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Variation of Average Moisture Content of Standing Sweetgum Trees in Louisiana

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VARIATION OF AVERAGE MOISTURE CONTENT OF STANDING SWEETGUM TREES IN LOUISIANA

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ABSTRACT

A study was conducted to determine if there is a significant variation in moisture content and specific gravity of sweetgum trees (Liquidambar styraciflua L.) within the state of Louisiana. Sweetgum was chosen because it can be found on a variety of sites and is an important hardwood pulp species. This information was sought because of its value to the business of buying wood by weight rather than by volume measure, and because moisture content and specific gravity are the main factors causing variation in the weight of wood. Samples were taken with an increment borer from three different sites– hilltop, slope and bottomland– at three geographical locations within the state and during each of the four seasons. Moisture content as a percentage of oven-dry weight was determined for each of 900 samples, but specific gravity was determined by the maximum moisture content method only for samples obtained in January 1968.

A review of pertinent literature indicates that most species of deciduous trees follow a definite seasonal pattern of moisture variation that is repeated each succeeding year. It was found in this study that the moisture content of standing sweetgum trees varies considerably from season to season.

There was a significant variation in moisture content between locations, but this variation was small and did not follow a definite geo-

graphic trend. The moisture content varied appreciably between sites at various times of the year, but when other variables were held constant the difference in moisture content between sites was not significant.

The average specific gravity varied only a little with geographic location but it was negatively correlated with the moisture content of the trees.

The study indicated that the use of different scaling factors for each season of the year is desirable.

INTRODUCTION

Even though pulpwood has been sold satisfactorily on a volume basis for over 50 years in the United States, buying by volume is not a very accurate method from the standpoint of wood volume or pulp yield. Taras (1956) stated that, in a total volume of 128 cubic feet, the salable volume of pulpwood may vary from 50 to 105 cubic feet because of taper, diameter, stick length, and other variables. Because of this, weight-scaling has replaced volume scaling at many mills and is now rapidly gaining prominence in the United States. It has the advantages of faster truck turn-around time, less chance of human error, better accuracy of volume prediction, savings on labor, and lower administrative costs due to less accounting and auditing time (Weldon 1967).

The inability to determine wood grade has been the main disadvantage of weight-scaling cited by industry, but the variation of moisture content and specific gravity is possibly even more important. Because of the varied characteristics of wood, one load may be considerably heavier than another of the same size and species. This might cause widely differing prices to be paid for a given volume of wood substance. In fact, the average weight of southern yellow pine per thousand board feet may vary as much as 12,000 pounds between geographic areas (Bair 1965).

Since specific gravity and moisture content are responsible for the variation in wood weight, these factors were the object of this investigation. A great deal of research has been done on specific gravity, especially with softwoods; however, little work has been done with moisture content in standing trees and its relation to pulp yield.

The majority of previous attempts at studying wood-weight variables were limited to weighing a number of pulpwood or sawlog loads and obtaining the average weight. For instance, Row and Guttenberg (1966) studied log weights but did not take into consideration moisture variation due to season or geographic location, which may be important factors related to wood weight. The basic characteristics of wood moisture and specific gravity must be known before weight-scaling can be considered accurate. Therefore, an attempt was made in this study to determine if a significant variation in moisture content exists in standing trees of sweetgum (Liquidambar styraciflua L.) between seasons of the year, geographic locations and the effect this might have on moisture content. Sweetgum was selected because it is an important pulpwood species in the South and is found on a variety of sites.

LITERATURE REVIEW

Moisture Content

Most sources of reference pertaining to wood moisture deal with wood characteristics other than weight. A survey of literature failed to reveal any information concerned directly with moisture content variation in weight-scaling, but studies have been made on moisture content in standing trees. Because of the large number of logs that would sink when placed in streams, R. D. Gibbs (1958) studied moisture content variation in standing trees of many species in Canada for 35 years. He found that the moisture content patterns of related genera such as *Populus* and *Salix* behave alike, as do species of the same genus, but there are notable exceptions. For instance, wood of *Fraxinus americana* L. grown in Montreal is very dry. It has little more than enough water to saturate the cell walls in almost 8 months of the year. The moisture increased in June up to about 80 percent and then dropped off steadily until it reached about 35 percent. Other species of ash behave the same way. Eastern hemlock (*Tsuga canadensis* L.) showed a marked water loss in winter, a summer maximum moisture content in June and July, a low at the end of the summer, and a steady increase from September to November and December. Curves constructed by Gibbs for eastern white pine (*Pinus strobus* L.) samples taken from 3-year old twigs showed

a surprising maximum water content in September followed by a sharp decline, and a low in May. Tamarack (Larix laricina K.) differed from white pine in that its maximum moisture content occurred in late June, followed by a sharp decline; whereas that of Juglandaceae wood showed definite peaks in early July and late December. In Minnesota, Jensen and Davis (1953) found that the moisture content of aspen (Populus tremuloides Mich.) was highest in the summer and lowest in the winter, with the months of May and October showing the greatest change. In addition, he observed that the moisture contents of samples from widely separated areas were consistently and substantially different.

Most species cited by Gibbs (1935) were studied over a period of years. They showed definite patterns of moisture distribution but often with considerable variation during a particular year. He believed that seasonal precipitation causes abnormal moisture fluctuation. As an example, the moisture content of birch (Betula populifolia Marsh.) and poplar (Populus deltoides Bartr.) trees in Montreal in 1931 dropped from 92 percent in early June to 54 percent in August. The months of June and July were not unusual but August was exceptionally dry. In contrast, the moisture content of these trees in August of the preceding year was 81 percent when precipitation was normal. Jameson (1960) differed from Gibbs in that he found no relationship in moisture content and rainfall in pinyon pine (Pinus edulis Engelm.), Utah juniper (Juniperus osteosperma

(Torr.) Little), alligator juniper (J. deppeana Steud.), and one-seed juniper (J. monosperma (Engelm.) Sarg.). The moisture content of pinyon pine and juniper was near the yearly minimum in June even though there were 2 inches of rain in May and June but was maximum in September when there was no rain.

