Multidecadal trends in burn severity and patch size in the Selway-Bitterroot Wilderness Area, 1900-2007

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Introduction

Introduction: Although increases in wildfire extent and number of large fires are well documented for recent decades, we know little about multi-decadal trends in burn severity and patch size despite their implications for ecological effects and fire management [1,2].
We provide a unique and valuable context for evaluating whether or not wildfires have burned more severely in recent decades as they have increased in size, duration, season length, and annual fire extent since the mid 20th century [3].

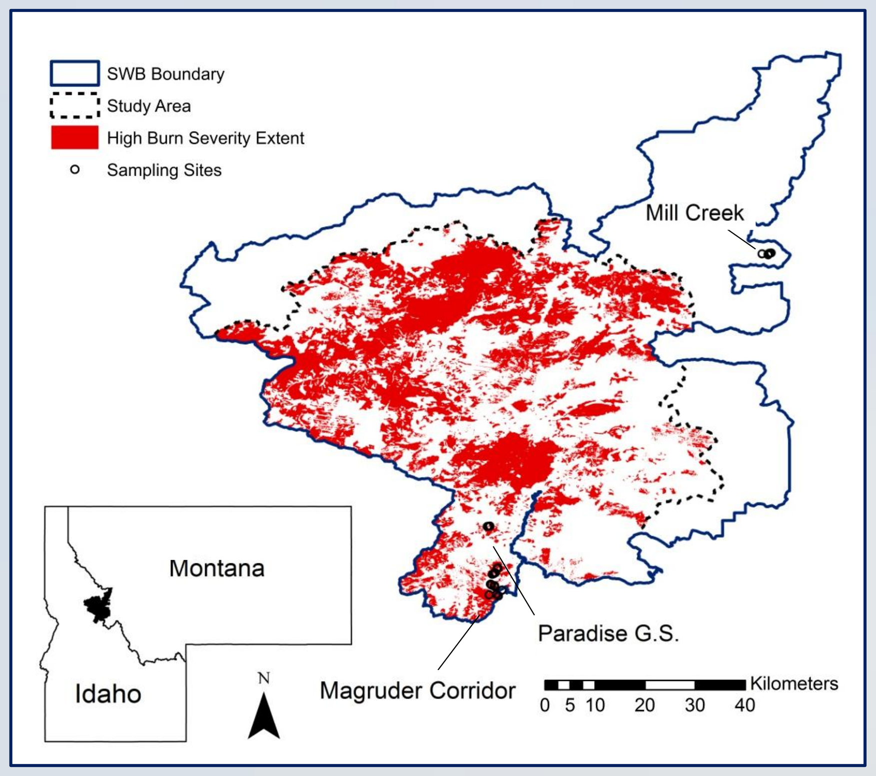

Figure 1. The Selway-Bitterroot Wilderness Area on the border of Idaho and Montana. Study area encompasses 346,304 ha within the Selway-Bitterroot Wilderness Area. Colored areas represent only high severity burn extent from 1900-2007 . Sampling sites were accessed from Mill Creek, Paradise Guard Station, and Magruder Corridor.

Objectives:

1) Evaluate if area and proportion burned severely have increased through time from 1900 – 2007.

2) Evaluate how patch characteristics of high severity fires have changed through time 1900 - 2007.

3) Assess the degree to which distance-to-edge affects post-fire vegetation response in high severity burn areas.

Looking across to Magruder Ridge field sites, Magruder Corridor, Selway - Bitterroot Wilderness Area, 12 years post-burn. © Ashley Wells

Background: We analyze the change in area and proportion of area burned severely across 346,304 ha in the Selway-Bitterroot Wilderness Area (SBW) in Idaho and Montana, USA using 30-meter resolution fire perimeters and burn severities inferred from 1900-2000 Historical Aerial Photograph Severity (HAPS) data using fire atlases and aerial photography and 1984-2007 satellite imagery from the Monitoring Trends in Burn Severity (MTBS) project .

Looking east towards the mouth of Mill Creek in the Selway-Bitterroot Wilderness Area, near Hamilton, MT, 12 years post-burn. © Ashley Wells

Justification

Vegetation response is greatly influenced by burn severity, but the effect of patch size has not been widely studied and longer-term studies are needed. Burn severity, which describes the degree of ecological change pre-fire to post-fire [4], has been shown to have increased in the Sierra Nevada Mountains [5], however a longer time series is needed to evaluate trends. Our research takes advantage of a unique data set with a long temporal series to examine multi-decadal trends across diverse topography and forest vegetation types to better understand the effects of high severity fires on the landscape.

