Variation in Inherent Wood Characteristics in Slash Pine

Sharon R. Miller, Jr. Group Leader
Union Bag-Camp Paper Corporation
Woodlands Research Department
Savannah, Ga.

The paper you have just heard on specific gravity variations for several species over an entire state introduces rather nicely my subject, entitled "Variation in Inherent Wood Characteristics in Slash Pine. " Specific gravity is the major inherent characteristic I am involved with here, along with moisture content and proportion of summerwood as they are related to specific gravity. Instead of covering a major geographic area such as the state of Mississippi, however, this study deals with variations between and within just a few carefully-selected trees. Let me outline how we got into this work and what we learned from it.

Several years ago, in 1955, we initiated a sizeable study concerning determinations of weight-volume relationships in slash pine and how these could be used operationally in our land management and wood procurement work. Our increasing emphasis upon weight measure of pulpwood prompted this study. We felt that we should know more about the factors that affect wood weight in order to use this method of measurement intelligently and accurately. For example, we hoped to obtain information aimed at eventually cruising timber in terms of weight rather than volume.

The study grew in scope as it progressed until finally we had data on many parts of the weight-volume picture. As a result, it was possible to go deeper into the matter than had previously been planned. We ended up with information on specific gravity, moisture content, and percent summerwood, plus additional information on density, bark content, etc. for a phenotypically homogeneous sample of slash pine trees over a restricted area. It is from these data that I intend to draw the text for my presentation here today.

First of all, I would like to explain briefly the study areas and procedures we used for obtaining these data since they have a bearing upon the application of the results. The areas we used were four different sites on our Experimental Forest about 20 miles northwest of Savannah. These can be described as:

1. Upland ridge or Hill site characterized by a deep, sandy soil and low water table.

2. Run or Hammock site, characterized by a layer of undecomposed hardwood litter on top of incorporated humus and fine sand, with abundant or over-abundant moisture but generally good drainage.

3. Flat site, characterized by its low, level topography, palmetto-gallberry understory, and seasonal flooding.

4. Pond site, characterized by its bowl-like topography, with standing water present for long periods of the year.

Within each of these sites, 24 slash pine trees were selected--8 in the 7-inch d. b. h. class, 8 in the 9-inch d. b. h. class, and 8 in the 11-inch d. b. h. class. These d. b. h. classes were chosen because we felt that they covered the normal range of pulpwood sizes. In selecting the trees, other variables such as age, height, live crown ratio, and amount of adjacent competition were required to fall within fairly narrow limits in order to minimize outside effects and give a homogeneous sample for each site and size class.

A cutting schedule was set up whereby two trees in each d. b. h. class on each site were selected to be cut, measured, weighed, and sampled at a specified time during the year. Four such equally spaced cutting dates or seasons--Spring, Summer, Fall, and Winter--were used. Thus, we had three major variables consisting of site, season of cutting, and d. b. h. class.

As each tree was cut, it was marked into five foot bolts up to a minimum top diameter inside bark of four inches. Each bolt, starting with the butt bolt, was cut from the stem, weighed rough to the nearest one-half pound, measured for rough diameter at both ends and in the middle, weighed peeled, and measured peeled for diameters. A one- to two-inch sectional disk was then cut out of each peeled bolt at the midpoint. Two diametrically opposite wedges of about 30 degrees were cut from each disk, and these wedges were immediately labelled and weighed to the nearest 0.1 gram. This essentially completed the field work.

The volume--by the water-displacement method--and moisture content of each wedge was determined soon after it was cut. Percent summerwood for each bolt was calculated for the two wedge samples using a technique that allows an accurate and fairly rapid determination of the proportion of summerwood in the round tree. This technique, incidentally, was described by myself and Barry F. Malac in the November 1956 Journal of Forestry. Our use of wedges for determinations of specific gravity and moisture content and this technique for summerwood percent determinations gave us measurements of these three characteristics on a common basis representing round timber such as a tree or a stick of pulpwood.

