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How Visualizing Ecosystem Land Management Assessments (VELMA) modeling quantifies co-benefits and tradeoffs in Community Forest management

Please click Ctrl-L for full screen viewing of this presentation

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[1] U.S. Environmental Protection Agency; [2] CSRA; [3] ICF International; [4] Nisqually River Council; [5] Nisqually Land Trust; [6] Washington Environmental Council; [7] Washington Department of Natural Resources

2018 Northwest Community Forest Forum
Astoria, Oregon

Outline

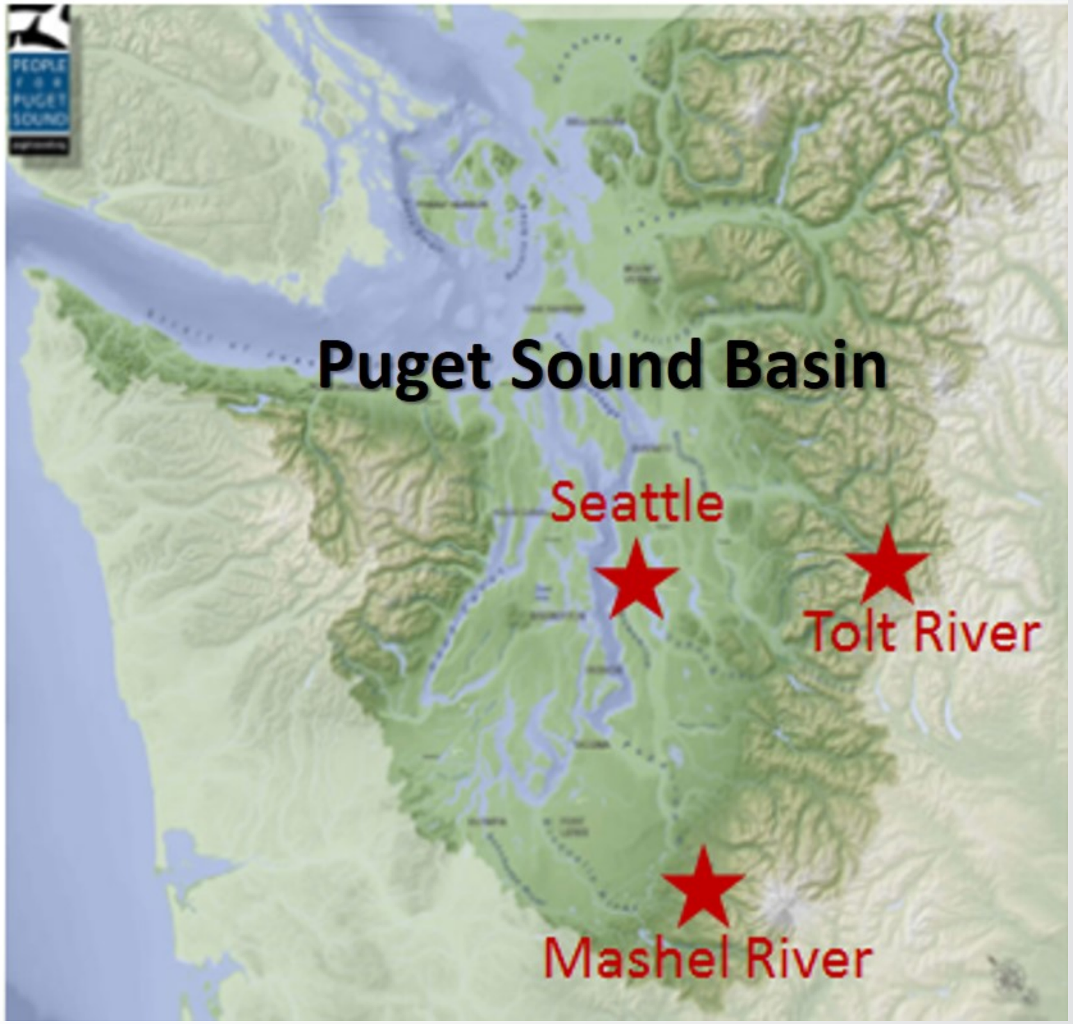
- What is VELMA? Where and how is it being used?
- How can VELMA help community forest managers quantify co-benefits and tradeoffs?
- Example application: Nisqually Community Forest
- Scaling up from watersheds to regional basins

VELMA PNW Applications

Purpose: Demonstrate and transfer VELMA and associated tools to *Communities, Tribes, States of WA and OR* to use in formulating watershed restoration plans

Applications:

- Puget Sound Subwatersheds: Salmon recovery, drinking water, flood protection, carbon sequestration, community-based forestry…
- Puget Sound Basin (12,138 mi^2): Whole-basin framework linking terrestrial, estuarine and ocean models informing Puget Sound recovery planning



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- Puget Sound Basin (12,138 mi^2): Whole-basin framework linking terrestrial, estuarine and ocean models informing Puget Sound recovery planning
- Tillamook Bay Estuary & Watersheds (560 mi^2): Restore upland, floodplain, estuarine eco services

Nisqually Community Forest (NCF)

How best to get from

this  ***back to this***  ***?***

- Tools for whole-watershed restoration planning
  - Ecohydrology (VELMA)
  - Stream shade & temperature (Penumbra)
  - Fish habitat (EDT)
- Tool transfer to Community Forest stakeholders

Mashel River Watershed… a key part of the Nisqually Community Forest vision

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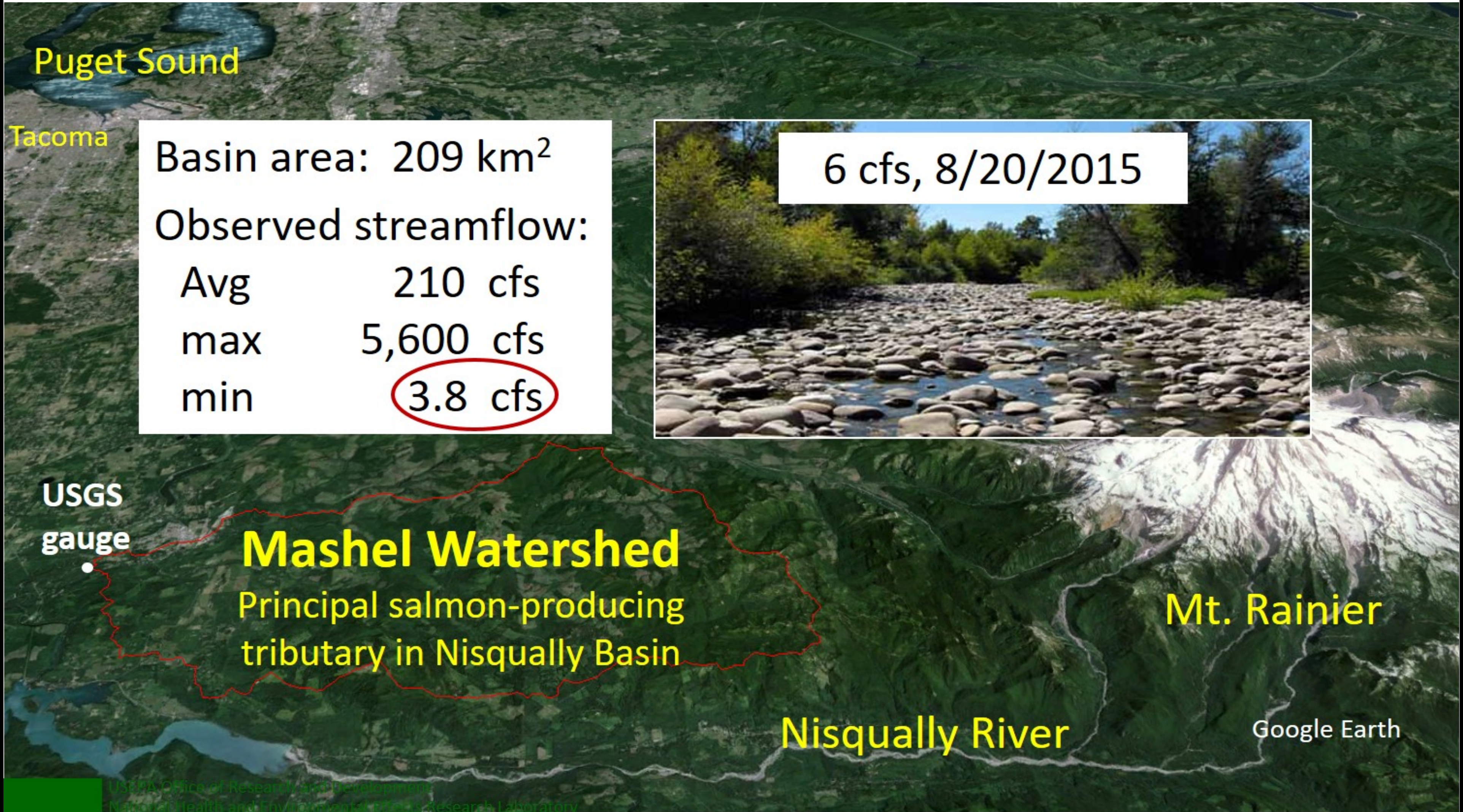
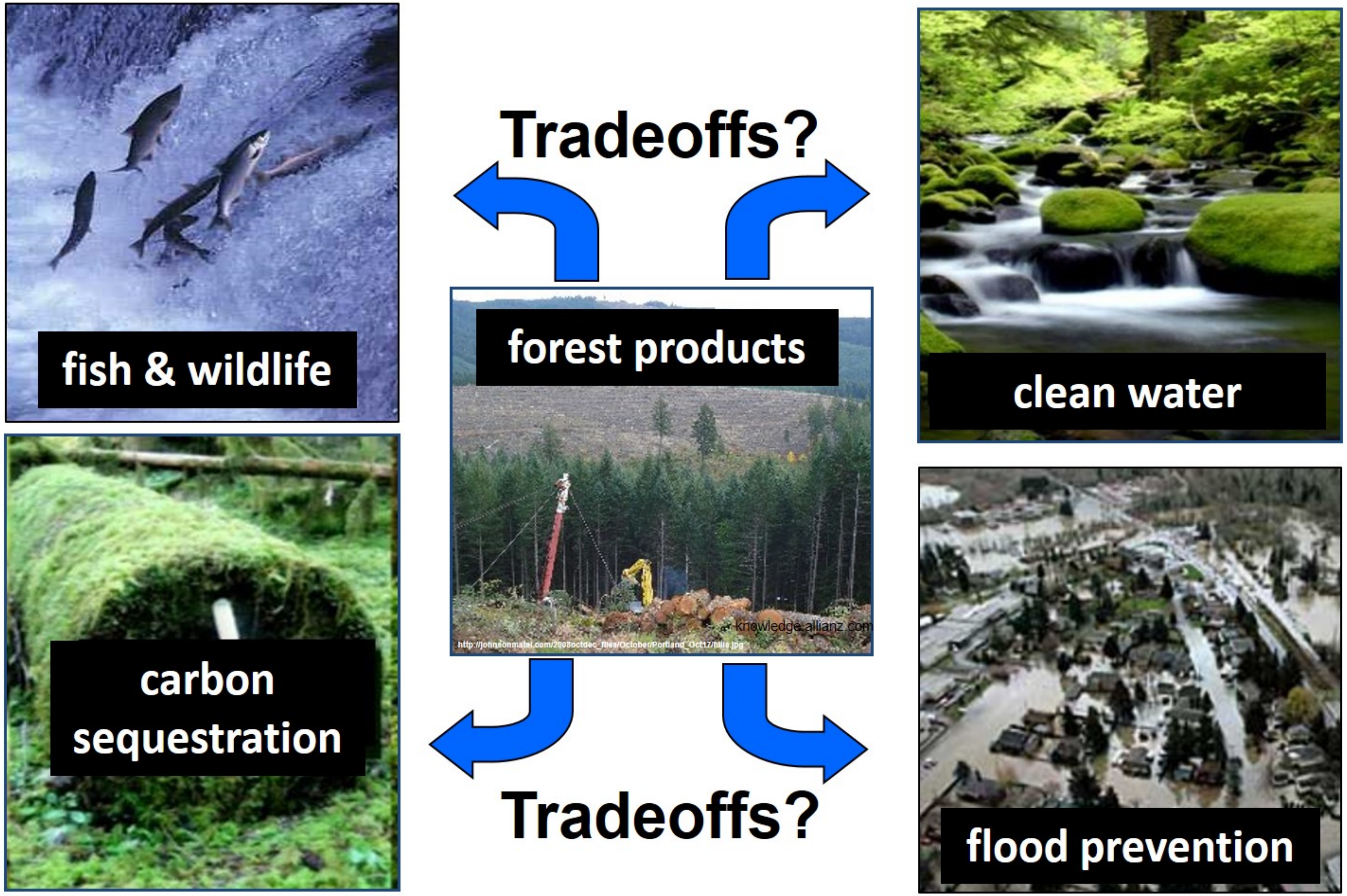