This difference can possibly be accounted for by the fact that Jameson studied only conifers, whereas Gibbs studied both hardwoods and conifers. Gibbs (1935) found that conifers have very little seasonal variation. Miller (1959) confirmed Gibbs' findings. In his study of slash pine (Pinus elliottii Engelm.) in Mississippi, he found that the seasonal variation in moisture content was only slightly significant at the 5 percent level of probability. Clark and Gibbs (1957) also found an insignificant moisture content variation in moisture content of ponderosa (Pinus ponderosa Laws.) and Douglas-fir [Pseudotsuga menziesii (Mirb.) Franco] which he attributed to be associated with weather conditions. Gibbs (1935, 1958), Todorovski (1959), Jensen and Davis (1935), and others state definitely that hardwoods have significant moisture variation between seasons of the year and have consistent patterns of fluctuation. Smith and Goebel (1952) indicated that hickory samples in South Carolina showed some seasonal variation in moisture content but without a definite trend. In contrast, Gibbs (1958) found definite trends for the same spe-

cies growing in Montreal with the peak occurring in July (Figure 1).

The variation of moisture content due to site is not as well documented. Chalk and Bigg (1956), working with Sitka spruce (Picea sitchensis (Bong.) Carr.), in England, reported that trees having the highest moisture content were from sites which had the highest rainfall and vice versa. Miller (1959) found no definite variation in the moisture content of slash pine (Pinus elliottii Engelm.) due to difference in site. Fielding (1952), on the other hand, found that the moisture content in Monterey pine (Pinus radiata D. Don.) at Mt. Burr, Australia, varied up to 16.1 percent between October and April but the variation was dependent on site quality. Generally the month of October had the highest and April the lowest moisture content.

An interesting study which relates the availability of water to moisture content in the standing tree was done by Barrow (1951) on Douglas-fir poles. Three poles of approximately the same size were cut at varying distances from a stream. These distances were respectively 15 yards, 47 yards and 250 yards from the edge of the water. The tree nearest the stream had the highest moisture content and the one farthest away had the lowest.

Although moisture distribution within the tree was not studied directly in this investigation, it is relevant to note that some authors indicate that moisture content increases upwards from the base of the

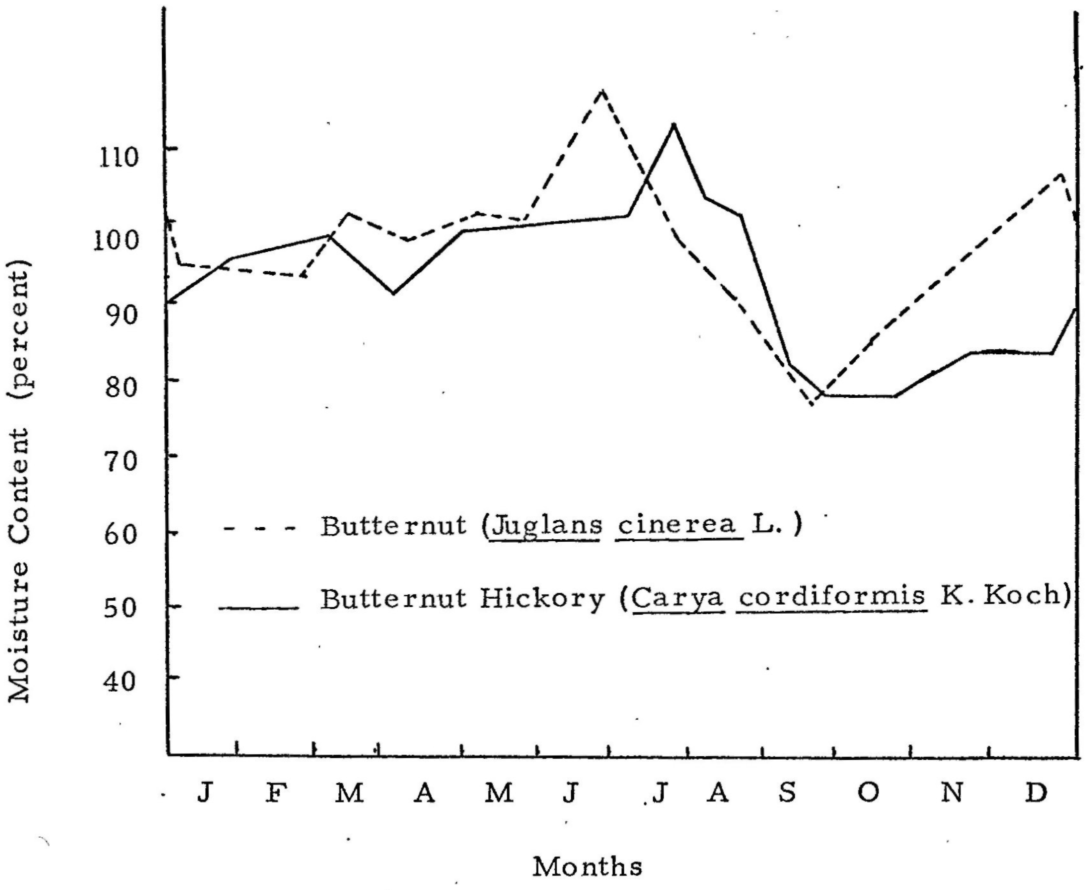

Figure 1. Seasonal variation in moisture content of hickory trees in Montreal (after Gibbs 1958).

tree to the twigs, while others believe the opposite to be true. Gammon (1965) found that the moisture content increased 9 percent for each 10-feet increase in height of white pine (*Pinus strobus* L.) trees in New Hampshire. Clark and Gibbs (1957), working with different species of birch in Montreal, found that the moisture content was highest at the top and lowest at the bottom but it fluctuated during the year. The water content at the top would coincide with the water content at the base or drop slightly below it in early spring and late fall. On the other hand, Todorovski (1959) stated that, with rare exceptions, the moisture content of oak (*Quercus sessiliflora*) was greater near the butt than near the top of the tree. Peck (1949) also mentioned that the butt log contained more water than the top log.

Specific Gravity

Because specific gravity is a very important variable in the weight of wood it cannot be ignored in any study on wood-weight relations. Not only does specific gravity affect the weight of wood but it also affects the amount of pulp in a given volume of wood substance. Mitchell (1964) stated that an increase or decrease of only 0.02 in specific gravity of southern yellow pine in the southeastern region of the United States means an increase or decrease of 100 pounds in dry weight of a cord of pulpwood, or 50 pounds of dry processed pulp. He further indicated that there was a tendency for specific gravity to increase from the northwest

to the southeast within the region to such an extent that the effect of geographic location on specific gravity can be recognized. Geographic location in itself does not directly affect specific gravity but it is the environmental factors such as soil, rainfall, length of growing season, mean temperature, etc. within a geographical region which affect the specific gravity of wood.

