* Mill.)

by
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INTRODUCTION

This report is the fifth in a series covering the wood density surveys of the minor species of yellow pine in the Eastern United States.[1] Literature review and historical information regarding these surveys were presented in "Part I—Spruce Pine (*Pinus glabra* Walt.)" by Taras and Saucier (1968) and will not be repeated here.

The objectives of the survey were:

(1) To obtain data that will provide an estimate of the average specific gravity of unextracted wood of each minor species, and establish the degree of variation about each mean.

(2) To evaluate increment core/tree specific gravity relationships and develop regression equations for predicting tree specific gravity from increment core specific gravity.

(3) To examine the geographic trends of wood specific gravity within the range of each species, from east to west and from north to south.

[1]This study was conducted in cooperation with the Forest Products Laboratory, the Northeastern Forest Experiment Station, the Southern Forest Experiment Station, state forestry services, the pulp and paper industries, the southern pine plywood and sawmill industries, and numerous private forest owners throughout the Southern and Eastern United States.

MATERIALS AND METHODS

Species

Virginia pine (*Pinus virginiana* Mill.) grows throughout the northern Piedmont and foothills of the Appalachian Mountains from central Pennsylvania southwestward to northeastern Mississippi, Alabama, and northern Georgia (fig. 1). The species is also found as far north as Long Island, New York, and in scattered areas of Ohio and southern Indiana. Virginia pine is also known as scrub pine, Jersey pine, spruce pine, and poverty pine. It was considered a "forest weed tree" 60 years ago, but with increasing demands for wood its value as a commercial species has improved.

Virginia pine is intolerant of shade and usually grows in pure stands as a pioneer species. It is found on the poorest of heavy, dry soils on abandoned farmland where much of the A horizon has been eroded away. It is also found in mixed stands growing with shortleaf, pitch, Table-Mountain, loblolly, and white pines, and with various oaks, red maple, hickories, blackgum, and sweetgum (Fowells 1965, pp. 471-477). It is susceptible to windthrow because of its shallow root system and is easily damaged by fire because of its thin bark (Slocum and Miller 1953).

Virginia pine is small to medium in size, reaching 40 to 60 feet in height with d.b.h.

