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AN ANALYSIS OF THE GROWTH-RINGS OF *PINUS CARIBAEA* VAR. *BAHAMENSIS* ON NORTH ANDROS ISLAND, BAHAMAS

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ABSTRACT

Pinus caribaea var. *bahamensis* is a tropical or sub-tropical pine occurring on Andros, Abaco, Grand Bahama, New Providence and the Caicos islands in the Bahamas. The potential economic importance of this species has long been recognized.

While many tropical or sub-tropical trees produce poorly defined rings or no rings at all, most tropical pines produce well defined rings. It has been questioned whether or not the distinct growth-rings observed in *Pinus caribaea* var. *bahamensis* are annual in occurrence. The purpose of this study was to determine the periodicity of the formation of growth-rings in *P. caribaea* var. *bahamensis* on North Andros Island.

Core section and stem cross sections were collected and examined microscopically. Measurements were made of latewood, earlywood and total ring width.

This study concludes that the growth-rings of this species on North Andros are annual in occurrence and although intra-annual rings occur, they are generally identifiable as such. Also, there is a marked decrease in the widths of the annual rings after 18 - 25 years of growth. These findings should be important in the commercial management of this economically valuable tree.

INTRODUCTION

Pinus caribaea Morelet var. *bahamensis* Barr. & Golf. is a tropical or sub-tropical pine endemic in the Bahamas Archipelago. It occurs on the islands of Andros, Abacco, Grand Bahama, New Providence and on the Caicos Islands.

Andros is the largest of the Bahama Islands. It is in reality not one island, but several separated by wide bights or shallow channels (Nickrent, Eshbaugh and Wilson, 1988). This study was conducted on North Andros, the northernmost and largest of these islands. North Andros is located approximately 250 miles due east of Key West, Florida.

Approximately 61,000 hectares of North Andros is covered with pinelands (Lamb, 1973). These areas are dominated by *Pinus caribaea* var. *bahamensis*.

The potential economic importance of *Pinus caribaea* as a lumber and pulpwood species has been recognized since the early twentieth century. *Pinus caribaea* has been planted in tropical and sub-tropical areas of Africa, Asia, South America and the Pacific Islands with varying degrees of success (Lamb, 1973). Bahamian pine produces a high-grade, close-grained lumber which compares favorably with similar types of softwoods from anywhere in the world (March, 1949).

A concession to cut timber in the Bahamas was granted in 1900, however, large-scale cutting by the Andros Lumber Company did not begin on Andros until 1947 (Lamb, 1973). March reported that in 1949, the output of sawn lumber from Grand Bahama and Andros exceeded 1,000,000 cubic feet. In 1968, the concession controlled by the Andros Lumber Company was assumed by the Owens-Illinois Corporation. Their operation ended on Andros in 1973 (Lamb, 1973). Since that time, very little commercial cutting trees has taken place on Andros.

The distinct growth rings normally associated with the wood of most temperate trees develop as a result of variations in cambial activity which, in turn, are the result of those trees being subjected to annual

variations in a seasonal temperate climate (Halle, Oldeman, and Tomlinson, 1978). The annual rings typically found in temperate trees are characterized by precise boundaries between the thick-walled cells of the latewood and the relatively thin-walled cells of the earlywood of the next growing season (Glock, Germann, and Agerter, 1963; Kozlowski, 1971; Halle, Oldeman, and Tomlinson, 1978).

Many tropical and sub-tropical trees produce poorly defined rings or no rings at all. Or, rings may be formed which are not annual in nature (Tomlinson and Craighead, 1972; Jacoby, 1989). While many tropical and sub-tropical trees do not produce clearly defined rings, most tropical and sub-tropical pines produce clear rings (Johnson, 1980).