The hardwoods differ from the pines in that they do not show the same geographical trend. Davis (1933) took numerous samples of white oak, red oak, and sweetgum from various sawmills from South Carolina to east Texas and found no definite trend in specific gravity from one area to another. However, a great deal of difference existed between individual mills which he related to local stand history such as age and local growth conditions. Walters and Bruckmann (1965) showed considerable variation in specific gravity of cottonwood in different stands throughout the state of Illinois.

METHODS AND PROCEDURES

Most previous research work on tree moisture content and specific gravity was based on small numbers of samples. Very often the trees were first felled and their numbers usually limited from one to about 100. The two favored methods of obtaining samples are (1) core samples taken with an increment borer and (2) samples cut from cross-sections of trees. In order to establish a firm statistical basis for this study and reduce the possibility of bias, a much larger number of samples was taken. It was not economically feasible to cut a large number of trees for sampling purposes; therefore, the core sample method was used. According to Chalk and Bigg (1956), Ranatunga believed that there was a difference between the two methods because of a slight squeezing out of water by the increment borer; but they themselves found very little difference.

Field Procedure

An effort was made to determine the relationship of moisture content and specific gravity of sweetgum trees on different sites, during different seasons of the year and at different locations in the state of Louisiana.

Nine hundred samples were taken from nine different sites, namely: three in Morehouse parish near the Arkansas-Louisiana line (northern

area); three in Kisatchie National Forest in Rapids parish, southwest of Alexandria (central area); and three in West Feliciana parish about half way between St. Francisville and the Angola State Prison (southern area) (Figure 2). An attempt was made to find suitable locations in each of these three geographical areas where sweetgum trees could be found growing on three different site classes— hilltop, slope and bottomland. Such an area was found in each of the three geographical locations. Samples were not taken from the extreme southern part of Louisiana because no area could be found with enough difference in elevation to provide sufficient site differentiations.

Increment core samples were made four times, on the third week of April, July and October of 1967 and January of 1968. For each of the four seasons, 25 trees between 6 and 12 inches in diameter were sampled from each of the nine sites. Each tree was randomly selected and a 4.5 mm core approximately 5 inches long was extracted at 4.5 feet from the ground. Immediately after a sample was removed from a tree it was tightly wrapped with commercial Saran Wrap in order to prevent moisture loss. All the samples from each site were then bundled together, bound securely with a rubber band and placed in a plastic bag for further protection against moisture loss. These bundles were placed in an insulated container containing dry ice to lower the rate of evaporation of water. Freezing the samples was necessary since there was no means of accur-

Figure 2. A map showing the three geographical areas where samples were taken.

ately weighing them in the field and there was as much as 36 hours lapse before they could be processed in the laboratory.

Laboratory Procedure

As soon as the core samples arrived at the laboratory, they were weighed to the nearest one hundredth of a gram with a top-loading automatic Sartorius balance. They were then placed in an oven at a temperature of about 105° C for several days until no further weight loss could be detected. Each sample was then weighed and the moisture content calculated. Moisture content was expressed as a percent of oven-dry weight of the wood substance.

Specific gravity was also determined but only with the group of samples collected during January of 1968. Because of the difficulty that would be encountered in determining volumes of cores which were not exactly of the same length, the maximum moisture content method was chosen for determining specific gravity. The oven-dry samples were placed inside a large desiccator and soaked in water for about one month. During this period, a vacuum was pulled on the samples twice daily, each time for 15 minutes. When the samples were completely saturated, they were again weighed. The specific gravity of each sample was calculated using a table (Fogg 1967) based on the following formula:

$$G_f = \frac{1}{\frac{W_s - W_o}{W_o} - \frac{1}{G_{so}}}$$

where W_s is the saturated weight, W_o the oven dry weight, G_{so} the specific gravity of wood substance, and G_f the specific gravity of wood based on green volume.

RESULTS AND DISCUSSION

Moisture Content

An analysis of variance (Table 1) indicated a highly significant statistical difference (P= 0.01) in the moisture content of standing sweet-gum trees among seasons of the year and among geographical locations; but, there was no significant difference due to variations among sites. The interactions among these variables were found to be highly significant in all cases.

Variations Due to Season

Figure 3 shows that the variation of the combined average moisture content of the three geographical areas among seasons of the year was quite high. Samples taken in April, July, October and January averaged 105.3, 121.1, 91.7, and 97.8 percent moisture content respectively. Table 2 shows that there is considerable variation in moisture content due to seasons on each individual site and at all three geographical areas. This variation is also shown statistically in Table 1 by the interactions among variables. This effect has never been seriously considered in previous studies of weight-scaling but is a major factor.

Gibbs (1958) believed that the variation of moisture content due to season in deciduous trees is associated with the ascent of sap in trees, hence, the water content would be high during leaf-opening. He stated

Table 1. Analysis of variance of moisture content between effect of factors and factor interactions

Source of Variation	D. F.	SS	MS	F-Ratio
Season (Se)	3	110446.00	36815.33	266.48**
Location (L)	2	3345.64	1672.82	12.10**
Site (Si)	2	150.89	75.45	.546 N.S.
Se x L	6	13505.30	2250.88	16.29**
L x Si	4	5195.62	1298.90	9.40**
Se x Si	6	6428.67	1071.44	7.75**
Se x L x Si	12	4209.56	350.79	2.54**
Error	864	119363.37	138.15	