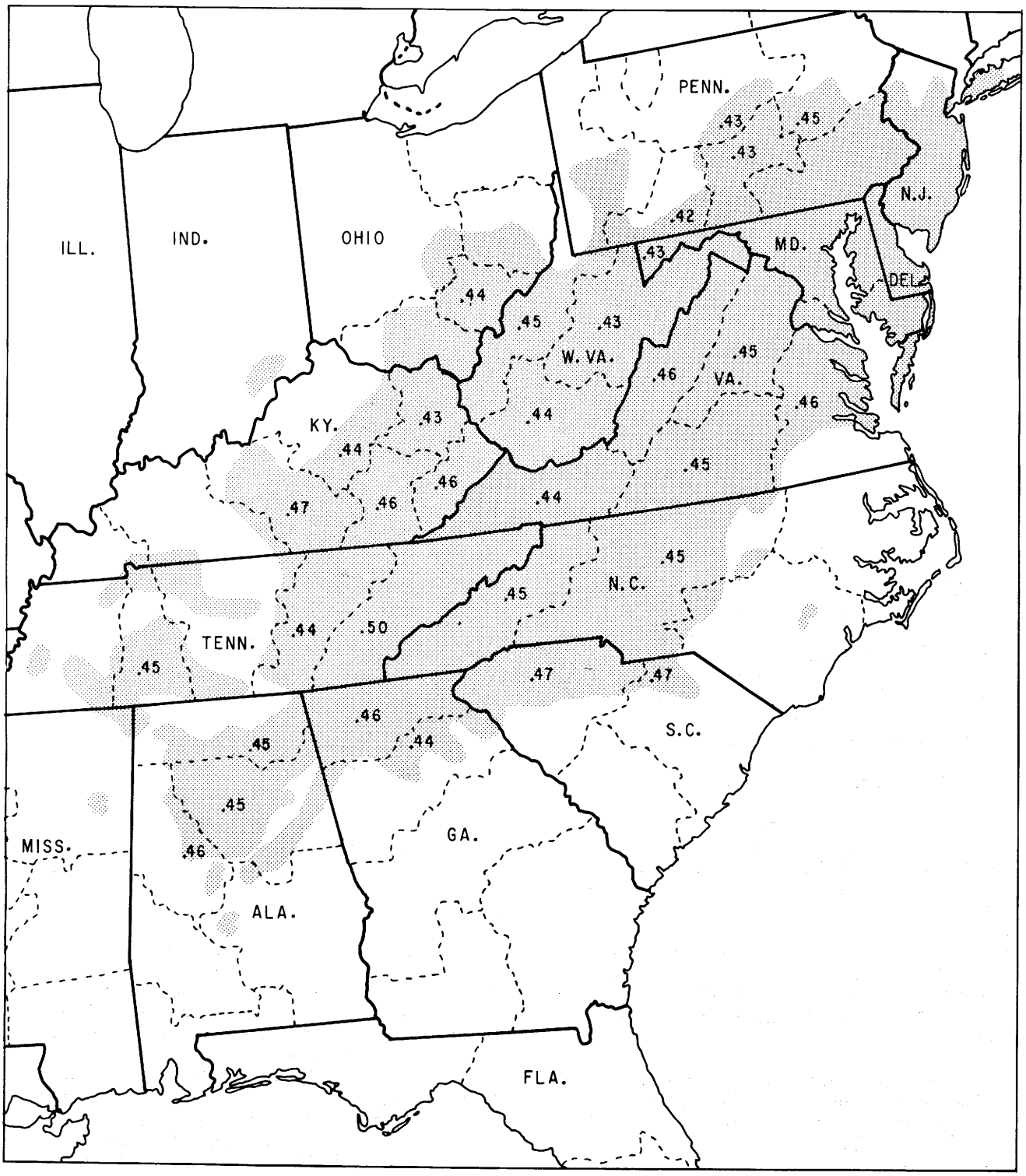

Figure 1.—*The natural range of Virginia pine. Numbers indicate average unextracted increment core specific gravity by Forest Survey Units.*

ranging up to 20 inches (fig. 2A). The largest diameter recorded for the species is 30.8 inches and the greatest height is 105 feet (Slocum and Miller 1953). Young Virginia pines are characterized by crowns that appear narrow and spruce-like with persistent dead branches; the crowns of mature trees are short and sparsely foliated with numerous persistent cones (Harlow and Harrar 1950).

The needles of Virginia pine are about 2 inches long, yellow-green, stout, usually twisted, and grow in fascicles of two (fig. 2B). The cones are 2 and 3 inches long (resembling those of shortleaf pine), but after opening, they are flatter based and persist for several years. Cone scales are thin, flat, and terminate in a sharp prickle (fig. 2C). The bark on young stems is thin and smooth, eventually becoming plated with thin, dark, red-brown scales (fig. 2D).

Field Sampling Procedure

Crews collected cores from Virginia pine while conducting routine Forest Survey inventories in Alabama, Georgia, South Carolina, North Carolina, and Virginia. In Georgia and North Carolina, every fifth forest inventory plot was a specific gravity sample plot. In Virginia and South Carolina, specific gravity data were collected from 10 percent of the regular Forest Survey inventory plots. In Alabama, sample plots were located on a 12- by 12-mile grid.

The trees sampled at each plot were selected with frequency proportional to basal area. A basal area factor of 10 square feet per acre was used in Georgia and North Carolina; a factor of 37.5 square feet per acre was used in Alabama, South Carolina, and Virginia. A single increment core was taken at breast height from each tree.

In order to sample Virginia pine over its entire range, a supplemental survey was made over the remainder of the range by personnel from the Forestry Sciences Laboratory, Athens, Georgia.

Forty plots were randomly selected, with the probability proportional to the commercial forest area within Forest Survey Units[2] containing Virginia pine. A 6-mile grid system was used to locate plots randomly within survey units. At each plot location, a random azimuth was selected along which the first 30 trees, over 5.0 inches d.b.h. and showing no signs of heartrot, were sampled by removing two increment cores from opposite sides of each tree. Total height, merchantable height to a 4-inch top, and d.b.h. of each sample tree were recorded.

The trees to be used for analyzing increment core/tree specific gravity relationships were selected at 10 locations within the range of Virginia pine. Two increment cores were taken from each of at least 24 trees at each location before they were felled. Beginning at the butt end of the tree, 1-inch-thick disks were cut at 5-foot intervals to a 4-inch top. Total height and merchantable height to a 4-inch top were recorded, along with diameter of each disk.

Laboratory Procedures

The specific gravity of all unextracted and extracted increment cores was determined with the maximum moisture method described by Smith (1954). The specific gravity of the wood disks was determined by the buoyancy method (Heinrichs 1954) and is based on green volume and ovendry weight.

Increment cores from all trees sampled in the supplemental survey were extracted after unextracted specific gravity was determined. These extractions were made with a mixture of two parts benzene and one part ethyl alcohol for 24 hours. No wood disks were extracted.

