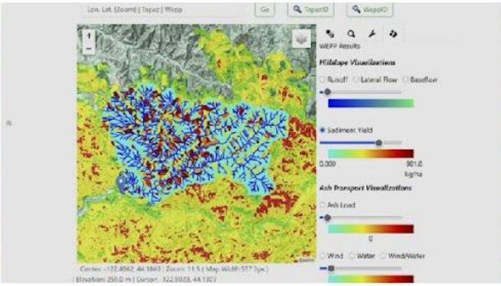
Supporting Resilient Water Management with Earth Observations, Models, and Decision-Support Tools in Fire-Affected Landscapes




Mariana Dobre

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University of Idaho
Department of Soil and Water Systems

University of Idaho

WWAO Connecting the Drops Webinar
09/18/2025

Rocky Mountain Research Station

Common questions from managers:

How much erosion occurs under different forest treatments?

Where are watershed erosion hotspots?

What are typical erosion rates by treatment?

Which soil and land physical properties drive erosion?

How do burn severity and vegetation recovery affect erosion?

Can answer!

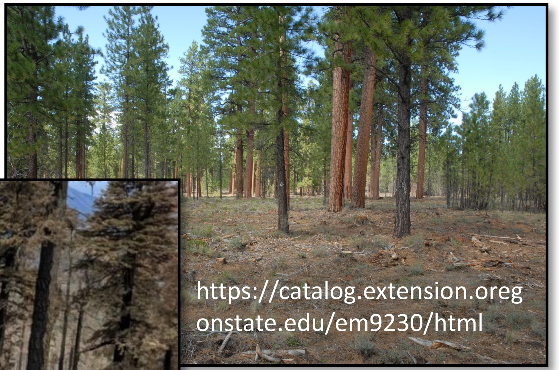
How can we better protect water resources, lives, and properties?

Cannot answer!


Photo John Wark, Reuters


Bladon et al., 2014, EST


Photo Jan Nyman

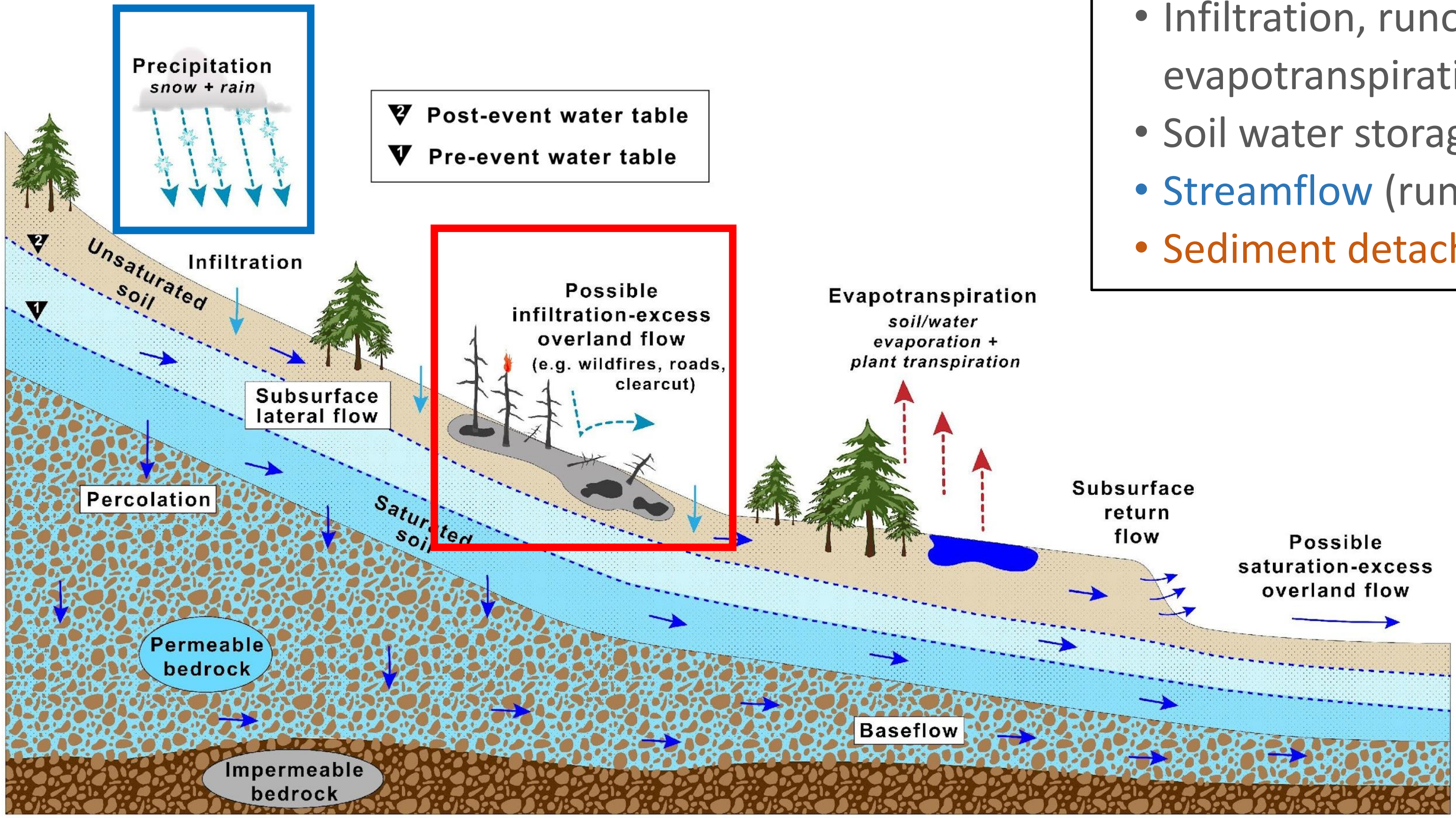

https://catalog.extension.oregonstate.edu/em9230/html


InciWeb, Museum Fire, BAER

Use hydrologic models and data to answer management questions

Water Erosion Prediction Project (WEPP)

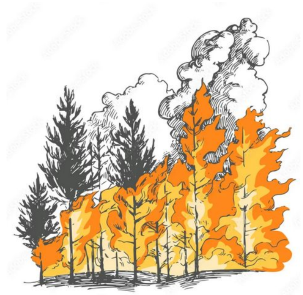
<u>Full process-based hydrologic model</u>
(daily, hourly, or event-based)
- Snow accumulation and melt
- Infiltration, runoff (saturation/infiltration excess), evapotranspiration, interception, percolation
- Soil water storage with multilayer profile
- Streamflow (runoff, lateral flow, baseflow)
- Sediment detachment, transport, and deposition



Total storm
Rainfall intensity
Storm duration

Simulates infiltration-excess runoff

Uses post-disturbance soil erodibilities



WEPPcloud Lew et al., (2022); Dobre et al., (2022)

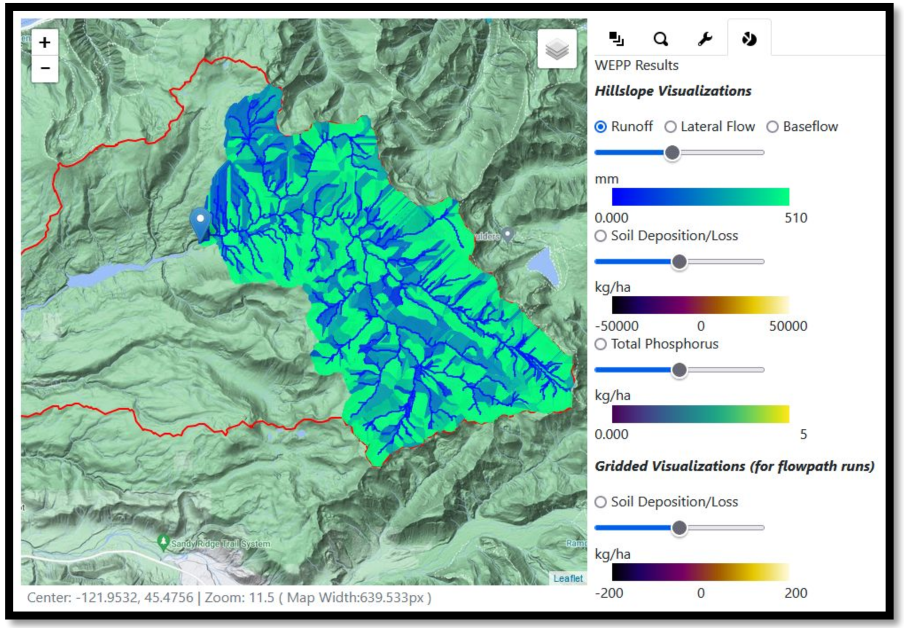
https://wepp.cloud/

Free online widely-used hydrology and erosion model designed for land management and wildfire.

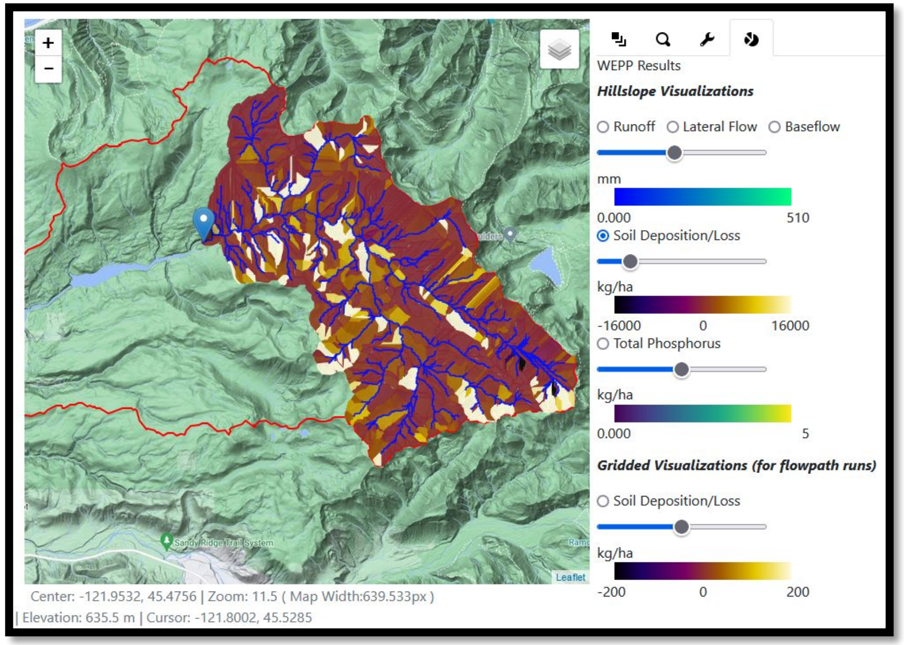
Simulates pre- and post-disturbance surface runoff and soil erosion.

Uses:	From:
DEM	10-m or 30-m DEM
SOILS	SSURGO/STATSGO
CLIMATE	CLIGEN – stochastic Daymet – 1 km GridMet – 4 km
VEGETATION/MANAGEMENT	NLCD, RAP database

Surface Runoff

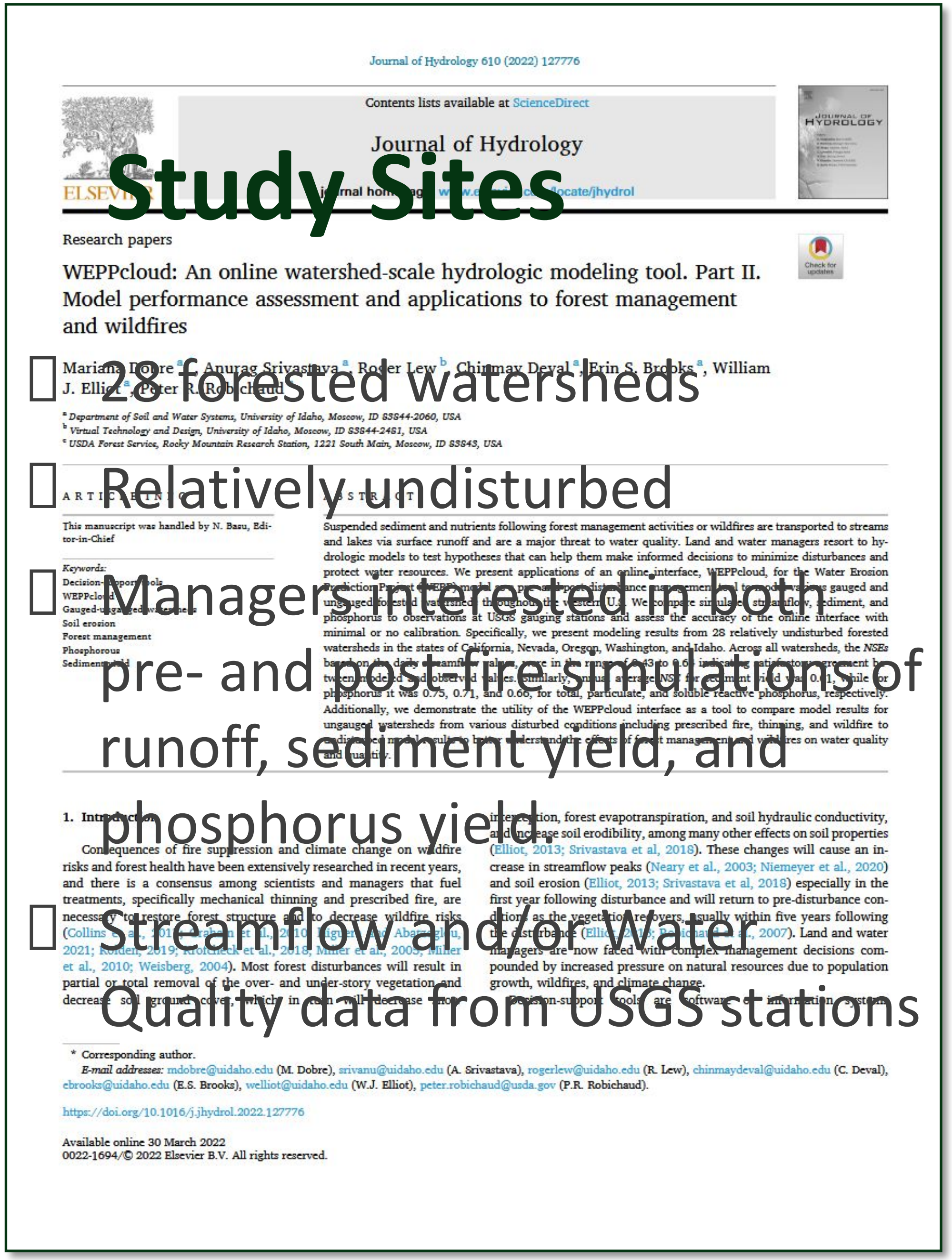


Sediment Yield



Study Sites

- 28 forested watersheds
- Relatively undisturbed
- Managers interested in both pre- and post-fire simulations of runoff, sediment yield, and phosphorus yield
- Streamflow and/or Water Quality data from USGS stations



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Research papers

WEPPcloud: An online watershed-scale hydrologic modeling tool. Part II. Model performance assessment and applications to forest management and wildfires

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ABSTRACT

Suspended sediment and nutrients following forest management activities or wildfires are transported to streams and lakes via surface runoff and are a major threat to water quality. Land and water managers resort to hydrologic models to test hypotheses that can help them make informed decisions to minimize disturbances and protect water resources. We present applications of an online interface, WEPPcloud, for the Water Erosion Prediction Project (WEPP) model as a pre- and post-disturbance management tool to model various gauged and ungauged forested watersheds throughout the western U.S. We compare simulated streamflow, sediment, and phosphorus to observations at USGS gauging stations and assess the accuracy of the online interface with minimal or no calibration. Specifically, we present modeling results from 28 relatively undisturbed forested watersheds in the states of California, Nevada, Oregon, Washington, and Idaho. Across all watersheds, the *NSEs* based on the daily streamflow values, were in the range of 0.43 to 0.6[illegible] indicating satisfactory agreement between modeled and observed values. Similarly, annual average NSE for sediment yield was 0.[illegible]1, while for phosphorus it was 0.75, 0.71, and 0.66, for total, particulate, and soluble reactive phosphorus, respectively. Additionally, we demonstrate the utility of the WEPPcloud interface as a tool to compare model results for ungauged watersheds from various disturbed conditions including prescribed fire, thinning, and wildfire to undisturbed model results to better understand the effects of forest management and wildfires on water quality and quantity.

