Dendrochronologic Confirmation of Old Growth Hemlock Age from the Panuke Lake Area, Nova Scotia

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Introduction

The Maritimes oldest living tree has been known to grow in Fundy National Park and is a red spruce close to 500 years old. Several hemlock trees have been sampled in Cape Breton that are in the 450 year old range. Although old growth forests have become rare in the Canadian Maritimes, a few exceptionally old trees have managed to escape several centuries of frequent forest disturbances.

During the summer of 2021 Nova Scotia Department of Natural Resources and Renewables staff collected increment core samples from trees in the Panuke Lake area. One of these trees stood out as one of the exceptionally old, rare trees. The tree-rings were exceedingly tight and narrow at several locations along the tree-core, and preliminary counts indicated the tree was about 500 years old. Only thorough measuring and cross-dating could the count be confirmed.

Objective

The hemlock tree in question was found to be up to five centuries old on preliminary investigation. The objective in this conformational study was to resolve areas of narrow tree-rings and accurately count the age of the tree (Figures 3 and 4). In addition, the tree-rings were to be measured to produce a tree-ring curve demonstrating the productivity of the hemlock tree during its long life. This measured time series allowed cross-dating to be completed using a nearby hemlock chronology with considerable length back to the late 1500's.

Research question

What is the age of tree-rings present on the increment core sample and what is the estimate of missing tree-rings that were not captured by the sampling process? How old is the tree?

Methods

Field Sampling

Panuke Lake

Increment cores were collected by Nova Scotia Department of Natural Resources and Renewables staff from trees in the Panuke Lake area in the summer of 2021. One hemlock in particular was of interest and it was 51.1 cm DBH and 18m in height (see cover photo), with extremely tight tree-rings. The tree was approximately 30% percentile of basal area (e.g. a few larger diameter trees, but in top 1/3).

The stand details follow:

Forest Ecosystem Classification – Vegetation type – "SH3" (Neily et. Al. 2011) [Forest Vegetation types - SH3 | novascotia.ca]
Stand composition – Hemlock-Red Spruce

Moose Brook

In 1982, increment cores from a stand of hemlock trees were collected by Edward Cook between East Moose Lake and West Moose Lake, about eight kilometres east of Panuke Lake. These samples have been named "Moose Brook" (Figure 1).

Figure 1. Location of the sample site of the Moose Brook hemlock tree-ring chronology collected by Edward Cook in 1982. Panuke Lake appears to the left or west side of the map, while Five Mile Lake appears north and slightly east of Moose Brook sample site.

Lab Preparation

The NS Lands and Forestry increment cores were glued onto slotted mounting boards. Although the increment cores had previously been surfaced, the board was re-sanded at the Acadian Forest Dendrochronology Lab using 120 grit sanding belts, up to 400 grit. Then the sample was hand sanded using 600 grit and 1500 grit. This allowed the cellular structure of the hemlock wood to be made clearly visible.

The samples from Moose Brook were prepared using standard dendrochronological techniques by Edward Cook's team, cross-dated and uploaded to the International Tree-Ring Data Base.

Measuring and Cross-dating

From pith to bark, the increment core sample was measured on a Velmex stage measuring system under an Omano boom microscope with measurements made by a VRO positioning system (Fig. 2) and recorded by Tellarvo software (Brewer, 2013). The resulting decadal format data set, with micron level accuracy, were assembled and statistically evaluated with COFECHA software (Holmes, 1986a, Grissino-Mayer, 2001). COFECHA uses Pearson's product moment correlation values to assist in accurately dating samples. All individual tree-ring series in the set are broken down into 50 year segments, overlapped by 25 years, to create a correlation matrix, aiding in the cross-dating procedure. The statistical evaluation along with visual investigation under the microscope, were combined to cross-date the sample and ensure measurement errors, false-rings, missing-rings or anomalous radial growth did not confound the temporal organization of measurements in the tree-ring series (Speer, 2010). This included the careful pattern-matching of wood fragments mounted backwards.

