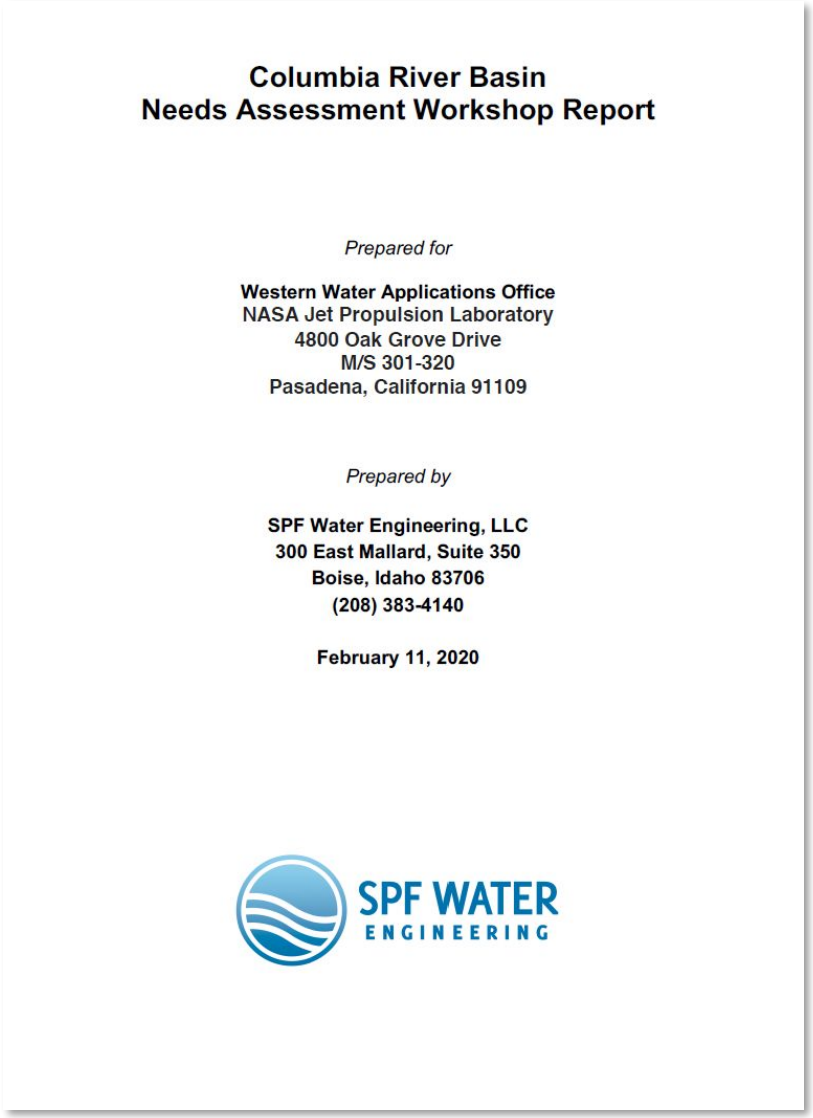
Improving predictions of water yield and sediment loads in the Columbia River Basin through the incorporation of Landsat-derived vegetation parameters into an existing online process-based hydrology and erosion model (WEPPcloud)

Research Team:
University of Idaho: Mariana Dobre, Roger Lew, Anurag Srivastava, Erin Brooks;
Washington State University: Julie Padowski, Ming-Liang Liu, Jennifer C. Adam;
Partners:
USDA Forest Service Rocky Mountain Research Station: Peter Robichaud
Washington State Department of Health, Office of Drinking Water: Mike Means,
USFS PNW Region, BAER Program: Alexandra G. Rozin

University of Idaho

Washington State University

Columbia River Basin Needs Assessment Workshop Report



Columbia River Basin
Needs Assessment Workshop Report

Prepared for

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February 11, 2020

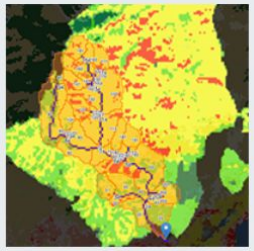
SPF WATER ENGINEERING

- Agriculture
  - Crop Mapping
  - Evapotranspiration/Consumptive Use
  - Irrigation
- Water Quality
  - Cyanobacteria
  - Stream Temperature
  - Turbidity
- Water Supply
  - Evapotranspiration
  - Groundwater Recharge & Storage
  - Snow Water Equivalent
  - Streamflow Monitoring
- Watershed Health
  - Habitat Management
  - Land Use & Land Cover
  - Surface & Groundwater Interaction
  - Stream Temperature Dynamics

WEPPcloud

https://wepp.cloud/

United States (including Hawaii and the Virgin Islands)



WEPPcloud-(Un)Disturbed for United States

The WEPPcloud-Disturbed allows users to upload a burn severity map and predict erosion based on fire severity. Optionally, the user can forgo uploading a burn severity map to model unburned conditions. It uses SSURGO to create 7778 soils and NLCD to parameterize landuse for unburned conditions. For fire and treatment conditions soils and managements are procedurally generated and parameterized from the disturbed database based on soil texture and landuse. This allowing forests, shrubs, and grass to be burned based on landuse. The parameterization is intended to provide meaningful comparisons between unburned, burned, and treatment conditions. In the long-term disturbed is envisioned to replace the WEPPcloud-PEP interface.
This interface also incorporates the Wildfire Ash Transport And Risk estimation tool (WATAR).

Start Disturbed Run (CONUS)

Start Disturbed-Hawaii Run (Experimental)

Start Disturbed-Alaska Run (Experimental)

7289 projects and 424,624 hillslopes (284,655 WATAR hillslopes) ran since January 1, 2023

European Union

WEPPcloud-EU

WEPPcloud for Europe.

Managements are assigned based on ESDAC landuses. Soils are built from ESDAC and EU-SoilHydroGrids data. U.S. climate stations are selected based on E-OBS monthly precip and temperatures.

The PeP interfaces provide post fire erosion modeling and ash transport modeling. Parameterizes soils based on burn severity and soil texture using Disturbed WEPP soil files. The PeP interface incorporates the Wildfire Ash Transport And Risk estimation tool (WATAR).

Start EU WEPPcloud-Disturbed Run

790 EU projects and 45,756 hillslopes ran since January 1, 2023

EU WATAR hillslopes ran since January 1, 2023 34,924

Australia

WEPPcloud-AU

WEPPcloud for Australia.

Managements are assigned based on Land Use of Australia 2010-11. Soils are built from ASRIS soil data. U.S. climate stations are selected based on AGDC monthly precip and temperatures.

