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Oregon Post-fire Research and Monitoring Symposium: Abstract Compendium

Office of Research and Development
Center for Public Health and Environmental Assessment

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Oregon Post-fire Research and Monitoring Symposium: Abstract Compendium

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INTRODUCTION

Following the 2020 Labor Day fires in western Oregon, several state and federal agencies, along with universities, Tribes, and other organizations, formed the Oregon Governor's Post-fire Research and Monitoring Team to share awareness of each other's activities and to coordinate post-fire monitoring and research. The collaborative operates as an element of the Oregon Governor's Natural and Cultural Resources Recovery Task Force. Technical experts from across organizations are identifying and documenting research and monitoring activities underway, assessing knowledge and data gaps in those efforts, and exploring opportunities for collaboration. This post-fire research and monitoring collaborative facilitates shared stewardship by increasing awareness of post-fire research and monitoring efforts by various state and federal natural resource agencies, Tribes, and organizations, and promoting shared learning from past fires in Oregon.

The 2023 Post-fire Research and Monitoring Symposium was organized by the Oregon Governor's Post-fire Science Team and was held February 7-9, 2023 at Oregon State University, Corvallis, Oregon. The Symposium aimed to increase awareness among those conducting post-fire research and monitoring in Oregon to provide an opportunity for scientists to share what they are learning or hoping to learn from the recent westside Oregon fires. The symposium also provided an opportunity for practitioners and policy makers to begin discussions on how new discoveries can inform future decision making. Ultimately, the symposium was held to promote collaboration between groups and create networks that are or will be engaged in post-fire research, monitoring, and management.

This report summarizes presentations and discussions following the multi-disciplinary, post-fire symposium. The technical content of this report is based solely on information and discussions from the conference. Approximately 750 participants attended some portion of the conference, with nearly half in person. Attendees represented stakeholders with common interest in fire, including federal, state, and local government agencies and laboratories; academia; Tribes; non-profits; and the private sector.

The Conference consisted of 38 speaker presentations, 45 poster presentations, and 3 invited discussion panels. Topics covered by the presenters included: the intersection of climate and wildfire, post-fire forest dynamics, post-fire impacts to aquatic and riparian habitat and organisms, human impacts of wildfire, wildlife impacts of wildfire, post-fire hydrogeomorphic change, post-fire soil and debris flow hazards, and pre- and post-fire management. The panels included discussions on the topics of air quality during and after wildfire, post-fire water quality, and pre-fire land management. These panels were titled, "The future of air quality during wildfires in western Oregon", "The next pre-fire landscape: how does a new landscape management paradigm emerge?", and "Fire in riparian areas – implications to future water quality management." This report consists of the symposium agenda followed by the presentation and poster abstracts from the Post-fire Symposium. Abstracts are grouped by topic and not with the order in which they were presented at the event.

*** Underlined author was the presenter. Abstracts without an underlined author was a poster presentation.*

SYMPOSIUM AGENDA

Day 1: February 7th, 2023

Time	Topic	Speaker
8:30 – 8:40	Welcome!	**Cheryl Friesen, Science Liaison, USFS**
8:40 – 9:00	Oregon Governor's Post-Fire Research and Monitoring Team	**Jessica Halofsky, Director, U.S. Forest Service Northwest Climate Hub and Western Wildland Environmental Threat Assessment Center, and James Markwiese, Chief, Ecology Effects Branch, U.S. Environmental Protection Agency**
9:00 – 9:20	Cultural Perspectives on Fire	***Briece Edwards, Deputy THPO; Manager of the Historic Preservation Office, Confederated Tribes of Grand Ronde***
	Investigating How Present-Day and Future Climate will Influence Wildfire	
9:20 – 9:45	Climate change modifies future burn probability, size, and frequency of wildfires in Oregon's West Cascades	***Alex Dye, OSU***
9:45 – 10:10	Forest fires in Western Cascadia: evaluating climatic drivers to inform climate-adaptive management responses	***Crystal Raymond, Univ. of Washington***
10:10 – 10:30	**Break**	
10:30 – 10:55	FIA remeasurement within 2020 Labor Day Fires reveals supremacy of fire weather over forest structure, error associated with mapped burn severity products, and statistical estimates of live to dead carbon pool conversions	**Jeremy S. Fried, Sebastian Busby and Angel Klock*, USFS PNW Research Station***

Time	Topic	Speaker
10:55 – 11:20	Spatial patterns of burn severity in Western Cascadia: characteristics, drivers, and implications for post-fire landscapes	***Brian J. Harvey, Univ. of Washington***
11:20 – 11:45	Large influence of soil moisture on wildfires, biological disturbance agents, and tree growth in Pacific Northwest coniferous forests	***E. Henry Lee, EPA***
11:45 – 12:00	Flash-Talk: 800 years of post-fire forest recovery data in west side Douglas-fir forests	***Andrew Merschel, PNW Research Station and OSU***
12:00 – 1:30	**LUNCH ON YOUR OWN and DEMONSTRATION/POSTERS** **We encourage you use this opportunity to network and learn!** ***Posters and demonstrations in the lobby***	
1:30 – 1:55	A 3600-year history of vegetation and fire dynamics from the Bull Run Watershed Management Area, Mt. Hood National Forest	***William "Buzz" Nanavati, Portland State Univ.***
1:55 – 2:20	Fire refugia, old forests, and northern spotted owls: a synthesis of key concepts, trends, and toolsets for local to regional conservation planning	***Cameron Naficy, OSU***
2:20 – 2:45	Exploring how microclimates and biotic factors influence post-fire forest plant communities	***Cole Doolittle, Marquette Univ./ HJA Experimental Forest***
2:45 – 3:05	**Break**	
	Delayed Mortality Flash Talks ***Facilitated by Andres Holz, Portland State Univ.***	
3:05 – 3:20	Sizing up the elephant in the room: Remote sensing of post-fire delayed tree mortality in westside forests of the Pacific Northwest	***Matthew Reilly, USFS PNW Research Station***
3:20 – 3:35	Spatio-Temporal Patterns and Drivers of Fire Refugia in the Western Oregon Cascades	***Alec Dyer, Portland State Univ.***

Time	Topic	Speaker
3:35 – 3:50	Post-wildfire delayed mortality in Douglas-fir and western hemlock	***Andrés Holz, Portland State Univ.***
3:50 – 4:05	Understanding drivers of post-fire delayed mortality in temperate rainforests	***Andrés Holz, Portland State Univ.***
4:05 – 4:15	***Group Q&A***	
	Early-Seral Forest Flash Talks ***Facilitated by Alex Rozin, Post-Fire Program Lead, USFS R6***	
4:15 – 4:25	Patterns and drivers of conifer regeneration following stand-replacing wildfire in western Cascadia	***Madison Laughlin, Univ. of Washington***
4:25 – 4:35	Composition and diversity of early-seral forest communities vary with burn severity and pre-fire stand age following fire in western Cascadia	***Liliana Rangel-Parra, Univ. of Washington***
4:35 – 4:45	Twenty-year post-fire recovery in western Oregon: Tracing early seral trajectories with a spatially balanced forest inventory sample	***Oriana Chafe and Jeremy Fried, USFS PNW Research Station***
4:45 – 4:55	**Group Q&A**	
4:55 – 5:00	**WRAP UP**	***Cheryl Friesen, Science Liaison USFS***
5:00 – 7:00	***<u>POSTER SESSION AND SOCIAL</u>*** ***Posters will be staffed with the authors/co-authors***	

Day 2: February 8th, 2023

Time	Topic	Speaker
8:00 – 8:05	Welcome!	**Cheryl Friesen, Science Liaison, USFS**
8:05 – 8:30	All lands, All Hands: Caring for our natural and human environments	***Doug Grafe,*** Wildfire Programs Director, Governor's Office
	The Fire Continuum	
8:30 – 9:25	PANEL DISCUSSION: **The future of air quality during wildfires in Western Oregon**	***Facilitated by James Markwiese, EPA, with: Rick Graw, USFS; Steve Dietrich, LRAPA; Hollie Smith and Heidi Huber-Stearns, UofO; Tom Roick, DEQ; Dr. Carol Trenga, OHA; Kyle Chapman, OIT; and Cassandra Mosely UofO***
9:25 – 9:50	Examining wildfires from other regions and fire regimes yields insights into future patterns of burn severity in western Cascadia	***Michele Buonanduci, Univ. of Washington***
9:50 – 10:15	Impacts of forest structure and fire severity on reburn potential in western Cascadia	***Jenna Morris, Univ. of Washington***
10:15 – 10:35	**Break**	
10:35-11:00	Rock Creek post-fire restoration monitoring	***Jeff McEnroe, BLM***
11:00 – 12:00	PANEL DISCUSSION: **The next pre-fire landscape: how does a new landscape management paradigm emerge?**	***Facilitators: James Dickinson, BLM and Alex Rozin, USFS*** ***Panel: Andrew Puerini and Dustin Hawks, Confederated Tribes of Grand Ronde; Barbara Garcia and Rebecca Lloyd, USFS***
12:00 – 1:30	**LUNCH ON YOUR OWN and DEMONSTRATION/POSTERS** **We encourage you use this opportunity to network and learn!** ***Posters and demonstrations in the lobby***	

	Water and Riparian Habitat in the Post-Fire Environment	
1:30 – 1:55	Riparian vegetation dynamics two years after mixed severity fire in the western Cascades, Oregon	***Laura J. Six, Ashley Coble, Jake Verschuyl, NCASI***
1:55 – 2:20	Quantifying the effects of wildfire on water quantity, water quality, aquatic ecology, and fish: the Hinkle Creek Watershed Study revisited	***David Roon, OSU***
2:20 – 2:45	Post-fire hyperspectral surveys for periphyton to protect drinking water quality in three Cascade Range rivers following the September 2020 wildfires	***Kurt Carpenter, USGS***
2:45 – 3:05	**Break**	
3:05 – 3:45	Forested streams, fire, and large wood across a gradient of fire severity and forest stand age What happens to fish when their forest is on fire? Answers from 24 Oregon streams	***Ashley A. Coble, NCASI*** ***Brooke Penaluna, USFS PNW Research Station***
3:50 – 4:20	Holiday Farm Fire: Impacts on shade/stream temperature on private timberland Holiday Farm Fire: Impacts to the upstream extent of fish distribution in headwater streams on private timberlands	***Mark River, Weyerhaeuser Co.*** ***Jason Walter, Weyerhaeuser Co.***
4:20 – 5:00	PANEL DISCUSSION: **Fire in riparian areas – implications to future water quality management**	***Facilitated by Aaron Borisenko, DEQ*** ***Lorrayne Miralha, OSU; David Donahue, EWEB; Julie Harvey, DEQ; and Kurt Carpenter, USGS***

7:00 – 8:00 - ***In CH2M Hill Alumni Center Ballroom***

EVENING SPECIAL EVENT

FOLLOWING FIRE: A Resilient Forest / An Uncertain Future

A Photographic Essay

www.followingfire.com

Over two years and dozens of site visits to the Holiday Farm Fire area along the McKenzie River, we have explored the art-science interface in burned forest. The photographic work has developed along four paths: Chronosequence, Typology, Documentary and Fine Art. Each photo technique and resulting body of works open distinctive opportunity for conversation.

The post-fire landscape is both devastating and starkly beautiful. The skeletal forest quickly gives way to a succession of biota (fire fungi, fire moss, fireweed), and successions of forms, colors, and processes, revealing the amazing resilience of forests. But, quickly, we sense the uncertain future posed by climate change, invasive species, and intensive forest management.

David Paul Bayles[1], Photographer, and Fred Swanson[2], Retired USFS Geologist

[1] David Bayles: *David currently lives and photographs in western Oregon, where highly efficient industrialized tree farms supplanted the massive old growth forests many decades ago. He is currently working on a long term project with disturbance ecologist Frederick J Swanson, documenting the forest recovery after the massive 2020 Holiday Farm Fire in the McKenzie River watershed.*

His photographs have been published in numerous magazines including Orion, Nature, Terrain, Audubon, Outside, The L.A. Times Sunday Magazine and others. Public collections include The Portland Art Museum, Santa Barbara Art Museum, Jordan Schnitzer Museum of Art, The Baldwin Collection MTSU, The Harry Ransom Center, Wildling Museum and others. His book Urban Forest, Images of Trees in the Human Landscape was chosen by The Christian Science Monitor as one of their seven favorite books of 2003. The Bancroft Library at UC Berkeley created the David Paul Bayles Photographic Archive in 2016 as a permanent home for his entire life's work.

Sierra Club Urban Forest, by David Bayles. 2 dozen books given away free at the event

[2]*Fred Swanson: Fred Swanson is a retired US Forest Service, Pacific Northwest Research Station, Research Geologist with a focus on the geology-ecology interface, including disturbance ecology in the face of fire, floods, volcanic eruption, and other processes. Since 2000 he has facilitated engagement of creative writers and artists in the H.J. Andrews Experimental Forest and Mount St. Helens landscapes through the Spring Creek Project for Ideas, Nature, and the Written Word, based in Oregon State University. More than one hundred writers and artists have taken part in residencies and much of their work is documented in The Forest Log on the Spring Creek webpage and in several books.*

The Forest Log: https://liberalarts.oregonstate.edu/centers-and-initiatives/spring-creek-project/programs-and-residencies/long-term-ecological-reflections/forest-log

Day 3: February 9th, 2023

Time	Topic	Speaker
8:00 – 8:05	Welcome!	***Facilitated by Bill Burns, DOGAMI***
	Post-fire Soils and Debris Flow Hazards	
8:05-8:25	Quantifying impacts of forest fire on soil carbon in a young, intensively managed tree farm in the western Oregon Cascades	**Katherine McCool, OSU**
8:25-8:45	Soil carbon persistence and pyrogenic carbon signature in Oregon's Western Cascades one year post fire	**Hayley Peter-Contesse, OSU**
8:45 – 9:05	Evaluating the occurrence and spatial patterns of soil water repellency in the Deschutes National Forest, Oregon	**Brittany Johnson, UW**
9:05 – 9:30	Evaluating the controls on post-fire debris flows in the Pacific Northwest	***Ben Leshchinsky, OSU***
9:30 – 9:55	National Weather Service services for post-fire debris flow hazards in Northwest Oregon	***Andy Bryant, NOAA***
9:55 – 10:15	**Break**	
10:15 – 10:40	Recent observations of post-fire debris flows in five megafires in the western cascades, Oregon	***William Burns, DOGAMI***
10:40 – 11:05	Pairing on-the-ground observations with real-time telemetered rainfall data to develop a post-fire debris flow inventory in Oregon	***Francis Rengers, USGS***
11:05 – 11:30	Dealing with post-fire soil movement in a complex human environment: the Gorge!	***Michael J. Zimmerman, Senior Engineering Geologist, ODOT Region 1***
11:30 – 11:55	Navigating the world of building back communities, and the importance of good science to inform hazard mitigation and post fire reconstruction	***Stan Thomas, Deputy Director, Oregon Department of Emergency Management. Mitigation and Recovery Division***
11:55- 12:00	**Wrap-up, End**	***Cheryl Friesen, Science Liaison, R6***

2. CLIMATE AND WILDFIRE

Four of the presentations examined wildfire behavior, severity, and climate. For example, by examining the relationship between fire behavior and projections of energy release component, Dye et al. investigated how wildfire probability, size, and frequency could change in a warming climate. Raymond et al. developed statistical relationships between area burned and a large set of weather and seasonal climatic variables including temperature, precipitation, drought indices, and wind in western Cascadia. They found that "the key climatic predictors of wildfire for this region emerged as seasonal (60-day prior) and short-term (7-day prior) temperature, and wind speed." Lee et al. addressed the role of soil moisture in tree growth, fire, and tree mortality from biological disturbance agents in the Pacific Northwest (PNW), and they found that "increased rates of disturbance by fire and insects in the PNW and tree growth decline are most strongly associated with decreasing available soil water (ASW) in recent decades, and the area burned westside in 2020 was most strongly associated with antecedent climatic conditions of anomalously low ASW."

Climate Change Modifies Future Burn Probability, Size, and Frequency of Wildfires in Western Oregon and Washington

Alex Dye[1], Matthew Reilly[2], Karin Riley[3], Andy McEvoy[2], Rebecca Lemons[1], John Kim[2], and Becky Kerns[1,2]

[1]Oregon State University

[2]USFS Pacific NW Research Station

[3]USFS Rocky Mountain Research Station

The moist forests of Oregon's West Cascades are historically a low frequency-high severity fire regime. Large, devastating fires have occurred in the region, such as the infamous September 2020 fires that burned throughout the western Pacific Northwest. However, it remains uncertain how fire probability, size, and frequency could change in the future for this region. it remains uncertain how this could change in the future. Using projections of energy release component (ERC) derived from 28 global climate models, we simulated thousands of plausible fire seasons with the stochastic spatial fire spread model FSim for both mid- (2040–2069) and end-century (2070–2099). Relative to the contemporary baseline (1992–2020), annual burn probability increases by a median of about 30% by mid-century and about 320% by end-century. Future changes to fire probability, size, and frequency are robustly explained by the projected number of days per year exceeding the 80^{th}, 90^{th}, and 97^{th} percentiles ERC, demonstrating that ERC is a reliable predictor of fire behavior; we leverage this relationship to construct a statistical clustering of GCM projections based on common features of projected fire risk.

Forest Fires in Western Cascadia: Evaluating Climatic Drivers to Inform Climate-adaptive Management Responses

Crystal Raymond[1], Karin Bumbaco[1], Nick Bond[1], Brian Harvey[1], Josh Halofsky[2], Dan Donato[2]

[1] *University of Washington*

[2] *Washington Department of Natural Resources*

Climate is a critical driver of wildfire in the western US, influencing area burned, seasonality, and frequency of large fires. However, most documented relationships with climate are limited in western Cascadia, where fires have been historically and naturally large and severe, yet infrequent. A lack of fires in this area in contemporary records, such as Monitoring Trends in Burn Severity, along with the importance of wind as a driver, has complicated statistical analysis of climate-fire relationships. At a convening on western Cascadia wildfire in 2018, federal, state, local and tribal entities identified a strategic science need: improved information on the climatic drivers of wildfire on the westside. Since the 2018 convening, several wildfires have burned in western Cascadia, most notably the 2020 Labor Day fires, making such an analysis of climate-fire relationships both more urgent and feasible. Using a subset of fires that burned between 2000 and 2020 in northwestern Oregon and western Washington (the high-severity fire regime), we developed statistical relationships between area burned and a large set of weather and seasonal climatic variables including temperature, precipitation, drought indices, and wind. The key climatic predictors of wildfire for this region emerged as seasonal (60-day prior) and short-term (7-day prior) temperature, and wind speed. Using thresholds for small and large fires identified by the statistical relationships, we explored 12 regional climate model simulations to identify projected changes in temperature and winds, jointly and independently, to provide insights on the likelihood of future climatic conditions that support wildfire in western Cascadia. Taken together, understanding of climate drivers and the future likelihood of conditions conducive to large wildfires can help decision-makers and resource managers in this region explore climate-risk reduction activities, and associated funding and actions, needed to foster societal climate resilience.

