Mountain Hemlock Growth Dynamics on Vancouver Island

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Introduction

Mountain hemlock (*Tsuga mertensiana*) trees are a major component of the Mountain Hemlock biogeoclimatic zone in the coastal mountains of British Columbia. These stands are under increasing pressure as timber harvesting extends upwards into the montane zone, and their successful management requires an understanding of how they will respond to future climatic changes (e.g. Graumlich and Brubaker 1986; Woodword et al. 1994). This paper summarizes research designed to describe the radial growth of mountain hemlock trees at four sites in Strathcona Provincial Park on Vancouver Island (Figure 1). We chose to focus on these stands as previous research shows climate plays an important role in limiting tree growth and establishment within this zone in coastal British Columbia (Brooke et al. 1970).

Methodology

A mountain hemlock tree-ring chronology was developed from 158 increment-core samples (108 trees), which were assessed using a computerized WinDENDRO^{TM} (Ver. 4.1.2) image-processing tree-ring measurement system (Guay et al. 1992). The cores were crossdated and verified using the software program COFECHA (Holmes 1992). The age-growth trends inherent within each tree-ring series were removed using a double detrending procedure within ARSTAN (Holmes 1992).

Fritts (1976) and others have established a methodological framework that uses statistical techniques to factor out the climatic influences on this radial growth. In this instance the software program PRECONK (Ver. 5.1) developed by Fritts (1994) was used. PRECONK invokes a principal component analysis to maximize the climatic signal within a tree-ring series (Fritts et al. 1971) and calculates a response function to identify the climatic variables most limiting to growth (Blasing et al. 1984). The climatic data required for the analysis were derived from the Comox climate station (1945-1995), located approximately 35 km east of the study site (Figure 1).

Results

Our analyses of increment cores led to the development of a cross-dated chronology extending from 1500 to 1994 A.D. (series correlation 0.531). As shown by Figure 2, the chronology indicates that enhanced radial growth characterizes the1530s-1580s, 1750-1810s and 1870-1940s. Notable intervals with suppressed radial growth include 1500-1530s,1710-1750s, and 1820-1870s (Figure 2).

The PRECONK analysis showed that mountain hemlock radial growth was significantly correlated ($r^2 = 0.621$) to both air temperature (positive) in July and precipitation (snowfall) (negative) in the preceding winter (November and January). While the positive association between mountain hemlock growth and air temperature is a reflection of how warm growing-season temperatures enhance conifer metabolic processes (Owens and Blake 1985), the negative relationship to winter snowfall is usually assumed to be a reflection of the important physiological role of deep seasonal snowpacks (Fonda and Bliss 1969; Brooke et al. 1970). To illustrate the interplay of these two variables, a response surface (*cf.* Graumlich and Brubaker 1986) was constructed which expressed tree growth (1954-1994) as a function of the average July temperature and seasonal snowpack (April 1) recorded at the nearby Forbidden Plateau snow survey station (No. 3B01 BC Ministry of Environment; Figure 1). This analysis revealed that, over the 40 years of record, the greatest increments of radial growth occurred during cool summers that began with a shallow snowpack, while the least amount of radial growth occurred during seasons that began with below normal snowpacks and ended with very warm summer air temperatures (Figure 3). Significantly, our analyses demonstrated that when the seasonal snowpacks exceeded 4 m in depth, radial growth was significantly reduced, regardless of the growing-season temperature (Figure 3).

Like many biogeoclimatic zones in the Pacific Northwest, the climate of the Vancouver Island montane zone is influenced by recurring