1. Introduction

Consequences of fire suppression and climate change on wildfire risks and forest health have been extensively researched in recent years, and there is a consensus among scientists and managers that fuel treatments, specifically mechanical thinning and prescribed fire, are necessary to restore forest structure and to decrease wildfire risks (Collins et al., 201[illegible]; [illegible] et al., 2010; [illegible] Abatzoglou, 2021; [illegible], 2019; [illegible] et al., 2018; Miller et al., 2003; [illegible] et al., 2010; Weisberg, 2004). Most forest disturbances will result in partial or total removal of the over- and under-story vegetation and decrease soil ground cover, which in turn will decrease [illegible] interception, forest evapotranspiration, and soil hydraulic conductivity, and increase soil erodibility, among many other effects on soil properties (Elliot, 2013; Srivastava et al, 2018). These changes will cause an increase in streamflow peaks (Neary et al., 2003; Niemeyer et al., 2020) and soil erosion (Elliot, 2013; Srivastava et al, 2018) especially in the first year following disturbance and will return to pre-disturbance conditions as the vegetation recovers, usually within five years following the disturbance (Elliot, 2013; [illegible] et al., 2007). Land and water managers are now faced with complex management decisions compounded by increased pressure on natural resources due to population growth, wildfires, and climate change.

Decision-support tools are software [illegible] information systems [illegible]

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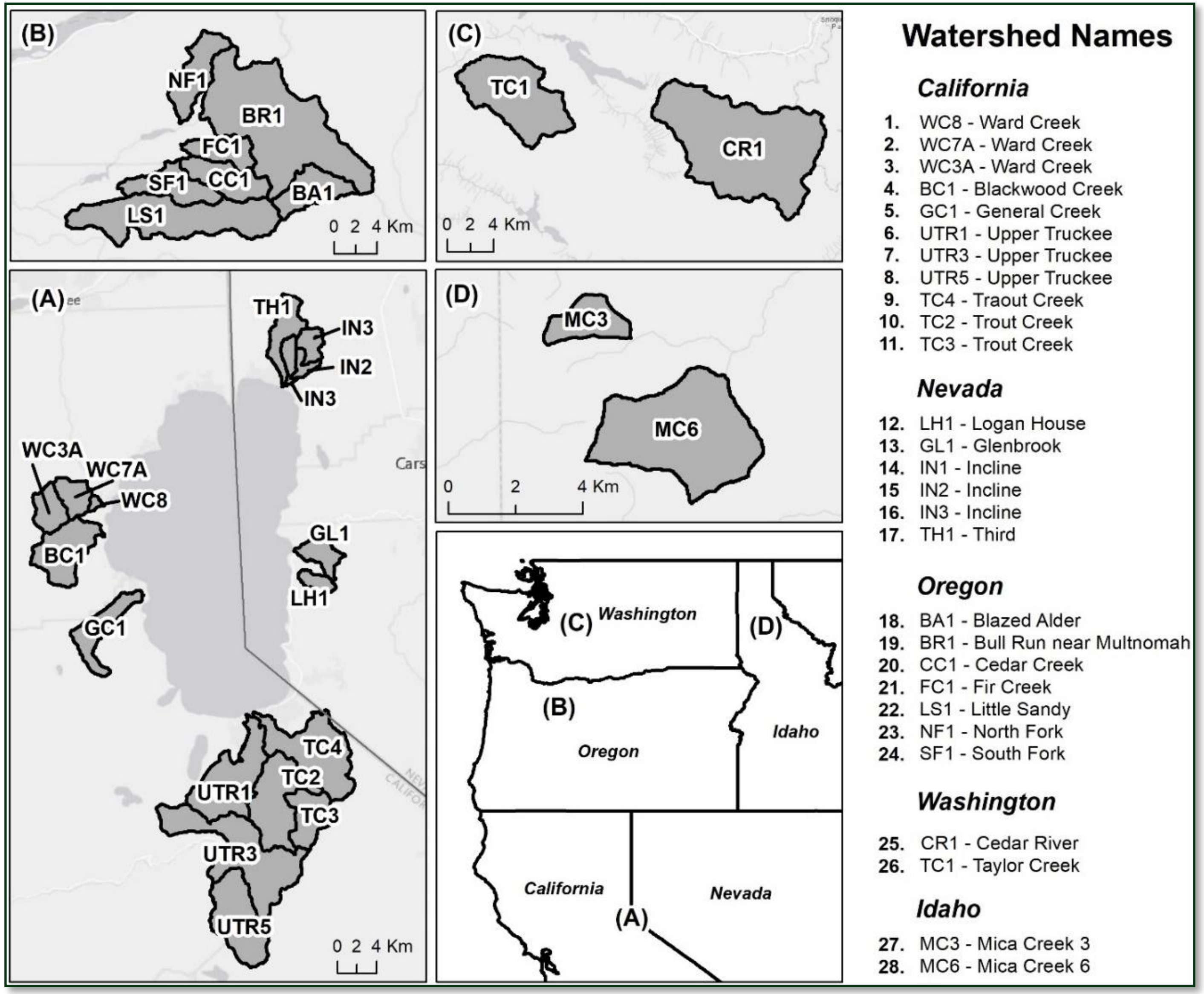
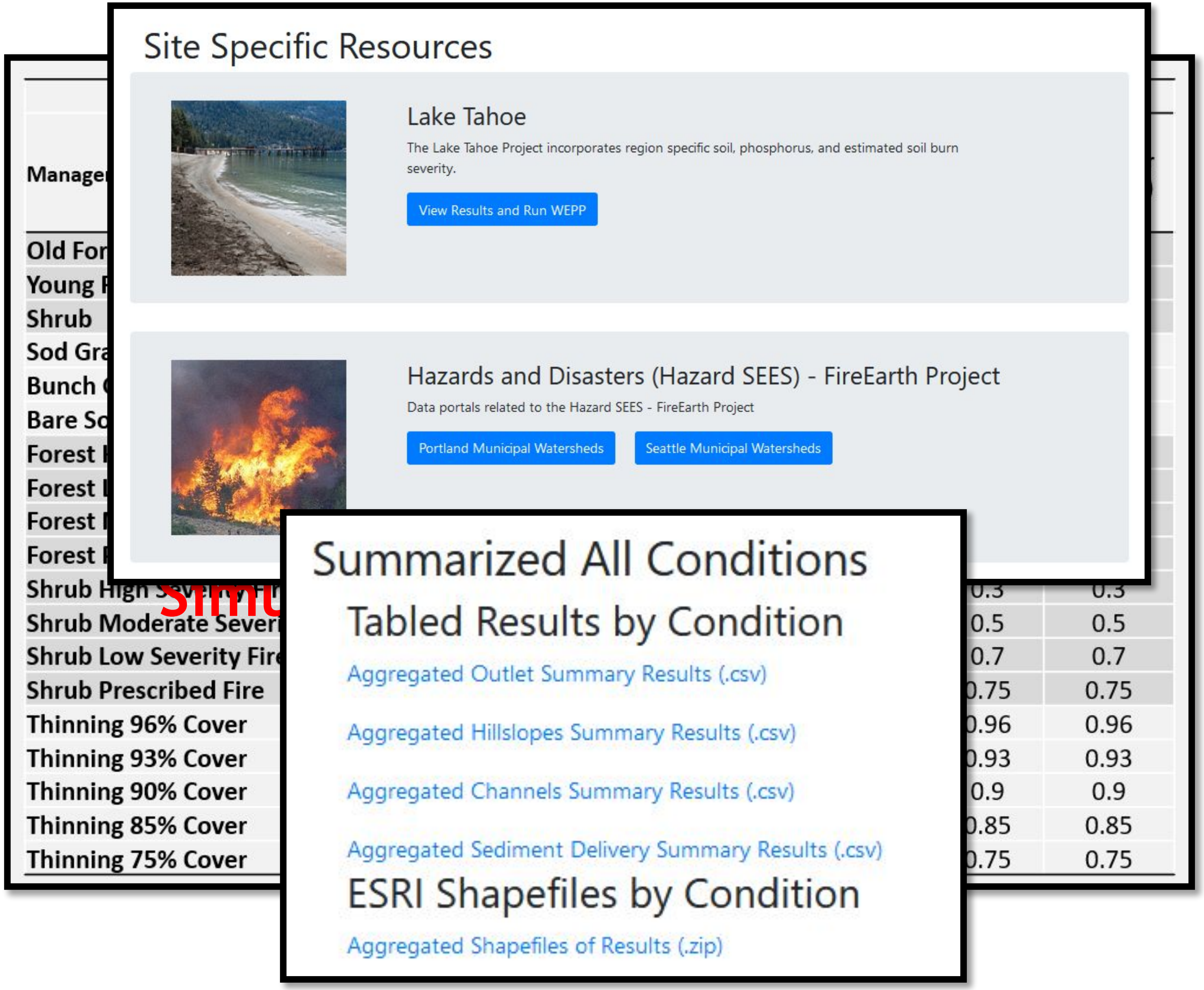
0022-1694/



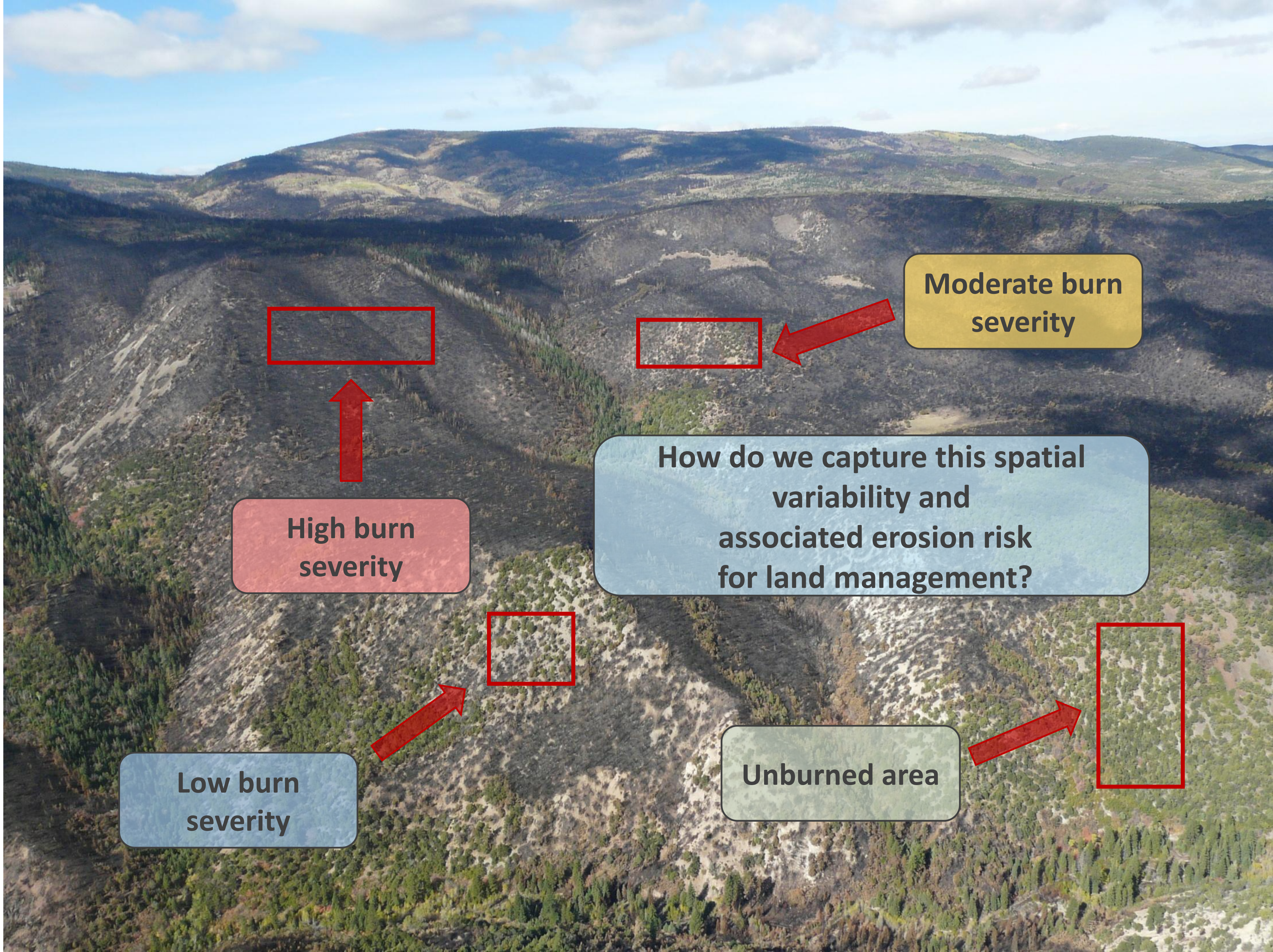
Application of WEPPcloud to undisturbed conditions