Large Influence of Soil Moisture on Wildfires, Biological Disturbance Agents, and Tree Growth in Pacific Northwest Coniferous Forests

E. Henry Lee[1], Peter A. Beedlow[1], Steven P. Cline[1], Colin Welk[2], James Markwiese[1], Ronald Waschmann[1]

[1] U.S. Environmental Protection Agency, 200 SW 35th Street, Corvallis, OR 97333, USA

[2] Oak Ridge Associated Universities, 200 SW 35th Street, Corvallis, OR 97333

Droughts in the Pacific Northwest (PNW) of the United States are causing tree mortality and increasing tree die off from wildfire and biological disturbance agents (BDAs, i.e., pests and pathogens) but the disturbance-climate relationships are not well understood. Significant tree mortality has been linked to prolonged drought in recent decades in western North America. However, our understanding of drought's influence on forest susceptibility to wildfires and BDAs is limited due to a lack of soil moisture data. We address the role of soil moisture in tree growth, fire, and tree mortality from BDAs in the PNW based on long-term data from a network of monitored field sites in the Douglas-fir region of western Oregon established by the United States Environmental Protection Agency in the late 1990s. We examine the relationships between climate and area burned by fire to compare the fire-climate relationships between biomass-rich and biomass-poor ecoregions in the PNW. Our findings indicate that increased rates of disturbance by fire and insects in the PNW and tree growth decline are most strongly associated with decreasing available soil water (ASW) in recent decades, and the area burned westside in 2020 was most strongly associated with antecedent climatic conditions of anomalously low ASW. Understanding the important role of soil moisture in forest disturbances by fire and BDAs in the PNW is critical for assessing risk and managing our limited resources to mitigate the socioeconomic and ecological impacts of climate change to the environment and public health.

Leveraging NASA Data to Aid Public Understanding of the Fire Cycle

Jenessa Stemke

NASA FireSense Intern

The technology sector in fire data collection and response is fast advancing. NASA has many assets that are useful in monitoring the fire cycle, which are primarily used for management. There is still significant untapped potential in leveraging NASA data sources to visually communicate fire science. Fire responders have cited public misunderstanding and associated political interference as a challenge to effective landscape management. Spaceborne and airborne data sources relevant to fire include vegetation density, vegetation greenness (using NDVI) vegetation moisture (using NDMI), soil moisture (using SAR data), thermal hotspots (VIIRS). Communicating connections with post-fire landscape health, pre-fire conditions and active fire behavior can bring tangible evidence to explain both how fire activity has become more severe, and provide compelling stories to how we can address this alarming trend.

I'll show a few examples of how post-fire landscape health can be communicated to the public, within the context of the entire fire cycle using spaceborne and airborne data. One such tool is the use of VIIRS thermal hotspots in a 3-D time series and comparison of pre-fire conditions and post-fire burn severity. This can be made available to the public in narrated video, as well as a web-based user interface that allows people to explore data in detail at their own pace. A prime example would be highlighting post-fire vegetation survival in the West Spodue Prescribed burn area within the 2021 Bootleg Fire perimeter. I would also like to solicit input on how to effectively communicate fire science for a public audience using NASA data sources.

3. POST-FIRE FOREST DYNAMICS

Twenty-one of the symposium presentations addressed post-fire forest dynamics. Of these, two presentations reconstructed long-term environmental histories to examine post-fire forest recovery and reburn (Merschel et al. and Nanavati et al.). Four presentations discussed delayed tree mortality after fire in the Pacific Northwest (Reilly et al., Dyer and Holz, Hersey and Holz, Holz et al.). For example, Reilly et al. introduced "a remote sensing-based approach for mapping delayed mortality using Landsat time series imagery, aerial photos, and forest plot data from fires in California, Oregon, and Washington."

Another five of these presentations focused on early seral forests and seedling performance after fire (Laughlin et al., Rangel-Parra et al., Fletterick and Greene, LeTendre et al., Morrissette et al.). For example, Laughlin et al. investigated the patterns and drivers of conifer regeneration following stand-replacing wildfire in western Cascadia, while Rangel-Parra et al. examined the composition and diversity of early seral forest communities.

Multiple presentations examined the concept of fire refugia, which are areas that remain unburned or minimally effected by fire within a fire perimeter (Krawchuck et al., Naficy et al., Davis et al.). Krawchuck et al., for example, constructed a suite of models to "evaluate drivers of fire refugia and severity, to produce probability surface maps for fire refugia, intermediate-severity fire, and high-severity fire, and to examine how probability shifts under low, moderate, and extreme fire weather and fire growth scenarios." Multiple presentations also addressed spatial patterns of burn severity (Harvey et al., Cansler et al., Buonanduci et al.) and potential for reburn (Morris et al).

FIA Remeasurement within 2020 Labor Day Fires Reveals Supremacy of Fire Weather Over Forest Structure, Error Associated with Mapped Burn Severity Products, and Statistical Estimates of Live to Dead Carbon Pool Conversions

Jeremy S. Fried[1], Sebastian Busby[1] and Angel Klock[1]

[1]USDA Forest Service PNW Research Station

The Forest Inventory and Analysis (FIA) program collects a spatially balanced and statistically representative sample of forested lands in the Pacific Northwest. We implemented a Fire Effects and Recovery Survey (FERS) remeasurement protocol on 248 FIA plots within the footprints of six 2020 "Labor Day Fires" that burned over 700 thousand acres of west Cascades forests under mostly extreme, yet temporally variable fire weather. Given that these fires burned across a broad range of ownerships and management histories, our dataset can address important, policy-relevant questions related to fire effects and forest management in mesic westside forests and estimate ecological impacts. To illustrate potential uses and strengths of this dataset, we present preliminary findings concerning (1) the influence of stand structure on fire effects, (2) live to dead carbon pool conversions including salvage logging, and (3) classification error associated with modeled burn severity products. Ongoing post-post-fire remeasurement, already underway, will pay dividends with empirically based, statistically representative descriptions of post-fire ecosystem trajectories and carbon dynamics, with and without active management. Such critical information on short and long-term fire outcomes and drivers will only emerge with continuing investment in inventory analysis, including growth, removals and mortality compilation and dogged attention to analytical quality control and assurance.

800 Years of Post-fire Forest Recovery Data in West Side Douglas-fir Forests

Andrew Merschel[1], Matthew Reilly[2], James Johnston[3]

[1]USFS PNW Research Station and the College of Forestry at Oregon State University
[2]USFS PNW Research Station
[3]College of Forestry at Oregon State University

Recovering and adapting to recent wildfires in western Oregon and Washington is an enormous challenge that can be informed by an understanding of how severely burned forests historically transitioned from early seral ecosystems into mature and old-growth forests. Some historical maps and accounts of 19th and early 20th century wildfires depict a fire regime characterized by infrequent large, high-severity fires. However, systematic, temporally precise, and accurate tree-ring reconstructions of historical fire regimes and forest dynamics that could test this characterization are lacking in west side forests. Tree ring records provide longer records of historical fires and post-fire forest development that predate European records by several centuries. In addition, they precisely link fire events to tree establishment and can describe the historical role of low- and moderate-severity fire and reburns that followed severe wildfires.

Since 2018, we have developed 110 new reconstructions of fire and forest development across the Umpqua, Willamette, Mt. Hood, and Gifford Pinchot National Forests. We address three questions using 20th century records of historical wildfires and forest conditions, and the newly developed tree-ring records. How long did early seral ecosystems persist following historical wildfires? How common were reburns? What diversity of development pathways and forest conditions historically occurred post-fire? These reconstructions document enormous diversity in fire frequency and effects across west side forests over the past 8 centuries. Following severe wildfires, low- and moderate-severity reburns that diversified age structure were common, and open early seral conditions and Douglas-fir establishment usually lasted for several decades to a century. Variation in the severity, timing, and amount of reburns following severe fires historically drove broad diversity in the composition and structure of young, mature, and old-growth forests on the west side. These records provide critical context for interpreting post-fire monitoring datasets and evaluating post-fire recovery.

A 3600-year History of Vegetation and Fire Dynamics from the Bull Run Watershed Management Area, Mt. Hood National Forest

William Nanavati[1], Daniel Gavin[2], Andrés Holz[1], Megan Walsh[3]

[1]Dept. of Geography, Portland State University
[2]Dept. of Geography, University of Oregon
[3]Dept. of Geography, Central Washington University

The recovery of mesic western Cascade forest following fires, such as those that occurred in 2020, is of great concern. Much of our ecological understanding of post-fire recovery of westside forests is based on information that spans the past few hundred years – a brief snapshot relative to the frequency of past fires. We present a new sediment record from Upper Goodfellow Lake (3122 ft) located in the Bull Run Watershed Management Area of Mt. Hood National Forest. This record provides a 3600-year environmental history from the *Tsuga heterophylla* and *Abies amabalis* forest ecotone. Pollen, charcoal, and geochemistry are compared with dendroecological records to assess long-term ecological responses to fires. Between ~3600 and 2400 calibrated years before present (BP), Pinus and open forest taxa were present and fires occurred every ~200 years. After a fire at ~1800 BP, erosion increased and Ceanothus and Alnus expanded at the expense of T. heterophylla, suggesting that local, severe, and possibly repeated burns cleared the nearby forest. Pseudotsuga increased ~100 yr post-fire and T. heterophylla recovered ~300 years post-fire, suggesting recovery to pre-fire conditions. Three fires between ~1400 and 900 BP were associated with increased Alnus and Pinus at the expense of T. heterophylla, suggesting open conditions. Low fire activity during the last ~900 years facilitated an increase in Cupressaceae (mainly Thuja) and Pseudotsuga at the expense of Alnus. The Bull Run Fire in 1493 CE increased erosion and expanded Alnus at the expense of coniferous taxa. Following the Bull Run Fire, T. heterophylla recovered and increased to above pre-fire levels within 200 years post-fire, until recent logging and slash burning. These results suggest that similar-to-present forest conditions persisted near Upper Goodfellow Lake for >3600 years with fires as frequent as 200 years/fire. However, recovery to pre-fire conditions following severe, repeated fires took multiple centuries.

Exploring How Microclimates and Biotic Factors Influence Post-fire Forest Plant Communities

Cole J. Doolittle[1,2], David M. Bell[2,4], Meg A. Krawchuk[2,3], Joseph A. LaManna[1,2], Andrés Holz[2,5], Catalina Segura[2,6]

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Understanding how forest plant communities respond and recover following disturbance is key to determining drivers of local biodiversity as well as predicting future shifts in forest community composition under climate change. However, quantifying species-specific responses to disturbances remains challenging, particularly within structurally complex old-growth forest communities where conditions vary over short spatial and temporal scales. For example, complex topography, steep elevational gradients, and diverse forest structural conditions arising from varied disturbance histories have dramatic effects on fine-scale variation in temperature and moisture dynamics under forest canopies. These microclimatic conditions, in turn, likely influence plant regeneration patterns on the forest floor, thus influencing future forest structure and community composition. To capture the changing effects of microclimate and biotic interactions on forest plant communities we have established a network of understory plant survey plots and microclimate sensors across a fire severity gradient at the H.J. Andrews Experimental Forest Long-Term Ecological Research site in Blue River, Oregon. The Holiday Farm Fire, part of the Labor Day 2020 fire complex, burned through the several experimental watersheds at the H.J. Andrews, including forest inventory plots established in the 1970s. By combining these existing datasets with our new sampling efforts, we hope to untangle relationships between post-fire forest structures, microclimates, and plant regeneration patterns. Here, I present the focus and scope of this study, and share early evidence for fire severity and microclimates influencing regeneration dynamics for two socio-ecologically important tree species: Douglas-fir (Pseudotsuga menziesii) and western hemlock (Tsuga heterophylla), which together make up more than 62% of plant biomass in the region. By better understanding the factors influencing plant regeneration following wildfires, we can generate predictions and conservation strategies tailored to mitigating forest change and biodiversity loss in a changing world.

Spatial Patterns of Burn Severity in Western Cascadia: Characteristics, Drivers, and Implications for Post-fire Landscapes

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Spatial patterns of burn severity affect the landscape arrangement of key dimensions of forests (e.g., patterns of tree regeneration, early seral plant communities, carbon). However, insight on the characteristics and drivers of burn severity patterns is particularly lacking in forests shaped by infrequent and severe fires, as opportunities to study events are inherently rare. In this study, we developed regional maps of burn severity for forests west of the Cascade Crest in Washington and northern Oregon, USA ('western Cascadia') for all fires from 1984 to 2020 using a network of field plots and field-calibrated satellite burn severity maps. We then characterized patterns and drivers of high-severity (stand-replacing) fire, to build understanding of the spatial signature of the western Cascadia fire regime. Further, we asked if the historic Labor Day fires of 2020, which burned under extreme conditions associated with a regional synoptic wind event, had qualitatively different burn severity patch configurations than other fires that occurred in the past 3.5 decades. For all fires that burned between 1984 and 2020 in the western Cascades, the percentage of area burning as stand-replacing was variable for smaller fires (ranging from <5 to >75%), but was consistently ~50% for fires >2,500 ha in extent. Across all fires, more than 75% of stand-replacing patches were smaller than 1 hectare in size, though collectively those small patches accounted for less than 1% of total stand-replacing fire. Conversely, 12 individual patches of stand-replacing fire, all resulting from the 2020 Labor Day Fires, were larger than 1,000 ha in size and accounted for >70% of total stand-replacing burned area regionwide. Our findings address an important knowledge gap in understanding burn severity patterns characteristic of western Cascadia, and provide insight into how mechanisms of resilience to fire are spatially distributed in post-fire landscapes.

Did Ecological Forest Restoration Treatments in Dry Forest Moderate Burn Severity of the 2021 Bootleg Fire?

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In July 2021, the Bootleg wildfire burned across ~412,000 acres in south-central Oregon, including 12,000 acres of The Nature Conservancy's Sycan Marsh Preserve, where numerous tribal, academic, and public agency scientists have studied the ability to safely restore the role of fire in these dry forests through ecological thinning and by reintroducing fire via controlled burning during safe conditions. These "ecological forest restoration treatments" were conducted to improve the health of the ecosystem, increase resilience to warmer and drier weather, and to moderate the intensity and severity of wildfires. Preliminary results at the both the plot and landscape scales support that areas previously treated with prescribed fire, either alone or in combination with thinning, burned with lower severity during the Bootleg wildfire; the majority of these areas were either unchanged or burned with low severity (0–25% of trees killed), while in untreated areas the majority burned with high severity (>75% tree mortality). Areas that had been ecologically thinned without controlled burning after the thinning burned during Bootleg with moderate to high severity, but with lower severity than untreated areas. The preliminary results from our evaluation at Sycan are well aligned with a robust and growing body of research across western North America demonstrating the effectiveness of ecological forest restoration treatments that include the reintroduction of fire. Future work will include an in-depth analysis of treatment effectiveness across the entire Bootleg fire. We will couple a fire-wide analysis of treatment effectiveness with focused analysis of the treatments in Sycan, for which we have detailed treatment implementation data, information on fire management actions during the wildfire, and pre-fire forest structure measurements from aerial lidar. Analysis methods will parallel past research across multiple fires in northcentral Washington, and more recent case study of treatment effectiveness in the 2021 Schneider Springs wildfire in Washington.

Examining Wildfires from Other Regions and Fire Regimes Yields Insights into Future Patterns of Burn Severity in Western Cascadia

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In western Cascadia, the region west of the Cascade Crest in Washington and northern Oregon, large wildfires have historically been infrequent, with stands severely burning every one to several centuries. As climate changes worldwide, large increases in future area burned are expected to occur in historically cool, wet systems such as western Cascadia, where fire activity has been strongly limited by climate and ignitions rather than fuel. Developing post-fire response plans for western Cascadia requires an understanding of the high-severity patch structure within fire events (i.e., the size and shape of patches), as areas burned at high severity are where management intervention is often of greatest priority. However, the sparseness of empirical data for western Cascadia limits our understanding of fire and fire effects in this region and presents a challenge for quantifying the expected range of burn severity patterns using data from this region alone. Leveraging a satellite fire severity dataset of 1,615 fire events from the Northwest US between 1985 – 2020, we present an approach for characterizing expected patch-level burn severity patterns in the data-sparse and infrequent-fire region of western Cascadia. We ask: (Q1) How do burn severity patterns in western Cascadia compare to other fire regimes across the Northwest US? (Q2) How might the range of future burn severity patch structure in western Cascadia vary, depending on the size of future fire events? The objective of this research is to help land managers in western Cascadia develop expectations and strategies for adapting to a warmer, drier future that is likely to bring more frequent fire events.

Understanding Post Wildfire Management Effects on Forest Stand Structure and Woody Fuel Loadings

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A warming climate and large, severe wildfires have become the norm in seasonally dry forests of the interior western USA, causing uncharacteristically large, contiguous, stand-replacing patches (e.g., 100% basal area mortality). Active postfire management activities (e.g., salvage logging) can reduce the potential for reburns, but are controversial and quantitative data is needed to compare the ecological tradeoffs between active and passive management following larges wildfires. We established a national postfire monitoring project to provide quantitative data on postfire stand structural characteristics, fuel dynamics, seedling survival and regeneration, and shrub and herbaceous regeneration following the 2020 Beachie Creek and Archie Creek fire perimeters on the Bureau of Land Management (Roseburg District), Bureau of Land Management (Northwest Oregon District) and Umpqua National Forest (NF). Projects are also established on 1) Sierra NF, 2) Plumas NF, 3) Mendocino NF, 4) Shasta Trinity NF, 5) Umpqua NF, 6) Klamath NF, 7) Fremont-Winema NF, 8) Umatilla NF, 9) Boise NF, 10) Eldorado NF, 11) Rogue River-Siskiyou NF, 12) Colville NF, and 13) Confederate Tribes of Coville Reservation. We use a combination of ground-based, experimental studies (paired-sample and complete randomized block design) and simulation modeling (Fire and Fuel Extension to the Forest Vegetation Simulator) to characterize postfire fuelbed characteristics and quantify the short-and long-term effects of active (e.g., salvage logging) and passive (e.g., no action) management treatment effects on fuel dynamics and forest succession following large stand-replacing wildfires. Project outputs will inform postfire management interventions to move trajectories toward desirable future conditions and improves the scientific basis for prioritizing postfire restoration treatments, reforestation strategies, and fuel management strategies.

