Extension Note

BC Journal of Ecosystems and Management

The fire history of a 416-year-old western larch tree in southeastern British Columbia

L.R. Mark Hall[1]

Abstract

The fire history obtained from pre-settlement fire-scarred trees provides useful benchmarks for the restoration of dry interior, fire-dependent forest ecosystems. In the Rocky Mountain Trench of southeast British Columbia, historical benchmarks obtained from periods prior to significant European influence (i.e., pre-1850) are common reference points for forest ecosystem restoration. This extension note discusses the fire history of a 416-year-old western larch (*Larix occidentalis*) whose growth rings recorded 268 years of fire history before 1850. The study tree's estimated mean fire interval (MFI) is 34.1 years, and its fire intervals ranged from 19 years to 51 years. The tree did not record a fire during the last 130 years of its life. This extension note also discusses the development of a network of cross-dated benchmark sites across the landscape that would create a master fire chronology for the region. Such a chronology would reflect the natural variability of historical fire patterns, helping policy-makers, managers, recovery teams, and restoration practitioners understand the spatial and temporal distribution of landscape-scale disturbances that historically have created fire-dependent ecological communities (many of which include wildlife and plant species now at risk). The creation of a benchmark network would also refine dry interior forest restoration/conservation programs and improve their efficacy.

KEYWORDS: *fire history, historical benchmark, master chronology, restoration, Rocky Mountain Trench, western larch.*

Contact Information

1 Consultant, Box 344, Jaffray, BC V0B 1T0. Email: markhall@xplornet.com

Hall, L.R. Mark. 2008. The fire history of a 416-year-old western larch tree in southeastern British Columbia. *BC Journal of Ecosystems and Management* 9(2):5–10. URL: ***http://www.forrex.org/publications/jem/ISS48/vol9_no2_art2.pdf***

Introduction

The fire history obtained from pre-settlement fire-scarred trees can provide useful benchmarks for restoration practitioners, researchers, and policy-makers restoring dry interior forest ecosystems. Such historical benchmarks obtained from the period prior to significant European influence are common reference points for contemporary ecological restoration initiatives (Gayton 2001). A significant portion of the Rocky Mountain Trench of southeastern British Columbia is classed as having been influenced by frequent stand-maintaining fire events (i.e., every 4–50 years). The purpose of this extension note is to document the fire history of a single western larch (*Larix occidentalis*) that exhibits 268 years of fire history prior to the year 1850, the commonly accepted beginning of significant European influence in the area (Gray *et al.* 2003). Seven of the eight fires recorded on the study tree occurred in this pre-European settlement period. This paper concludes by recommending a comprehensive network of benchmark sites be developed to support the creation of a master fire chronology for the region that reflects the natural variability of historical fire patterns, both temporally and spatially.

Background

On May 26, 1998, a region southeast of Cranbrook, B.C. experienced a severe weather event. High winds sheared off and uprooted entire tracts of forest and numerous individual trees. Among the windthrow was a veteran larch near Norbury Lake Provincial Park (Figure 1). An initial examination of the tree's main bole revealed a number of classic fire scars. Several cross-sections were cut from the base—the best cross-section provided estimates of age and fire history.

Fire History of the Norbury Lake Tree

The cross-section used for the fire history analysis of the Norbury Lake tree was taken from ground line and contained the intact pith. Determination of tree age, as well as the identification of fire scars, estimation of the year of each fire, and calculation of the tree's mean fire interval (MFI) followed the direct ring counting methodology described by Barrett and Arno (1988) (whereby each individual tree ring between the pith and the cambium is counted). This method of determining a tree's age is subject to error and can affect the precision