As we determined it, specific gravity represents the dry weight of wood per unit of green volume using the metric system of measure; moisture content percent represents the amount of moisture in terms of weight in comparison to the oven-dry weight of the sample; and percent summerwood represents the amount of summerwood area as compared to the amount of total cross-sectional area in the sample. Wood characteristics presented on a tree basis are properly weighted so that the figures represent weighted combinations of the bolts making up the trees Needless to say, we found substantial differences in these characteristics both between and within trees.

Now with the experimental procedure out of the way, let's get down to the meat of the study--the results. First of all, I want to cover the effects of the three main variables --site, season of cutting, and tree size--upon tree specific gravity and moisture content, These were tested employing the analysis-of-variance approach and using a 5% level of significance for accepting or rejecting the hypothesis that no effect exists. D.b.h. was eliminated as an influencing factor on specific gravity and moisture content early in the game; soon after came the effect of Season of Cutting, although this variable tested very close to the 5% level. Actually, it was close enough so that its effect upon moisture content and specific gravity became a matter of discussion for some time. It was not too difficult to accept the possibility of Season affecting moisture content, but any effect of Season upon specific gravity was rather difficult to visualize. A survey of available literature plus various inquiries into the matter failed to shed any further light upon the question. Consequently, we presently hold to the feeling that Season of Cutting has no real effect upon either moisture content or specific gravity. I may be opening up an old controversy by even mentioning this subject here today, but there it is for what it is worth.

Site alone was not a significant factor in specific gravity or moisture content, but a sizeable interaction existed between Site and D.b.h. A careful examination of the data indicated that Site consistently influenced specific gravity and moisture content in the larger two d.b.h. classes but the consistency and degree broke down in the lower d.b.h. class. At first we thought we had something that we could put our finger on, but a closer look at the basic data showed that there was a sizeable difference in average age between Sites. An array of the average ages indicated that Site and Age could easily be used interchangeably as variables. Various publications list Age as having an influence upon specific gravity, so we are not sure if Site is the real factor in the interaction. All I will venture to say is that some element, probably age, plus d.b.h. measurably affects the specific gravity of living trees.

After dispensing with the three main variables, various regressions and mean values were determined for a number of different wood characteristics. Curvilinear regressions were tested and retained where significant. Figure 1 presents the curvilinear correlation between, specific gravity as the dependent variable and moisture content as the independent variable. I will not go into the equation itself but merely want to point out the high multiple correlation index of about 0.92. This regression and most of the ones to follow were calculated using 855 individual measurements from that many bolts. By the way, the two sets of measurements obtained from the two wedges cut from each bolt were averaged resulting in one set of figures for each bolt. Although the strong relationship between specific gravity and moisture content is nothing new, we think the method of obtaining the data and the way of presenting it resulted in an improved measure of that relationship as evidenced by the very high correlation index.

Figure 2 summarizes the relationship found between specific gravity and percent summerwood; in this case, however, a test for curvilinearity indicated that a straight line was adequate and this was used. Although the correlation coefficient is not quite as high as between specific gravity and moisture content, still the highly significant coefficient of about 0. 78 indicates a strong relationship between the two variables.

Figure 3 presents the relationship of moisture content to percent summerwood and in this case a curvilinear regression again proved worthwhile. The correlation index is about the same as that for specific gravity and percent summerwood. This was expected due to the strong tie-in between specific gravity and moisture content.

A slightly different approach to the problem is presented in Figure 4, In this instance we were trying to find if it would be possible to determine the weighted average specific gravity of the merchantable portion of a tree by just measuring the specific gravity at the midpoint of the first bolt. As you can see by the high correlation coefficient of about 0. 86, this seems to be a real possibility. This relationship could possibly be the most useful one of those discussed thus far.

The most important factor yet to be considered is the matter of bolt number or position in the tree. Bolts were numbered consecutively starting with the butt bolt as Bolt Number 1. The literature is sprinkled with information on the variation of moisture content and specific gravity relative to position in the tree, and Figure 5 emphasizes the degree and consistency of this effect as we found it for moisture content. No effort has been made to smooth out the results; each point represents an average figure for that position in the tree. I might point out to you that beyond Bolt #8 the number of samples starts falling off rapidly. Hence the more erratic path of the points. Figure 6 shows the effect of bolt number upon specific gravity. Note that in this case the dependent variable decreased with increasing height in the tree, whereas moisture content increased with increasing height in the tree.

