

Final Report: 2015 NADEF Introductory Group
Spruce Budworm Reconstruction Using 19th Century Salvaged Wood from Maine

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Introduction

In June 2015, the North American Dendroecological Fieldweek (NADEF) met for its 25th anniversary at Acadia National Parks, Schoodic Institute. Five Groups sought to address separate dendroecological questions using field and laboratory analysis. The Introductory Groups Primary Goals were to: (1) learn the fundamentals of dendrochronology, which included, the developing of their skills for site selection, data collection, analysis, and laboratory techniques (2) develop modern chronologies from the Blueberry Hill and Schoodic Point sites, and to (3) reconstruct spruce budworm outbreaks.

The state of Maine, located on the northeast coast of the U.S., is characterized as deciduous dominant in the south and coniferous dominant in the eastern coastal areas. Acadia National Park is located along Maine's east coast, which includes Mount Desert Island and some smaller islands. The park, established as the second National Park by President Theodore Roosevelt, comprises nearly 47,000 acres of land and represents the unique transition between the northern boreal and eastern deciduous ecosystems (Fraver *et al.*, 2007). These ecosystems are predominantly spruce and fir; typical of a boreal influence (Fraver *et al.*, 2007). Dominant coniferous species include red spruce (*Picea rubens*), white spruce (*P. glauca*), black spruce (*P. mariana*), and balsam fir (*Abies balsamea*). (Fraver *et al.*, 2007).

Timber harvesting has become an important economic resource for the state in the last century. Approximately 90% of Maine is forested land, and timber harvesting of softwoods and hardwoods in the area has been occurring for the last two centuries. In the last decade, changes in the global economy and its lingering uncertainties have had large impacts on the forest industry in the state (FMF Partners, 2015).

Maine Heritage Timber Company (MHT) is a business specializing in commercial wood products, such as, wood flooring and furniture made from submerged logs. These submerged logs are a residual byproduct of logging practices during the 19th century, in which the trees were cut into logs, placed in a body of water or river for ease of transport to the saw mills for processing (Michor 2003). Oxen and horses were the main transportation of timber through the forest. If the tree was a softwood, it would be placed on the river for transportation. If it was a hardwood, it would be taken by horse or oxen to the railways, or directly to the mills (Rogers 1962). The idea being, that hardwoods are more dense than softwoods, and therefore would sink during transportation on the river. At the turn of the century, trees were cut into four foot sections, to allow for vast amounts of wood to be floated down rivers for the pulp industry. Many of these logs became trapped along portions of rivers and tributaries, while log driving companies conjured up new ways of controlling (dams) the flow of rivers. Water temperature and its anaerobic condition at the bottom, naturally slows the oxidizing and decomposition of submerged logs. Owing to the prevailing environmental conditions, these logs have been wonderfully preserved, and

allowed for a wonderful opportunity for the group to use dendrochronological techniques to reconstruct spruce bud worm outbreaks of the past.

Spruce budworm (*Cloristoneura fumiferana*; SBW) is an insect endemic to North America. SBW larvae defoliate conifers, especially true firs and spruce species (Rauchfuss and Ziegler 2011). It causes dramatic growth reductions and widespread mortality due to preferential feeding on the current year's buds, as well as the developing foliage of mature conifers (Fraver et al 2007). A study conducted by Fraver et al 2007 reconstructed a long history of eastern SBW outbreaks in northern Maine. The major outbreaks in their study correspond to documented outbreaks in eastern Canada (1709, 1762, 1808, 1914, and 1976), however, there are three additional eastern Canadian outbreaks that did not occur in Maine (1830s, 1870, and 1940s) according to Fraver et al 2007. Based on this evidence, a mean outbreak return interval of 67 years was calculated, which is twice that of the documented interval return in eastern Canada. This difference could be due to multiple factors including differences in microclimates, species longevity, forest types and associated stand dynamics.

Most of the SBW outbreak studies were conducted in Canada and northern Maine, with no documented studies of SBW outbreaks in Acadia National Park. Acadia National Park consists mostly of SBW host species. Therefore, it is necessary to determine how often SBW outbreaks had occurred in the past in order to develop a plan for future forest management and insect control procedures.

Methods

Study Area

This study was conducted on the Schoodic Peninsula in Acadia National Park in Maine (Figure 1). Two coastal red spruce sites were selected based on estimated stand age and health: (1) Schoodic Point, SH and (2) Blueberry Hill, BH. At SH, [Lat-44.332812; Long-68.060946; Elevation: approx. 60ft. (18.3m)], the selected trees lined the shore's rocky face and bordered the ocean (Figure 2). Sampled red spruce had an average height of 39.9ft. (12m). At BH, [Lat-44.332812; Long-68.0609945], sample trees were located in mixed spruce/fir forest approximately 0.5 miles up Alder trail on the east side of Schoodic Peninsula. The average canopy height was 133ft. (41m).

