Dating a Historic Cabin on Eva Lake, Mount Revelstoke National Park: An application of Dendrochronology

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Abstract

Dendrochronology was applied to date a historic cabin at Eva Lake in Mount Revelstoke National Park, British Columbia. The cabin is significant due to its close association with the formation of the national park, along with its historical use as a warden patrol cabin. The researcher's goals were to (1) determine the year of cabin construction using dendrochronological methods, (2) determine probable species used for construction and (3) to test the effectiveness of dendrochronology in dating wooden structures. The lowest year inscribed on a cabin log was 1932, but the reported year of construction is 1928. Ten tree-cores were collected from Engelmann spruce (*Picea engelmannii*) and Subalpine fir (*Abies lasiocarpa*) to build living tree-ring chronologies for the area. Ten samples were taken from the cabin to build a floating chronology, which was cross-dated with the living chronologies. Statistical analysis in COFECHA displayed a higher series correlation value for the living spruce chronology in comparison to the living fir chronology. Cross-dating the living spruce chronology with the floating cabin chronology resulted in a high-quality master chronology with a series intercorrelation value of 0.541 and a mean sensitivity of 0.200. The spruce/cabin chronology provided the valuable end dates ranging from 1926-1928. The latter date indicates logs were harvested in early spring or summer of 1928 with construction of Eva Lake cabin occurring soon after. The result indicates that dendrochronology is an accurate method to date historic structures.

Introduction

Dendrochronology is a versatile dating technique used in the social and physical sciences. The principle behind dendrochronology is to measure the width between tree-rings from core samples (Stokes & Smiley 1968). Different trees exhibit different patterns in ring widths based on external factors such as climatatic fluctuations (Splechtna *et al*. 2000). Dendrochronology is increasingly used to date historic wooden structures. The method is applied in many areas of the southeastern United States, where European settlers built cabins and houses out of timber (Bortolot *et al*. 2001; Wight & Grissino-Mayer 2004; Lewis *et al*. 2009). The year of construction of a cabin can be obtained by comparing tree-ring samples from the cabin with samples from the surrounding trees. Cross-dating ensures that samples from historic structures receive an appropriate year, and thus assumptions about the date of construction can be made (Wight & Grissino-Mayer 2004). The principle behind cross-dating is that trees from the same area tend to develop the same patterns of ring widths over a given period of time (Douglass 1941). Tree core samples, together with COFECHA, will indicate the most probable species used for construction. This is of importance where cabins have been heavily weathered or if the bark has been stripped. COFECHA was developed by Richard L. Holmes of the University of Arizona in 1982, and assesses the quality of cross-dating in tree-ring series (Grissino-Mayer 2001). COFECHA is used as a tool by dendrochronologists to assist in deciding to include or reject a portion of a series for a site chronology (Grissino-Mayer 2001). In this study, COFECHA is applied to assist in finding the construction date and in the discovery of the primary tree species used.

Previous work on Eva Lake cabin produced a conservation report indicating the cabin's historic value. This assessment provides insight into the condition and style of the cabin, including the year of construction. However, it fails to state the method used to date the cabin, and it is assumed the date was most likely obtained from Parks Canada's records. One objective of this study is to determine the effectiveness of using dendrochronology for dating wooden structures. Lewis *et al*. (2009) has found that occasionally dates of buildings are erroneous, and dendrochronology can be used to serve as an accurate historical dating method. The verification of the Eva Lake cabin construction year is made possible using dendrochronological techniques, along with referencing the living tree-ring chronology (Grissino-Mayer & van de Gevel 2007). Interest in the Eva Lake cabin, due to its historical and cultural significance, serves as an ideal site to apply and verify dendrochronological methods.

Eva Lake is situated within Mount Revelstoke National Park and was first discovered by Eva Hobbs who was a resident of Revelstoke. Ms. Hobbs was a schoolteacher at Central School where she was influenced by the principal, Mr. Miller, who was an avid member of the Revelstoke Mountaineering Club (Burchinshaw 1986). Eva subsequently joined the mountaineering club and took part in many excursions on Mt. Revelstoke (Burchinshaw 1986). In 1910, members of the club hiked to Miller Lake (named after Mr. Miller) and decided to explore further (Burchinshaw 1986). Eva was ahead of the group and the first person to see the lake, which resulted in her colleagues naming it after her (Burchinshaw 1986).

Upon the urging of Revelstoke citizens for their own national park, a 260 square kilometer area was founded in 1914 (McLeave 2008). This led to the construction of several cabins and lodges for visitors. At Balsam Lake, a cabin was built in 1919 for a local fire warden, and a tourist lodge was opened in the park in 1940 (Knapik & Coen 1974). The tourist lodge was made easily accessible with the construction of the Meadows-in-the-Sky Parkway in 1927. Unfortunately, Eva Lake cabin is the only structure in existence today, which may be attributed to its remote location within the park. The site is only accessible via a hiking trail, and thus the creation of a living chronology for the area was conducted in close proximity to the cabin.