Figures 7 and 8 summarize some of the results concerning other relatively minor aspects. First of all, in Figure 7, it is interesting to note the lack of change in green wood density with increasing height in the tree. As we used it, wood density represents green weight in pounds per green cubic foot. The theory is that the reduction in specific gravity, which deals with dry weight, is offset by an increase in absolute moisture content resulting in a stable green density up the tree. This points up the fact that moisture content percent as such is often concealing. Percent moisture can actually vary

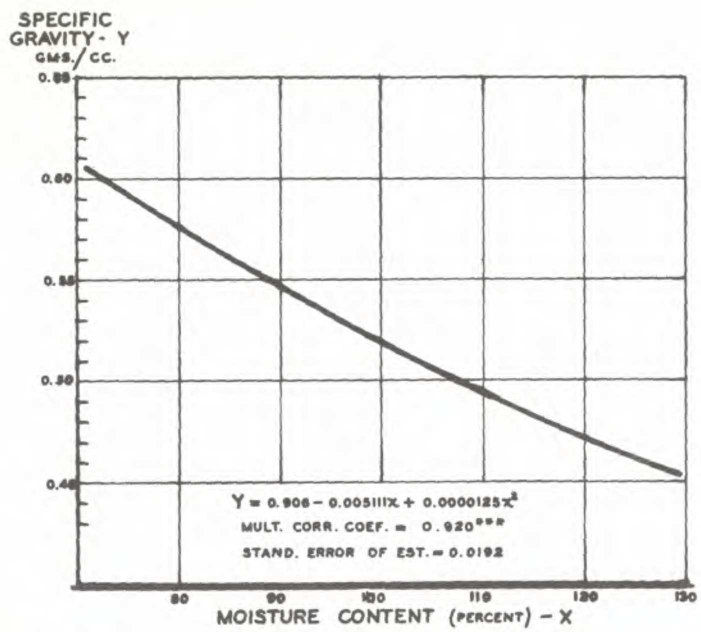

Figure 1. Relationship between specific gravity and percent moisture content for slash pine (855 samples from 96 trees).

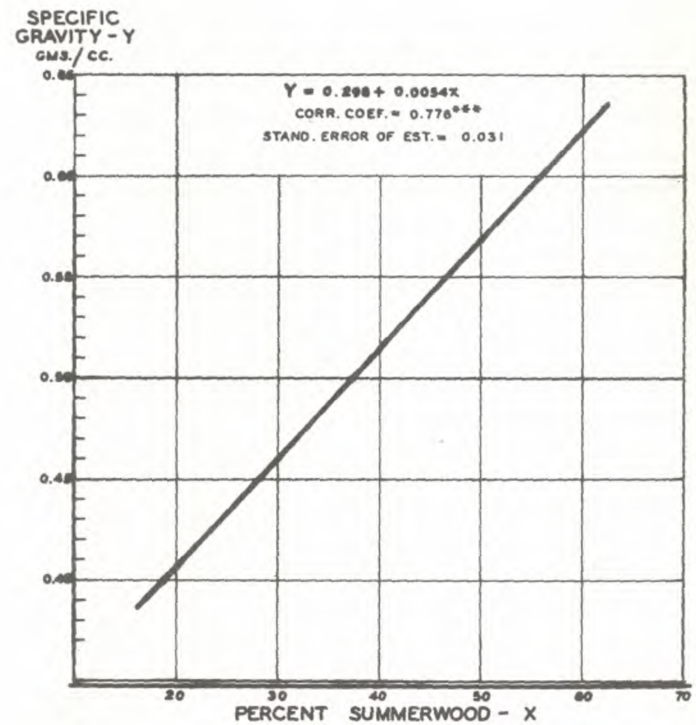

Figure 2. Relationship between specific gravity and percent summerwood for slash pine (855 samples from 96 trees).