Impacts of Forest Structure and Burn Severity on Reburn Potential in Western Cascadia

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Recent fires have burned nearly half a million hectares west of the Cascade Crest in Washington and Oregon (‘western Cascadia’), raising concerns about wildfire risk to forests and communities. Climate-driven increases in fire activity promote the likelihood of reburns with consequences for forest recovery, human values, and management operations. Historical evidence suggests western Cascadia forests have a tendency to reburn multiple times in the decades following an initial burn, though mechanisms of reburn potential are not fully understood. To address this uncertainty, we characterized post-fire fuel profiles in moist conifer forest stands distributed across recent (2017–2020) fires in western Cascadia, asking: how is reburn potential influenced by (a) pre-fire stand age and (b) burn severity? Within each fire, we measured live and dead surface and canopy fuel loads in 1-ha plots established 2–4 years post-fire. Plots were stratified by pre-fire stand age (young, mid-seral, late-seral structural classes) and burn severity (unburned; low, <30% mortality; stand replacing, ≥90% mortality). Differences in fuel profiles across strata were analyzed using generalized linear models. Preliminary results suggest post-fire fuel loads increased with pre-fire stand age, but had more variable responses to burn severity. Total and live post-fire canopy fuels decreased–and dead fuels increased–with burn severity. Post-fire surface fuels generally decreased with burn severity, though effects were greater for coarse fuels than fine fuels. These findings highlight the dominance of pre-fire stand structure on controlling outcomes of infrequent high severity fire in western Cascadia forests, with important implications for guiding management decisions. Future work incorporating additional sampling in the 2020 Oregon Labor Day fires and fire simulation modeling is underway to further characterize reburn potential and offer insights into post-fire recovery trajectories of western Cascadia forests.

Fire Refugia and Fire Severity in Forests of the PNW: Models, Drivers, and Applications

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Recent stand-replacing wildfires in old forests of the Pacific Northwest (PNW) have increased land manager and scientific interest in fire refugia that can provide important ecosystem services during a time of rapid change. Fire refugia are locations that burn less severely or less frequently than the surrounding landscape, and contribute critical heterogeneity to forest ecosystems. The overall goal of this project is to model, map, and share information on fire refugia essential for the conservation and adaptation of mature and old forest ecosystems in the PNW across western Washington, western Oregon, and northern California overlapping with the Northwest Forest Plan area.

We showcase a suite of fire refugia models and products. We developed boosted regression tree models trained on remotely-sensed contemporary (2002-2017) fire refugia, intermediate fire severity, and high-severity fire effects in forests, using topography, fuels/vegetation, fire weather, fire behavior, and climate as explanatory variables. This framework enabled us to represent normal versus extreme fire growth events – the latter exemplified by the 2020 Labor Day fire events. We used these models to evaluate drivers of fire refugia and severity, to produce probability surface maps for fire refugia, intermediate-severity fire, and high-severity fire, and to examine how probability shifts under low, moderate, and extreme fire weather and fire growth scenarios. We tested the predictive capacity of the models on the 2020 and 2021 fire footprints in the region, showing the value of the modelling tools as durable predictors of forest persistence within contemporary and future fire environments.

The fire refugia model suite aims to inform regional conservation planning efforts, project-level planning where old forests and habitat for old-forest associated species are high priorities, and to facilitate critical discussions about the geography of fire and old forests, and their coexistence, as fire activity accelerates with climate warming.

Fire Refugia, Old Forests, and Northern Spotted Owls: a Synthesis of Key Concepts, Trends, and Toolsets for Local to Regional Conservation Planning

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Recent fire activity in the Pacific Northwest (PNW) has caused substantial declines in old forest, raising concern about future old forest and associated species such as the northern spotted owl (NSO). In this context, predictive models of fire refugia are an important tool for identifying and understanding the biophysical factors influencing old forest persistence in the face of climate-driven increases in fire activity. We present results from studies examining the drivers and patterns of predicted and observed fire refugia and fire severity in relation to old forest, NSO nesting/roosting (N/R) cover, and post-fire NSO survival and movement following recent wildfires. Drawing on a series of case studies, we outline how fire refugia models can inform conservation planning for old forest species at regional to project-level scales across the PNW.

Fire refugia probability was positively correlated with old forest and N/R cover. Fire refugia and severity models were effective in predicting the patterns observed in recent wildfires, but prediction skill and spatial patterning differed dramatically between extreme versus normal fire spread events. During extreme fire spread, overall fire severity was higher and old growth and N/R cover burned with equal or greater severity than younger forests, whereas the inverse was true during normal spread events. Only portions of old forest and N/R cover overlap with observed fire refugia, forming zones of persistent and ephemeral old forest and N/R cover that fire refugia models help to identify. Post-fire NSO survival and movement were strongly influenced by the proportion and pattern of burn severity and fire refugia. By combining these datasets, we provide needed insight and robust toolsets that can be used to project fire effects on old forest and associated species for planning and management prioritization at multiple scales.

Wildfire Effects on Northern Spotted Owl Territory Densities. What's Normal and What's Resilient?

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Climate change is altering fire regimes in the western United States. In one fire season alone, the 2020 megafires burned about 8900 km^2 of forest within the northern spotted owl (*Strix occidentalis caurina*) range, resulting in the loss of about 1510 km^2 (a 4-percent loss) of forest cover type used for nesting and roosting. It is important to understand how climate change may affect the geography, frequency, and severity of large wildfires and their effects on population recovery and long-term survival of this species. The Northwest Forest Plan effectiveness monitoring program has monitored the owl's habitat and populations for decades; generating data and developing scientific methods to shed light on this subject.

Here, we compared the effects of two types of large wildfires that burned in recent years in the southwestern Cascades of Oregon. The first type is the normal mixed-severity wildfire, common within most of northern spotted owl's range. The second is the abnormal, historically infrequent, yet extremely large and high-severity type (i.e., megafires). Both types burned equivalent areas, yet the later type had a 16-fold larger impact on territorial northern spotted owl habitat carrying capacity. We posit that the northern spotted owl evolved to exist in forests that burned with moderate frequency and mixed severity. Historically, infrequent megafires would have likely caused local extirpations, but the extent of spotted owl habitat throughout its range was large enough that these megafires didn't risk long-term connectivity and owl persistence. Contemporary spotted owl populations occur in a landscape where habitat is now largely confined to federally managed forests covering less than half of the historical extent. We consider these landscapes are no longer resilient to megafires from the owl's perspective.

Delayed Mortality:

Sizing Up the Elephant in the Room: Remote Sensing of Post-fire Delayed Tree Mortality in Westside Forests of the Pacific Northwest

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Delayed tree mortality following fire is commonly observed in forests world-wide, yet we lack a generalizable method for quantifying delayed mortality at landscape scales. We introduce a remote sensing-based approach for mapping delayed mortality using Landsat time series imagery, aerial photos, and forest plot data from fires in California, Oregon, and Washington. We then compare the extent and timing of delayed mortality, as well as the magnitude and effects on landscape patterns of burn severity in seven fires from the westside of the Pacific Northwest. The method predicted the presence of delayed mortality in 30-meter Landsat pixels cells with 78% accuracy based on aerial photo interpretation and performed nearly as well at estimating the magnitude of delayed mortality as plot-based methods for mapping immediate mortality. Delayed mortality was evident across 6 to 25% of the area within fire perimeters and exhibited highly clustered spatial patterns. Most delayed mortality occurred in the first two years post-fire, but individual fires were highly idiosyncratic in terms of the timing of delayed mortality from three to five years post-fire. Areas initially mapped as unburned/very low-severity (<10% basal area mortality) were reduced by an average of 40% and patch size declined after five years. High-severity (>75% mortality) patch size increased, and total area burned at high severity increased 16.5%. Approximately 50% of the burned area in the high elevation mountain hemlock zone experienced delayed mortality, followed by the silver fir zone at 40%, and the western hemlock zone at 17%. The area affected by delayed mortality also varied among stand structural types, with approximately 32% of mature and old-growth forests experienced delayed mortality. This method can refine mapping of unburned areas and fire refugia, update estimates of habitat and carbon loss, and provide a more comprehensive assessment of landscape and regional-scale fire effects and trends.

Spatio-Temporal Patterns and Drivers of Fire Refugia in the Western Oregon Cascades

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Increasingly frequent, severe, and large wildfires across the western United States may threaten long-term forest resilience as remnant patches of live trees post-fire, known as fire refugia, become scarce with limited successful forest regeneration following a wildfire. Delayed tree mortality can substantially reduce the extent of fire refugia over time, limiting natural tree regeneration that in turn can promote forest conversions to alternative or non-forest states. Although post-fire delayed tree mortality (PFDTM) is well understood at the individual tree level, very little is known about the effect of PFDTM across larger spatial scales. The 2020 Labor Day fires prompted the U.S. Forest Service to remeasure over 200 burned Forest Inventory and Analysis (FIA) plots annually within five megafire perimeters, creating a statistically-representative sample of detailed fire effects across the wildfire events. For the first time in the western Cascades, there is sufficient empirical data to answer critical research questions regarding delayed tree mortality and forest resilience. The proposed research pairs unique post-fire FIA field data with high-resolution remotely-sensed imagery to examine the spatio-temporal effect of PFDTM on fire refugia at the landscape-level in the western Cascades. By quantifying the spatial and temporal patterns of PFDTM and answering questions about the mechanisms behind delayed mortality, a framework can be developed for continuously improving our understanding of the disturbance landscape ecology of temperate rainforests over time. The methodological framework proposed here has the potential to improve our understanding of primary and secondary fire effects on delayed mortality as well as long-term impacts of wildfire on forest resiliency. This will be a critical part of understanding ecosystem resilience to climate change as trends and fluctuations outside of the historically observed ranges of climate variability will continue to create conditions for increased frequency and intensity of wildfires in the western Cascades.

Post-Wildfire Delayed Mortality in Douglas Fir and Western Hemlock

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Climate change is expected to increase the frequency and severity of wildfires, as well as the intensity and the frequency of droughts. Remnant patches of live trees post-fire, otherwise known as fire refugia, are critical for successful forest regeneration following wildfire, especially in obligate-seeding conifer forests. Postfire delayed tree mortality (PFDTM; defined here as tree mortality occurring after one-year postfire) can substantially reduce the extent of fire refugia over time, limiting natural tree regeneration that in turn can promote forest conversions to alternative or non-forest states. To evaluate the effects of climatic and competition stress on PFDTM, we collected treering cores from paired live and dead Pseudotsuga menziesii and Tsuga heterophylla, controlling for tree size and tree-level burn severity (scorching and charring), and measured tree density around focal trees, in an old growth stand affected by the 2020 Holiday Farm Fire in the H.J. Andrews Forest LTER in the western Cascade mountains in Oregon. Cores were scanned, delineated, and crossdated using CooRecorder and CDendro using species-specific, unpublished local master chronologies. Here, we present the approach and preliminary results of our study, where we hypothesize that trees that died following the fire had higher pre-fire stress; i.e., lower radial growth trends, than their live counterparts. This effort aims at contributing towards a better understanding of the mechanisms that influence PFDTM and management practices for more resilient forests.

Understanding Drivers of Post-fire Delayed Mortality in Temperate Rainforests

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Increasingly frequent, severe, and large wildfires across the western United States, compounded with warming conditions and increasingly frequent droughts, are threatening long-term forest resilience. Remnant patches of live trees post-fire, otherwise known as fire refugia, are critical for successful forest regeneration following wildfire, especially in obligate-seeding conifer forests. Post-fire delayed tree mortality (PFDTM; defined here as tree mortality occurring more than one-year post-fire) can substantially reduce the extent of fire refugia over time, limiting natural tree regeneration that in turn can promote forest conversions to alternative or non-forest states. Additionally, and in the absence of fire, extreme drought events disproportionately impact large and tall trees and lead to widespread decline and mortality. While PFDTM at the individual tree level is relatively well understood in dry forests in western North America, little is known about the mechanisms of PFDTM in mesic and productive ecosystems, such as temperate rainforests in the western Cascade Mountains. Following the 2020 Holiday Farm Fire, we collected treering cores from paired live-dead Douglas-fir (*Pseudotsuga menziesii*) and Western hemlock (*Tsuga heterophylla*) to explore the influence of climate (both antecedent and postfire) and tree density (i.e., as competition proxy), controlling for tree-scale burn severity and tree height, in an old-growth forest at the H.J. Andrews Experimental Forest Long Term Ecological Research Network in Blue River, Oregon. We additionally installed and are monitoring dendrometer, microclimate, and soil moisture on a subset of western hemlock trees that were injured, but survived the fire, stratified by tree height and burned severity classes to track sub-diurnal scale dynamics. Here, we report preliminary findings on our subset of Western hemlock trees, where taller individuals burned at high severity appear to be more likely to die than their shorter counterparts, and trees that burned more severely grew slower than trees burned at lower severity irrespective of height.

Early Seral Forests:

Patterns and Drivers of Conifer Regeneration Following Stand-replacing Wildfire in Western Cascadia

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Post-fire tree regeneration is a key mechanism of forest resilience to stand-replacing wildfire. While patterns and drivers of post-fire tree regeneration have been relatively well-studied in historically fire-frequent forests across western North America, insights are currently limited in forests characterized by infrequent and severe fire regimes like those of the western Cascades in Washington and Oregon, USA ('western Cascadia'). Recent wildfire activity (2015-2020) in western Cascadia has provided a unique opportunity to address this knowledge gap. Here, we asked: how is post-fire conifer regeneration across western Cascadia affected by pre-fire stand age, burn-patch size, and topo-climatic conditions? We established 39 1-hectare long-term monitoring plots across strata of pre-fire stand age and forest zone in four wildfires in western Cascadia. In each plot, we collected data on post-fire conifer species composition and abundance. We used generalized linear models to test how conifer establishment rates (seedlings ha-1 yr-1 above 10 cm) and regeneration rates (seedlings ha-1 yr-1 of all heights) responded to (a) pre-fire stand age, (b) distance to the nearest live seed source within stand-replacing patches, and (c) post-fire topo-climatic conditions. In general, regeneration was abundant across stands and we found that a) conifer regeneration rates and tree species richness increased with pre-fire stand age, b) regeneration rates decreased sharply with distance to the nearest live seed source, and c) establishment rates were greater in areas characterized by cooler and wetter macrosite (e.g., greater post-fire precipitation) and microsite (e.g., greater bryophyte ground cover) conditions. Our study provides critical insight on the drivers of post-fire tree regeneration following stand-replacing wildfires in western Cascadia, and informs what factors are likely to support greater forest resilience to fire. Our findings can help inform land management strategies for post-fire responses under the uncertainties of climate change and fire in infrequent, stand-replacing fire regimes.

Composition and Diversity of Early-seral Forest Communities Vary with Burn Severity and Pre-fire Stand Age Following Fire in Western Cascadia

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Naturally occurring post-fire plant communities, also known as complex early seral forests (CESFs), support high levels of biodiversity and ecosystem function, and influence successional trajectories, habitat provisioning, and provide culturally important foods to Native Americans. Compared to post-fire tree regeneration, relatively little is known about CESFs, especially in systems characterized by infrequent high-severity wildfires. We studied CESF plant communities after recent wildfires in western Washington and Oregon ('western Cascadia') to ask: (Q1) how does the flora of CESF communities compare to unburned forests, and (Q2) how do (a) community composition and (b) diversity within and between stands vary with pre-fire stand age and burn severity? We established 86 1-ha plots in four wildfires stratified by pre-fire stand age (young, mid-seral, late-seral) and burn severity (unburned, low, <30% mortality; stand replacing, ≥90% mortality) and measured percent cover for graminoids, bryophytes, and vascular plants to species. Across all stands, we observed 204 vascular plant species. Burned stands had 83 unique species and were dominated by native herbs and fire-adapted shrubs. Community composition varied widely across stands within and among strata, with variations driven strongly by burn severity and secondarily by pre-fire stand age. Within-stand diversity was high (22-32 species per plot) across strata, with the exception of mid-seral unburned stands (11.9 species per plot); evenness did not differ among strata. Our findings have important implications for understanding and managing forests characterized by infrequent stand-replacing fire regimes. For example, our results show that an abundant, though relatively species-poor, forest condition in western Cascadia (mid-seral forests) may experience the greatest increase in biodiversity and compositional heterogeneity following fire. Further, different combinations of pre-fire stand age and burn severity occurring within fires each provide unique CESF community assemblages and thus different habitats and early successional pathways.

Post-fire Arrival Time and Cohort Survivorship of Sexually Reproducing Trees

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Serotinous species have an advantage over other sexually reproducing species in post-fire regeneration as large severe patches do not present a dispersal constraint. But there is an underappreciated second advantage: they germinate in the first post-fire summer when seedbeds are most clement, granivory is lowest, and competition with shrubs is minimized. By contrast, non-serotinous species must wait for a large seed crop to invade the adjacent burn. Using field data we show a number of examples of age-specific survivorship declining with cohort arrival time. We conclude that for non-serotinous species, the interaction of mast crops and the requirement for early arrival means that subsequent species composition of the forest canopy is an essentially random process (the lottery model) whereas for serotinous species, adequate regeneration is reliable.