Answering management questions

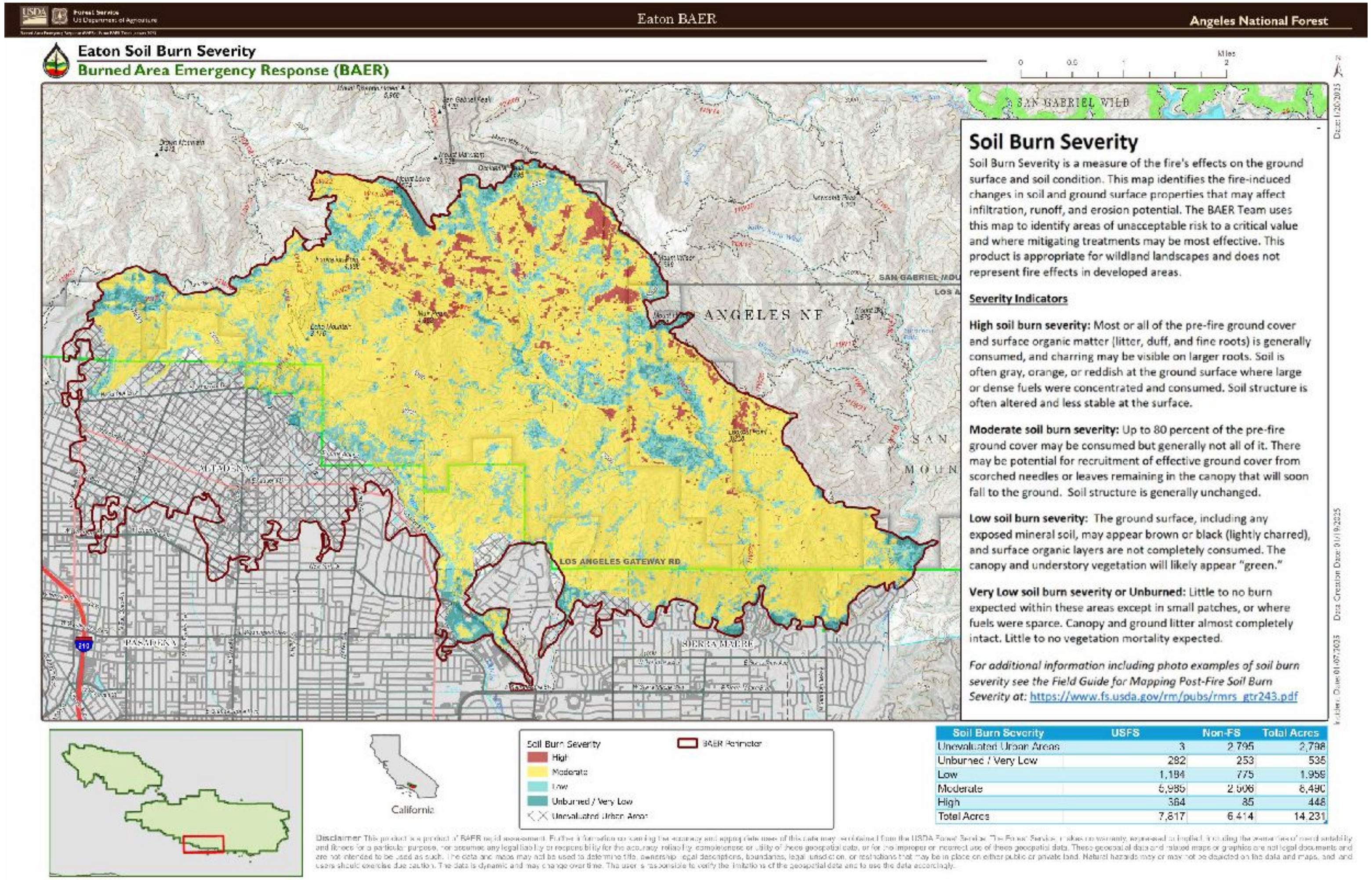
- Alter key soil and management properties to reflect post-treatment conditions
- Simulate different management scenarios
- Provide model results to managers by hillslope, channel, and watershed



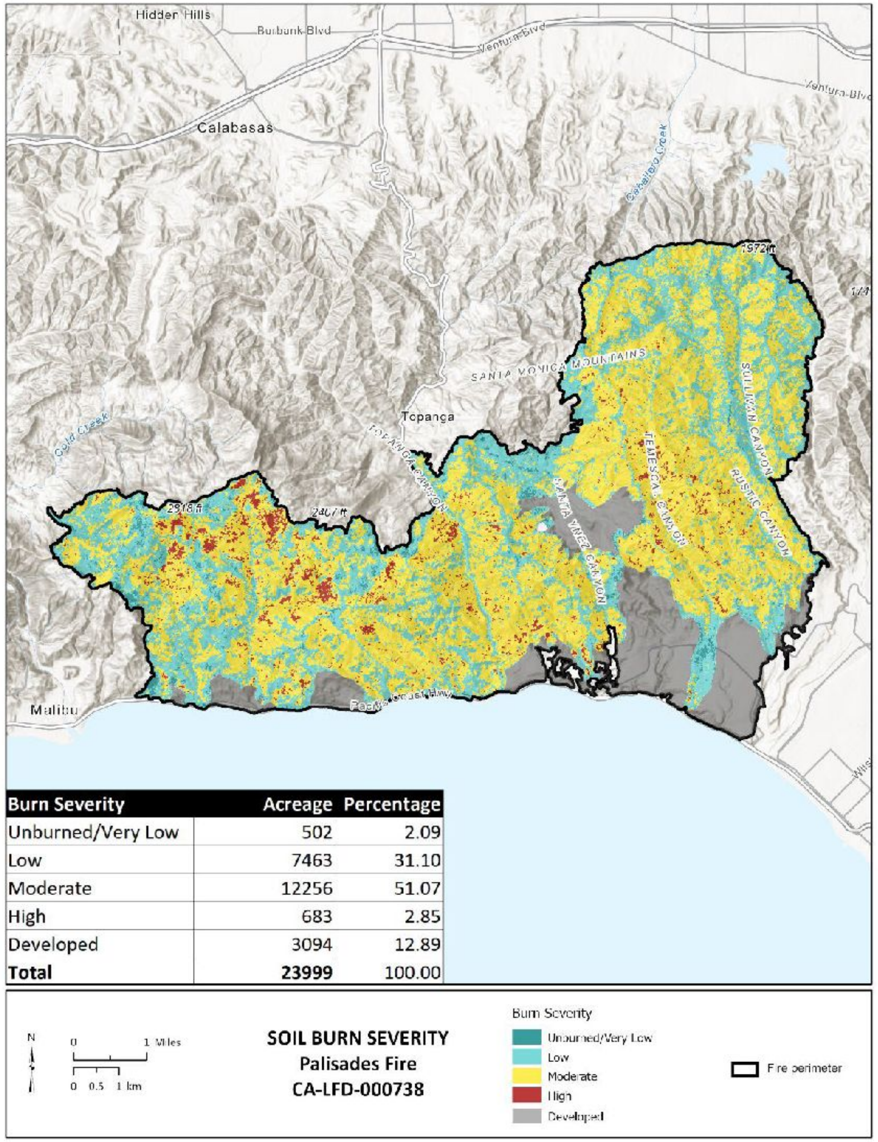
Fire Mosaic


Moderate burn severity
High burn severity
How do we capture this spatial variability and associated erosion risk for land management?
Low burn severity
Unburned area

Capture variability with Soil Burn Severity maps



Soil Burn Severity	USFS	Non-FS	Total Acres
Unevaluated Urban Areas	3	2,795	2,798
Unburned / Very Low	282	253	535
Low	1,184	775	1,959
Moderate	5,985	2,506	8,490
High	364	85	448
Total Acres	7,817	6,414	14,231

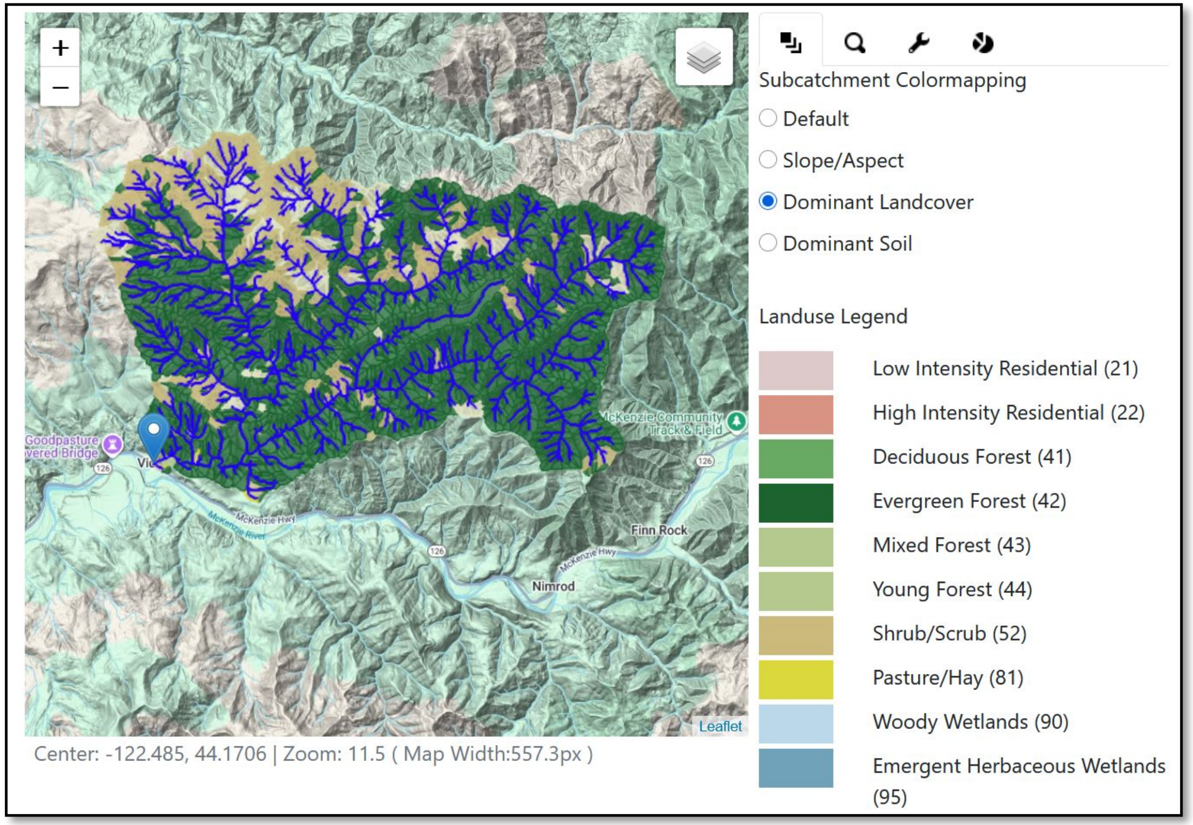


Burn Severity	Acreage	Percentage
Unburned/Very Low	502	2.09
Low	7463	31.10
Moderate	12256	51.07
High	683	2.85
Developed	3094	12.89
Total	**23999**	**100.00**

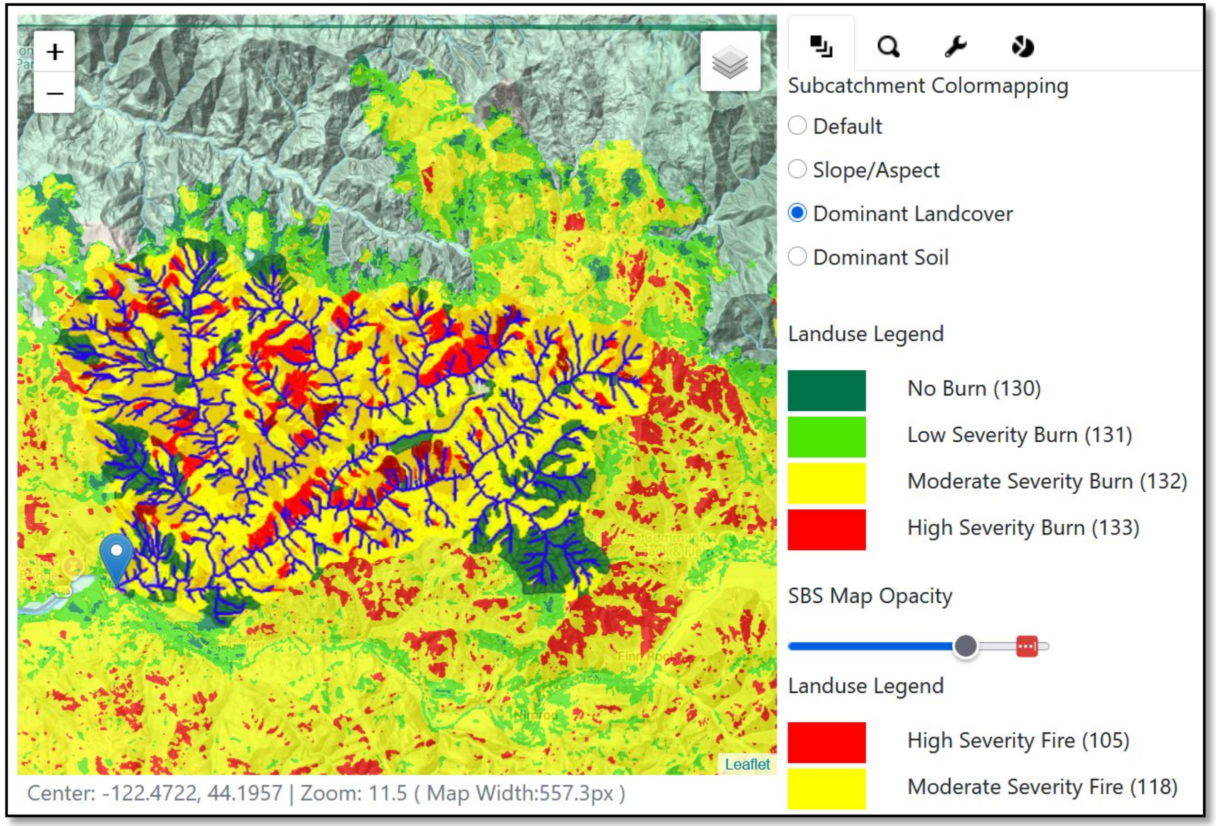
Not the same as Vegetation Burn Severity (MTBS)