Study Site

The study site is located in the Interior wet belt zone of British Columbia, a unique interior rainforest 500 kilometers inland from the Coast Mountains (Loukas *et al*. 2002). Mount Revelstoke National Park lies just above the town of Revelstoke, and is part of the Columbia Mountain system (Figure 1). The national park protects 260 square kilometers of the Selkirk Mountains and includes the study site at Eva Lake; at roughly 1950 metres asl (above sea level) it is almost at tree line (McLeave 2008). The Meadows-in-the-Sky Parkway takes visitors to the summit of Mount Revelstoke and from there it is about a six kilometer hike into the study site. The Eva Lake cabin (51^{o}04’27”N 118^{o}06’33’’E) is situated in close proximity to Eva Lake and was historically used as a warden patrol cabin (PWGSC, Heritage Conservation 2007).

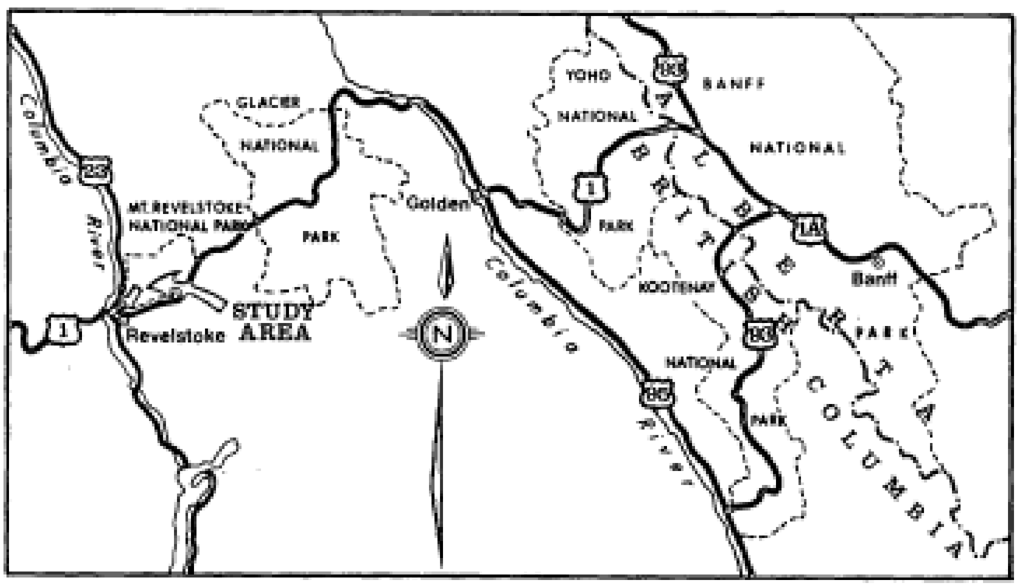

Figure 1. Location of Study Area (Knapik & Coen 1974).

The site is part of the Engelmann Spruce-Subalpine Fir biogeoclimatic subzone, where Engelmann spruce (*Picea engelmannii*) and Subalpine fir (*Abies lasiocarpa*) are the dominant tree species (Achuff *et al*. 1984). The site is part of the Upper Subalpine zone, which is between 1900-2200 meters asl, and receives 1995 millimeters of mean annual precipitation (McLeave 2008). Lengthy winters with high snowfall and short summers characterize the region. In Revelstoke, average temperatures range from 18.2° Celsius in July to and -5.3° Celsius in December (Parks Canada 2010). Due to the high elevation of Eva Lake compared to Revelstoke, winter temperatures are probably lower than indicated in Revelstoke.

The region around the study site is geomorphologically diverse. A variety of granitic and metamorphic rocks fill the landscape, with the underlying bedrock belonging to the Clachnacudainn Salient structure of the Shuswap Metamorphic Complex (Knapik & Coen 1974). A receding glacier, characterized by sculpting and excavating, formed the cirque lake presently named Eva Lake. This formation resulted in a small knoll where the cabin was constructed (PWGSC, Heritage Conservation 2007). The terrain plummets on the northeast side of the lake and rises to the southeast and northwest. The study site is fairly accessible by foot, however, the trail is narrow and thus construction material most likely came from the area surrounding the cabin.