Impacts of Spatial Variation and Fire Frequency on Microbial Mediation of Conifer and Shrub Seedling Performance

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Forest ecosystems provide many services, ranging from pollution abatement to supporting biological diversity. These ecosystem services are intimately linked to belowground microbiota that drives biogeochemical cycling and alters successional dynamics. However, increasingly frequent wildfires and concomitant drought may impact successional trajectories and contribute to the conversion of forest to shrubland. While historical fire regimes played a vital role in sustaining healthy forests, little is known about the cumulative effects of the increasing frequency of high-severity contemporary wildfires on forest soil microbial communities and forest regeneration. To determine how the frequency of high-severity wildfire and drier post-fire climates are associated with revegetation dynamics, we utilize a glasshouse experiment to measure how living soil inocula from fire-exposed central Oregon field sites impact tree versus shrub recruitment. We examine dominant community members, *Abies grandis* (grand fir) and *Ceanothus velutinus* (snowbrush), as our focal species. We find strong spatial heterogeneity in the impact of soil microbiota on *A. grandis* and *C. velutinus* seedling performance and drought tolerance, which suggests that soil microbes can play a significant role in successful revegetation. However, the frequency of wildfires had inconsistent impacts on altering microbial impacts on plant performance. This suggests that wildfire may have complex and idiosyncratic impacts on microbial mediation of revegetation.

Management Implications of Growing Alder After Intense Westside-fire

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Red alder has long been recognized for its ecological role in responding to natural disturbances including wildfire in the Pacific Northwest. Rather dramatic alder effects on soils have been widely established (i.e., nitrogen fixation, increasing mineral-soil organic matter, and weathering release from primary minerals) that have in many places benefitted the growth of other tree species like Douglas-fir and have wildlife and other benefits. There have been many observations of alder dampening intensity or otherwise altering fire behavior that led Leo Issac to interplant alder between Douglas-fir in a mile-long fire break after the Yacolt burn at Wind River, N of the Columbia River in the Cascades in 1934. The Yacolt burn was a series of fires from 1902 to 1929, with the initial fire very similar to the 2020 Labor Day Fires in Oregon, burning 238,920 acres from September 8 to 12, 1902. Although never experimentally proven, recent wildfire behavior (Holiday Farm Fire) in mixed alder-fir plantations on the Willamette NF LTEP experiment provides a new supportive anecdote. The Wind River trial provides long-term data that show increases in C sequestration in alder-influenced Douglas-fir stands that are 3time that without alder at year 87. Recent spatial analyses of growth of pure alder relative to pure Douglas-fir stands (based on empirically derived G&Y models) suggest that alder can grow more and capture more C in the next 30 years on many westside sites (without considering reducing the extent of wildfire by alder fire breaks, restoring soil fertility, or any effect on subsequent growth of other trees). Taken together, we suggest some trials of alder interplanting in the reforestation efforts following the 2020 Labor Day Fires across different fire intensity and soil types, with Douglas-fir controls.

4. POST-FIRE IMPACTS TO AQUATIC AND RIPARIAN HABITAT AND ORGANISMS

Fifteen of the symposium presentations were on the topic of post-fire impacts to aquatic and riparian habitat and organisms. Two studies investigated riparian vegetation dynamics after the 2020 Oregon wildfires (Six et al. and McKenzie et al.). Roon et al. quantified the effect of wildfire on water quantity, water quality, aquatic ecology, aquatic habitat, and fish after the 2020 Archie Creek wildfire. Coble et al. and Penaluna et al. examined 24 streams in the Cascade Range in western Oregon to investigate recruitment of large wood post-fire (Coble et al.) and impacts to aquatic habitat and fish (Penaluna et al.). Four of the presentations investigated wildfire impacts on aquatic organisms such as flatworm parasites (Broughton), cutthroat trout (Ivie et al.), salamanders (Warren and Swartz), and upstream fish extent (Walter et al.). Other topics discussed in this section include post-fire stream temperature changes (River et al.), increased amounts of algae and cyanobacteria in periphyton (Carpenter et al.), dissolved organic carbon (Wampler et al.), impacts of wildfire on long-term watershed monitoring trends (Wall et al.), and post-fire river restoration (McEnroe and Thorne et al.).

Effects of Wildfire on Aquatic Habitat in the Area of the Northwest Forest Plan

Sara Wall[1], Marcía Snyder[1], Christine Hirsch[1], Rebecca Flitcroft[1], Joe Ebersole[2]

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The effect of wildfire on aquatic habitat over time in not well understood and relies on collection of ongoing data over long time periods. In Western Oregon, Washington and Northern California, the Aquatic and Riparian Effectiveness Monitoring Program (AREMP) has been collecting ongoing monitoring data to support management of forest lands under the Northwest Forest Plan (NWFP) (~99,000 km^2 / 24.5 million acres). Data collection for this program began in 2002 and includes 261 randomly selected watersheds with at least 25% federal ownership that are surveyed on an approximately 8-year return interval. During the operating time-period of this monitoring program, increases in the intensity and severity of wildfires has occurred throughout western states. Due to the extensive distribution of watersheds, and consistent sampling intensity of the field survey program, about half of the watersheds sampled by AREMP have burned due to wildfire since 1988. This project analyzes the extensive pre- and post-wildfire data collected by the AREMP program to allow comparisons among ecoregions, wildfire intensities, and burn extents on in-stream aquatic habitat with a special focus on post 2020 Cascade Range wildfire effects. We have found extensive entry of wildfire into forest lands throughout the range of the NWFP. Of the 219 AREMP watersheds, 120 (55%) have burned at least once since 1984, and of these, 61 have experienced multiple wildfires. Patterns of aquatic habitat vary by ecoregion and stand composition. Further analysis will explore the role of stand age, wildfire return interval, high intensity precipitation events, and time since wildfire to better capture the response of aquatic habitat to wildfire.

Riparian Vegetation Dynamics Two Years After Mixed Severity Fire in the Western Cascades, Oregon

Laura J. Six[1], Ashley Coble[2], Jake Verschuyl[2]

[1]Weyerhaeuser Company

[2]National Council for Air and Stream Improvement (NCASI)

In late summer of 2020, widespread forest fires in the Oregon Cascades burned at different severities, and across different forest types including riparian areas. The response to fire within riparian areas and specifically that of understory riparian vegetation is not well understood. In the absence of an intact overstory, riparian understory vegetation may serve a critical function in the post-fire recovery of the aquatic ecosystem by providing shade. We examined site and vegetation characteristics following mixed severity fire within riparian management zones adjacent to small perennial streams at 30 study sites, stratified by burn severity and stand age. In the riparian area adjacent to each stream, we collected data on overstory, shrub, and forb layer vegetation.

Overstory canopy cover and shrub layer cover and species richness decreased with increasing fire severity within one year after fire, and these changes remained stable in year two. While forb layer cover showed some increase with fire severity after one year, these increases were more pronounced two years following fire, especially in upland plots. Forb layer species richness also showed increases with fire severity, but these changes were stable between one and two years after fire. Common forb species varied with burn severity: in high severity plots, species adapted to open disturbed environment were common (e.g., fireweed, willowherb, and hairy cat's ear), while in plots with no evidence of burn, forbs typical in forested environments were common (e.g., sorrel, sword fern, and piggy-back plant). In the absence of the overstory, both shrub and forb layers provided little shade to streams two years after fire, but this will likely change long-term. Our results illustrate the complexity of vegetation response after mixed severity fire, especially within forested buffers, which are ecologically important.

Post-fire Riparian Vegetation Response Following the Beachie Creek Fire on Santiam State Forest

Sean McKenzie[1], Tyson Wepprich[1], Sarah Dyrdahl[2], Jeremy Groom[3], Ian Hayes[1], and Mike Hogan[1]

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[2]American Rivers

[3]Groom Analytics

The Beachie Creek Fire burned 77,955 ha across a mosaic of private and public ownership, including 9,603 ha of the 19,212 ha of State Forests in the Oregon Department of Forestry's North Cascade District. The Oregon Department of Forestry manages lands under its purview following a "Greatest Permanent Value" mandate, which provides a variety of social, economic, and environmental benefits through time and across the landscape to the people of Oregon. Two important environmental benefits that State Forests provide include aquatic habitats and drinking water, which are directly impacted by riparian vegetation structure and composition. However, there is a paucity of information on post-fire riparian vegetation response on the westside of the Cascade Mountain Range in the Pacific Northwest as a function of burn severity. Furthermore, the efficacy of potential restoration treatments needs further development. To improve this knowledge gap, the Oregon Department of Forestry installed a network of vegetation monitoring plots comparing riparian vegetation response between stream reaches that experienced stand-replacing fire with those that that experienced non-stand replacing fire severity. Additionally, the Oregon Department of Forestry began an experiment comparing changes in riparian plant community structure among three restoration treatments including a diverse tree and shrub planting, a single species conifer planting, and an untreated control. Here, we present results from the first year of monitoring data as well as pre-treatment data from our restoration experiment.

Quantifying the Effects of Wildfire on Water Quantity, Water Quality, Aquatic Ecology, and Fish: The Hinkle Creek Watershed Study Revisited

David Roon[1], Kevin D. Bladon[1], Dana Warren[2], Kate McCredie[2], and Jansen Ivie[2]

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[2]Department of Forest Ecosystems & Society, Oregon State University

Wildfires are widespread natural disturbances that influence the structure of forested landscapes in many regions around the world. Due to the random nature of wildfires, there have been relatively few studies with pre-fire data, which has hindered our ability to isolate fire effects. However, the 2020 Archie Creek Fire has provided a rare and unique opportunity by burning >131,000 acres (~531 km^2) of forested land in the Western Cascades of Oregon. The fire burned catchments that were monitored during the Hinkle Creek Paired Watershed Study (2001–2011). Following the fire, we re-established the research sites to quantify the effects on streamflow, water quality (suspended sediment, temperature, nutrients), aquatic ecology, aquatic habitats, and fish. In this presentation, we will share preliminary results from the first two years after fire and compare our observations with results from the original Hinkle Creek study. Preliminary post-fire responses emerging from the watershed suggest fire-associated reductions in canopy cover, increases in stream temperature, increases in stream nutrient concentrations, which are likely interacting to result in increased primary production and fish biomass. Collectively, these datasets will allow us to quantify wildfire effects on water quantity, water quality, and aquatic ecology. Moreover, our research will enable us to contrast the effects of wildfire with the effects from timber harvest. As such, the results from our study will provide a whole-system perspective of wildfire effects on fish and their habitats with direct relevance to land managers and policy makers who may be developing response plans to future wildfires

Drivers of Carbon Concentration and Character through a River Network Following a 2020 Oregon Wildfire

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The 2020 Oregon Labor Day fires were some of the largest and most severe wildfires in the last century for the region, producing uncertainty about the effects of the large fires. An effect of particular concern, due to the location of the wildfires near to major urban centers, is drinking water source quality. The 2020 Holiday Farm wildfire burned ~18% of the McKenzie River sub-basin, which is the source water for ~200,000 people. Post-fire, the greatest water treatment challenges are often due to elevated turbidity and dissolved organic carbon (DOC), these water quality parameters are also critical to the health of aquatic ecosystems. Past studies have illustrated variable responses of DOC after fire; thus, it is important to improve our understanding of the underlying drivers of post-fire DOC changes. We are collecting ~130 water samples across the McKenzie sub-basin, four times during the year, capturing variation in streamflow conditions. Samples will be analyzed for DOC concentrations and excitation emission matrices (EEMs) to describe the source, size, and aromaticity of the dissolved organic matter. We will develop spatial stream network (SSN) models, multiple linear regression models with added spatial autocorrelation to account for the stream network. We will test a range of landscape and fire characteristics as predictor variables for the models, which will identify drivers of carbon concentrations and character. Additionally, the models will enable us to predict carbon concentrations and character along the stream network at a high spatial resolution (~100 m) and identify hotspots of DOC export, which may facilitate future high temporal studies. Overall, we hope to better understand the mechanisms of carbon transport to streams after wildfire, which will help us create better models describing post-fire conditions. Understanding how wildfire alters DOC is critical to preserve aquatic ecosystem health and source water quality.

Post-fire Hyperspectral Surveys of Periphyton to Protect Drinking Water Quality in Three Cascade Range Rivers Following the September 2020 Wildfires

Kurt Carpenter[1], Paul Diaz[1], Natalie Hall[1], Tyler King[1], Carl Legleiter[2], Will Long[1], Adam Mumford[1], Wesley Noone[1], Brandon Overstreet[1], Sean Payne[1], Barry Rosen[3], and Noah Schmadel[1]

[1] U.S. Geological Survey, Water Science Centers (OR, ID, MD-DE-DC)
[2] U.S. Geological Survey, Observing Systems Division
[3] Florida Gulf Coast University

The September 2020 wildfires burned large swaths of forest in Oregon's Cascade Range, affecting several streams critical for municipal drinking water supply. Post-fire continuous and discrete monitoring conducted by USGS shows many adverse effects in streams and downstream rivers where drinking water intakes are located, including higher concentrations of dissolved organic carbon, suspended sediment, nitrate, phosphorus, and other water-quality constituents. Increased nutrient availability fuels the growth of attached benthic algae (periphyton) that produce large diurnal fluctuations in pH and dissolved oxygen that can adversely affect aquatic life. Increased amounts of algae and cyanobacteria in periphyton can degrade drinking water quality when they produce taste and odor compounds, cyanotoxins, and cause the formation of potentially toxic levels of disinfection by-products in treated drinking water. A new USGS study adds novel remote sensing techniques using hyperspectral cameras deployed from satellites, planes, drones, tripods, and a microscope to identify and perhaps quantify different types of periphyton in three Cascade Range rivers. Ultimately, this approach will allow better tracking of periphyton populations and increase understanding of how river biota mediate and modulate water quality effects from wildfires.

Forested Streams, Fire, and Large Wood Across a Gradient of Fire Severity and Forest Stand Age

Ashley Coble[1], Brooke Penaluna[2], Laura Six[3], Jake Verschuyl[2]

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[3]*Weyerhaeuser*

Wildfire is a landscape disturbance process important for recruitment of large wood (LW) into streams, and post-fire management may also play a role. We used a stratified random sample of 4th order watersheds that represent a gradient of fire severity from reference to completely burned watersheds and pre-fire stand age to determine whether mean watershed stand age (pre-fire) or fire severity affected riparian overstory survival, riparian coarse wood (CW), and in-stream LW. Within the first post-fire year, as fire severity increased, in-stream LW diameter declined, and riparian CW volume and diameter increased, suggesting potential future recruitment of larger diameter wood to streams from riparian zones in severely burned watersheds. Recruitment of small diameter LW suggests fires killed younger trees in the most severe fires. As fire severity increased from unburned references to severely burned watersheds, riparian tree mortality and salvage logging increased while canopy cover and LW diameter decreased. Pre-fire stand age was not an important predictor of in-stream large wood or riparian coarse wood. Overstory mortality in burned riparian areas was lower for red alder (12%) than for two coniferous species: Douglas-fir (83%) and western red cedar (68%). Our results link forested streams, fire, and LW by identifying key relationships among riparian CW and in-stream LW that change with fire severity. We highlight an important function of red alder in riparian zones as a fire-resistant species, suggesting greater survival of red alder in riparian areas may help facilitate a more rapid recovery for forested streams in fire-prone landscapes. Continued comprehensive aquatic and riparian ecosystem monitoring as these watersheds recover from wildfire will aid in understanding long-term effects of post-fire management activities (salvage logging) on aquatic ecosystems.

What Happens to Fish When Their Forest is on Fire? Answers From 24 Oregon Streams

Brooke Penaluna[1], Ashley Coble[2], Laura Six, Jake Verschuyl[2]

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Climate change coupled with fire suppression has led to an increase in fires worldwide, including in the Pacific Northwest where forests and fish are highly valued. However, the links among forests, fire, and aquatic-riparian responses, including fish remain unclear as few fires have burned in that region as of recent. Then, in 2020, forest fires consumed 1,221,324 acres (494 km2) in western Oregon across land ownerships. Owing to the fires burning at differing severities, a range of riparian forest conditions have resulted leading to different trajectories of recovery for forests, fish, and aquatic-riparian responses. We evaluated fish and aquatic-riparian responses across 24 watersheds (4th order) in the Cascade Range of western Oregon that were selected with a stratified random design to include both a gradient of forest stand age (pre-fire) and fire severity, including unburned sites. Fire severity exerted a strong control on aquatic-riparian responses explaining most of the variation in our PCA analysis with forest stand age (pre-fire) explaining less suggesting that fire resets and defines aquatic-riparian ecosystems. Within the first year following the fires, as fire severity increases, we reveal that more severe fires burn more overstory riparian vegetation leading to declines in riparian forest canopy cover, pieces of large wood in streams, and fish densities suggesting that forests, fish, and fires are linked. For fish, the declines in the severely burned watersheds may be from emigration to nearby refugia or from mortality. It also likely that large wood will recruit to streams once big enough winter storms come to naturally move it there. Alongside those declines, severe fires lead to an increase in riparian tree mortality, salvage logging, light, and dissolved organic matter (DOM) concentrations as expected. Interestingly, although macroinvertebrate densities increase with fire severity, their diversity declines with an overall decrease in EPT taxa and scrapers and an increase in chironomids. We will continue to evaluate recovery of fishes and aquatic-riparian responses in these watersheds over the next few years (and will add eDNA metabarcoding) to help understand the links amongst forests, fish, and fires which will inform westside prioritization of watersheds.

Holiday Farm Fire: Impacts on Shade/stream Temperature on Private Timberland

Mark River, Peter James, Jason Walter, Renata Tarosky, Travis Schill, Miranda Fix

Weyerhaeuser Co.

We will present pre-fire (2010-2019) and post-fire (2021) data for a series of 22 watersheds on private timberland in the Holiday Farm Fire footprint. Our study watersheds range along a gradient from completely unburned to moderate/severe burn over most of the watershed. As expected, shade decreased most dramatically on severely burned sites, and stream temperatures also increased dramatically in severely burned watersheds. 2021 was a hot and dry year in the Cascades, so having control (unburned) watersheds is critical to parsing out the short-term effects of fire from the stream temperature increase due to fluctuating climatic conditions. Ongoing/future monitoring of these watersheds will allow us to better understand how quickly shade and stream temperature returns to pre-fire conditions.

Holiday Farm Fire: Impacts to the Upstream Extent of Fish Distribution in Headwater Streams on Private Timberlands

Jason Walter, Renata Tarosky, Travis Schill, Mark River, Peter James

Weyerhaeuser Company.