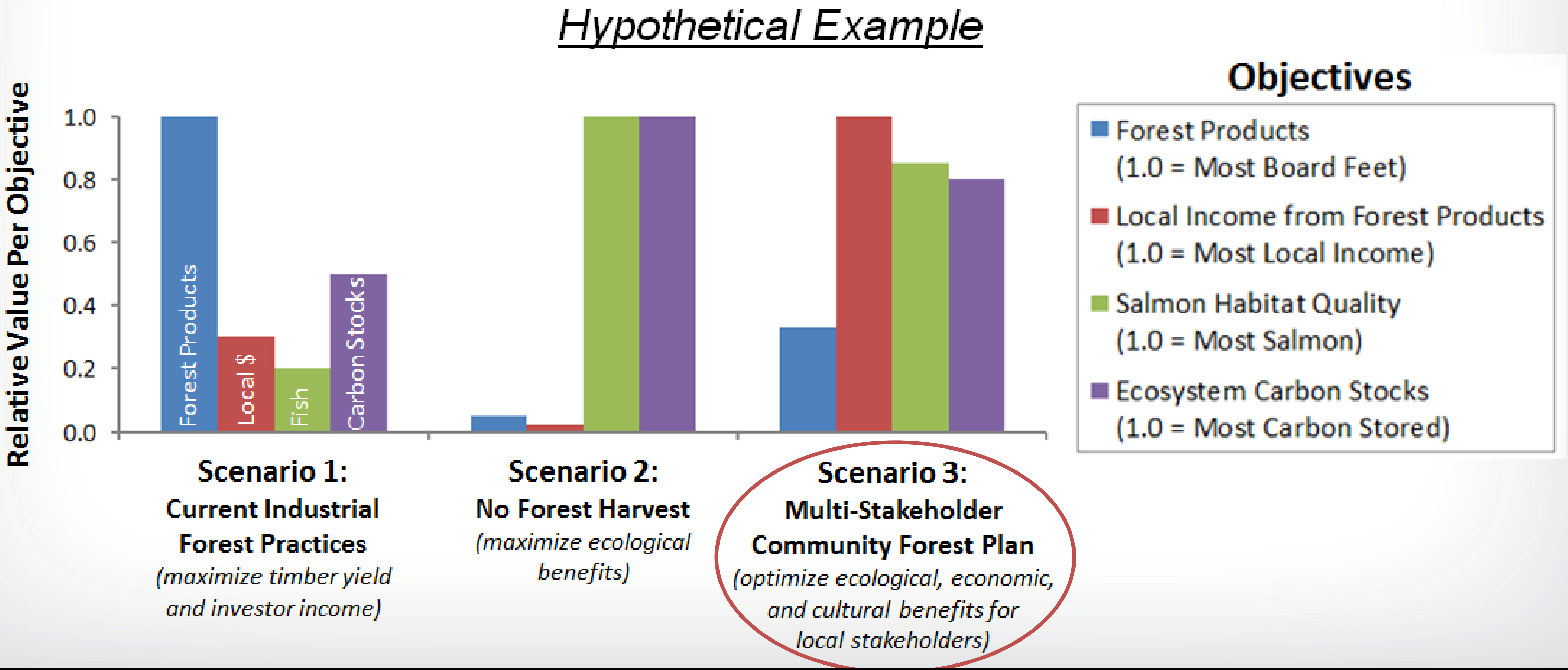
Mashel River Watershed… a key part of the Nisqually Community Forest vision

Mashel Watershed Land Owners	Objectives
Forest Industry	Forest products, profit, conservation easements
WA DNR: Elbe State Forest	Forest products, clean water, salmon, recreation
Nisqually Land Trust and Community Forest	Salmon, cultural traditions, sustainable forest-sector jobs, recreation, tourism, carbon sequestration
Town of Eatonville	Clean drinking water, flood control, recreation

Can models help identify strategies for balancing tradeoffs among diverse objectives?