Start AU-Disturbed WEPPcloud Run w/ WATAR (Experimental)

695 EU projects and 40,161 hillslopes ran since January 1, 2023

EU WATAR hillslopes ran since January 1, 2023 21,848

Working towards a WEPPcloud – Earth Interface

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

https://wepp.cloud/

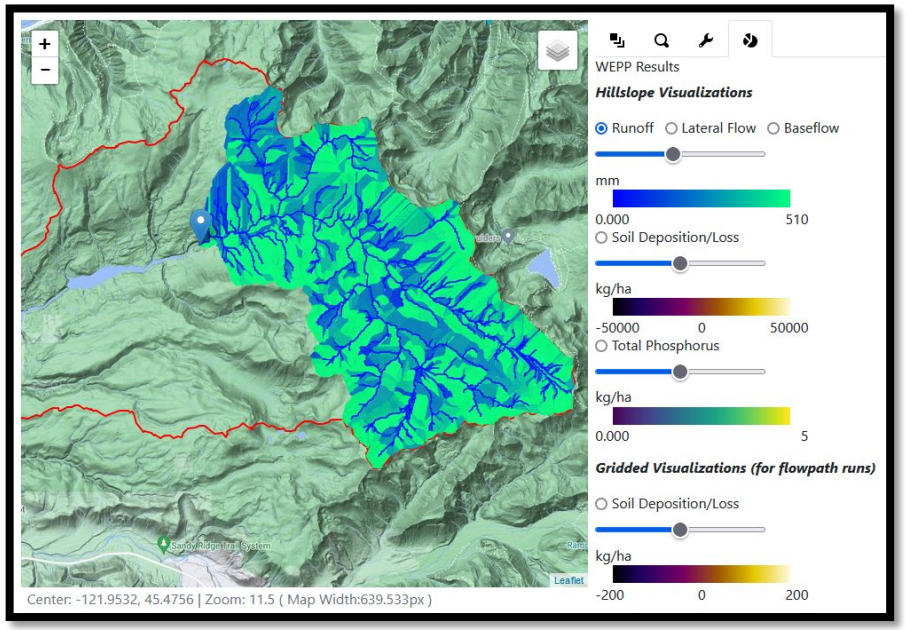
Free online widely-used hydrology and erosion model designed for land management.

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

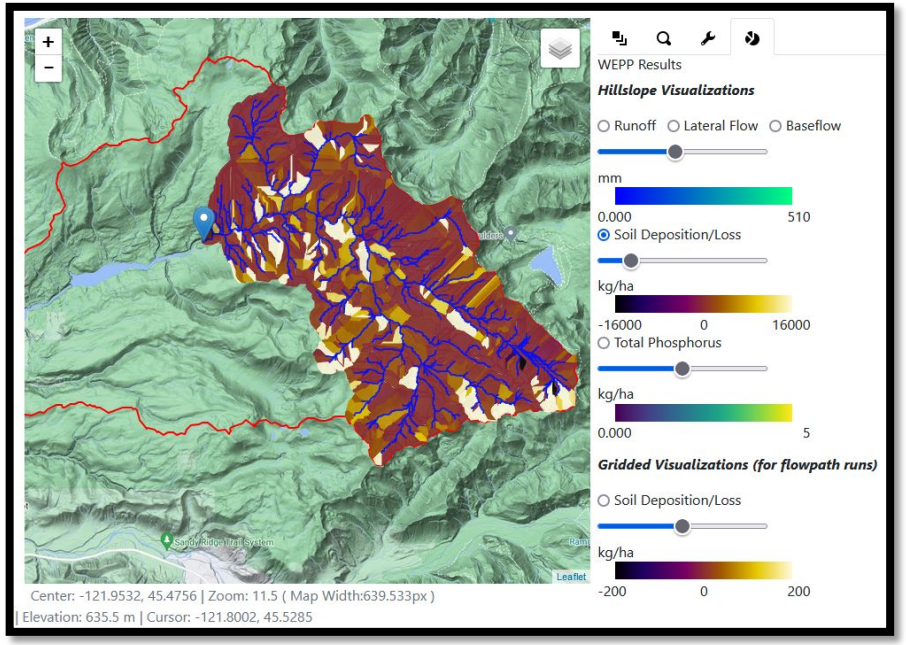
Uses:	From:
DEM	10-m or 30-m DEM
SOILS	SSURGO/STATSGO
CLIMATE	CLIGEN – stochastic Daymet – 1 km gridMET – 4 km Nexrad
VEGETATION/MANAGEMENT	NLCD (2001 - 2021)

Static!

Surface Runoff



Sediment Yield



Goal and Objective

Goal:
Improve predictions of water yield and sediment loads in the Columbia River Basin.

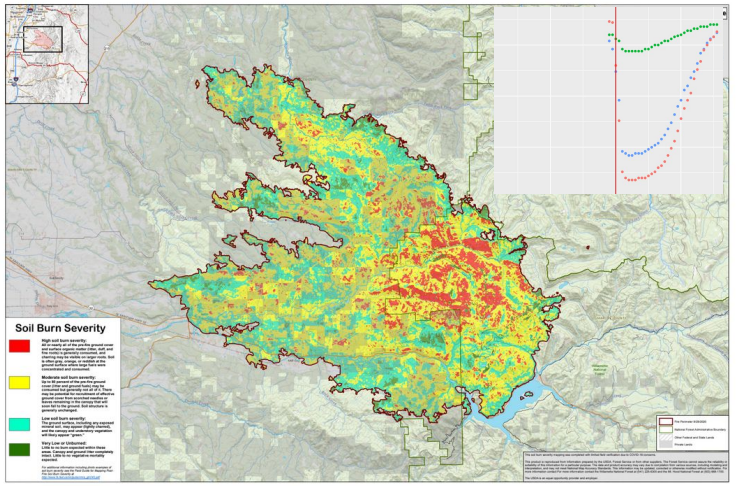
Main Objective:
Enhance WEPPcloud to dynamically account for vegetation changes in both historical and future climate scenarios.

(With a focus on Wildfires)

Methodology – Represent vegetation regrowth

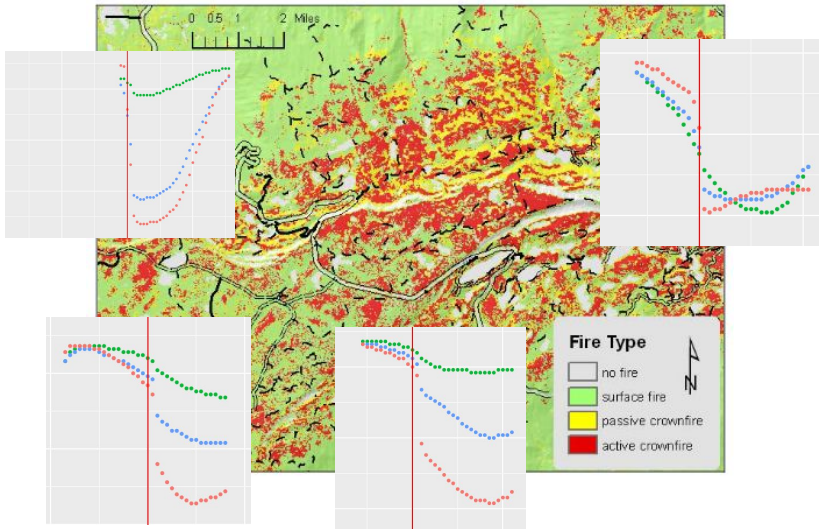
Historic Wildfires

From actual historic
Canopy Cover
(by Soil Burn Severity)



Simulated Wildfires

From historic
Canopy Cover
from nearby wildfires
(by simulated Soil Burn Severity)



NASA data

Rangeland Analysis Platform (RAP)

https://rangelands.app/

Cover estimates produced by combining 75,000 field plots collected by BLM, NPS, and NRCS with historical Landsat satellite record (1986 – 2023).

eMapR – Oregon State

http://emapr.ceoas.oregonstate.edu/

Land use and tree canopy cover (1983 – 2017) derived from Landsat.