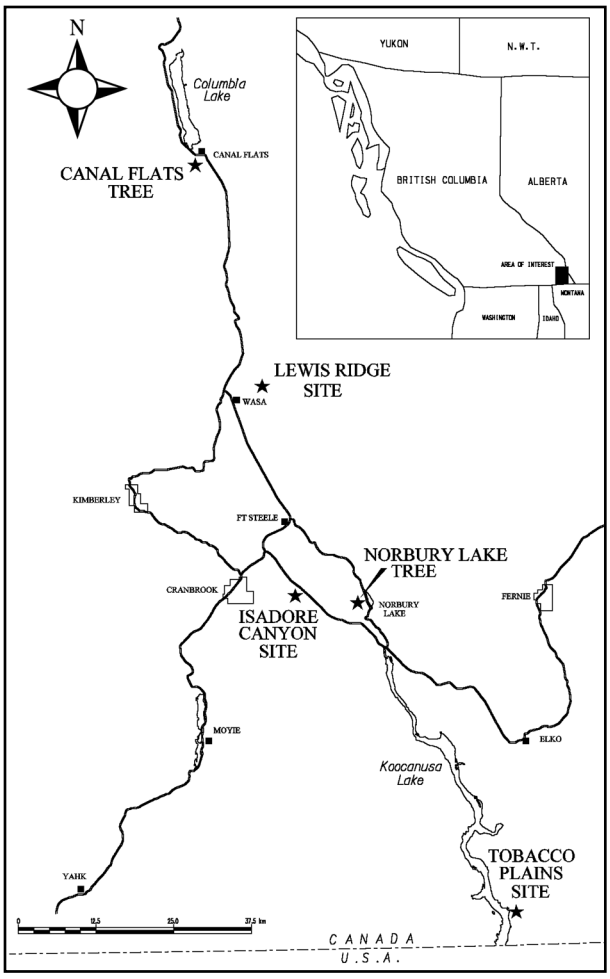

FIGURE 1. Geographic location of the Norbury Lake tree and four nearby benchmark locations.

in dating fire scars. Errors can occur for the following reasons:

- one or more annual growth rings is missing,
- a false ring is counted as an annual growth ring,
- the pith is rotten,
- the year of tree death is unknown, and (or)
- the number of years for the tree to reach the height where the cross-section age was taken is not known or factored into the total age of the tree.

Cross-dating ring-width patterns to a master chronology[1] is a more accurate method of dating tree rings and fire scars than direct ring counting. In a Montana study, Arno *et al.* (1995) reported that cross-dating direct growth-ring counts with a master chronology for the area showed 67% of the innermost

[1] A master fire chronology is a chronological collection of all documented fire dates in a designated area determined by cross-dating.

tree rings determined from direct counting fell within 3 years of the cross-dated age. In addition, the majority of the remaining ring data fell within 3–10 years of the cross-dated age. Therefore, the ages and dates determined from the direct ring counts of the Norbury Lake tree are considered to be approximations.

The Norbury Lake larch is estimated to have germinated in the year 1582, making it 416 years old at the time of death (Table 1). Eight separate fires were identified on the tree (Table 2). The first fire is estimated to have occurred in 1628 when the tree was 46 years old, and the last fire is estimated to have occurred in 1867 when the tree was 285 years old (Table 2). The fire intervals ranged from a minimum of 19 years to a maximum of 51 years (Table 2). There is no evidence of fire scarring during the last 130 years of the tree's life. The tree's MFI is estimated at 34.1 years over its entire lifespan and 36.7 years for the pre-settlement period (Table 2).

Comparison with other Benchmarks

The Norbury Lake tree and the Canal Flats tree, also a western larch (Figures 1 and 2), are local individual fire history benchmarks—their fire scars are dated using direct growth-ring counts. The Isadore Canyon and Lewis Ridge sites (Figures 1 and 2) are fire history benchmark sites that are determined by the analysis of numerous individual fire-scarred trees and the cross-dating of ring-width patterns to a master chronology for each site. On the other hand, the fire history of the Tobacco Plains site is determined from the direct ring counts on numerous individual trees without cross-dating the ring data to a master chronology. The MFI for the Canal Flats tree is estimated to be 31 years (calculated from Gayton 2001). At the Isadore Canyon, Lewis Ridge, and Tobacco Plains sites, the MFIs were 14.1, 18.9, and 6.4 years, respectively (Dorey 1979; Gray *et al*. 2003). Note that the MFI for an individual tree will usually be greater than the MFI for a site (Barrett and Arno 1988).