**Significant at the 1 percent level of probability

N. S. - Not Significant

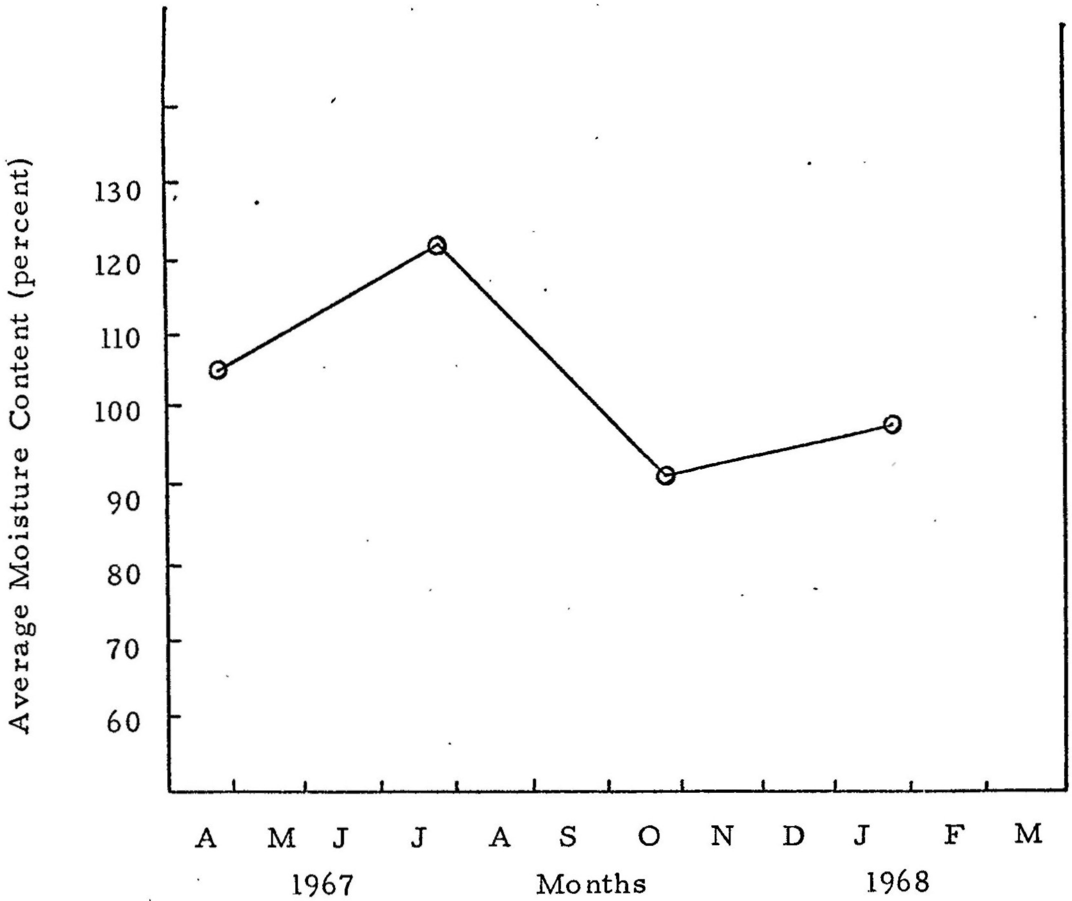

Figure 3. Average moisture content of standing sweetgum trees at different times of the year from three geographical locations in Louisiana

Table 2. Average moisture content of standing sweetgum trees during different times of the year at each site-geographical area combination

Geographical Area	Moisture content at different times of the year			
	April	July	October	January
	Percent			
Northern Area				
Hilltop	95.2	123.5	89.2	104.0
Slope	96.6	109.9	90.7	96.3
Bottomland	98.4	126.5	97.4	99.7
Central Area				
Hilltop	106.0	133.0	93.2	98.3
Slope	115.2	124.3	93.0	90.9
Bottomland	108.3	129.9	90.8	97.5
Southern Area				
Hilltop	101.8	118.3	96.8	95.7
Slope	118.9	115.7	90.3	101.6
Bottomland	106.8	110.7	83.9	96.1

that during the summer and early fall there might be a decreasing amount of water in both the bark and the wood. The bark would lose water by evaporation faster than it would enter from the wood; whereas the wood would lose water by breaking of the water columns, because of tensional stresses, so that the cell cavities become filled with gas. These changes would result in a minimum of water at the end of the leaf season (Figure 4). At the time of the leaves' fall, the transpiration process is greatly reduced and one might expect a refilling of water in the tree. However, the expected increase in moisture content during this period is not universal with every tree species.

According to Gibbs (1968), the coming of cold weather causes a period of "physiological drought" following cessation or slowing of tree activity. In general, trees in the North refill completely with water by this time. If refilling is slow they may be caught by the bitter cold of winter when they are not yet completely replenished. Some trees refill completely; whereas others either refill only partially before they go into winter "rest" or do not refill at all. With the coming of spring, there is a "rising of the sap" and the active tissues are refilled with water just before leaf-opening. Most trees in the North experience a rapid increase in water content of this period.

The ideas put forth by Gibbs are for trees in the North, hence they cannot be compared directly but can only be related to trees in