Tradeoffs for Alternative Forest Management Scenarios



Linking Models for Salmon Recovery Planning

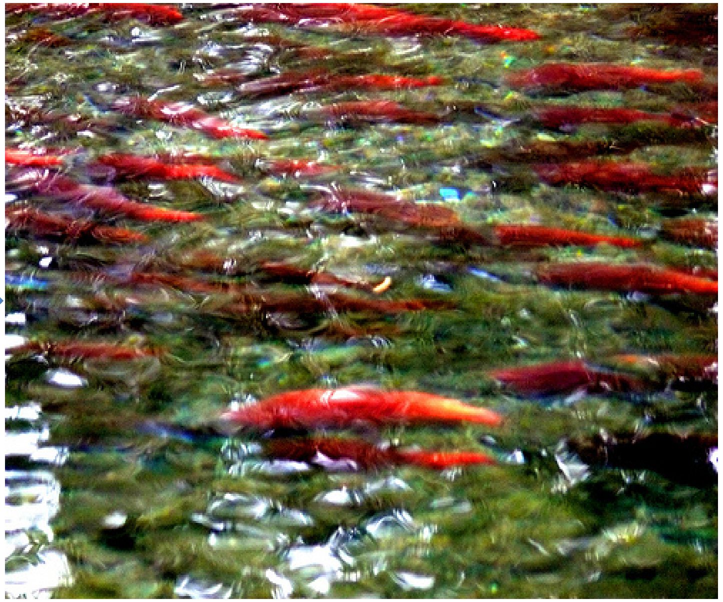
VELMA: Peak & Low Flow*

VELMA: Large Woody Debris

Large

Penumbra: Stream Temperature

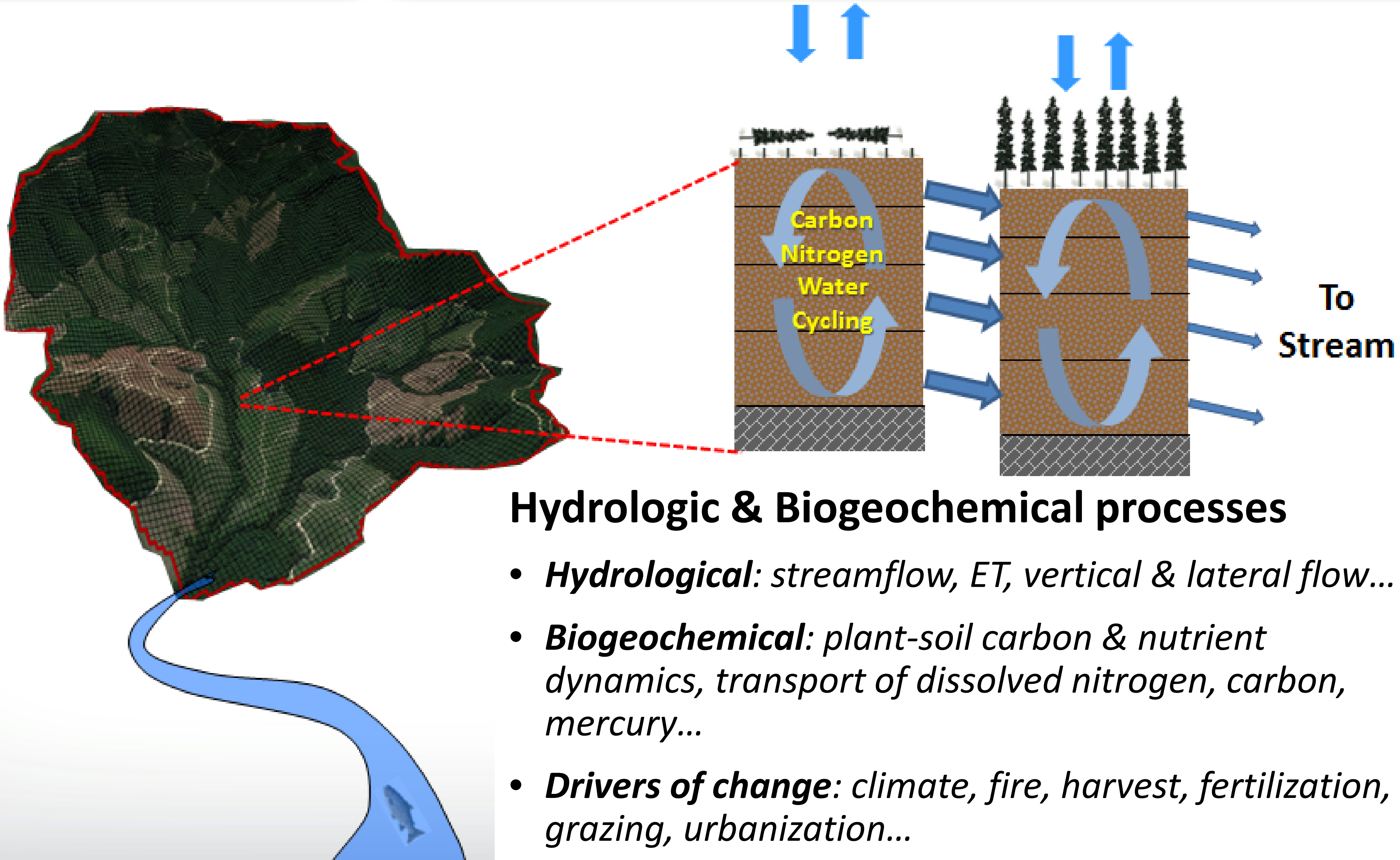
EDT: Fish Habitat



*Sediment model in development

VELMA Ecohydrological Model

Integrated decision support for whole watershed restoration

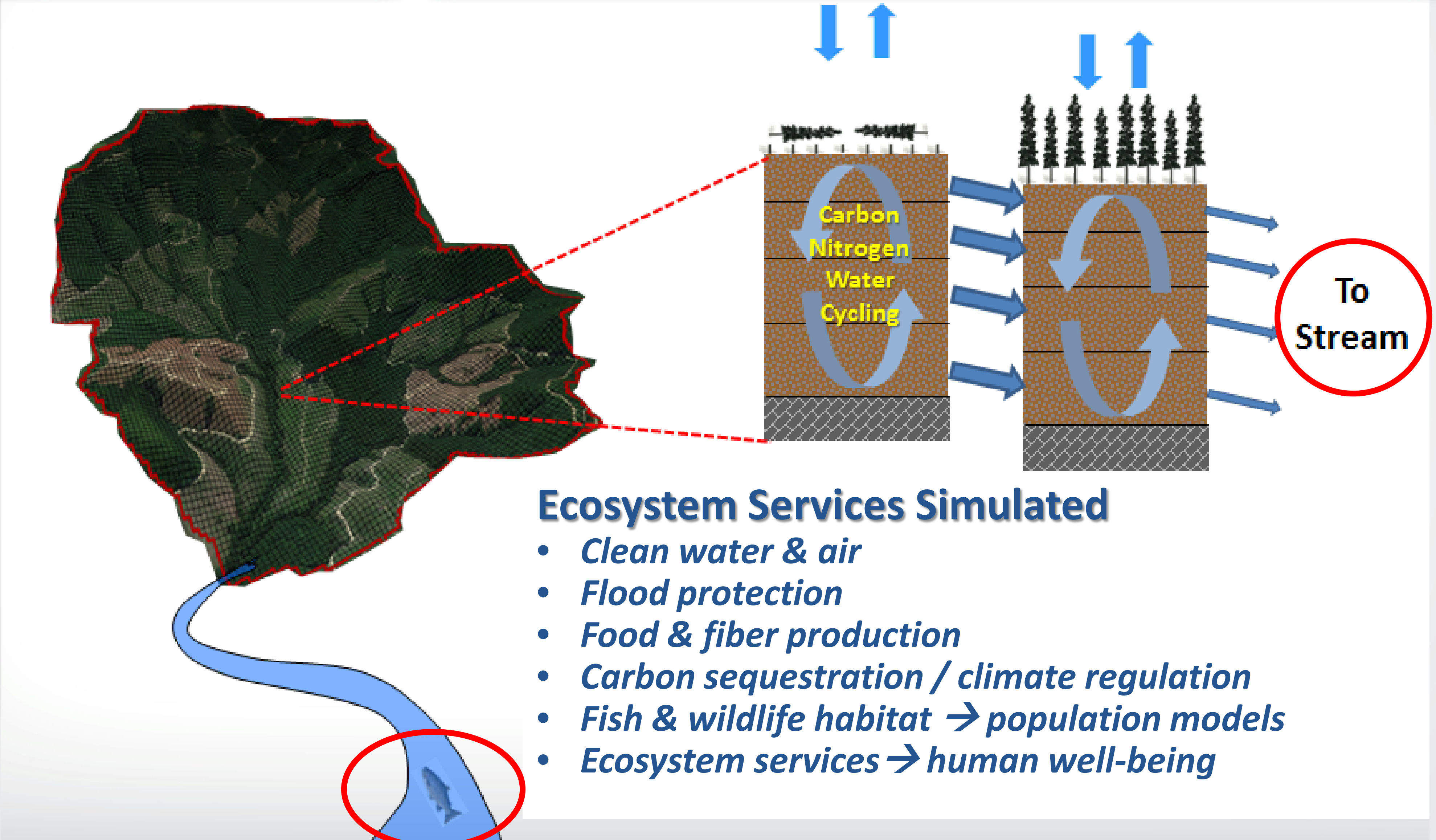


Hydrologic & Biogeochemical processes

- ***Hydrological***: *streamflow, ET, vertical & lateral flow…*
- ***Biogeochemical***: *plant-soil carbon & nutrient dynamics, transport of dissolved nitrogen, carbon, mercury…*
- ***Drivers of change***: *climate, fire, harvest, fertilization, grazing, urbanization…*

VELMA Ecohydrological Model

Integrated decision support for whole watershed restoration



Ecosystem Services Simulated

- *Clean water & air*
- *Flood protection*
- *Food & fiber production*
- *Carbon sequestration / climate regulation*
- *Fish & wildlife habitat → population models*
- *Ecosystem services → human well-being*

VELMA Ecohydrological Model

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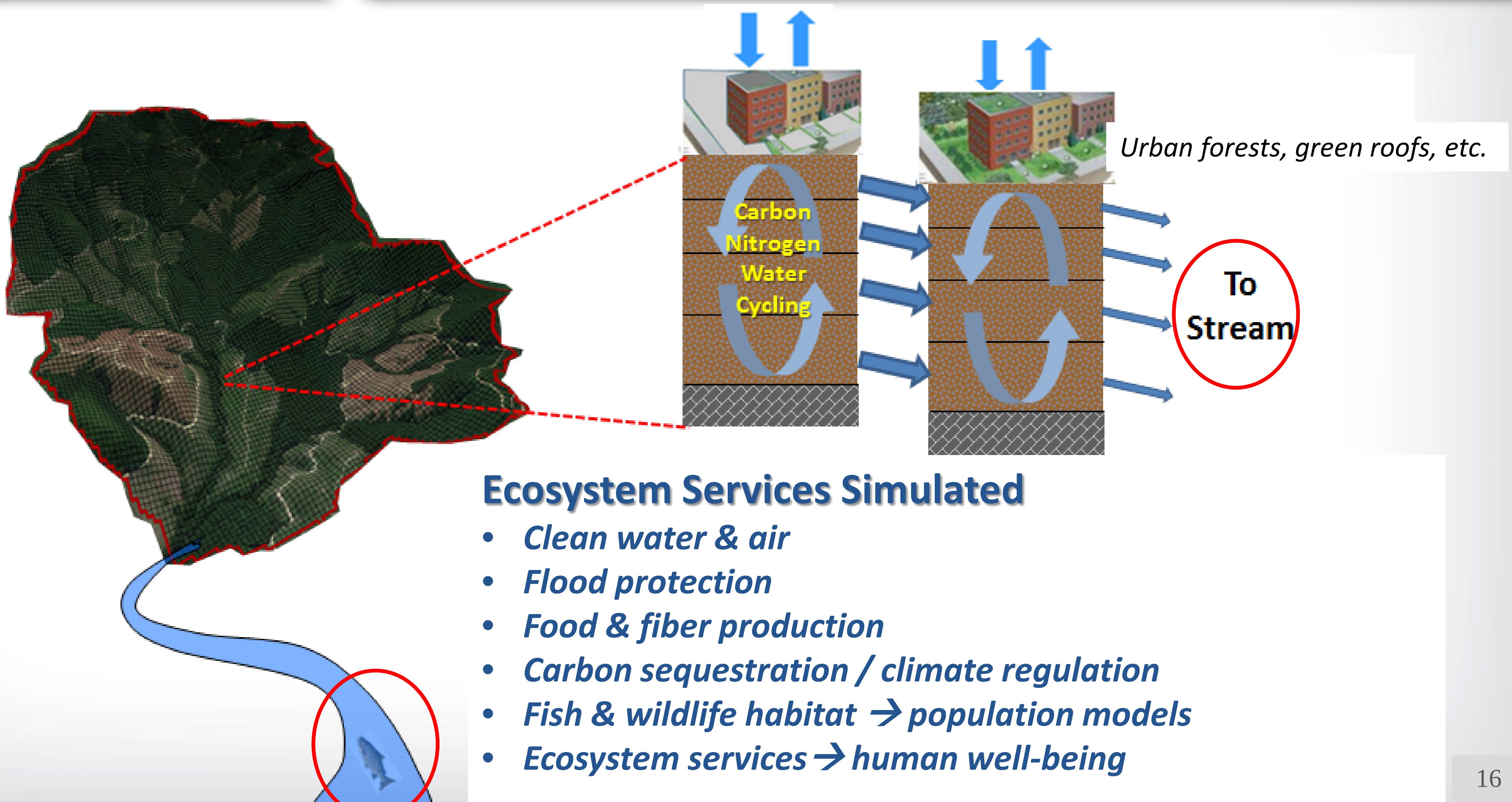

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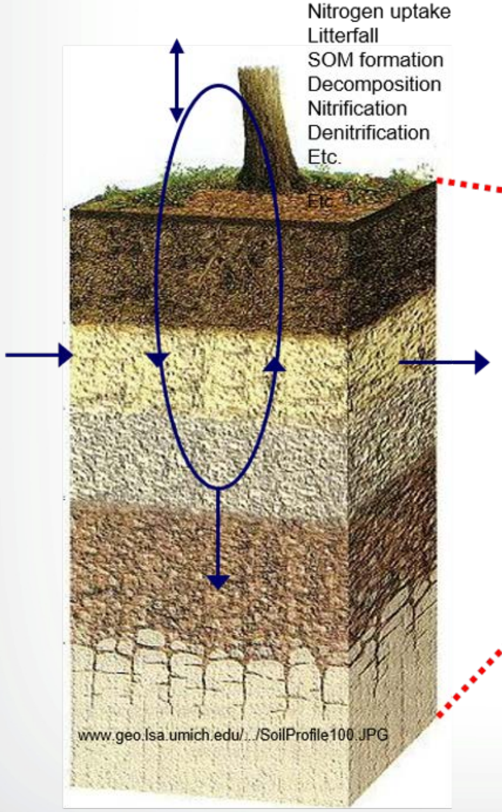
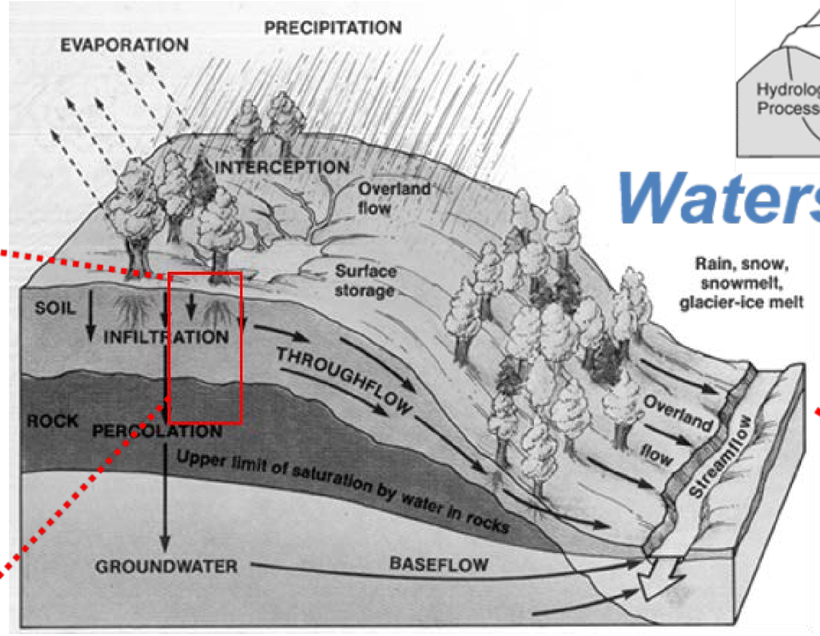
- *Ecosystem services → human well-being*

VELMA simulates how hydrological, soil and vegetation processes interact across spatial and temporal scales….

