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PNW

Forest System Health:

Evaluating trade-offs for water, fire, biofuels, and fish

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Pacific Northwest National Laboratory

U.S. DEPARTMENT OF ENERGY BATTELLE

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Acknowledgements

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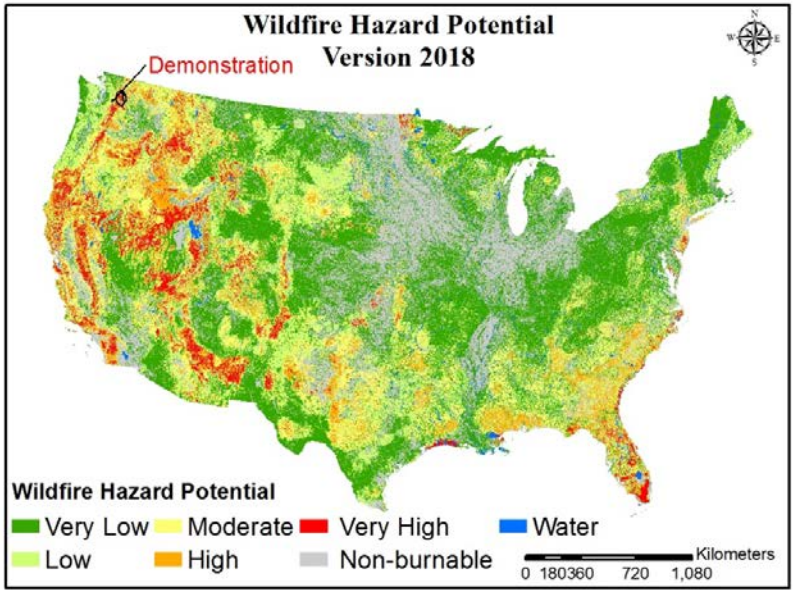
Goal Statement

Challenge: Forest restoration is being used to reduce wildfire risk and has been identified as a potentially significant source of bioenergy – however, additional planning and decision support tools are needed to access economic and environmental sustainability.



- **Goal:** This research is developing and demonstrating an analysis framework **to prioritize how and where to target forest restoration (timber harvest and thinning) to have the greatest benefit for bioenergy, reduce severe wildfire risk, increase water yield, and improve ecosystem services.**
  - Multi-agency collaboration between DOE-BETO and USFS R&D

- Capabilities developed under this project will provide an analysis framework for the bioenergy industry to increase forest derived biomass in a publicly and ecologically acceptable manner
  - General capability is suitable for a range of forest management planning activities

Restoring fire-prone forests in a changing climate

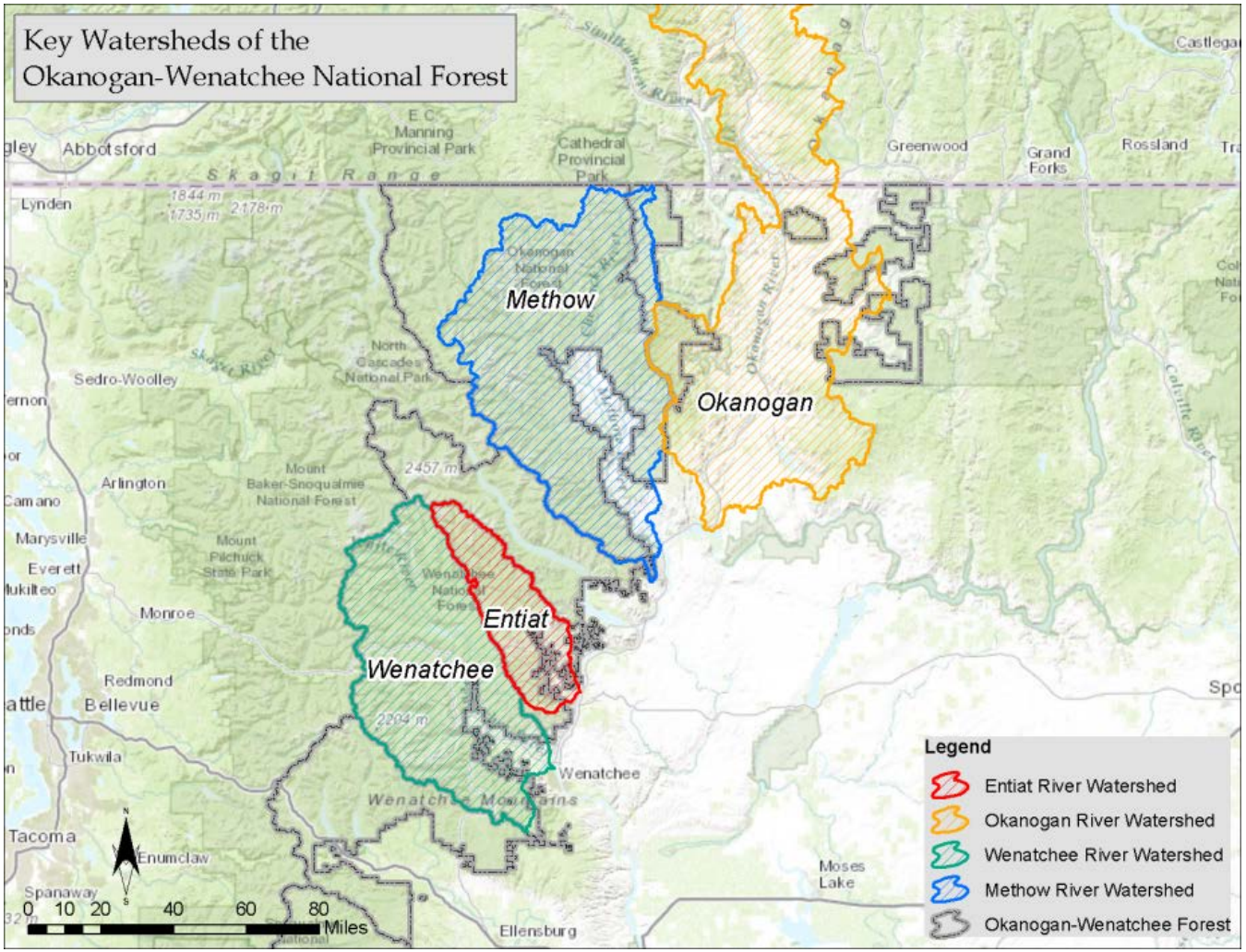
- Snowmelt is the dominant driver of streamflow in the western US
- Expanded forest area and forest densification have reduced snow accumulation and the hydrographs of fire excluded areas
- Efforts to improve forest health and reduce wildfire fuels are focused on reducing canopy cover in over-stocked forests via mechanical thinning and prescribed fire. There is potential to leverage these investments to achieve
  - Concurrent hydrologic benefits – increased snowpack and summer streamflow
  - Economic and societal benefits through collection of residue for bioenergy
- We examine the interplay among forest restoration, snowpack, streamflow, wildfire and smoke intensity, and biomass for energy across treatment scenarios using a decision support application designed for that purpose.