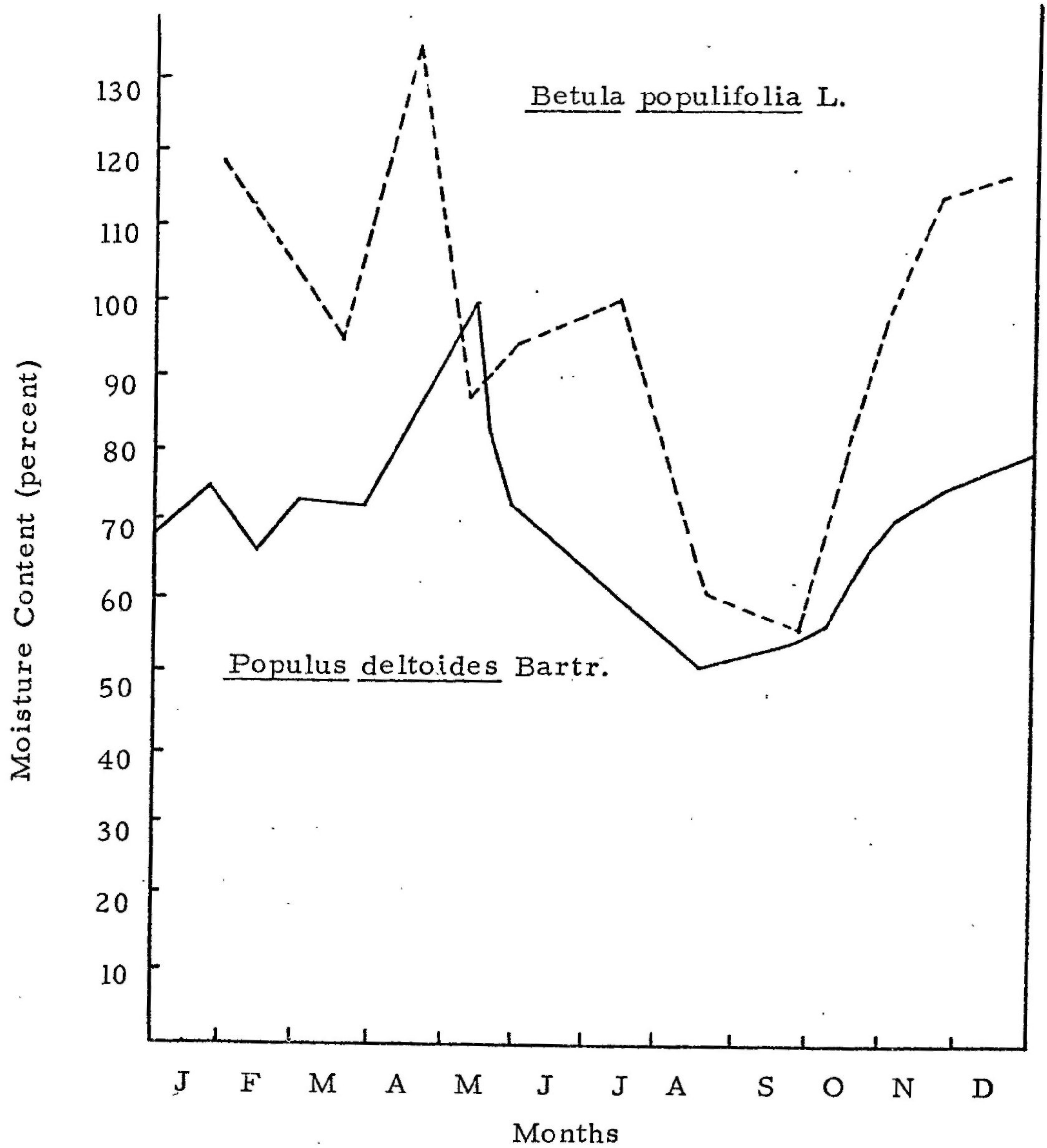

Figure 4. Moisture content variation of trees in Canada (after Gibbs 1958).

Louisiana. In the South, budding in the spring and leaf-fall in the autumn may perhaps affect the moisture content of standing trees in some species.

Another possibility that may be considered is the effect of rainfall and mean temperature as factors affecting moisture variation. Satturlund (1957) stated that diurnal decreases in the moisture content of living trees are due to transpiration losses at rates exceeding the absorptive capacity of tree roots during the day-light hours, thus depleting moisture storage in the tree. At night the tree is well watered, since the absorption of moisture by roots replenishes the internal moisture supply and takes place at a more rapid rate than transpiration. Kramer (1937) had the same idea and expressed the opinion that the rate of water intake probably is determined largely by the rate of water loss.

It seems reasonable then to assume that, if the amount of water available to a tree is low and transpiration is high, a depressed moisture content would result. Figure 5 shows the seasonal relationship, from April 1967 through January 1968, of rainfall and temperature with moisture content of sweetgum trees in each of the three locations. Weather data for the prior three months are plotted over the date of the end of the three-month period. It shows that moisture content could have been affected by rainfall and temperature. When moisture content was low in the spring, rainfall and temperature were correspondingly low, and vice