In 2020, the Holiday Farm Fire burned approximately 173,000 acres in the central Oregon Cascades. Coincidentally, a large percentage of the most severely burned acres associated with the fire were on private timberlands owned by Weyerhaeuser Company where comprehensive data on the upstream extent of fish distribution in 24 headwater streams had been collected prior to the fire. These pre-fire data provided the opportunity to assess both the short-term impacts of the fire on fish distribution, and to monitor potential longer term post-fire impacts on fish distribution and stream temperature in these streams. Short-term impacts of the fire on fish distribution were assessed via backpack electrofishing surveys in the spring of 2021. Where the location of the uppermost detected fish changed relative to the original survey, we measured the distance to the previous uppermost fish point and recorded stream habitat characteristics associated with the new point. These data suggest minimal short-term fire impacts on the upstream extent of fish distribution, with the location of the uppermost detected fish at the same point pre- versus post-fire in 11 of 24 streams. Where variability did exist, movement was almost always within the range of distances identified in previous studies that assessed annual and seasonal variability in the upper extent of fish distribution in streams in unburned watersheds. This study is ongoing, with additional annual fish distribution surveys and stream temperature monitoring efforts in place to better understand the potential longer-term impacts of the fire and resulting conditions on these headwater systems moving forward.

Rock Creek - Post-fire Restoration Monitoring

Jeff McEnroe

Bureau of Land Management

On September 8, 2020, the Archie Creek fire devastated the Rock Creek watershed burning over 70% of the watershed with nearly 100% tree mortality. The Roseburg BLM and the Partnership for the Umpqua Rivers (PUR) moved in fast after the fire and completed the largest post-fire restoration project in BLM history. The partnership also implemented a robust effectiveness monitoring effort including a large-scale water quality and macroinvertebrate research project, 8000 meters of snorkel surveys, and over 11 miles of thermal and orthoimagery flights. The preliminary results of this monitoring will be shared at the symposium.

How Flood and Fire Mosiacs in a Stage Zero Reach of the South Fork McKenzie River May Interact to Boost Biodiversity and Resilience

Colin Thorne[1], Megan Colley[2], Patrick Edwards[2], Rebecca Flitcroft[3], Andrés Holz[2], Mickey Means-Brous[4], Kevan Moffet[5], Lisa Renan[3], Pek Wijayratne[3], Steve Dugdale[1], Richard Field[1], Matthew Johnson[1], Michela Mariani[1], Liberty Mgbanyi[1], Britt Pugh[1], Franzisca Schrodt[1], Sam Valman[1]

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[3]U.S. Forest Service
[4]Colorado State University
[5]Washington State University

In 2020, the Holiday Farm Fire burned enveloped 80 hectares of the lowermost South Fork McKenzie River Valley, where a Stage Zero river restoration project has been underway since 2018. Resultingly, the restored area has become a natural laboratory where interactions between the shifting habitat mosaics created by floods and fire can be observed. Here, we describe the results obtain to date and plans for future monitoring and analysis.
The South Fork McKenzie project focuses on reversing decades of channel incision and simplification by returning the river to its condition prior to anthropogenic disturbance. This is achieved by removing flood embankments, infilling the incised channel, re-connecting historical floodplains and wetlands, and adding thousands of pieces of large wood to dissipate stream energy and promote ecological recovery.

The significance of the link between fire and ecology is captured in the oft quoted, but unproven hypothesis that, ‘pyrodiversity begets biodiversity’. Even at this early stage in post-fire studies, some important insights have emerged. First, damage to plants and soils in the restored floodplain-wetland is highly variable. Second, wetlands and wet woodlands in the restored area provided refugia during the blaze and, post-fire, the variety of species visiting the restored area has increased. Third, interactions between the wildfire and restored area's topographic, hydrologic, and ecologic patchiness resulted in a 'fire mosaic' that reinforced and shifted the pre-existing flood mosaic in ways likely to facilitate post-fire recovery. One of the aims of reconnecting this river-floodplain-wetland system is to increase river and ecological resilience to floods, droughts, and invasive species. Remotely sensed observations and field measurements made to date suggest that Stage Zero restoration may also increase resilience to wildfires, which are likely to become increasingly destructive as climate changes. This hypothesis will also be tested through continued field monitoring, remote sensing, and spatial analysis.

Does Fire Severity Affect Parasite Prevalence and Abundance?

Farallon Broughton

Oregon State University

Digenean trematodes (Platyhelminthes: Digenea) are diverse and ecologically important flatworm parasites with complex, multi-host life cycles. They are parasitic castrators and behavioral manipulators that increase food web connectance and stability and can act as ecosystem engineers; however, we lack a clear understanding of how trematodes respond to disturbance events, including wildfires, that impact stream ecosystems. Where fire severity is intense, trematode prevalence, abundance, and richness should decrease with decreases in the density of viable hosts for each life stage and with changes in abiotic conditions (turbidity, water quality, flow, temperature) that affect host-finding capability and survival. Where frequency or intensity is high, disturbance events can cause discontinuity between stream networks that may disrupt complex life cycles. The stream-dwelling snail *Juga plicifera* is common throughout western Oregon and serves as the first intermediate host for the trematode *Nanophyetus salmincola*, which vectors Salmon Poisoning Disease. We explored trematode infection prevalence and cercarial output across a gradient of fire severity and stand age for 24 sites (17 sites where snails were present and 7 reference sites) in the Cascade Range in Summer 2021. We present preliminary results detailing the association between fire severity, stand age, and trematode prevalence and abundance.

Quantifying the Response of Coastal Cutthroat Trout to Wildfire in the Oregon Cascades

Jansen Ivie[1], Dana Warren[1], Kevin D. Bladon[2], David Roon[2]

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The occurrence of large, high severity wildfires has increased in many regions, including the Western United States, in the past few decades. Shifts in the wildfire regime have increased interest in the effects of wildfires on a range of ecosystem components, including water quantity, water quality, and aquatic ecology. Past studies have found a range of fish responses to wildfire. However, a lack of pre-fire data in most systems affects our ability to explicitly quantify the magnitude of wildfire impacts on abundance, condition, and distributions of fish populations. In 2020, the Archie Creek Fire burned the forests of the Hinkle Creek Paired Watershed Study (HCPWS) in the in the Umpqua River basin of the Western Cascades of Oregon. The original HCPWS quantified forest harvesting effects on water quantity, water quality, and fish populations from 2002–2011. These earlier data provided the rare opportunity to quantify fish responses to wildfire. In the second year after the fire, we used the same methods as in the HCPWS (single-pass electrofishing in stream pools) to estimate relative fish abundance through ~2.7 km of South Fork Hinkle Creek. We made a longitudinal comparison of cumulative mass of age 1+ Coastal cutthroat trout (*Oncorhynchus clarki clarki*). By quantifying fish in every pool through the mainstem of South Fork Hinkle Creek, this study provides a whole river (rather than reach-scale) assessment of how fish populations respond to wildfire disturbance in headwater streams on managed forest land in the Pacific Northwest. Relative to the most recent two years of the HCPWS (2010. 2011), our preliminary data suggests limited effects of fire on fish condition.

Evaluating Fish and Salamander Populations One Year After Severe Fire in Western Oregon Headwater Ecosystems

Dana Warren, Allison Swartz

Dept. Forest Ecosystems & Society/ Dept. Fisheries, Wildlife and Conservation Sciences, Oregon State University

Wildfire is becoming increasingly common and severe in forested landscapes across western North America. However, our understanding of the impacts of fire on streams and stream biota is not well settled because the loss of riparian cover after severe fire can have positive or negative impacts on stream biota, depending upon the system and the community. Increased light can lead to elevated stream temperatures and altered habitat conditions for cold-water adapted aquatic vertebrates, and if temperatures exceed thermally stressful levels, they can negatively impact coldwater fish. However, increased light to previously light limited systems can also increase autotrophic basal resources, potentially leading to greater production for aquatic consumers. To evaluate these two potential post-fire responses, we capitalized on a set of pre-existing data to conduct a replicated before-after control-impact study evaluating initial (1-year) effects of wildfire on forested headwater stream ecosystems in western Oregon. Pre-fire sampling of biofilm accrual and populations of fish and salamanders was conducted across six study sites in summers of 2018 and 2019. Three of these sites burned in the 2020 Holiday Farm fire, and we returned to all six sites (burned and unburned) in summer 2021. Unsurprisingly, stream temperature and chlorophyll-*a* accrual increased substantially relative to the reference reaches. We observed slight relative increases in adult fish in one stream, but slight declines in the other two. Overall, changes in biomass, density or condition of adult cutthroat trout or pacific giant salamanders were minor. However, we saw consistent and notable increases in the density, mean weight and length of juvenile (age-0) cutthroat trout after the fire. Our findings demonstrate that fire can increase temperature and basal food resources and it suggests that these changes benefit juvenile trout, with more limited effects on adult fish and salamanders.

5. IMPACTS OF WILDFIRE ON PEOPLE AND COMMUNITIES

Eight of the symposium presentations were on the topic of the human impacts of wildfire. Of these presentations, one was a panel discussion titled, “The future of air quality during wildfires in Western Oregon,” which offered a range of perspectives on “living with smoke, the future of smoke policy, fire management, [and] strategies to reduce wildfire smoke in Oregon’s forests.” Another panel titled “Fire in riparian area – implications for future water quality management” discussed water quality impacts from wildfires in Western Oregon. An additional three presentations also discussed water quality implications from wildfires (McCredie et al., Ryder et al., Stabach and Patton). Fisher and Kun Kang et al. reported on structural damage from wildfire in the wildland-urban interface. Stan Thomas was an invited speaker from the Oregon Department of Emergency management who addressed community recovery following the 2020 Labor Day fires.

The Future of Air Quality During Wildfires in Western Oregon

Facilitated by James Markwiese[1] with: Rick Graw[2], Steve Dietrich[3], Hollie Smith and Heidi Huber-Stearns[4], Tom Roick[5], Dr. Carol Trenga[6], Kyle Chapman[7] and Cassandra Mosely[4]

[1]Environmental Protection Agency

[2]USFS Pacific NW Research Station

[3]Lane Regional Protection Agency

[4]University of Oregon

[5]Oregon Department of Environmental Quality

[6]Oregon Health Authority

[7]Oregon Institute of Technology

This panel discussion considered the future of air quality considering growing wildfires in Western Oregon. Representatives from community airsheds, state government and academia comprised the air quality panel and offered a range of perspectives on living with smoke, the future of smoke policy, fire management, strategies to reduce wildfire smoke in Oregon's forests. Risk tradeoffs in land management strategies were considered regarding prescribed burning versus wildfire smoke exposure. Oregon State representatives discussed the future of smoke monitoring as well as health impacts in respiratory hospitalizations in Portland Oregon. Strategies to reduce smoke exposure and increase community smoke resilience were discussed with lessons learned from case studies of smoke-impacted communities. This session generated discussion from a range of stakeholders on wildfire smoke, which impacts the health or Oregon's residents.

Presentations in the panel discussion on the future of air quality during wildfires in Western Oregon include the following:

- Graw, R (United States Forest Service), Post-2022 PNW Wildfire Season- Smoke Considerations
- Dietrich, S (Lane Regional Air Protection Agency), How did the community of Oakridge endure the 37 days of unhealthy levels of smoke from the Cedar Creek Fire?
- Hollie Smith and Heidi Huber-Stearns, (University of Oregon), Oakridge Cedar Creek Fire, Internal After-Action Review Summary
- Roick T (Oregon Department of Environmental Quality), Trenga C (Oregon Health Authority), The Future of Air Quality Monitoring in Response to Western Wildfires
- Chapman K, (Oregon Institute of Technology), Oregon Tech's Center for Advancing Interdisciplinary Research on the Environment (AIRE)
- Mosely C, (University of Oregon), Community wildfire resilience and the role of regional smoke research centers in understanding smoke impacts

Spatiotemporal Patterns of Water Quality to Wildfires in the Western United States

Lorrayne Miralha[1], Kevin Bladon[1], Jana Compton[2], Aaron Borisenko[3]

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Multiple drought-related wildfires burned forests across the western United States (U.S.) during the 2020 fall season. Wildfires can significantly affect hydrologic processes such as streamflow and nutrient transport to stream, however, the natural variability of its behavior combined with spatially complex landscape patterns and hydrologic factors create uncertainties about the postfire effects on aquatic ecosystems. Because wildfire effects on water quality are less commonly reported than the effects on ecosystems, we investigated the spatiotemporal relationship between landscape patterns and water quality before and after the 2020 wildfire season in the pacific northwest. Specifically, we sought to examine the effect of fire on normalized difference vegetation and water indices (NDVI and NDWI), enhanced vegetation index (EVI), streamflow, and water quality (phosphorus (P), nitrogen (N), organic carbon (OC)) from 2001 to 2022 in two watersheds in Oregon (Archie Creek and South Obenchain). Landscape parameters were based on MODIS remote sensing products, and the water quality data was provided by the Department of Environmental Quality and Environmental Protection Agency in Oregon, US. We used flow exceedance probability, load duration curves, and breakpoint analysis to evaluate the seasonal patterns between nutrient loads and landscape characteristics (NDVI, NDWI, and EVI) for the pre- (2001 – 2020/10) and post-fire (2020/11 - 2022) periods. Post-fire streamflow and nutrient load responses varied seasonally. Streamflow significantly decreased after the fire during fall and summer in both regions. However, increases in winter and spring streamflow were observed in the area with the highest variability in flow regime (Archie). Nutrient loads significantly increased after fire in the winter season in both areas. While increases in N and OC loads during the fall season were observed at Archie creek, a relatively small load increase was observed for N during spring and for OC during summer in South Obenchain. Load duration curves and flow exceedance probabilities suggested a shift towards higher values for OC loads after the fire, with higher load values exceeding drinking water systems treatment capability for TOC in the western U.S. (>4 mg/l). Breakpoint analysis suggested significant shifts in NDVI and EVI after the fire and a considerable declining trend in NDWI starting ~ 2 years prior to the 2020 fire season. The breakpoints for the landscape metrics also aligned with the changes in nutrient loads in both regions. These findings are critical to a more holistic understanding of the spatiotemporal effects of fire in vulnerable areas such as forested headwaters that provide habitat for numerous aquatic species and are the primary source of drinking water in the western US. Our results provide insights into the spatial variability of postfire effects and may support future regional management strategies.

The Influence of Harvest History, Fire Severity, and Post-fire Soils on Water Quality in the Hinkle Creek Watershed, Western Oregon

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The impact of large, high severity wildfires on soil health and stream water quality remains poorly understood, in part, due to the lack of tightly controlled, landscape scale experiments that integrate fire and land use activities. In September 2020, the Archie Creek fire (53,230 ha) burned the Hinkle Creek watershed, an intensively managed Douglas-fir (*Pseudotsuga menziesii*) plantation, which was previously studied from 2002 – 2011 to investigate the effects of forest harvesting on water quality. Here, we leverage this existing study site to compare pre-harvest, post-harvest, and post-fire in-stream nitrate (NO_3^-), ammonium (NH_4^+), and total nitrogen (TN). We also quantify the effect of fire on saturated hydraulic conductivity, soil nitrogen (NO_3^-, NH_4^+), and active soil carbon to understand the mechanisms driving stream nitrogen responses. We applied a chronosequence study design across a matrix of forest harvesting to disentangle the potential variability in fire effects. In 2021, we began collecting stream water samples at the historic locations. Within the riparian zones, we collected replicate bulk density soil cores (0-5 cm) and nutrient samples (0-15 cm) at 63 sites. Historically, stream NO_3^- did not vary substantially in the harvested catchments; the average pre- and post-harvest concentrations were 0.15 mg L^{-1} 0.03 ± (SE) and 0.18 mg L^{-1} ± 0.02, respectively. However, preliminary results from our post-fire study indicate a substantial variation among streams. At one site, the average pre- and post-fire concentrations were 0.15 mg L^{-1} ± 0.02 and 0.16 mg L^{-1} ± 0.04, while at another site, the concentrations increased from 0.03 mg NO_3^- -N L^{-1} ± 0.01 to 1.46 mg NO_3^- -N L^{-1} ± 0.15. Critical questions remain about the timing and legacy of nutrient pulses after wildfire. Results from this study will help to disentangle the effects of pre- and post-fire land management actions on water quality and soil health.

An Overview of US Army Corps of Engineers Research on Post-wildfire Water Quality and Ecology

Jodie L. Ryder, Kathleen E. Inman, Lauren L. Melendez

U.S. Army Corps of Engineers (USACE)

As the stewards of over 400 reservoirs, the USACE cannot ignore the potential impacts of climate change and extreme weather events on reservoir water quantity and quality. This presentation will give an overview of a research effort recently initiated to develop information and tools to help managers maintain the water quality and ecology of reservoirs affected by wildland fires. This effort encompasses monitoring, analysis, and modeling approaches. Detroit Lake and the associated watersheds in the Cascade Range of Oregon, serve as an example site experiencing non-stationarity following two wildfires that affected almost ½ of the watershed area in 2020. We'll discuss our preliminary efforts to develop assessment tools for the historical and post-fire water quantity and quality observations at Detroit Lake in the context of their surrounding climate and land use changes. We'll also present on our plan for the development of rapid monitoring capabilities and expansion to other sites.

Bear Creek Oregon – Post-fire Water Quality Monitoring

Greg Stabach[1] *and Amy Patton*[2]

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On September 8, 2020 a brush fire stoked by strong winds erupted to burn more than 3,200 acres in the heavily urbanized Bear Creek watershed of Southern Oregon. In total 2,537 homes, 18 mobile home parks, and 171 commercial properties were destroyed in the fire.

After the fire multiple agencies and organizations came together to discuss the need to evaluate the potential impacts to water quality due to the fire and to coordinate monitoring efforts. It has been shown that wildfires have the potential to impact public and private drinking water systems and impact stream ecology for years. There was also a concern that other fire-related compounds were entering area streams including materials used to fight the fires and toxic materials from destroyed homes and businesses.

Water quality monitoring by local agencies began almost immediately after the fire and has continued throughout post-fire emergency stabilization and long-term recovery. The monitoring was expanded in 2021 with the receipt of grant money, which has supported sample analysis and data processing. The monitoring program is evaluating the primary impacts, how long the impacts persist, and the effectiveness of control and remediation efforts.

Periodic in-stream grab samples and storm-event outfall samples have been collected and analyzed for metals, volatile organic compounds, semi-volatile organic compounds, including dioxins, furans, polybrominated substances, per- and poly-fluorinated alkyl substances (PFAS), total organic carbon (TOC), total dissolved solids, phosphorus, nitrogen and others. Additional samples were collected and analyzed for pesticides. Sample collection and analysis also included a limited number of 6-PPD quinone (6-PPDQ) samples comparing burned and non-burned urbanized stormwater catchment areas.