Forest restoration scenarios for a fire- dominated landscape

- Previous land management has led to increased wildfire fuel load
- Goal: restore landscape to a pattern more consistent with a wildfire-dominated region
  - more frequent, less intense wildfire, varied locations
- Restoration through
  - commercial thinning + Rx burning
  - Rx burning in other locations
- Only consider biomass for energy associated with the commercial activities

(From WDNR 20-Year Forest Heath Strategic Plan Eastern Washington)

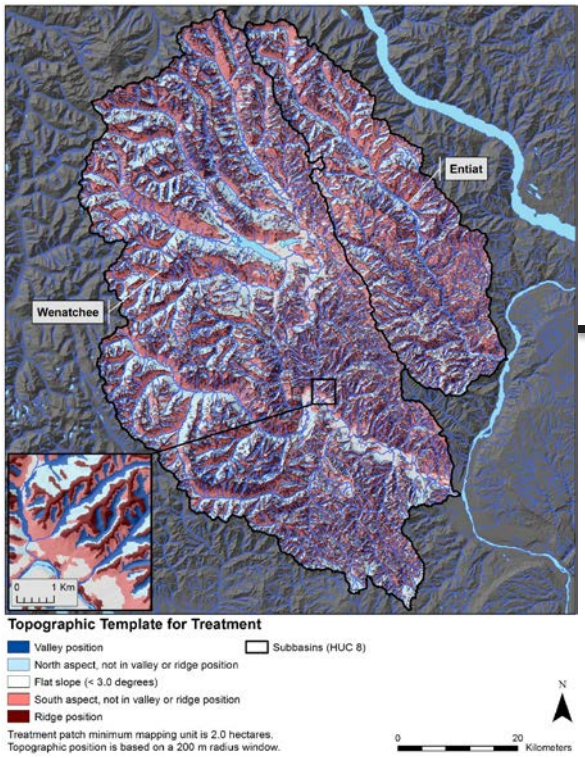
Wenatchee and Entiat study watersheds



Multi-Scale Approach

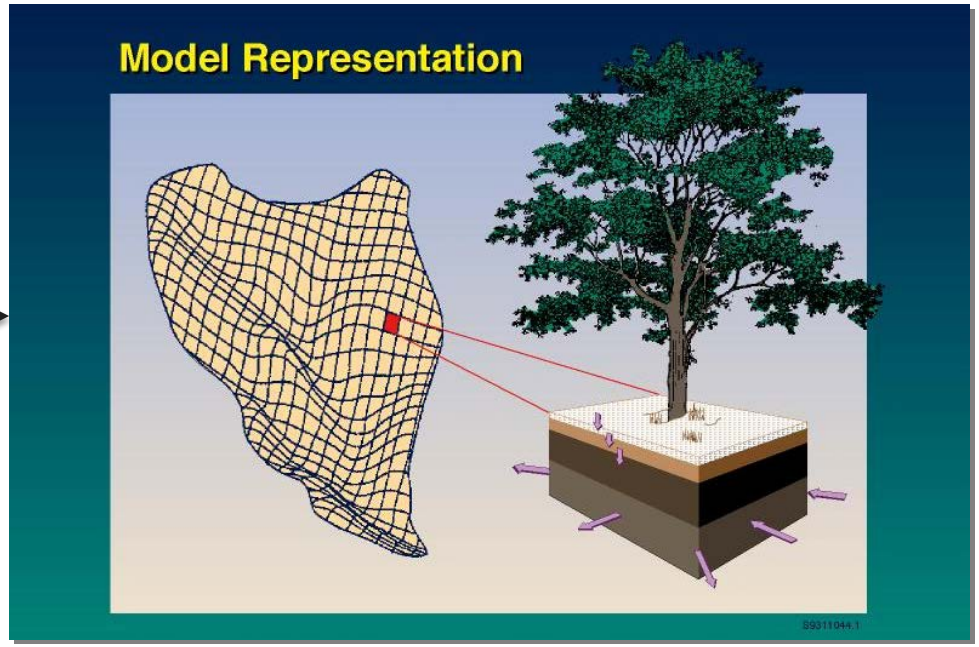
- Base data and models applied at 30-m spatial resolution
- Forest restoration scenarios at the patch scale (10s-100s of hectares)
- Analysis at patch and subbasin scale (10,000 – 25,000 ha)

Restoration Scenario



Location, type, intensity, and biomass yield

Hydrologic Impacts



Snowpack, stream discharge and temperature by reach

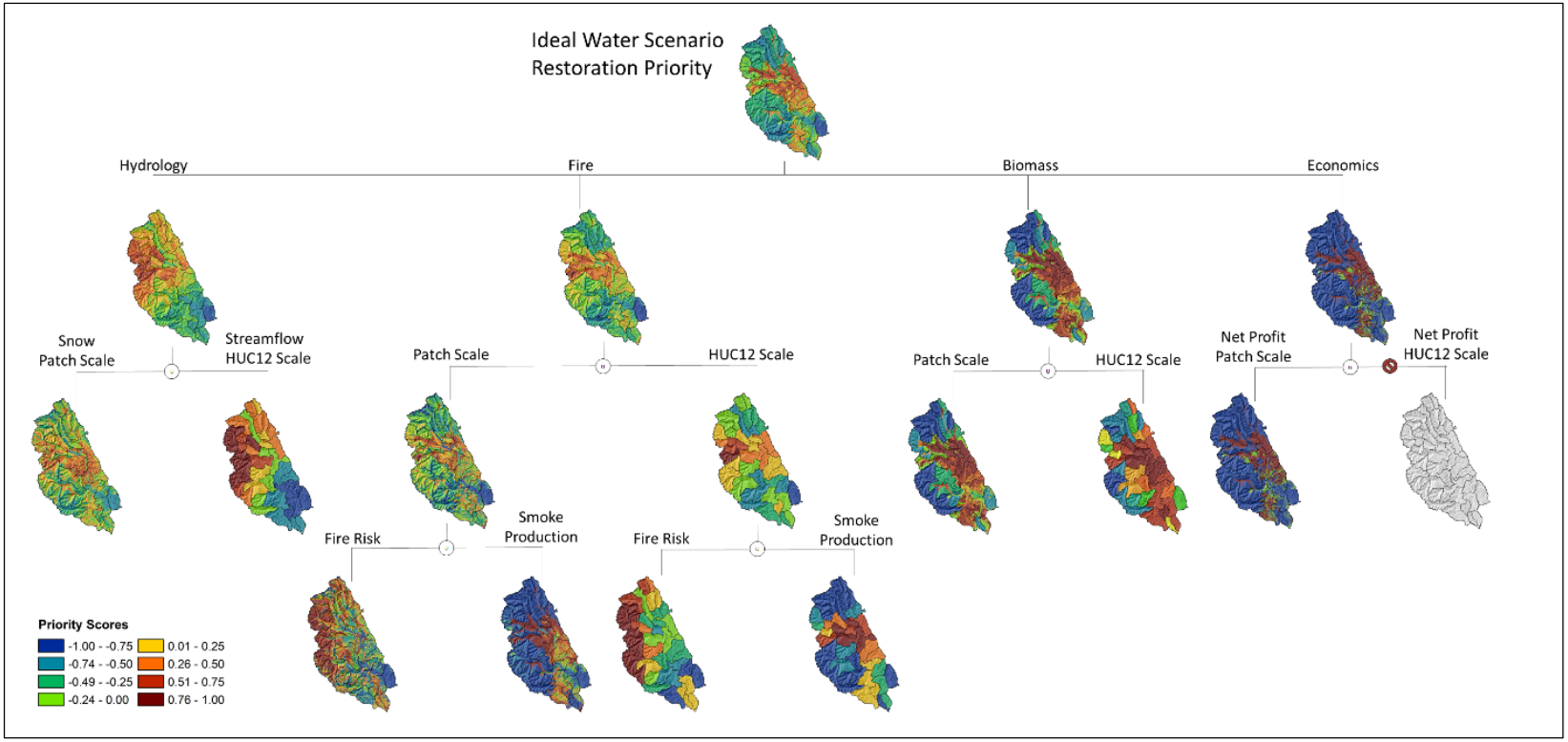
Restoration Scenarios

Management scenario	Objective	Treatment
Maximum Biomass	Treatment design intended to **maximize fire hazard abatement and biomass related objectives**, while still maintaining minimum credible standards for a thinning treatment design.	Remove all trees when no large (>=25” DBH) are present, and all shade tolerant trees <25” DBH and all trees < 10” DBH otherwise
Ideal Water	**Maximize hydrologic productivity**	Within each pixel, remove all trees within a gap of size 1.2 * maximum tree height
Principles-based Restoration (RA1)	Apply a principles-based approach to landscape management (sensu, Hessburg et al. 2015)	Treat 49% of the landscape using a combination of treatment intensities
Prescribed-burning Only	Re-introduce fire as an ecological process	Implement late-season prescribed burning