Observation Point, Selway-Bitterroot Wilderness Area, 12 years post-burn. © Ashley Wells

Methods

Step 1: Quantify the area and proportion of area burned severely through time using the two data sets in ArcGIS.

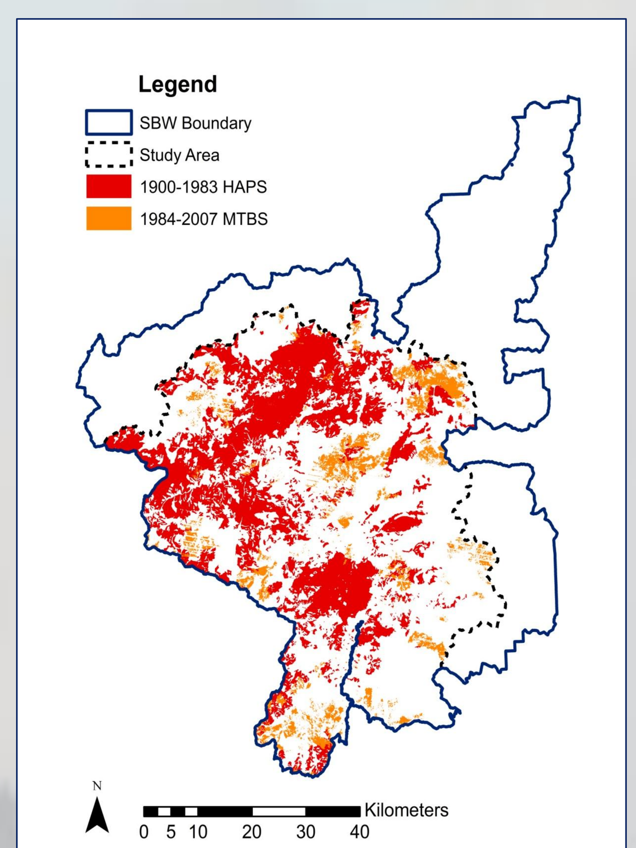

Figure 2. Selway-Bitterroot Wilderness Area with HAPS data in red (1900-1983) and MTBS data in orange (1984-2007) for only high severity extent.

Step 2: Compare and justify merging the HAPS and MTBS datasets.

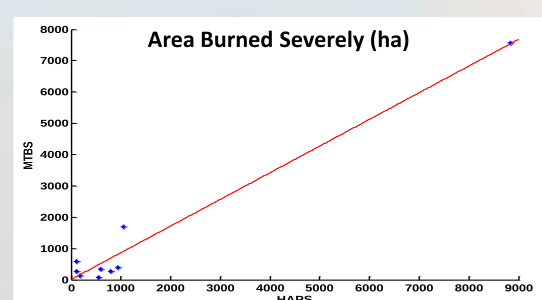

Figure 3. Comparison of area burned severely for HAPS and MTBS datasets for the 9 years of overlap (1984, 1985, 1986, 1987, 1988, 1991, 1994, 1996, 2000). Wicoxon rank sum p = 0.60

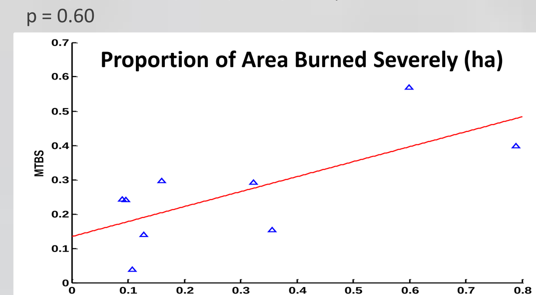

Figure 4. Comparison of proportion of area burned severely for HAPS and MTBS datasets for the 9 years of overlap (1984, 1985, 1986, 1987, 1988, 1991, 1994, 1996, 2000). Wicoxon rank sum p = 0.93