Table 3 presents the different fire history data sets for fires recorded at the five locations shown on Figure 1. Figure 2 represents the fire history data from Table 3 shown as a chronological timeline. Although the direct ring count and the cross-dating methods are displayed together, a direct comparison of the actual year of each fire obtained from each method is not valid. However, the timeline hints at fire date correlation. A number of sets of pre-settlement fire years obtained from the individual trees are within 10 years of a fire year determined at one of the two sites where the more precise cross-dating method was used. For example,

TABLE 1. Attributes of the Norbury Lake fire tree and its location

Attribute	Description
Tree species	Western larch (*Larix occidentalis*)
Geographic location	Norbury Lake, B.C.
BCGS mapsheet	82G.053
Estimated germination year	1582
UTM co-ordinate (zone 11, NAD 87)	609249, 5488603
Total estimated age (uncorrected)	416 years
Date of tree mortality	May 26, 1998
Diameter outside bark at ground line	1120.5 cm
Diameter outside bark at breast height (1.3 m)	72.2 cm
Total height	29.4 m
Crown characteristics	76% live crown; base of live crown was 7.0 m above the ground
Stem characteristics	Forked at 12 m above the ground
Fire scar orientation	240° (facing southwest)
Rooting depth	1.2 m
Soils	Loamy sand/sand; glacio-lacustrine parent material
Biogeoclimatic ecosystem classification	IDFdm2 - 03
Slope	Flat
Elevation	860 m ASL

TABLE 2. Fire history of a 416-year-old western larch tree found near Norbury Lake, B.C.

Fire	Year	Tree age (years)	Fire interval (years)
1	1628	46	46
2	1648	66	20
3	1668	86	20
4	1709	127	41
5	1754	172	45
6	1797	215	43
7	1848	266	51
8	1867	285	19
Mean Fire Interval (MFI) (years)			*34.1*
Pre-settlement (prior to 1850) MFI (years)			*36.7*

TABLE 3. Raw fire history data sets for five different locations in the Rocky Mountain Trench of southeast British Columbia

Norbury Lake tree	Canal Flats tree[a]	Isadore Canyon site[b]	Lewis Ridge site[b]	Tobacco Plains site[c]
1628	1628	1595	1586	1813
1648	1648	1639	1619	1821
1668	1674	1664	1629	1828
1709	1689	1683	1694	1837
1754	1713	1705	1697	1844
1797	1768	1718	1708	1848
1848	1796	1729	1719	1856
1867	1836	1751	1725	1867
	1874	1780	1751	1873
	1907	1802	1794	1879
		1812	1815	1885
		1826	1821	1895
		1827	t1831	1898
		1849		1901
		1864		1905
		1873		1908
		1892		1911
		1894		1920
				1933
				1940

[a] Gayton 2001

[b] Gray *et al.* 2003

[c] Dory 1979

the timeline in Figure 2 shows fire years recorded by the Canal Flats and Norbury Lake trees in 1628 and a fire at the Lewis Ridge site in 1629. As well, fires recorded by the Canal Flats and Norbury Lake trees have dates that are 2 and 3 years apart from a 1794 fire at the Lewis Ridge site. About thirteen other potentially common sets of fire periods can be described from these data sets. If the direct ring count method was more precise in ascertaining fire dates, such patterning of fire periods may have important implications to dry interior forest restoration and land management in the Rocky Mountain Trench.

Management Implications

Knowledge of fire history generated from the study of small, isolated, and undisturbed pre-settlement benchmark sites provides a reference for the restoration of adjacent areas having similar biogeoclimatic characteristics. However, a limited number of benchmark individual trees or sites may not provide reliable local information about the patterns, timing, and magnitude of fire disturbances across the landscape.

Extrapolating an MFI over large areas based on only a few sources will not be sensitive to the different fire histories in different habitat types. Conversely, the fire intervals of large areas are often limited in use for characterizing disturbances in smaller stands (Arno and Petersen 1983). Preferably, restoration policy-makers and practitioners should use data (correlated in a master chronology) that represents the size and complexity of their local landscape rather than information extrapolated from non-local ecosystems or limited data sources.

