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Pinus tropicalis Growth Responses to Seasonal Precipitation Changes in Western Cuba

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INTRODUCTION

The total tree-ring width, earlywood width and latewood width, as well as wood density, depends mostly on environmental and climatic conditions of the current and previous years. It is well known that the sensitivity of trees to climatic variability increases when limiting factors occur. Many different chronologies have been used for revealing past climatic trends that have included reconstructions of air temperature, precipitation and pressure. Results obtained by Fritts (1976), Briffa *et al.* (1983, 1988), Shiyatov (1986), Schweingruber (1988), Wu *et al.* (1990) and others demonstrate the usefulness of dendrochronological methods for analysing climate in extratropical latitudes where the growth of trees can be limited by thermal conditions. Our study deals with the variability of radial growth of trees growing in tropical climates where precipitation is the most dynamic temporal factor.

MATERIAL AND METHODS

Cuba is characterized by a tropical trade climate with a mean January temperature of 22.5°C and a mean August temperature of 28.0°C. Total annual precipitation is 1000–1200 mm, with some years experiencing up to 2200 mm. The rainy (May to October) and dry (November to April) seasons comprise equal portions of the annual total. Meteorological data between 1906 and 1986 from Las Vegas, located in the Havana province, and two short time series from two sites nearest to our study site – La Palma (1967–1986) and Pinar del Rio (1967–1984) – were used to analyse the effects of precipitation on pine growth.

Between eight and ten trees of *Pinus tropicalis* were sampled from each of the three sites, all within the Sierra de los Organos, in the Pinar del Rio province of western Cuba. Two cores were taken from each tree using a regular increment borer. Site 3 is situated on the north-facing macroslope of Sierra de Rossario at a height of about 300–350 m a.s.l. Site 4 is situated on the south-facing macroslope of the Sierra de los Organos at the same elevation as the previous one. This site constitutes a slope of northwest exposure with slope inclination <25°. Site 5 is situated on a pass in the Los Jasminos Mountains at a height of 200 m a.s.l.

Because of the extremely individual response of tree-ring growth to environmental changes it was a problem to synchronize the samples not only from the same site, but sometimes also from one tree. So, further analysis was mostly carried out on the base of individual cores. Lightwood and darkwood widths (the terms 'earlywood' and 'latewood' may not be appropriate in the traditional sense) were measured with a model MBC-10 microscope, while wood density measurements were made with an RDK-1D X-ray densitometric instrument. The latter allowed us to determine more precisely the boundary between annual layers. The biological growth trends were removed from the tree-ring time series by standard dendrochronological methods.

RESULTS

Our analyses revealed typical features of the annual ring formation under tropical climatic conditions with a well-expressed course of annual precipitation. Under these conditions, growth occurs throughout the year and trees have rather wide rings visible to the unaided eye. The formation of lightwood occurred during the wet summer season, while darkwood formed during the dry winter season. With violation of the normal annual precipitation course (decrease of monthly precipitation within the wet season and/or increase of precipitation in one of the months during the dry season) layers of darkwood form within a layer of lightwood and vice versa (Fig. 12.1). This testifies to high sensitiveness of *Pinus tropicalis* to intra-annual precipitation variability, but it causes the formation of intra-annual ('false') rings that make further revealing of annual tree rings, as well as crossdating, hard. Density diagrams were made for all samples to overcome this impediment. The false rings were identified as variability of density of low amplitude. Abrupt changes in wood density were specified as tree-ring boundaries.

Comparison of inter-annual precipitation variability with tree-ring growth showed that a decrease of at least 150 mm average monthly precipitation was necessary for formation of darker and denser wood after the lightwood. In contrast, an increase of average monthly precipitation of 70–100 mm was sufficient to induce formation of lightwood (Table 12.1). The trees appeared to be more sensitive to an increase in precipitation during a dry season than to a reduction of precipitation during a rainy period. We found that the formation