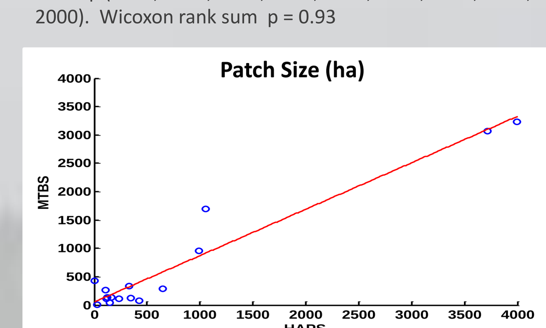

Figure 5. Comparison of severely burned patch sizes for HAPS and MTBS datasets for the 9 years of overlap (1984, 1985, 1986, 1987, 1988, 1991, 1994, 1996, 2000). Wicoxon rank sum p = 0.63

Step 3: Sample 20 locations in the SBW from the widespread fire year 2000 to assess post-fire tree seedling density and understory species diversity 12 years post-fire. Field data were collected 10m, 40m, and 80m from the unburned edge to evaluate edge effect for large high severity patches.

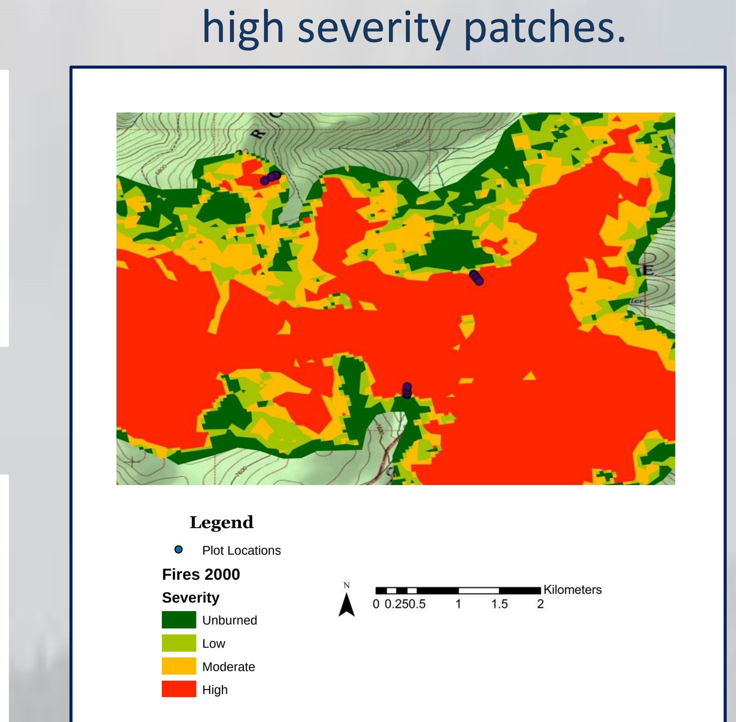

Figure 6. Map of three sites sampled in Magruder Corridor from the unburned edge into a high severity patch. 30-m transects were placed parallel to the unburned edge at 10m, 40m, and 80m.