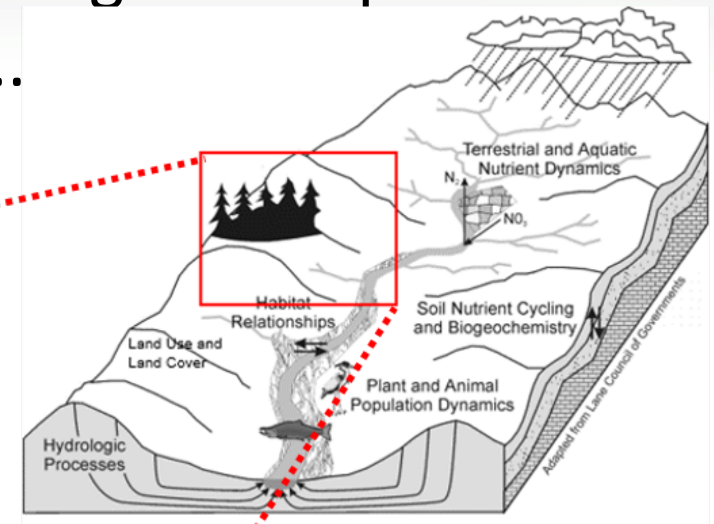
plots to watersheds, days to centuries



Plot-scale processes



Hillslope-scale processes

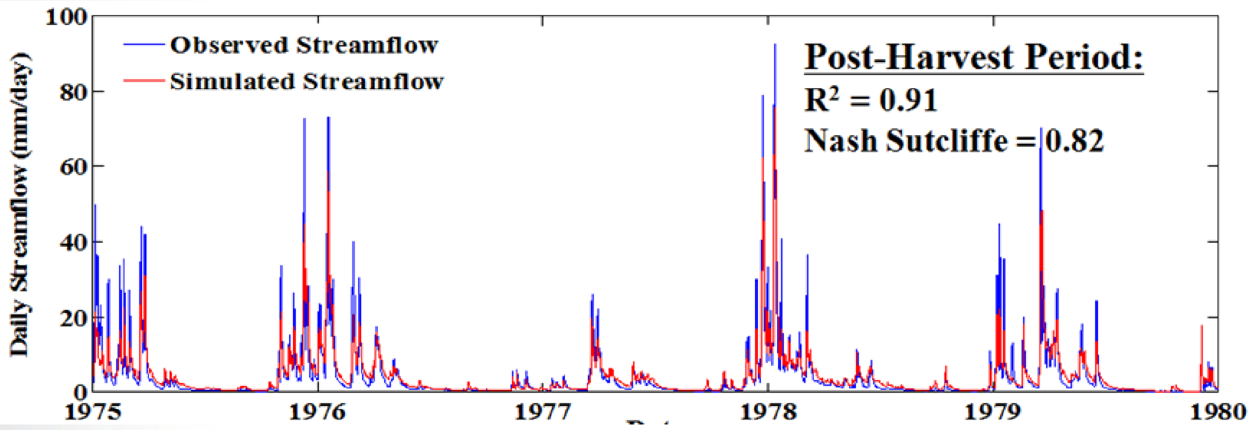


Watershed-scale processes

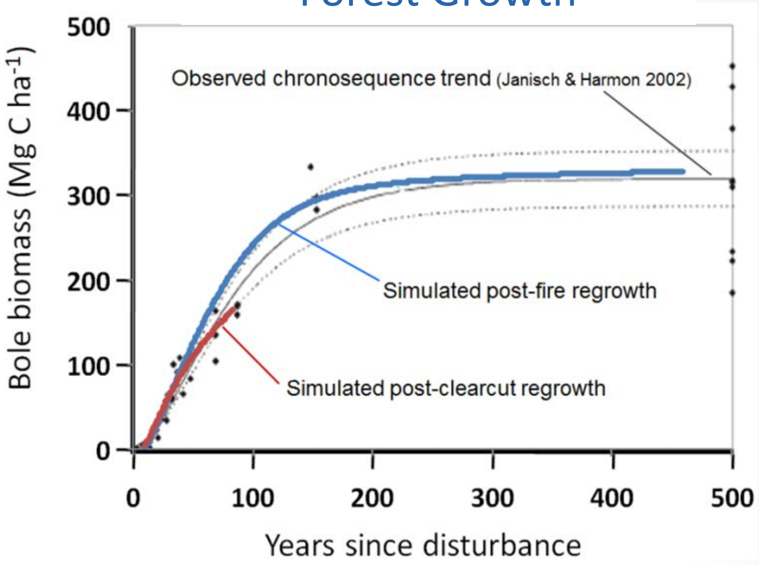
VELMA Validation Examples

HJ Andrews Experimental Forest, Watershed 10 (Abdelnour et al. 2011 and 2013, in *Water Resources Research)*