Capture burn severity variability in WEPPcloud

Undisturbed Landcover

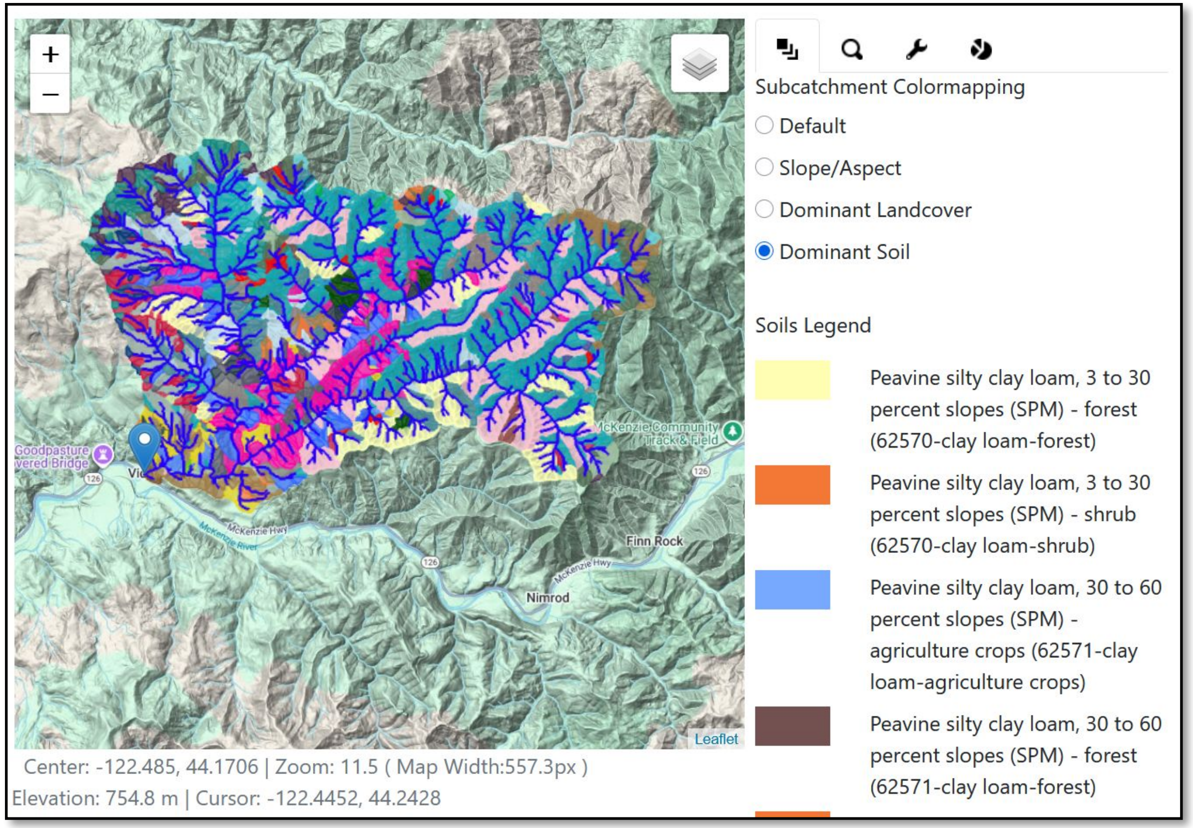


Post-fire landcover based on SBS

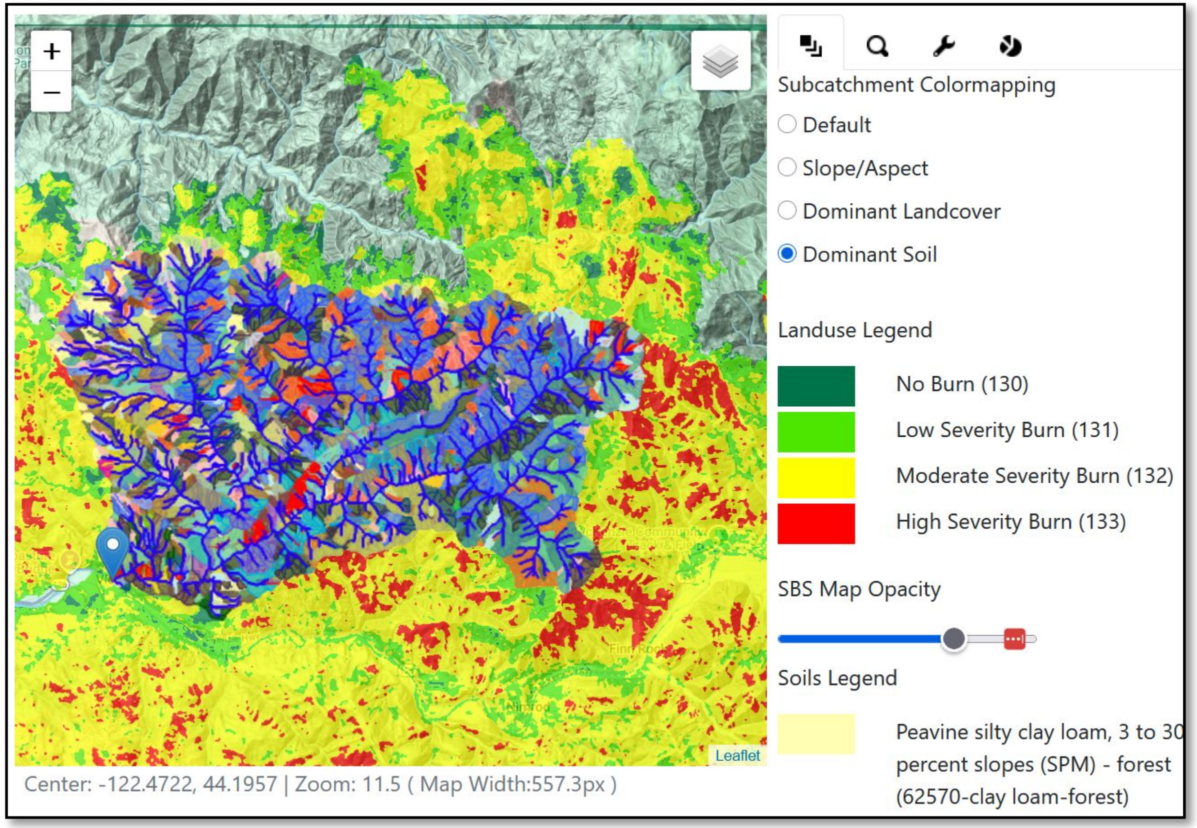


Capture this variability with WEPPcloud

Undisturbed Soils



Post-fire soils based on SBS

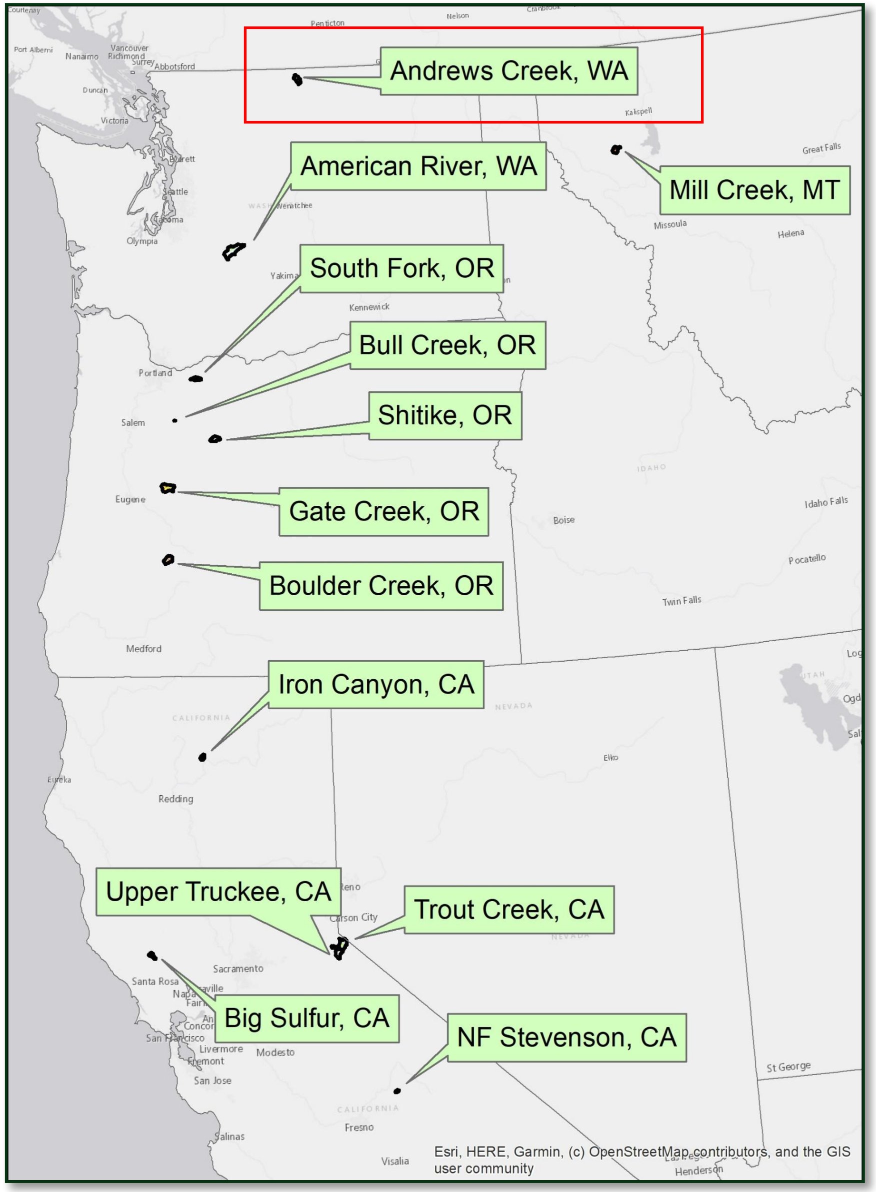


Post-fire model parameterization based on field data

luse	stext	ki	kr	shcrit	avke	ksflag	ksatadj	ksatfac	ksatrec	pmet_l	pmet_	rdmax
forest	clay loam	400000	2.00E-05	0.5	35	0	0	1.5	0.3	0.95	0.8	2
forest	loam	400000	3.00E-05	1	50	0	0	1.5	0.3	0.95	0.8	2
forest	sand loam	400000	8.00E-05	2	60	0	0	1.5	0.3	0.95	0.8	2
forest	silt loam	1000000	5.00E-05	1.5	40	0	0	1.5	0.3	0.95	0.8	2
forest high sev fire	clay loam	1500000	6.00E-05	0.5	14	0	1	100	0.3	0.95	0.8	0.3
								100	0.3	0.95	0.8	0.3
								100	0.3	0.95	0.8	0.3
								100	0.3	0.95	0.8	0.3
								1.3	0.3	0.95	0.8	0.3
forest low sev fire	loam	1000000	8.00E-05	1	20	0	0	1.3	0.3	0.95	0.8	0.3
forest low sev fire	sand loam	400000	0.00012	2	20	0	0	1.3	0.3	0.95	0.8	0.3
forest low sev fire	silt loam	1000000	0.0001	1.5	13	0	0	1.3	0.3	0.95	0.8	0.3
forest moderate sev fire	clay loam	1500000	5.00E-05	0.5	18	0	0	1.3	0.3	0.95	0.8	0.3
forest moderate sev fire	loam	1000000	8.00E-05	1	20	0	0	1.3	0.3	0.95	0.8	0.3
forest moderate sev fire	sand loam	400000	0.00012	2	20	0	0	1.3	0.3	0.95	0.8	0.3
forest moderate sev fire	silt loam	1000000	0.0001	1.5	13	0	0	1.3	0.3	0.95	0.8	0.3
forest prescribed fire	clay loam	1500000	5.00E-05	0.5	18	0	0	1.3	0.3	0.95	0.8	0.5
forest prescribed fire	loam	1000000	8.00E-05	1	20	0	0	1.3	0.3	0.95	0.8	0.5
forest prescribed fire	sand loam	400000	0.00012	2	20	0	0	1.3	0.3	0.95	0.8	0.5
forest prescribed fire	silt loam	1000000	0.0001	1.5	13	0	0	1.3	0.3	0.95	0.8	0.5

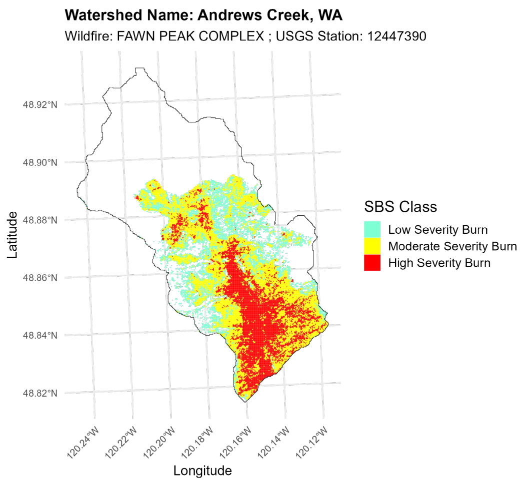
- **Effective hydraulic conductivity**
- **Interrill- and rill-erodibilities and critical shear**

