



Climate - Radial Growth Relationships in Some Major Tree Species of British Columbia

Introduction

This study examines the influence of climate on tree-ring properties of several major tree species: Pacific silver fir (*Abies amabilis* (Dougl. ex Loud.) Forbes), subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), and lodgepole pine (*Pinus contorta* var. *latifolia* Dougl. ex Loud.). Our three objectives were to determine how (1) tree-ring properties change along an elevation gradient, (2) short-term climatic influences are correlated with tree-ring properties, and (3) long-term climatic influence on tree-ring properties.

Materials and methods

Pacific silver fir was sampled in high-elevation old-growth stands in the subalpine Mountain Hemlock zone in southern coastal BC; subalpine fir was sampled in second-growth stands across the montane Sub-Boreal Spruce zone and the subalpine Engelmann Spruce - Subalpine Fir zone in central and southern BC, respectively; and Douglas-fir and lodgepole pine were sampled in old-growth stands within the northern Interior Douglas-fir zone in central BC. The cores or discs were dated and each was measured for ring width (RW). For some tree species we also measured other tree-ring properties such as latewood width (LW), mean ring density (RD), latewood density (LD), and maximum density (MXD). The measurements were done using a Win-DENDRO II system and X-ray densitometry. We analyzed relationships between elevation and selected tree-ring properties, using elevation as a surrogate for local climate. Using dendrochronological methods, we developed tree-ring chronologies and related them to climatic data available from the nearest climate station.

Ring-climate relationships along an elevation gradient

The influence of elevation on tree-ring properties was investigated for subalpine fir. The elevation gradient from 620 to 2,100 m reflected changes that occur within montane boreal and subalpine boreal climates. All measured ring properties were significantly negatively correlated with elevation (Figure 1A and B), and MXD and RD were significantly positively correlated with LW (Figure 1C and D). This means that the elevation gradient in boreal climates coincides with a forest productivity gradient: site index, ring width, and ring density decrease with increasing elevation.

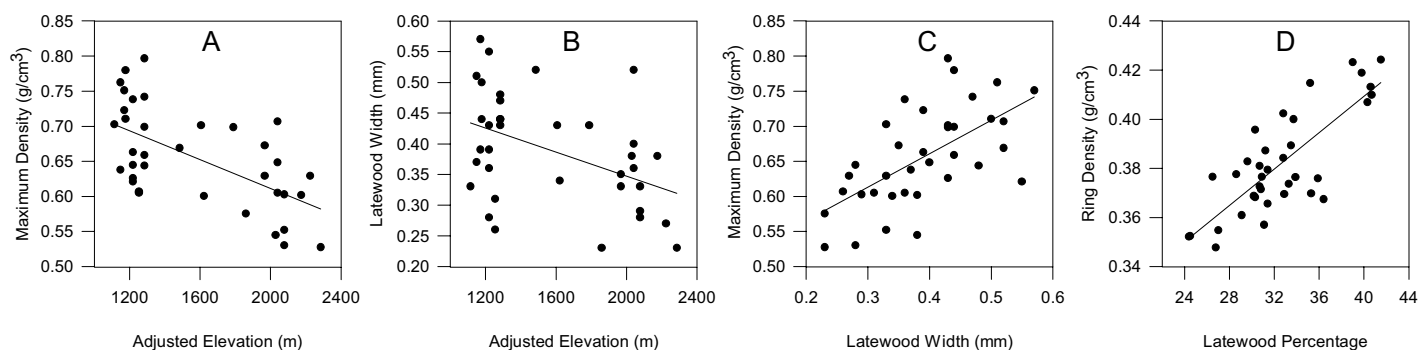


Figure 1. Scattergram and fitted regression line of: A - maximum density on adjusted elevation ($R^2 = 0.35$); B - latewood width on adjusted elevation ($R^2 = 0.17$); C - maximum density on latewood width ($R^2 = 0.36$) and D - ring density on percent of latewood ($R^2 = 0.62$).

Short-term climatic influences

Short-term climatic influence on maximum ring density was investigated for Pacific silver fir and subalpine fir (Figure 2). In both species MXD was significantly positively correlated with the current year August temperature, and significantly negatively correlated with late summer precipitation. This pattern suggests that warmer and drier late summer conditions lead to greater maximum ring density. For Pacific silver fir, density may also be increased by an early warm spring. However, warm temperatures in other seasons appear to have a negative effect on density, as seen in the negative correlations of previous year fall temperatures in low-elevation subalpine fir.