Results & Conclusions

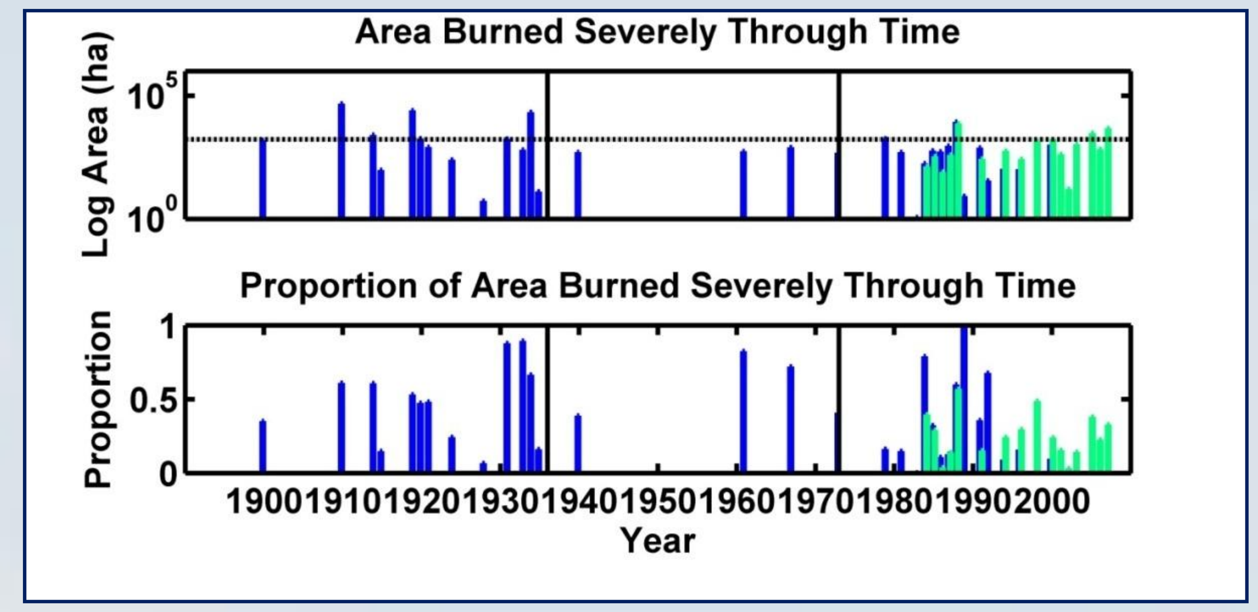

Figure 7. Total area burned severely through time (ha) **(top)** and proportion of area burned severely through time **(bottom)** for the years 1900 – 2007 for 346,304 ha in the Selway -Bitterroot Wilderness Area. Burn severity inferred for HAPS data (blue) using fire atlases and aerial photos 1900-2000, high severity was defined as >70% tree canopy mortality. MTBS data (green) uses satellite inferred perimeters and severity 1984 – 2007, high severity is based on RdNBR values. Dashed line represents 90th percentile of area burned severely. Vertical lines divide the three fire management periods.

Burn Severity Varies Through Time

Early years (1900 - 1934) experienced a large extent of high severity fire, followed by lesser extent in Middle years (1935 - 1974), and some increase in Late years (1975 – 2007).

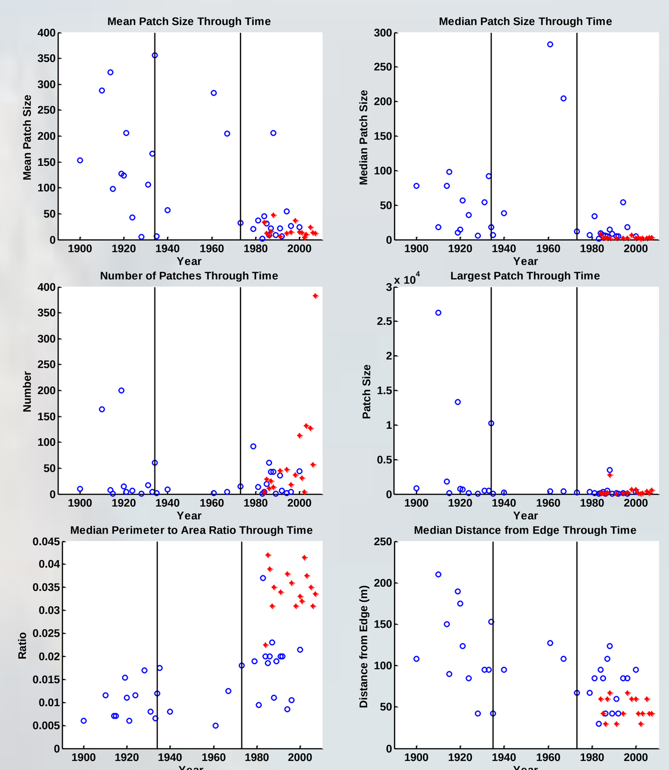

Figure 8. Mean patch size (ha), median patch size (ha), number of patches, largest patch (ha), median distance to edge (m), and median perimeter-to-area ratio through three fire management periods. HAPS data is blue and MTBS data in red.

