ANALYSIS OF SEASONAL, DIURNAL, AND NOCTURAL GROWTH PATTERNS OF YOUNG LONGLEAF PINE

John C. Gilbert, Ralph S. Meldahl, John S. Kush, and William D. Boyer[1]

Abstract—Forty longleaf pine (*Pinus palustris* Mill.) trees initially ranging from 1 to 1.5 m in height were measured on the Escambia Experimental Forest from 1969 through 1980. The trees were evenly divided between two soil types. From 1969 through 1970, height and diameter measurements were recorded one to four times weekly during the growing seasons and once a month during the dormant seasons. Daily height growth measurements were recorded in the morning and again in the evening during the peaks of these two growing seasons to determine diurnal and nocturnal growth. Follow-up height and diameter measurements were recorded periodically from 1971 through 1980. To test the effects shading had on growth patterns, cheesecloth was suspended over 10 randomly selected trees from each soil type during the first growing season. Analyses of variance were used to identify potentially significant differences in growth between shade treatments and soil types.

INTRODUCTION

There are still many unanswered questions concerning the growth of young longleaf pine. Tree growth is affected by a multitude of abiotic and biotic stresses on a continuous basis, such as light intensity, moisture, temperature, wind, insects, pathogens, and plant competition (Kozlowski and Pallardy 1997). Research efforts have not clearly explained the growth patterns of young longleaf pine or how the environmental stresses are directly or indirectly affecting growth. To determine growth patterns of young longleaf pine, it is necessary to directly observe the height and diameter growth over time and record pertinent environmental factors at the site level. A data set of this size has the potential to answer questions about patterns of young longleaf pine growth on different scales.

Project Background

A study was designed to determine how environmental conditions affect the height and diameter growth of young longleaf pines. The study was initiated in 1969, and data were collected until 1980. However, due to a lack of time and funding, the project was not completed. The data analyses were resumed in 2003.

PROCEDURES

Plot Layout

The site for this study was the Escambia Experimental Forest (EEF) near Brewton, AL. The EEF is a 3,000-acre forest that was established in 1947 when T.R. Miller Mill Company leased the land to the U.S. Department of Agriculture, Forest Service, for 99 years at no cost (Boyer and others 1997). The EEF has been used extensively for longleaf pine research (Boyer and others 1997). Forty longleaf pine trees were selected for the study. The study site was a naturally regenerated longleaf pine stand that was the product of the 1955 seed crop. All the selected trees were between 1 and 1.5 m tall. Twenty longleaf pine trees were selected on each of the two soil types that were present in the stand. One soil type was a Lucy loamy sand, and the other was a Wagram loamy sand. The taxonomic class for both soils is loamy, kaolinitic, thermic Arenic Kandiudults (Soil Survey Division, Natural Resources Conservation Service 2003). Both soils have an average site index of 20.4 m, and the depth of the A horizon of both soils is very similar. However, the Lucy loamy sands can have a slightly thinner A horizon and a B horizon with a higher clay content at shallower depths than the Wagram loamy sands (Mattox and others 1975). The trees on the Lucy loamy sand were located on the crest of a ridge, and the trees on the Wagram loamy sand were located on a slope at the base of the ridge.

Ten of the trees on each of the two soil types were randomly selected for artificial shading. The randomly-selected trees were shaded with cheesecloth during the first year of the study. The cheesecloth was stretched across a square meter frame that was structured to keep the cheesecloth at least 1 m above the growing tip of the tree. The structures were periodically checked and adjusted. The growing tips of the shaded trees received a reduction of about 30 percent of the full sunlight they would normally receive at the peak of the diurnal cycle. The cheesecloth was installed on March 28, 1969, and removed September 24, 1969.

Growth Measurements

The data for this study were collected from 1969 through 1980. Intensive growth and environmental measurements were taken from 1969 through 1970. Heights were measured one to four times weekly. During the month of April, leaders were measured in the morning and again in the evening to determine diurnal and nocturnal growth differences. Nineteen diurnal and nocturnal height growth measurements were taken in 1969, and 16 were taken in 1970. Heights were measured monthly during the dormant season. Separate records were kept for each new leader.

Since at the initiation of the study the trees had not reached breast height (1.37 m), diameters were measured at 10 cm above the soil surface. Diameters were measured weekly during the growing season and monthly during the dormant season. Follow-up height and diameter measurements were taken periodically from 1971 through 1980.

[1] Graduate Student, Associate Professor, and Research Associate IV, respectively, Auburn University, School of Forestry and Wildlife Sciences, Auburn, AL 36849; and Research Forester Emeritus, USDA Forest Service, Southern Research Station, Auburn, AL 36849.

Citation for proceedings: Connor, Kristina F., ed. 2006. Proceedings of the 13th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS–92. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 640 p.