The average specific gravity of the individual 5-foot bolts within each tree was computed as the mean of the bolt's terminal disks. The average specific gravity of the tree was determined by weighting the average bolt specific gravity by bolt volume. Formulas for all these computations are shown in the Appendix. A discussion of the analysis of the increment core/tree specific gravity relationship data is presented in an office report available from the Forestry Sciences Laboratory, Carlton Street, Athens, Georgia 30601.

RESULTS AND DISCUSSION

Virginia Pine Specific Gravity and Its Variation

The average specific gravity of unextracted Virginia pine increment cores was .449, based on the average of one whole

[2]Forest Survey Units are subdivisions of a state based in part on county boundaries and in part on physiography of the state. They are established for the purpose of sampling and reporting results efficiently.

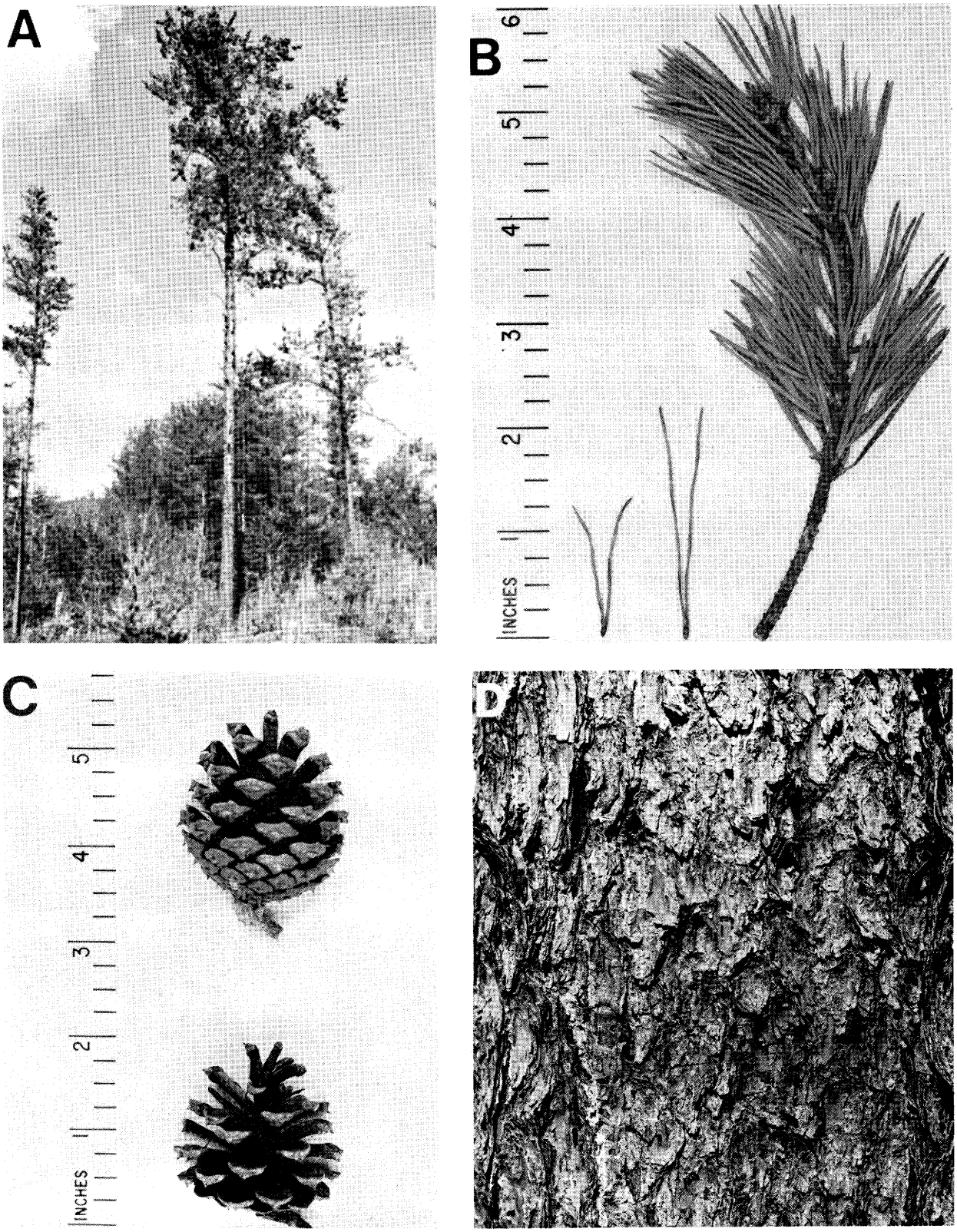

Figure 2.—*Botanical features of Virginia pine*: (*A*) *mature tree*, (*B*) *needles*, (*C*) *open and partially open cones*, (*D*) *bark*.

increment core from 2,114 trees collected over the range of the species. The standard error of the mean increment core specific gravity was .009, and the standard deviation of the individual observations about the mean was .055. The average tree sampled was 8.1 inches d.b.h. and 32 years old.