"False" or intra-annual rings are known to occur not only in temperate trees, but also in those tropical and sub-tropical trees which have been shown to exhibit annual rings. "False" rings are known to be the result of a variety of conditions, such as drought or temporary or partial defoliation due to insects, disease, wind, etc. (Larson, 1962; Glock, Germann, and Agerter, 1963; Stokes and Smiley, 1968; Kozlowski, 1971). Any condition which results in the temporary cessation or slowing and further resumption of cambial activity can result in the formation of an intra-annual ring. Such rings are characterized by a gradual transition outward from dense, thick-walled latewood-type cells to much less dense, thin-walled earlywood-type cells (Glock, Germann, and Agerter, 1963; Kozlowski, 1971).

Johnson (1980) found that intra-annual rings occur in *Pinus oocarpa* in Honduras and suggested that their occurrence is related to dry periods within the wet season. The formation of annual growth-rings in the wood of *Pinus elliottii* var. *densa* (south Florida slash pine) has been reported by Tomlinson and Craighead (1972). They also noted the frequent presence of "false" or intra-annual rings within the annual rings of this species and that these may be a drought response since this part of the rings is formed in spring when dry weather is often pronounced. *Pinus elliottii* var. *densa* (South Florida slash pine) has been reported by Tomlinson and Craighead (1972). They also noted the frequent presence of "false" or intra-annual rings within the annual rings of this species and that these may be a drought response since this part of the ring is formed in spring when dry weather is often pronounced. *Pinus elliottii* var. *densa* is generally considered to be closely related to *P. caribaea* var. *bahamensis* and grows in Florida under similar environmental conditions to those experienced by *P. caribaea* in the Bahamas.

This study resulted from a suggestion by Bob West, then with the Forestry Division of the Department of Lands and Surveys of the Bahamas. The Forestry Division was interested in determining whether or not it was possible to age caribbean pine by simple ring counting.

Wood of *Pinus caribaea* var. *bahamensis* is collected on North Andros reveals the presence of obvious growth-rings. The formation of annual growth-rings in *P. caribaea* is reported by Lamb (1973) to take place where there is a well defined alternation of a rainy season followed by a dry season. He also states that the majority of *P. caribaea* var. *bahamensis* growing in the Bahamas produces several rings in the wood each year. March (1949) implies that bahamian pine can be aged by simple ring counting, thus indicating the formation of annual rings. This conflicting information indicates that the formation of growth-rings in *P. caribaea* var. *bahamensis* has not been adequately studied.

The purpose of this study was to determine the periodicity of the formation of the growth rings of *Pinus caribaea* var. *bahamensis* on North Andros Island by determining whether the rings formed are true annual rings or if they are the result of factors which are intra-annual in occurrence.

METHODS AND MATERIAL

The collection of material on which this study was based was carried out on North Andros Island during May and June of 1990 with the help of the personnel of the Forestry Division of the Department of Lands and Surveys of the Bahamas.

Individual trees selected for sampling were

chosen subjectively based on the suggestions provided by Stokes and Smiley (1968) and Fritts (1976). These suggestions include selecting trees which appear to be healthy and in good condition and ones which are free from obvious injury or damage from insects, wind or other environmental conditions.

Radial core samples were collected from at least ten trees at each of ten sites using an increment borer yeilding 5 mm diameter cores. The cores were taken at breast height (approximately 1.3 meters) and at specific compass directions in order to provide some degree of standardization.

The core samples were placed in individual screw-cap polystyrene tubes to which a preservative solution (formaldehyde-propionic acid-ethanol) was added. This procedure provides protection from core breakage and allows for the later examination of the cores in an essentially fresh condition.

One stem cross section was collected from a tree at each of three of the sites. These were necessary to provide some information regarding the occurrence of partial or incomplete rings and the variation of the width of individual rings within a tree.

As much climatic data as was available were collected from the Bahamian Agricultural Research Center (BARC) and from Mr. Edwin Lee, operations Manager of the Department of Water and Sewerage. These data consist of eight years of precipitation records and six years of temperature records collected at the BARC facility and approximately two and a half years of precipitation records collected by Mr. Lee at the pumping station near north end of the island.