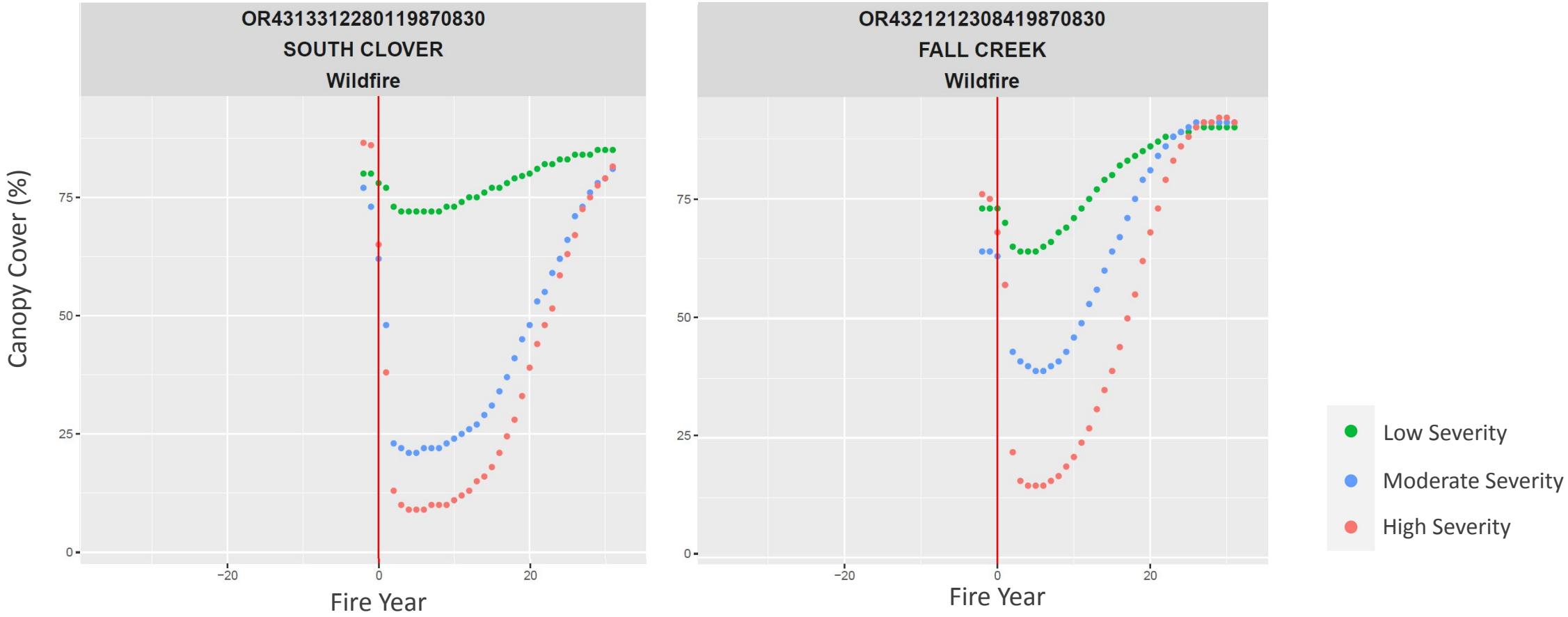
Wildfire Maps

Soil Burn Severity (2012 – 2022; derived from Landsat)

MTBS dNBR6 maps (1984 – 2022; derived from Landsat)

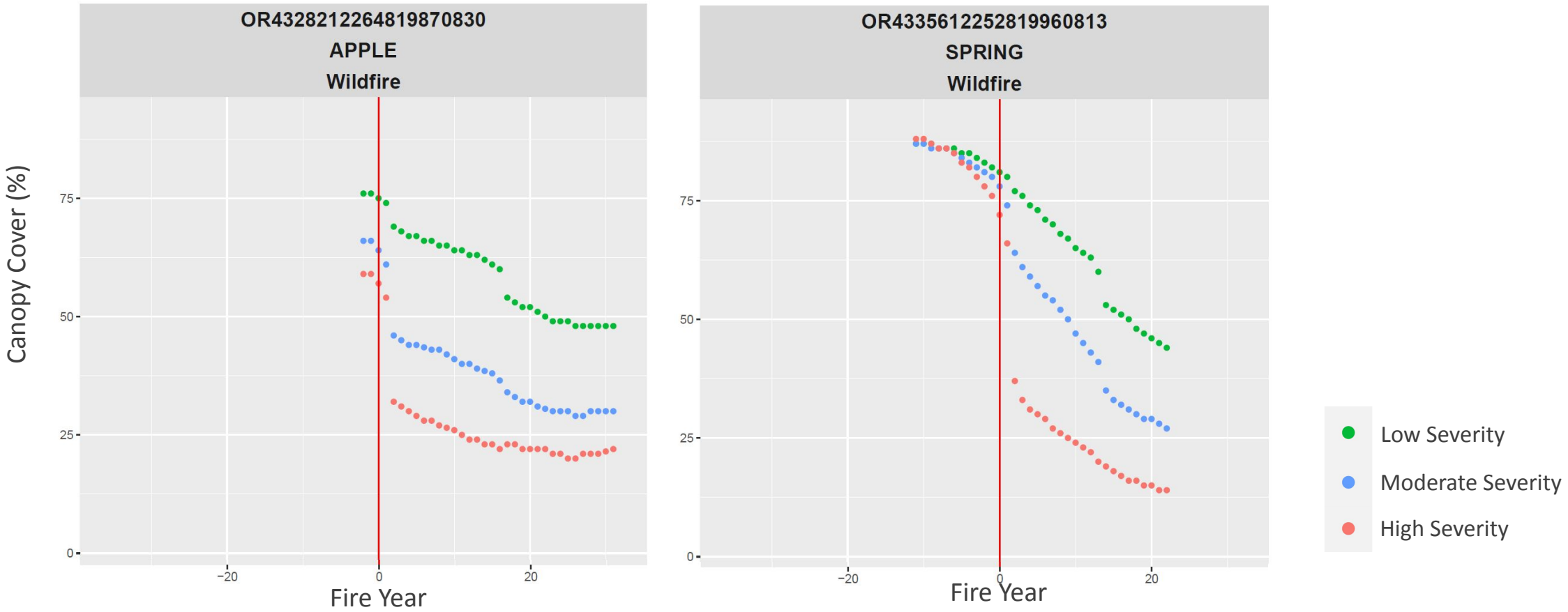
Development

- Acquired and analyzed Landsat-derived historic annual canopy cover data.
- Calculated regional vegetation regrowth curves for stochastic simulations.
    - calculated annual average canopy cover by ecoregion, fire, and fire severity



Development

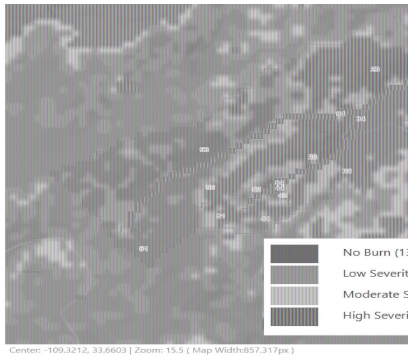
Not all burned areas have the same recovery!