The estimated average tree specific gravity for Virginia pine was obtained by using the following regression equation:

$$\text{Tree specific gravity (Y)} = 0.19442 + 0.56175(\text{sp. gr., 1 unextracted core}) \quad (1)$$

When the specific gravity of all the trees sampled was adjusted to tree specific gravity using equation (1), the average tree specific gravity was .447, with a standard deviation from regression of .004.

The specific gravity of unextracted increment cores and the estimated tree specific gravity by three diameter classes (4.0 to 8.9 inches; 9.0 to 14.9 inches; and 15.0+ inches) are presented in table 1 for each Forest Survey Unit sampled.

The average unextracted increment core specific gravity is shown in figure 1 to illustrate specific gravity changes with geographic location. There appear to be no east-west or north-south trends in increment core specific gravity. The relative uniformity of Virginia pine specific gravity over its entire range may be associated with the restricted site conditions where it grows.

Table 1.—*Specific gravity data for Virginia pine by states and by Forest Survey Units within states*

State, survey unit, and number	Locations sampled	Diameter class	Trees sampled	Mean diameter of sampled trees	Mean age of sampled trees	Increment core specific gravity: Mean and standard error	Increment core specific gravity: Standard deviation	Estimated tree specific gravity[1] mean and standard error	Approximate timber volume[2]
	Number	*Inches*	*Number*	*Inches*	*Years*				*Million cu. ft.*
Alabama									
West-central (4)	3	4.0-8.9	9	6.3	25	.452 (.010)	.027	.448 (.006)	16.3
		9.0-14.9	1	11.0	48	.560 (---)	---	.509 (---)	11.7
		15.0+	0	---	---	---	---	---	---
North-central (5)	5	4.0-8.9	19	6.8	20	.444 (.005)	.052	.444 (.004)	70.4
		9.0-14.9	3	10.5	31	.483 (.038)	.065	.466 (.010)	58.0
		15.0+	0	---	---	---	---	---	---
North (6)	1	4.0-8.9	6	6.5	22	.452 (.018)	.044	.448 (.007)	21.3
		9.0-14.9	3	12.4	52	.457 (.024)	.041	.451 (.010)	12.3
		15.0+	0	---	---	---	---	---	---
State total	9	4.0-8.9	34	6.6	21	.448 (.008)	.047	.446 (.003)	108.0
		9.0-14.9	7	11.4	42	.483 (.018)	.048	.466 (.010)	82.0
		15.0+	0	---	---	---	---	---	---
Georgia									
North-central (4)	2	4.0-8.9	2	6.6	16	.430 (.040)	.071	.436 (.012)	6.3
		9.0-14.9	1	9.6	23	.460 (---)	---	.453 (---)	9.5
		15.0+	0	---	---	---	---	---	---
North (5)	15	4.0-8.9	31	6.5	21	.448 (.012)	.047	.446 (.003)	90.8
		9.0-14.9	13	11.9	46	.488 (.011)	.042	.468 (.005)	73.0
		15.0+	1	21.6	58	.470 (---)	---	.458 (---)	8.3
State total	17	4.0-8.9	33	6.5	21	.447 (.012)	.047	.445 (.003)	97.1
		9.0-14.9	14	11.8	44	.486 (.010)	.041	.467 (.005)	82.5
		15.0+	1	21.6	58	.470 (---)	---	.458 (---)	8.3
Kentucky									
Northern Cumberland (1)	3	4.0-8.9	74	6.9	24	.434 (.006)	.033	.438 (.002)	---
		9.0-14.9	16	9.9	29	.435 (.008)	.031	.439 (.004)	---
		15.0+	0	---	---	---	---	---	---
Eastern (2)	1	4.0-8.9	25	6.4	26	.460 (.006)	.031	.453 (.003)	---
		9.0-14.9	5	10.6	28	.494 (.025)	.056	.472 (.008)	---
		15.0+	0	---	---	---	---	---	---
Blue Grass (3)	1	4.0-8.9	24	7.2	21	.440 (.007)	.036	.441 (.003)	---
		9.0-14.9	6	10.2	22	.432 (.008)	.020	.437 (.007)	---
		15.0+	0	---	---	---	---	---	---

Table 1.—*Specific gravity data for Virginia pine by states and by Forest Survey Units within states (continued)*