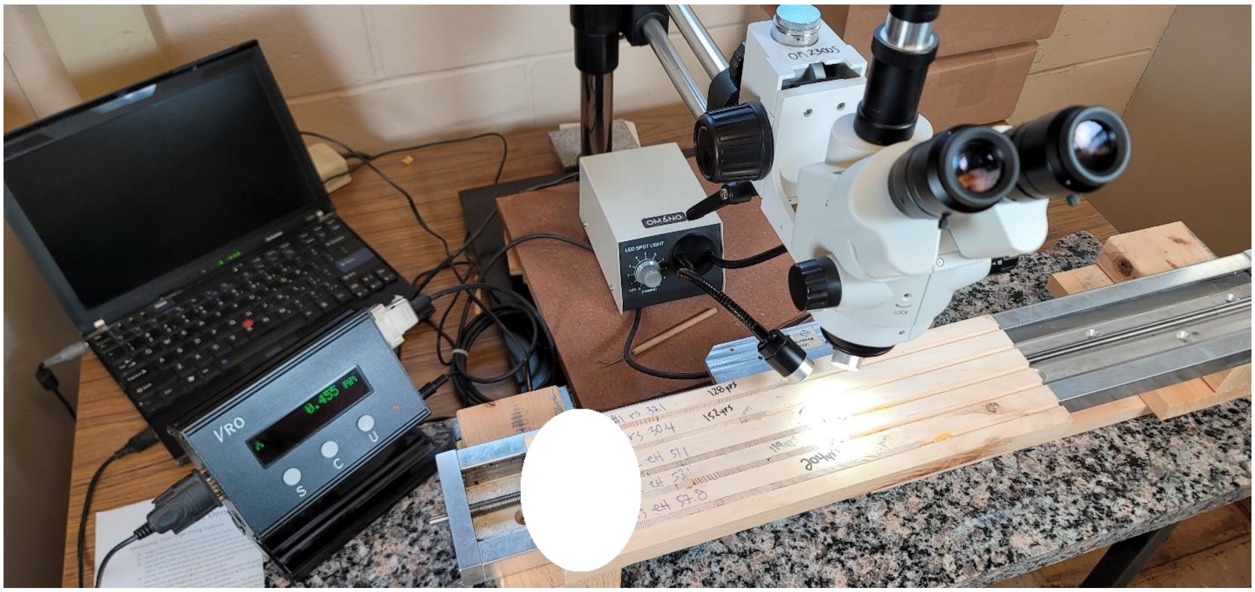

Figure 2. Velmex stage measuring system with the Panuke Lake sample. Photo cr: Ben Phillips

Figure 3. Tight tree-ring section of the Panuke Lake increment core sample prepared for measuring. Photo cr: Ben Phillips.