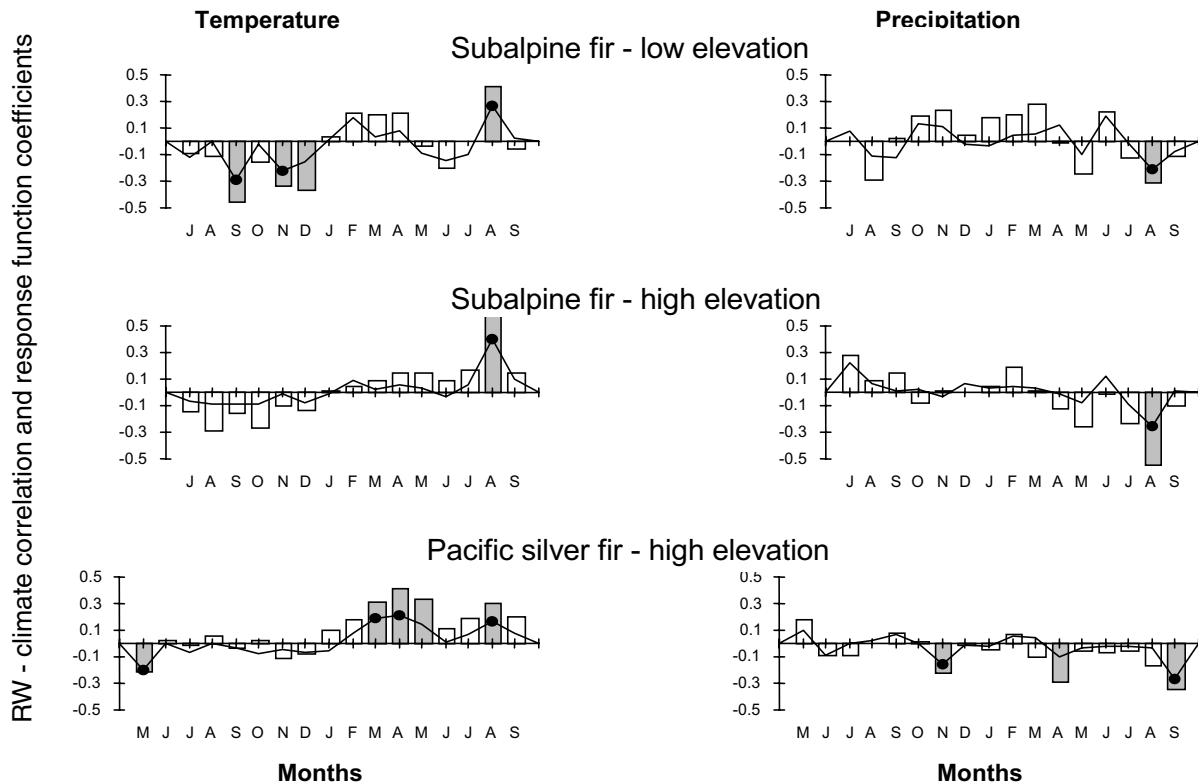


Figure 2. Correlations (bars) and response functions (lines) for chronologies of maximum density (MXD) indices on mean monthly temperature and precipitation. For low- and high-elevation subalpine fir, monthly climatic parameters are for 15 months (July of previous year to September of the current year) from 1946 to 1992; for high elevation Pacific silver fir monthly climatic parameters are for 17 months from 1892 to 1990. Bullets indicate months of significant correlations, shaded columns indicate months of significant response.

The short-term climatic influence on ring width was also investigated for subalpine fir, Douglas-fir and lodgepole pine (Figure 3). In low-elevation subalpine fir, lower temperatures and higher precipitation in the early growing season appear to improve growth (significant negative correlation and response to mean May and June temperatures, and significant positive response to May precipitation). The high-elevation trees showed a distinctly different pattern with both positive and negative correlations and responses to temperature and precipitation.

