Cross-scale assessment of spatiotemporal patterns and drivers of fire effects in mixed-severity fire regime forests of *Larix occidentalis*, Glacier National Park

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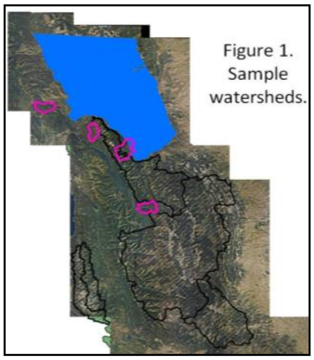
Figure 1. Sample watersheds.

The extent and frequency of wildfires in Glacier National Park and the broader Northern Continental Divide Ecosystem (NCDE) have increased in recent decades, in close association with warming climatic trends, greater frequency and severity of droughts, and longer fire seasons. Predictions of future fire activity in the region suggest unprecedented increases in the frequency of large, climate-driven fires and possible shifts to novel vegetation-climate-fire relationships. However, the ecological impacts of current or future projected increases in fire activity are not well understood, especially in forests of the region characterized by mixed-severity fire regimes. In these forests, landscape scale patterns of fire severity are spatially complex and they may vary substantially over time as well. Therefore, a clear understanding of the impacts of increased fire activity in these forests requires quantification of the spatiotemporal patterns of fire severity over long time series and broad areas. We employed a novel combination of dendroecology, analysis of historical aerial photographs and remote sensing of modern fires to reconstruct spatiotemporal patterns of fire severity over the past 250+ years for mixed-conifer western larch forests of the NCDE.

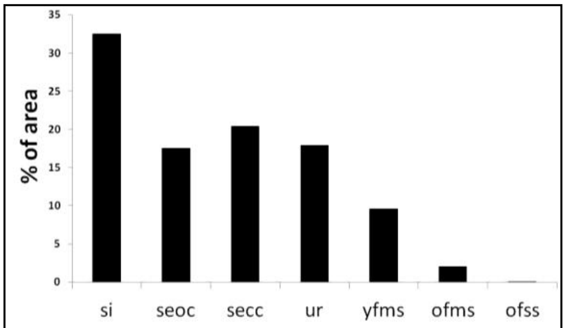

Figure 2. Forest structural types organized from young to old

Our study incorporated four watersheds oriented along a north-south gradient and encompassing drainages with all three major forks of the Flathead River basin (Figure 1). Analysis of forest characteristics interpreted from 1:15,840 scale stereo photo pairs revealed large scale patterns in forest structure that were strongly influenced by historical fire. A striking result of this analysis is the extent of each study watershed that experienced high-severity fire historically, as evidenced by the preponderance of young, stand initiation forest types (Figure 2). Contrastingly, old forest types were exceedingly rare in all of our drainages and the remainder of forest area was in mid successional stages (Figure 2). Dendroecological analysis of fire history and forest establishment patterns generally reinforced these interpretations, indicating that most sites had regenerated following a high-severity fire that left only a few large western larch or Douglas-fir trees alive (Figure 3). In many sites, subsequent low- to moderate-severity fires were also documented, suggesting that interannual climatic variability does play a role in patterns of fire severity. Remote sensing analysis of fire severity patterns based on the differenced normalized burn ratio (dNBR) indicate that modern wildfires are burning predominantly at low-moderate severity with a significant proportion of high-severity fire as well (Fig. 4).

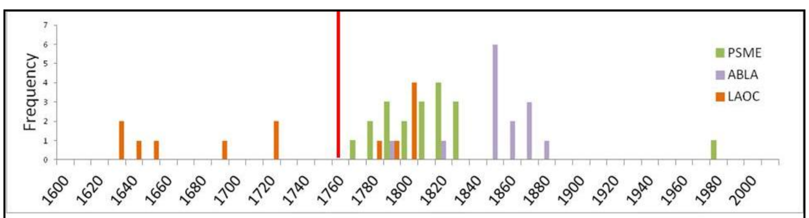

Figure 3. Tree establishment and fire dates for a sample stand

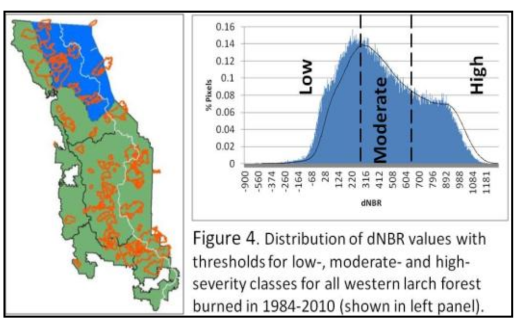

Figure 4. Distribution of dNBR values with thresholds for low-, moderate- and high-severity classes for all western larch forest burned in 1984-2010 (shown in left panel).

Our analysis suggests that western larch forests historically and currently experienced large amounts of high-severity fire that had strong influences on landscape patterns of forest structure. But fire severity patterns varied temporally, in part influenced by interannual climate variability, and low- to moderate-severity fires also were widespread in certain years. Further analysis of fire severity-climate relationships in our data will help to quantify the role that climate plays in structuring fire severity patterns.