State, survey unit, and number	Locations sampled	Diameter class	Trees sampled	Mean diameter of sampled trees	Mean age of sampled trees	Increment core specific gravity: Mean and standard error	Increment core specific gravity: Standard deviation	Estimated tree specific gravity[1] mean and standard error	Approximate timber volume[2]
	Number	*Inches*	*Number*	*Inches*	*Years*				*Million cu. ft.*
Kentucky (continued)									
Southern Cumberland (4)	3	4.0-8.9	65	7.2	30	.457 (.009)	.036	.451 (.002)	----
		9.0-14.9	25	10.0	32	.452 (.002)	.026	.448 (.003)	----
		15.0+	0	----	----	----	----	----	----
Pennyroyal (5)	2	4.0-8.9	24	6.9	34	.464 (.015)	.034	.455 (.003)	----
		9.0-14.9	36	10.7	38	.479 (.014)	.034	.463 (.003)	----
		15.0+	0	----	----	----	----	----	----
State total	10	4.0-8.9	212	7.0	27	.448 (.002)	.031	.446 (.001)	----
		9.0-14.9	88	10.3	33	.461 (.009)	.040	.453 (.002)	----
		15.0+	0	----	----	----	----	----	----
Maryland									
Western (2)	4	4.0-8.9	77	7.5	45	.434 (.009)	.033	.438 (.002)	----
		9.0-14.9	43	10.3	43	.432 (.007)	.032	.437 (.003)	----
		15.0+	0	----	----	----	----	----	----
North Carolina									
Piedmont (3)	22	4.0-8.9	115	6.4	20	.445 (.005)	.032	.444 (.002)	----
		9.0-14.9	48	10.6	31	.470 (.011)	.074	.458 (.002)	----
		15.0+	9	16.3	43	.479 (.011)	.037	.463 (.001)	----
Mountain (4)	8	4.0-8.9	32	6.7	20	.440 (.010)	.039	.441 (.003)	94.3
		9.0-14.9	14	11.4	31	.454 (.017)	.050	.449 (.005)	88.3
		15.0+	1	17.4	55	.530 (----)	----	.492 (.017)	5.4
State total	30	4.0-8.9	147	6.5	20	.444 (.002)	.032	.444 (.001)	317.8
		9.0-14.9	62	10.8	31	.467 (.004)	.078	.457 (.002)	265.8
		15.0+	10	16.4	44	.484 (.005)	.036	.466 (.005)	25.4
Ohio									
Southeastern (2)	1	4.0-8.9	22	6.9	26	.436 (.009)	.042	.439 (.005)	----
		9.0-14.9	8	9.7	28	.439 (.014)	.039	.441 (.006)	----
		15.0+	0	----	----	----	----	----	----
Pennsylvania									
Southwestern (4)	1	4.0-8.9	27	6.3	33	.420 (.006)	.033	.430 (.003)	----
		9.0-14.9	3	9.3	39	.417 (.017)	.030	.429 (.010)	----
		15.0+	0	----	----	----	----	----	----
North-central (5)	1	4.0-8.9	23	7.6	51	.438 (.007)	.034	.440 (.004)	----
		9.0-14.9	7	10.0	54	.417 (.014)	.037	.429 (.006)	----
		15.0+	0	----	----	----	----	----	----
South-central (6)	2	4.0-8.9	36	7.1	46	.423 (.001)	.042	.432 (.003)	----
		9.0-14.9	24	11.1	50	.441 (.007)	.034	.442 (.003)	----
		15.0+	0	----	----	----	----	----	----
Northeastern (7)	1	4.0-8.9	14	7.2	54	.450 (.009)	.032	.447 (.005)	----
		9.0-14.9	16	10.2	62	.447 (.010)	.040	.445 (.004)	----
		15.0+	0	----	----	----	----	----	----
State total	5	4.0-8.9	100	7.0	45	.430 (.006)	.032	.436 (.002)	----
		9.0-14.9	50	10.8	54	.438 (.006)	.033	.440 (.002)	----
		15.0+	0	----	----	----	----	----	----
South Carolina									
Northern Coastal Plain (2)	1	4.0-8.9	2	7.2	26	.470 (.012)	.018	.458 (.012)	----
		9.0-14.9	0	----	----	----	----	----	----
		15.0+	0	----	----	----	----	----	----
Piedmont (3)	8	4.0-8.9	13	7.4	22	.456 (.011)	.033	.451 (.005)	----
		9.0-14.9	20	10.9	30	.474 (.005)	.054	.461 (.004)	----
		15.0+	1	21.6	44	.530 (----)	----	.492 (.017)	----
State total	9	4.0-8.9	15	7.4	23	.458 (.010)	.032	.452 (.004)	----
		9.0-14 9	20	10.9	30	.474 (.005)	.054	.461 (.004)	----
		15.0+	1	21.6	44	.530 (----)	----	.492 (.017)	----