Cabin

Eva Lake cabin measures 3.4 meters by 4.3 meters and is one of the oldest remaining structures in the park (PWGSC, Heritage Conservation 2007). Despite its relatively small size, it was originally built to house a park warden, and today, campers and day hikers use it as a shelter. The cabin is designated as a recognized federal heritage building due to its close origin with the formation of the national park. The National Parks Service employed a standard design (which was native to western Canada) in all of its warden cabins, and Eva Lake cabin is a good example of this style (Figure 2) (PWGSC, Heritage Conservation 2007). Composed of only a single room, log purlin roof, porch extension, and horizontal log walls, the structure radiates rusticity (Figure 3) (PWGSC, Heritage Conservation 2007). Yet it displays high craftsmanship with hewn dove-tailed corners and interior log surfaces (PWGSC, Heritage Conservation 2007). Hewing is the process of chiseling down, with an axe or drawknife, the rounded ends of logs so they can be 'stacked' easily when meeting at a 45 degree angle in the formation of a corner. There are two windows, one on the north facing side and one on the west. Only the north facing window is original. The door of the cabin is a ledged plank door in relatively good condition, most likely due to its sturdiness. The roof is supported by purlin logs (or beams) spanning north to south with the support of a midspan cross log (PWGSC, Heritage Conservation 2007). Sheathing boards are located below the weathered roof shingles.

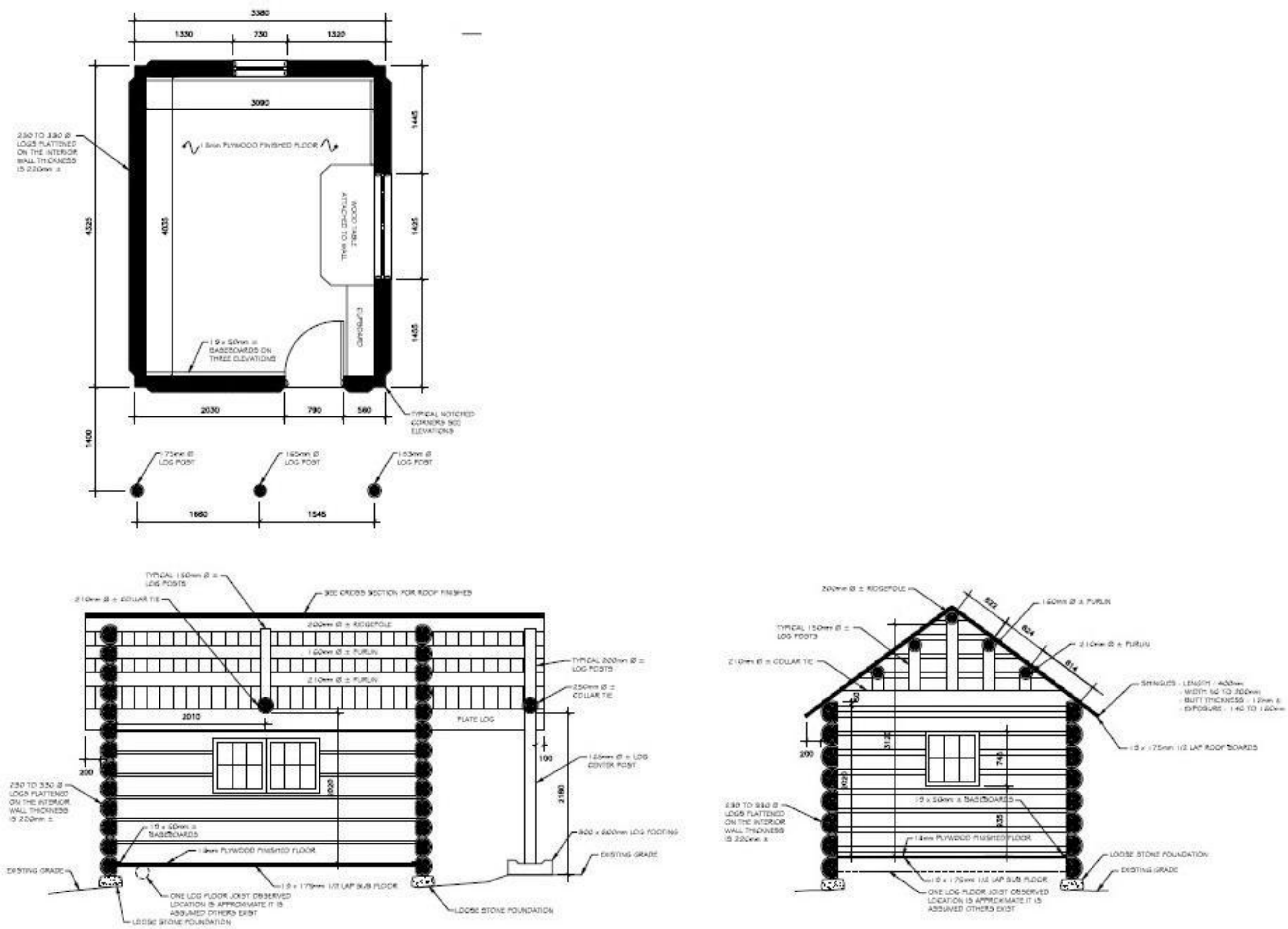

Figure 2. Eva Lake cabin floor plan (PWGSC, Heritage Conservation 2007).