In-stream sample sites are located on Bear Creek above and below burned areas allowing for comparison. Samples are also being collected during heavy storm events at three residential stormwater catchments – 2 in burned neighborhoods, 1 control. Several data-sondes are deployed and linked to provide real-time discharge, turbidity, and other data from above and below the burned area.

Navigating the World of Building Back Communities, and the Importance of Good Science to Inform Hazard Mitigation and Post Fire Reconstruction

Stan Thomas

Deputy Director, Oregon Department of Emergency

Stan Thomas is the Division Director for Mitigation and Recovery in Oregon's Department of Emergency Management. He addressed how we build back communities in Oregon following the 2020 Labor Day wildfires, in particular documenting impacts and support (state and federal) provided for the 2020 wildfire event that burned over a million acres. This was the first activation of Oregon's disaster recovery plan. Stan discussed the state's wildfire setup and considered transportation impacts, and local, tribal and county-level impacts, state and federal agency organization, and considerations for the state's disaster emergency planning. The next disaster recovery plan will be informed by practice and lessons learned from the 2020 fires that swept through western Oregon for future wildfire mitigation and response strategies.

Impact of Home and Lot Characteristics on Structure Survival During Wildland-urban Interface Wildfire

Erica Fischer

Oregon State University

On December 30, 2021 the Marshall Fire ignited in Boulder County, Colorado. Driven by hurricane force wind gusts and sustained winds of 80 - 96 kph, the small grass fire intensified and spread. An initial in-field survey of over 200 homes was conducted using a form developed by the team prior to deploying to the field. The data gathered included the home address, structure type (freestanding, apartment building, townhouse), home damage state (damaged, destroyed, standing), approximate temperature of foundations at destroyed homes, stories above ground, visible damage on property, proximity to destroyed structures (including outbuildings), and characteristics of neighboring homes (including distance to). This data was supplemented with information from Zillow, Google Earth, and Google Maps. These sources provided information on construction year, pre-fire vegetation, exterior cladding, proximity to fire hydrants, fencing and fencing material, proximity to ditches and creeks, proximity to open space, and if the home was in an isolated neighborhood (two or less points of egress) or on a cul-de-sac. The results of this analysis suggest spacing between homes plays large role in home-to-home wildfire spread in suburban communities. Other factors of note included home construction year, and characteristics of the immediate defensible space zone. Proximity to firefighting resources and ease of access also played a role in home outcome. Further regression analyses will be performed to determine which predictor variables have little effect on outcome and can be removed from the model and if any predictor variables exhibit nonlinear behavior.

Residential Structural Damage Detection From Wildfires Using Deep Learning to Analyze Uncrewed Aerial System (UAS) Imagery

Dae Kun Kang, Michael J. Olsen, Erica Fischer

School of Civil and Construction Engineering, Oregon State University

Post-wildfire assessments of housing provide emergency managers and jurisdictions vital, quantifiable information to characterize the overall extent of damages to structures as well as help to establish detailed disaster mitigation plans to prevent future losses. These quantifiable damage assessments provide the basis for financial loss and cost analyses used to develop disaster declarations by federal and state governments. Therefore, damage assessments must be performed quickly after a wildfire to ensure a rapid and efficient recovery. Unfortunately, these assessments require extensive on-site investigation, necessitating substantial resources in time and personnel as well as posing many safety risks. This presentation describes an efficient and effective methodology to perform damage assessments of housing after a wildfire using deep learning techniques to efficiently analyze unmanned aircraft systems (UAS) imagery of residential areas. The methodology was developed using UAS imagery acquired after the 2021 Marshall fire in Boulder County, Colorado as a part of the NSF-funded GeoExtreme Events Reconnaissance team. First, a high resolution (cm-level) orthographic image of the wildfire-affected area was developed from the UAS imagery. Next, classification rules were developed to define the degree of damage to structures. Houses within a portion of the orthoimage were then classified based on these rules to create data to train the deep learning models. The model was then applied to the entire orthophoto to complete the damage assessment. Application of this efficient methodology reduces the need for on-site investigation and associated safety risks as well as enables decision-makers to rapidly assess a large area to determine the relative degree of damage to structures and develop cost estimates for a community for damages after a wildfire.

6. WILDFIRE IMPACTS ON WILDLIFE

Five of the symposium presentations addressed impacts to wildlife from fire in western Oregon. Three of these presentations focused on terrestrial salamanders (Stephens, Cousins et al., and Olson and Cousins). Rex McGraw investigated mammalian relative abundance after the 2020 Archie Creek Wildfire. Miles et al. discussed their study to observe wildlife habitat utilization in the 2020 Archie Creek and Beachie Creek fire complexes burn scars.

Large Downed Wood as Post-fire Refugia for Terrestrial Salamanders in Pacific Northwest Forests

Paige Stephens

Oregon State University Department of Fisheries, Wildlife, and Conservation Sciences

Climate change, wildfire, timber harvest, and land conversion alter the availability of downed wood in forests of the western United States. Numerous taxa rely on downed wood for temperature and humidity refugia. Downed wood may play a key role in enabling the persistence of climate-sensitive, low-vagility species like terrestrial salamanders (family *Plethidontidae*) after high severity wildfire. However, few studies have quantified the relationship between the quantity, size, and quality of downed wood and terrestrial salamander occupancy—especially in harsh microclimate conditions following high severity fire. We quantified terrestrial salamander occupancy, abundance and diversity and relationships with downed wood in mesic mixed-conifer forests along three major latitudinal bands and three time-since-high-severity-fire categories in the western Cascades of Oregon. Ensatina (*Ensatina eschscholtzii*) were observed most frequently, but Dunn's Salamander (*Plethodon dunni*), Western Red-Backed Salamander (*Plethodon vehiculum*), and the at-risk Oregon Slender Salamander (*Batrachoseps wrighti*) and Clouded Salamander (*Aneides ferreus*) were also detected. Terrestrial salamander detections, occupancy, and abundance were greatest in sites with no fire on record while diversity (Shannon-Wiener diversity index = 0.94) was greatest in sites that recently burned. We found strong evidence of a positive association between terrestrial salamanders and large downed wood amount; the estimated odds of occupancy increased with greater quantities of downed wood available, and 87% of salamander detections occurred in association with downed wood. The majority of terrestrial salamanders detected in association with downed wood were found in or near rotten downed wood (92%), fire-altered downed wood (58%), and downed wood greater than 11.5 cm in diameter and greater than 0.65 m in length (80%). These findings may provide guidance on conservation priorities to maintain persistence of terrestrial salamanders in the face of climate change, continued timber harvesting, and increasing climate-driven wildfire conditions.

Herpetofaunal Communities Accelerating Post-fire Ecosystem Recovery

Cousins, Christopher[1], Mark Leppin[1], Anna Neill[1], M. Radin[1], and Deanna H. Olson[2].

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The increasing intensity and frequency of wildfires necessitates understanding their effects and post-disturbance recovery trajectories. Wetlands and associated wet-meadow habitats could act as fire refugia, facilitating post-fire recovery due to persistence of biota with key ecological functions. Amphibians and reptiles are centrally nested in wetland ecosystem food webs, and could persist in fire refugia, retaining their ecosystem functions as predators and prey. Members of the Oregon State University Herpetology Club in collaboration with the US Forest Service 10 wetland-meadow complex sites to assess herpetofaunal diversity in past areas with and without fire in the Sisters Ranger District, Deschutes National Forest, eastern Cascade Range, central Oregon. Past fires occurred in 1999 through 2012, and herpetofaunal surveys occurred in 2018. Coverboard arrays were deployed in meadows adjacent to wetlands, and basic pond surveys using visual and dip net surveys were conducted in wetlands for animal assessments. Reptiles were not observed. Five amphibian species were recorded among sites, with the Cascades Frog (*Rana cascadae*) and the Long-toed Salamander (*Ambystoma macrodactylum*) dominating captures. There was no apparent pattern between amphibian occurrences and either fire occurrence or time since fire. Hydrological conditions including water retention through the summer has been associated with amphibian occupancy at wetland sites of the Eastern Cascade Range in this region in the past, and our study supports that as well, as sites with abundant amphibians retained water longer into the summer and fall.

Larch Mountain Salamanders (*Plethodon Larselli*) Persist in Talus Slopes Within Burned Areas of Eagle Creek Fire, Columbia River Gorge, Oregon

Deanna H. Olson[1]*, and Christopher Cousins* [2]

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The forested talus slopes of the Columbia River Gorge in Oregon are the among the most well-known habitats of the Larch Mountain Salamander, *Plethodon larselli*, a forest-associated species with sensitive conservation status (e.g., globally imperiled, NatureServe). It has been managed under the Survey and Manage provision of the federal Northwest Forest Plan to ensure persistence on federal lands in its small range. In 2017, the Eagle Creek Fire burned through areas with known sites of this species, and questions were raised of fire effects on the salamander. Our ongoing study aims to understand if there is a signature of the effects of Eagle Creek fire on *P. larselli* occurrence. We randomly selected 12 known sites of *P. larselli*, 6 burned and 6 unburned, in the forested slopes of the Columbia River Gorge, Oregon. Surveys were conducted in 2021 and 2022, the first years post-fire in which we were permitted to conduct field surveys. In 2021, 18 *P. larselli* were detected at 6 sites; in 2022, 30 *P. larselli* were detected at 9 sites. In all, detections at 10 of 12 surveyed sites is recorded, with the two sites having no detections across two years of survey effort being unburned known sites. Five additional amphibian species were detected during surveys, with *P. dunni* and *Ensatina eschscholtzii* being the most common, and no strong pattern with fire; they were each detected at 5 of 6 burned sites in 2022, for example. Due to uncharacteristically dry conditions in spring 2021 and wet conditions in 2022, and cryptic tendencies of *P. larselli*, we plan a 2023 field season with multiple site visits in order to more reliably assess their detection probabilities across burned and unburned sites. Nevertheless, at this time, they are persisting in the area of the Eagle Creek Fire.

Changes in Mammalian Relative Abundance Before and After the Archie Creek Wildfire in 2020

Rex McGraw

Bureau of Land Management, Roseburg District

The Archie Creek Wildfire ignited September 8, 2020 and burned over 131,000 acres of mixed conifer forest land in a checkerboard of federal and private ownership – including over 40,000 acres administered by the Roseburg District Bureau of Land Management. The Archie Creek wildfire was declared contained on November 16, 2020. An array `of remote camera trapping stations sampling faunal relative abundance had been deployed from February 22, 2016 through August 9, 2020 within the area affected by the Archie Creek Wildfire (n = 96 camera stations; > 10,400 trap nights). To date, Wildlife staff have re-deployed 19 camera stations at the same locations to compare pre-fire (3,603 trap nights) and post-fire fauna (2,751 trap nights). Preliminary results suggest that carnivores have a mixed response to the Archie Creek Wildfire thus far; Western Spotted Skunk (*Spilogale gracilis*), Striped Skunk (*Mephitis mephitis*), Short-tailed Weasel (*Mustela erminea*), Black Bear (*Ursus americanus*), and Virginia Opossum (*Didelphis virginiana*) show significant decreases in abundance while Gray Fox (*Urocyon cinereoargenteus*) is the only carnivore with significant increase in post-fire relative abundance. Rodents also exhibit a mixed response following the Archie Creek Fire - Humboldt's Flying Squirrel (*Glaucomys oregonensis)* have significantly reduced relative abundance; but, Deer Mice (*Peromyscus maniculatus*) have significantly greater abundance post-fire. Columbian Black-tailed Deer (*Odocoileus hemionus columbianus*) and Elk (*Cervus elaphus*) appear to have greater abundance post-fire, although the trends are not statistically significant. Re-sampling camera stations in the post-fire landscape of Archie Creek Wildfire is ongoing for more thorough comparison.

Wildlife Response to Wildfire in the Oregon Cascade Mountains

Hayden Miles[1,2], Melanie Davis[1], DeWaine Jackson[2]

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In Oregon, and throughout the Pacific Northwest, there is an urgent need to document how wildlife species and their habitats recover from severe, large-scale fires. This is especially true in the western Oregon Cascade Mountain Range, which experienced an extreme wildfire season in 2020, enduring five wildfires that each exceeded 100,000 acres in size. Understanding how these large-scale disturbances impact wildlife resources in Oregon is extremely important for their conservation and management. The goal of this project is to gain an understanding of how wildlife recolonize areas with different burn intensities and management histories, the length of time it takes for population recovery, what species fail to recolonize, and the challenges associated with management of fire impacted habitats.

This study is taking place in the burn scars of the 2020 Archie Creek and Beachie Creek fire complexes, which cover an area that (prior to the fire) contained habitat utilized by over 30 Oregon Conservation Strategy Species. 60 long-term monitoring sites will be established in both the Archie Creek and Beachie Creek burn scars and will be monitored for two years. Study sites are composed of a trail camera, audio recording unit, and 4 cover boards. At each site trail cameras and audio recording units will be active year-round, and cover boards will be monitored every 3 months. Vegetation plots will be monitored at each site in late spring, assessing spring species present, percent of ground cover, and vegetation height.

7. POST-FIRE SOIL AND HYDROGEOMORPHIC CHANGE

Ten of the symposium presentations addressed post-fire hydrogeomorphic change. Hammer and Booth measured post-fire soil saturated hydraulic conductivity, repeat terrestrial lidar data, and water pressure to derive a runoff-response model to estimate likelihood of overland flow and soil erosion. Sanders et al. examined the effects of the 2017 Eagle Creek fire on long-term catchment retreat in the Columbia River Gorge. Other topics included post-fire changes in snow-water storage and snowmelt (Gleason et al.), watershed hydrologic response (Tai et al. and Kang et al.), post-fire fluvial geomorphic changes (Wilcox), and deep-seated landslide carbon stocks (Cleland). Additionally, three presentations focused on post-fire soils, specifically soil organic matter (Bowman) and carbon storage (Peter-Contesse et al. and McCool et al.).

Post-fire Hydrologic and Erosional Processes in the Riverside Burn Area, Oregon

Morena N. Hammer, Adam M. Booth

Department of Geology, Portland State University

Overland flow and runoff-initiated debris flows following wildfires have been rare in the forested Pacific Northwest. This study documented hydrologic processes and erosion patterns related to potential debris flow initiation at two high burn severity plots in the 2020 Riverside fire perimeter. In the South Fork Clackamas River and Memaloose Creek watersheds, we measured saturated hydraulic conductivities of soils, collected repeat terrestrial lidar data, and recorded water pressure in a small ephemeral gully. We used those data to derive a runoff-response model, and then drove the model with a precipitation time series to interpret if and when episodes of overland flow and soil erosion likely occurred. Saturated hydraulic conductivities were generally high and variable, averaging 70 mm/hr, but ranging from 3 to 202 mm/hr. Consequently, distinct spikes in gully water pressure that could be attributed to surface water runoff were rare, occurring four times in December and January of the 2020-2021 winter. More specifically, our runoff-response model suggested that infiltration excess overland flow occurred during at least two of those storms, on 30 December 2020 and 12 January 2021, when maximum 5-min rainfall intensities were 58 and 84 mm/hr, respectively. Vertical differencing of sequential terrestrial lidar scans showed patchy surficial soil erosion averaging 2 mm over 6 months, which we attributed to widely distributed rainsplash, rather than concentrated rilling, based on field observations. Turbidity recorded at a downstream gauge on the Clackamas River had two large peaks, on 20 December 2020 and 12 January 2021, which suggested most of that erosion occurred during those two storms. These results collectively indicate that even in severely burned parts of the western Oregon Cascades, infiltration rates can remain high enough to limit overland flow and surficial erosion to relatively rare, high intensity rain storms, keeping the likelihood of runoff-initiated debris flows low.

Effects of the Eagle Creek Fire on the Long-term Retreat of the Dodson Catchments, Columbia River Gorge, OR

Maryn Sanders[1], Joshua Roering[1], William Burns[2], Nancy Calhoun[2], Ben Leshchinsky[3]

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In rocky, forested steeplands, talus accumulates along slopes and ravels into channels, which can be evacuated as in-channel bed failures that travel long distances as debris flows. Over longer timescales, hillslopes can form thick colluvial deposits which are reinforced by tree root networks, where shallow landslides can periodically mobilize these deposits into debris flows. Disturbances such as rainfall, snowmelt, frost weathering, and fire can modulate the mechanical conditions driving the rate and spatial occurrence of these processes; however, the relative importance of each on hazard potential and landscape evolution is poorly understood. As a result, we are unable to predict how a changing climate will modulate erosion rates and hazards in these settings. Along the Columbia River Gorge, numerous alluvial fans have accumulated debris flow deposits near Dodson, OR since the valley was excavated by the Missoula Floods ~13 kya. To constrain long-term erosion rates here, I conducted a mass balance calculation by mapping fan deposits, correlating catchment areas, and constraining the age of the fans to the end of the Missoula flood period. Preliminary results show that minimum basin-averaged erosion rates range from 2.2 to 31 mm/yr and correlate with average catchment slope–these results allude to a high frequency of debris flows throughout the Holocene. Shallow landsliding is likely modulated by century-scale disturbances such as wildfires–aerial photos show potential shallow landslide scars following storm events in 2021, likely as a result of the 2017 Eagle Creek Fire reducing root cohesion within colluvium. Channels failures, however, may continue to occur frequently outside of post-fire conditions due to talus production, coupled with steep channels and frequent intense storms. Understanding controls on mass wasting in this region is vital to providing accurate risk analyses and regional emergency planning for highly trafficked transportation systems at the base of these catchments.

Hydrogeomorphic Response of Steep Streams to the 2020 Archie Creek and Holiday Farm Fires

Andrew Wilcox

University of Montana

Severe wildfire may alter steep mountain streams by increasing peak discharges, elevating sediment and wood inputs into channels, and increasing susceptibility to landslides and debris flows. In the Pacific Northwest, where mean annual precipitation is high and mean fire return intervals range from decades to centuries, understanding of steep stream response to fire is limited. The objective of this study was to evaluate the hydrologic and geomorphic response of steep streams to the large-scale and severe 2020 fires in the Western Cascade Range, Oregon, focusing on sites in the Archie Creek and Holiday Farm fires. In the 1.5 years after the fires, peak flows in burned sites were below the two-year recurrence interval flood. Sediment inputs to streams consisted of two large landslides initiated from road fill failure, slumps, sheetwash, and minor bank erosion. There was a 50% increase in the number of large wood pieces in burned sites after the fires. Changes in fluxes of water, sediment, and wood in burned streams induced shifts in the balance of sediment supply to transport capacity, initiating a sequence of sediment aggradation and bed-material fining followed by erosion and bed-material coarsening. Gross channel form showed resilience to change, and an unburned reference reach exhibited little morphologic change. Post-fire recruitment of large wood will have long-term implications for channel morphology and habitat heterogeneity. Below-average precipitation during the study period, combined with an absence of extreme precipitation events, was an important control on channel responses. Climate change may have a complex effect on stream response to wildfire by altering precipitation and vegetation recovery patterns.