Reclaimed logs for this study were provided by Maine Heritage Timber and were available for sampling on the company's property in Millinocket, ME (Figure 3). Each sample was visually evaluated for type of wood (hardwood or softwood), species, and potential age. This can be determined from the signature characteristics of slight decay, turn of the century logging signatures and transportation marks.

Field and Laboratory Procedures

Observations were made from within the stand to identify potentially, the older trees in the stand. Significance was based on DBH (diameter at breast height) on species, presumed age, and potential

records of SBW infestations. This was accomplished by visually noting characteristics such as multiple leaders, sweeps in the stems and stunted growth. A total of 33 red spruce trees were selected for sampling (9 from SH and 24 from BH). Two cores per tree were obtained using Haglof increment bores 5.15mm (Stokes and Smiley 1960). In all, 74 core samples were collected, placed in straws, labeled, and brought back to the lab for further analysis.

Cross-sections were collected from MHT, where hundreds of previously submerged logs were available. Cross-sections were obtained using a chain saw, then numbered, labeled, and packaged for transportation back to the lab for further study.

In the lab all cores and cross-sections were dried and prepared using standard dendrochronological techniques (Stokes and Smiley 1968). Samples were sanded with a belt sander using progressively finer grit sandpaper: 40 (428 μm), 120 (116 μm), 220 (66 μm), 320 (36 μm), and 400 (23.6 μm) (Orvis and Grissino-Mayer, 2003). Samples were further sanded by hand using 30, 15, and 9 μm paper to clarify latewood (LW) and earlywood (EW) ring boundaries prior to dating and crossdating.

Cores and cross-sections were checked using the skeleton plot method for the groups first attempt at dating the samples (Stokes and Smiley 1968). Skeleton plotting, as well as the list method, were used in an attempt for the students to become familiar with the wood [latewood thickness, marker years] (Speer 2010).

Raw ring widths (RW) measurements were created using a Velmex sliding-stage stereomicroscope, with Measure J2X software (0.001mm accuracy). The cores were measured starting from the first year of growth to the bark and the cross-sections - from the pith to the last complete ring. All measured data was saved in .raw format and then transferred to the .txt format. The files with ring width value was created for the living trees from BH, SH and undated MHT cross-sections. Those files were run with COFECHA, a quality control program, to check the dating accuracy of our samples (Holmes, 1983).

Results and Discussion

We were able to build a modern chronology from 11 cross-dated cores spanning 145 years from 1870-2014, with a series intercorrelation of 0.481 with samples from BH. To extend our modern chronology time series, we used Ed Cook's chronology from Ironbound Island (1982), obtained from the International Tree-Ring Data Bank (ITRDB). Our BH chronology cross-dated well with Cook's Ironbound (1982), confirming the accuracy of our preliminary visual dating as well.

Initially we used the BH samples and Ironbound (1982) samples to attempt dating of the undated cross-sections from MHT, obtained from Quakish Lake, but no definitive signals emerged from the COFECHA outputs. The samples partially cross-dated but with results not as positive as we had hoped,

therefore, we theorized this was due in part to the vast regional differences contributed to their geographic locations.

A *Picea rubens* chronology used in the (Fraver et al 2007) paper, was obtained from The University of Maine. The samples were collected from Maine's north central interior forest, and cross-dated against our submerged log measurements. Fraver's chronology was chosen based on presumed microclimatic similarities. Unlike coastal forest, interior forest regions have a different amount of precipitation, as well as other climate disturbances. The combined chronology included, 779 series spanning 353 years from 1649-2001, with mean intercorrelation of 0.521. The MHT crosssections were able to be dated primarily due to the state of the condition of the samples being so well preserved.

Conclusion

Overall, our group was able to successfully cross-date *Picea rubens* (Red Spruce) from the Blueberry Hill site with Cook's 1982 Ironbound Island Chronology. The Schoodic Point samples were not able to be measured or cross-dated because of the poor quality of the sample. From the samples that were properly cross-dated, Blueberry Hill, Ironbound Island, 2 samples of the submerged logs from MHT, and using Fraver et al 2007's, Red Spruce chronologies, we were able to determine the following SBW Outbreaks, which have been confirmed in Maine and Canada: 1708-1721, 1755-1760, 1765-1769, 1805-1814, 1834-1845, 1868-1892, 1949-1952, 1976-1986. Additionally, we were able to document a low growth rate in 1956-1959, which could be attributed to undocumented SBW outbreaks. Also, from 1678-1690 we found a suppression zone in the rings, evidence of a suspected SBW outbreak in Maine (Fraver et al 2007).

Our outbreaks chart was created based on the combined BH and MHT chronologies. The BH chronology was not a satisfactory number of years, extending only till 1870. Some of the outbreaks were registered in one chronology, but not present in the other. That could mean the coastal trees are more sensitive to SBW outbreaks or the suppression of the rings in these instances could have been due to environmental conditions.