Both Douglas-fir and lodgepole pine showed a strong positive response and correlation to precipitation in August of the previous year (Figure 3). Greater precipitation in this period may result in increased nutrient storage in the biomass and may increase foliar efficiency in the following year. Both species also showed a significant negative response to mean June temperature of the current year, suggesting below-normal temperatures in early summer may favour radial growth. Lower temperatures in the late spring may reduce the plant moisture stress which typically occurs in the study area.

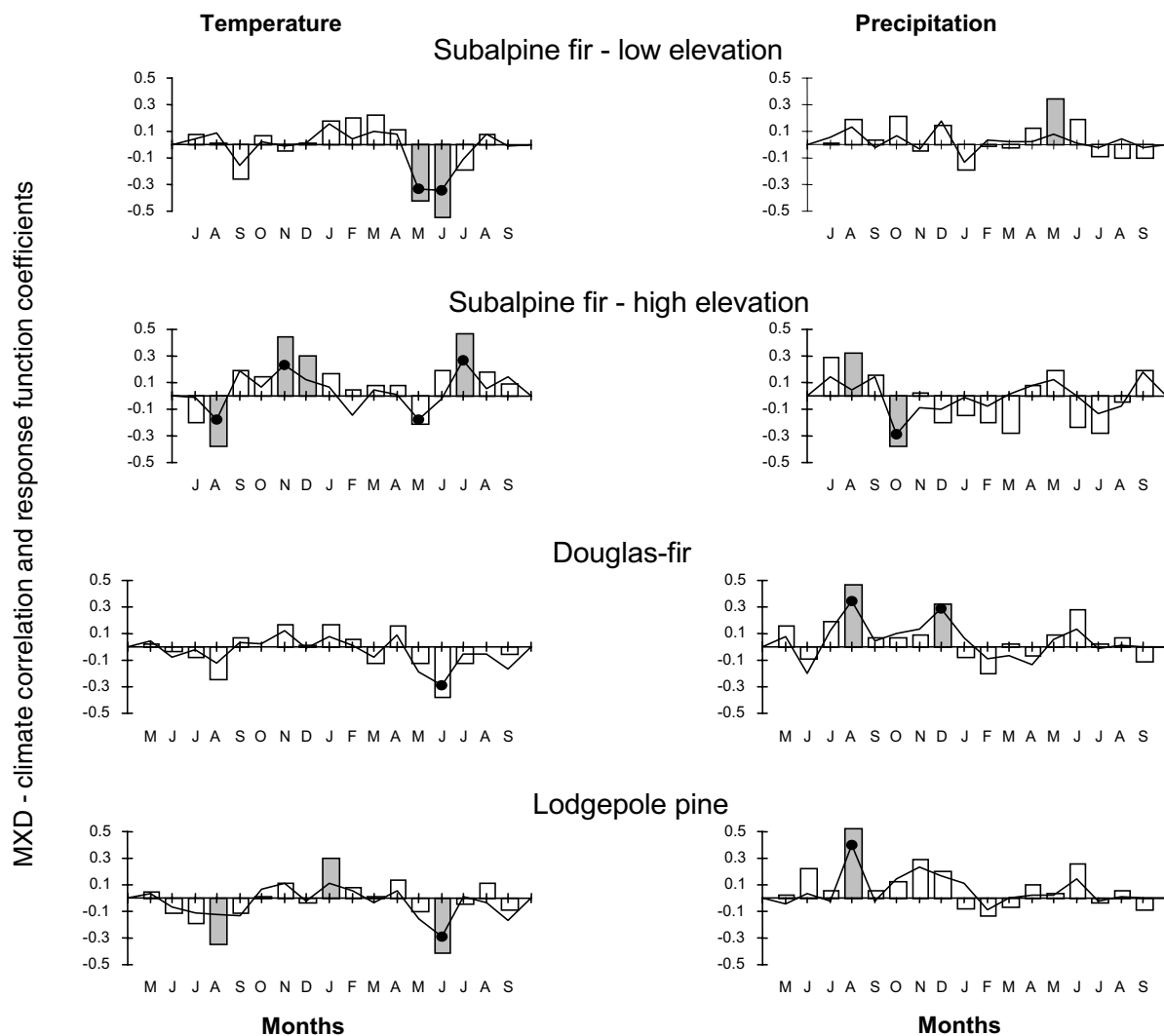


Figure 3. Correlations (bars) and response functions (lines) for chronologies of ring-width (RW) indices on mean monthly temperature and precipitation. For low- and high-elevation subalpine fir, monthly climatic parameters are for 15 months (July of previous year to September of the current year) from 1946 to 1992; for Douglas-fir and lodgepole pine monthly climatic parameters are for 17 months from 1948 to 1995. Bullets indicate months of significant correlations, shaded columns indicate months of significant response.