Calibrating Post-fire Streamflow Predictions in the PNW

Leah Tai[1]*, Hazel Wood*[2]*, Kyle Wright*[2]

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While there is a general consensus that post-fire streamflow increases, often orders of magnitude greater than pre-fire flows, methods to estimate post-fire streamflows vary greatly and often rely on professional judgement with few opportunities for validation. Burned watersheds can yield runoff that quickly produces flash floods and large sediment and debris loading that put critical downstream values at risk. Improving post-fire hydrologic modeling in the PNW will improve our ability to forecast risks and impacts from wildfire. In the 2020 Beachie Creek Fire and 2022 Cedar Creek Fire, hydrologic response modeling was conducted immediately post-fire using a paired gage methodology to validate common peak-flow estimation techniques such as the USGS regression, WEPP, and the curve number methods. This paired gage analysis estimated peak streamflow increases of 130% above pre-fire levels for the Little North Santiam, a high to moderately burned watershed in the Beachie Creek fire. A case study from the Lionshead fire revealed post-fire streamflow increases ranging from approximately 50-350%, depending on the timing and magnitude of the peak-flow event. These observations provided a mechanism for calibrating post-fire response in similar stream types in the western Cascades. Post-fire paired gage analyses provide a robust validation to existing methods, and important opportunities to continue to monitor and understand changes to streamflow response post-fire.

Hydrologic Responses to the 2020 Labor Day Fires in Western Oregon

Hyunwoo Kang[1], Lorrayne Miralha[1], Kevin D. Bladon[1], Jana Compton[2]

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Effects of wildfires on vegetation cover and soil properties can dramatically change watershed hydrology and water quality in Pacific Northwest (PNW) regions. In September 2020, extensive and high-severity wildfires occurred in western Oregon due to strong winds and long periods of warm and dry conditions. This study evaluated the hydrologic responses of the fire based on observed streamflow and satellite-based meteorologic data including precipitation (P), potential evapotranspiration (PET), and actual evapotranspiration (ET). Nine burned and five unburned watersheds were selected and delineated with varying fire characteristics (e.g., burned areas, and burn severities). Burn severities of the watersheds were represented by the average Differenced Normalized Burn Ratio (dNBR). Runoff ratio, ET ratio, and Budyko Curve analyses were used to compare hydrologic conditions for the pre- (2001 - 2020) and post-fire (2021 - 2022) periods. Increases in runoff ratio and decreases in ET ratio were observed during the post-fire period, and the magnitude of differences was larger as the fire severities and burned areas increased. The Budyko Curve also showed robust differences in the evaporative index (Δd) with highly burned watersheds due to dramatic decreases in ET, while differences between less burned and unburned watersheds were insignificant. In addition, strong linear relationships were found between average dNBR and Δd, and burned areas and Δd. The R2 values were 0.76 and 0.84 in 2021, and 0.56 and 0.38 in 2022, which revealed the linear relationships were weaker in 2022 due to vegetation recoveries. Our findings suggest that increases in runoff and decreases in ET are likely to initiate and persist at least 2 years after the disturbances. Since the duration and seasonality of post-fire impacts are still debatable, our findings bring new insights into the post-fire responses and may facilitate conversations among watershed managers in the PNW region.

Postfire Changes in Snow-water Storage and Snowmelt in the Western Oregon Cascades

Kelly E. Gleason, Nani Ciafone, Sage Ebel, Megan Guinn, and Anton Surunis

Portland State University

Snowpacks act like high mountain reservoirs, but are vulnerable to climate change, while the vast majority of forest fires occur in the seasonal snow zone. Forest fires further exacerbate the influence of warming climate on snow-water storage through feedbacks between shifting post fire forest-snow interactions. Charred forests shed black carbon and burned debris, which accumulates and concentrates on the snowpack, reducing snow surface albedo. Forest fires may increase snow accumulation, but accelerate snowmelt rates, and advance the timing of snow disappearance and associated peak streamflow for years following fire. Using empirical data from in-situ field measurements, snow mass energy balance monitoring, multi-scale remote sensing, and physically-based snow modeling, we evaluate the spatial and temporal variability of forest fire effects on snow-water storage, snowmelt, and mid-winter snowmelt during rain-on-snow events in recently burned forests in the western Oregon Cascades. We characterize, parameterize, and model the spatial and temporal variability of the watershed-scale effects of burned forests and rain-on-snow events on snow-water volume, snowmelt rate and timing, streamflow, and sediment transport. This research provides important data for algorithm development and parameterizations of key processes which are currently unrepresented in hydrologic models, but may have profound influence on post-fire hydrologic responses and associated impacts to infrastructure. By characterizing key headwater processes we will help improve the predictive capacity of flood risk and sediment transport in burned forested watersheds across the Pacific Northwest.

Stability From Instability: Quantifying Total and Pyrogenic Carbon Stocks in Deep-seated Landslides

Nicole Cleland

Earth Surface Processes Lab, Department of Earth Sciences, University of Oregon

Soils store more carbon than the biosphere and atmosphere combined and may serve an important role in understanding and potentially mitigating climate change. With increasing frequency, severity, and size of fires, we need to quantify how wildfires impact the production, cycling, and storage of pyrogenic carbon (PyC), which is a small but highly stable component of soil organic carbon (SOC) stocks. Because SOC research focuses on the top meter, less is known about dynamics of deep soil organic carbon. In deep, highly weathered critical zones, such as deep-seated landslides, SOC below 1 m can contribute significantly to total SOC stock. To quantify the role of deep-seated landslides for storing SOC and PyC, we sampled a >7 meter deep soil and weathered bedrock profile on a ~1 My landslide deposit in the Oregon Coast Range. Given the 200-300 year return interval of stand-replacing fires in this region, abundant slide deposits may constitute a substantial reservoir of PyC. From the core samples, we measured SOC density, soil texture, and Fe content throughout the profile. To address how stability of carbon varies with depth, we measured mineral-associated and particulate organic carbon fractions by density and size fractionation; and PyC fractions through digestion. This work will help to improve SOC inventory predictions and understanding the role deep-seated landslides have in PyC storage and deep critical zone development.

Quantifying Impacts of Forest Fire on Soil Carbon in a Young, Intensively Managed Tree Farm in the Western Oregon Cascades

Katherine McCool[1], Scott Holub[2], Si Gao[3], Brett Morrissette[1], Jessica Blunn[1], Adrian Gallo[1], Jeff Hatten[1]

[1]Oregon State University, Department of Forest Engineering, Resources, and Management

[2]Weyerhaeuser Company

[3]California State University Sacramento, Department of Environmental Studies

Forest soils in the Pacific Northwest contain immense amounts of carbon (C) that lead to highly productive tree farms. Increasing acreage burned by severe wildfire threatens belowground carbon stocks and future site viability in the western Oregon Cascades. This study investigates forest soil carbon changes after the 2020 Holiday Farm wildfire in a young, intensively managed Douglas-fir tree farm in western Oregon. This longitudinal study was established to detect soil carbon changes after a harvest; it therefore offers insight into long-term soil carbon dynamics after the compounding disturbances of clearcut harvest and wildfire.

Forest floor, 0-15, and 15-30 cm depth soil samples were collected for physical and chemical comparisons over three sampling periods: pre-harvest, post-harvest, and post-fire. Overall, soil carbon decreased by 54.9±3.7 Mg C/ha , equivalent to 38.1±2.2% of whole-site soil carbon. 70% of losses were in the forest floor and 30% were in the mineral soil. Carbon stock losses were driven by decreases in mass at every level. Carbon concentration was unchanged at most levels. These losses are significantly higher than most previously studied soil carbon decreases from severe wildfire. Carbon losses will increase outputs to the atmosphere, exacerbating the warming effects of climate change, and may lead to impeded growth for newly planted seedlings.

The Impacts of Fire History on Soil Organic Matter Composition Using High Resolution Mass Spectrometry

Maggie Bowman

Environmental Molecular Science Laboratory

While significant progress has been made in understanding global carbon (C) cycling, the mechanisms regulating belowground C fluxes and storage are still uncertain. New molecular technologies have the power to elucidate these processes, yet we have no widespread standardized implementation of molecular techniques. To help address this gap, we have developed a crowdsourced soil core research program to build a Molecular Observation Network (MONet) for analyzing molecular and microstructural data that describe soil structure, soil organic matter (SOM) chemistry, and soil microbiology. Known as the 1,000 Soils Pilot and based at the Environmental Molecular Sciences Laboratory (EMSL), we use Fourier-transform ion cyclotron resonance- (FTICR) and liquid chromatography- (LC) mass spectrometry (MS) ; X-ray Computed Tomography (XCT), water retention curves; metagenomic sequencing; and standard biogeochemical measurements to enable new insights into soil C cycles. We collected soil cores in partnership with the Confederate Tribes of Warm Springs from three burn areas and are able observe changes in organic matter (OM) composition related to burn history.

Soil Carbon Persistence and Pyrogenic Carbon Signature in Oregon's Western Cascades One Year Post Fire

Hayley Peter-Contesse, Kate Lajtha, Amy Mayedo, Regina O'Kelley

Oregon State University

Wildfires have the potential to dramatically alter the carbon (C) storage potential, ecological function, and the fundamental mechanisms that control the C balance of PNW forested ecosystems. Forest soils hold vast quantities of C in soil organic matter, and the balance between C stabilization and destabilization influences not only forest C processing, but also atmospheric C and global temperature.

Root-derived, microbially processed C compounds make up a substantial portion of mineral-associated organic matter, a fraction of mineral soils that tends to persist in soils as a result of the integrated physical, chemical, and biological mechanisms of organo-mineral complexation. Events like high intensity wildfire that cause major interruptions to C processing, in addition to causing direct tree mortality, may also impede root and rhizosphere function by releasing an influx of dead fine root material while simultaneously arresting root exudation.

We explore the question: How does a major disturbance like wildfire influence (1) the processes that control soil C stabilization and (2) the consequent soil C persistence? We collected mineral soils at four depth increments from burned (low, moderate, and high soil burn severity classes) and unburned areas across the footprint of the 2020 Holiday Farm Fire. We then density fractionated the soils to separate mineral-associated and particulate organic matter fractions. Each fraction was further analyzed to determine pyrogenic C content using the benzene polycarboxyl acid (BPCA) method followed by quantification with HPLC. Our preliminary results relate total C and pyrogenic C content by density fraction to soil burn severity class, with implications for both short- and long-term soil C persistence post fire.

8. POST-FIRE SOIL AND DEBRIS FLOW HAZARDS

Eight of the symposium presentations addressed post-fire soil and debris flow hazards. Two studies examined changes to soil hydraulic properties after fire in western Oregon (Johnson and Wetherholt, Quinn and Moffett). Leschinky discussed their study investigating possible landscape controls on post-fire debris flows in western Oregon. Selander et al. presented on evaluating existing U.S. Geological Survey post-fire debris flow likelihood models for debris flows in western Oregon. Burns et al. offered recent observations of post-fire debris flows and takeaways in the aftermath of the 2020 Labor Day Fires in western Oregon. Rengers et al. discussed their multi-agency effort to create a post-fire debris flow inventory in Oregon. Andy Bryant presented on the National Weather Service's efforts to mitigate post-fire debris flow hazards in Oregon and Michael Zimmerman presented on how the Oregon Department of Transportation addresses post-fire hazards in the complex human environment that they manage.

Evaluating the Occurrence and Spatial Patterns of Soil Water Repellency in the Deschutes National Forest, Oregon, U.S.A.

Brittany Johnson[1], Jalene Weatherholt[2],

[1]School of Environmental and Forest Sciences, University of Washington

[2]US Forest Service Southwestern Regional Office

As the annual area of land impacted by wildfire continues to increase due to years of fuel build-up and climate change, managers and communities focus more intensely on mitigating the post-fire risk of topsoil erosion due to weakened soil structure and impeded water infiltration. Fire can exacerbate soil water repellency (SWR), forming a layer of substrate coated with hydrophobic compounds which hinders water infiltration and increases surface soil erosion risk and runoff. Although SWR occurs naturally in many areas, it is usually patchy and does not inhibit water movement. However, fire can increase the connectedness and extent of SWR leading to topsoil loss, nutrient limitations, increased root water stress, and ultimately slower ecosystem recovery. This study examines the naturally hydrophobic soils of Oregon's Deschutes National Forest following the Green Ridge Fire in 2020 across varying degrees of burn severity to 1) examine the relationship between SWR and management relevant burn severity classes, 2) quantify an appropriate spatial scale over which to evaluate SWR properties, and 3) determine which environmental factors drive patterns in SWR. We found that both canopy and soil burn severity metrics did significantly explain some variation in SWR following fire; however, there were few patterns in SWR within burned soils aside from an increase in the heterogeneity of hydrophobic conditions after fire. SWR significantly dissipated with depth while the range of spatial autocorrelation of SWR extended only ~5 m. Due to fine-scale variation, soils measured at just a few point locations within a post-fire ecosystem may misrepresent the true levels of SWR, or even fail to record any SWR presence. Future work should focus on determining an efficient post-fire soil evaluation protocol with adequate density and scale of sampling over which to evaluate SWR while also incorporating the influence of environmental factors to inform management decisions.

Post-fire Soil Hydraulic Properties Affected by the 2020 Labor Day Fires, OR

Dylan S. Quinn, Kevan B. Moffett

Washington State University Vancouver, School of the Environment, Vancouver, WA

In early September 2020, the western Cascade range experienced an extreme episodic fire weather event characterized by unusually strong wind and extremely low vapor pressure deficit. Across the Oregon and Washington Cascades, nearly 500,000 hectares of forested land was burned within a one week period. While there has been substantial research into fire effects on soils across many regions globally, there are few datasets which characterize the hydraulic changes in the high-severity, long return interval fire regime of the Cascades seasonal temperate rainforest region. In this study, we collected soil samples for field and laboratory hydraulic analysis across four distinct soil texture classifications found in the Riverside, Lionshead, Beachie Creek, and Holiday Farm fires in Central Oregon. Key hydraulic and physical properties including tension and ponded hydraulic conductivity, water retention characteristics, water repellency, particle size distribution, and organic matter content were collected under field and laboratory conditions. 53% of sites exhibited moderate to strong water repellency with silty and clayey soils showing more frequent hydrophobicity than sandy loam soils. Similarly, water repellency was significantly related to remotely-sensed burn severity metrics (dNBR) for the clay and silt loam soils, but not for other textures. Infiltration rates were also influenced by a combination of texture, water repellency, and sample saturation, where high water repellency promoted large differences in infiltration rates based on the degree of saturation and the infiltration method - ponded vs. tension. The datasets produced from this work will be further used in numerical hydrological modeling and be invaluable for broadening the geographic scope of our understanding of fire effects on soil and water resources.

Evaluating the Controls on Post-fire Debris Flows in the Pacific Northwest

Ben Leshchinsky

Oregon State University

Wildfire is known to amplify the likelihood and magnitude of debris flows in steep terrain. Post-fire debris flows typically occur during the winter wet season, suggesting that rainfall-driven erosion is a strong control on in-channel preconditioning and triggering of these hazards in the immediate year or two following fire. However, in the cool, wet climates of the Pacific Northwest (PNW), debris flows frequency seems to remain elevated following the first several winters owing to infiltration-driven debris flows controlled by shallow landslides. The longer-term potential for shallow landslides and their associated post-failure mobility appears to be enhanced by the decay of root systems associated with tree mortality. However, the timescales of this amplification or attenuation of post-fire debris flow likelihood and magnitude are poorly-constrained in the PNW. An interagency team of academic and government researchers are working to evaluate the temporal controls on post-fire debris-flow initiation and their impact on transportation infrastructure. This research focuses on (1) monitoring the hydrological and climatic conditions associated with landslides in several burn scars in western Oregon, (2) physical characterization of soil and root strength following wildfire, and (3) interpretation of topographic change in select areas of extensive debris-flow activity. This recently launched four-year project is intended to better characterize controls on the delayed triggering of post-fire landslides and their associated debris flows and improve existing models that reflect the amplification and subsequent attenuation of this hazard with landscape recovery.

Evaluating the Performance of the USGS Post-fire Debris-flow Likelihood Model in Western Oregon

Brittany Selander[1], Jason W. Kean[1], Matthew A. Thomas[1], Francis K. Rengers[1], Jaime Kostelnik[1], Nancy C. Calhoun[2], William J. Burns[2]

[1]U.S. Geological Survey
[2]Oregon Department of Geology and Mineral Industries

Oregon is experiencing an increase in wildfire activity that has left steep terrain susceptible to debris flows. To help evaluate post-fire hazards, the U.S. Geological Survey (USGS) has conducted debris-flow hazard assessments for recent burn areas in western Oregon. The hazard assessments estimate the likelihood of debris flows as a function of topographic slope, soil burn severity, soil erodibility, and short-duration (≤ 60 minute) rainfall. The USGS likelihood model is calibrated with data from southern California, where post-fire debris flows are primarily triggered by distributed surface-water runoff and erosion. While tested in other semi-arid regions across the western U.S., model applicability in wetter climates like western Oregon have not been evaluated due to lack of post-fire debris flow observational data. Recent field observations in western Oregon from partners at DOGAMI suggest debris-flow initiation by shallow landslides or in-channel failures of stored material. We hypothesize that improved predictions may be obtained using longer-duration metrics of rainfall more appropriate for shallow landslide or in-channel initiation processes and through model recalibration. Results are not yet finalized, but progress will be reported at the meeting. Here, we used a new post-fire debris-flow inventory to quantitatively evaluate model performance and explore ways to improve predictions in this region. Specifically, we compared observations of rainfall intensity and debris-flow activity (or no activity) to model predictions of debris-flow likelihood. We evaluated model performance with the normalized Matthews Correlation Coefficient (nMCC), for which a value of 1 suggests perfect prediction of debris-flow occurrence and a value of 0 suggests perfect misclassification. We found that the USGS likelihood model has an nMCC of 0.53 for Oregon. This indicates that the model is moderately accurate at predicting post-fire debris-flow occurrences in western Oregon but has considerable room for improvement.