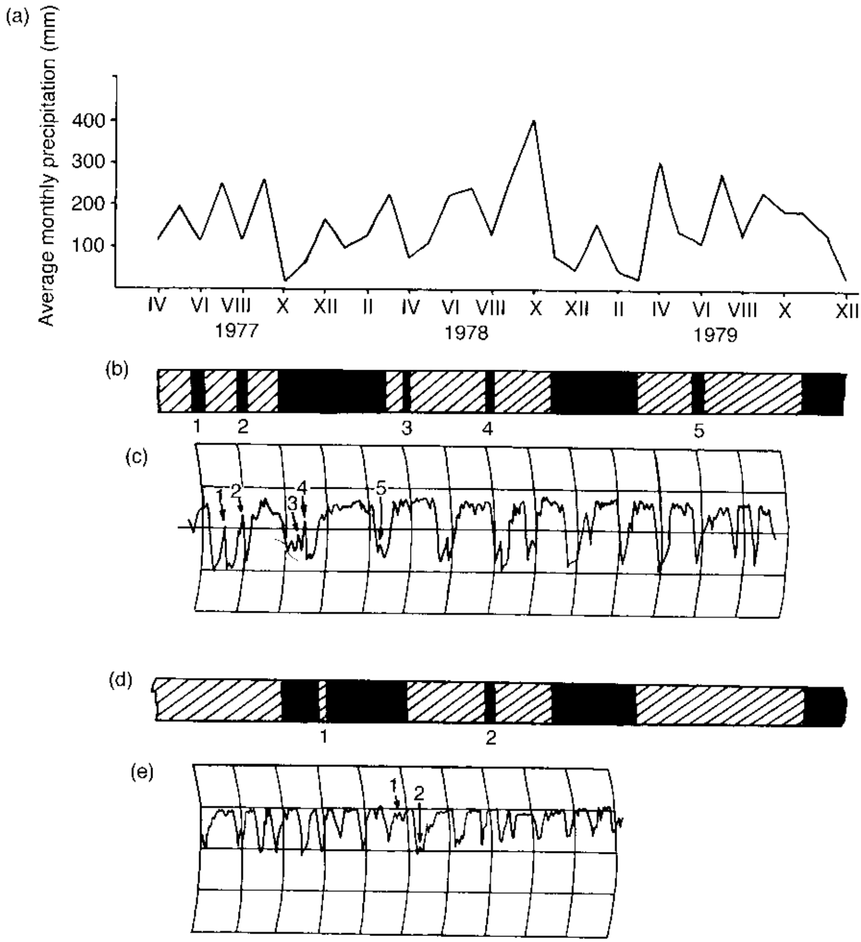

Fig. 12.1. Tree-ring growth response to intra-annual precipitation variability in western Cuba. (a) Average monthly precipitation in La Palma (April 1977 to December 1979); (b) alternation of lightwood (inclined lines) and darkwood, sample 44, site 4; (c) density diagram of sample 44 (1, 2, ... 5 – 'false' rings); (d) alternation of lightwood and darkwood, sample 23, site 3; (e) density diagram of sample 23 (1,2 – 'false' rings).

of lightwood did not occur when average monthly precipitation was less than 200 mm.

We also found a positive correlation (all correlation coefficients exceeding 0.5) between growth of darkwood and dry season precipitation at all of our study sites (Fig. 12.2). A negative correlation between growth of lightwood and wet season precipitation was typical at sites 3 and 4. A positive correlation

Table 12.1. Abrupt change in the amount of precipitation followed by the formation of layers with different density (1 – number of cases, 2 – precipitation change in mm, 3 – standard deviation).

Meteorological station	Seasons					
	Wet			Dry		
	1	2	3	1	2	3
La Palma	13	−215	138	16	104	60
Las Vegas	33	−167	119	23	73	42

between growth of lightwood and wet season precipitation was found only at site 5, obviously due to good drainage and lasting insolation.

CONCLUSIONS

Pinus tropicalis sensitiveness thresholds to average monthly precipitation change were estimated for dry and wet seasons, respectively. We conclude that the association between tree-ring growth of *Pinus tropicalis* and inter-annual precipitation demonstrates the possibility of climate reconstructions being conducted on dendrochronological tree-ring data from tropical regions.

SUMMARY

We investigated the tree-ring growth variability of *Pinus tropicalis* growing under tropical climate conditions at three sites in western Cuba. We found that the amount and temporal dynamics of precipitation was the dominant factor that determined the formation of tree-ring structure under stable temperature conditions.

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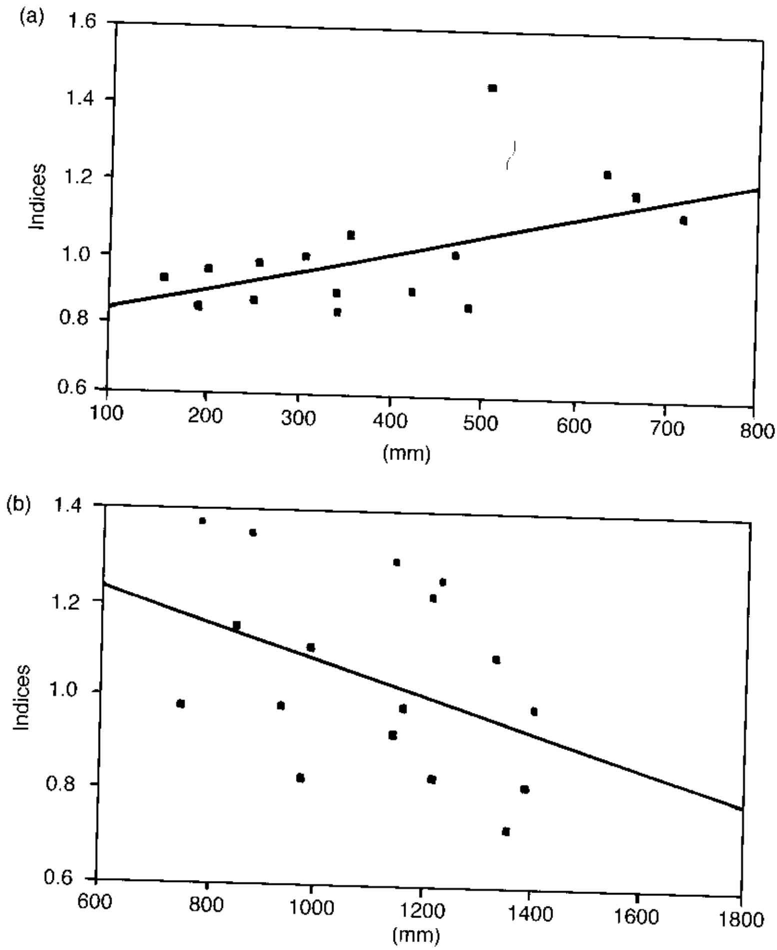

Fig. 12.2. Relationship between darkwood (a) and lightwood (b) growth and amount of precipitation for dry and wet seasons, respectively (sample 14, site 3, La Palma).

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