The core samples were prepared for ring-width measurement and examination of the ring characteristics by surfacing on a sliding microtome. Measurements of earlywood width, latewood width and total ring-width were carried out on the core samples using a stereo microscope with a camera lucida attachment. An appropriate scale was drawn on paper and placed under the mirror so as to superimpose the image of the scale onto the specimen being examined. The measurements were taken at a magnification of 60x. This technique permitted measurements to 0.01 mm. The measurements were recorded along with observations on the occurrence and relative widths of what appeared to be "false" rings.

In most modern tree-ring studies, measurements are made using a microscope equipped with a measuring stage connected to an electronic recording device which feeds the data into a computer. Although the measurement technique used in this study is generally considered outdated, in light of the expense of the aforementioned equipment, it provides a method by which a basic study such as this can be conducted in nearly any laboratory.

RESULTS AND DISCUSSION

Microscopic examination shows that growth-rings fitting the traditional description of true annual rings occur in the wood of *Pinus caribaea* var. *bahamensis* on North Andros. Examination of the stem cross sections reveals that some annual rings may not form in all portions of the stem and thus may be missing from some radial core samples. False rings are relatively common and are generally detected by their appearance. It is probable, however, that conditions are occasionally such that an intra-annual ring is formed which appears to be a true annual ring and is measured as such.

The abrupt transition from the last latewood cells of one growth-ring to the first-formed earlywood cells of the next is usually very distinct in *Pinus caribaea* var. *bahamensis* and leaves little question as to the boundary between growth-rings (Figs. 1 and 2). This transition is apparent not only because of the changes in cell characteristics but also by an abrupt change in color from dark brown to light brown.

Intra-annual or "false" rings are relatively easy to identify in *Pinus caribaea* var. *bahamensis* by the gradual transition from earlywood cells to latewood-like cells and an equally gradual transition back to earlywood (Figs. 1 and 3). Intra-annual rings also tend to occur in closer proximity to the latewood of the year in which they were formed to the latewood of the previous year.

Since there is relatively little seasonal variation in temperature but a marked seasonal variation in rainfall and generally an extended

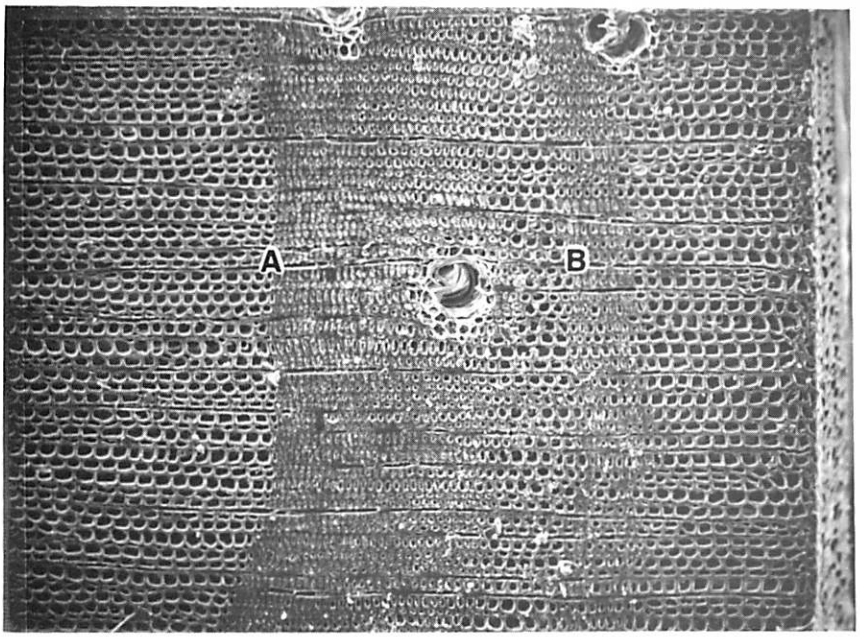

Fig. 1. Scanning electron micrograph of a surfaced core sample showing the cellular characteristics of a true annual ring boundary (A) and the boundary of an intra-annual ring (B).

