Wildfires as fuel treatments – burn mosaics and wildfire management

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Back in its day, the 2006 Tripod Complex was one of the largest wildfires in Washington State history. The nearly 175,000 acre fire burned a large, contiguous area of dry, mixed conifer forests of ponderosa pine and Douglas-fir and higher elevation forests of Engelmann spruce, subalpine fir and lodgepole pine. The wildfire event was impressive not only in its size but also severity – over 65% of the area burned as stand-replacement fires with nearly 100% tree mortality (**Figure 1**).

One of the remarkable features of this large wildfire was that even during extreme fire weather days, a number of recent past fires acted as barriers to fire spread. When the Tripod Complex encountered landscape burn scars from past wildfires in 2003, 2001, 1994 and even 1970, it wrapped around the past burn perimeters and burned only at their margins. The resulting landscape resembles a jigsaw puzzle with an extremely large puzzle piece represented by Tripod and other pieces represented by older fire events.

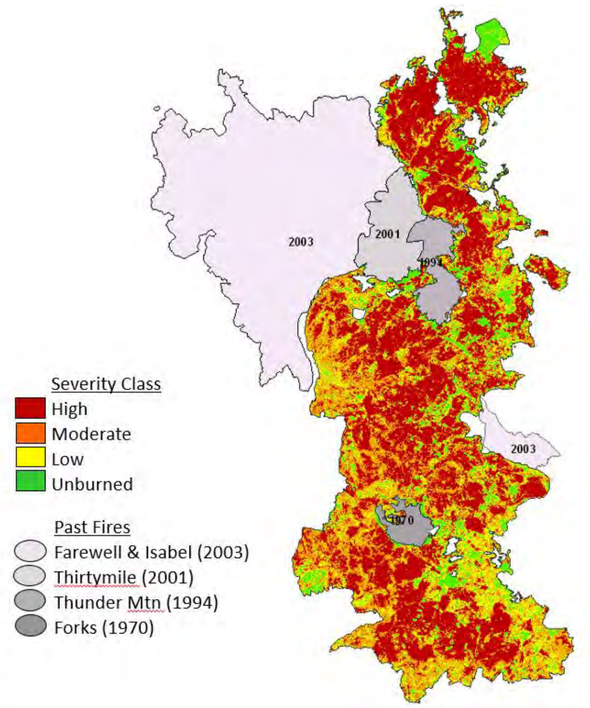

Figure 1 *Burn severity map of the 2006 Tripod Complex fire with recent past fires in gray. Red high severity and orange moderate severity classifications were field validated as areas that had nearly 100% tree mortality.*

Large fires over 100,000 acres in size, commonly referred to as megafires, are becoming increasingly common in western North America. Following the 2006 Tripod Complex fires, a series of large fire events have burned in the surrounding mixed conifer forests. In each event, past fires, now including the Tripod, have interacted with the subsequent fires, in most cases acting as complete barriers to spread or where fuels have accumulated enough to allow fires to spread through older burns (> 15 years), supporting a much lower-intensity fire than in surrounding, mature forests.

With reduced surface fuels such as downed wood, grass, shrubs, and crown fuels, past burn scars often are valuable for wildland fire managers and firefighting operations. Recent burns can provide defensive space and may represent areas that do not need to be directly defended in the event of a subsequent fire. For example, in North Central Washington, the 2014 Carlton Complex fires and the 2015 Okanogan Complex fires burned into the southern edges of the Tripod perimeter and in both cases, suppression resources were not allocated to these areas because fire spread was predicted to be minimal into the old fire area (**Figure 2**).