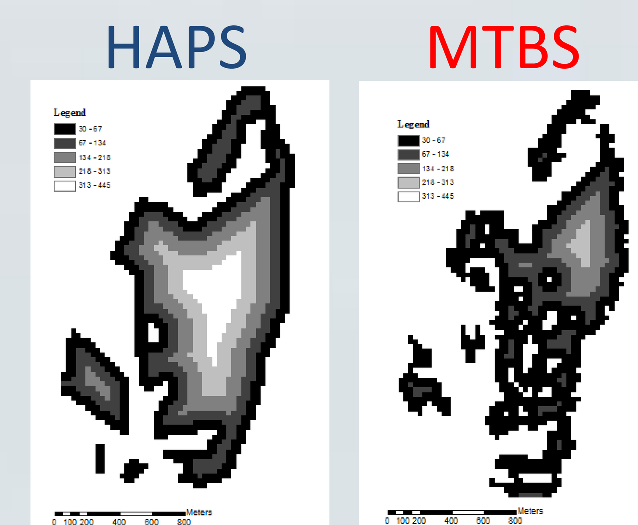

Figure 9. Distance to edge for the same patch burned with high severity in 1984 from HAPS (**Left**) and MTBS (**right**) data. Mean and median distance to edge were 133 m and 95 m for HAPS. Mean and median distance to edge were 70 m and 60 m for MTBS. This patch, the only patch burned in our study area in 1984, was mapped by both HAPS and MTBS, and it is a good representation of the differences in mapping techniques.

More and Smaller High Severity Patches

79% of our study area has burned and 49% of that severely in our 108-yr record. This lasting legacy of fire on the landscape supports the notion that previous fires have limited the size of subsequent fires.

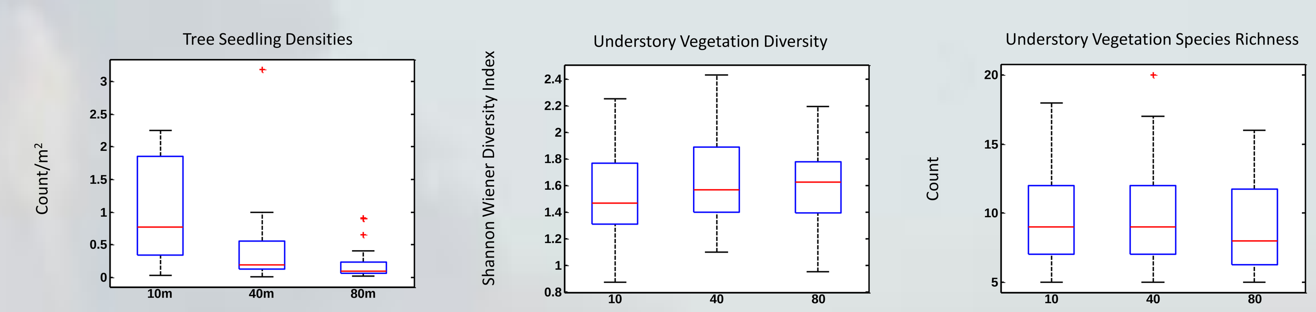

***Figure 10*. Left:** Densities of tree seedlings (aggregate of all species found) at varying distances from the unburned edge into a high severity burn patch. **Center:** Understory vegetation calculated using the Shannon Wiener Diversity Index. **Right:** Understory vegetation species richness (count) at distance from unburned edge. For all graphs N=20.

Tree Seedling Densities Decrease as Distance from Edge Increases

This is likely related to seed source. The unburned edge has less effect for understory vegetation diversity and species richness because many fire tolerant species resprout post-fire or establish from existing seed banks.

ACKNOWLEDGEMENTS
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References

[1] Morgan, P., Gibson, C.E., Heyerdahl, E.K., 2008. Multi-season climate synchronized forest fires throughout the 20th century, northern Rockies, USA. Ecology 89, 717-728. **[2]** Keeley, J.E., 2009. Fire intensity, fire severity and burn severity: a brief review and suggested usage. International Journal of Wildland Fire 18. **[3]** Westerling, A.L., Hidalgo, H.G., Cayan, D.R., Swetnam, T.W., 2006. Warming and earlier spring increase Western U.S. forest wildfire activity. Science 313, 940-943. **[4]** Lentile, L.B., Holden, Z.A., Smith, A.M.S., Falkowski, M.J., Hudak, A.T., Morgan, P., Lewis, S.A., Gessler, P.E., Benson, N.C., 2006. Remote sensing techniques to assess active fire characteristics and post-fire effects. International Journal of Wildland Fire 15. **[5]** Miller, J.D., Safford, H.D., Crimmins, M., Thode, A.E., 2009. Quantitative Evidence for Increasing Forest Fire Severity in the Sierra Nevada and Southern Cascade Mountains, California and Nevada, USA. Ecosystems 12, 16-32.

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