GROWTH PATTERNS OF *PINUS ELLIOTTI* VAR. *DENSA*

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GROWTH PATTERNS OF *PINUS ELLIOTTII* VAR. *DENSA*

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Seasonal periodicity of tree growth has been observed in a great number of species. Man's interest in this phenomenon apparently stems from early times, probably predating recorded history (Studhalter 1955). In the southern United States a number of workers have studied the seasonal aspects of tree growth (Byram and Doolittle 1950, Jackson 1952, Young and Kramer 1952, Eggler 1955). The current study with South Florida slash pine (*Pinus elliottii* Engelm. var. *densa* Little and Dorman) is unique in that the tree is the southernmost native and the only sub-tropical pine in the United States (Little and Dorman 1954).

STUDY METHODS

Periodic seasonal growth was studied from December 1955 to December 1959 on the Corkscrew Experimental Forest.[1] Ten dominant trees in a natural stand of South Florida slash pine were measured over the 4-year period. In 1955 the trees averaged 15 years of age, 6.4 inches in diameter at breast height, and 34.4 feet in total height. The estimated forest site index was 48 for age 25 (Langdon 1959). The understory vegetation consisted primarily of saw-palmetto (*Serenoa repens* (Bartr.) Small) and wiregrass (*Aristida stricta* Michx.). The soil was classified as a Sunniland fine sand.

Vernier growth bands (Hall 1944) made from sheet aluminium according to specifications described by Schopmeyer (1955) were used to measure diameter growth at breast height. Prior to installing the band, the rough portions of the bark were shaved and sanded to provide a snug fit. Heights were measured using an Abney level from a 100-foot reference point established for each tree. All measurements were made biweekly between 8:30 and 9:00 A.M. during the 4-year period. Circumference readings were made to the nearest 0.01 inch, and height readings to the nearest 0.5 foot.

Although the study was not specifically designed to correlate the effects of environmental factors with growth, records are presented of rainfall, ground-water levels, and soil moisture that were kept on the Forest, along with U. S. Weather Bureau records of day length, maximum and minimum temperatures, and long-term mean monthly rainfall from Fort Myers, Florida.

RESULTS

South Florida slash pine has several seasonal growth characteristics that differ from those reported for other species in the United States. Diameter growth occurred throughout the year and exhibited a fairly uniform year-to-year biweekly pattern during the course of the study. Height growth was also observed year-long, but it was more erratic and showed considerable variation by periods from year to year.

Periodic diameter growth

The average biweekly diameter growth diagram for the 4 years (Fig. 1) reveals several significant points. First, appreciable diameter growth took place over a relatively long period of 10 months, and a measurable but lesser amount occurred during the other 2 months. Second, two main peaks of growth were observed, one in the spring and one in the fall with a lesser peak in May. Third, although year-to-year variations in biweekly growth may be observed from the diagrams, the general pattern of growth between years is surprisingly similar if the minor fluctuations are discounted.

The spring flush of diameter growth started in early February and peaked in the first 2 weeks of March. About 37% of the annual growth occurred in the 3-month period of February through April. The late spring and summer growth was fairly steady except for a slight peak in May followed by a drop-off in June and July. The growth in the 4-month period from May through August amounted to about 35% of the annual growth. A surge of growth was also observed in late September. The fall growth (September through November) accounted for nearly 25% of the annual growth. The growth that occurred in December and January was significant, not because of its large amount (which was only slightly more than 3% of the total), but rather because a measurable amount did occur in that season.

Total annual diameter growth averaged 0.463, 0.537, 0.458, and 0.347 inch per year for 1956, 1957, 1958, and 1959, respectively. The 4-year average was 0.451 inch with a coefficient of variation of 25%. Total average growth of the 10 trees for the 4-year period was 1.805 inches. Measurements of the growth-rings at the conclusion of the study indicated that about 12% of this total average growth (or 0.221 inch) was bark growth.

Periodic height growth

Biweekly height growth showed considerable variation in the year-to-year measurements, and a consistent pattern was not apparent. More precise measurements might have revealed a more rhythmic or more uniform growth. Height growth occurred in all but one biweekly period during the 4 years of the study. Average annual height growth was 1.98 feet, varying from 1.90 to 2.60. The greatest proportion of the annual growth (55 percent), including two peaks, occurred in the period from March through May. Amount of height growth was about the same in the summer-fall season (June-November, 22%) and in the winter season (December-February, 23%). Growth in the latter period was most noticeable because at this time terminal buds elongated and the flowers and conelets were set.