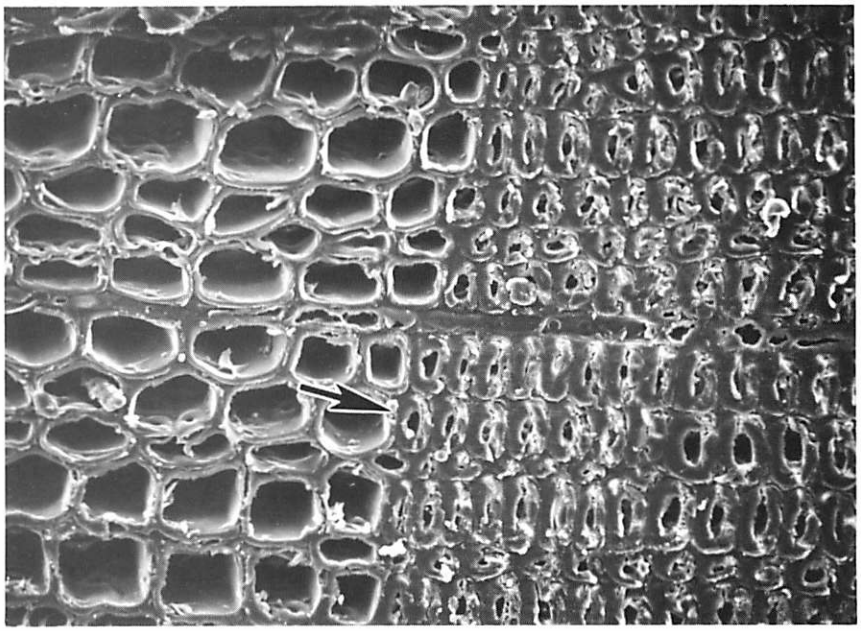

Fig. 2. The abrupt transition (arrow) from latewood cells to earlywood cells characteristic of the boundary of a true annual ring.

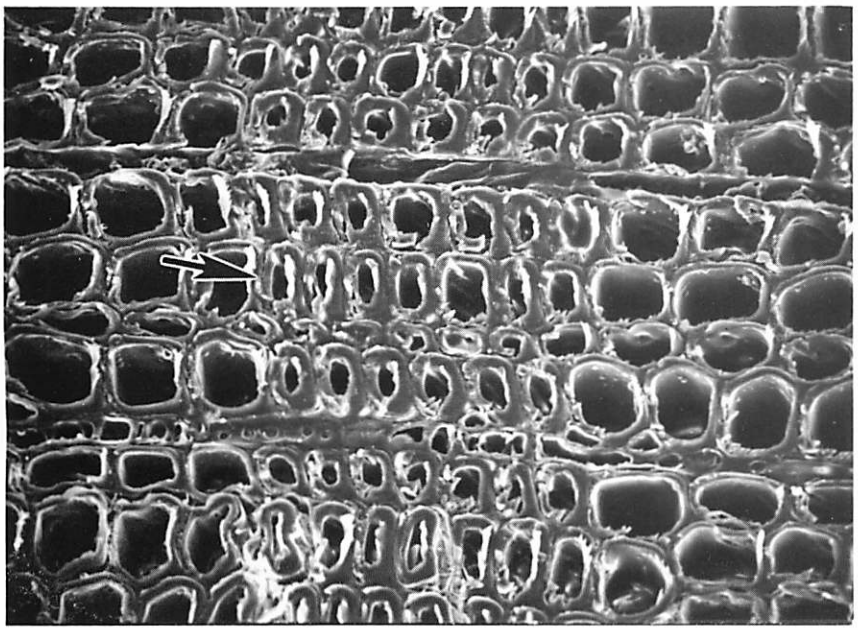

Fig. 3. The gradual transition (arrow) from latewood cells to earlywood cells characteristic of the boundary of an intra-annual ring.