Tradeoffs Considered

- Fire
  - Flame length
  - Total carbon release
  - Smoke production (PM2.5 and < PM10)
- Biomass
  - Merchantable
  - Non-merchantable (residue for energy)
- Hydrology
  - Snowpack characteristics
  - Streamflow (annual, monthly, late season)
- Economics
  - Collection costs
  - Hauling costs

Decision Support

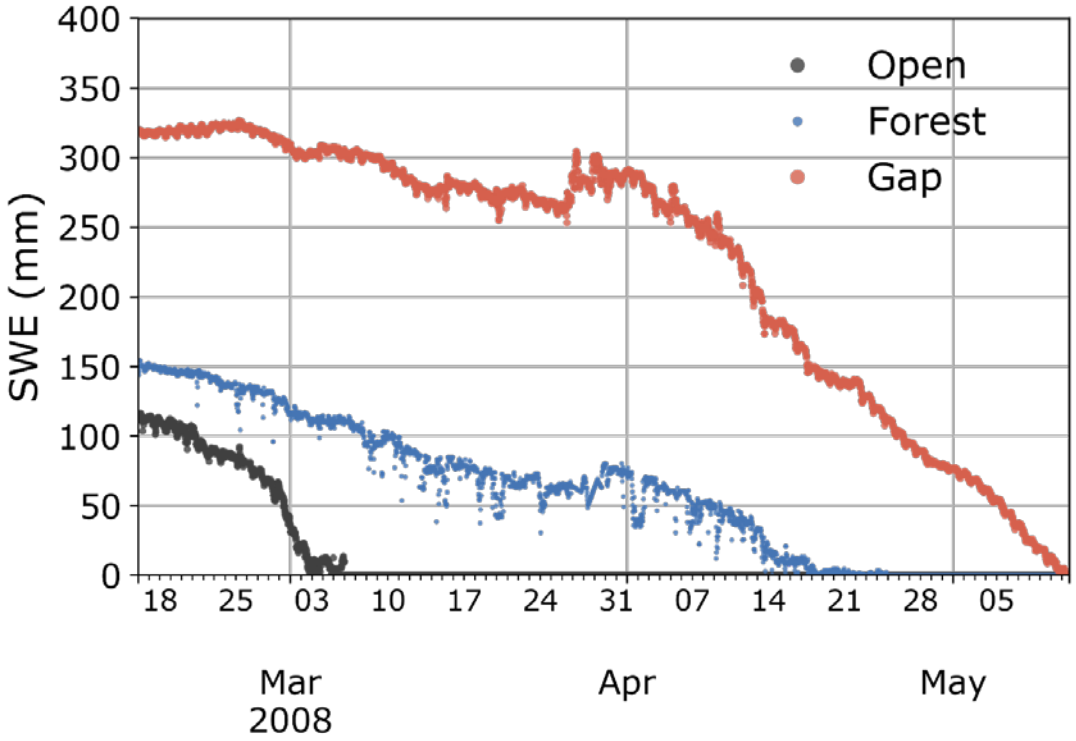


Forest cover affects snowpack and summer stream flow

- Reduction in forest cover may **increase or decrease** snow duration depending on local topography, climate, and canopy characteristics
- Snow tends to last longer in the open where winter air temperature is greater than -1 C or precipitation is higher than 300 mm.
- These conditions vary over relative short distances in mountainous regions of Washington State

(Lundquist, 2013 based on global data)

Forest canopy conditions impact the volume and timing of snowmelt



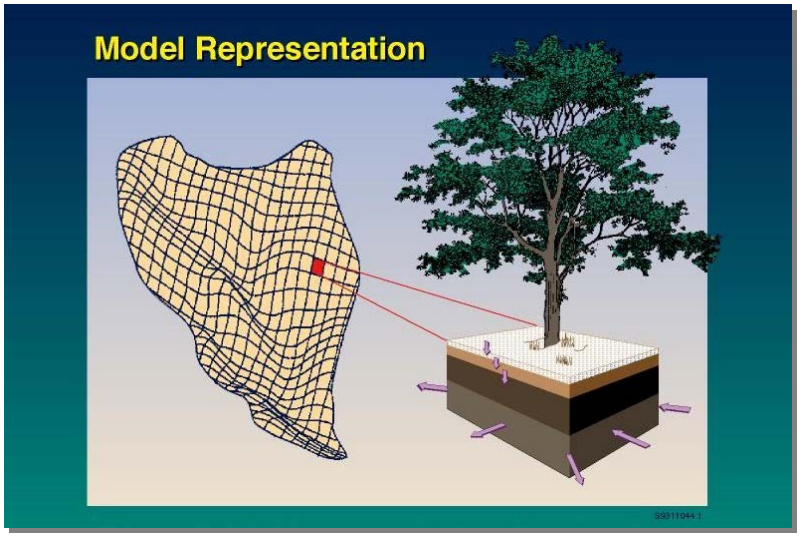
Single location at U. of Idaho Experimental Forest

Peak snow water equivalent (SWE) in the canopy gap is twice that of the adjacent forest, and snow cover remains ~three weeks longer

Models must account for varied landscapes and scales

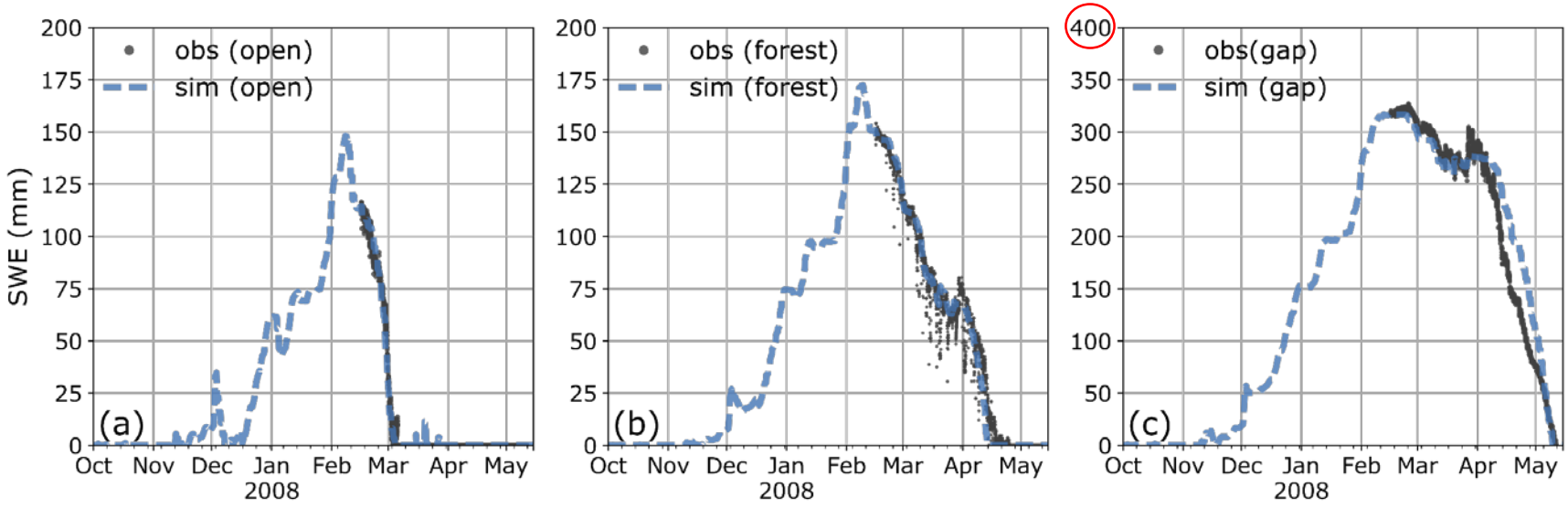
Distributed Hydrology Soil Vegetation Model (DHSVM)