In addition to the preliminary results of the NADEF fieldweek project, future analysis will include sampling more *Picea rubens* and non-host species from Schoodic Peninsula, and then analyzing the data to correlate against existing chronologies. By creating a good chronology for coastal red spruce species, we could look at the climate response of those trees and then compare it with inland red spruce. The cross-sections from MHT were significant for SBW reconstructions, but in order to further prove our findings and be able to report with high level accuracy, that the additional suppression zones we discovered (1678 to 1690) were fact SBW outbreaks, we would need to analyze responses (i.e. PDSI,

precipitation, etc.) from our species versus those of other non-host species to rule out climatic responses aren't false being recorded as SBW outbreaks.

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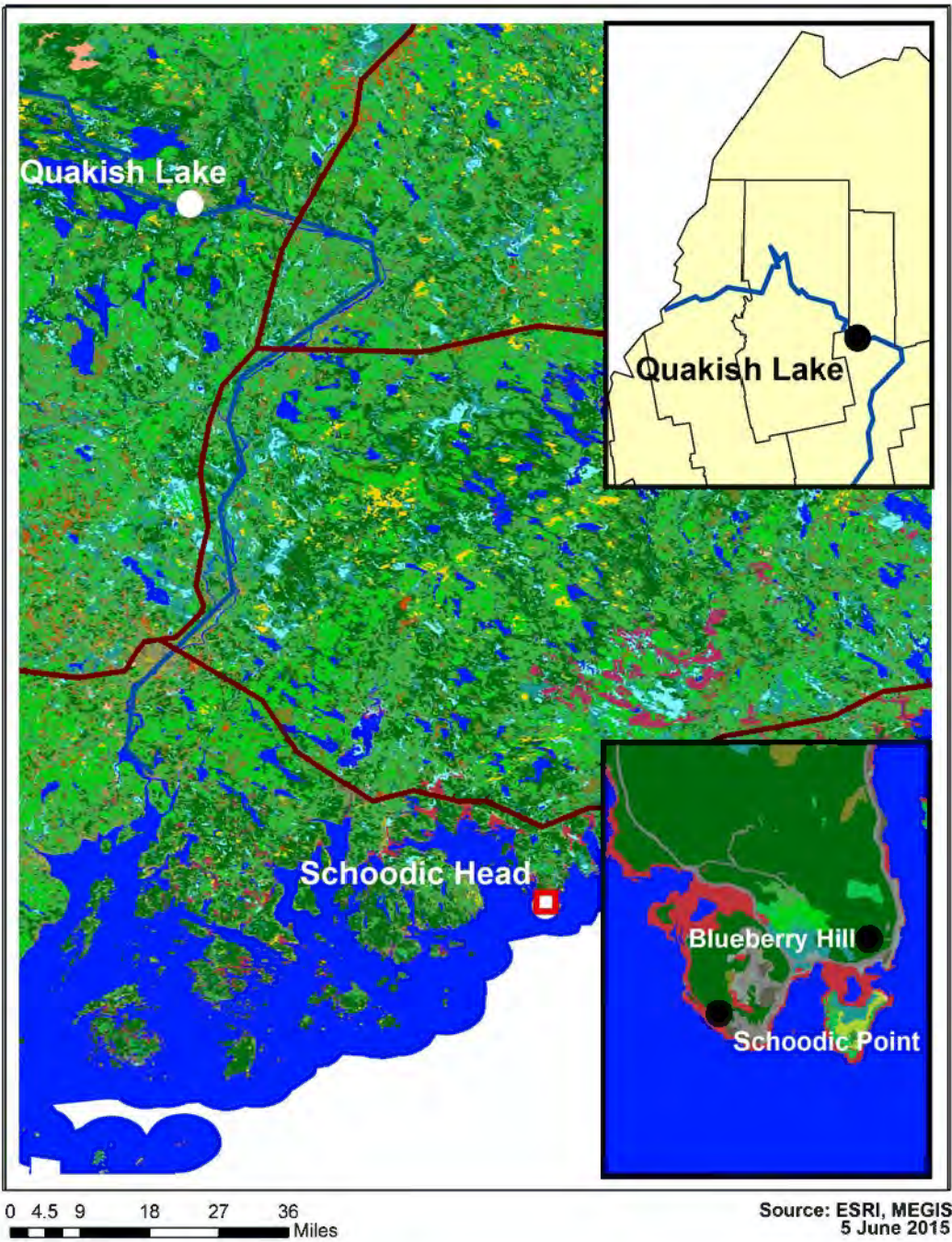


Figure 1: Field map



Figure 2: Research team



Figure 3: Jim Speer cutting samples at the Maine Heritage Timber Company