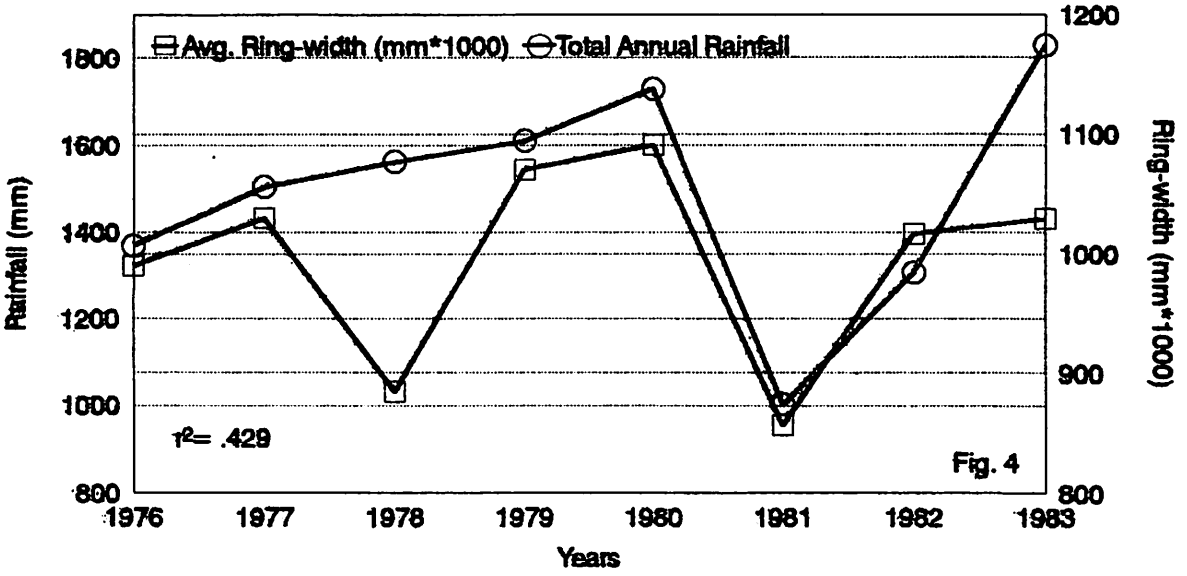

Figure 4. Graph showing the relationship between rainfall and growth-ring width for an eight year period (1976-1983).

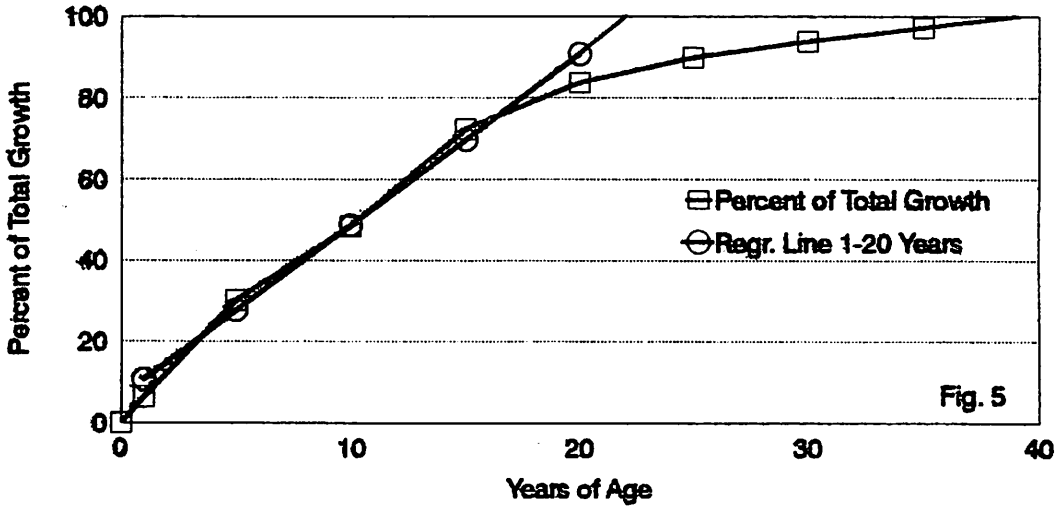

Figure 5. An example of the growth-trend in a tree of *P. caribaea* var. *bahamensis*.