- Predicts snow accumulation, melt, and runoff under different canopy and weather conditions
- Represents spatial variation in topography, weather, vegetation, & soils at **10 to 90-m spatial resolution**
- Extensive use in the scientific community, well vetted



A useful model creates simulations that match actual data

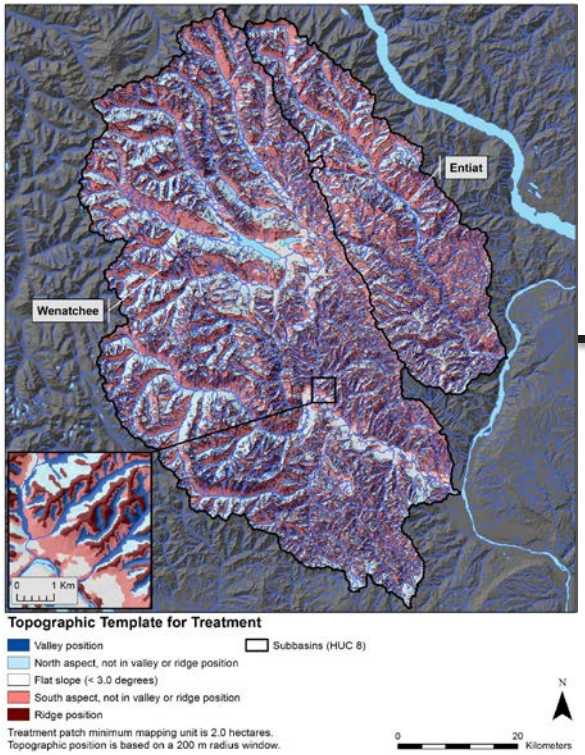
U. of Idaho Experimental Forest



- The model has been well validated in **open** areas (Snow Telemetry stations) across the western US
- Model shows good agreement with observations under three canopy conditions

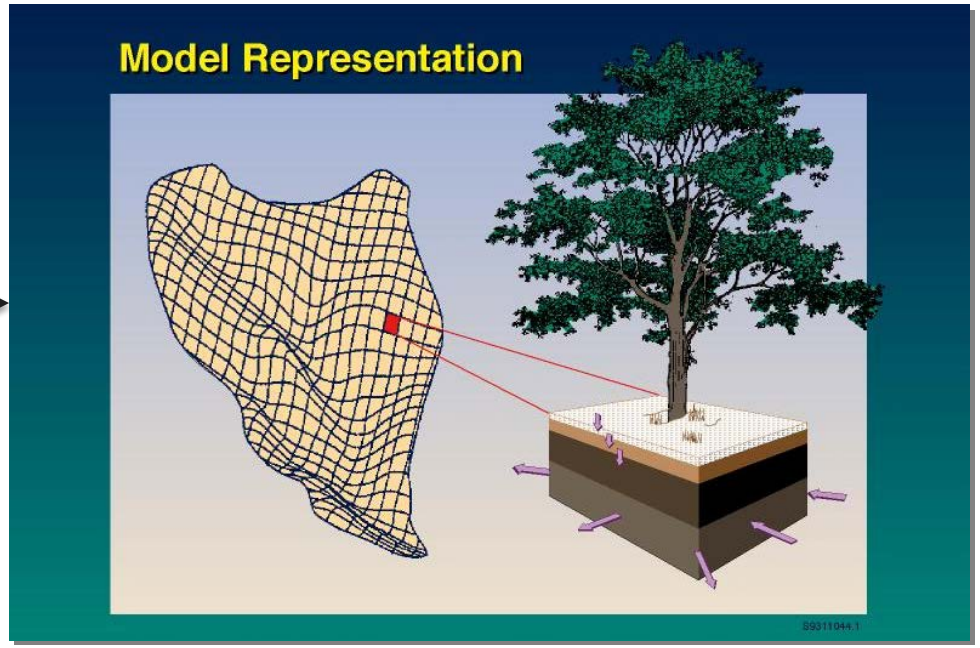
Mapping restoration scenarios to DHSVM

Restoration Scenario



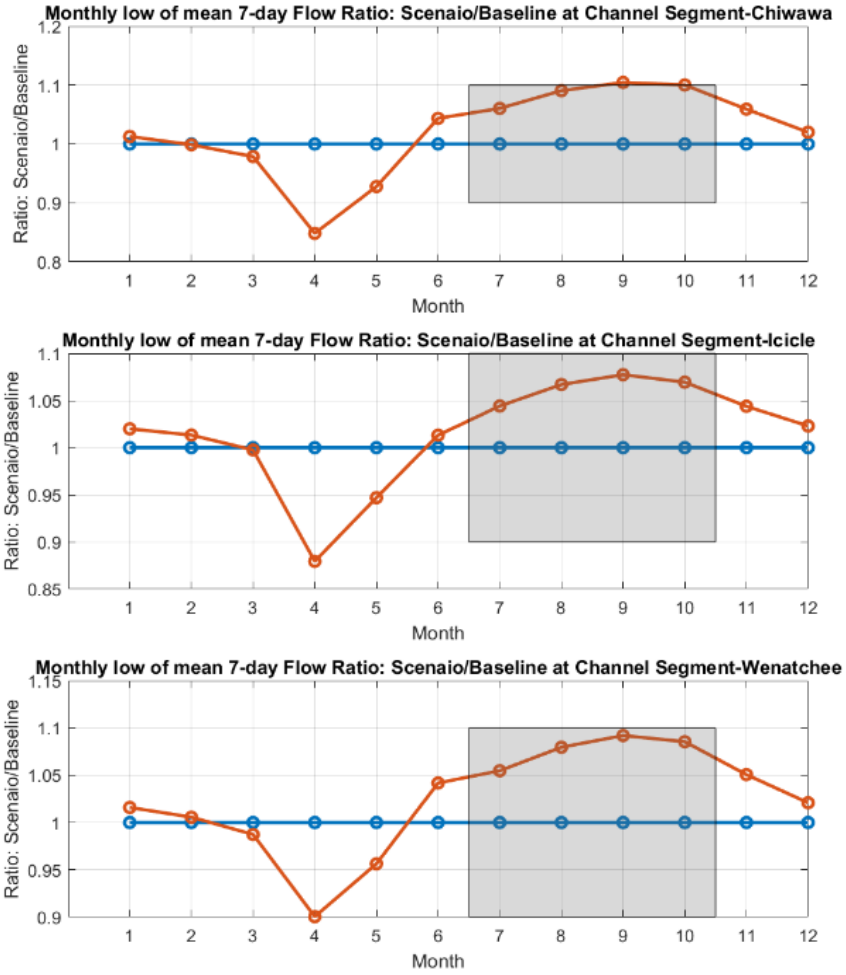
Location, type, intensity, and biomass yield