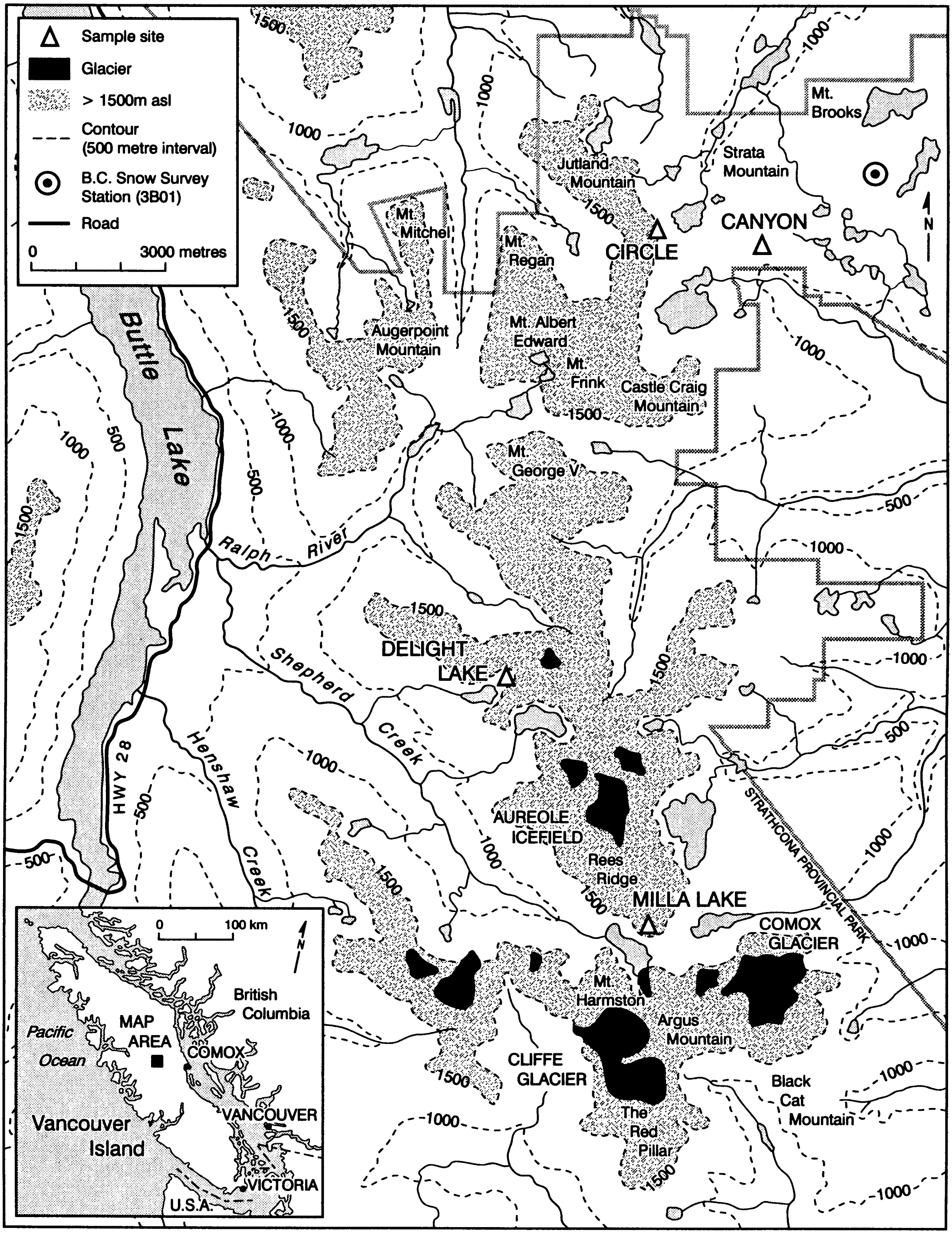

Figure 1. Location map of the sampling sites and climate stations.