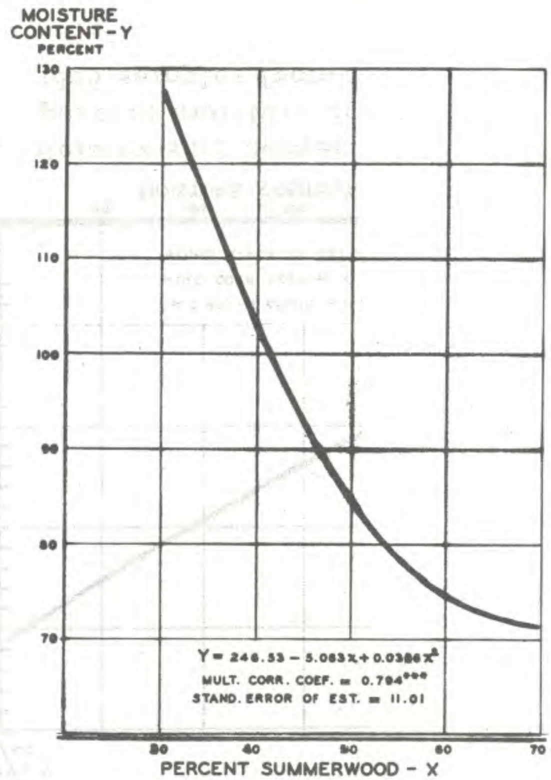

Figure 3. Relationship between percent moisture content and percent summerwood for slash pine (855 samples from 96 trees).

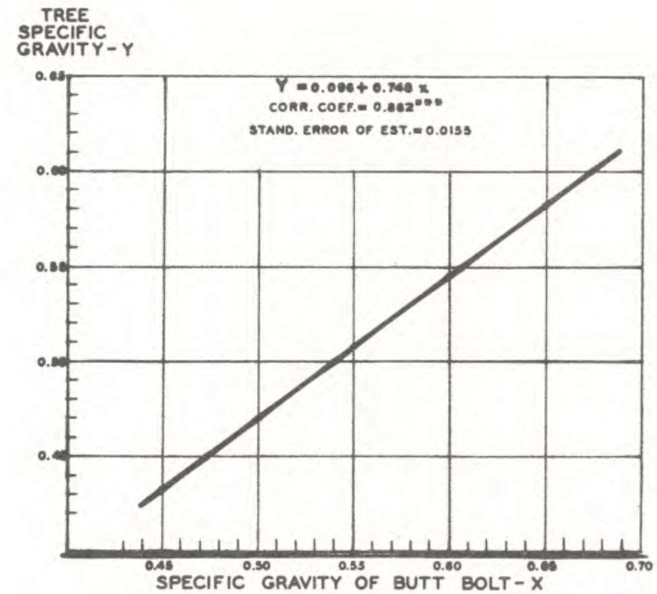

Figure 4. Relationship between specific gravity of entire merchantable stem and specific gravity of butt bolt for slash pine (96 paired measurements from 96 trees).

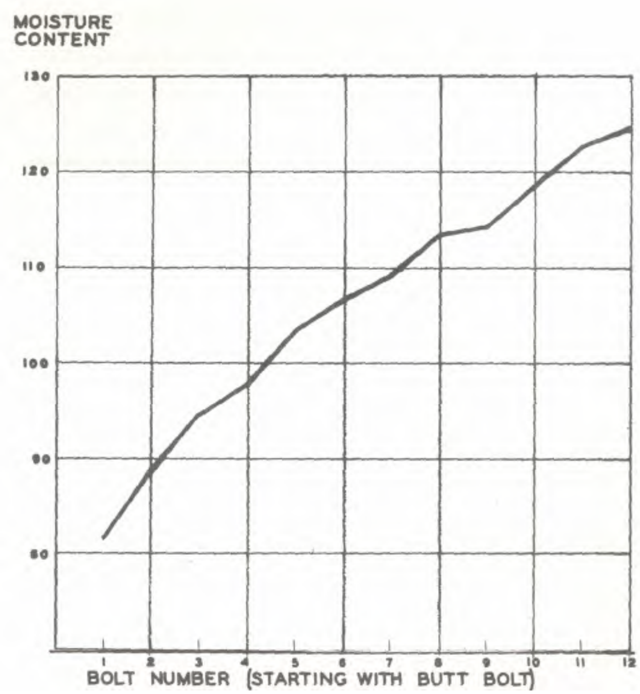

Figure 5. Relationship between percent moisture content and position in the tree for slash pine (855 samples from 96 trees).