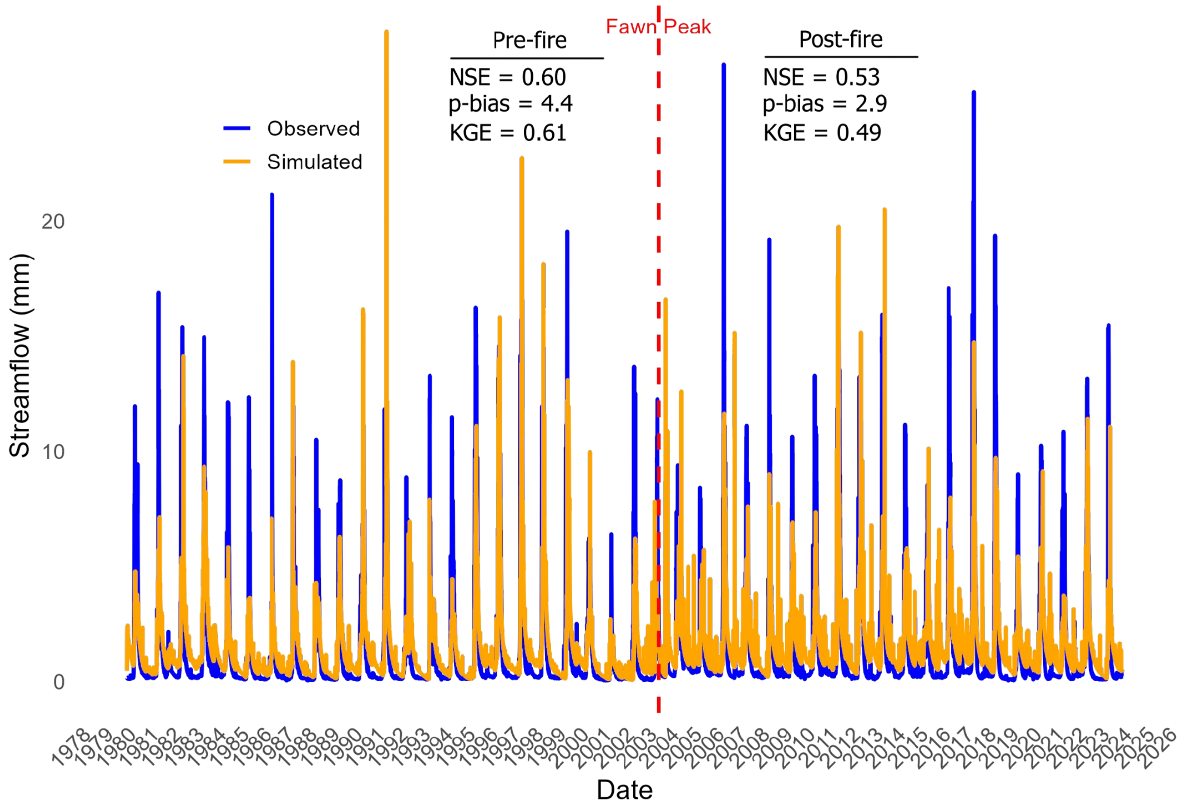
Pre- and Post-fire simulations



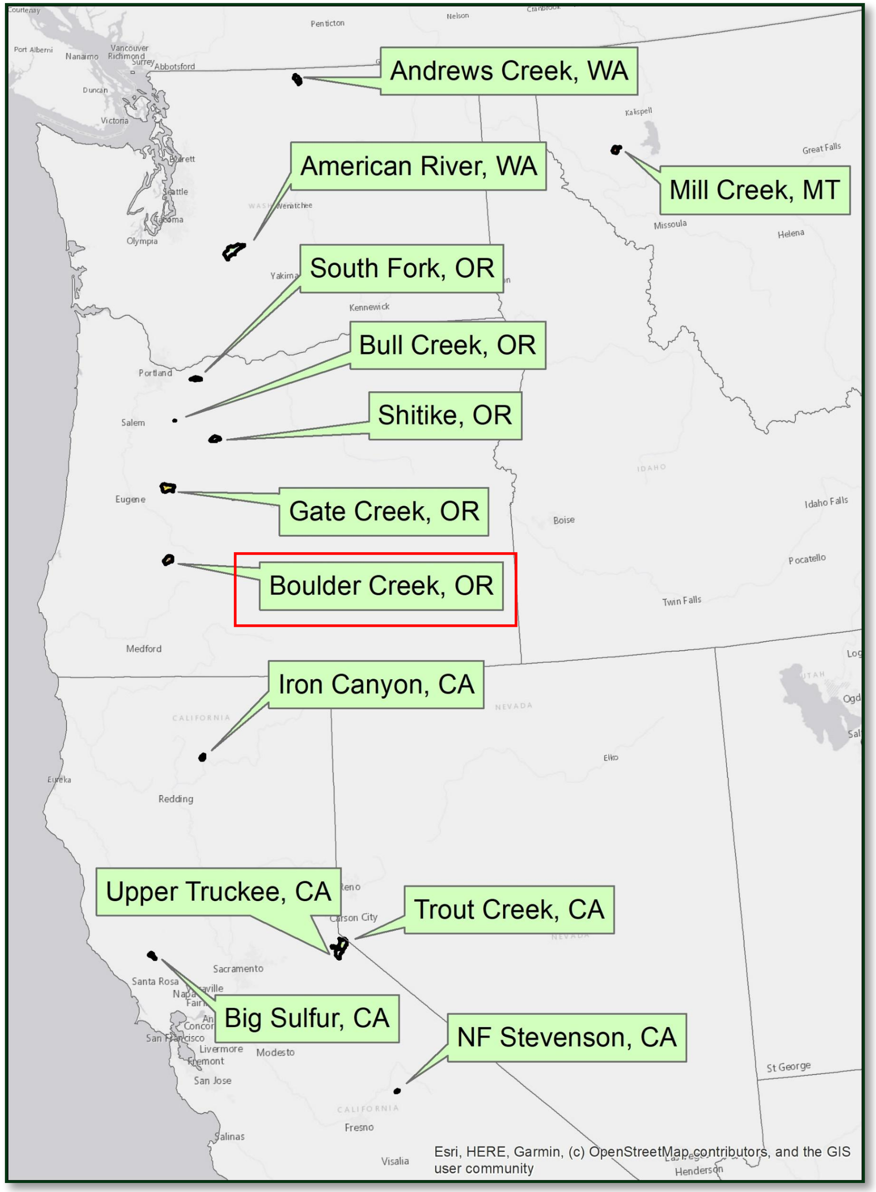
Streamflow

Minimal or no calibration



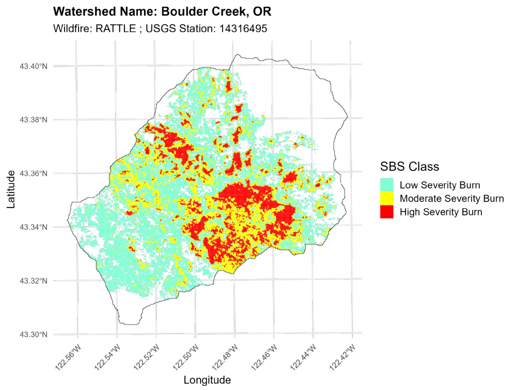


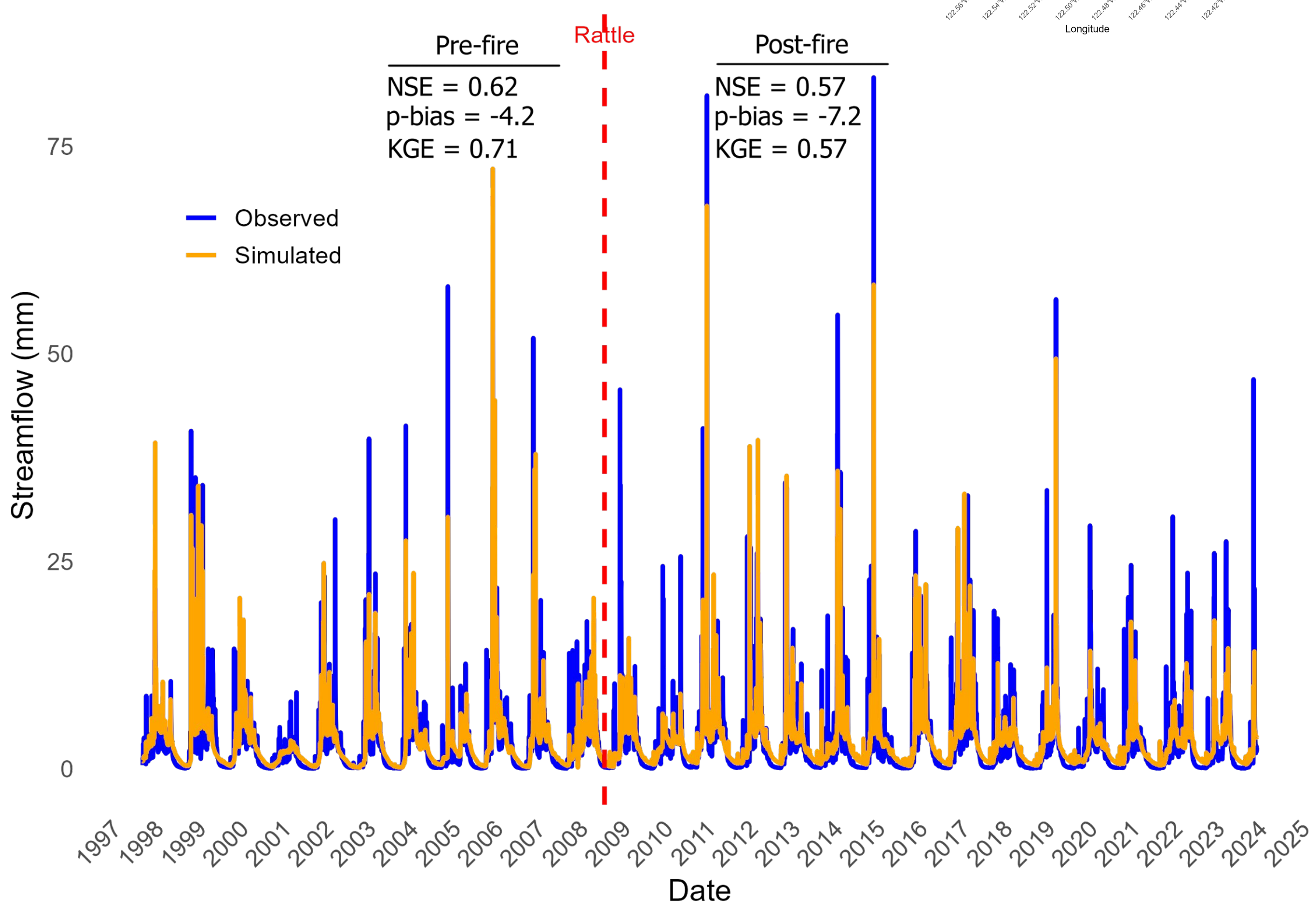
Pre- and Post-fire simulations



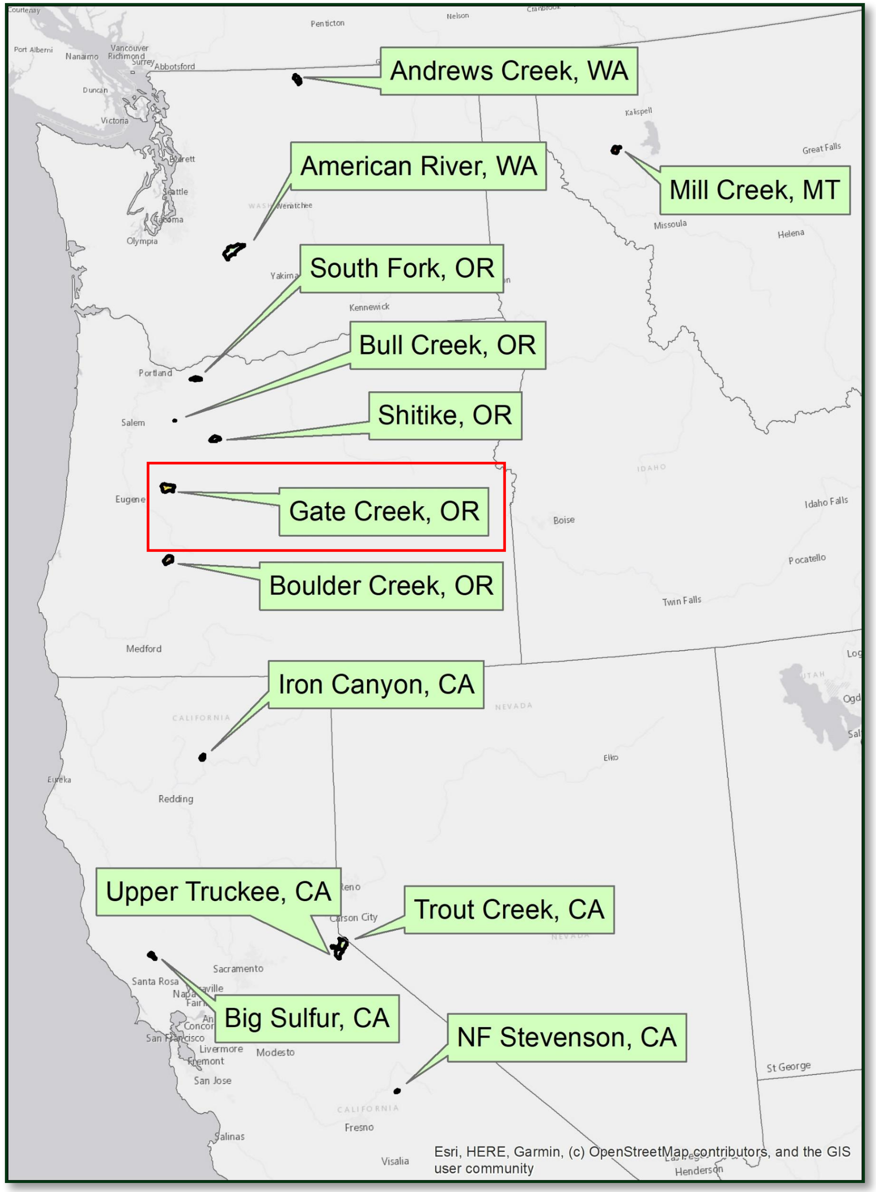
Streamflow

Minimal or no calibration



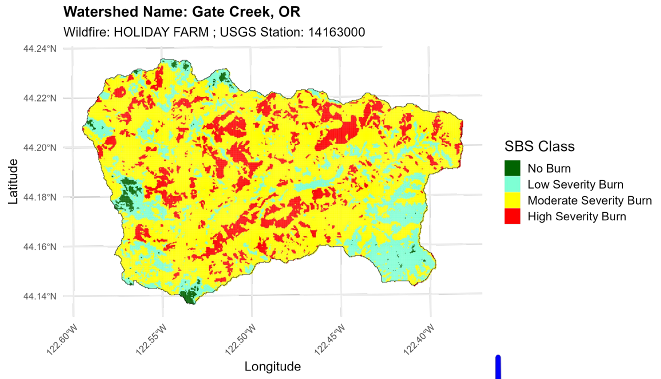


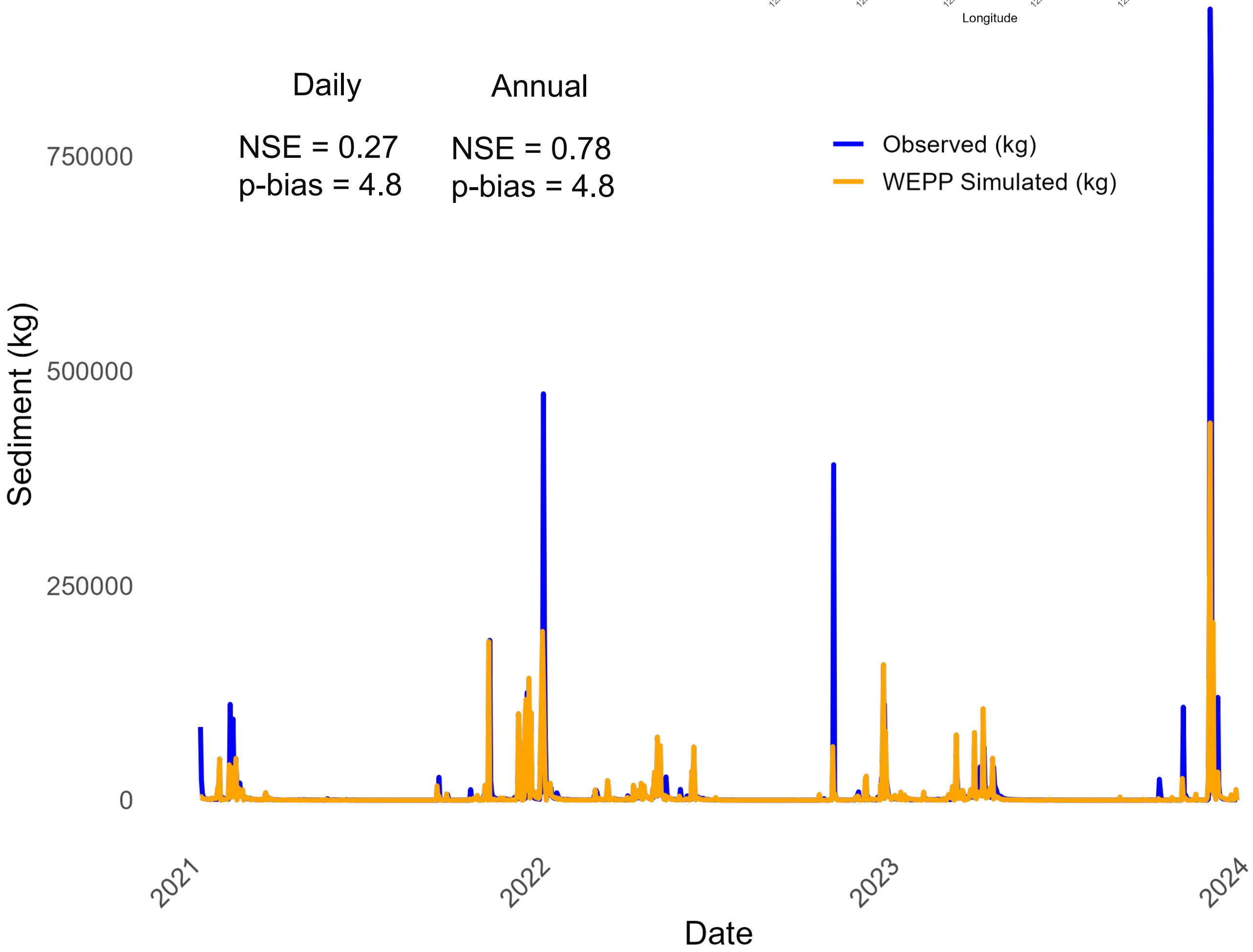
Pre- and Post-fire simulations



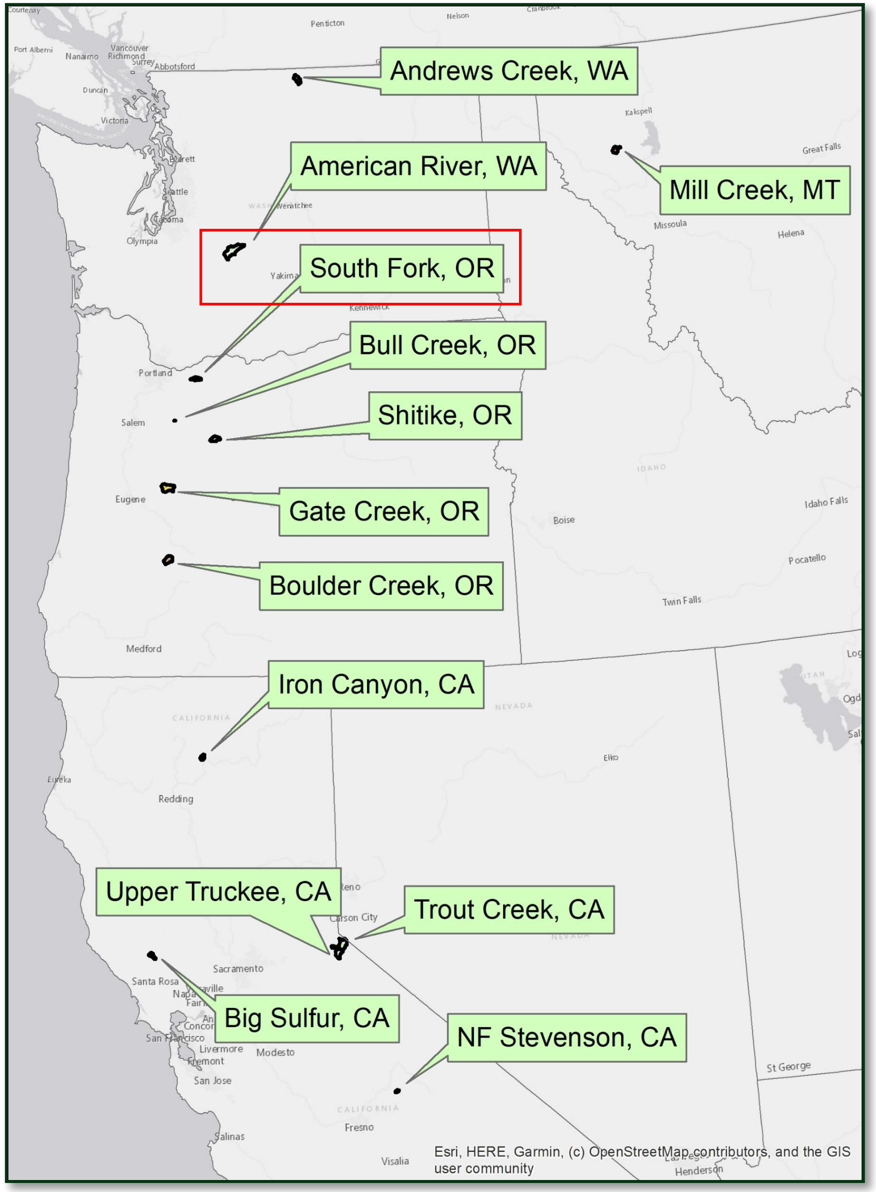
Sediment

Minimal or no calibration



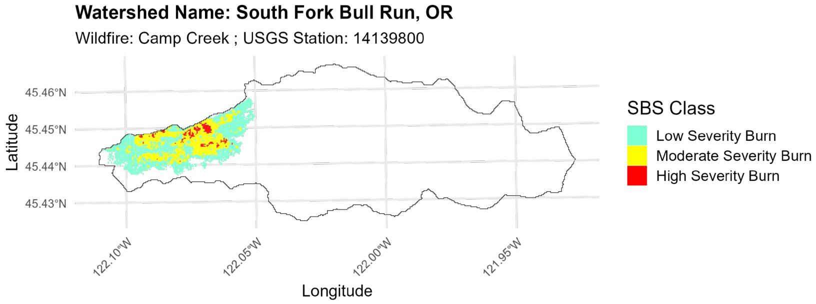


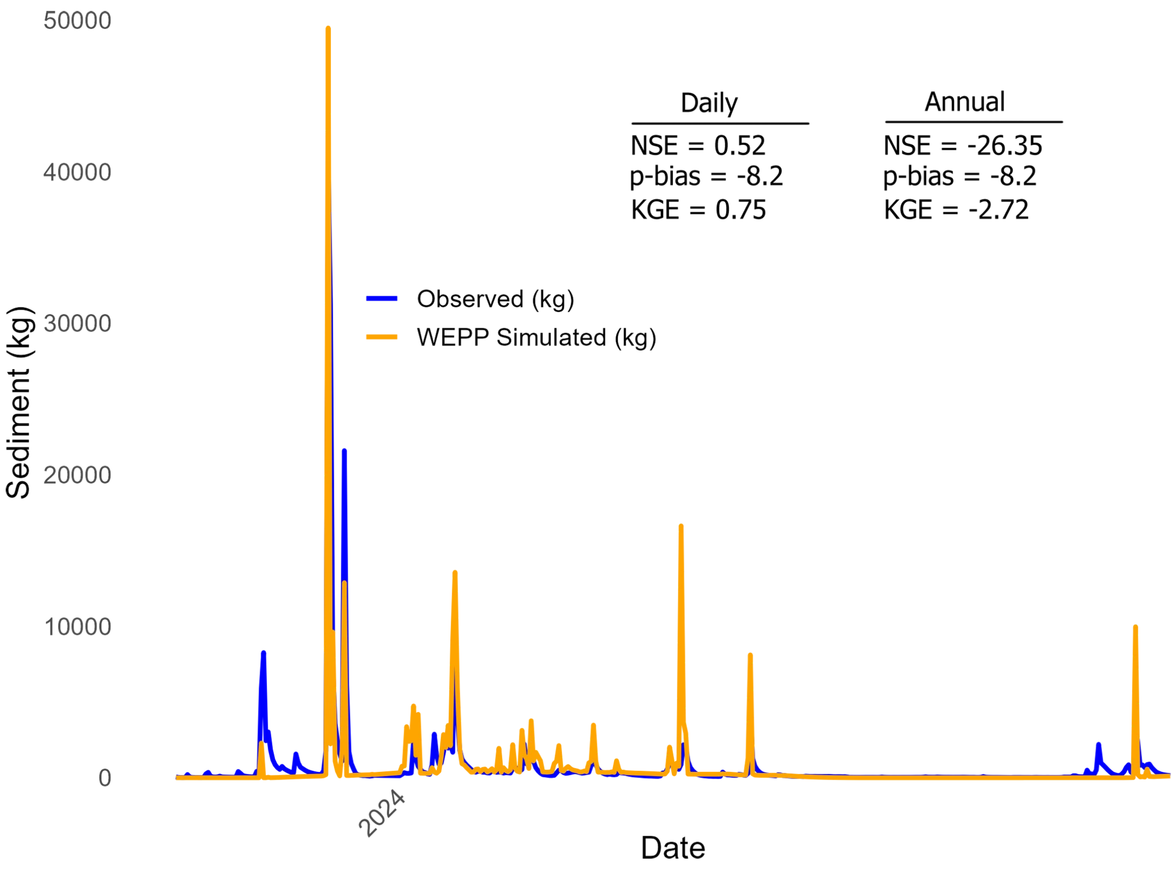
Post-fire simulations



Sediment

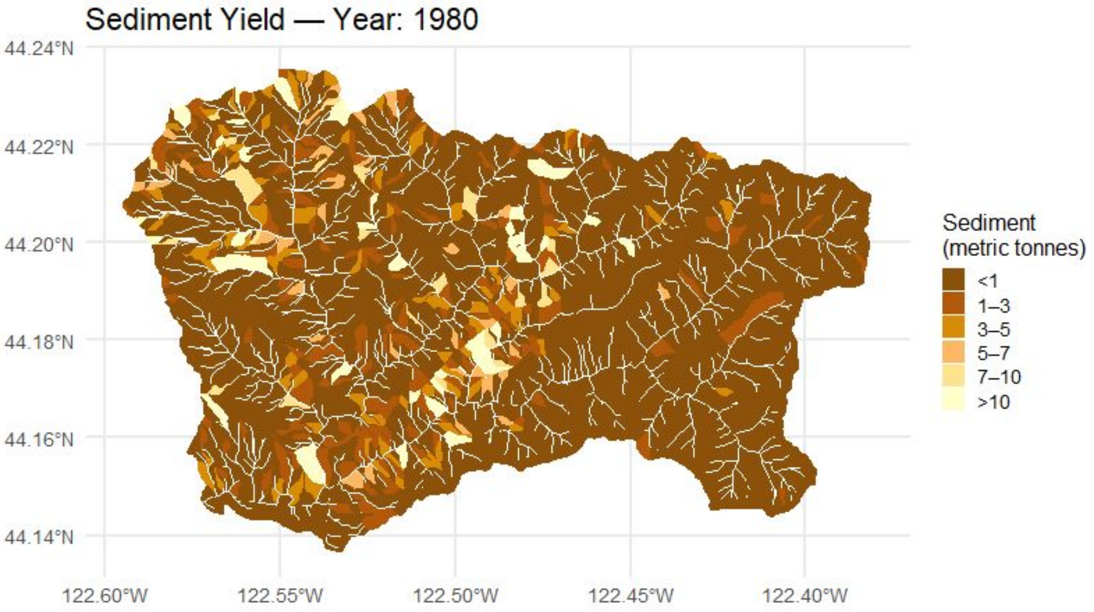
Minimal or no calibration



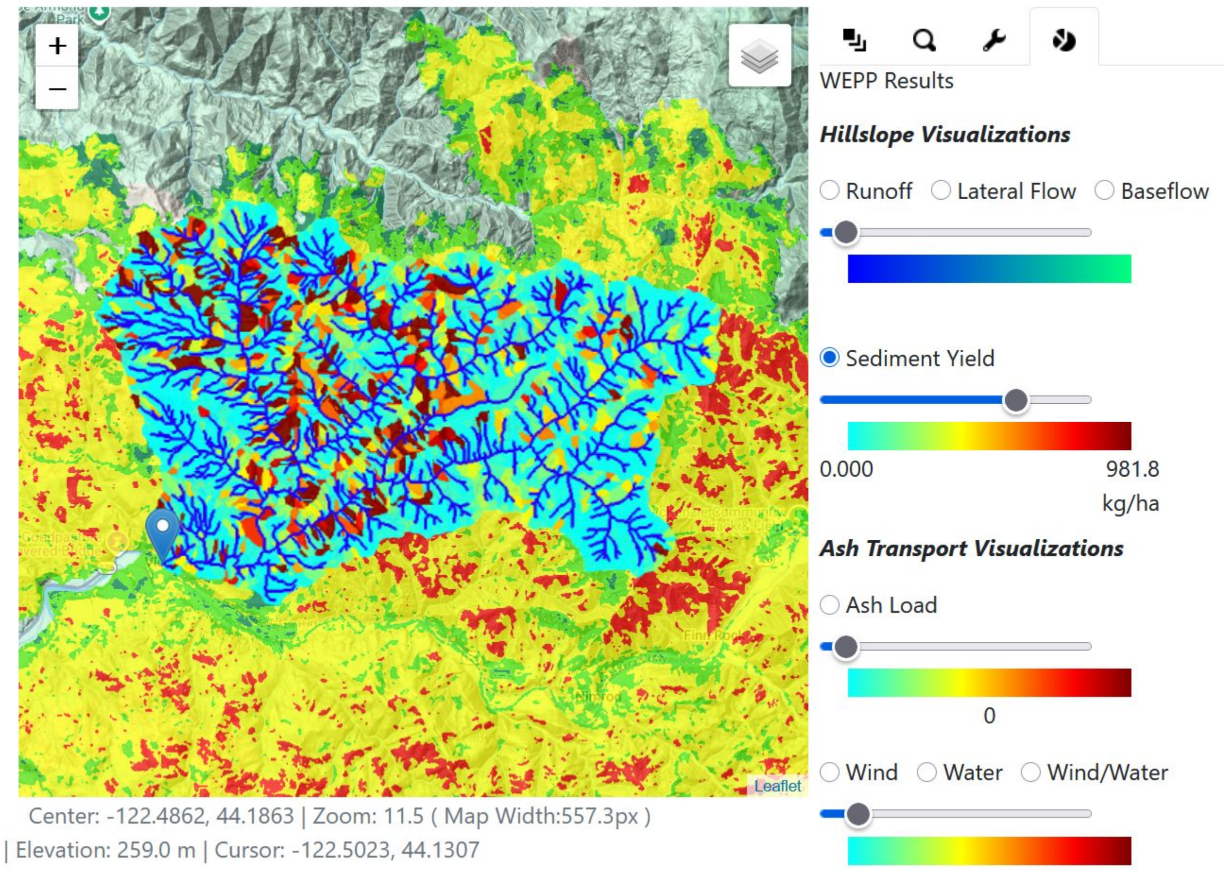