Table 1.—*Specific gravity data for Virginia pine by states and by Forest Survey Units within states (continued)*

State, survey unit, and number	Locations sampled	Diameter class	Trees sampled	Mean diameter of sampled trees	Mean age of sampled trees	Increment core specific gravity: Mean and standard error	Increment core specific gravity: Standard deviation	Estimated tree specific gravity[1] mean and standard error	Approximate timber volume[2]
	Number	*Inches*	*Number*	*Inches*	*Years*				*Million cu. ft.*
Tennessee									
West-central (2)	2	4.0-8.9	49	7.0	22	.444 (.013)	.032	.444 (.002)	----
		9.0-14.9	9	9.4	23	.467 (.005)	.027	.457 (.006)	----
		15.0+	2	17.6	43	.515 (.006)	.009	.484 (.012)	----
Plateau (4)	3	4.0-8.9	64	6.8	26	.443 (.002)	.029	.443 (.002)	----
		9.0-14.9	26	9.9	29	.447 (.009)	.036	.445 (.003)	----
		15.0+	0	----	----	----	----	----	----
Eastern (5)	2	4.0-8.9	33	7.6	40	.498 (.012)	.024	.474 (.003)	----
		9.0-14.9	26	10.7	44	.508 (.019)	.043	.480 (.003)	----
		15.0+	1	15.4	34	.480 (----)	----	.464 (.017)	----
State total	7	4.0-8.9	146	7.1	28	.456 (.010)	.030	.450 (.017)	----
		9.0-14.9	61	10.2	35	.476 (.018)	.053	.462 (.002)	----
		15.0+	3	16.8	40	.503 (.011)	.024	.477 (.010)	----
Virginia									
Coastal Plain (1)	13	4.0-8.9	55	6.9	28	.459 (.010)	.044	.452 (.002)	109.2
		9.0-14.9	34	10.9	41	.470 (.005)	.044	.458 (.003)	110.8
		15.0+	4	16.0	51	.468 (.005)	.019	.457 (.008)	7.2
Southern Piedmont (2)	14	4.0-8.9	137	6.7	23	.443 (.005)	.053	.443 (.001)	290.4
		9.0-14.9	54	10.6	34	.466 (.009)	.060	.456 (.002)	190.7
		15.0+	4	16.6	49	.457 (.012)	.039	.451 (.008)	9.9
Northern Piedmont (3)	15	4.0-8.9	114	6.7	23	.446 (.005)	.032	.445 (.002)	206.4
		9.0-14.9	52	11.0	33	.456 (.006)	.044	.450 (.002)	159.8
		15.0+	0	----	----	----	----	----	----
Northern Mountain (4)	11	4.0-8.9	60	6.6	33	.462 (.007)	.053	.454 (.002)	74.1
		9.0-14.9	20	11.7	55	.475 (.006)	.040	.461 (.004)	44.7
		15.0+	0	----	----	----	----	----	----
Southern Mountain (5)	7	4.0-8.9	26	6.9	21	.430 (.011)	.038	.436 (.003)	34.9
		9.0-14.9	10	10.0	23	.452 (.010)	.046	.448 (.005)	25.6
		15.0+	0	----	----	----	----	----	----
State total	60	4.0-8.9	392	6.7	25	.448 (.001)	.046	.446 (.001)	715.0
		9.0-14.9	170	10.9	37	.464 (.001)	.049	.455 (.001)	531.6
		15.0+	8	16.3	50	.462 (.007)	.028	.454 (.006)	17.1
West Virginia									
Northwestern (1)	4	4.0-8.9	98	6.6	30	.443 (.008)	.053	.443 (.002)	----
		9.0-14.9	22	10.2	59	.476 (.019)	.053	.462 (.004)	----
		15.0+	0	----	----	----	----	----	----
Northeastern (2)	4	4.0-8.9	82	7.2	34	.433 (.004)	.033	.438 (.002)	----
		9.0-14.9	36	10.8	40	.439 (.007)	.029	.441 (.003)	----
		15.0+	2	15.1	40	.420 (.051)	.012	.430 (.012)	----
Southern (3)	5	4.0-8.9	117	6.6	31	.442 (.005)	.070	.443 (.002)	----
		9.0-14.9	32	10.9	50	.448 (.013)	.049	.446 (.003)	----
		15.0+	1	15.2	60	.440 (----)	----	.441 (.017)	----
State total	13	4.0-8.9	297	6.7	32	.440 (.002)	.063	.441 (.001)	----
		9.0-14.9	90	10.7	47	.451 (.005)	.047	.448 (.002)	----
		15.0+	3	15.1	47	.427 (.005)	.012	.434 (.010)	----
All States	166	4.0-8.9	1,475	6.8	29	.445 (.009)	.055	.444 (.001)	----
		9.0-14.9	613	10.7	39	.460 (.009)	.055	.453 (.001)	----
		15.0+	26	16.7	46	.474 (.006)	.033	.461 (.003)	----
Total (all classes)	166		2,114	8.1	32	.449 (.009)	.055	.447 (.004)	----