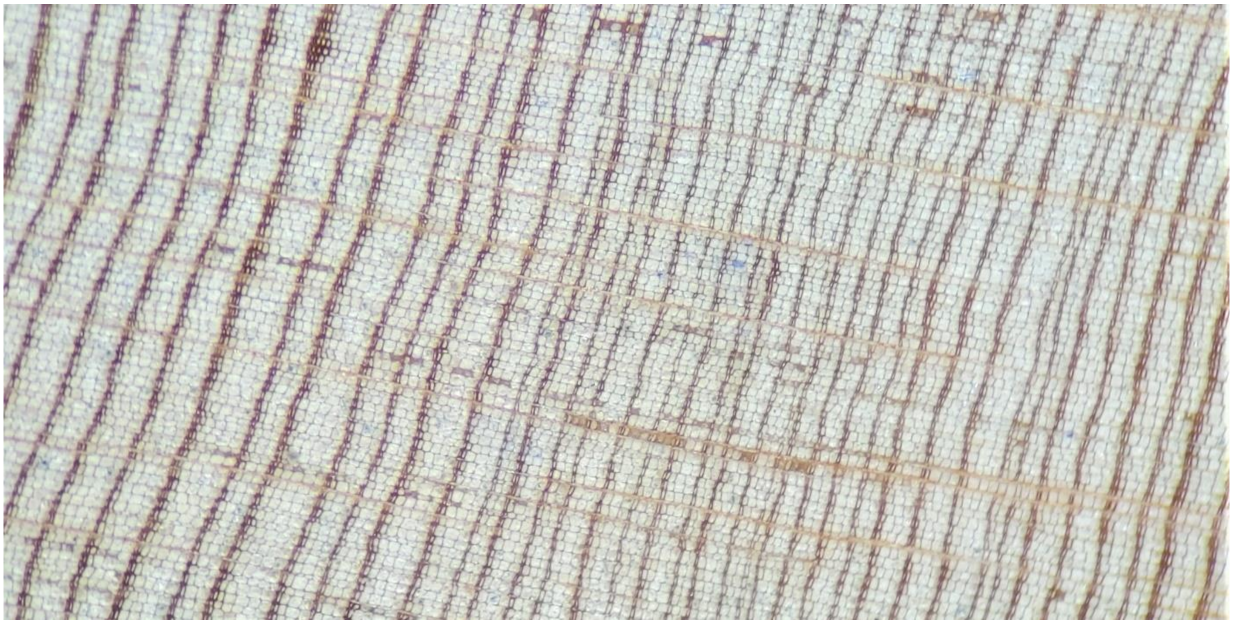

Figure 4. *Tight tree-ring section of the Panuke Lake increment core sample under the light microscope at 150X magnification. Note that some rings are only three cells in width.   Photo cr: Ben Phillips.*

Results

Panuke Lake Hemlock

The Panuke Lake hemlock sample spanned a time period from 1490 to 2021, covering 532 years from the tree-rings nearest the pith to the last tree-ring next to the bark (Table 1). Average radial growth for the hemlock was 0.381 mm per year, but fluctuated over time with a standard deviation of 0.328 mm and a maximum tree-ring size of 2.18 mm. After cross-dating, the sample produced an interseries correlation coefficient with the Moose Brook hemlock chronology of 0.452 ($p<0.001$), demonstrating a commonly shared radial growth signal (Table 1).

Table 1. Tree-ring chronology data is displayed in this table for the raw radial growth data of the Panuke Lake sample.

	Time Span	Sample #	Series Length (years)	Avg measurement (mm)	Standard Deviation (mm)	Interseries correlation coefficient
Hemlock	1490-2021	1	532	0.381	0.328	0.452

Raw Radial Growth Curve

The raw average radial growth curve for the Panuke Lake hemlock is illustrated in Figure 5. Between 1490 and 1640 the radial growth rate remained low, then a radial growth release occurred in the 1640's. Disturbance of nearby trees likely allowed much more light through the forest canopy at this time. From the 1640's release through to the early 1800's, the tree grew at a faster average growth rate of 0.7 mm per year, which is still much slower than the average annual radial growth rate of one millimeter calculated from over 200 other old growth hemlock trees sampled around southwest Nova Scotia (Phillips and Smith, 2021). Since 1850 the tree has grown at a slow average rate of 0.19 mm per year.