Figure 3. Exterior of Eva Lake cabin, clockwise from top right: East, South, West, and North sides (PWGSC, Heritage Conservation 2007).

Eva Lake cabin has weathered throughout the years and is in need of preservation. The wall logs are clearly weathered and display checking due to the cabin's harsh alpine climate (PWGSC, Heritage Conservation 2007). Presently, the log's cores are sound, but if they are left to deteriorate they will rot (PWGSC, Heritage Conservation 2007). All of the wall logs are all original except for the sill logs, which are less weathered and contain bark (PWGSC, Heritage Conservation 2007). Evidence of replacement can be seen at cabin's corners where the sill logs are not tied into the notching (PWGSC, Heritage Conservation 2007). The accuracy of dendrochonological dating is increased when core samples contain bark. Unfortunately, because the sill logs are replacements, they could not be incorporated into the floating chronology.

Methods

Field Methods

Samples were gathered on September 14 and 15, 2010 by a four-person research team. To start, the researchers needed to determine the target tree species, and age, for the living chronology. Eva Lake cabin was examined to determine the approximate year it was built, and the age of the trees used for construction. Graffiti etched into the cabin by visitors provided a rough estimate of construction date. The oldest date found was August 3, 1932. Manually counting tree rings on the exposed corners determined the approximate age of the trees used for construction. Two logs were counted and the average tree age was estimated at 150 years. Therefore, the researchers estimated that the age of the trees needed for the living chronology was approximately 230 years old (2010-1932= 78 years, 78+150= 228 years). Next, the species of trees used to build the cabin needed to be determined. This was accomplished by identifying the tree species surrounding the cabin. The two dominant species were Engelmann spruce and Subalpine fir. Given the remote location of the cabin, the researchers inferred that the cabin was built using local trees. It was unclear whether the wall logs were spruce or fir; therefore a living chronology was gathered for both species.

Ten spruce trees and ten fir trees were used to produce the living chronologies. Sample size was determined by the amount of field time, which was limited to roughly four hours. Trees were chosen based on their proximity to the cabin and their estimated age. Age of trees was estimated by stem circumference and by other visual cues such as bark. For example, bark on the fir trees tended to appear scalier with age. Fortunately, there were several old trees in close proximity to the cabin. GPS coordinates and elevation were not recorded for each tree sampled, because all the trees were close to the cabin and had the same aspect. Thus, changes in location or elevation are negligible. Core samples were extracted at breast height, perpendicular to the stem, using a five millimeter increment borer. Due to limited field time only one sample was extracted from each tree.

Ten cabin samples were used to produce the floating cabin chronology. Sample size was limited by the amount of field time and by the need for discretion. Due to the cabin's heritage status the samples were taken from discrete locations. Unfortunately, no samples were extracted from the front of the cabin due to its high visibility. Using a five millimeter increment borer, samples were extracted from various locations on the remaining three sides of the cabin (Figure 4).