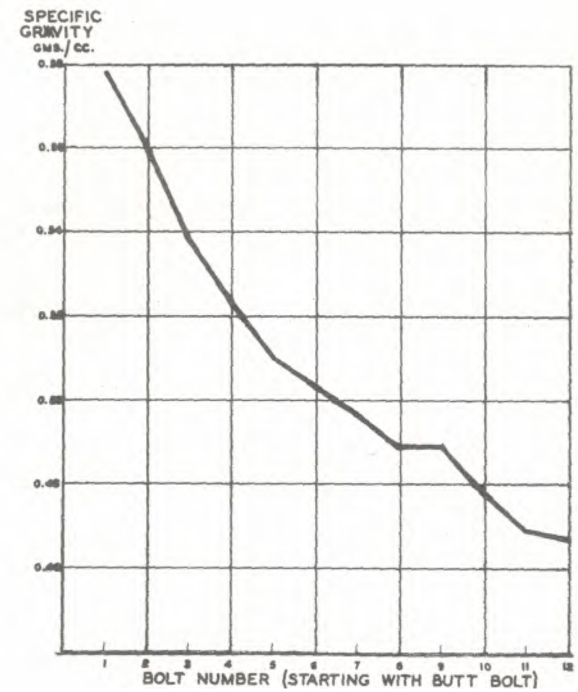

Figure 6. Relationship between specific gravity and position in the tree for slash pine (855 samples from 96 trees).

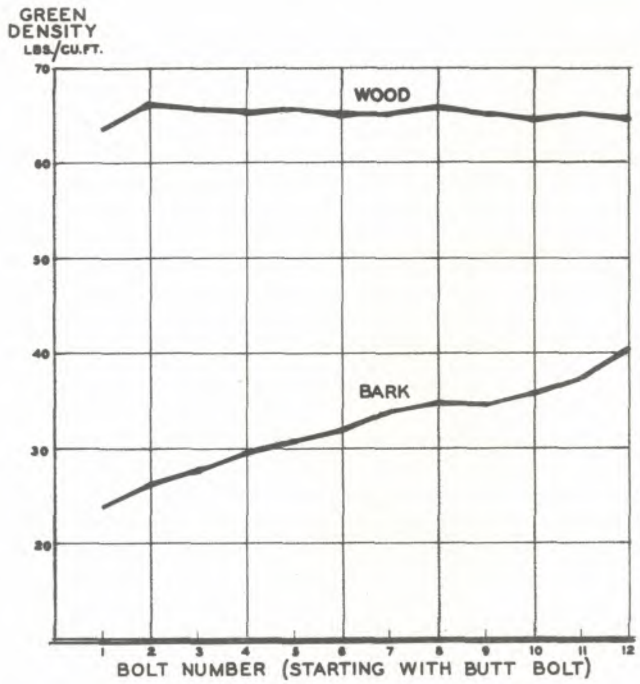

Figure 7. Relationship between green wood and green bark density and position in the tree for slash pine (855 samples from 96 trees).

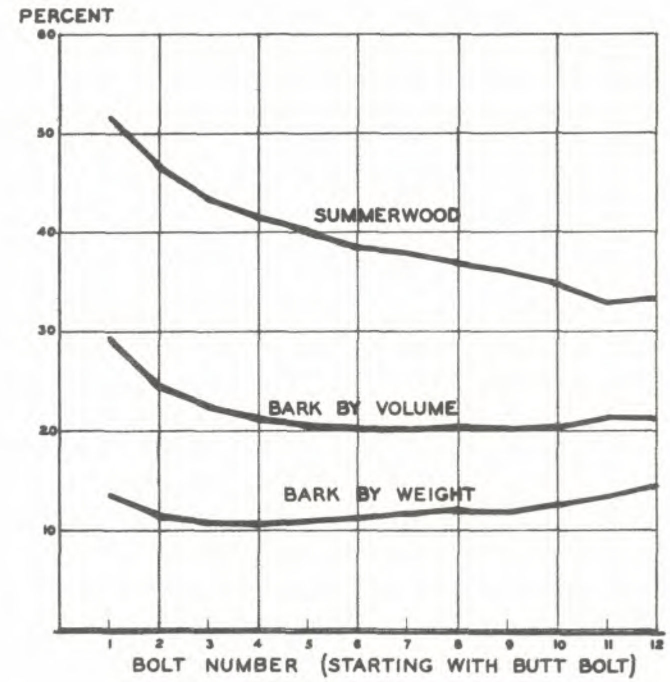

Figure 8. Relationship of percent summerwood, bark by volume, and bark by weight to position in the tree for slash pine (855 samples from 96 trees).