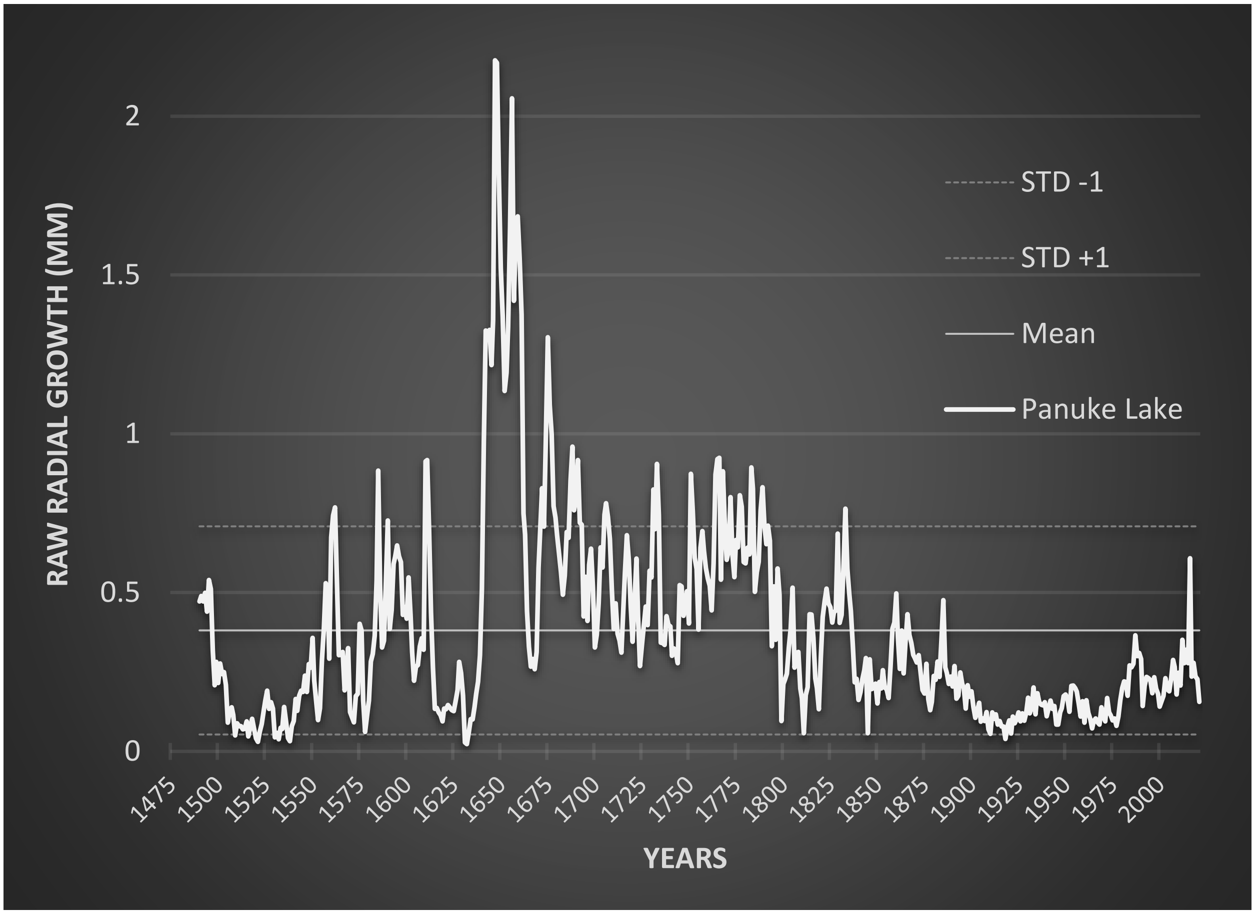

Figure 5. The Panuke Lake hemlock raw tree-ring curve is seen in a thicker white line. Annual data is measured in millimeters. The mean radial growth is displayed by the thin white line, while plus and minus one standard deviation lines are plotted in faint dashed grey lines.

Moose Brook Chronology

When compared visually to the Moose Brook chronology, the Panuke Lake hemlock pattern-matches well (Figure 6). Many of the annual peaks and valleys in the radial growth curves climb and fall together, demonstrating the 0.452 correlation value. The radial growth release in the Panuke Lake hemlock occurs during the 1640's, while the Moose Brook chronology release occurs in the early 1800's. Beyond those two major disparities, it is apparent these two tree-ring curves have been controlled by similar environmental conditions.