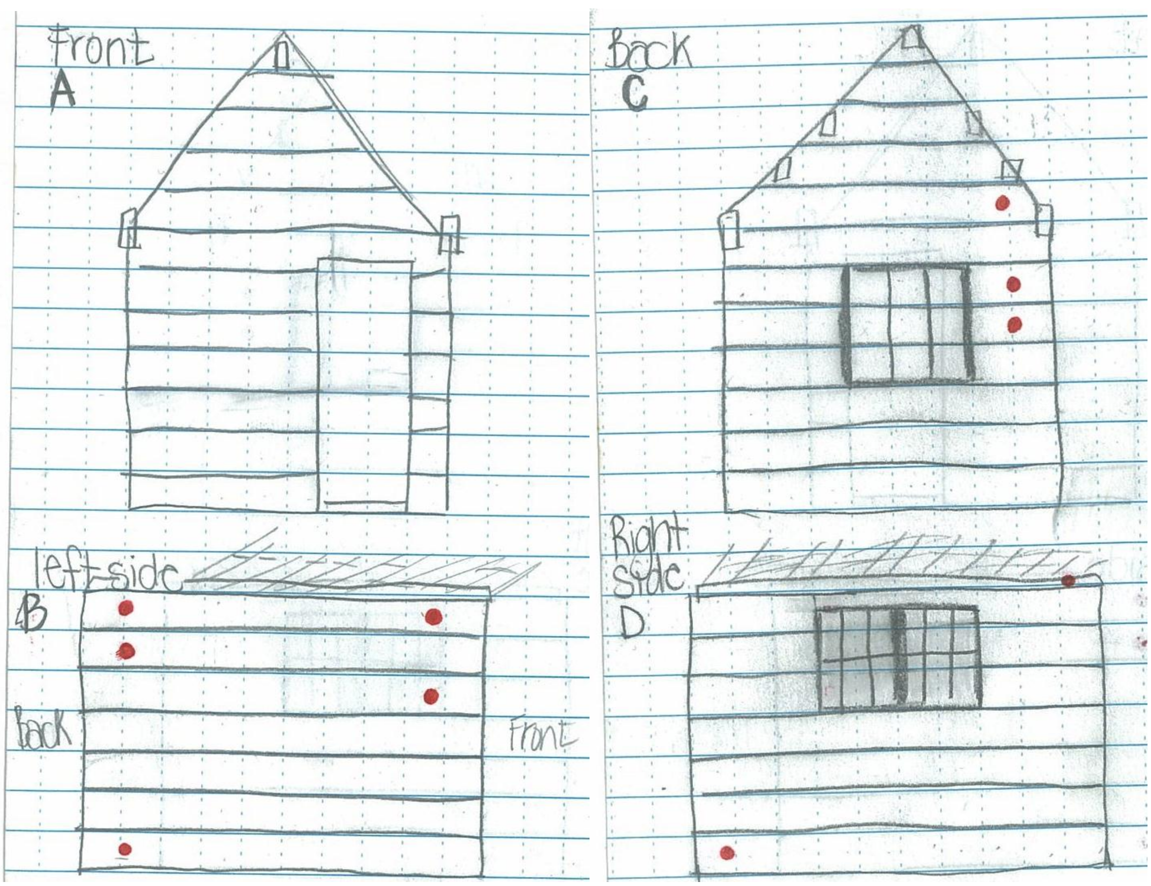

Figure 4. Field sketches of Eva Lake cabin. Red dots show approximate location of the extraction of core samples.

Lab Methods

Once the samples air-dried, they were mounted and glued onto slotted mounting boards. Next, the samples were sanded to a 600-grit polish to render the rings visible (Stokes & Smiley 1964). The samples were individually scanned using a high-resolution flat bed scanner and imported into WinDENDRO (Version 6.1D 1998). WinDENDRO measures the ring widths of each sample to the nearest 0.01 mm (Guay *et al*. 1992). Rings that were too narrow using WinDENDRO were further examined under a microscope. This was used to identify earlywood on one of the cabin samples. The International Tree Ring Database (ITRDB) software program COFECHA, was then used to determine the series intercorrelations (Pearson's r-values). Engelmann spruce and Subalpine fir were processed into two separate living chronologies. The samples were cross-dated at 50 year segments, lagged by 25 year periods, with a minimum Pearson's r-value of 0.3281 (NOAA 2008). COFECHA flags a sample as "A" if the correlation is lower than 0.3281, therefore; a correlation is considered significant if it is higher than this value (NOAA 2008). To fix the errors flagged by COFECHA, and to subsequently increase the series intercorrelation, the chronologies were adjusted using the software program EDRM (Edit Ring Measurment). EDRM was used to shift the rings of the samples so that they were consistent with the years of the rest of the series (Wight & Grissino-Mayer 2004). If the adjustments were too complex for EDRM, then the samples were manually re-analyzed using WinDENDRO. Once both living chronologies were corrected, and had acceptable series intercorrelations, cabin samples were added to each chronology. The individual cabin samples were separately adjusted to provide a higher correlation with the living chronologies. The living/cabin chronology with the highest series intercorrelation was used to determine the construction date.

Results

The cabin was built in 1928. Eva Lake cabin was primarily built with Engelmann spruce. The fir chronology has a series intercorrelation (Pearson's r-value) of 0.537 and a mean sensitivity of 0.184. The fir/cabin chronology has a Pearson's r-value of 0.506 and a mean sensitivity of 0.187. The spruce chronology has a Pearson's r-value of 0.616 and a mean sensitivity of 0.203. The spruce/cabin chronology has a Pearson's r-value of 0.557 and a mean sensitivity of 0.200.

Table 1. Spruce descriptive statistics and results from the segment testing conducted by COFECHA.

Series	Begin Year	End Year	Years	No. of flags	Correlation Value w/ Master	Mean Sensitivity
10EVA04C	1835	1908	74	0	0.478	0.165
10EVA11C	1726	1866	141	2	0.323	0.194
10EVA05C	1747	1879	133	0	0.476	0.239
10EVA09C	1851	1926	76	2	0.221	0.19
10EVA06C	1830	1927	98	2	0.407	0.183
10EVA07C	1810	1926	117	1	0.417	0.194
10EVA03C	1769	1927	159	3	0.337	0.169
10EVA03i	1783	2010	228	2	0.537	0.249
10EVA4i	1757	2010	254	1	0.608	0.243
10EVA02	1837	2010	174	0	0.766	0.21
10EVA22	1708	2010	303	1	0.517	0.167
10EVA21	1920	2010	91	0	0.598	0.187
10EVA14	1791	2010	220	2	0.444	0.144
10EVA09A	1838	2010	173	0	0.681	0.205
10EVA09B	1770	2010	241	3	0.503	0.214
10EVA17	1743	2010	268	0	0.671	0.194
10EVA21	1920	2010	91	0	0.598	0.187
10EVA15A	1863	2010	143	0	0.708	0.212
10EVA15B	1836	2010	175	1	0.585	0.218
10EVA18	1741	2010	270	0	0.649	0.199
10EVA02	1837	2010	174	0	0.766	0.21
total or mean:			3529 or 172	20	0.541	0.200

Table 2. Fir descriptive statistics and results from the segment testing conducted by COFECHA.