without any difference in the absolute amount of water per given volume. Green density does not give a clear picture of the amount of wood substance present, and the latter is often the most important factor. Note also in Figure 7 that bark density appears to increase with increasing height in the tree.

The bark information presented in Figure 8 is interesting and may be useful in the future. It should be emphasized, however, that bark volume represents gross volume including air space in fissures. Percent bark tends to decrease rapidly at first, levels out, and then gradually curves upward. This must reflect tree form to some degree plus other factors. Percent summerwood, shown also in Figure 8, falls off with increasing height in the tree the same as specific gravity.

Table 1 gives you a brief summary covering nearly all of our results. All the many values determined are broken down in different ways to give you an idea of the magnitude and direction of differences. I included only the results for three different positions in the tree since I wanted to keep the table compact. Overall average figures presented at the bottom of the large table may be more meaningful to you than any of the other things I have presented today. From the literature I have seen, most of these values agree reasonably well with other results; there is quite a bit of variation in specific gravity results over the range of slash pine, however. Our main point is that our results represent properly weighted averages for the entire merchantable stem of trees and are representative of round timbers.

Height and age values are presented by Sites, in Table 2, to illustrate the possibility of several factors causing the variation in specific gravity. This variation was at first attributed to an interaction of Site and D. b. h.

In closing, I would like to say that we feel we have profited by this work in many ways. First and most important of all, we have gained a more intimate knowledge of the quantitative and qualitative aspects of individual inherent tree characteristics. As far as tree improvement work is concerned, we now have a better understanding of what we want, what we have, and how we can deal with it.

Table 1. Summary of wood and bark results by four major variables for slash pine.

Item	Bark % by wt.	Bark % by vol.	Green bark density lbs/cu.ft.	Green wood density lbs/cu.ft.	Specific gravity gms/cc.	Moist. cont. %	Summer-wood %
Bolt #1	13.6	29.5	23.9	63.4	.578	81.6	51.7
Bolt #4	10.8	21.1	29.5	65.4	.523	97.8	41.6
Bolt #8	12.0	20.5	34.8	65.9	.489	113.4	37.0
Hill site	11.9	25.2	25.9	64.9	.507	104.3	41.2
Hammock site	11.7	22.5	29.8	64.9	.538	94.6	44.9
Pond site	11.7	22.7	29.5	65.3	.523	101.7	41.8
Flat site	11.6	22.8	29.0	65.4	.544	92.5	43.3
7" d.b.h.	12.9	25.3	28.4	64.7	.527	98.1	41.9
9" d.b.h.	11.9	23.5	28.7	65.0	.534	96.3	43.3
11" d.b.h.	11.2	22.4	28.7	65.4	.527	98.9	42.9
Spring	12.1	24.2	28.3	65.7	.526	98.9	43.2
Summer	11.8	22.1	29.9	63.2	.527	97.4	43.0
Fall	11.9	23.4	29.2	65.7	.540	93.5	42.6
Winter	11.0	23.2	27.0	66.1	.525	102.1	42.7
Overall average*	11.7	23.2	28.6	65.1	.529	97.9	42.9

* Combined results for all bolts, all sites, all d.b.h. classes, and all seasons.

Table 2. Average age, total height, and specific gravity figures by sites.

Item	Average height	Average age at breast ht.	Specific gravity
Hill Site	53'	22 yrs.	.507
Hammock Site	71'	39 yrs.	.538
Pond Site	65'	30 yrs.	.523
Flat Site	63'	36 yrs.	.544

(Note similarity in effect of site and age upon specific gravity.)