Identifying “hotspot” areas for erosion

Undisturbed



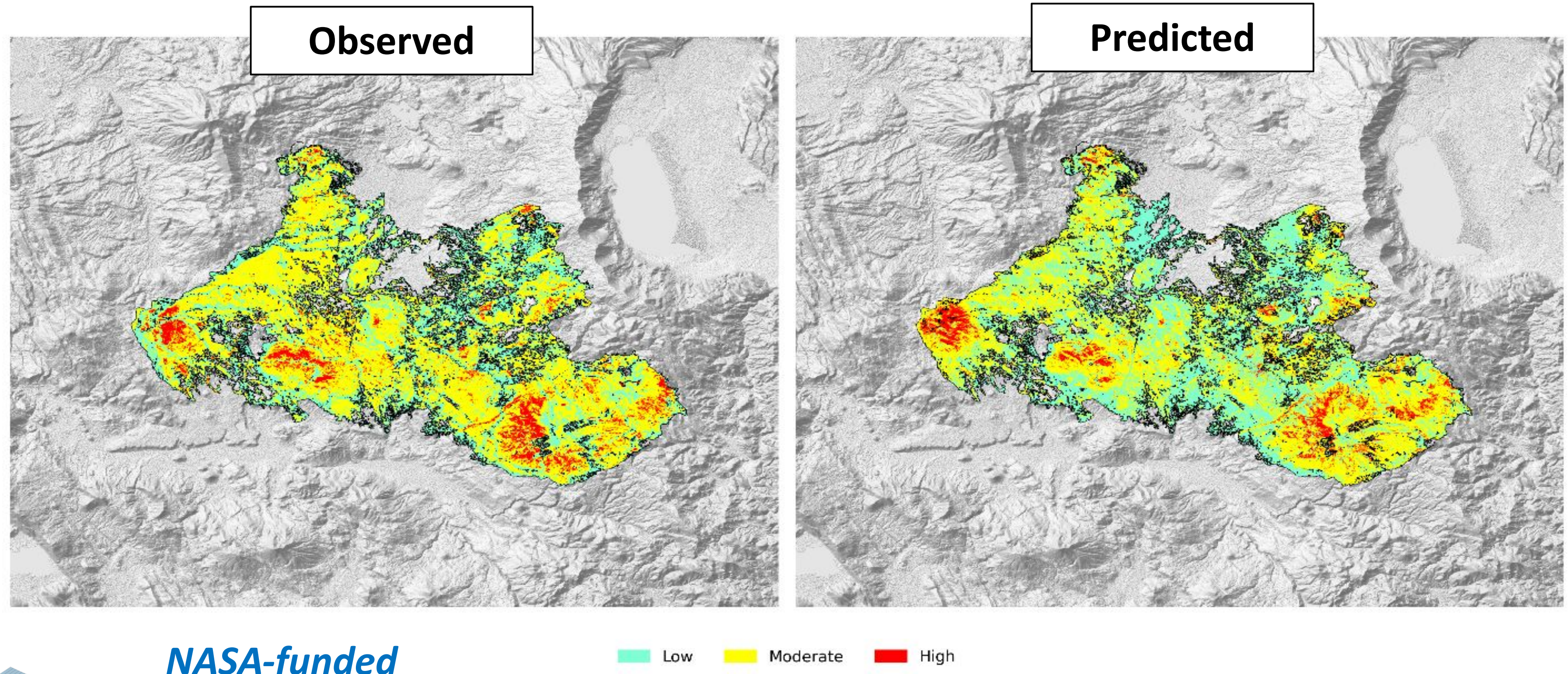
Post-fire



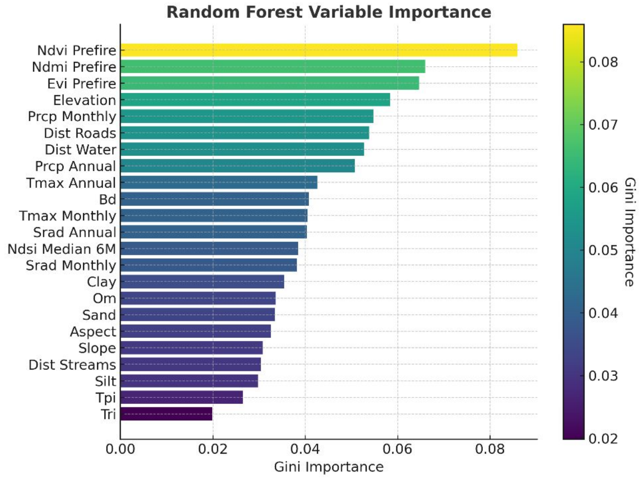
For areas that have not yet experienced a wildfire

Apply ML to train the model on post fires and predict potential SBS maps based on ~160 EO data including elevation, soil, landcover, and satellite-derived variables.

Overall accuracy was 59.4% (low = 0.603, moderate = 0.608, high = 0.427)



Bootleg Fire, OR
July–August 2021
burned ~413,765 acres



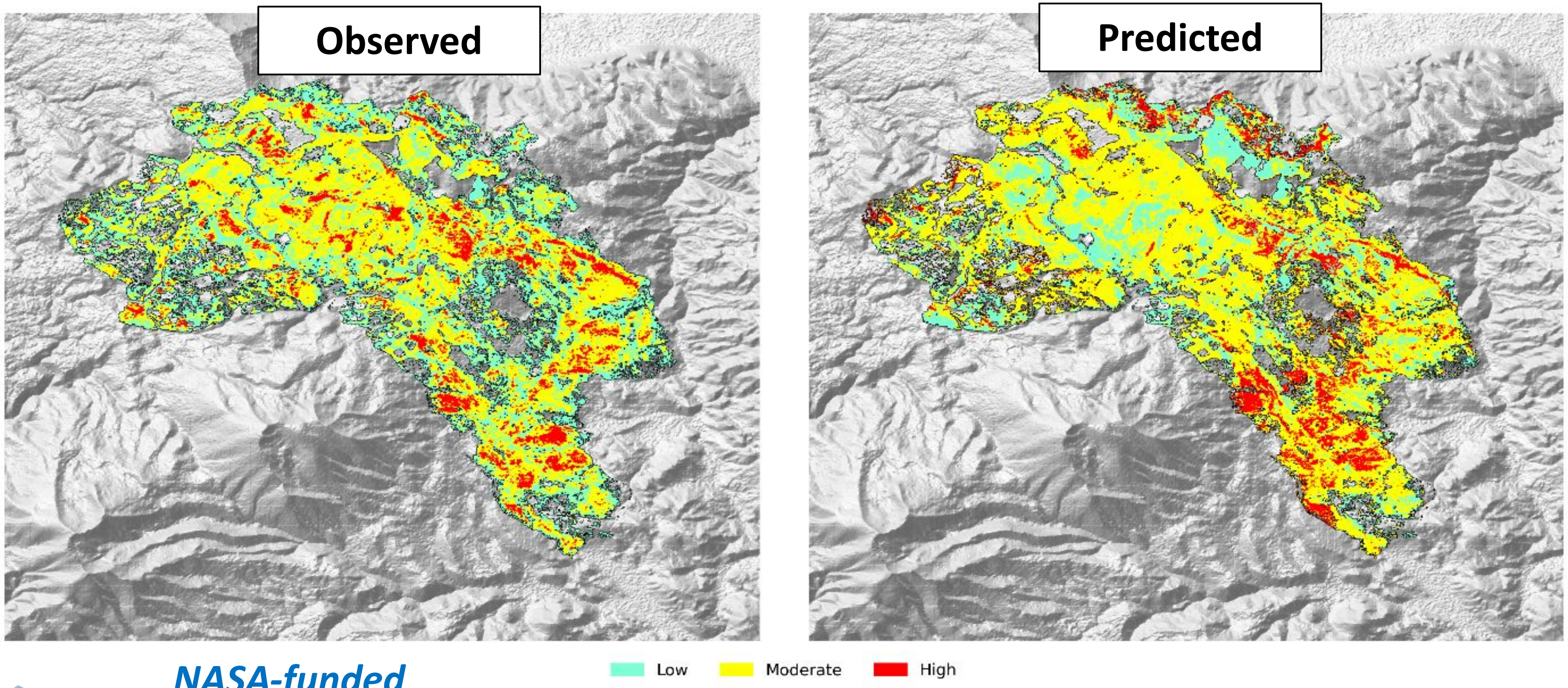
NASA-funded

Washington State University, University of Idaho
University of Nevada, Reno, Forest Service

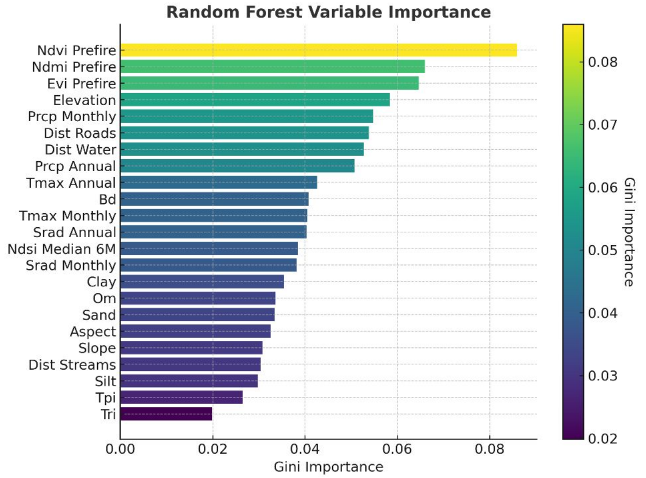
For areas that have not yet experienced a wildfire

Apply ML to train the model on post fires and predict potential SBS maps based on ~160 EO data including elevation, soil, landcover, and satellite-derived variables.

Overall accuracy 53.3% (low = 0.467, moderate = 0.611, high = 0.348)



Watson Creek Fire, OR
August–September 2018
burned ~59,923 acres



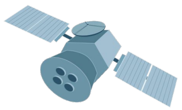
NASA-funded
Washington State University, University of Idaho
University of Nevada, Reno, Forest Service

Building a Decision Support Tool for Water Utilities

Improvements will include:

- Ash transport modeling
- Subsurface C and N with the RHESSys model
- Streamflow and sediment simulations for predefined scenarios:
  - Undisturbed
  - Rx
  - Thinning
  - Wildfire (based on predicted SBS)
  - Defined by partners