NWS Services for Post-fire Debris Flow Hazards in Northwest Oregon

Andy Bryant

National Weather Service

The mission of NWS Portland is to provide weather, water and climate data, forecasts, warnings, and decision support services for protection of life and property and enhancement of the economy. Wildfires of 2017 and 2020 created a potential hazard not seen for many decades in NW Oregon: post-fire debris flows. NWS Portland has developed new services, including weekly overview briefings with details on precipitation timing and amounts to support land management and emergency management partners. NWS Portland has also implemented new tools for rapidly assess debris flow threats for the issuance of watches and warnings.

Recent Observations of Post-fire Debris Flows in Five Megafires in the Western Cascades, Oregon

William Burns[1], Nancy Calhoun[1], Jason Kean[2], Francis Rengers[2]

[1]Oregon Department of Geology

[2]U.S. Geological Survey, Geologic Hazards Science Center

To better understand the influence of wildfire on debris-flow occurrence in the Pacific Northwest, we surveyed five burn areas in Oregon for debris-flow activity during the 2020-21 and 2021-22 winter rainy seasons. The sites include four burn areas that are the result of Oregon's devastating 2020 Labor Day megafires: Riverside, Lionshead-Beachie Creek, Holiday Farm and Archie Creek; as well as the 2017 Eagle Creek burn area. Each of these fires burned west of the Cascades, on the rainy side of the mountain range. We conducted field surveys after several major rain events, most of which were the result of moderate to intense atmospheric river storms. Additionally, we used aerial photos acquired by the Oregon Department of Transportation for two of the burn areas to identify initiation areas and transport zones, which were otherwise difficult to see in the field. We identified 56 debris-flow events, 17 flood-scour events, 26 shallow landslides, 9 rockfall instances, and 226 drainages that did not display evidence of a flood or debris flow. These non-events are important to build a dataset of null events needed for rainfall threshold analyses. Following event identification, we further characterized sites containing debris flows using additional feature classes, including initiation points, transport lines, and deposition polygons. We identified 22 initiation points, 72 nonunique transport lines, and 39 deposition polygons. In this presentation, we will provide observations of the variety of mass movement events within the burn areas, as well as comparisons between the 2020-21 events and events the following year. We will also compare these post-fire events to non-fire debris-flow events within the same geographic extents in four out of five of the burn areas (excluding Riverside). Initial observations suggest differing initiation styles between non-fire debris flows and post-fire debris flows.

Pairing on-the-Ground Observations with Real-time Telemetered Rainfall Data to Develop a Post-fire Debris Flow Inventory in Oregon

Francis Rengers[1], Rielly King[3], Bill Burns[2], Nancy Calhoun[2], Benjamin Leschinsky[3], Joshua Roering[4], Jason Kean[1], Brittany Selander[1], Nicolas Mathews[1]

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[4]University of Oregon

In the past 10 years there have been several large wildfires in Oregon in steep terrain, creating potential debris flow hazards. In order to create a post-fire debris flow/flood inventory, the U.S. Geological Survey (USGS) has relied on observational data from partners, such as the Oregon Department of Geology and Minerals (DOGAMI), to help to develop reliable inventories of debris flow and flood response. In addition, the response inventory also requires observations of meteorological data, and rainfall in particular. Currently, the USGS is partnering with local universities (Oregon State University and University of Oregon) to establish telemetered meteorological stations delivered in real-time. There are also existing telemetered reporting gages operated by a variety of agencies that are available via an application programming interface (API). Recently, the USGS has been developing automated software to acquire and process rainfall data near the recent Oregon fires from the existing meteorological stations. This presentation will discuss the use of this new software, including examples in burn areas from fires in 2020 (Holiday Farm, Riverside, Beachie Creek, Archie, and Lionshead) and 2017 (Eagle Creek). This presentation will also illustrate how the USGS is using partnerships to develop a more reliable post-fire response inventory for Oregon, which will be an important building block for improved post-fire debris flow models and hazard assessments in Oregon.

Dealing with Post-fire Soil Movement in a Complex Human Environment: the Gorge!

Michael J. Zimmerman

Senior Engineering Geologist, ODOT Region 1

After the Eagle Creek fire in 2017, the Oregon Department of Transportation (ODOT) was tasked with mitigating and responding to increased hazards along the Columbia River Highway. These post-fire hazards include rockfall, hazard trees, landslides and debris flows. The scenic waterfalls, parks, historic attractions, and scattered residences in the fire area are all located along the highway. This thin corridor of built infrastructure is sandwiched between the Columbia River and steep forested hillsides; all within the Columbia River Gorge National Scenic Area. In this complex human environment, the consequences of post-fire hazards can be severe. This presentation outlines ODOT's priorities after a fire and their methods for mitigating hazards within the constraints of the surroundings and resource limitations, while at the same time addressing the priorities of other regional stakeholders.

9. PRE- AND POST-FIRE MANAGEMENT

Ten presentations, including one panel discussion, were on the topic of pre- and post-fire management. The panel discussion titled 'The next pre-fire landscape: how does a new landscape management paradigm emerge?' facilitated a discussion among land management professionals on their experiences managing landscapes in the face of climate change and changing fire regimes (Dickinson et al.). Meigs et al. presented on lessons learned from the 2021 and 2022 fire seasons in Washington State. Dana Skelly presented their geospatial tool showing U.S. Forest Service Fuels Treatment Effectiveness Monitoring on large fires in Oregon and Washington. White et al. presented their management strategies to support post-fire restoration and pre-fire planning. Alex Rozin offered highlights of post-fire opportunities on National Forest System lands across the Pacific Northwest. Other topics addressed included identifying public priorities (Armatas et al.), post-fire management and monitoring by Oregon Department of Forestry (Wepprich), post-fire salvage logging (Zuspan and Reilly, Theve and Puttere), and biochar production and application (Celis and Puttere).

Panel Discussion:
The Next Pre-fire Landscape: How does a New Landscape Management Paradigm Emerge?

James Dickinson[1], Andrew Puerini[2], Barbara Garcia[3], Rebecca A. Lloyd[3], Alex Rozin[3]

[1]Bureau of Land Management

[2]Confederated Tribes of Grand Ronde

[3]U.S. Forest Service

The scale, quantity, and effects of wildfire has heavily impacted land management organizations driven in part by climate change, urban development, and legacy management practices. Land managers have an increasing need for a paradigm shift where fire is accepted as an integral landscape process which influences ecosystem characteristics to be dynamic in location and variable through time. Through a facilitated conversation, this panel of land management professionals will share their experiences of managing landscapes through these changing times. Themes will include the importance of place-based management, challenges of contemporary landscapes, preservation of our past, and the importance of distilling and refining knowledge.

Assessing the Work of Wildfire: Lessons From the 2021 and 2022 Fires Seasons in Washington State

Garrett Meigs, Ana Barros, Derek Churchill, Chuck Hersey, Annie Smith

Washington State DNR

Throughout the western US, wildfire presents perennial challenges and opportunities for communities, land managers, and policy makers. In recent years, wildfires have burned millions of acres in Washington State, inducing a wide range of effects across ecosystem gradients and forest types. In 2017, the Washington State Department of Natural Resources (DNR) launched the 20-Year Forest Health Strategic Plan to accelerate landscape-scale wildfire risk reduction, restoration, and climate adaptation across all lands. DNR staff have collaborated with many partners to prioritize planning areas and treatment needs, implement treatments, and monitor changes in landscape conditions and treatment effectiveness. To better understand the widespread impacts of the 2021 fire season, we piloted a rapid assessment to evaluate the work of wildfire – i.e., the degree to which fire effects were consistent with the landscape resilience and wildfire risk reduction objectives of the 20-Year Plan. Here, we present results from the 2021 and 2022 fires across eastern and western Washington. We highlight how wildfires have both positive and negative effects, depending on location, forest type, and landowner objectives. Using examples from the 2021 Schneider Springs Fire (east side) and 2022 Bolt Creek Fire (west side), we demonstrate approaches for mapping and monitoring fire effects, evaluating forest health treatment effectiveness, and engaging with wildfire managers to understand how they utilize treatments. Given recent trends and climate projections, characterizing and harnessing the work of wildfire will be increasingly important for forest health and landscape resilience.

USDA/USFS R6 Fuels Treatment Effectiveness Monitoring on Large Fires

Dana Skelly

USFS PNW Research Station

Federal policy has required monitoring of fuels treatments that were designed to mitigate against unwanted fire effects and/or be positioned to assist with control of fires for well over a decade for all land management agencies, and since 2009 in the USDA Forest Service. Yet as fire activity increases, the increased impacts to our workforce often have meant that this monitoring has been done with varying degrees of quality, if at all.

Since 2017, the Regional Fuels Program for the National Forests of Oregon and Washington has provided support to collect this data, looking at all active vegetation management treatments that intersect more consistently with fires and not just treatments designed for hazardous fuels work. During highly active years where we've had numerous intersections of these treatments with wildfires, we've been pioneering utilization of geospatial tools like Survey 1,2,3 for field data collection. This has enabled creation of public facing dashboards, which are available online for 2018 and 2021.

In working with a range of fire managers and resource specialists to collect the data and through subsequent presentations, we have greatly increased the operational use of these treated areas when we manage wildfires. 2018 we tripled the number of vegetative treatments that intersected with fires from the same effort in 2017—more than 900 between Forest Service and BLM units. 2021 saw another exponential leap in intersections with well over 1300 across forest service lands alone. This is not luck or accident. This reflects a change in management strategies.

We are using existing features to put the line in the right place the first time. We are focusing on strategies that have a high probability of success with the least amount of exposure. We are thinking about the consequences of deferred risk.

When we look at managing wildfires, we are framing the approach we take in terms of decision space. Decision space defines how broad or narrow our options are when the fire comes.

When we have increased our decision space through well-placed and well implemented vegetation treatments, we have the opportunity to look at fire from a proactive stance. We can consider the immediate risk of a fire to lives and property *and* we can consider the expected risk from a future fire that will happen under more extreme conditions.

Prioritizing Management Action and Inaction Across Large Landscapes to Support Post-fire Restoration and Pre-fire Planning

Angela M. White[1], Morris C. Johnson[2], Amy Markus[3], Elizabeth Pansing[4], Brian Morris[4]

[1]USFS Pacific Southwest Research Station

[2]Pacific Northwest Research Station

[3]Fremont-Winema National Forest

[4]American Forests

The legacy of fire exclusion, coupled with rapid changes in climate, have led to a dramatic increase in the frequency of large-magnitude disturbances across the west, including massive, high-severity stand-replacing fires. Given the scale of disturbance and implementation challenges, research and monitoring are needed to help prioritize management actions on the landscape including reducing or modifying forest fuels, facilitating reforestation, reducing the spread of invasive species, and maintaining forested habitat that can support wildlife populations. Prioritization of management actions to address these objectives will depend on work capacity and the ecological and societal context of where the fire occurred. The USFS Pacific Southwest and Pacific Northwest Research Stations are combining their efforts to answer some of the major land management questions emerging in this era of uncharacteristic wildfire. In collaboration with America Forests we are working with Fremont-Winema National Forest managers and partners that were impacted by the 2021 Bootleg wildfire. Desired outcomes for this project are to (1) collaborate with managers to prioritize management actions where they are most needed through the development of a restoration portfolio that, (2) incorporate research plans targeted to the restoration decisions, and (3) improve an understanding of the efficacy of different management actions to direct future landscape conditions that can support functioning ecosystems.

Post-fire Opportunities in the Pacific Northwest

Alex Rozin

US Forest Service PNW Region

Over the past decade, the Pacific Northwest has seen an increase in the scale, severity, and complexity of wildfires. This poster highlights post-fire opportunities on National Forest Service Lands across the Pacific Northwest.

Mapping, Prioritization, and Public Participation (M3P): Identifying Public Priorities and Needs for Post Wildfire Restoration

Chris Armatas[1], Lee Cerveny[2], Alyssa Thomas[3], Thomas Timberlake[2]

[1]USFS Rocky Mountain Research Station

[2]USFS Pacific Northwest Research Station

[3]USFS Pacific Southwest Research Station

Catastrophic wildfire has transformed ecosystems and displaced human communities in many regions of the western United States. To address this challenge, resource managers, tribal officials, and community leaders face difficult decisions about management of post-fire landscapes. Fundamentally, these decisions need to consider diverse (and sometime conflicting) public perceptions about what landscape benefits are important, where those benefits are derived, and how post-fire landscapes may be restored to meet public needs. In this poster, we present a structured approach based on sound social science to spatially assess public priorities for post-fire restoration approaches. This approach provides managers and planners with a scientifically rigorous understanding of the diverse publics, which can inform decision-making, as well as communication and public relations.

Post-fire Management and Monitoring in Santiam State Forest

Tyson Wepprich

Oregon Department of Forestry, State Forests Division

The 2020 Labor Day wildfires burned through approximately 24,300 acres (51%) of the Santiam State Forest. A mosaic of fire effects was observed ranging from unburned forest to total overstory mortality. The wildfire impacts created a new set of land management considerations for the Oregon Department of Forestry's (ODF) State Forest Division, which is mandated to use active management to achieve the "greatest permanent value" (ORS 530.050) to Oregonians.

After a multiple resource assessment, ODF embarked on different management strategies depending on the fire impacts, pre-fire forest condition, and land management goals. Post-fire management included repair of transportation and recreation infrastructure and hazard tree removal, logging of 51.6 million board feet of burned trees, reforestation with planting and aerial seeding, riparian revegetation, and new monitoring projects.

Santiam State Forest provides an ongoing natural experiment for how stands of different management histories interact with mixed severity fire and respond to post-fire management treatments. Reforestation is a primary concern, especially in stands with total canopy mortality and no planting. Aerial seeding will be monitored for recruitment success at different elevations and burn severities. ODF is partnering with researchers and other agencies to learn more about post-fire forest changes. For example, ODF had lidar collected in 2022 with USGS 3DEP funding over the majority of the Beachie Creek and Lionshead fires to aid in cross-ownership data needs.

Mapping Post-fire Salvage Logging in Western Oregon

Aaron Zuspan and Matthew J. Reilly

USFS Pacific NW Research Station Western Wildland Environmental Threat Assessment Center

Salvage logging is a post-fire management practice with complex ecological, economic, and social impacts. Despite substantial public interest, accurate estimates of the extent and distribution of salvage logging are limited. We introduce a remote sensing methodology using unsupervised change detection with multispectral Landsat imagery to map salvage logging over five large, high-severity wildfires that burned across multiple ownerships in the western Cascades of Oregon in 2020. We use these maps to characterize the extent, timing, and distribution of salvage logging by ownership and investigate its impacts on postfire landscape patterns. In the two years following fire, salvage logging took place across 9% of the burned forest extent, with 75% of operations taking place in the first year. Salvage rates varied with ownership and burn severity. The highest rates of salvage logging occurred in privately owned lands (12.3%) and areas with moderate burn severity (9.4%), with the lowest rates in federal lands (1.5%) and areas of low burn severity (7.0%). Salvage logging shrunk and fragmented patches of live remnant trees while increasing the distance between seed sources. The area of burned forest outside of seed dispersal distance (150m) from live remnant trees increased by 21%. These results highlight differences in post-fire management practices between ownerships in this region that may substantially affect future forest regeneration, early seral habitat, soil health, and carbon cycles. The methodology presented can improve understanding of salvage logging and its ecological impacts at a broad scale.

Post-fire Salvage Logging Soil Impact Monitoring on BLM Land in the Western Cascades of Oregon

Marissa Theve and Jennifer Puttere

Soil Scientists for the Northwest Oregon District BLM

In September and October 2020, the Beachie Creek and Riverside Fires burned several hundred thousand acres (334,013) including thousands of acres of Bureau of Land Management managed public lands in Marion, Clackamas and Linn Counties in Oregon (51,664). The Holiday Farm fire started on September 7, 2020, along Highway 126 west of McKenzie Bridge, Oregon and burned 173,393 acres, including approximately 18,528 acres administered by the BLM. Since that time, salvage logging has been taking place in the Cascades (Beachie and Riverside Fires) and Upper Willamette (Holiday Farm Fire) BLM Field Offices within the Northwest Oregon District. The BLM soil scientists covering these Field Offices have conducted post-harvest Soil Disturbance Monitoring (SDM) using the US Forest Service's method (Page-Dumroese et al. 2009). Here we present the findings of the SDM to illustrate the effects that salvage logging has on the soil resource on our public lands. It is our hope that these data can help inform public land use decision makers determine if salvage logging poses a risk to soils and forest productivity of the BLM Harvest Land Base, given the set of project design features and best management practices that have been selected for these salvage projects and implemented by the timber sale purchaser's heavy equipment operators.

Biochar Production and Application Within the Holiday Farm Fire Area

Jessica Celis and Jennifer Puttere

Bureau of Land Management

Within the Holiday Farm Fire perimeter, the Upper Willamette Field Office (UPW) of the Bureau of Land Management's Northwest Oregon District proposes to create biochar as an alternative means of slash disposal, to compare emissions of open pile burning versus place-based biochar creation, and to monitor the effects of biochar application on soils and vegetation affected by wildfire. The UPW is partnering with the Rocky Mountain Research Station to create biochar using an air curtain burner and has established five permanent plots to monitor the long-term impacts of biochar application on soils and vegetation. Biochar is understood to be a unique, easily-produced, and verifiably useful tool to amend soils which have experienced organic loss and/or other degradation. Additionally, biochar increases nutrient loading on the landscape and promotes water retention which is especially important on a burnt landscape with little to no canopy cover during a prolonged drought. Furthermore, biochar can tie up carbon and other nutrients beneficial for rapid native plant re-establishment which aids in invasive species suppression. Finally, studies have shown that the application of biochar works to quickly recover and stabilize landscapes. The general loss of vegetation from the Holiday Farm Fire gives us a unique opportunity to explore the use of an above ground air curtain burner to dispose of slash piles created by logging activity and to evaluate the effectiveness of biochar to: 1) reestablish soil nutrients after consumption of organic matter following a wildfire, 2) aid in the reestablishment of a native plant community, and 3) improve the outcome of tree survivability.

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