Environmental conditions

Day length for this latitude follows a constant pattern from year to year (Fig. 2). The actual hours of sunlight vary from this maximum, depending on cloud conditions. The shortest days, about 10.5 hours long, occur between December 8 and January 4, and the longest, about 13.8 hours, between June 5 and July 6. The 12-hour days occur at the time of the two equinoxes.

[1] Located 25 miles southeast of Fort Myers, Florida, and maintained by the Southeastern Forest Experiment Station, U. S. Forest Service, and the Alico Land Development Company, LaBelle, Florida, under a cooperative agreement.

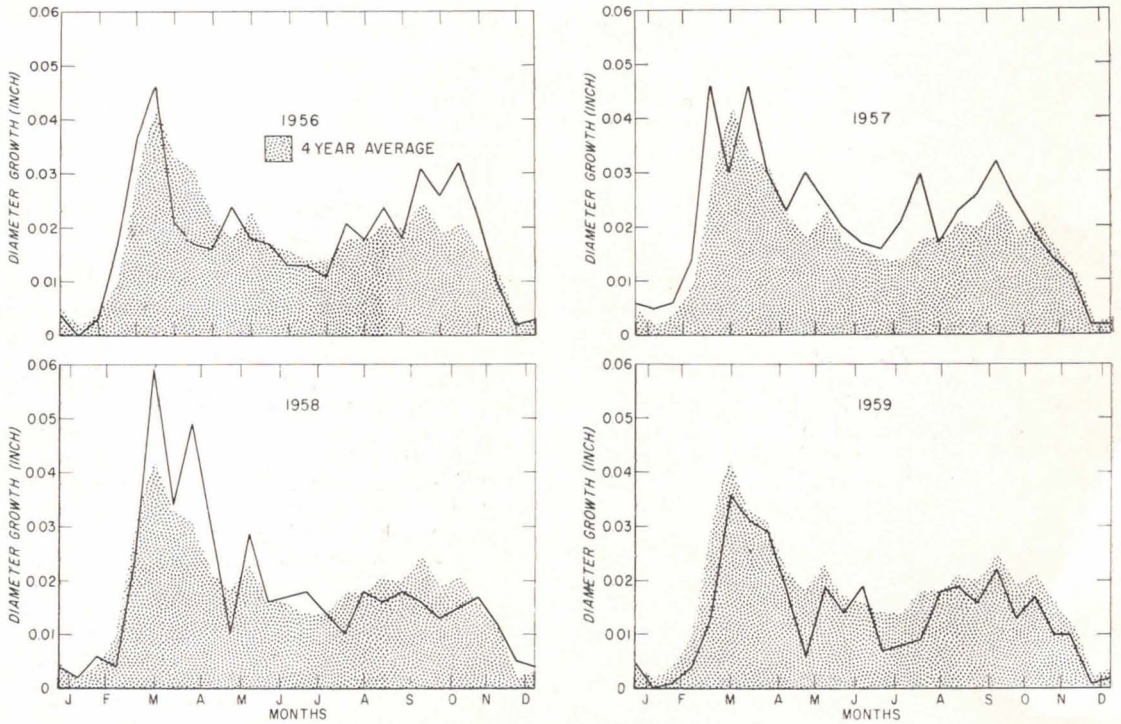

FIG. 1. Biweekly diameter growth of South Florida slash pine, 1956-59.

Monthly maximum and minimum temperature curves for the 4 years of the study (Fig. 2) are similar in shape to the day-length curve. These curves are quite uniform from March through October but show yearly variation in the remaining months when temperatures are influenced by the strong Arctic cold fronts which occasionally move into south Florida.

Yearly rainfall was 39.85, 63.64, 57.56, and 75.95 inches for 1956 through 1959, respectively, and the long-term average for Fort Myers was 53.27 inches. The year 1956 was a very droughty one; 1957 and 1958 had rainfall slightly above normal; and 1959 was very wet, particularly during the summer and early fall (Fig. 3).