Series	Begin Year	End Year	Years	No. of flags	Correlation Value w/ Master	Mean Sensitivity
10EVA04C	1835	1908	74	0	0.564	0.165
10EVA11C	1726	1866	141	2	0.277	0.194
10EVA05C	1747	1879	133	2	0.353	0.239
10EVA09C	1851	1926	76	2	0.298	0.19
10EVA06C	1830	1927	98	0	0.543	0.183
10EVA07C	1810	1926	117	1	0.404	0.194
10EVA03C	1769	1927	159	0	0.469	0.169
10EVA20	1821	2010	190	1	0.52	0.185
10EVA05	1834	2010	177	0	0.547	0.191
10EVA06	1867	2010	144	0	0.705	0.209
10EVA07	1867	2010	143	0	0.736	0.199
10EVA08	1860	2010	151	1	0.506	0.196
10EVA10	1813	2010	197	2	0.435	0.179
10EVA11	1822	2010	189	0	0.539	0.174
10EVA13	1783	2010	228	2	0.43	0.182
10EVA01	1862	2010	149	0	0.593	0.184
10EVA16	1796	2010	215	0	0.571	0.158
total or mean:			2581 or 152	13	0.499	0.188

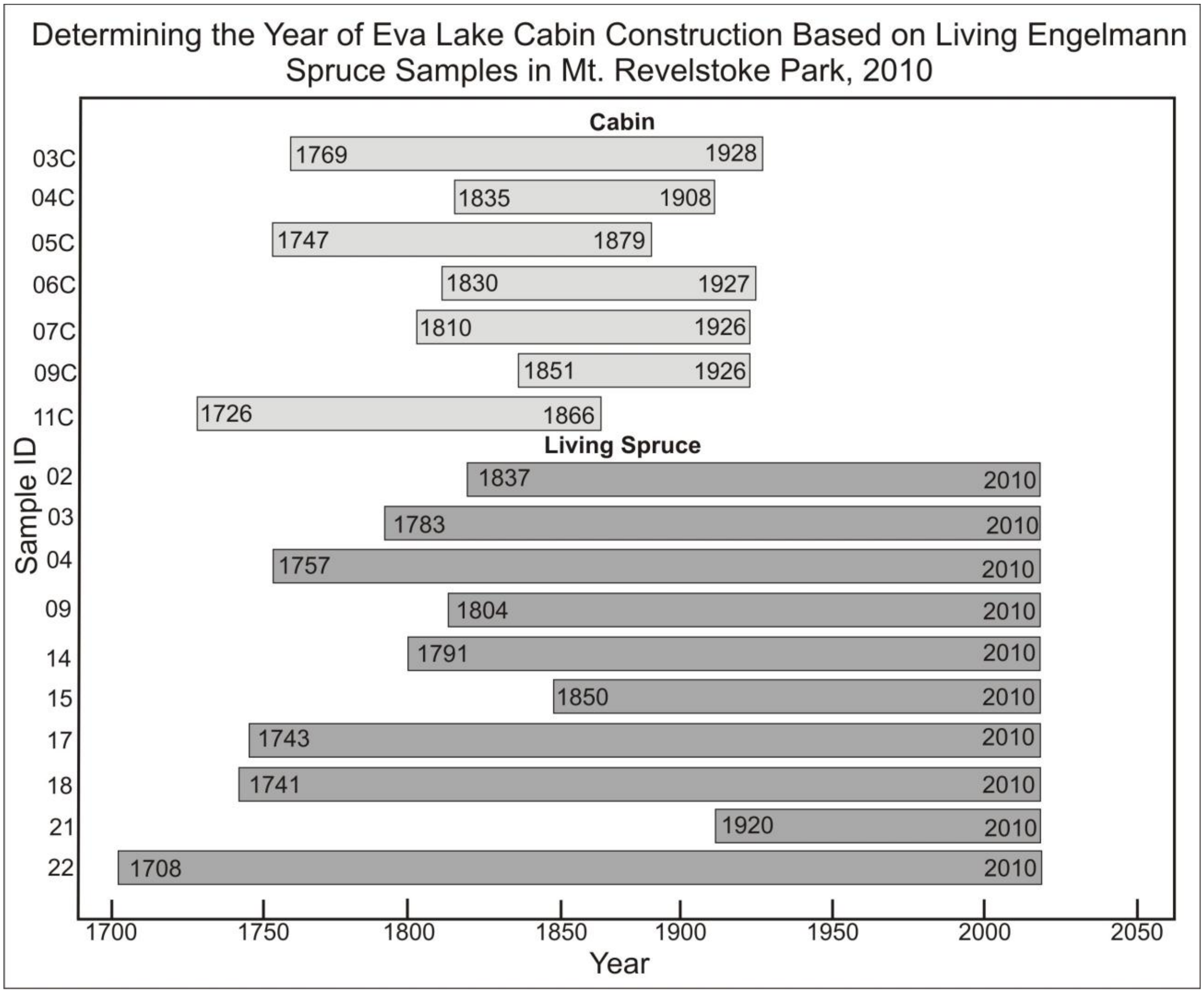

Figure 5. Representation of spruce/cabin master chronology.

Discussion

Pearson's r-value was used to determine the degree of statistical significance of the living chronologies. Series correlation measures the chronology's reliability, but varies by species and region. For example, a series correlation of 0.600 is high for an Engelmann spruce chronology in Canada, but low for a pinyon pine (family Pinaceae) chronology in Arizona (NOAA 2008). Common series correlation values are between 0.550 and 0.750 for most chronologies (NOAA 2008). The Engelmann spruce and the Subalpine fir living chronologies had significant series correlations, and the floating cabin chronology had significant series intercorrelation values with both living chronologies. The highest series correlations occurred in the living spruce chronology and the spruce/cabin chronology, whereas the lowest correlations occurred in the living fir and fir/cabin chronology. Different factors can decrease series intercorrelations. For example, series intercorrelation is reduced by misdating errors, and by tree-level influences on growth that are not common to other trees in the chronology (NOAA 2008). While the influence of the aforementioned factors was not measured in this study they were probably partially responsible for the differences in series intercorrelations.

An important measurable difference between the spruce and the fir chronologies was the mean sensitivity. Mean sensitivity measures the relative change in ring-width from one year to the next within a series (Grissino-Mayer & van de Gevel 2007; Lewis *et al*., 2009). Complacent ring growth (regular spacing between rings) indicates a low mean sensitivity and occurs if the trees were not under stress when they grew (Grissino-Mayer & van de Gevel 2007; Lewis *et al*., 2009). For example, very drought-sensitive conifers will have an approximate mean sensitivity of 0.650, whereas the mean sensitivity of complacent trees is approximately 0.150 (NOAA 2008). Complacent rings hinder cross dating because growth patterns are not readily apparent, whereas irregular ring widths create a