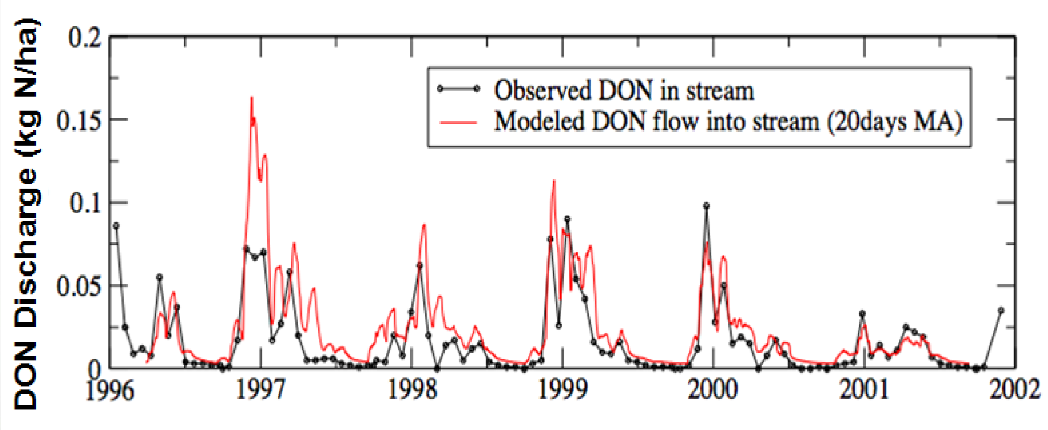
Streamflow



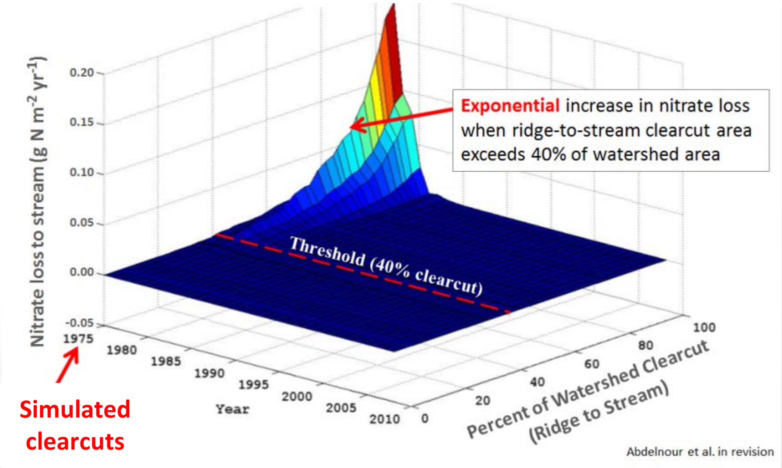
Forest Growth



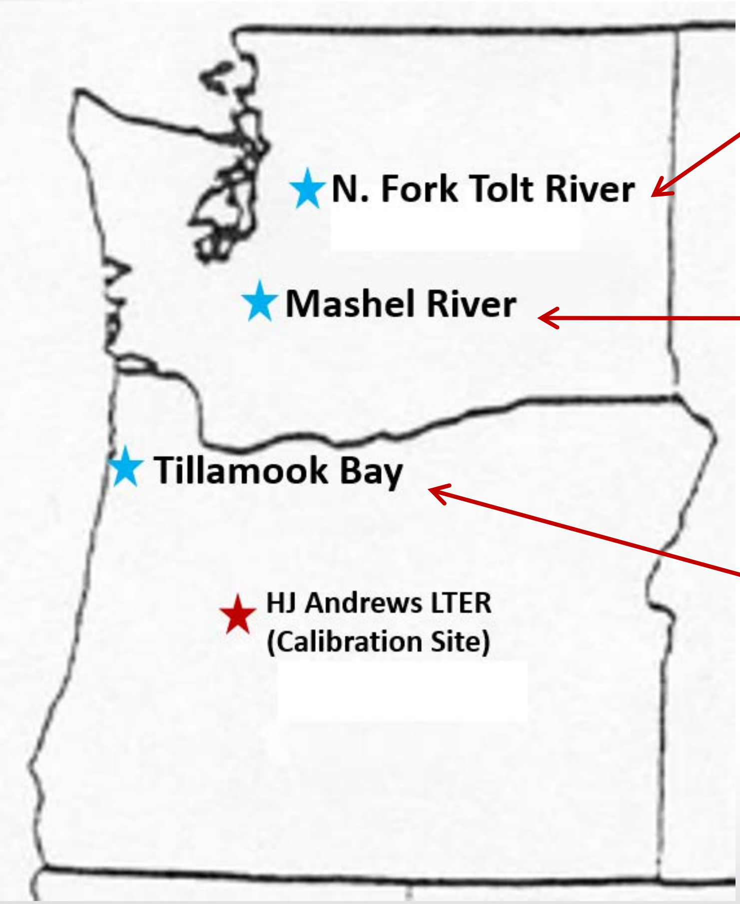
Stream Chemistry

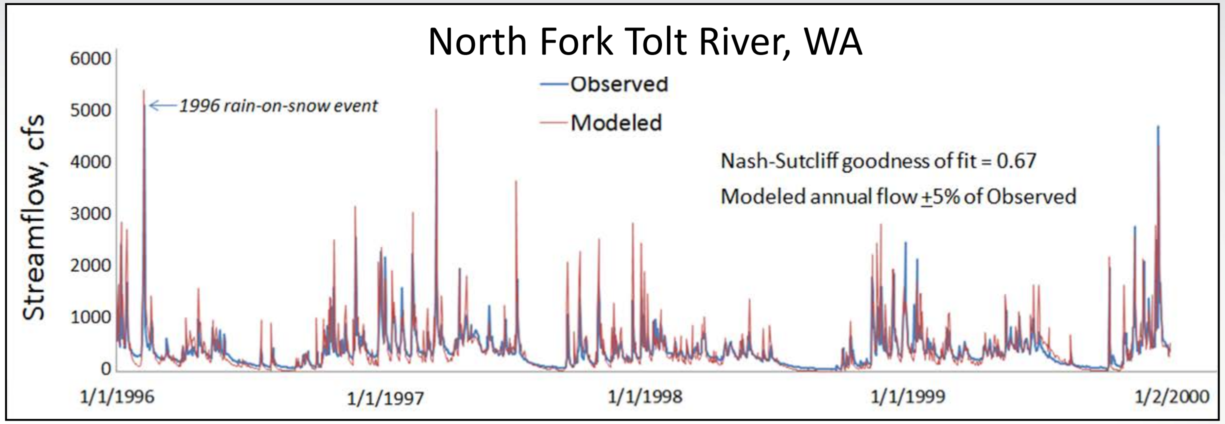


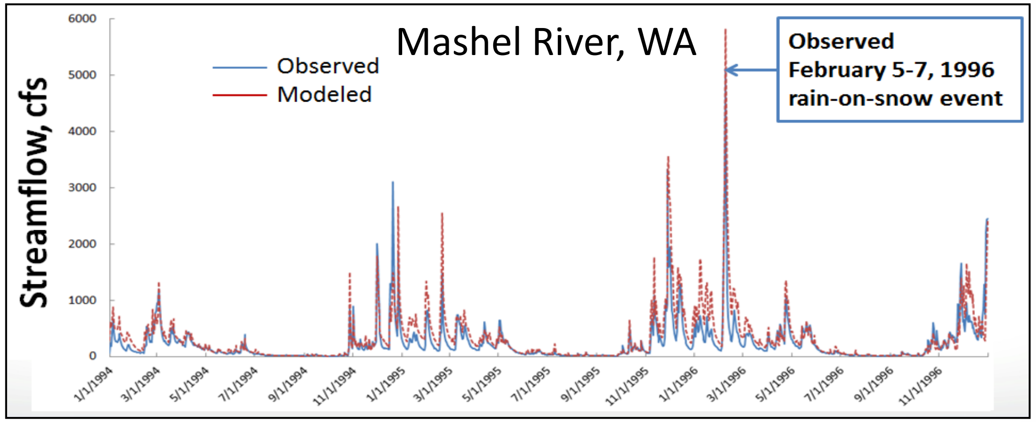
Stream Chemistry Response to Harvest and Riparian Buffers

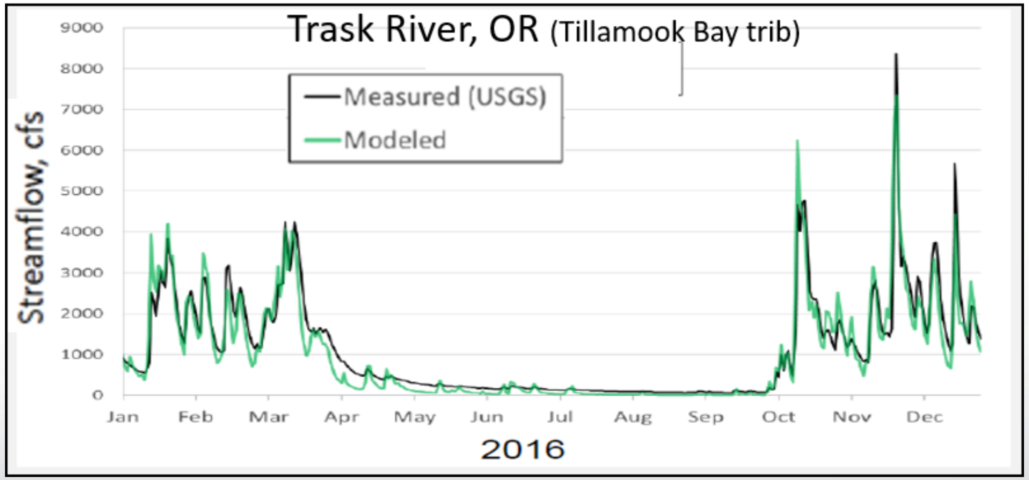


VELMA accurately captures peak and low flows when calibration site parameters (★) are transferred to other PNW locations (★) without calibration

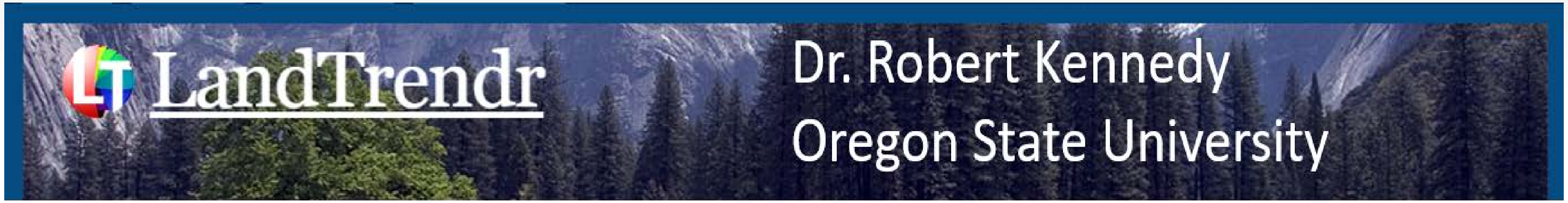






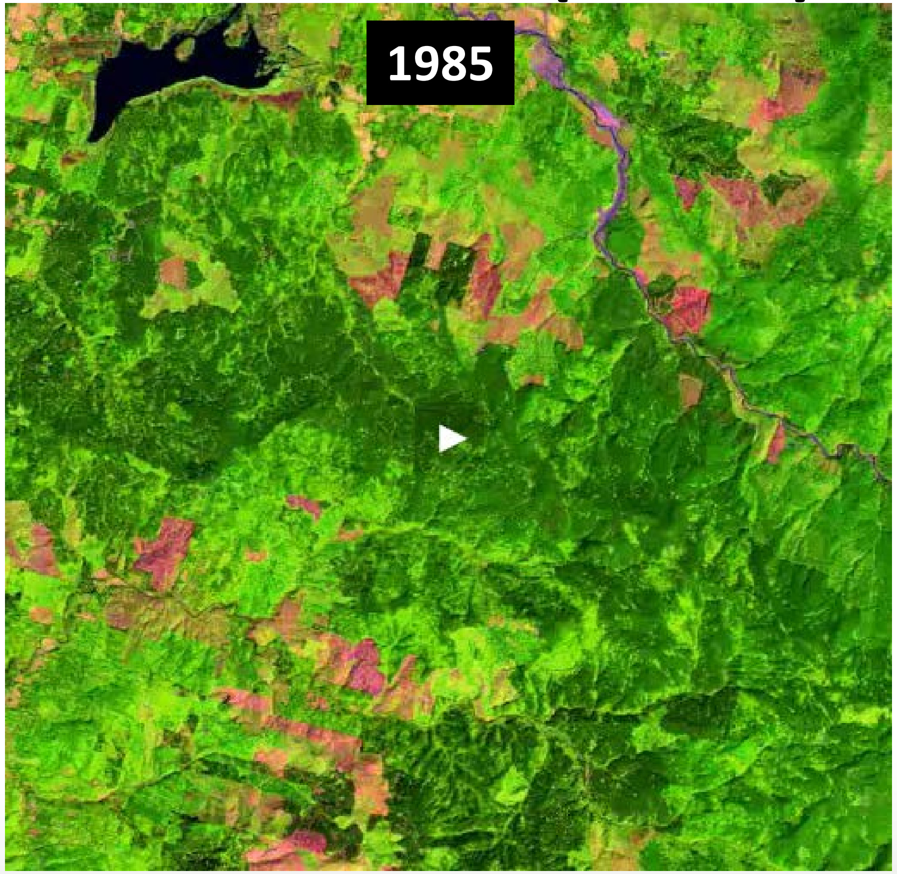


Remote Sensing of Land Use Change



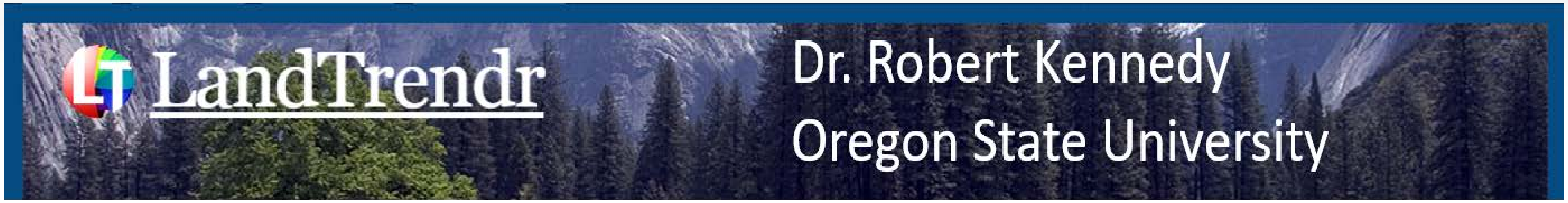
1985 – 2010 (movie)