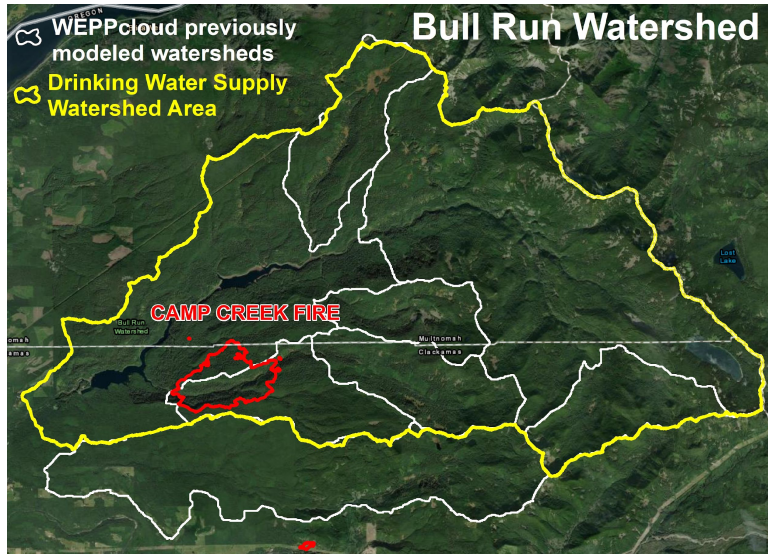


Model Development, Assessment, and Applications

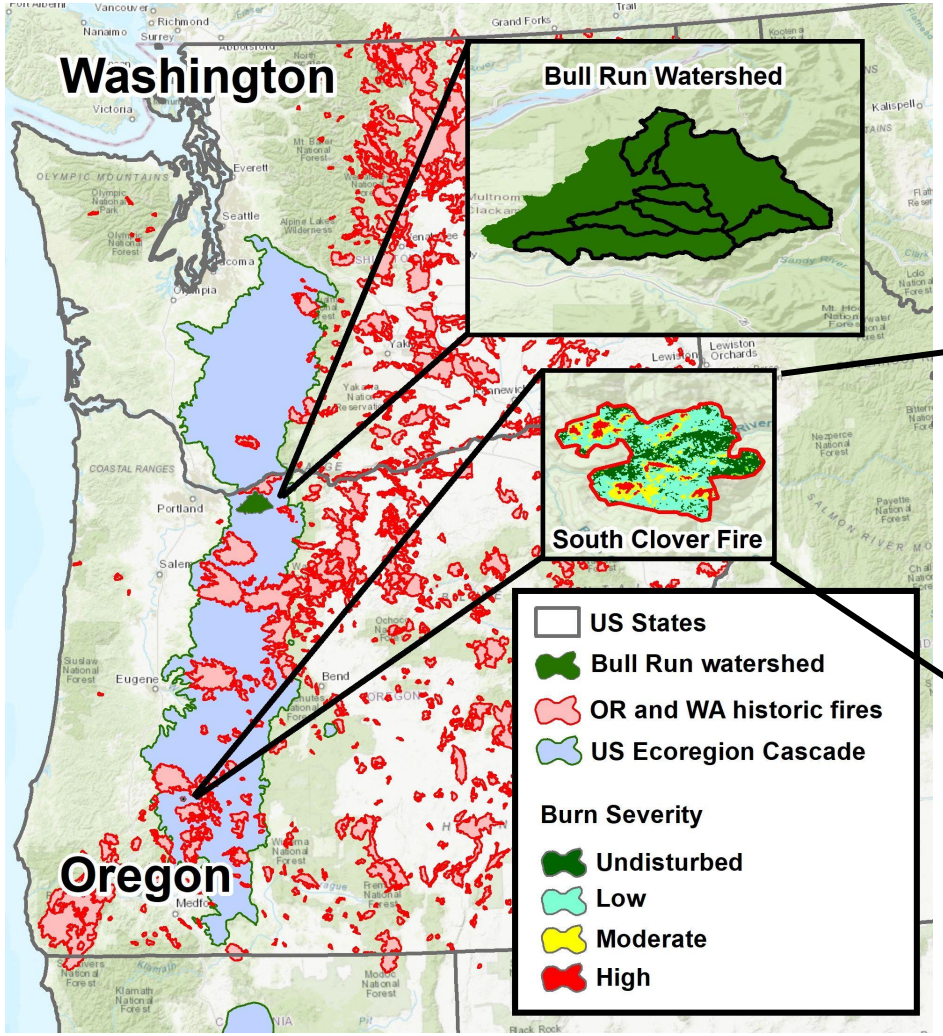
- Modified the WEPP model source code to read actual or stochastic canopy cover by soil burn severity.
- Changed soil properties to reflect changes in vegetation.
- Evaluated streamflow for WEPPcloud in a historic fire (Wallow Fire, 2011) based on data provided by partner.
- Applied the enhanced WEPPcloud interface to a partner-selected watershed.

Wallow Fire, Arizona, 2011

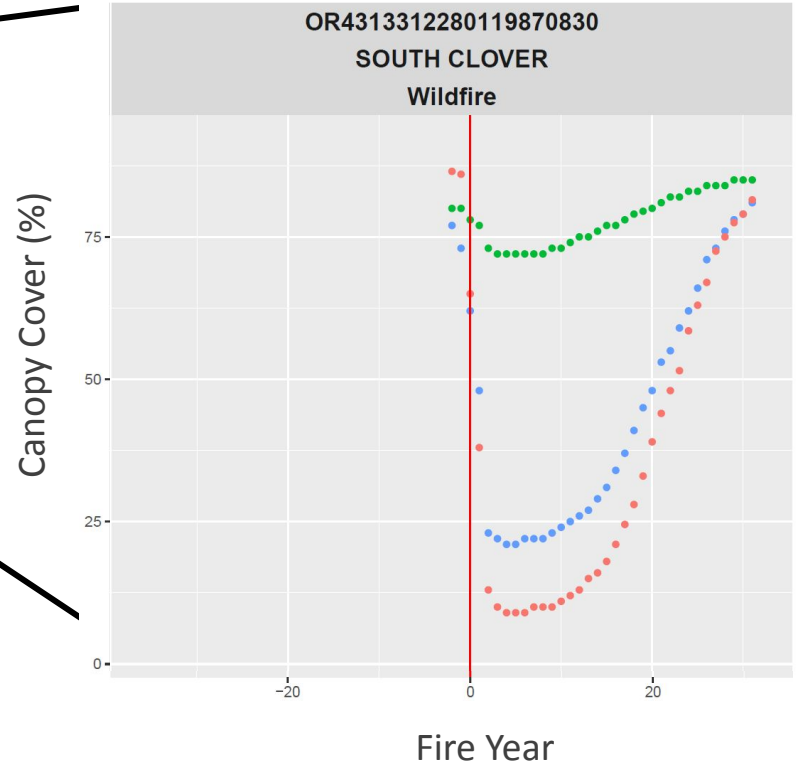




Model Assessment and Applications



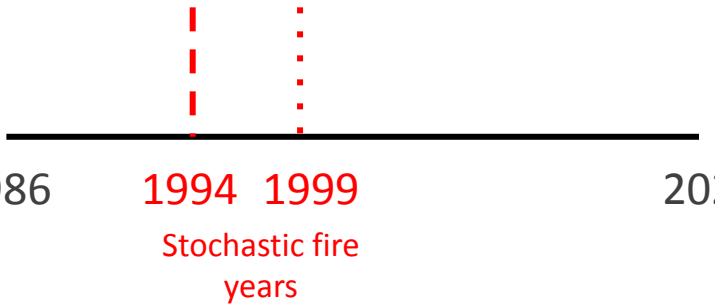
For watersheds that have not experienced a wildfire (such as Bull Run), use vegetation regrowth curves from other fires within the same ecoregion (e.g. South Clover).



