Persistence at the Tree Line: Old Trees as Opportunists

ANDREW J. TRANT,1,2 RYAN G. JAMESON1 and LUISE HERMANUTZ1

(Received 1 October 2010; accepted in revised form 16 February 2011)

ABSTRACT. While old trees have long been of interest, their significant role in responding to climate change at northern tree lines has been overlooked. Long-lived black spruces at the tree line in Labrador show a radial growth response that is synchronous with recent climate warming. The ability of individuals to persist with suppressed radial growth rates during adverse growing conditions may have significant implications for the rate at which these trees are able to respond when conditions become favourable.

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growth requires fewer growing degree-days than reproductive growth, which suggests that reproductive growth does not occur when radial growth is suppressed (Woodward, 1987). In the long term, the ability of black spruce to grow and regenerate vegetatively allows long-lived individuals to endure unfavourable climates and resume sexual reproduction when conditions improve.

Krummholz is the dominant tree form at many treelines. These low-lying trees, the result of winter wind desiccation and ice-crystal abrasion, rarely grow higher than the average snow depth (Scott, 1995). Nurse effects of deciduous shrubs, microtopography, and glacial erratics may play a significant role in the establishment and persistence of krummholz in otherwise inhospitable environments by protecting them from increased snow drifting and sheltering them in snow-free periods (see Fig. 1; Cranston, 2009; Daley, 2009). Since growing conditions at these higher elevations are often suboptimal, krummholz put down much less radial annual wood than forest trees of the same species; in our study area, mean ring size for krummholz is 0.17 mm, compared to 0.45 mm for forest trees.

Despite its old age and harsh growing conditions, the basal sample shows that the black spruce reported here has experienced a dramatic increase in annual radial growth (Fig. 2A) that matches the pattern of temperature increase observed in recent climate records (Bell et al., 2008). For
the greater part of the 20th century, ring width values were larger than the series mean, and these values have continued to increase from Little Ice Age minima around 1770 and 1850 (Fig. 2) to the present day. For the running mean (Fig. 2A: grey line), we used a 50-year window between points, excluding some of the interannual variation, in order to show this long-term trend. On a larger scale, a chronology for 22 radii from 20 stems of black spruce krummholz in the Mealy Mountains shows a similar pattern (Fig. 2B), with significant suppression of radial growth for the majority of the available record and dramatic recent increases that correspond to increases in growing-season temperature (Bell et al., 2008). This chronology was detrended using a modified negative exponential model that removes biological growth trends thus presenting standardized ring width indices.

These old krummholz may persist for centuries until conditions become more favourable, at which time they may increase radial growth rates and initiate sexual reproduction. Older trees are likely to have greater belowground biomass and access to resources essential to these processes. Once viable seeds are produced, expansion of the tree line could occur rapidly as strong winds disperse seeds from the “front line” of old tree islands. Light black spruce seeds, disseminated from semi-serotinous cones throughout the year, have the potential to travel great distances atop hard snow and ice layers during the winter. In slow-growing environments such as the tree line, the advantage may be given to those individuals who have been waiting.

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