- Old Forests
- Young Forests
- New Clearcuts



~400 mi^2 landscape NE of Kelso, WA

Remote Sensing of Land Use Change



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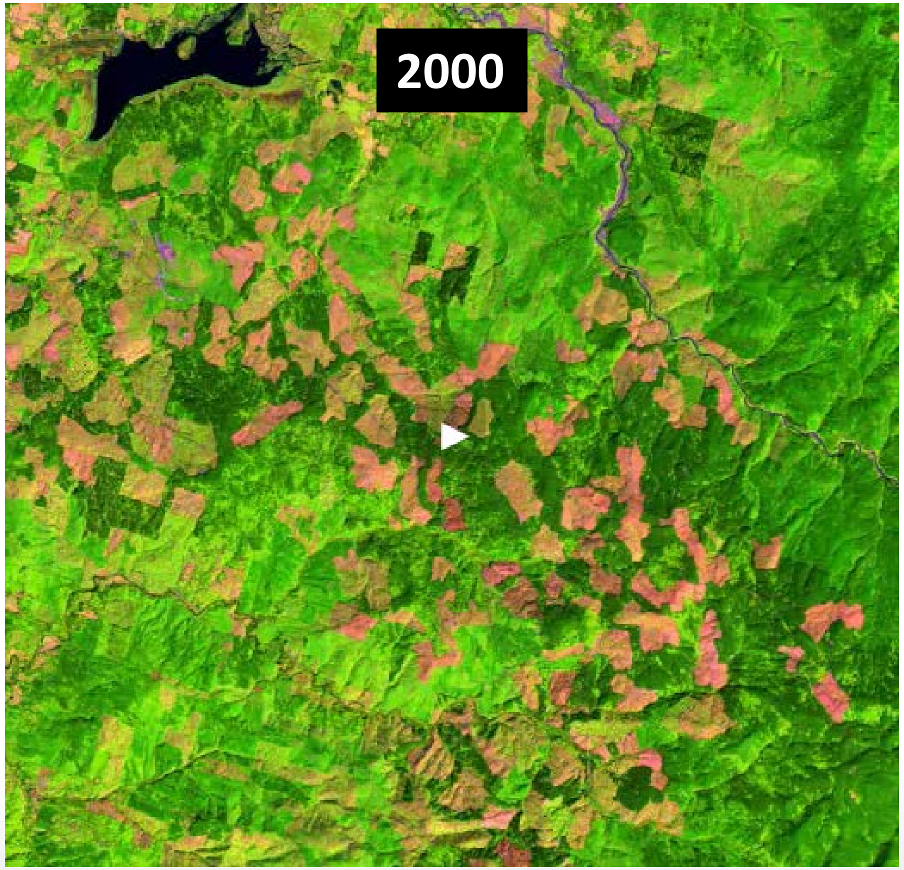

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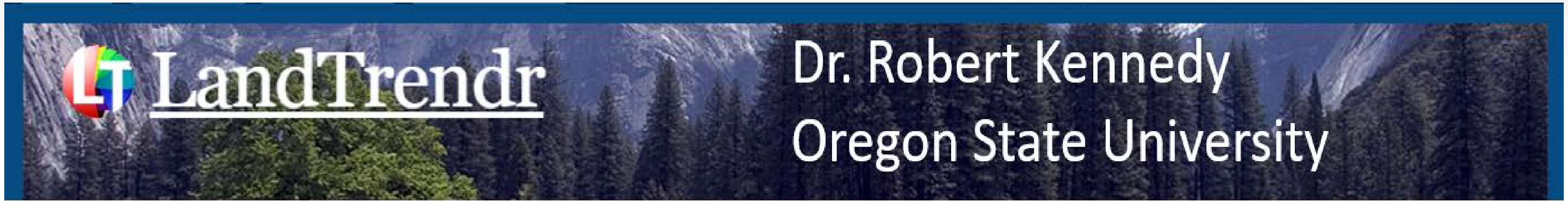

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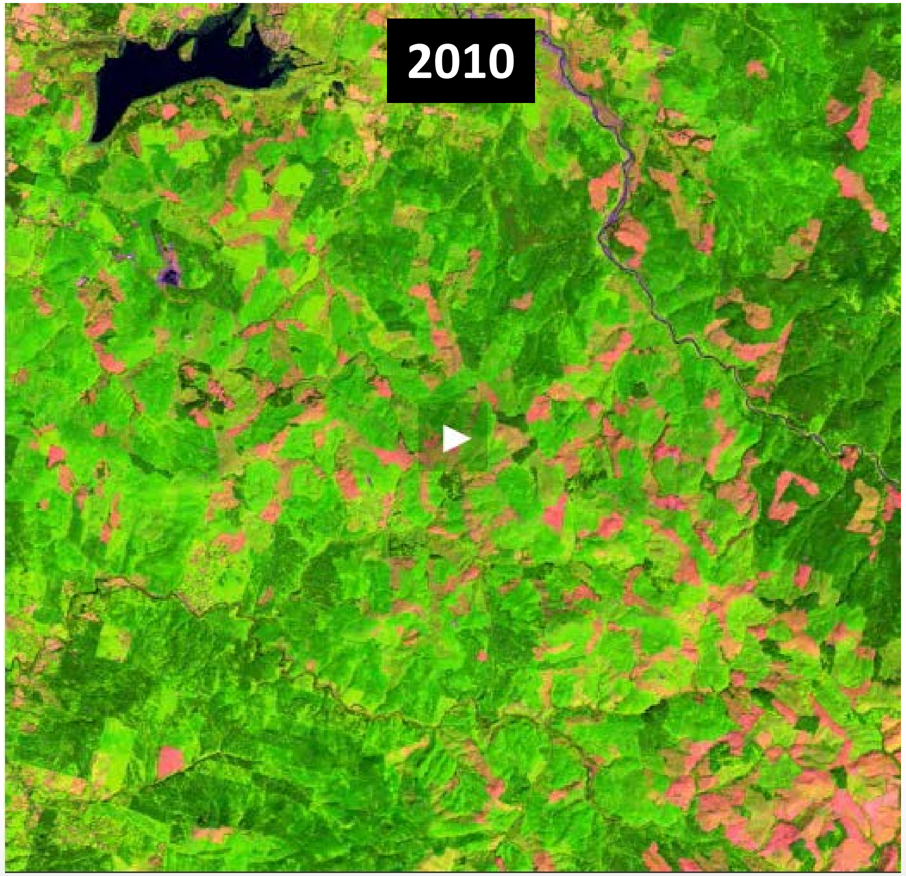


~400 mi^2 landscape NE of Kelso, WA

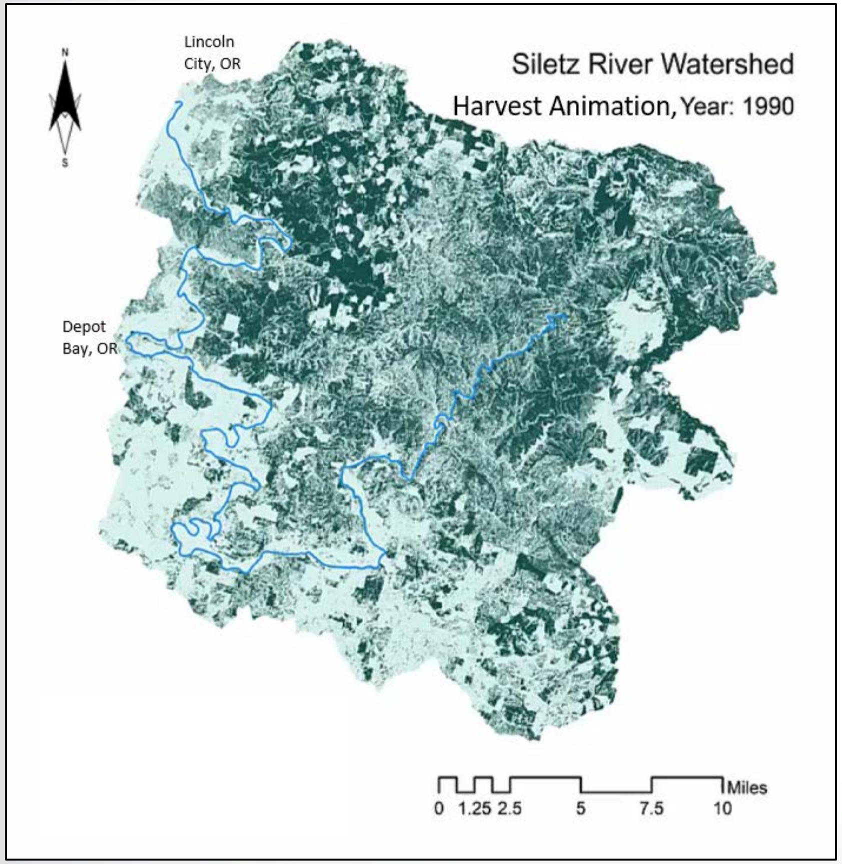
NW forest landscapes are much younger than 30 years ago