Model Assessment and Applications

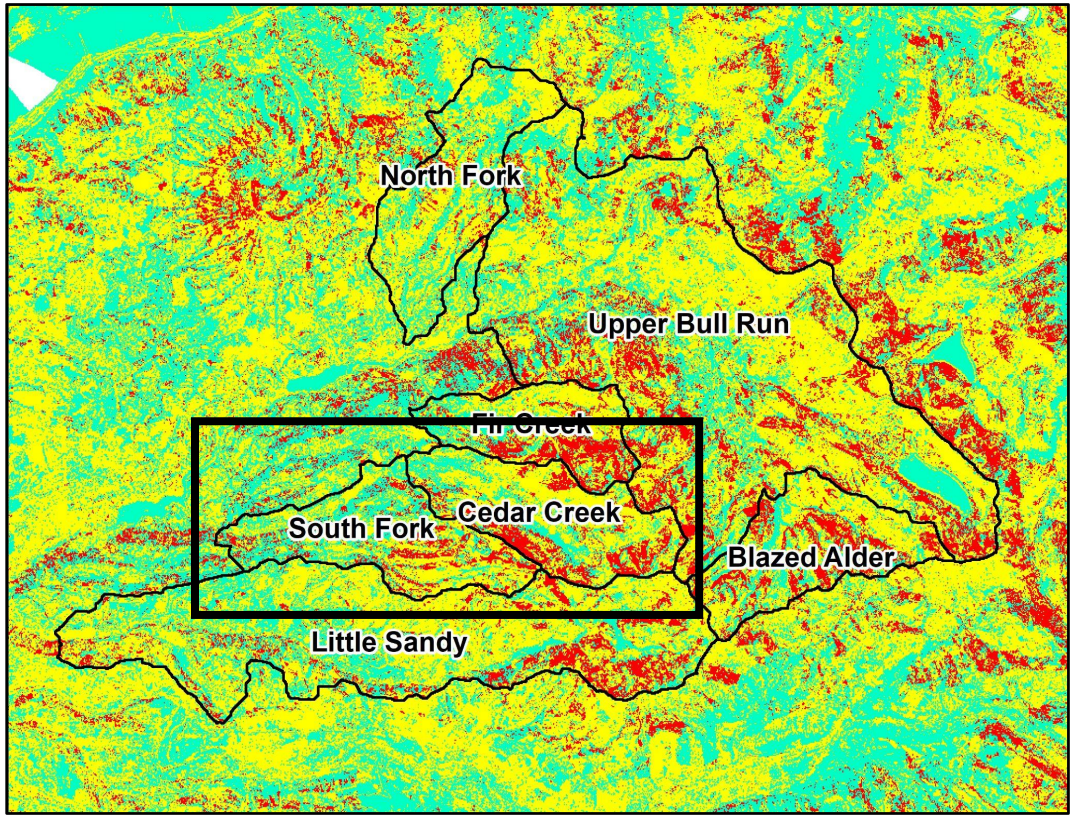
Run two wildfire scenarios:

Wildfire prior to wet years
Wildfire prior to dry years



Average Precipitation = 2,803 mm
Average Precipitation = 2,111 mm

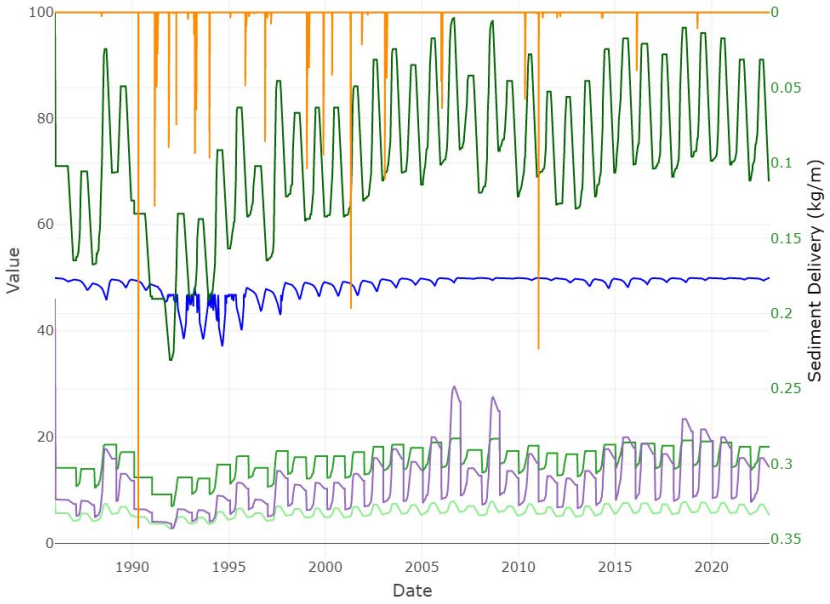
Simulated Soil Burn Severity



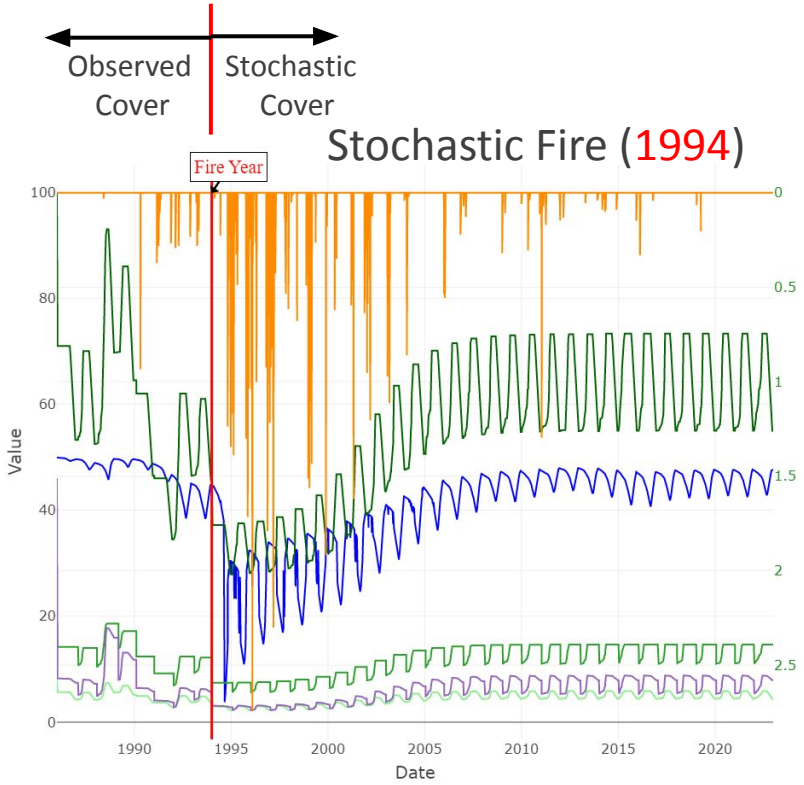
South Fork Watershed
Burned by the Camp Creek Fire, 2023