Environmental Measurements

An on-site weather station recorded air temperature and precipitation measurements daily during the entire study. Soil moisture was recorded on a weekly basis from March, 1969, until December, 1970. Environmental variables collected during April of each growing season were relative humidity, wind speed, and solar radiation.

RESULTS AND DISCUSSION

1969 through 1980

From 1969 through 1980, the average maximum yearly temperature was 26 °C, and the average minimum temperature was 12 °C. Average yearly precipitation was 157 cm. The driest year was 1971 with 112 cm of precipitation, while 1975 was the wettest year, with 230 cm of precipitation.

On average, the trees grew 12.8 m over the 12 growing seasons from 1969 to 1980. There were no statistically significant differences between average height growth on the two soil types or between the shading treatments over this period. All statistical tests were performed at the 0.05 level of significance. Average diameter growth was 7.20 cm. There were significant statistical differences between the two soil types with respect to average diameter growth over this period. Diameter growth for trees on the Lucy loamy sands was greater than diameter growth for trees on the Wagram loamy sands. However, there were no significant effects of the shading treatment on diameter growth.

1969 and 1970 Growing Seasons

Figure 1 shows the percent of average height and diameter growth by month from the initiation of the study in March, 1969, to the end of the intensive measurements in December, 1970. The main portion of the growing season began in March and ended in October. April was the peak of the growing season for height growth, representing over 30 percent of the growth each year. Diameter growth had similar patterns to height growth, but diameter growth seemed to persist into the winter months. However, this was a small percentage when compared to the most active portion of the growing season. Average daily temperature during the 1969 growing season was 28 °C. The total amount of precipitation during this time was 131 cm. During the 1970 growing season, there was a total of 155 cm of precipitation with an average daily temperature of 29 °C.

Table 1 shows average height and diameter growth for the 1969 and 1970 growing seasons. Cumulative average height

Table 1—Mean height and diameter growth by shade treatment and soil type for the 1969 and 1970 growing seasons. Trees were located on the EEF near Brewton, AL

Year	Site condition	Height growth	Diameter growth
		m	*cm*
1969	Not shaded	0.99	1.26
	Shaded	1.00	1.13
	Lucy	1.02	1.37
	Wagram	0.97	1.03
	Overall	0.99	1.20
1970	Not shaded	1.09	1.42
	Shaded	1.03	1.50
	Lucy	1.06	1.63
	Wagram	1.05	1.29
	Overall	1.06	1.46