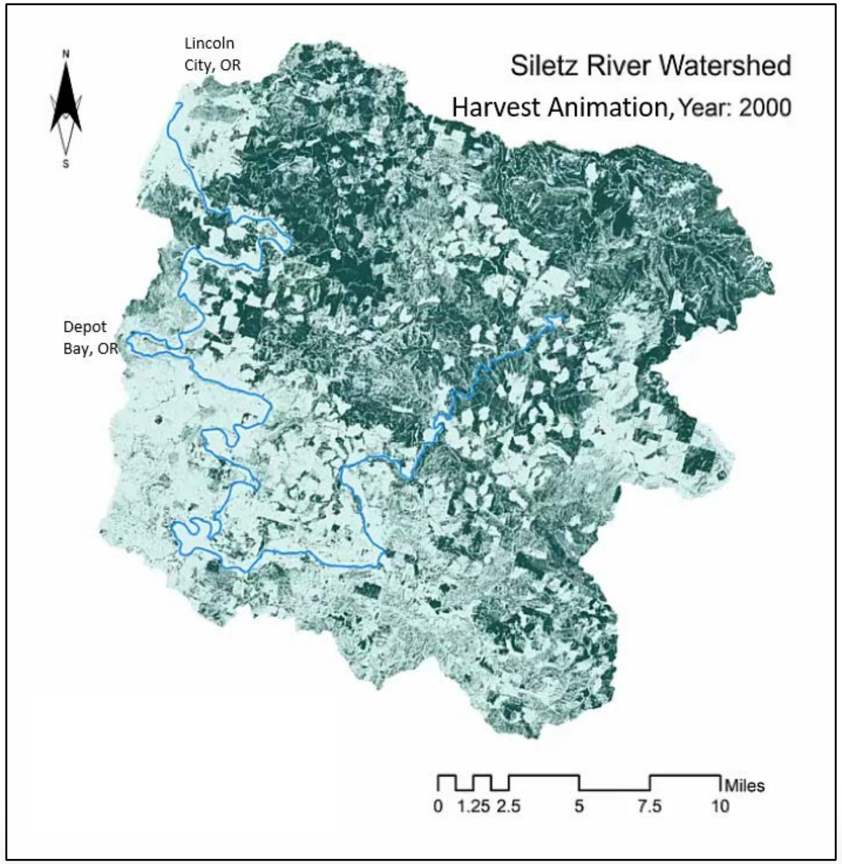
Forest Age
>80 years
<20 years

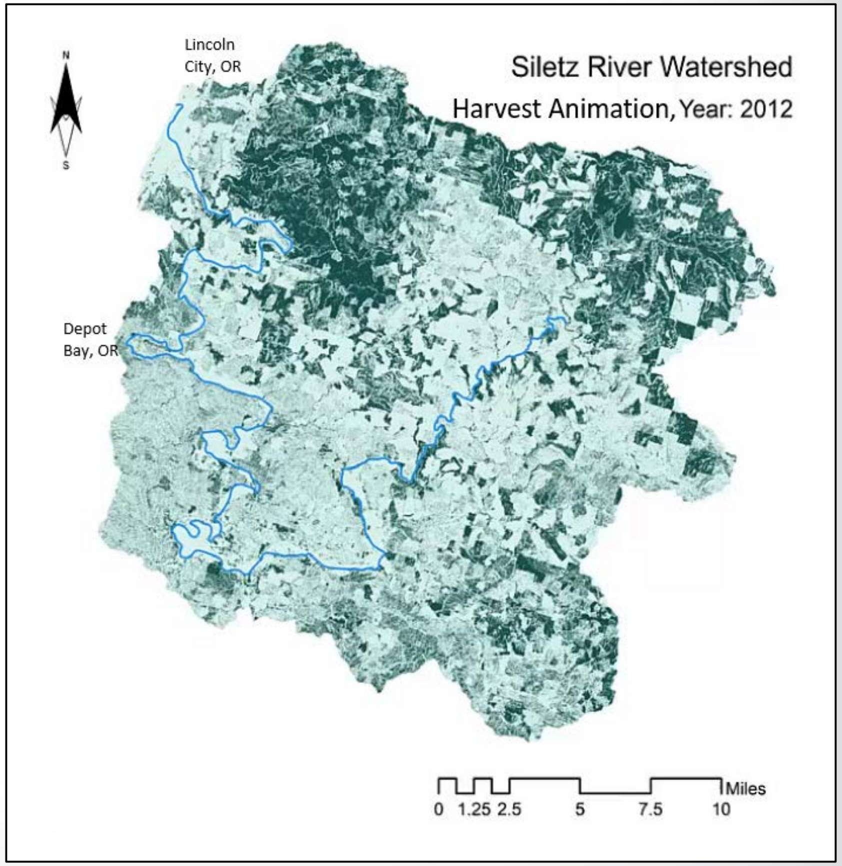
Siletz River Watershed, OR (373 sq. mi.)

Harvest Time Series

1990 → 2000 → 2012



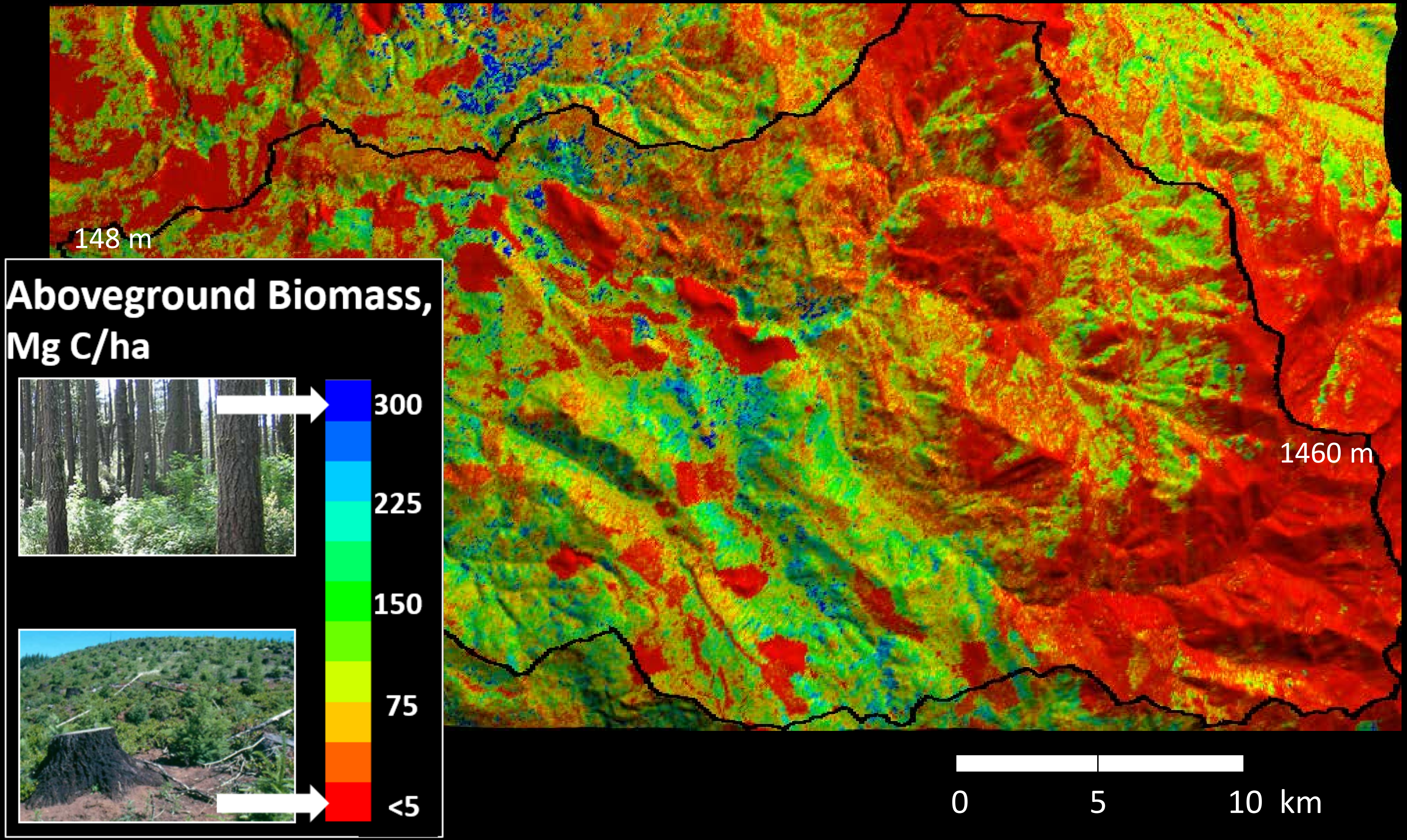




Slide courtesy of Jonathan Halama

Mashel Forest Biomass in 1990

LandTrendr Data



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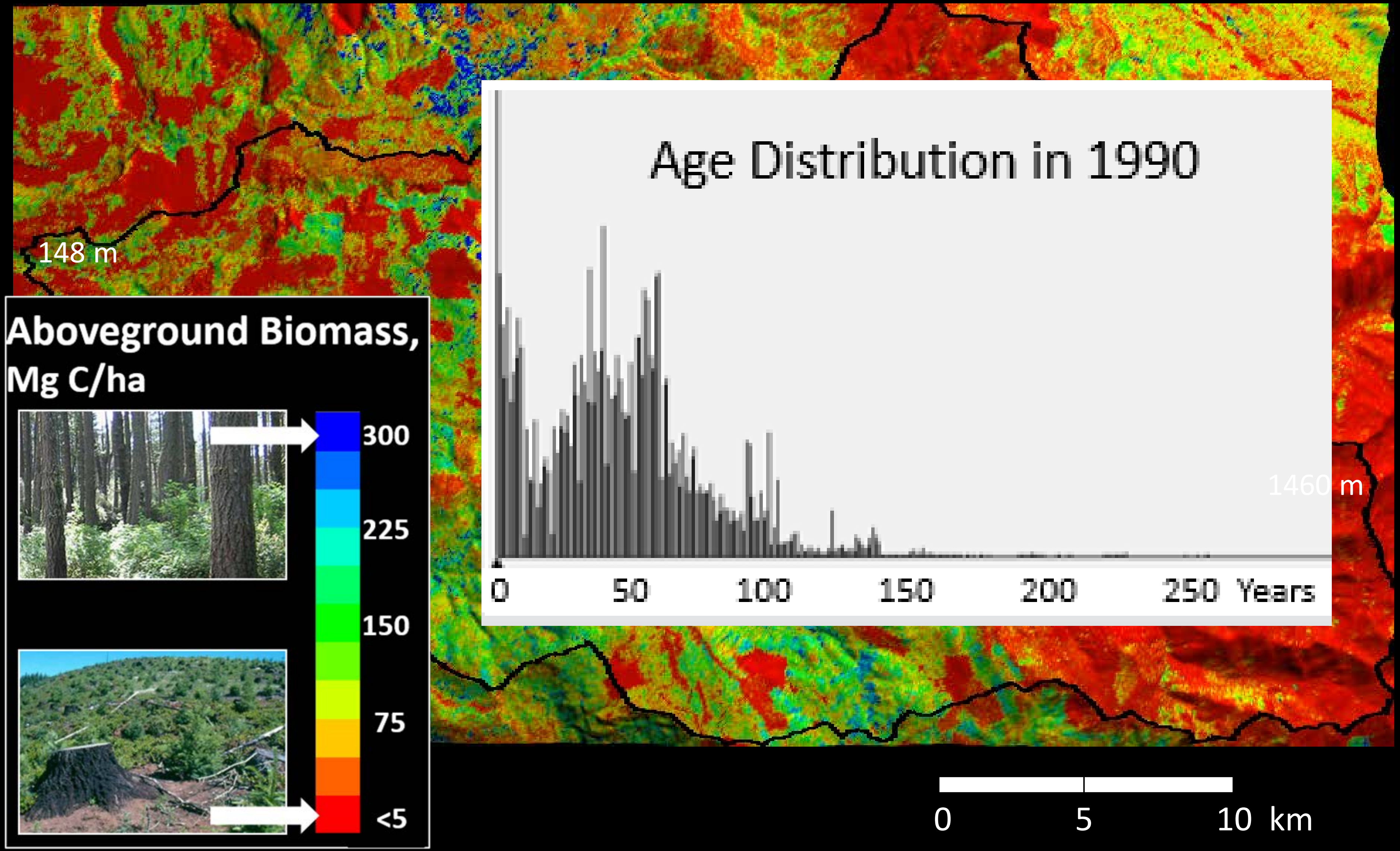