Current and past land management activities, such as land clearing and logging, reduce the chances of finding patches of undisturbed pre-settlement forests that are suitable for benchmarking. However, this extension note demonstrates that there are still opportunities to find individual benchmark trees within the altered landscape matrix. The natural history knowledge base of the southern Rocky Mountain Trench benefits greatly from finding and cataloguing benchmark trees that are well-distributed across the landscape. By using data from a network of such benchmarks, the multiple-site average fire interval can be applied to estimate the fire history of larger forest zones lacking fire-scarred trees (Barrett and Arno 1988).

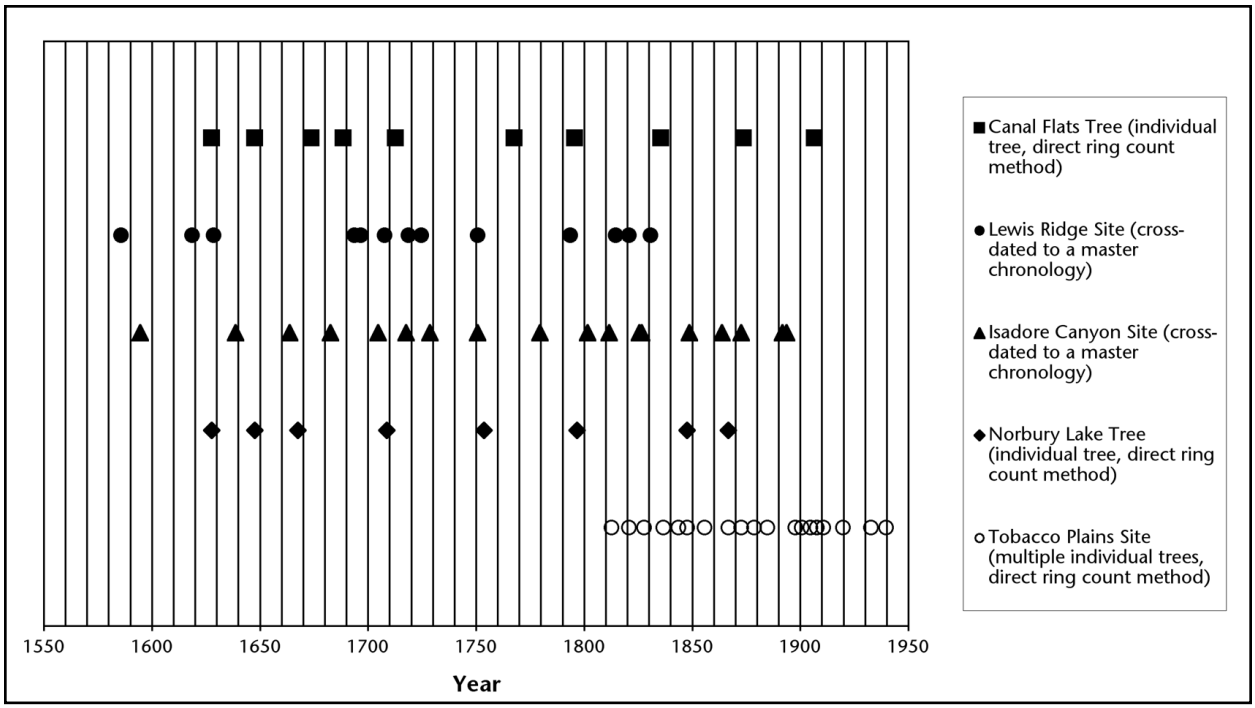

FIGURE 2. A timeline for five sets of fire history data from the Rocky Mountain Trench of southeast British Columbia.

The potentially common sets of fire years between the five locations shown in Figure 2 raises the following questions related to restoration and land management:

- Could additional cross-dating work determine whether fires from the Canal Flats and Norbury Lake trees occurred in the same years as fires recorded at the Lewis Ridge or Isadore Canyon sites?
- If fires did occur during the same year at these different locations, were they part of large contiguous fires or were they separate fires?
- If cross-dating to a master chronology permitted the Norbury Lake and Canal Flats trees to be compared to the Isadore Canyon and Lewis Ridge sites, would the data show any patterns indicating there were periods of significantly more fire disturbance on the landscape compared to other periods?
- Did any such periods of increased fire disturbance repeat themselves in a cyclic pattern?