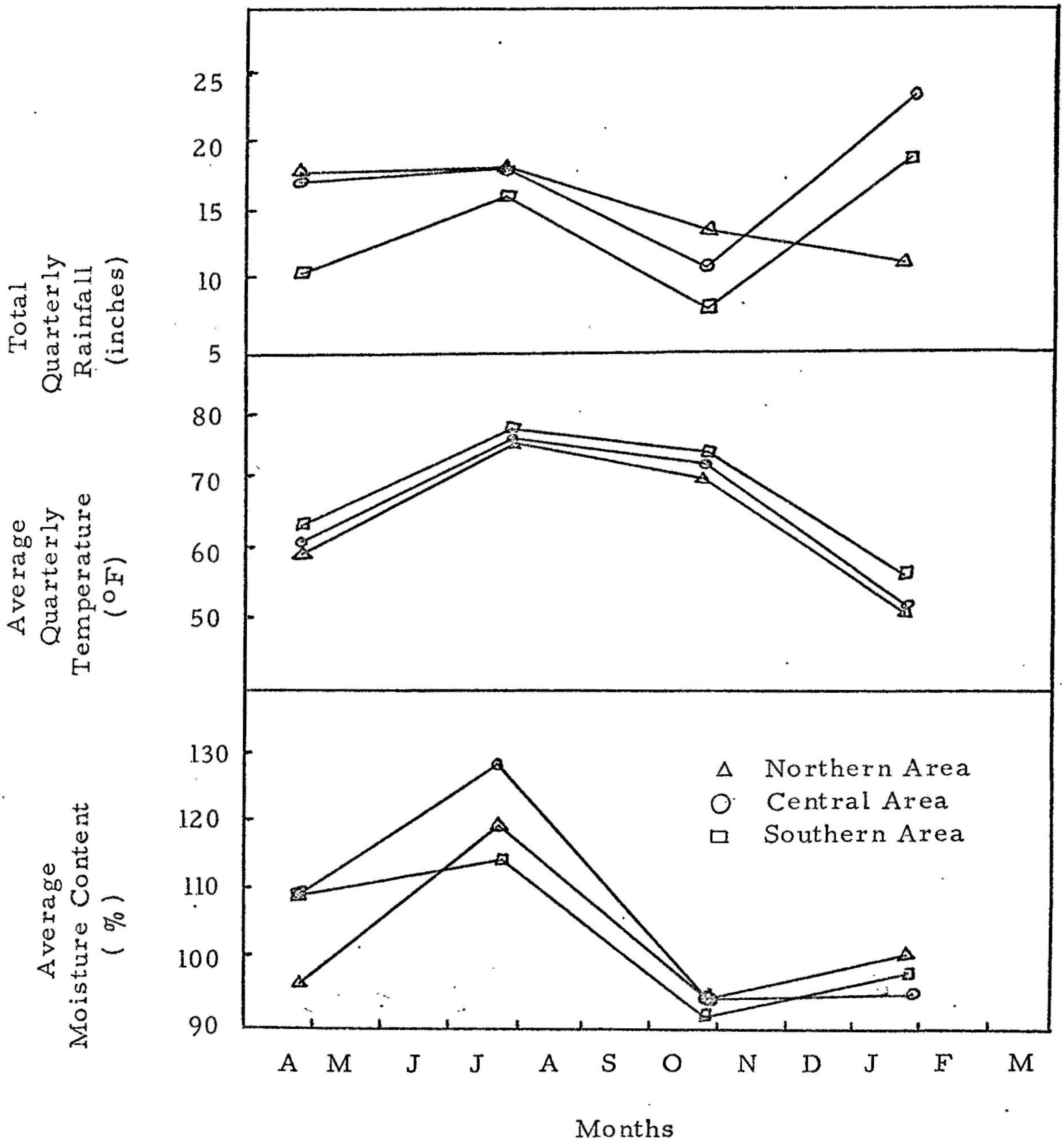

Figure 5. Relationship of quarterly average moisture content, total quarterly rainfall and quarterly average temperature with months of measurement for each of the three geographical locations.

versa in the summer. This is in agreement with Satterlund (1957) and Kramer (1937) who stated that high temperature and high rainfall in summer tend to cause trees to take in more water. In October, when rainfall was low and temperature was still high, moisture content was low. This phenomenon was explained by Gibbs (1935) as due to a depleted condition of water supply.

Variation Due to Location

Although the variation between locations was highly significant at the 1 percent level (Table 1), the numerical difference was small and contrary to initial exception, there was no consistent trend with latitude. Table 3 shows that the average moisture contents for the three geographical areas are, respectively, 102. 3 percent in the northern area, 106. 7 percent in the central areas, and 103. 1 percent in the southern area. Therefore, it can be assumed that no definite trend in moisture content due to geographical variations exists; rather, the variations in moisture content may be more dependent on localized factors including season and weather.

The interaction of season and location is highly significant at the 1 percent level of probability. This means that the difference in location is not consistent over all seasons and the variation is affected by seasons. The effect that season has on variation at each location is shown in Figure 5.

Table 3. Average moisture content of standing sweetgum trees at different geographical areas

Location	Average moisture content by month				Area Average
	April	July	October	January	
	- - - - - - - - - - - - - - Percent - - - - - - - - - - - -				
Northern Area	96.7	120.0	92.4	100.0	102.3
Central Area	109.8	129.1	92.4	95.6	106.7
Southern Area	109.9	114.9	90.4	97.8	103.1

Table 4. Average moisture content of standing sweetgum trees on different sites

Site	Average moisture content by area			Area Average
	North	Central	South	
	- - - - - - - - - - - - - - Percent - - - - - - - - - - - -			
Hilltop	102.9	107.6	103.2	104.6
Slope	98.4	105.9	106.6	103.6
Bottomland	105.5	106.6	99.4	103.8

Rainfall data obtained from the U. S. Weather Bureau (Table 6 Appendix) indicate that the total rainfall in the central area (Alexandria) was 69.73 inches for the period between April 1967 and January 1968. This is higher than in either the northern area (Bastrop) which had 42.83 inches or the southern area (St. Francisville) which had 59.96 inches (Figure 6). Thus, these data seem to indicate that the moisture content of standing trees is affected not only by season but also by precipitation. This is in agreement with the work of Chalk and Bigg (1956), who found that summer moisture content in Sitka spruce (Picea sitchensis, Carr.) was highest on the site with the highest rainfall and lowest with the lowest rainfall. They also found that the amount of moisture decreased in late summer for both species.

Krasnitsky (1961) found that topography and soil influence the formation and the amount of heartwood in ash. It is quite possible that the moisture content of sweetgum can also be affected by the amount of heartwood in the tree. It is known that the amount of heartwood in sweetgum varies considerably from tree to tree and is a function of the size of the tree. Peck (1949) gave the average moisture content of sweetgum sapwood as 137 percent and that of heartwood 79 percent. A strong interaction between site and location, as shown in Table 1, supports this idea. Since site has an influence on moisture content of trees at different