distinctive pattern that can be more easily matched between samples. Therefore, if a chronology has high mean sensitivity it will usually have a high series correlation. The living spruce chronology and the spruce/cabin chronology had higher mean sensitivities than the living fir chronology and the fir/cabin chronology. These results indicate that fir tree rings were more complacent than the spruce tree rings. Patterns were harder to detect between fir samples and thus the series correlations were reduced.

Many factors could have affected the calculated construction date of Eva Lake cabin. To start, a small sample size can produce lower series intercorrelations between the living and floating chronology, which reduces the confidence of the result (NOAA 2008). In this study, ten spruce samples, ten fir samples, and ten cabin samples were extracted. This is a small sample size when compared to other dendrochronological studies. For example, in a study completed by Hart *et al*. (2010) 40 increment core samples (20 trees, two cores per tree) were extracted from their study site. Furthermore, Hart *et al*. (2010) strengthened their living chronology by referencing six existing chronologies previously gathered from the area. In a different study completed by Lewis *et al*. (2009), a historic cabin was dated based on an extensive living chronology and 100 cabin samples. In the Lewis *et al*. (2009) study, only 39 out of 100 samples were deemed usable for analysis; therefore the large sample size was an asset. For the Eva Lake cabin, four out of ten cabin samples had end dates close to 1928. One of these samples, 10EVA03C, had a last measurable ring of 1927. Upon microscopic analysis, earlywood was detected after the last ring. The researchers inferred that the tree was felled in the spring or early summer of 1928. Even though this result is congruent with the date reported by The Eva Lake Cabin Conservation Report (PWGSC, Heritage Conservation 2007), a larger sample size would have increased the confidence of the result.

The negative effect of a small sample size is exacerbated if a chronology has low sample depth at the beginning of the series (NOAA 2008). If there are fewer old trees in the living chronology then it is more difficult to cross-date old trees from the floating chronology. To ensure a high sample depth at the beginning of the living chronology, the researchers cored trees that appeared to be older than 200 years. The mean tree age of the spruce chronology was 200 years. The mean age of the fir chronology was 178 years. Therefore, the spruce chronology had a higher sample depth at the beginning of the series than the fir chronology. The greater sample depth probably contributed to the higher series correlation of the living spruce chronology. However, a larger sample size would have improved the overall depth of both chronologies and increased the accuracy of the results.