Long-term climatic influences

Long-term climatic influences on ring width covering a period of several hundred years are presented only for Douglas-fir and lodgepole pine in a continental, summer-dry, cool temperate climate (Figure 4). Markers (extremely narrow rings following wider ones) were present in most samples, indicating the presence of strong macroclimatic signals in tree-rings. The most important marker was for 1869, which is recognizable as a trough in the plotted standard chronologies. Fire scars present in 8 of the 14 study stands were dated to occur in 1869.

There were similarities between Douglas-fir and lodgepole pine chronologies in 9 study stands. The long-term component of the chronologies indicates periods of more favourable climatic conditions (improved radial growth) and less favourable climatic conditions (suppressed radial growth). There were some common periods of suppressed growth in both species in most of the study plots; for example around 1869, 1920, and 1970. This pattern suggests common periods of adverse climatic conditions, such as the widespread fires in 1869, occur at about 50-year intervals.

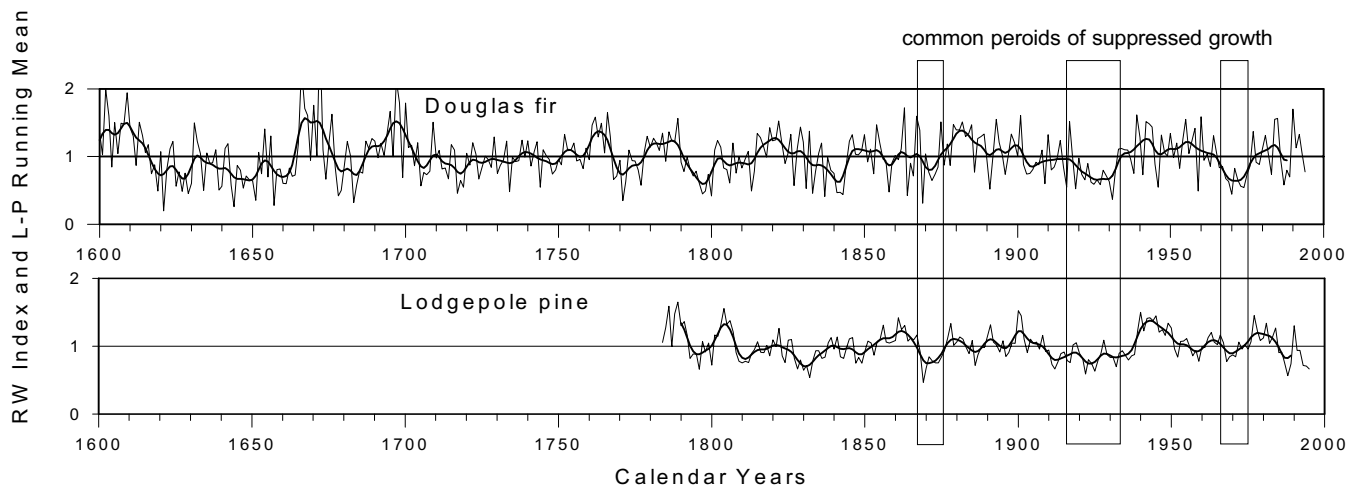


Figure 4. Indexed ring-width chronologies (thin line) for Douglas-fir and lodgepole pine from selected stands and their 13 year low-pass filter component showing long-term ring-width variation (thick line).

Summary

Our findings indicate that radial growth (ring width, late-wood width, ring density, late-wood density and maximum density) is influenced by climate more strongly in extreme conditions - cold or warm and dry climates - and that different species may have similar responses to similar climatic influences. When the influences of climatic factors on tree growth are known, we can better evaluate and predict the effects of climate change.

Reference

Splechtna, B., J. Dobry, and K. Klinka. 2000. Tree-ring characteristics of subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) in relation to elevation and climatic fluctuations. *Ann. For. Sci.* 57:89-100.

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