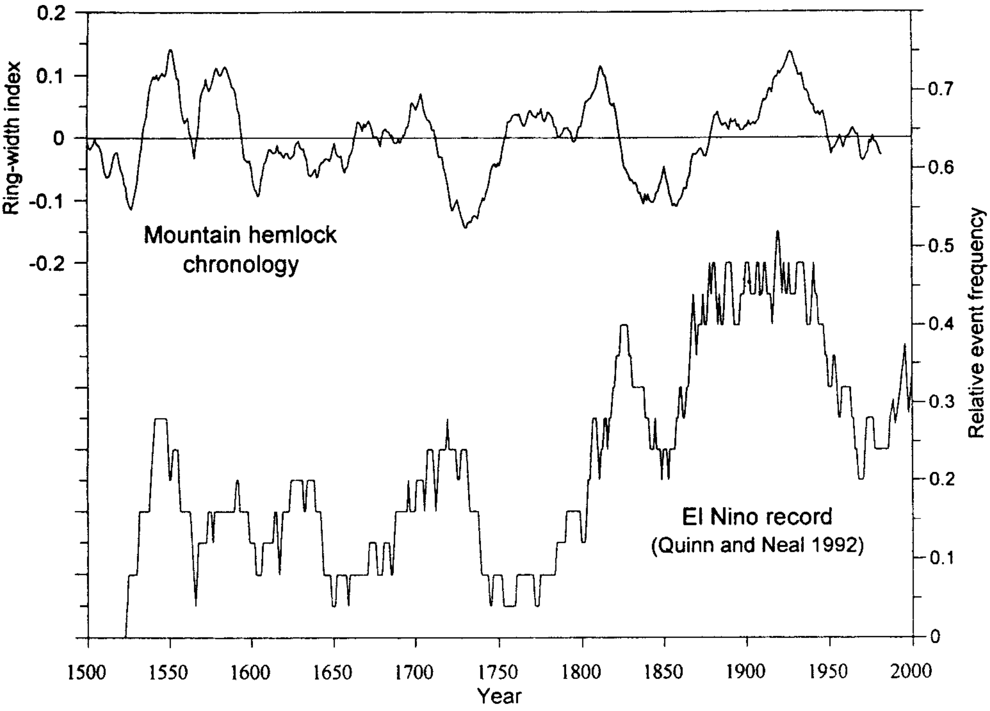

Figure 2. Mountain hemlock chronology and historical record of El Niño events compiled by Quinn and Neal (1992). A twenty-five-year running mean was used to smooth both records to highlight the inherent long-term trends.

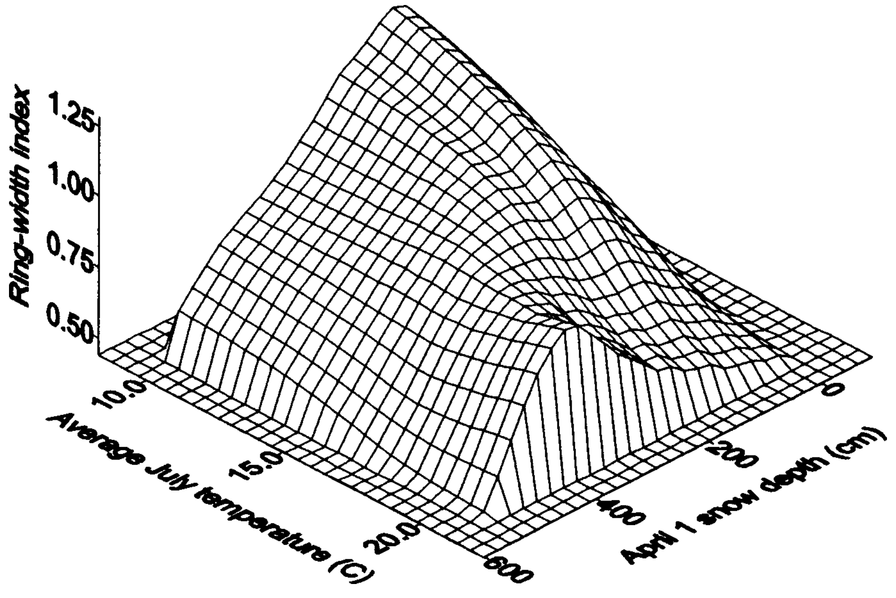

Figure 3. A response surface expressing the relationship between the annual mountain hemlock radial growth indice, average July air temperature and April 1 snow depth. Due to nonlinearity in the climatic variables, the 40 data points used were smoothed before modelling using second-degree polynomial equations. The figure indicates that between 1954 and 1994 enhanced radial growth occurred during cool summers that began with shallow winter snowpacks, or during warmer-than-normal summers that began with moderately deep snowpacks (< 4m).

climatic events occurring at several different timescales (Brubaker 1986; Wall 1992). It is interesting to note that, at the interannual/decadal scale, El Niño winters generally correspond to long-term intervals of enhanced radial growth within these stands of mountain hemlock trees (Figure 2). Based on the climate-growth relationships described, these intervals are interpreted as consisting of a series of cool summers that began with a shallow snowpack or a series of very warm summers that began with deep spring snowpacks.

Summary

Our research shows that the radial growth of mountain hemlock trees growing at high elevation on Vancouver Island are sensitive to changing climates and probably respond to common forcing mechanisms. While this behavior was shown to be correlated with the temperature of the growing season and the accumulated winter snowfall depth, a longer term perspective shows that it also reflects a response to global climatic forcing mechanisms such as El Niño.

Acknowledgements

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