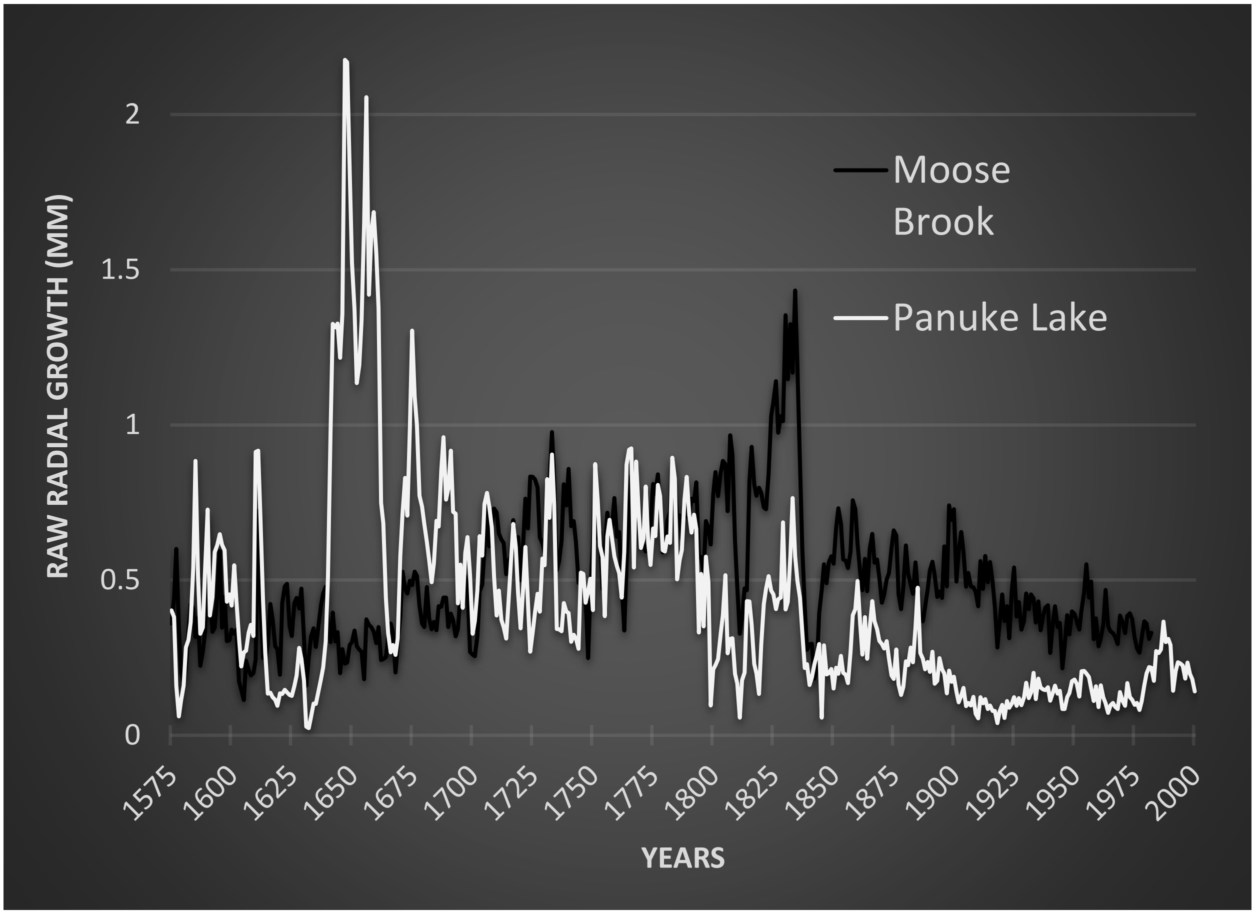

Figure 6. The Panuke Lake hemlock raw radial growth tree-ring series (white), along with the Moose Brook tree-ring chronology sampled in 1982 by Edward Cook (black). The Moose Brook tree-ring chronology demonstrates a 0.452 ($p<0.001$) correlation with the Panuke Lake sample. Moose Brook illustrates a minor radial growth release in the early 1800's. Note the Panuke Lake tree-ring series has been truncated in this figure at the years 1575 and 2000 to better match the shorter Moose Brook chronology.

Discussion

Comparison with the Moose Brook tree-ring chronology has confirmed no missing tree-rings are present from 1575 to the present in the Panuke Lake tree-ring curve. The fine surfacing process along with the Velmex measuring system identified an additional 30 tree-rings beyond initial ring counts. The total number of tree-rings present in the series amounted to a surprising 532 years. After examining the tree-rings present nearest the pith (Figure 5), a 0.5 mm radial growth rate is observable. An immature tree with such a low growth rate could take 15 to 20 years to reach 1.3 meters in height, or standard breast height, where the increment core was extracted on the tree. This indicates the Panuke Lake hemlock is likely ~550 years old. Both in measured tree-rings and total estimated age, this tree is the oldest living tree in the Canadian Maritimes known to science.

It is likely due to this tree's very low productivity level that it has been able to survive to this age. Old growth hemlock trees often have rot columns near their pith when the younger tree was growing at a faster rate. This tree demonstrates very slow early growth and did not experience a radial growth release until it was about 150 years old.

Conclusion

This report recognizes the Panuke Lake hemlock as the oldest living tree in the Canadian Maritimes known to science. At 532 measured years old, this tree likely established itself about 20 years earlier in the 1470's. It's slow radial growth rate ensured it did not grow too large too fast and enabled it to survive many disturbance events until it was found in 2021. At the very least this tree demonstrates the need to protect remaining old growth forests along with the carbon they store and the biodiversity they harbour.

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