Out of the ten samples extracted from the cabin, seven samples were used for analysis. Samples 10EVA02C, 10EVA08C, and 10EVA10C were not used because they were highly desiccated and therefore had low correlations with the living chronologies. Sample 10EVA10C was intact but was disregarded because it also had a low correlation with the living chronologies. This anomaly was explained in The Eva Lake Cabin Conservation Report which stated that sample 10EVA10C was extracted from was recently replaced sill log (PWGSC, Heritage Conservation 2007). Out of the seven cabin samples analyzed, four samples ended up with fairly accurate end dates (Figure 5). Three cabin samples did not have end dates near 1928: 10EVA11C, 10EVA05C, and 10EVA04C. The inconsistent end years may be caused by human sampling error, and the existence of inherent problems when dating historic structures.

There are many potential sources of error during the sampling of a historic cabin. To start, the researchers assumed trees used to build Eva Lake cabin were from the immediate vicinity. Hence, the samples used in the living chronologies were taken from trees adjacent to the cabin. Based on the high series intercorrelation of the spruce/cabin chronology, the researchers determined that the cabin was primarily built from Engelmann spruce. Secondly, the researchers were unable to determine the time between tree harvesting and cabin construction. For example, samples 10EVA06C, 10EVA07C, and 10EVA09C were extracted from trees that may have been cut down in 1926 or 1927, but not used until 1928. Thirdly, the samples needed to be discretely extracted from the cabin because it is a recognized federal heritage building (PWGSC, Heritage Conservation 2007). Therefore, sampling location was based on discretion rather than thoroughness, and no samples were taken from the front of the cabin. This is important because the logs at the front of the cabin were protected by the overhanging porch, and thus were less weathered. Samples from these logs could have increased the series intercorrelation of the spruce/cabin chronology. Fourthly, only one core was taken from each log/tree, whereas two samples are preferable because occasionally the ring patterns on an individual core may be irregular due to internal defects (Lewis *et al*. 2009). Furthermore, Lewis *et al*. (2009) assert that when extracting cabin samples, cores should be taken from both ends of the log because it is not always obvious which end is the basal end (and would thus have the most rings). Therefore, some of the cabin samples may have been taken from the distal end and may be missing rings. Lastly, some of the tree and cabin core samples did not include pith; thus the start year calculated in WinDENDRO may be later than the actual start year of the tree.

Even if sampling occurred without error, there are inherent problems associated with dating historic structures. Although the researchers took core samples from best preserved logs, the logs may have been modified prior to, or weathered after construction. There was no bark on any of the original logs (only on the replaced sill log). The bark may have been removed for construction. This would remove rings and alter the end years of some samples. Bark removal may account for the anomalous end years of samples 10EVA04C, 10EVA05C, and 10EVA11C. Moreover, the cabin is situated in a harsh alpine environment and weathers throughout the years. Weathering of logs caused checking and perimeter loss, which may have also contributed to the early end years of samples 10EVA04C, 10EVA05C, and 10EVA11C. Finally, the cabin samples were desiccated and prone to crumbling; therefore, a partial loss of rings may have occurred. Again, this may have affected the accuracy of the end dates. Outlined are many inherent problems with dating historic structures, which may account for inaccuracies in this study.

Regardless of the potential errors in this study, the end dates from three cabin samples were close to 1928. The end date of sample 10EVA03C was 1928 (based on earlywood after the last ring). This indicates that this tree was felled in the spring or early summer of 1928. The construction date of 1928 was verified in the Eva Lake Cabin Conservation Report (PWGSC, Heritage Conservation 2007).

Therefore, this study provided a unique opportunity to test the utility of dendrochronology in dating historic structures. Despite the small sample size, this study yielded accurate results, and the construction date calculated using dendrochronology was the same as the recorded construction date.

Conclusion

This study represents the first assessment of Eva Lake cabin using dendrochronology to determine, and verify, the year of construction. In this sense, tree-ring dates were used to test the accuracy of the year of construction published in the conservation report. In turn, the reverse is also tested; the published year verifies the accuracy of dendrochronological methods. While the report was helpful for determining the construction year, it failed to provide information about the tree species used to build the cabin. This is where the utility of dendrochronology is evident. This study also lends some insight into the probable species used to build the cabin. This new information contributes to the cultural and historical importance of Eva Lake cabin, and Mount Revelstoke National Park. Dendrochronology served as an accurate method to date Eva Lake cabin; thus other historic structures in the region should be tested with dendrochronology to add to their historical record. The focus now lies in preserving Eva Lake cabin for future enjoyment.

Acknowledgements

The researchers (Mani, Leah, and Jacqueline) would like to thank Dan Smith and Jim Gardner for the opportunity to participate in field school, and for passing on their knowledge of the area. We would also like to thank Kara Pitman, Jill Harvey, and Bethany Coulthard for their assistance in the field and the lab. Finally, we would like to thank Parks Canada for allowing us to learn and appreciate the beauty of our existing national parks.

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