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ORIGINAL ARTICLE

Climate–tree growth relationships of longleaf pine (*Pinus palustris* Mill.) in the Southeastern Coastal Plain, USA

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Abstract

Knowledge of tree growth/climate response relationships is important to dendroecological studies and dendroclimatic reconstructions, particularly in the Southeastern Coastal Plain where few such studies have been attempted. To this end, we developed tree-ring chronologies of total ring width, earlywood width, and latewood width from longleaf pine (*Pinus palustris* Mill.) at three sites in the Southeastern Coastal Plain to examine the climate–growth relationships for this tree species. The length of these chronologies is unprecedented for southern pine chronologies in the Southeast. We compared the tree-ring chronologies to monthly temperature, precipitation, Palmer drought severity index (PDSI), and Palmer hydrological drought index (PHDI) data from the pertinent climate divisions. We found that PDSI and PHDI have the highest correlation with longleaf pine growth, and the strongest relationships between longleaf pine growth and these variables occur between July and November. Precipitation in the spring and summer was also positively related to growth at all sites. The relationship between temperature and growth was the weakest among all climate variables, but warm summer temperatures had a consistent, negative relationship with longleaf pine growth. The climate signal in the latewood was generally more robust than for total ring width and earlywood width.
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Keywords: Dendrochronology; Longleaf pine; Southeastern Coastal Plain; Climate–growth relationships

Introduction

Understanding the relationship between longleaf pine (*Pinus palustris* Mill.) growth and climate is important because of the value of longleaf pine for climate reconstructions, dendroecological studies, archaeological tree-ring studies, modelers, and climatic change impacts in the Southeastern Coastal Plain. Longleaf pine trees are found across the breadth of the Coastal Plain from Virginia to East Texas in a variety of environmental settings. These trees are typically long-lived (400–500 years maximum ages), and few species, such as baldcypress (*Taxodium distichum* (L.) Rich.), in the Southeastern Coastal Plain exceed their longevity. Furthermore, their remnants are well preserved in many areas of the Coastal Plain because of their high resin content.

Results of dendrochronological research that use longleaf pine have been generally consistent with respect to moisture response in the growing season, but with some definite inconsistencies with regard to temperature response and lag effects. The first tree-ring studies were conducted in the 1930s, and involved sites in northern Florida and southern Georgia. Lodewick (1930) found

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no correlation between radial growth and temperature, but observed a strong positive correlation between radial growth and growing season rainfall of the current year. Coile (1936) found a negative correlation between radial growth and August temperature, and a positive correlation with early spring rainfall of the current year. Schumacher and Day (1939) found that the effect of precipitation on annual ring width was variable between several sites in Florida.

After a rather long period devoid of dendroclimatological research on longleaf pine, Zahner (1989) found that longleaf pine radial growth was negatively related to the severity of drought in southern Alabama. In southern Mississippi, Devall et al. (1991) developed a chronology from 1921 to 1987 and found that current August rainfall, September temperature, and February Palmer drought severity index (PDSI; positive significant response from 1968 to 1983) were the best predictors of radial growth. Some of these factors, such as February PDSI, did not consistently influence growth throughout the study period, however. Devall et al. (1991) also noticed an increase in growth after Hurricane Camille moved through the area in 1969.

Later, Meldahl et al. (1999) conducted a comprehensive dendroclimatological study in southern Alabama, examining earlywood and latewood widths and their correlation with monthly rainfall and temperature. They concluded that the most important factor driving total ring width was current growing season rainfall, particularly in March and September. Second, high temperatures generally had a negative effect on the tree growth, particularly in February through April. Third, latewood widths were much more variable than earlywood widths and generally had higher correlations with climate variables (Meldahl et al., 1999).

Foster and Brooks (2001) found significant positive correlations between tree growth and precipitation in the current spring and summer on xeric sites in west-central Florida, and with previous summer precipitation on intermediate sites. High summer temperatures in the previous summer were also significantly related to growth rates. Similarly, Atchley (2004) reported a positive tree-growth response to spring precipitation for longleaf pine at the Appalachicola Bluffs and Ravines Preserve, Florida. The most recent dendroclimatological study that used longleaf pine was conducted in southern Georgia (Grissino-Mayer, unpublished data) and showed a strong positive relationship between total ring width and winter/spring rainfall.

A comprehensive analysis of the climate response of longleaf pine across the Coastal Plain is lacking because no studies have been conducted in the West Gulf or Atlantic Coastal Plain. A number of studies have examined the climate–growth response of various species along both longitudinal and latitudinal gradients (Hofgaard et al., 1999; Cook et al., 2001; Pederson et al., 2004). Research from a multitude of sites is necessary to fully understand the climate/pine growth relationship because subtle differences in tree growth can occur due to site heterogeneity, and because there can be significant intraspecies variability in the climate response (Grissino-Mayer and Butler, 1993). Furthermore, these new tree-ring data represent the first collection of southern pine chronologies in the Southeast to extend into the 16th century, and can eventually be used in dendroclimatic reconstructions and dendroarchaeological research in the Coastal Plain.

Our study had three primary objectives: (1) develop three multi-century longleaf pine chronologies from eastern Texas, the Florida Panhandle, and coastal South Carolina; (2) determine the climatic factors that most influence tree growth at these sites; and (3) compare the climatic response of longleaf pine trees among the different sites. This study represents the first dendroclimatic analysis of longleaf pine at its western limit in Texas (West Gulf Coastal Plain) and in South Carolina (Atlantic Coastal Plain).

Material and methods

Study area

We collected samples from three sites in the Southeastern Coastal Plain: Big Thicket National Preserve in eastern Texas; Eglin Air Force Base (EAFB) in the Florida panhandle; and Sandy Island in coastal South Carolina (Fig. 1). The Southeastern Coastal Plain is a 160–320 km wide belt that extends from the Atlantic seaboard along the Gulf Coast to East Texas (Hunt, 1967). The belt of land is a relatively smooth plain that ranges from sea level to generally less than 90 m in elevation (Welch and McCart, 1963). Most of the Coastal Plain is covered by the Southeastern Pine Forest, which extends from eastern Texas to North Carolina (Hunt, 1967). Loblolly (*Pinus taeda* L.), longleaf, and slash (*Pinus elliottii* Engelm.) pines are widespread as are various species of oak (*Quercus* spp.) (Orme, 2002).

The climate across the Coastal Plain is fairly uniform, except for the slightly higher summer temperatures west of the Mississippi River Valley (Croker, 1969; Marks and Harcombe, 1981). The humid subtropical climate supports an annual rainfall from 117–165 cm. The abundant rainfall leaches soluble bases, plant nutrients, and colloidal material downward. Consequently, most of the soils in this climate have a low content of organic matter, low natural fertility, and high acidity (Overing et al., 1995). Mean annual temperatures range from 16 to 23 °C (Croker, 1969). The warm temperatures speed