[1]Estimates were made with equation (1):

$$Y = 0.19442 + 0.56175 \text{ (sp. gr., 1 unextracted core)}.$$

[2]From Forest Survey data of the Southern and Southeastern Forest Experiment Stations.

Increment Core/Tree Specific Gravity Relationships—Simple Linear and Multiple Regression Analyses

A discussion of the increment core/tree specific gravity relationships is given in an office report available upon request and will not be treated in detail here.

The increment core/tree specific gravity relationships examined by simple linear regressions are listed in table 2 for each plot sampled and for all sample plots combined. Also included in table 2 are the correlation coefficients and standard deviations from regressions.

Solvent extraction of the increment cores resulted in a 2-percent decrease in the coefficient of determination. Thus, there appears to be no reason for extracting Virginia pine increment cores to improve ability to predict tree specific gravity.

A stepwise multiple regression analysis was made to determine if the addition of d.b.h., age, total height, d.b.h./age, volume/age, 1/age, and total height/age would provide a higher coefficient of determination than that obtained with the simple regressions. None of the tree characteristics considered gave significant improvement in the relationship between one unextracted increment core and tree specific gravity.

Equation (1), a simple linear equation, was associated with 64 percent of the variation about regression and had a standard deviation from regression of .017. The best multiple regression equation had the reciprocal of age as the second variable, but the addition of this variable increased the coefficient of determination by only 1 percent over that for the simple linear regression using one extracted core to estimate tree specific gravity.

Relationship of Unextracted and Extracted Core Specific Gravity

The specific gravity of increment cores collected from trees in the western and northern parts of the species range were determined in both the unextracted and extracted condition. The average unextracted increment core specific gravity based on 1,200 increment cores was .451 and the extracted increment core specific gravity was .421, a decrease of 7.1 percent (based on the extracted core specific gravity value). From these data, a regression equation for predicting extracted core specific gravity from unextracted core specific gravity was developed. Equation (2) has a correlation coefficient of .86 and a standard deviation from regression of .015.

$$Y = 0.10315 + 0.70493\ X_1 \qquad (2)$$

Where: Y = specific gravity of one extracted increment core

X_1 = specific gravity of one unextracted increment core

Similar high correlations have been reported for the other minor species of southern yellow pine (Taras and Saucier 1968; Clark and Saucier 1969).

Table 2.—*Increment core specific gravity means, standard deviations, simple linear regression equations, coefficients of determination, and standard deviations from regressions for increment core/tree specific gravity relationships for each plot sampled and all plots combined*

County and state	Trees sampled	Increment core specific gravity mean and standard deviation	Regression equation	r	Standard deviation from regression
	Number				
Lawrence, Ala.	27	.469 (.033)	$Y = 0.20710 + 0.53266\ X_1$	.78	.014
Caldwell, N. C.	37	.482 (.033)	$Y = 0.18431 + 0.58561\ X_1$	.84	.013
Person, N. C.	24	.453 (.036)	$Y = 0.23283 + 0.47833\ X_1$	.68	.019
Washington, Ohio	25	.429 (.034)	$Y = 0.11185 + 0.74829\ X_1$	.87	.014
Bedford, Pa.	25	.489 (.057)	$Y = 0.32213 + 0.31491\ X_1$	.71	.018
McMinn, Tenn.	26	.485 (.032)	$Y = 0.24331 + 0.47386\ X_1$	.68	.017
Henry, Va.	33	.448 (.036)	$Y = 0.14820 + 0.66162\ X_1$	.90	.012
Prince Edward, Va.	36	.462 (.027)	$Y = 0.18786 + 0.58130\ X_1$	.71	.016
Albemarle, Va.	32	.445 (.032)	$Y = 0.17692 + 0.58179\ X_1$	.73	.018
Pocahontas, W. Va.	25	.448 (.036)	$Y = 0.25223 + 0.42924\ X_1$	.60	.021
All areas combined	290	.461 (.040)	$Y = 0.19442 + 0.56175\ X_1$	.80	.017

SUMMARY AND CONCLUSIONS

The average specific gravity of Virginia pine increment cores taken at d.b.h. was .449, based on one whole increment core from 2,114 trees collected over the range of the species. The average tree specific gravity of the species was estimated to be .447. There appear to be no distinct north-south or east-west geographic trends in specific gravity within the range of the species.