Model Assessment and Applications

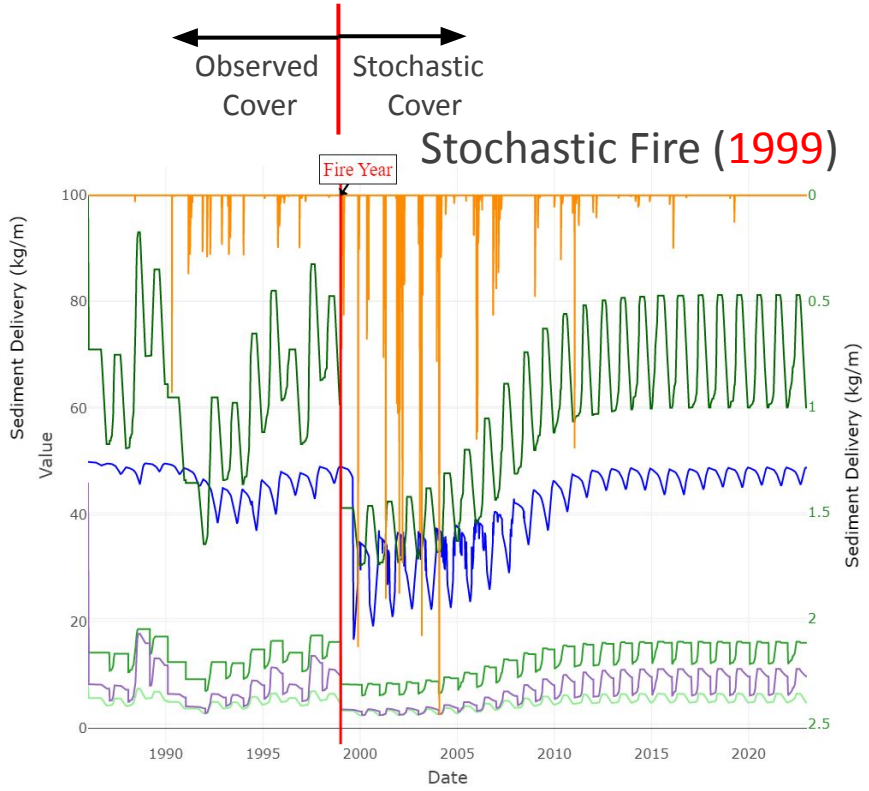
Observed Cover (Undisturbed)



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

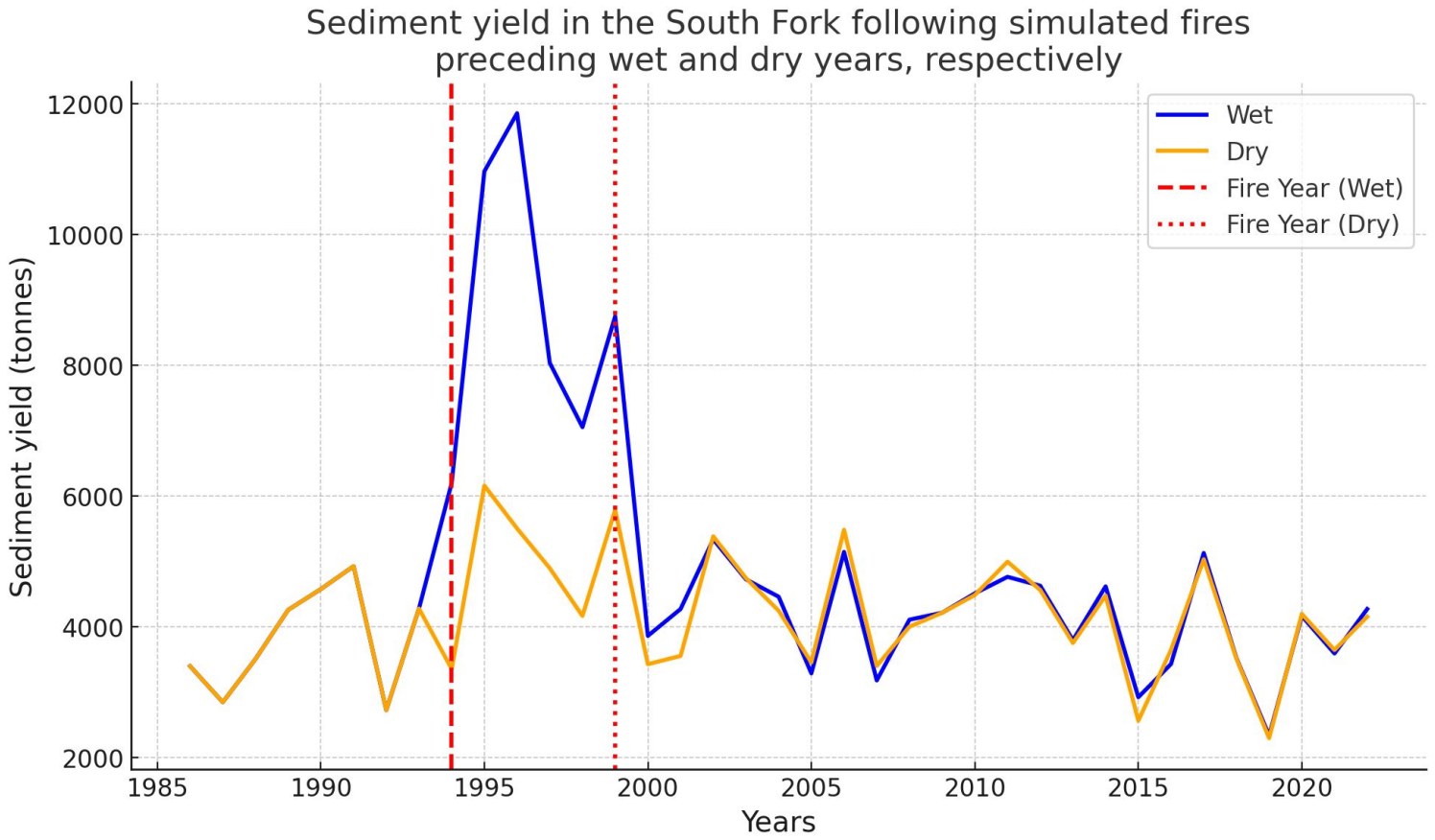


Canopy recovery can be changed to match other observed wildfires



Soil and vegetation parameters and soil erosion with time since fire

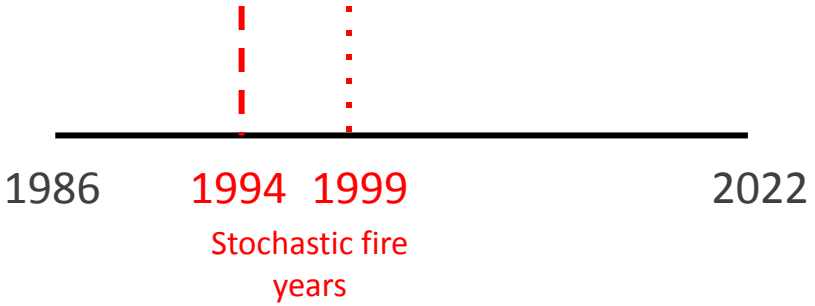
Model Assessment and Applications



Run two wildfire scenarios:

Wildfire prior to **wet** years

Wildfire prior to **dry** years



Average Precipitation = 2803 mm

Average Precipitation = 2111 mm

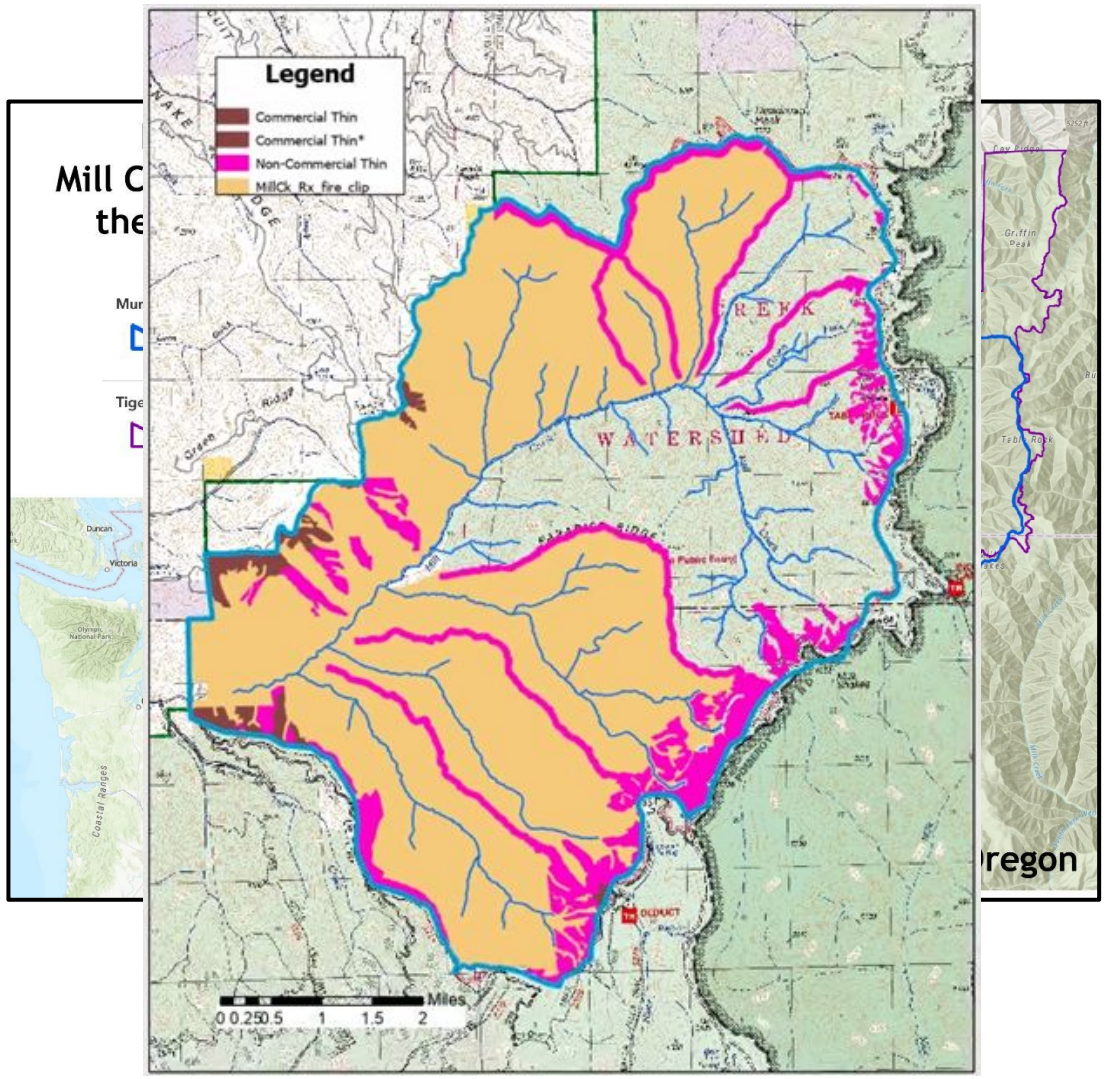
Project Potential Impact – Example

Partners:
- City of Walla Walla
- Umatilla National Forest
- Department of Natural Resources

Action:
Prescribed burning operations are expected to occur over the course of 5-10 years or longer, tentatively scheduled to begin in 2028

Need:
- Help with prioritizing hillslopes and timing of prescribed fire and thinning management scenarios

Proposed Treatments



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USFS PNW Region, BAER: Alexandra G. Rozin

Thank you!

Mariana Dobre
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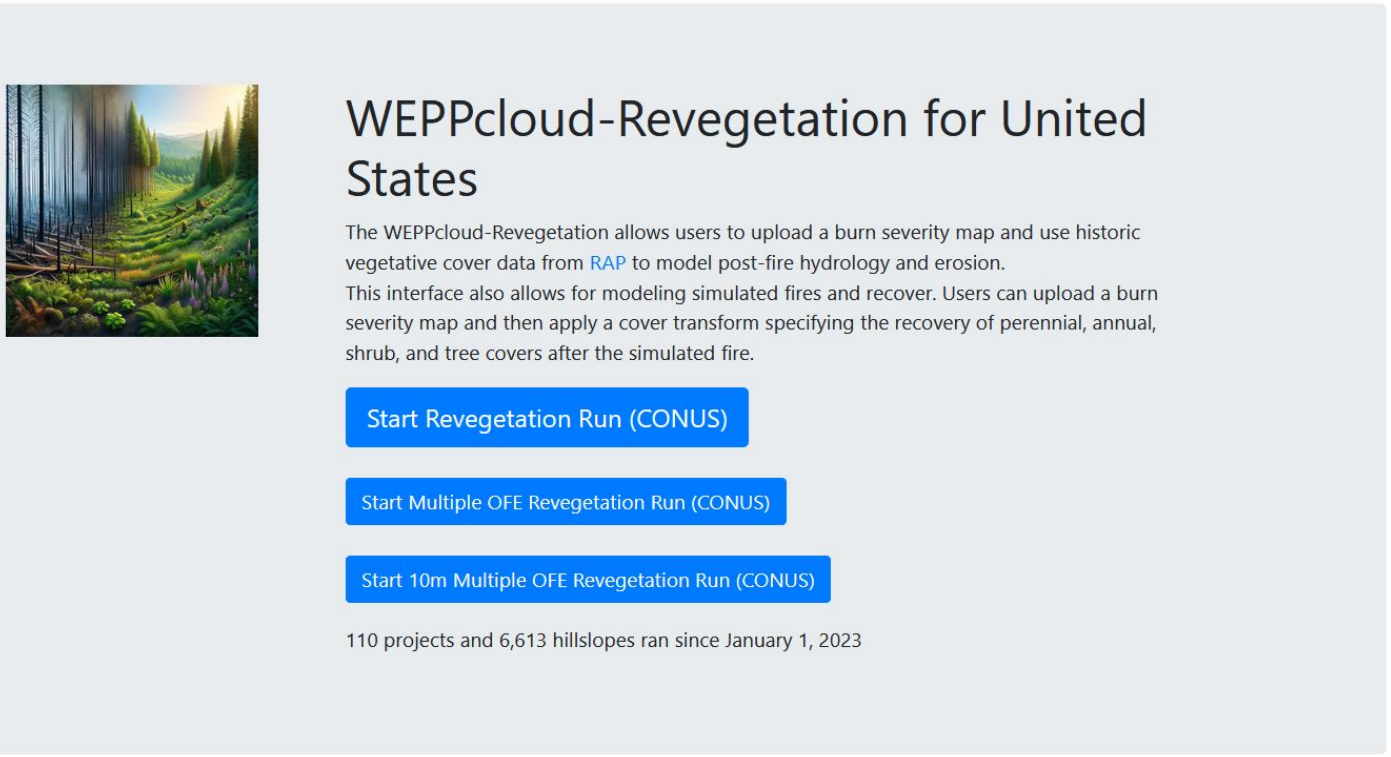
Sustained use plan

- Data and algorithms already incorporated into an operational interface.
  https://wepp.cloud/



Lessons learned and future possibilities

What worked well within your project?