Hydrologic Impacts



Snowpack, stream discharge and temperature by reach

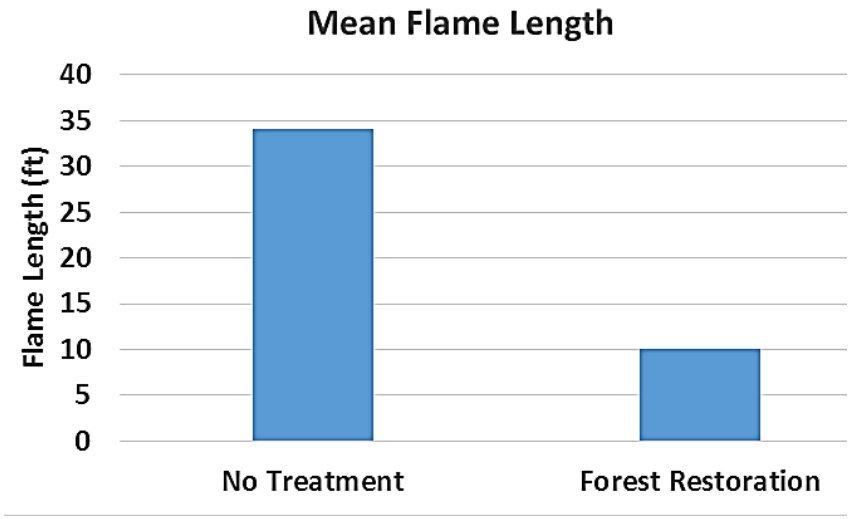
Forest restoration produces an increase in 7-day summer low flows

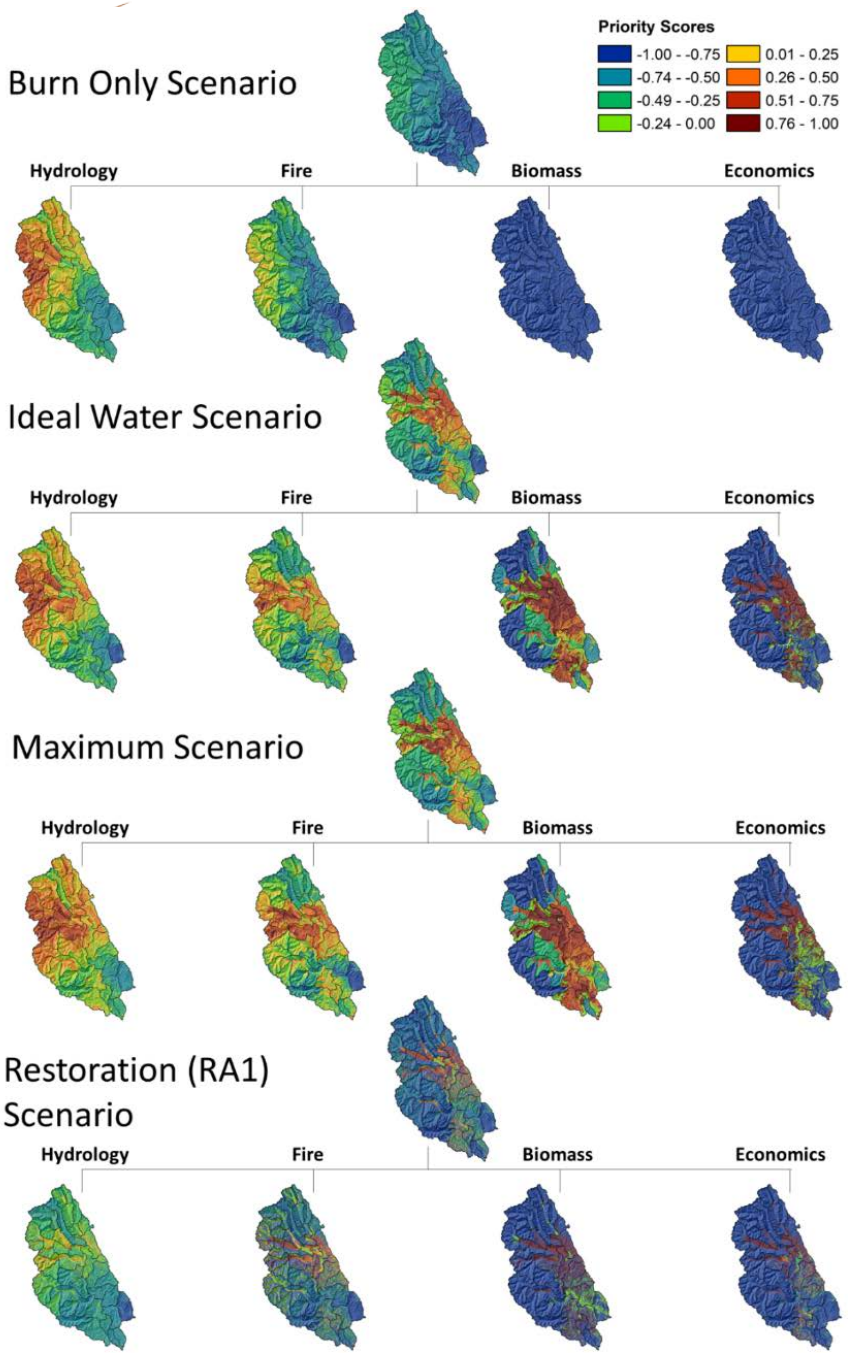


In areas where snowpack supplies late season flows, forest restoration can help increase critical summer low flows

Reduction in burn severity

- The goal of fuels management is not to reduce area burned, but to **reduce area burned severely** via reduction of surface and canopy fuels.
- We classified continuous values for CBD, flame length, and crowning index to describe treatment effects on the contagion of wildfire severity.
- **Flame length** under severe weather conditions, indicates the likelihood that direct fire suppression is an option.
  - Current evaluation is for restored locations. We can also model change in likelihood of spread between treated and untreated locations, not shown here.





Tradeoffs

- Fire
  - Flame length
  - Total carbon release
  - Smoke production
- Biomass
  - Merchantable
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- Hydrology
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- Economics
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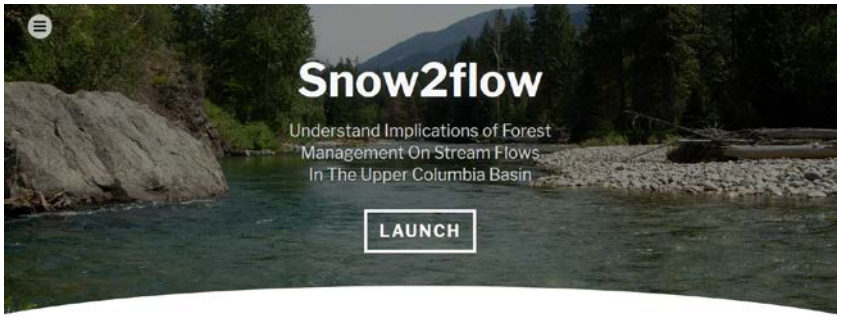
Summary

- We consider forest restoration scenarios to reduce fuel loading and return to landscape patterns more consistent with a wildfire dominated regime
- Introduction of gaps in the forest canopy generally increases snow accumulation and duration, leading to increased summer low flow
- Use of forest residue for bioenergy/bioproducts shows promise subject to market conditions, processing, and transport costs
- High resolution models and decision-making tools must evaluate tradeoffs over a range of spatial and time scales
  - Ability to consider uncertainty
  - Search for “multi-win” scenarios

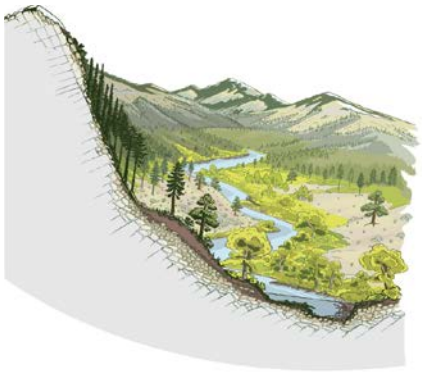
What's next?