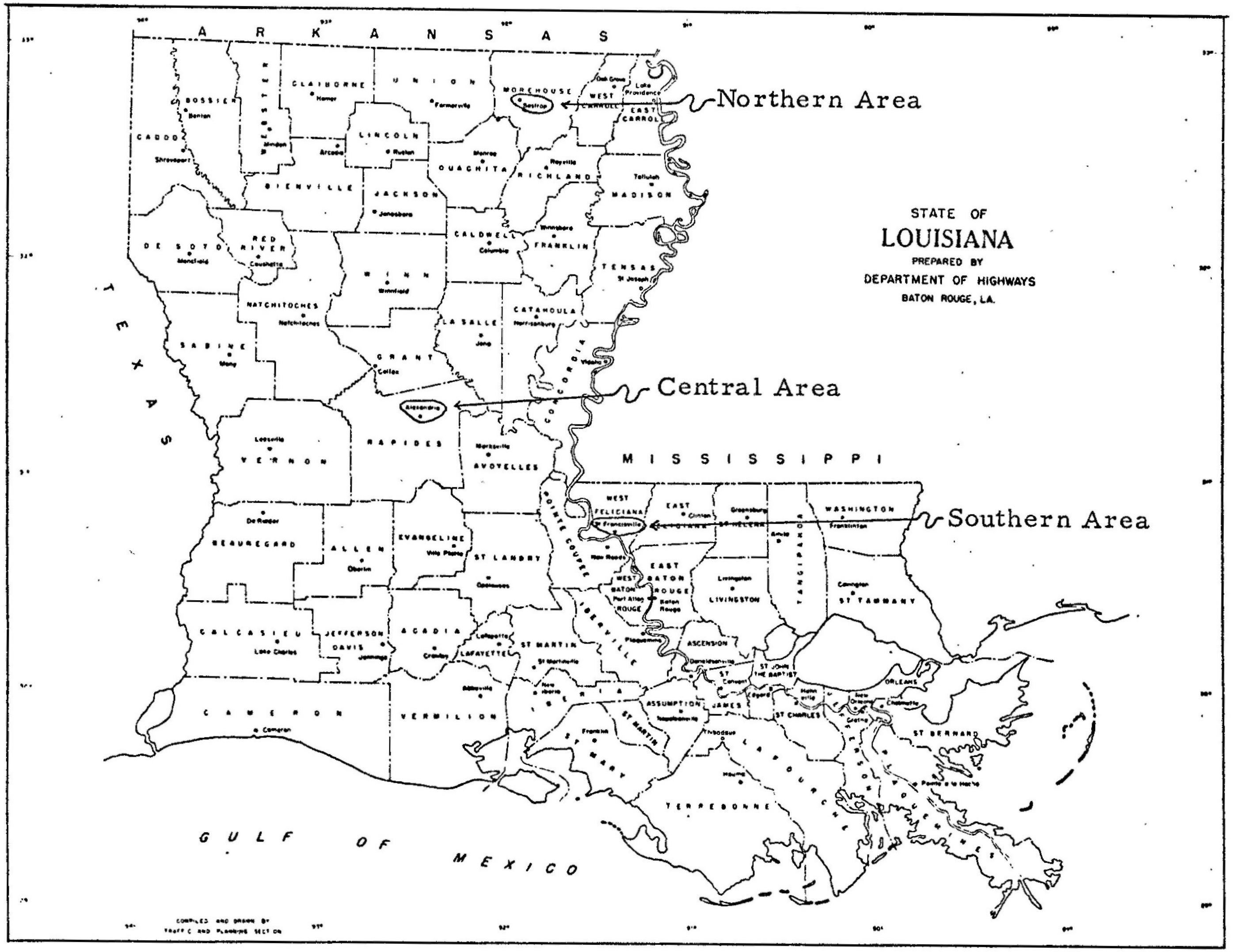

Figure 6. Locations of weather stations where weather data were obtained.

locations, the variation in moisture content can be related to heartwood formation. This study did not distinguish sapwood from heartwood, which might be useful.

Variation Due to Site

When site was studied in conjunction with other variables, considerable variation in moisture content was found (Table 2); but when other variables were held constant there was only 1 percent difference between the two extreme sites (Table 4). This was statistically not significant at the 5 percent level (Table 1). Even though some authors (Fielding 1952) maintained that site quality affects moisture content, there is a strong indication from the results of this study that site alone is not a dominant factor; rather, it is one of a multitude of variables causing moisture variation in standing sweetgum trees. Interactions of season and location with site (Table 1) demonstrate the complexity of factors affecting moisture content variation.

Specific Gravity

There was very little variation in average specific gravity among the three geographical locations. Nevertheless, the specific gravity was highest in the central area and lowest in the northern area (Table 5). This indicates no apparent trend with latitude and agrees with the findings of Davis (1933) for hardwoods. He explained that local stand history such as age, local growth conditions, and the degree to which it had been cut

Table 5. Average specific gravity at different geographical areas

Location	Average Specific Gravity (green volume basis)	Standard Deviation
Northern Area	.490	.034
Central Area	.502	.035
Southern Area	.493	.028

was the dominant factor that affected specific gravity in oaks and sweetgum. On the other hand, Mitchell (1964) found a definite trend in specific gravity throughout the range of southern pine and even within the state of Mississippi.

Figure 7 shows the relationship of average moisture content and average specific gravity for each of the nine states. The correlation coefficient is -0.757, which is significant at the 5 percent level. This is expected since a low-density wood can hold more water than a high-density wood. This difference will be greater if the amount of water in wood is expressed as a percentage of the oven-dry weight of wood, since the low density wood obviously will have lower dry weight. From the practical standpoint, such as in weight-scaling, this phenomenon may be important. For a given species (assuming this moisture content-specific gravity relationship holds true for any species), a high-density wood yields much more pulp than a low-density wood but it is the low-density wood that usually contains more water. Therefore, a low density wood can weigh as much or more than a high-density wood but they do not have equal monetary values.

The actual amount of water in wood, however, may be less dependent on specific gravity if it is not expressed in conventional moisture content (over-dry weight basis) term. Chalk and Bigg (1956) found that when the amount of water in wood is expressed in terms of the percentage

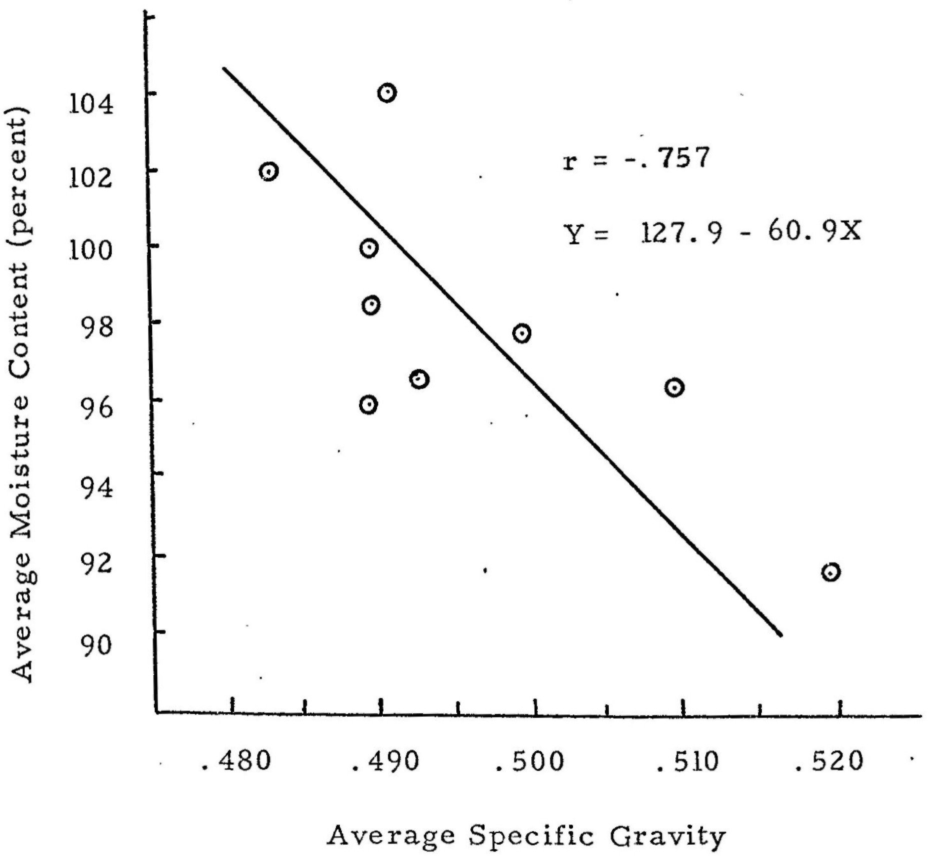

Figure 7. Correlation of average moisture content with average specific gravity for each of the nine sites.

saturation, the effect of specific gravity, and thereby the moisture variation, is greatly minimized.