@ ~350 water utility watersheds



NASA-funded
Washington State University, University of Idaho
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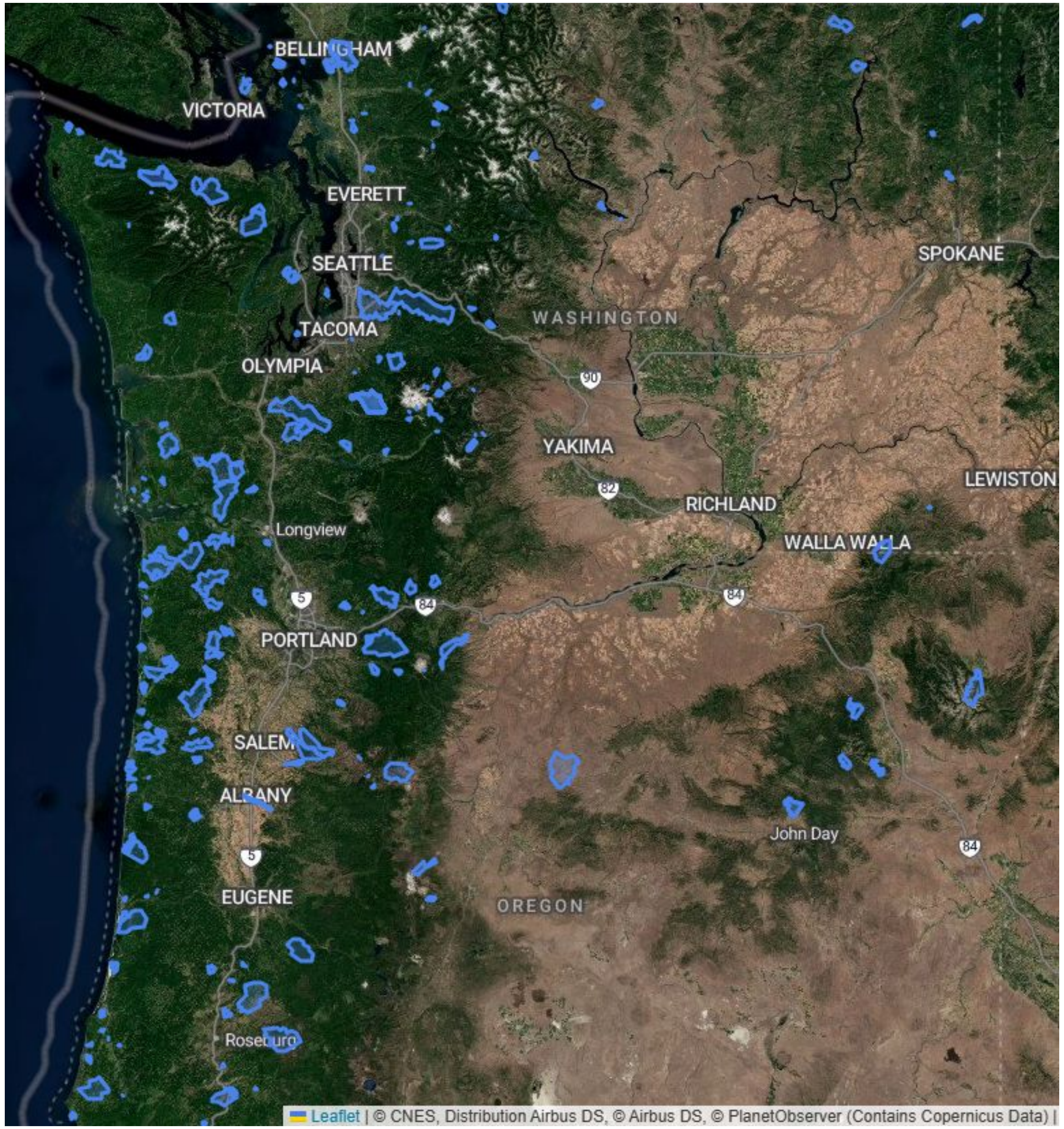
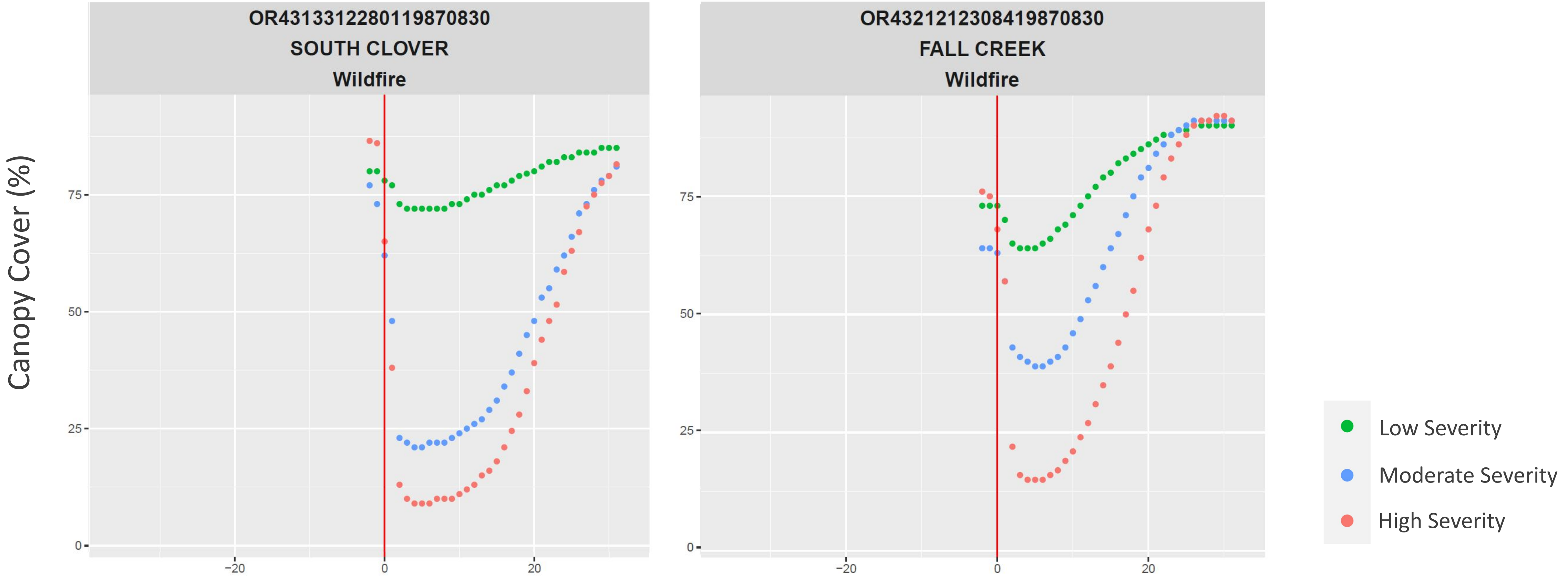
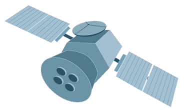


Erosion recovery with time since fire

Post-fire vegetation recovery varies!





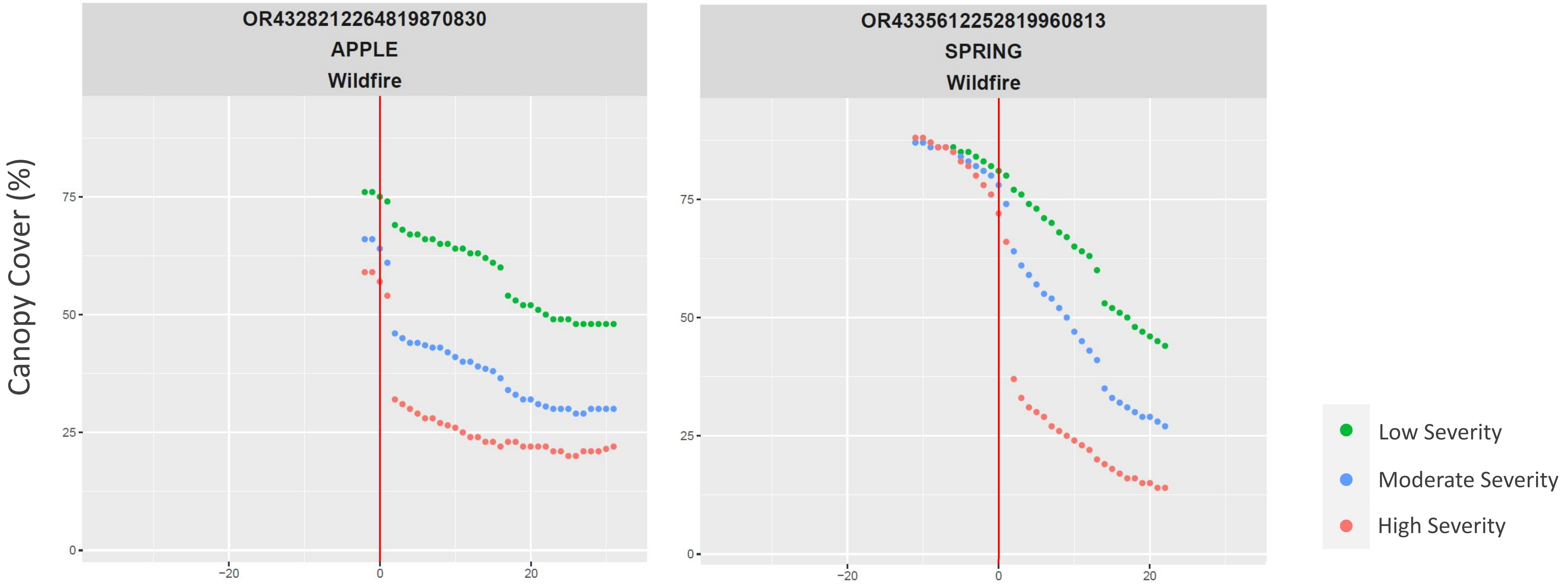
JPL-funded (WWAO)

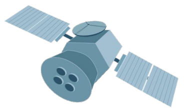
University of Idaho, Washington State University, Forest Service

Data from the Rangeland Analysis Platform
https://rangelands.app/

Erosion recovery with time since fire

Post-fire vegetation recovery varies!





JPL-funded (WWAO)

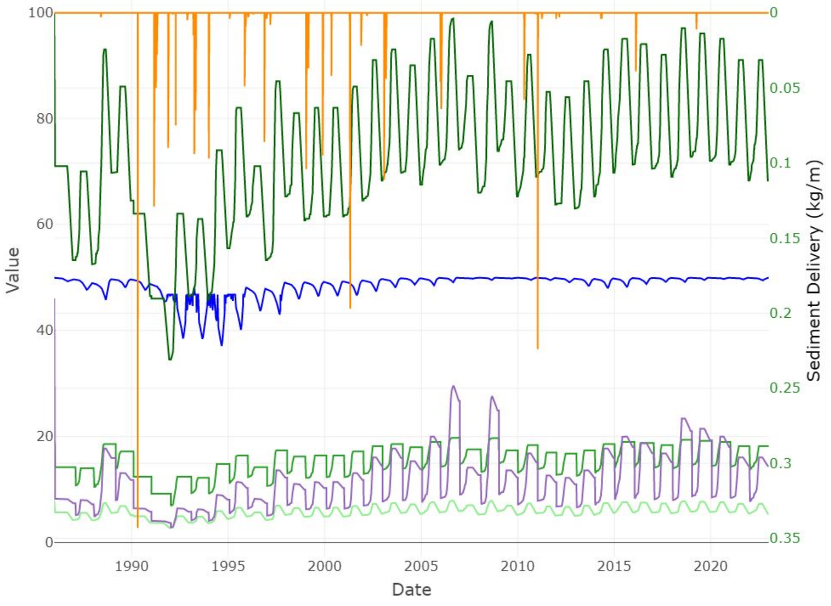
University of Idaho, Washington State University, Forest Service

Data from the Rangeland Analysis Platform
https://rangelands.app/

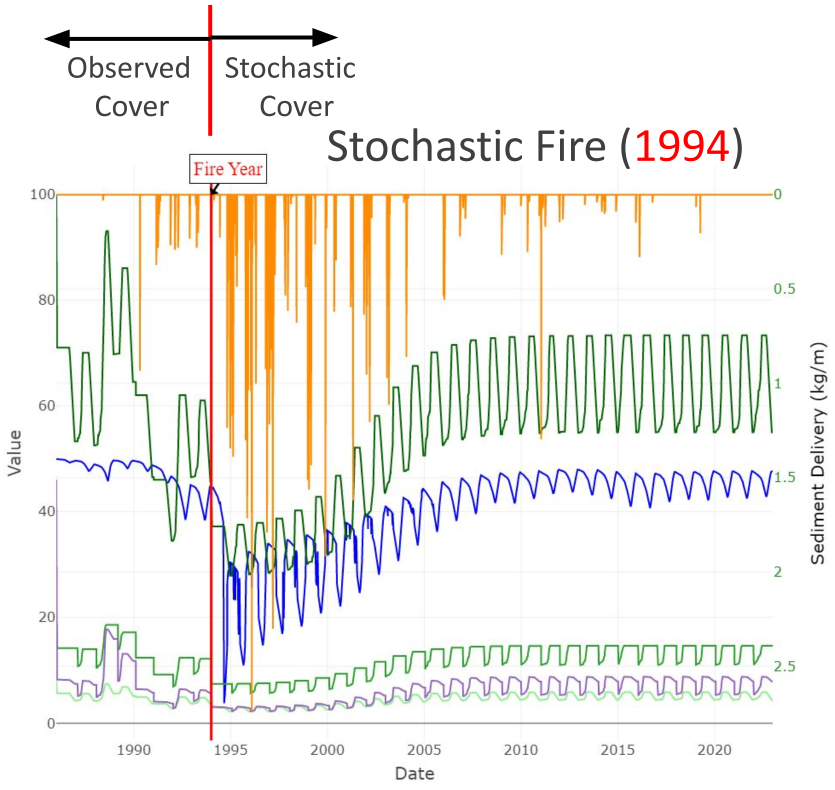
Developed WEPPcloud-Revegetation

Model parameterization

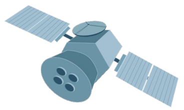
Observed Cover (Undisturbed)



Stochastic Fire (1994)



- Effective Hydraulic Conductivity (mm/h)
- LAI
- Canopy Height (m)
- Canopy Cover (%)
- Live Biomass (kg/m2)
- Sediment Delivery (kg/m)



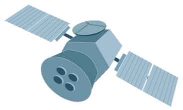
JPL-funded (WWAO)

University of Idaho, Washington State University, Forest Service

Other tools or tools in development

Debris Flow simulations

Wildfire Ash Transport And Risk (WATAR)



NASA-funded
Forest Service, RMRS, University of Idaho, ImageCat

Culvert Vulnerability Tool

DOT-funded through the Forest Service, Southern Research Station

Skid Trails DST

Forest Service, Pacific Northwest Research Station

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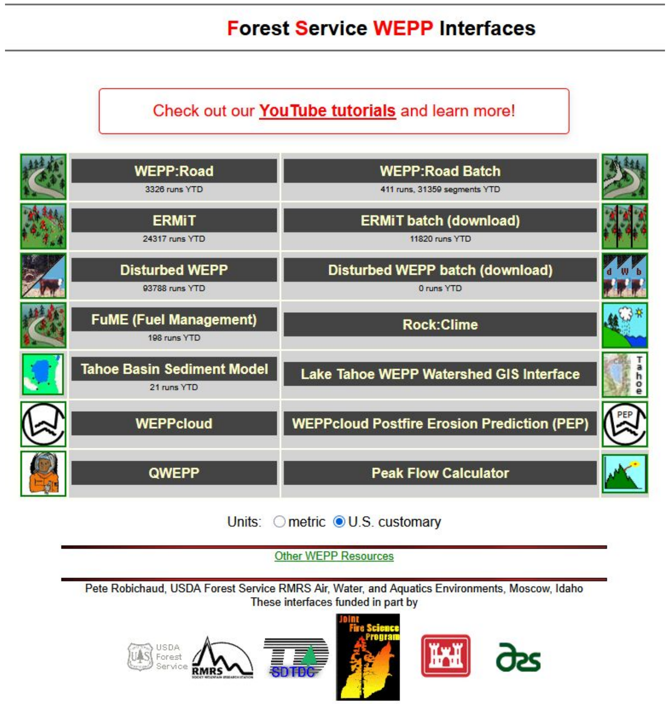
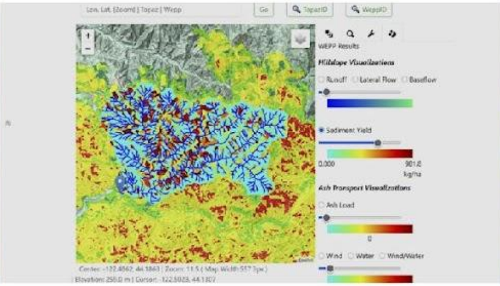


Developers of the FS WEPP set of tools for forest management and wildfires

Thank you!

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