The answers to these questions are important in refining the type, scale, and timing of dry forest restoration treatments on the landscape of southeastern British Columbia. Ultimately, these answers could also be used to improve the delivery of and impetus behind dry interior forest restoration programs, such as commercial harvesting, prescribed burning, pre-commercial thinning, and fuel modification treatments. Such answers may also benefit the conservation of fire-dependent plants and wildlife and recovery of some species at risk. A better understanding of the disturbance regimes that fostered these species would result in improved efficacy of recovery and conservation strategies.

Recommendations

Cross-dating the ring data to master chronologies would increase the precision of fire dates obtained from the direct ring counts of individual trees and thus would increase the number of fire history data sets available for direct comparison. Direct comparison of fire histories derived from locations throughout the land base would improve knowledge of the spatial distribution and temporal occurrence of historical fires in the Rocky Mountain Trench. Consequently, biodiversity conservation in the dry interior forests of southeastern British Columbia would benefit. This knowledge would be valuable in refining current landscape-level dry interior forest restoration programs initially developed using a limited number of benchmark data from direct ring counts on individual trees, findings from other

regions of North America, or interest-based resource use paradigms. It is important to stress that these historic benchmarks are disappearing and with them, their records of past events. Before this irreplaceable information is lost, restoration ecologists must continue to catalogue veteran fire-scarred trees and cross-date their data to master chronologies.

Acknowledgements

The cross-section of the Norbury Lake tree was prepared and labelled for education purposes through a grant from the Columbia–Kootenay Fisheries Renewal Partnership. The finished cross-section was donated to the Fort Steele Heritage Town museum where it is presently on public display.

References

Arno, S.F. and T.D. Petersen. 1983. Variation in estimates of fire intervals: A closer look at fire history on the Bitteroot National Forest. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, Utah. Research Paper INT-RP-481.

Arno, S.F., J.H. Scott, and M.G. Hartwell. 1995. Age-class structure of old growth ponderosa pine/Douglas-fir stands and its relationship to fire history. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah. Research Paper INT-301.

Barrett, S.W. and S.F. Arno. 1988. Increment-borer methods for determining fire history in coniferous forests. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, Utah. General Technical Report INT-244.

Dorey, R.J. 1979. A fire history investigation and the effects of fire exclusion on a ponderosa pine forest in southeastern British Columbia. BSc thesis. University of British Columbia, Vancouver, B.C.

Gayton, D.V. 2001. Ground work: Basic concepts of ecological restoration in British Columbia. Southern Interior Forest Extension and Research Partnership, Kamloops, B.C. SIFERP Series No. 3.

Gray, R.W., E. Riccius, and C. Wong. 2003. Comparison of current and historic stand structure in two IDFdm2 sites in the Rocky Mountain Trench. Unpublished draft report. Southern Interior Forest Extension and Research Partnership, Kamloops, B.C.

ARTICLE RECEIVED: **July 4, 2005**
ARTICLE ACCEPTED: **October 10, 2007**

Test Your Knowledge . . .

The fire history of a 416-year-old western larch tree in southeastern British Columbia

How well can you recall some of the main messages in the preceding Extension Note? Test your knowledge by answering the following questions. Answers are at the bottom of the page.

1. The exact year of a historical fire as determined from an analysis of a fire scar on a tree cross-section is more accurately determined by:
   A) Cross-dating ring width patterns to a master fire chronology
   B) Direct ring counts
   C) Calculating the mean fire interval

2. The mean fire interval of the Norbury Lake tree supports the conclusion that the Rocky Mountain Trench of southern British Columbia was historically subject to frequent stand-maintaining fires?
   A) True
   B) False

3. Using historical fire history data can be useful for:
   A) Policy-makers to refine current landscape-level dry interior forest restoration programs
   B) Species-at-risk recovery teams to understand the historical landscape scale disturbances that created fire-dependent ecological communities
   C) Both of the above

Answers

1. A
2. A
3. C