The best equation developed for predicting Virginia pine tree specific gravity was equation (1), in which the specific gravity of one unextracted increment core was the independent variable. Extracting a single core did not improve the prediction of tree specific gravity. The addition of a second or third independent variable involving such tree characteristics as d.b.h., age, or total height did not improve the prediction of tree specific gravity from an unextracted core.

Equation (2) was developed for predicting extracted increment core specific gravity from unextracted increment core specific gravity and was associated with 74 percent of the total variation in extracted increment core specific gravity.

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APPENDIX

Computational Procedures

1. Increment core specific gravity $= \dfrac{\text{ovendry weight of core}}{\text{green weight of core} - .3464\,(\text{ovendry weight of core})}$

2. Disk specific gravity $= \dfrac{\text{ovendry weight of disk}}{\text{displaced volume of disk}}$

3. Bolt specific gravity $= \dfrac{\text{specific gravity top disk} + \text{specific gravity bottom disk}}{2}$

4. Tree specific gravity $= \dfrac{\sum_{1-n} (\text{bolt volume} \times \text{bolt specific gravity})}{\sum_{1-n} \text{bolt volumes}}$

5. Bolt volume = bolt length, feet $\times \left[\dfrac{.005454\,(\text{d.i.b.})_t^2 + .005454\,(\text{d.i.b.})_b^2}{2}\right]$

   where: t = top of bolt
   b = base of bolt

6. (a) Mean core specific gravity $\bar{x} = \dfrac{\Sigma_i \Sigma_j X_{ij}}{m_1 n_1}$

   where: X_{ij} = the core specific gravity for the jth tree at the ith location
   m_1 = number of trees at each location
   n_1 = number of locations

   (b) The standard deviation of individuals was estimated from the sample range of the core specific gravities using the tabular values of the ratio of the standard deviation to the range.

7. Tree specific gravities were estimated from regression by:

   (a) Tree specific gravity (Y) = $b_0 + b_1 X_1$

   where: X_1 = specific gravity of 1 unextracted core

   (b) The standard error of the predicted mean tree specific gravity was estimated by--

$$S_{\hat{y}} = \left[S^2_{y.x}\left(\frac{1}{n} + \frac{(\bar{x}_1 - \bar{x}_2)^2}{\Sigma x_2^2}\right)\right]^{\frac{1}{2}}$$

   where: $S^2_{y.x}$ = residual mean squares
   n = number of trees in large sample
   $\bar{x}_1$ = mean unextracted core specific gravity of large sample
   $\bar{x}_2$ = mean unextracted core specific gravity of small sample

(c) The standard error of the core mean was approximated by the following computation when the variances were pooled to obtain the mean core specific gravity of more than one location:

$$\text{standard error} = \sqrt{\frac{K}{(\Sigma n_i)^3}\left(\frac{\Sigma S_i^2 + \bar{x}^2 \Sigma n_i^2 - 2\bar{x}\Sigma n_i S_i}{K-1}\right)}$$

where: K = the number of locations at which trees were bored for specific gravity

S_i = the sum of specific gravities of cores at the ith location ($= \Sigma_j X_{ij}$)

(d) When variances were not pooled the standard error of the mean was approximated by--

$$\text{standard error} = \frac{S}{\sqrt{n}}$$

where: S = standard deviation estimated from the sample range of core specific gravities

n = number of observations in sample

8. Percentage difference in specific gravity due to extraction $= \dfrac{\text{unextracted core sp. gr.} - \text{extracted core sp. gr.}}{\text{extracted core sp. gr.}} \times 100$

Clark, Alexander III, and Wahlgren, Harold E.
1970. Wood Density Surveys of the Minor Species of Yellow Pine in the Eastern United States. Part V--Virginia Pine (Pinus virginiana Mill.). Southeast. Forest Exp. Sta., USDA Forest Serv. Res. Pap. SE-64, 11 pp.

Specific gravity was determined for Virginia pine (Pinus virginiana Mill.) from 2,114 trees sampled over the range of the species. The average increment core specific gravity of the species was .449. Increment core/tree specific gravity relationships were examined, and equations for predicting tree specific gravity from increment cores were developed. The average tree specific gravity of the species was estimated to be .447. No geographic trends were detected in the specific gravity of Virginia pine.

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