



Forest Dynamics

White spruce (*Picea glauca*) forests are an important landscape component in Lake Clark and Katmai national parks and preserves and are monitored under the vital sign Vegetation Composition and Structure. Warming since the 1980s has led to increased spruce beetle-related mortality in older, denser forest stands, but also to increases in spruce growth and establishment in more open sites, particularly near the forest-tundra margin.



NPS/Amy Miller

High seedling counts recorded near treeline in Lake Clark National Park and Preserve.

White Spruce Distribution Shaped by Changes in Mortality and Recruitment

Forest monitoring sites arrayed along an east-west gradient (Lake Clark to Katmai) have provided clues to the future distribution of white spruce. Tree-ring data have shown that trees killed by the recent beetle outbreak were often moisture stressed prior to death and those that survived were better able to access snowmelt water (Csank et al. 2016). Outside of those areas of beetle kill, trees at most sites have shown increased growth in response to warming (Sherriff et al. 2017). Warmer periods have also supported periods of higher seedling recruitment in recent decades (Miller et al. 2017; Figure 1).

Variation in the distribution of different age classes of spruce (seedlings, saplings, trees) across space suggest that forests may be expanding into cooler parts of the landscape. Seedling and sapling abundance are greatest at sites in Katmai, near the western end of the climate gradient (Figure 2), where summers are cooler and wetter than in interior Lake Clark. In contrast, mature spruce stands are most abundant to the east, in interior Lake Clark (Figure 2). This variation in tree vs. seedling abundance suggest that the conditions that were favorable to spruce establishment in the past now occur on a different part of the landscape, several 100 kilometers to the west (Miller et al. 2017).



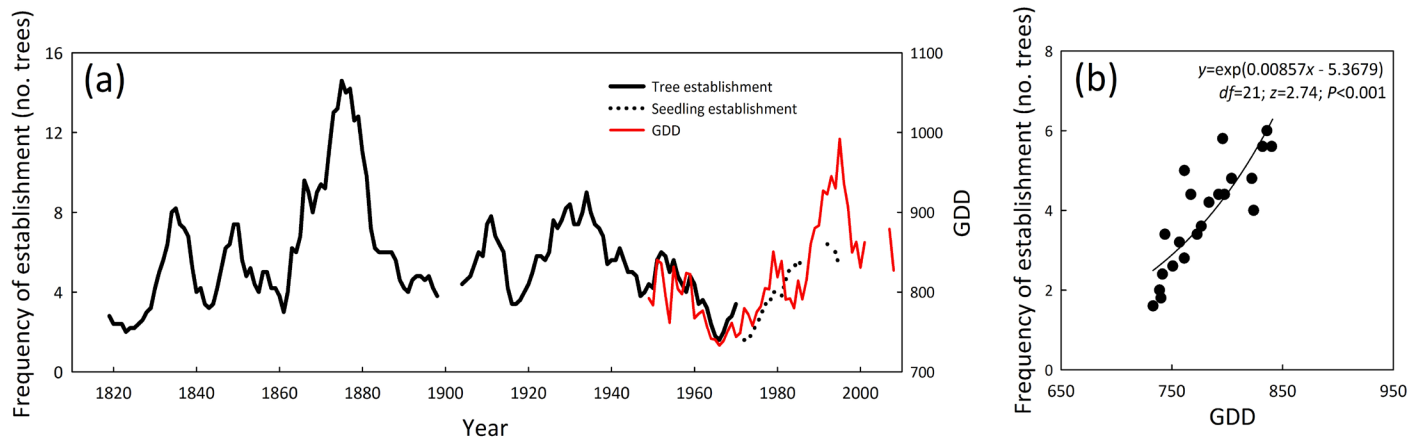


Figure 1. (a) Five-year running means for tree and seedling establishment by year and growing degree days (GDD; base 5°C; King Salmon, AK; 1946-1973) across Lake Clark and Katmai (n=30 sites; 1,284 cores). (b) Regression of five-year running means shows a positive relationship between establishment and GDD (1949-1970). From Miller et al. (2017).

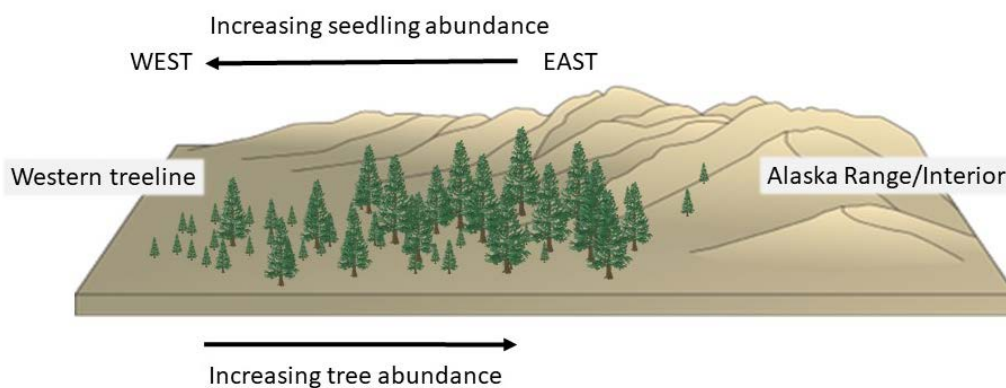


Figure 2. White spruce trees and seedlings show different distributions with longitude. Tree abundance is greatest to the east, but seedling abundance is greatest to the west, suggesting a moving front of spruce establishment near western treeline.

Methods

Forest monitoring characterizes stand structure and species composition through a suite of tree and understory measurements. Tree cores collected from white spruce have been used to characterize stand age structure, water status, and radial growth. Monitoring began in 2009 and is conducted at five-year intervals at each site.

References

- Csank, A. Z., A. E. Miller, R. L. Sherriff, E. E. Berg, and J. M. Welker. 2016. [Tree-ring isotopes reveal drought sensitivity in trees killed by spruce beetle outbreaks in southcentral Alaska](#). *Ecological Applications* 26:2001-2020.
- Miller, A. E., T. L. Wilson, R. L. Sherriff, and J. Walton. 2017. [Warming drives a front of white spruce establishment near western treeline, Alaska](#). *Global Change Biology* 23:5509-5522.
- Sherriff, R. L., A. E. Miller, K. Muth, M. Shriver, and R. Batzel. 2017. [Spruce growth responses to warming vary by ecoregion and ecosystem type near the forest-tundra boundary in southwest Alaska](#). *Journal of Biogeography* 44:1457-1468.