- Consider vegetation regrowth
  - Continued reduction in wildfire risk
  - Maintain improved streamflow and biomass supply
- Consider uncertainly
  - Biophysical models
  - Decision support
- Work with Washington State University on logistics and system dynamics
  - Michael Wolcott
  - Dane Camenzind and Lina Martinez (both located at PNNL)
  - Aviation fuel

Integrate bioenergy in Snow2Flow as a practical tool to support stakeholder analysis and decision making



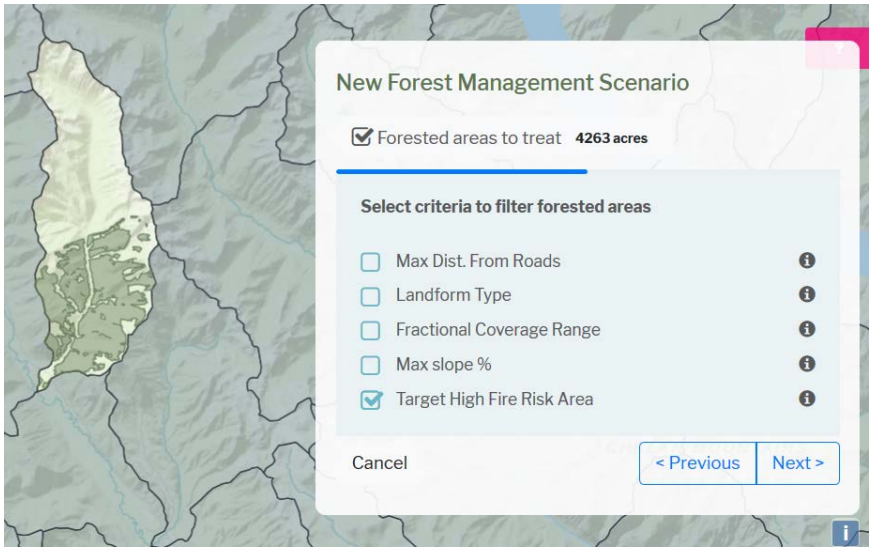
restoration practitioners support salmon recovery across North Central Washington. The easy-to-use website informs salmon recovery by assessing the effects of forest restoration activity on snowpack retention and subsequent water supply and timing.

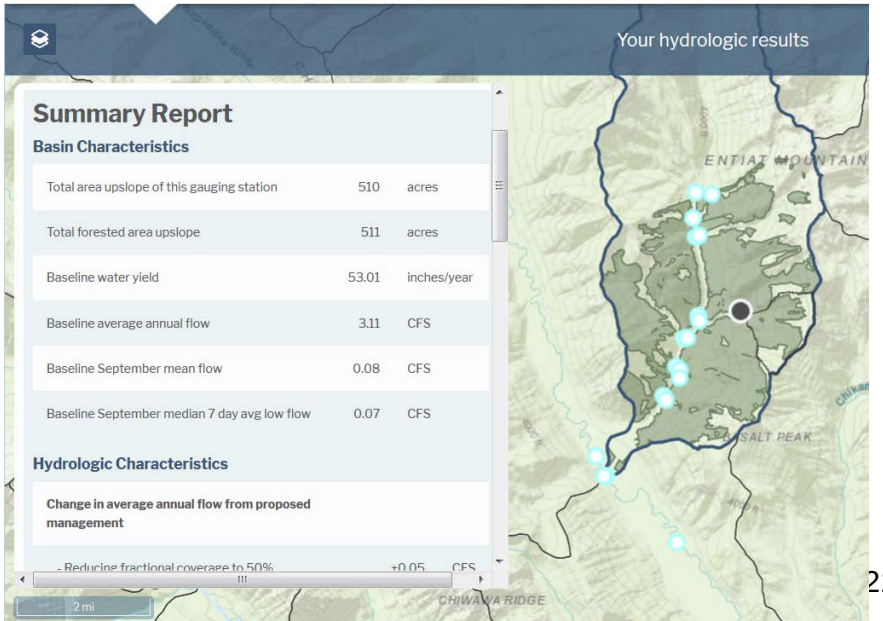


About the App

Water availability, especially during the late summer, affects salmon populations in the Upper Columbia. One of several approaches to increasing the amount of water available for instream flow in the late summer is by increasing the capture and duration of storage of mountain snowpack. This tool builds on Pacific Northwest National Laboratory's Distributed Hydrology Soil Vegetation model (DHSVM) to identify both how forest restoration activity affects downstream flows, and where to target upstream restoration activities to benefit specific in-stream locations.