Present Outlook and Future Needs

Weight-scaling today is an important part in the procurement of wood and is widely used, but the technique still needs improvement. The weight of wood is still not a very accurate method of predicting the volume of wood due to moisture content and specific gravity variations in standing trees. These variations cannot be controlled, but certain adjustments can be made when variations attributable to a given cause is consistent. This study shows that the variation of moisture content between seasons appears to be consistent in magnitude, which indicates the desirability of the use of different scaling factors for each season of the year. On the other hand, since the variations in moisture content due to locations and sites are not consistent, it may not be practical to have different conversion factors for various geographical areas.

It is evident that more work needs to be done. A better spectrum of moisture variations could have been obtained if samples had been taken each month rather than each quarter of the year. Also, since some other species of hardwoods besides sweetgum are purchased by weight, studies must be made on other species. Additionally, there is need to know more about heartwood formation and its causes because the type of wood influences, at least to some degree, the amount of water in

wood. The percentage of heartwood and sapwood was not determined in this study, but it might prove to be important.

SUMMARY AND CONCLUSIONS

A study was made to determine the variation of moisture content in standing sweetgum trees (Liquidambar styraciflua L.) due to different seasons of the year, different geographical locations, and different sites in Louisiana. This information was sought because of its relevance to weight-scaling of wood. Sweetgum was selected because it grows on a variety of sites and is an important hardwood pulp species.

Samples were taken with an increment borer from three site conditions— hilltop, slope and bottomland in north, central, and south Louisiana during April, July and October of 1967 and January of 1968, respectively. Twenty-five cores were obtained from each site for each season, giving a total of 900 samples.

An analysis of variance was made using a completely randomized design and the interactions between season, location, and site were determined. It was found that the variations between seasons and locations were statistically significant at the 1 percent level but the variations between sites were not. These variations were explained from Gibbs (1958) theory as due to rising sap in trees, rate of transpiration, and breaking of water columns under tension.

The variation between locations was significant at the 1 percent level since a large number of samples were used, but the actual per-

centage difference in moisture content between geographical areas was small and did not follow a consistent trend with latitude. Any variation was attributed to local weather factors.

Considerable variation in moisture content due to difference in site was found when the data were analyzed with other factors; however, the difference in moisture content was less than 1 percent when other variables were not considered. This was not statistically significant and indicated that the effect of site on moisture content was small.

Specific gravity was determined by the maximum moisture content method for core samples collected in January 1968 on each of the nine sites. The difference in specific gravity between sweetgum trees from different parts of Louisiana was found to be small, but there was a good correlation (negative) between specific gravity and tree moisture content.

The following conclusions were drawn from this study:

1. Moisture content of standing sweetgum trees varies appreciably between seasons of the year and between geographical locations. Since moisture content was high in July and low in October, it is probably related to soil moisture.
2. Site alone cannot be isolated as a factor causing variation in the moisture content of sweetgum trees.
3. Specific gravity does not vary consistently with different geographic locations.

4. The amount of moisture in standing trees is related to specific gravity. The January moisture content appears to be greater the lower the specific gravity.
5. Moisture content variation due to seasons should be taken into consideration in weight-scaling conversion factors.

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APPENDIX

Table 6. Record of monthly and quarterly average temperature for the three geographical locations

	Bastrop	Alexandria	St. Francisville
	°F		
Feb. 1967	46.9	47.9	51.1
Mar.	61.1	62.5	64.5
April	71.0	71.8	73.0
Average	59.7	60.7	62.9
May	72.0	71.9	73.5
June	80.5	80.2	81.3
July	79.8	79.4	80.7
Average	77.4	77.2	78.5
August	79.0	79.7	80.6
Sept.	72.4	73.5	75.8
Oct.	66.4	65.4	67.5
Average	72.6	72.9	74.6
Nov.	56.0	57.7	60.9
Dec.	49.9	51.9	56.9
Jan. 1968	44.4	46.2	51.6
	50.1	51.1	56.5
Total Average	64.9	65.7	68.6

Table 7. Record of monthly and quarterly rainfall for the three geographical locations

	Bastrop	Alexandria	St. Francisville
	Inches		
Feb. 1967	4.57	4.34	4.84
Mar.	1.34	2.03	2.56
April	4.13	10.81	10.13
Total	10.04	17.18	17.53
May	8.50	8.37	8.01
June	1.46	2.69	1.59
July	6.25	6.95	8.44
Total	16.21	18.01	18.04
August	4.02	3.19	5.55
Sept.	1.90	2.20	4.93
Oct.	1.84	5.59	2.57
Total	7.76	10.98	13.05
Nov.	1.44	.18	.45
Dec.	7.55	14.28	8.19
Jan. 1968	9.83	8.10	2.60
Total	18.82	23.56	11.34
Grand Total	42.83	69.73	59.96

VITA

Larry Gene Henderson was born in Almyra, Arkansas on September 4, 1940, where he attended elementary school for 3 years. He then went to Drew Central schools for 2 years and Monticello Jr. High for 2 years before moving to McGehee, Arkansas where he graduated from high school. In the fall of 1958, he enrolled at Louisiana Polytechnic Institute and in August, 1962, he received a B. S. degree in Forestry. October of 1962 found him in New Port, Rhode Island, at Officers' Candidate School of the U. S. Naval Reserve. In October of 1964, he married Karen Jean Lorance of La Mesa, California. After completion of his tour of active duty with the Navy, he entered Louisiana State University and is now a candidate for the Master of Forestry degree.

EXAMINATION AND THESIS REPORT

Candidate: Larry Gene Henderson

Major Field: Forest Products Technology

Title of Thesis: Variation of Moisture Content of Standing Sweetgum Trees in Louisiana

Approved:

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

Date of Examination:

May 22, 1968