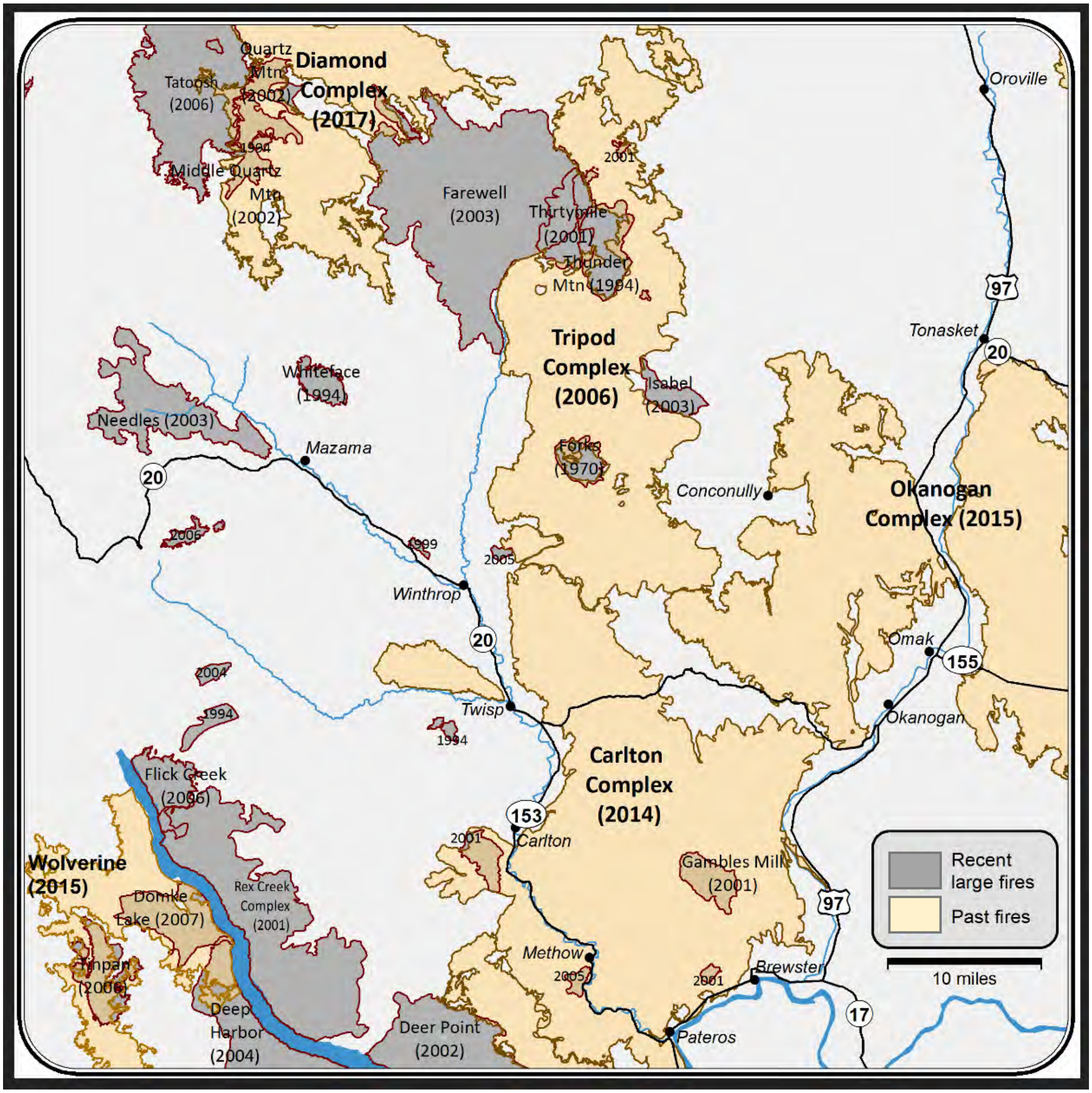

Figure 2 *Past fires (solid) overlaid by the 2006 Tripod, 2014 Carlton Complex, 2015 Okanogan Complex and 2017 Diamond Complex fire perimeters (lines) in north-central Washington State.*

Based on the effectiveness of past fires, our research team asked how large fires such as the Tripod might have been different without a legacy of fire exclusion. When we dug into the old fire start records from 1940 to 2006, we discovered that 310 active fire starts (defined as actively burning fires as opposed to lightning strikes) were contained within the Tripod perimeter alone. Within the massive perimeter of the 2007 East Zone fire, which burned over 300,000 acres of mixed conifer forests in central Idaho, 977 active fire starts were suppressed between 1940 and 2007.

The Reburn Project was motivated by a need to better understand wildfires as a type of fuel reduction treatment and to assess the impacts of fire suppression on forested landscapes. We first evaluated fire-on-fire interactions between past wildfires and subsequent large fire events (see Stevens-Rumann et al. 2016). Next, we created a landscape fire simulation tool that allowed us to explore the impact of fire management on the patterns of forest vegetation and fuels across landscapes. To do this, we created an iterative tool that uses historical ignition and weather data to evaluate potential burn mosaics compared to actual pre-wildfire landscapes under different wildfire management strategies.