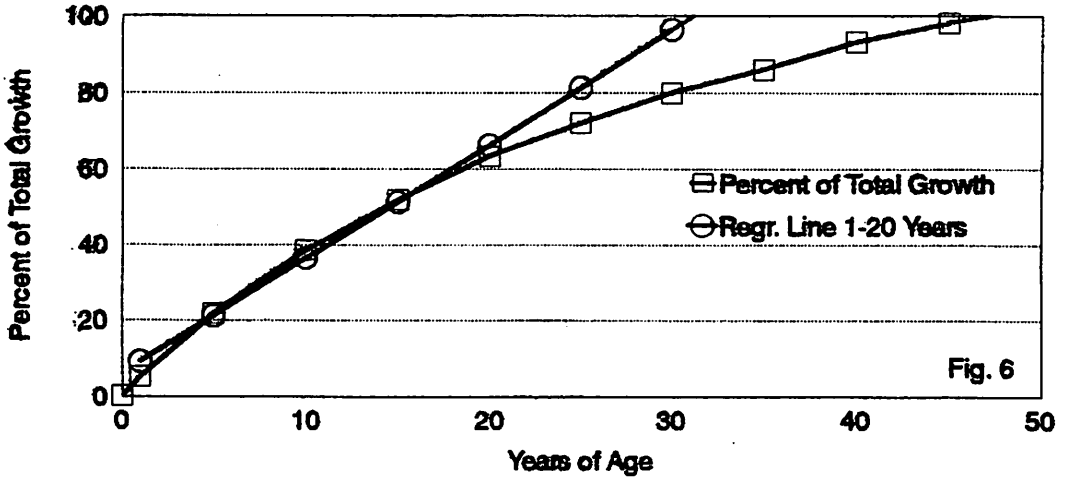

Figure 6. Average growth-trend in *P. caribaea* var. *bahamensis* on North Andros.

dry period in winter, it is likely that the lack of available water is growth-limiting for *Pinus caribaea* var. *bahamensis* in North Andros. However, the limited amount of weather data available makes calibration of rainfall with ring-widths somewhat questionable (Fig. 4).

Pinus caribaea var. *bahamensis* on North Andros has the potential to be useful in dedroclimatological work since it produces identifiable annual growth-rings. However, other factors may need to be considered, most notably the groundwater system which consists of a lens of fresh water floating on salt water. In some areas a permanent supply of fresh water reaches to within 3 - 4 feet of the surface. Lamb (1973) believes that the pines in these areas may benefit from this water supply by capillary action through the porous limestone even during extended dry periods. If this is the case, the pines on much of the island may be unsuitable for this type of study. An examination of climatological factors and groundwater levels in relation to growth-rings would be very interesting.

An important finding of this study from the standpoint of timber management is an observed decrease in the widths of the annual rings in many of the core samples after an age of between 18 - 25 years. There is some variation from site to site but an example of this trend is represented graphically in Fig. 5. This graph shows the cumulative ring-widths of a representative tree plotted as a percentage of the total accretion of wood diameter after 39 years. Also plotted is the regression line for the first 20 rings. This line represents the expected growth if the tree were to maintain its growth-rate as seen in the first 20 years. It also serves to emphasize the range in which the growth-rate declines. Figure 6 shows an average of a number of trees. Although the growth-trend is somewhat smoothed by averaging, note that the departure of the curve from the regression line still occurs in approximately the same range. This trend may be genetic in *Pinus caribaea* var. *bahamensis* or may result from competition as the crowns of the trees expand and the canopy closes. This finding may have an impact on the decisions made regarding the commercial management of this species which represents a valuable resource to the Bahamas.

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