http://s2fdemo.ecotrust.org/app





Thank you

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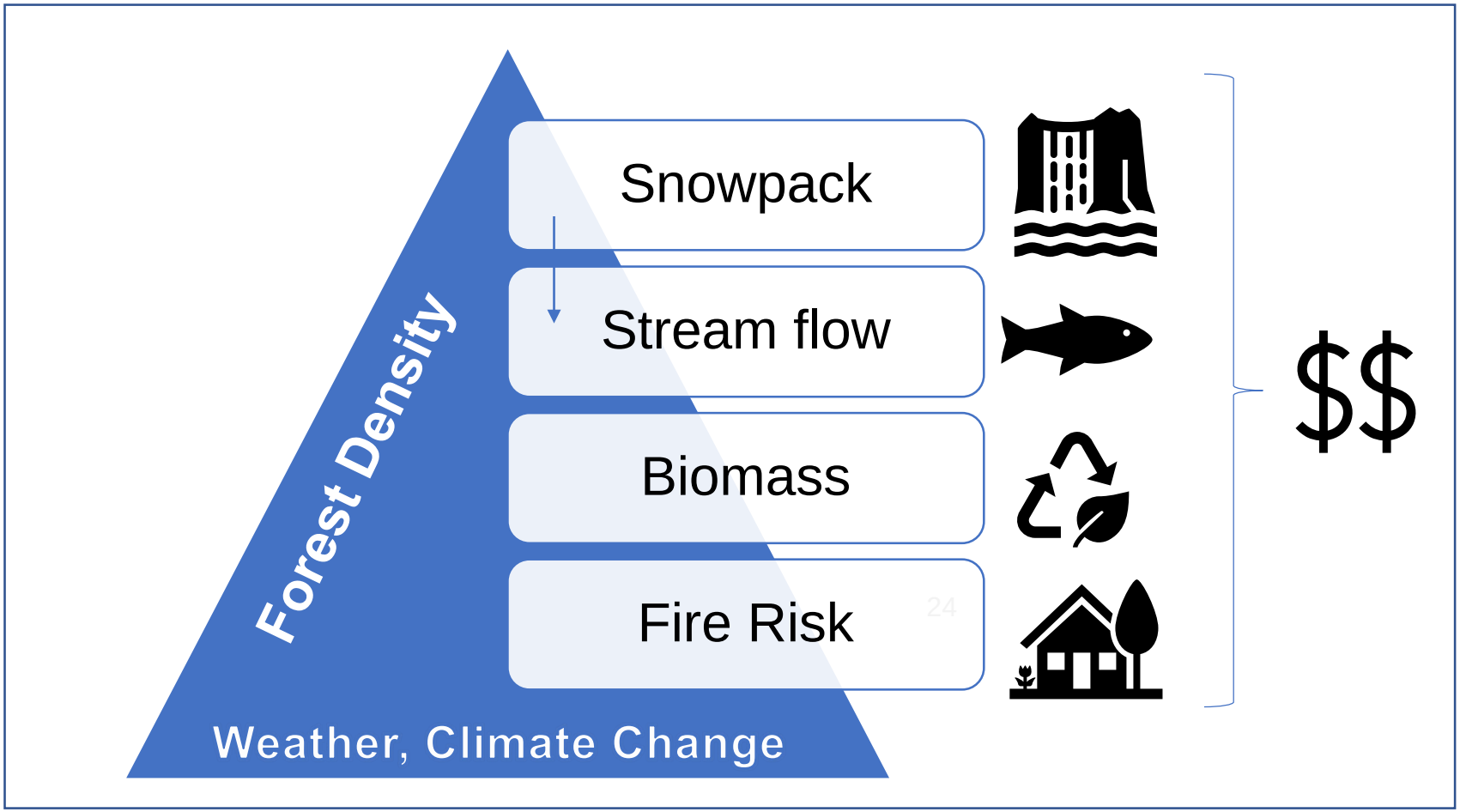
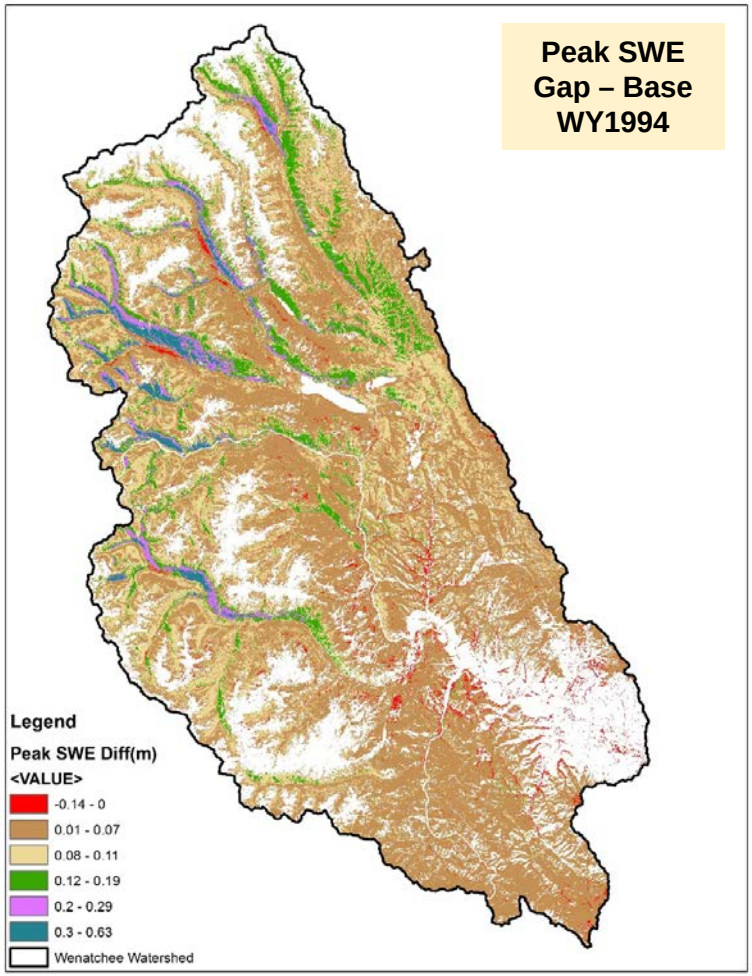
Backup slides

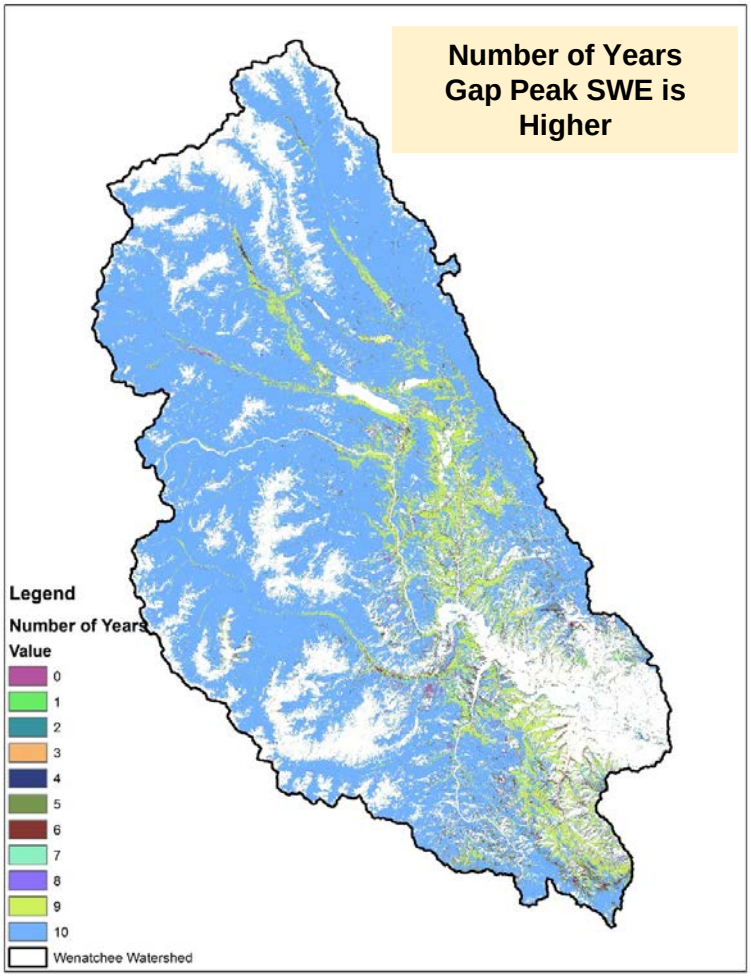
The challenge of integrated forest restoration



Goal: integrated decision tool for forest managers

The Impact of Gaps in the Forest Canopy on Peak SWE Changes with Location and Time





The type and intensity of forest restoration to increase water stored in snowpack is location specific and must consider climate variability

Impact of Restoration Treatments on Timing of Snow Disappearance Varies in Space and Time