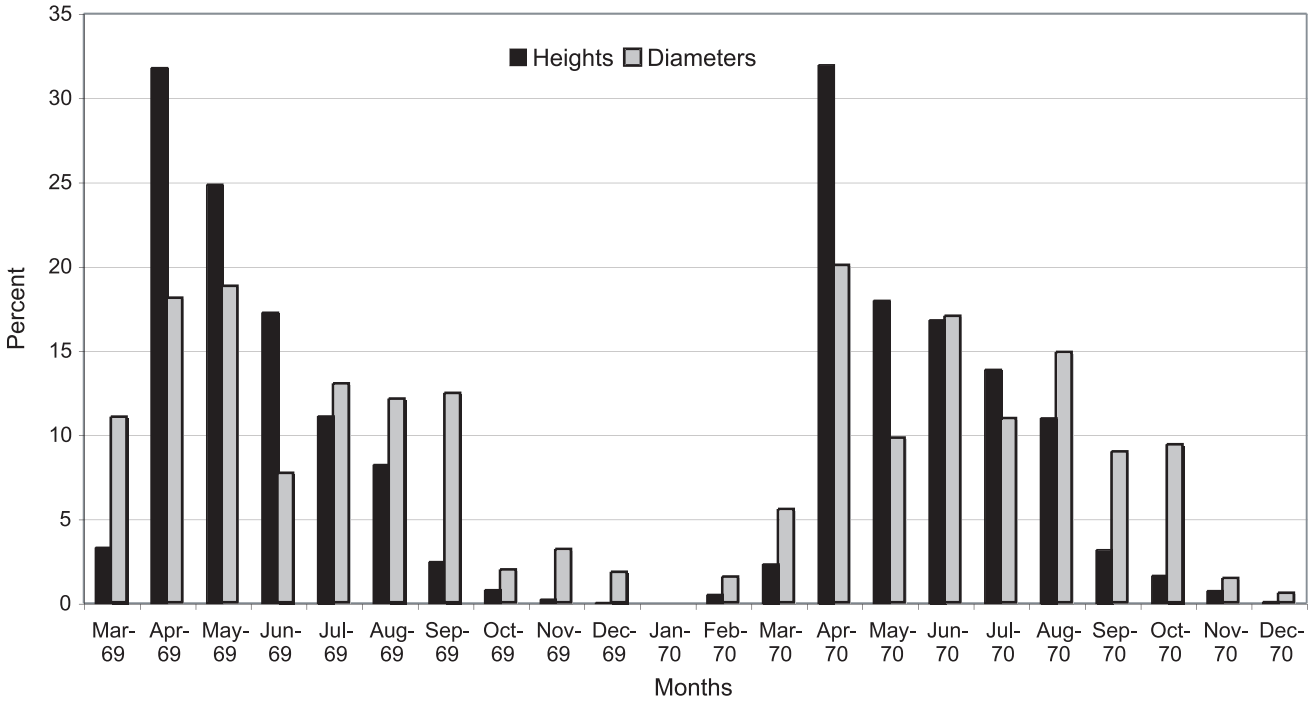

Figure 1—Percent of average monthly height and diameter growth plotted by month. Data were collected in 1969 and 1970 on the EEF near Brewton, AL.

growth over the two growing seasons was 2.1 m. There was not a significant statistical difference in height growth with respect to the shading treatments or between the two soil types during each growing season or over the 2-year period. Cumulative average diameter growth during the two growing seasons was 2.66 cm. In contrast to height growth, there were significant differences in diameter growth between the two soil types during each growing season and over the 2-year period. Diameter growth for trees on the Lucy loamy sands was greater than diameter growth for trees on the Wagram loamy sands. However, there were no significant differences in diameter growth between the shade treatments on the intervals tested.

Diurnal and Nocturnal Growth

The diurnal period between the morning and evening measurements was about 8 hours, and the nocturnal period between evening measurements and the following morning measurements was about 16 hours. During the 19 days the trees were measured in 1969, the average daily temperature was 26 °C. The average temperature during the night was 12 °C. During the 16 days the trees were measured in 1970, the average daily temperature was 28 °C, while the average nightly temperature was 14 °C. The total amounts of precipitation during these measurement periods in 1969 and 1970 were 10.16 cm and 14 cm, respectively. Average height growth over the 19 days was 21.64 cm. About 35 percent of the growth occurred during the diurnal period, while about 65 percent occurred during the nocturnal period. During the 16 days the trees were measured in 1970, average height growth was 20.44 cm. About 25 percent of the growth occurred during the diurnal period, and about 75 percent of the growth occurred during the nocturnal period. The large percentage of growth occurring during the nocturnal periods is possibly due to the time in which the trees were measured. The evening measurements occurred between 4:00 p.m. and 6:00 p.m. The trees continued to receive a few more hours of sunlight until nightfall. There was not a statistically significant difference between the soil types or the shade treatments for average diurnal or nocturnal growth during the measurement periods in April of 1969 or 1970.

CONCLUSIONS

The shading treatment resulted in a reduction in direct solar radiation of about 30 percent, which seemed to have no significant effect on either height or diameter growth of the young longleaf pines. Soil type did not appear to affect height growth, but there were differences in diameter growth. Diameter growth for trees on the Lucy loamy sands was better than diameter growth for trees on the Wagram loamy sands. This could possibly be due to a moisture gradient caused by the higher clay content in the Lucy loamy sands. To understand more about why height and diameter growth patterns behave as they do, the relationships between growth and the environment will need to be further explored. Future examinations between the different intervals of growth measurements and the environmental variables recorded have the potential to answer more questions about how height and diameter growth were being affected by the environment.

ACKNOWLEGMENTS

The authors would like to thank the staff of the Escambia Experimental Forest for their work in collecting data, Dean Gjerstad for his input as a committee member, and Andy Zutter, Anshu Shrestha, and Arpi Shrestha, student workers of the Longleaf Pine Stand Dynamics Lab, for their assistance in entering data.

LITERATURE CITED

Boyer, W.D.; Ward, G.A.; Kush, J.S. 1997. The Escambia experimental forest marks fifty years of research on the ecology and management of longleaf pine. Southern Journal of Applied Forestry. 21(1): 47.

Mattox, M.G.; Duncan, L.A.; Neal, H.B. [and others]. 1975. Soil survey of Escambia County, Alabama. United States Department of Agriculture, Soil Conservation Service and Forest Service, in cooperation with the Alabama Department of Agriculture and Industries, and the Alabama Agricultural Experiment Station. 98 p.

Kozlowski, T.T.; Pallardy, S.G. 1997. Physiology of woody plants, second ed. San Diego, CA: Academic Press, Inc. 411 p.

Soil Survey Division, Natural Resources Conservation Service. 2003. United States Department of Agriculture. Official Soil Series. Descriptions [Online WWW]. Available URL: http://ortho.ftw.nrcs.usda.gov/osd/ [Accessed 27 Oct 2003].