Ground-water levels follow trends similar to those described for rainfall. In the droughty year of 1956, the ground-water levels were 4 feet or lower for more than 3 months of the year, but the soil moisture in the 2- to 10-inch soil depth dropped to the wilting point in only one biweekly period in late March. Excess soil water (or flooding) was experienced for a short period in 1958 (Fig. 3) and for a more prolonged period in 1959.

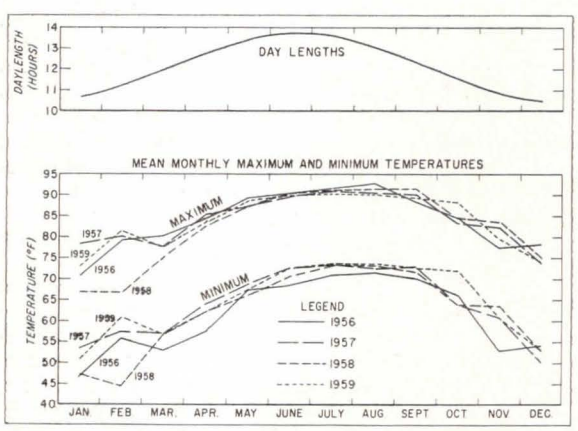

FIG. 2. Day length and monthly maximum and minimum temperatures, Fort Myers, Florida, 1956-59. (U. S. Weather Bureau data.)

DISCUSSION

The period of appreciable radial growth of South Florida slash pine (about 10 months) is less than the

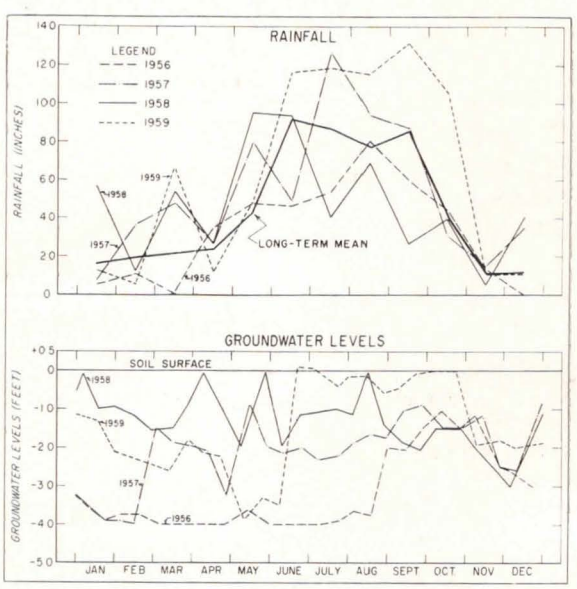

FIG. 3. Monthly rainfall and ground-water levels at the Corkscrew Experimental Forest.

12-month growth reported for trees in the tropics (Glock 1955), but is considerably longer than the cambial growth reported for the Navel orange in California (Reed and MacDougal 1937), or the growth of pine in central Georgia (Jackson 1952) or North Carolina (Byram and Doolittle 1950, Young and Kramer 1952). This long season and pattern of radial growth explains in part the high proportion of summer wood to spring wood and its high wood density, reported with a specific gravity as high as 0.845 (Olson 1952).

The two major peaks of diameter growth occur in spring and fall at about the time of the vernal and autumnal equinoxes, and at periods of nearly equal day length. This day-length relationship seemed to be quite strong even during the fall of 1956 and the spring of 1958 when temperatures were lower than normal.

Although 1956 was a droughty year, diameter growth did not appear to be strongly affected by lack of moisture, probably because the wilting point was not reached in the lower soil depths where moisture was available to the trees. Conversely, excess soil water appeared to have more overall effect in depressing growth. In 1959, a year of high rainfall and ground-water levels, both diameter and height growth were considerably below the other 3 years.

The height growth of South Florida slash pine occurs intermittently throughout the year, similar to certain tropical tree species (Kramer and Kozlowski 1960). This growth differs from the northern pines which generally complete their growth in the first 6 or 8 weeks of the growing season (Kienholz 1941) and from other southern pines which grow from 5 to 8 months of the year (Byram and Doolittle 1950).

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