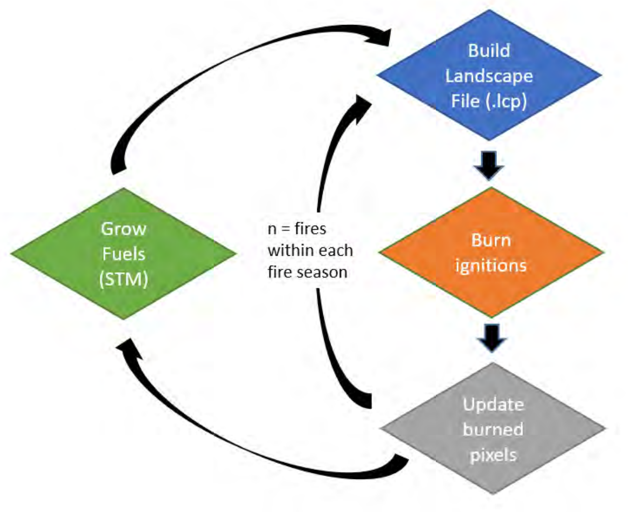

Figure 3 *System diagram of the Reburn Simulation Tool.*

The Reburn simulation modeling tool iteratively models fire spread using historical fire start and weather data for each recorded fire start. The Tripod landscape, for example, begins with recorded fire starts in 1940. Vegetation and fuels are modeled on an annual time step using a State and Transition Model that has pathways to reflect low-, moderate- and high severity effects on forest vegetation and tracks forest growth and fuel accumulations over time. The simulation tool keeps track of each fire and over time models the spatial and temporal dynamics of fire and vegetation. FSPro is a fire growth model used within the Wildland Fire Decisions Support System to inform wildland fire operations (US Forest Service https://wfdss.usgs.gov/ wfdss_help/ WFDSSHelp _FSPro_Ref.html). As a fire growth model, FSPro is intended for runs of hundreds to thousands of iterations to develop burn probability surfaces of likely fire spread and fire behavior (flame length). In this unique case, we used FSPro as a short-term fire growth model to predict the fire intensity and spread of each fire. We chose FSPro to integrate into our tool because it allowed us to input weather streams on a daily basis over each modeled fire event (**Figure 3**). However, other fire behavior models could be selected in future versions of this tool.

There are too many uncertainties involved with fire-spread modeling and historical weather records to create precise snapshots of how our fire management decisions could have shaped landscape patterns. In particular, wind speed and direction are impossible to reconstruct from historical records. To address this uncertainty, we ran each management scenario 25 times to evaluate how patterns might change based on random draws from wind scenarios. Results from our simulation modeling, albeit hypothetical, provide some compelling illustrations of how actively removing fires from forests that were historically supported by frequent fire have large ramifications for landscapes and their relative susceptibility to future fires. The following are results for the Tripod landscape in which we evaluated the resulting landscapes for 4 different wildfire management scenarios using recorded fire start data and historical weather records from 1940 to 2006 (**Figure 4**).

Complete absence of fire (no fire). In this scenario, we evaluated how 66 years of no fire would alter the landscape mosaic. The resulting landscapes reflects the maturation of forests and relatively homogenous landscapes of young- and old-forest multistory structures. This landscape bears a marked resemblance to the actual pre-fire Tripod landscape and the highly contagious patterns of vegetation and fuels that supported the actual wildfire event.

Modern Suppression. The modern fire suppression scenario was designed to represent contemporary wildland fire management in which only the fires that escape suppression (the 2-3% of fires that burn under extreme fire weather and cannot be suppressed) were allowed to burn. In general, results demonstrate a general infilling of the landscape with more mature forests prior to 2006 similar to the no-fire scenario. However, in some of the 25 scenarios we ran, large fires actually occurred prior to 2006. These results were understandable in that 2003, 1994 and earlier years also supported large fire growth that might have burned the pre-Tripod landscape under certain weather conditions.

Partial Suppression. The partial suppression scenario allowed for managed wildfires in the late-summer and fall fire seasons and escaped wildfires. Simulations of the partial suppression scenario generally demonstrate finer-grain landscape mosaics at lower elevations that support dry, mixed conifer forests (southern portion of study area) and mixed severity at higher elevations (northern portion of study area). In the example presented here, a large fire had recently burned in the cool high-elevation mixed conifer forests in the far north of the study area. Pockets of mature and old forests are supported throughout this landscape and are often associated with changes in topography (north slopes, mountain cirques).

No suppression. In this frequent-fire scenario, the landscape supports a relatively low percentage of mature forest and had the finest patchwork of vegetation of any of the scenarios. Patches of young forest multistory and old forest multistory were generally surrounded by recent burns (black pixels) and regenerating forest.

The simulation modeling results from our study offer a unique perspective of the long-term consequences of our wildfire management decisions – in particular, the implications of fire management decisions for future wildfire events. Of our four scenarios, the No Fire and

Modern Suppression scenarios represent "boom and bust" landscapes in which continuous mature forests are capable of supporting large fire spread. The partial wildfire and no suppression landscapes have finer-grained patch mosaics and would have presented a markedly different landscape to fire managers in the 2006 Tripod Fire. Specifically, the partial and no suppression landscapes support a much more diverse landscape that is less susceptible to large, stand-replacing fire events and supports a wide range of forest ages.