- Pre-existing long-term vegetation cover data processed for contiguous US (RAP, eMapR)

What could have been improved upon?

- Applying the model to Long-Term Ecological Research (LTER) watersheds
- Multiple plant types in WEPP

Were there any goals you did not achieve during the project and what were the barriers?

- Modeling other management practices such as thinning or prescribed fires

Lessons learned and future possibilities

Are there opportunities for data/tool expansion to other geographies or inclusion of new datasets?

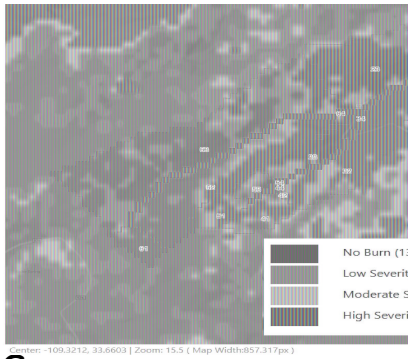
- Simulating multiple wildfires or forest management activities
- Incorporating more advanced forest growth routines (e.g. ALMANAC, FORESTFEST, or RHESsyS)
- Integration of time-series data on forest plant species and spatial maps of forest disturbances

If there are opportunities, what are the resources needed to seek those out?

- Incorporating 30–m derived OPEN-ET
- Use of SMAP for modeled soil moisture
- Post-wildfire short-term forecast
- Expand WEPPcloud to perform global simulations (WEPPcloud-Earth)

Model Assessment and Applications

Wallow Fire, Arizona, 2011

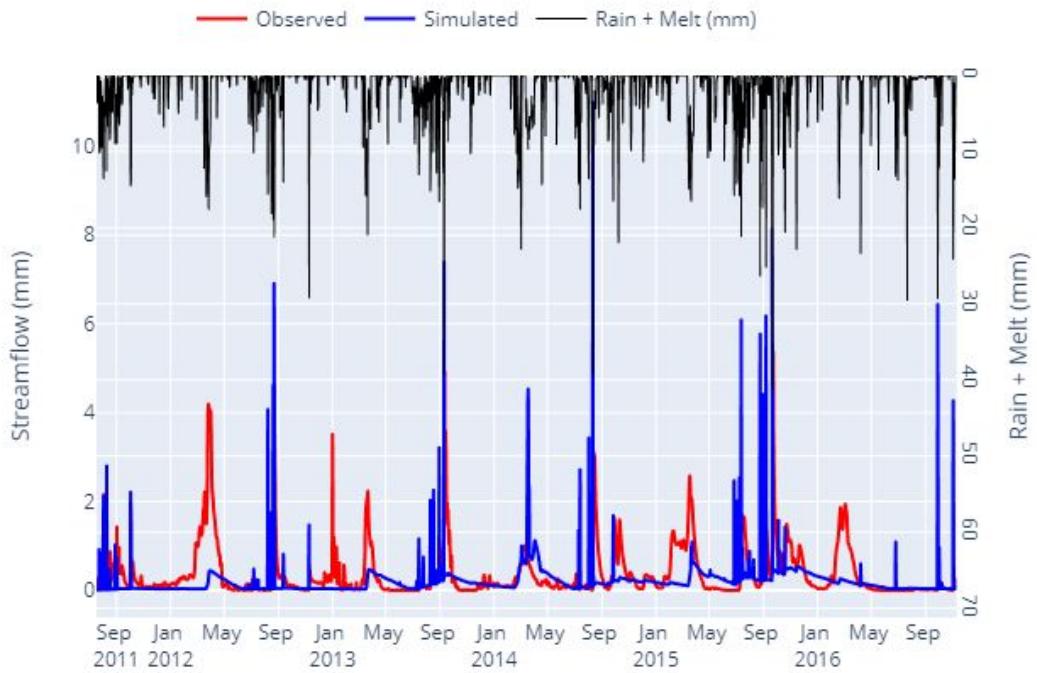


3. Modified the WEPP model source code.
4. Changed soil properties to reflect changes in vegetation.

With Static* Vegetation Cover

Summer/Fall: KGE = 0.06; NSE = −1.46; bias = −24

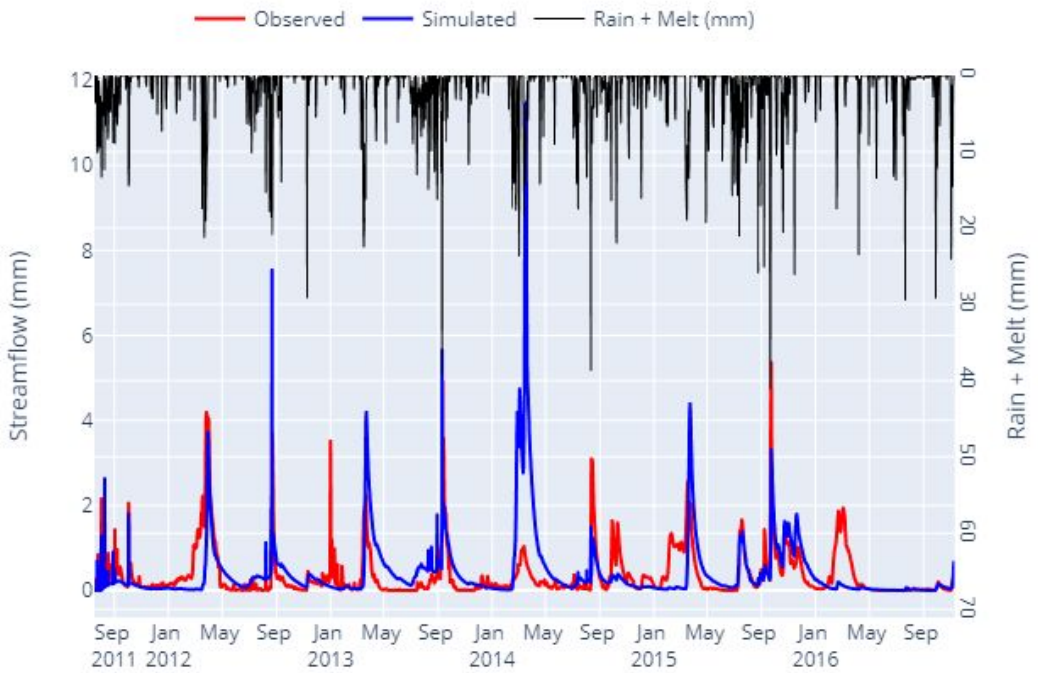
Winter/Spring: KGE = −0.06; NSE = −0.2; bias = −41



With Dynamic (Observed) Vegetation Cover

Summer/Fall: KGE = 0.64; NSE = 0.42; bias = 5

Winter/Spring: KGE = −0.04; NSE = −1.93, bias = 26



*Not proper comparison as the model with static vegetation cover should be interpreted for the first-year post fire only.

Uncalibrated model runs