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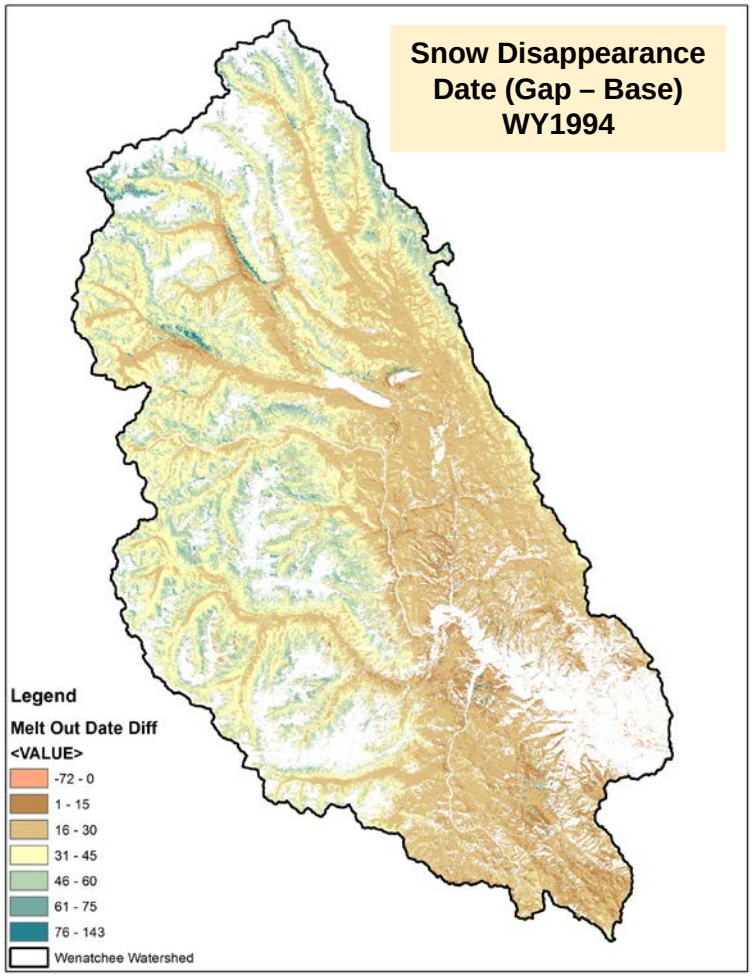
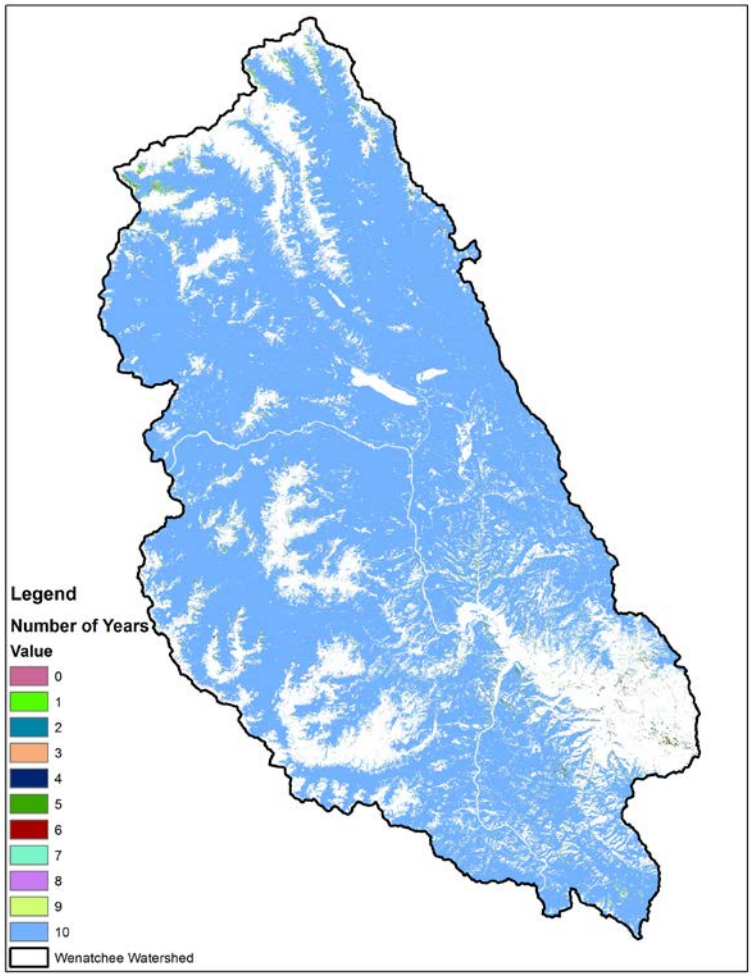
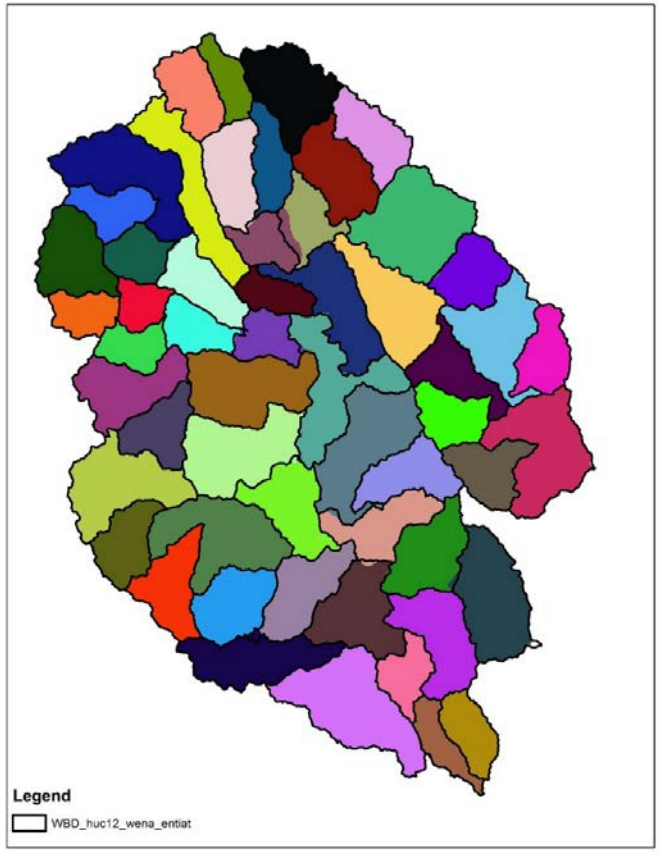
Number of Years Gap SWE Lasts Longer

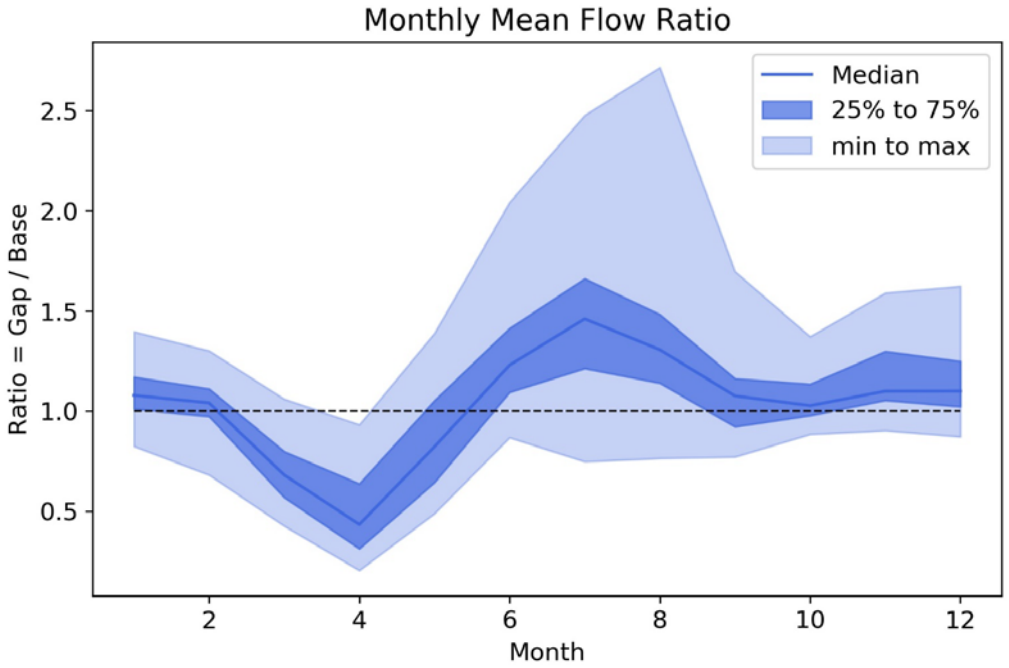




The type and intensity of forest restoration to increase snowpack duration is location specific, but less sensitive to climate variability

The Impact of Forest Restoration on Streamflow Changes with Location & Time





- $Ratio = \frac{Gap\ scenario}{No\ treatment}$

- Generally increased annual flow volume
- Reduced spring flow and increased the summer flows

Forest restoration planners must consider impacts on land, water, and economics