These alternative landscapes also have implications for wildlife habitat in that the boom and bust landscapes tend to support a high percentage of late-successional habitat and much lower percentages of early successional habitat. In contrast, the partial and no suppression habitats are much more diverse and could conceivably support a wider range of wildlife species at any one time. Because of these implications for wildlife habitat, results of this study are being used to evaluate the potential consequences of wildfire management strategies on the carrying capacity of Canada lynx in the Tripod study area. With the onset of larger and more severe fires in the 21st century, optimal lynx habitat has dramatically declined in north-central Washington. Exploring alternatives to modern fire suppression may offer potential solutions for sustaining critical habitat for lynx and other wildlife species.

Acknowledgements
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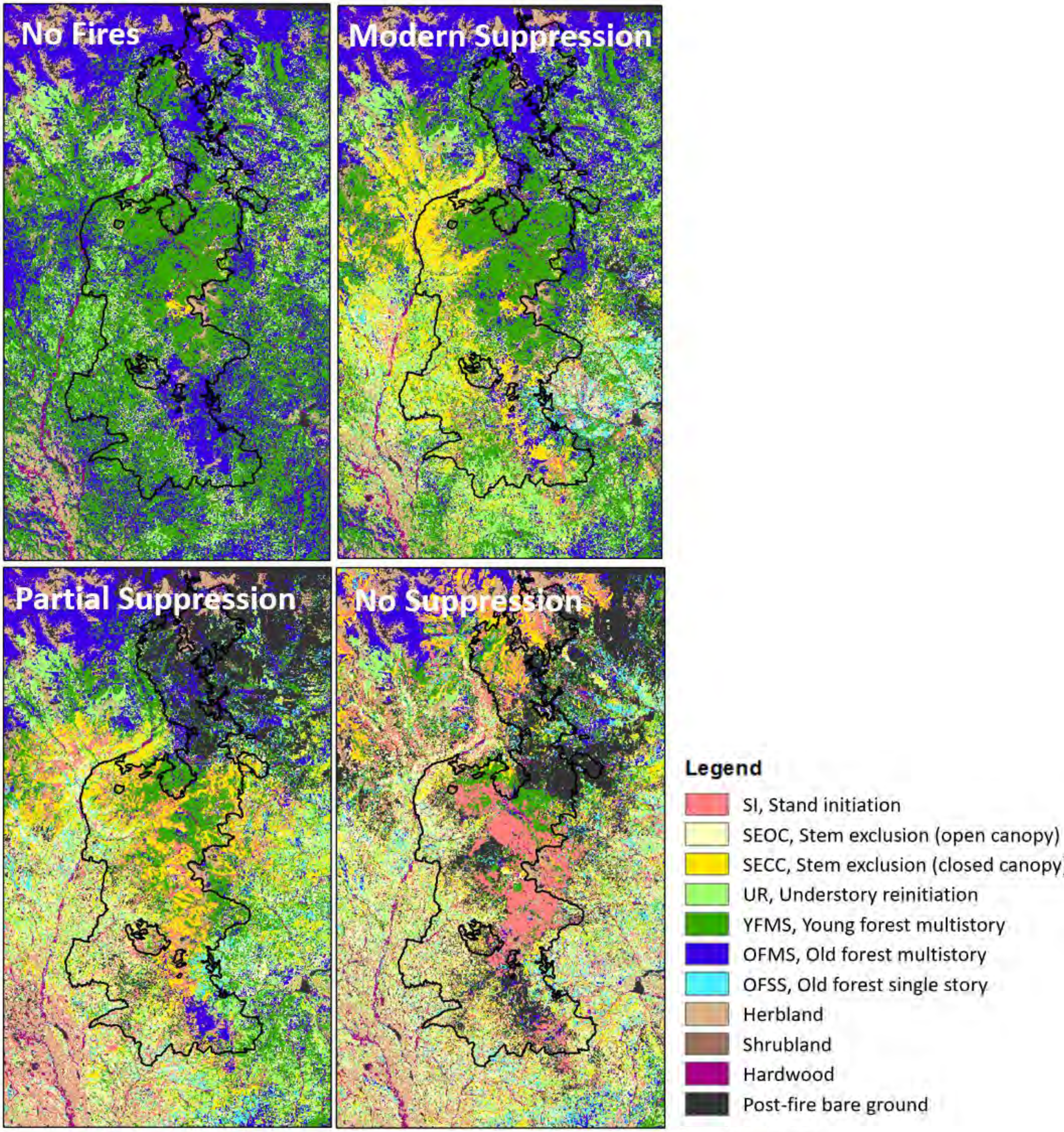

Figure 4 *Alternative landscapes representing the outcome of 4 wildland fire management scenarios based on recorded fire start data from 1940 to 2005 in the Tripod study area. Stand structural classes are displayed, ranging from post-fire bare ground (black) to old forest multistory (dark blue).*