Wildfire legacies in Jasper National Park

Traditionally, forest fires have been thought of as high-severity disturbances that kill trees and initiate new even-aged forests. Most timber harvesting and silvicultural systems in British Columbia are designed to emulate such high-severity events. However, research conducted in the Tree-Ring Lab at UBC's Faculty of Forestry contributes to growing evidence throughout western Canada that wildfires are much more variable than previously thought. New research shows that historical wildfires in the montane forests of Jasper National Park were variable and complex, but much of that diversity has been lost during the 20th century. This research has recently been completed by Raphaël Chavardès as part of his master's degree, under the supervision of Dr Lori Daniels in the Department of Forest and Conservation Sciences and in collaboration with Parks Canada, Foothills Research Institute and Hinton Wood Products.

Understanding fire regimes is critical as it underpins silvicultural systems, biodiversity conservation and wildfire management. A fire regime describes the size, location, timing, frequency and severity of consecutive forest fires through time. High-severity fire regimes – the infrequent high-severity crown fires that kill many trees are most familiar. In contrast, low-severity fire regimes are characterized by frequent surface fires that kill few trees but leave cambial scars on thick-barked individuals. "Mixed-severity fire regime" is a relatively new term that describes the patterns and legacies of diverse wildfires across space and time. For example, a single wildfire can burn at low, medium or high severity in different parts of the forest leaving complex patterns of living and dead trees. Similarly, a single patch of forest can burn at high, medium and low severity during consecutive fires resulting in multiple age cohorts, fire scars on veteran trees, complex stand structure and diverse species composition. In short, mixed-severity fire regimes include diverse wildfires that drive stand and landscape diversity.

Raphaël used multiple lines of evidence to reconstruct detailed fire histories and forest dynamics through time at 29 montane sites in Jasper. He used a tree-ring analysis method known as "crossdating" in which the narrow and wide patterns in tree rings are matched among trees to ensure an exact calendar year is determined for each ring. He assigned a precise calendar year to 18 fires that burned between 1646 and 1915. Fire-scars were found at 20 of 29 study sites, most commonly on thin-barked lodgepole pine. Up to 5 fire-scars embedded in thick-barked Douglas-fir provided evidence of recurring surface fires that burned every 30 to 60 years, on average. High-resolution tree ages from increment cores revealed 460-year old spruce trees, other veteran trees that survived multiple fires over their lifespan, and many cohorts of trees that established after widespread fires in 1827, 1889 and

1905. Combined, fire-scars, veteran trees and post-fire cohorts of trees were legacies of past fires of mixed severity at 18 of 29 sites. At the other 11 sites, single even-aged tree cohorts were evidence of high-severity fires in the 1800s and early 1900s.

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Thus, Raphaël was able to provide strong evidence of mixed-severity fires over the past 350 years in Jasper.

Raphaël's research revealed nuanced relationships between fire and forest dynamics. The traditional model of succession in which lodgepole pine establishes first after fire and is later replaced by shade-tolerant spruce oversimplifies forest dynamics in Jasper and could mislead interpretations of disturbance history. Instead, detailed reconstructions showed that lodgepole pine, hybrid spruce and Douglas-fir simultaneously established after low- to high-severity fires so that forest canopies are mixed in composition. In contrast, subcanopies are strongly dominated by shade-tolerant spruce, regardless of fire history. Tree-ring analysis revealed the subcanopy spruce were similar in age to their neighbouring canopy trees. Small subcanopy trees do not represent recent recruitment of trees. Instead, species-specific growth rates and adaptations to shade resulted in size stratification among species and canopy layers. Raphaël concluded that assessments of fire history based on canopy tree composition and tree sizes without high-quality age data could be misleading.

In a second landscape-level component, Raphaël cross-dated fire-scars and tree ages sampled at 172 sites to show that the fire regime of Jasper has changed dramatically during the 20th century. Over the past 350 years, 18 fires left fire scars and fire frequency was greatest from the 1880s to 1915, consistent with well-documented human use of fire by First Nations, European settlers and people of dual ancestries. In stark contrast, Raphaël found no fire-scars after 1915. The simultaneous, long fire-free intervals at all 172 sites during the 20th century are unprecedented in his multi-century fire-scar record.

The lack of fire during the 20th century has been explained by some researchers as a result of a warm but wet climate after the Little Ice Age, making climate unsuitable for forest fires. Alternatively, fire suppression by human impacts would explain the observed shift in the fire regime. Using tree ring-widths as a proxy record for past droughts, Raphaël was able to show that the 18 fires between 1646 and 1915 burned during significant droughts. Since 1915, there were several years and decades when climate was conducive to forest fires. Nevertheless, a lack of fire scars was found during these droughts, even though there were young thin-barked trees at all study sites that could have recorded fire had a fire burned. The documentary fire records for Jasper also indicate few or no fires. After the Park was created in 1907, local families were displaced, removing fire as a land and resource management tool. As of 1913, fire protection and suppression were implemented and have become increasingly effective with modern technology. Raphaël concluded that human impacts exceeded the effects of climate variation, and the change to the fire regime was primarily due to fire exclusion and modern suppression.

In the absence of fires of a range of severities during the 20th century, forest stands have developed similarly and landscape diversity in the montane forests of Jasper National Park has decreased. Today's landscape is dominated by relatively uniform, closed-canopy forests that have not burned for many decades. Wildfires are needed in these forests to increase their diversity and make them more resilient to ongoing environmental change, including climate change. Raphaël's research provides strong support for modern fire policies such as allowing managed wildfires and the use of forest thinning and prescribed burning to restore ecosystems and mitigate fuel hazards in Jasper National Park.

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Surface fires recorded as scars in the rings of thin-barked lodgepole pine. This tree from Jasper National Park recorded 3 surface fires in 1878, 1889 and 1905