VELMA

Peak and Low Flows

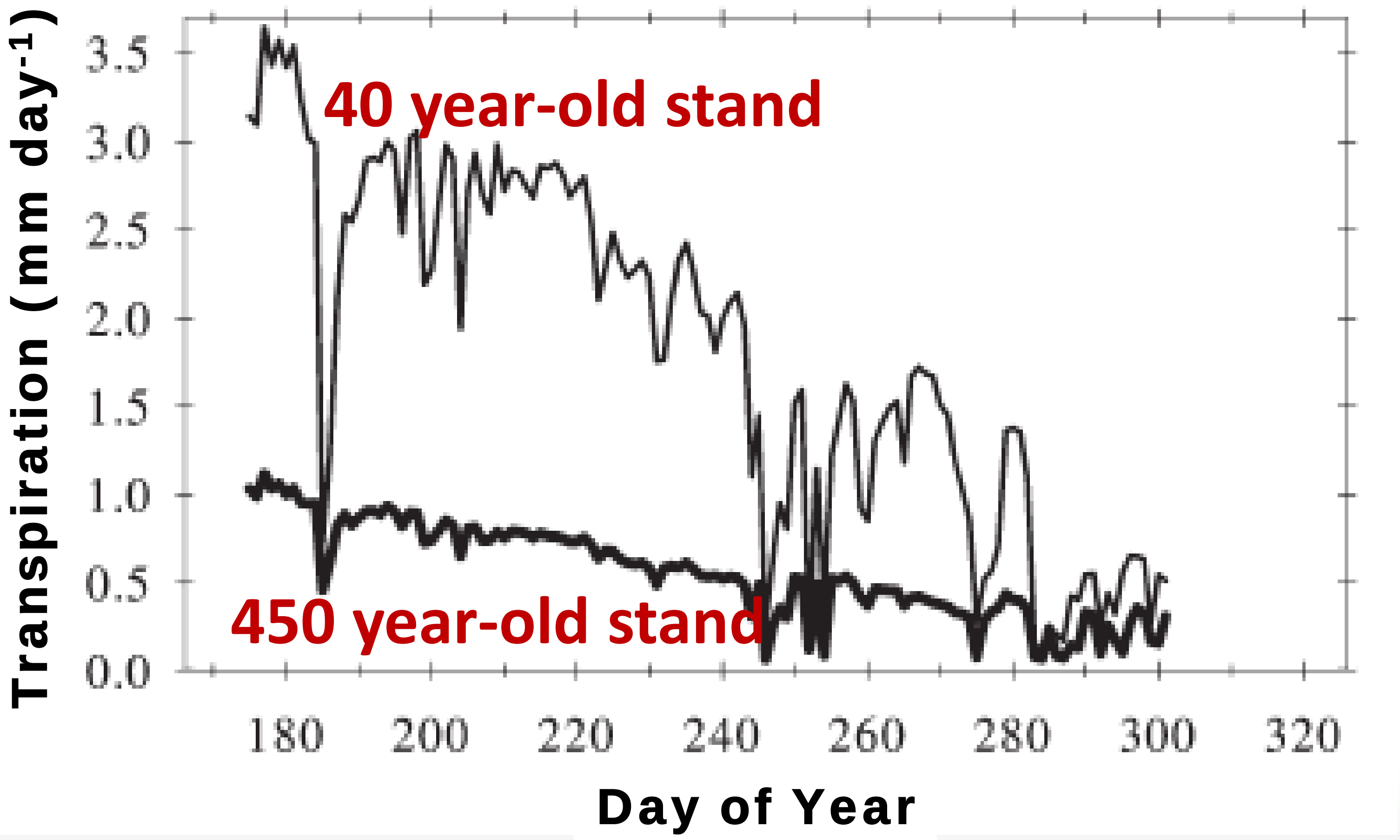
2006 Nov 6

2015 Aug 20

Young vigorously growing forests can transpire over three times more water than old forests

Figure 3 from Moore et al. 2004, Tree Physiology 24, 481-491

(Research conducted at HJ Andrews Experimental Forest, OR)



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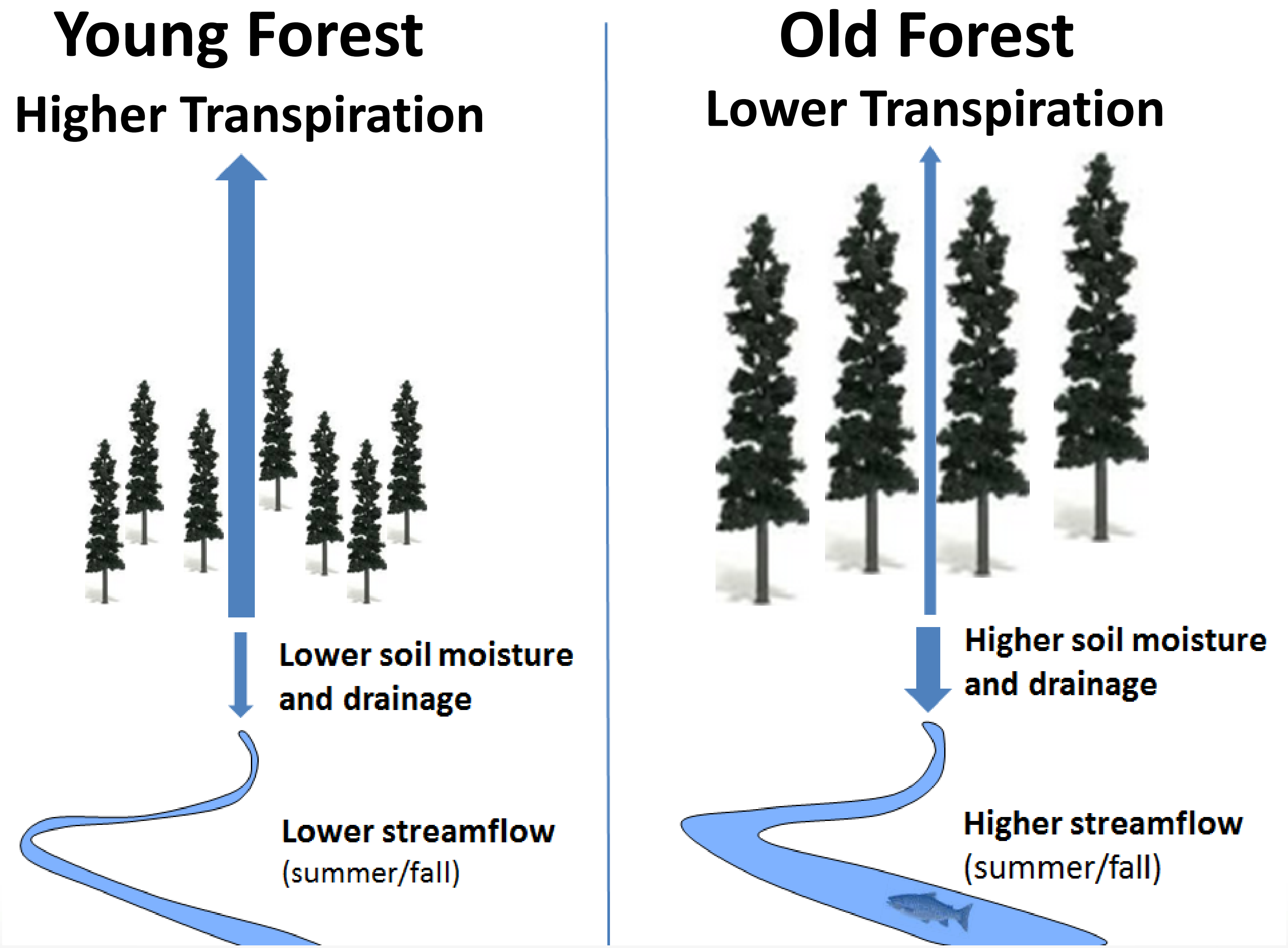
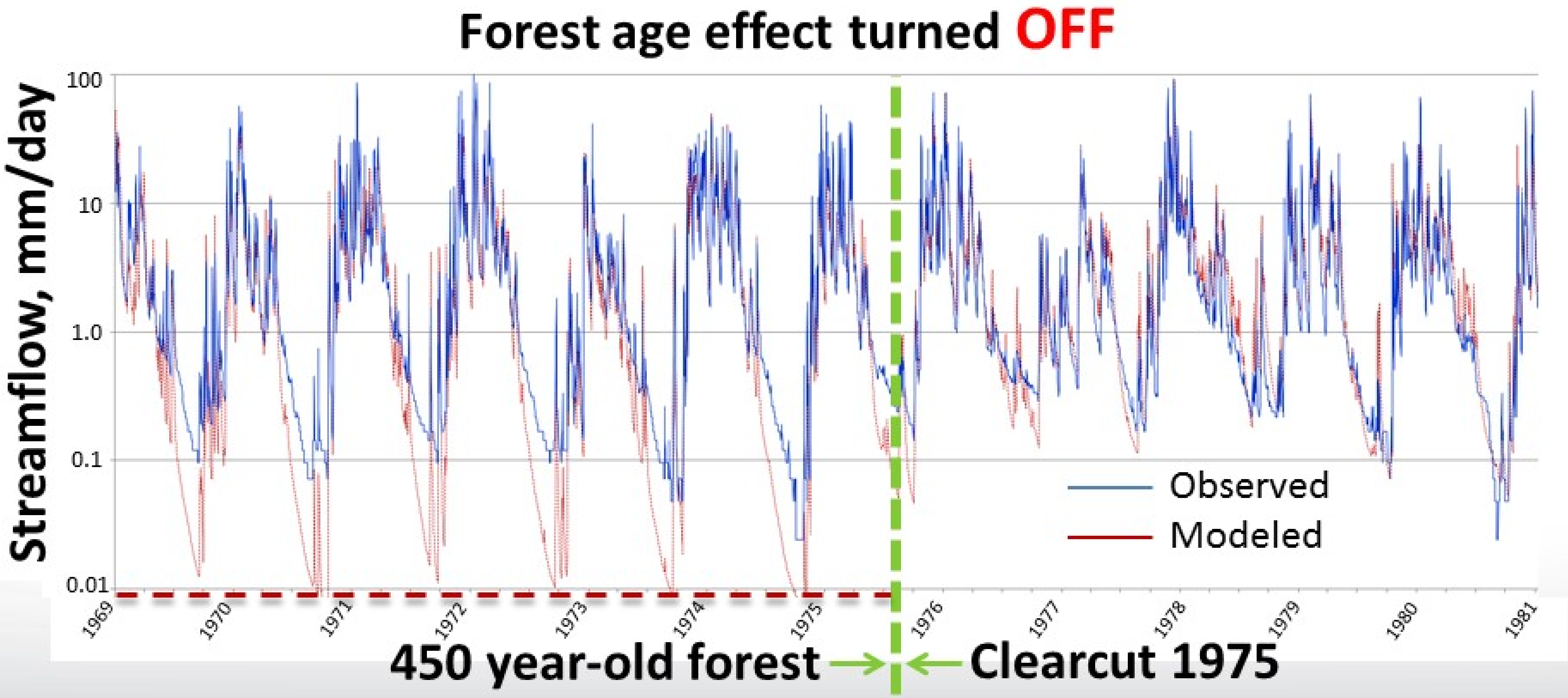


Watershed 10, HJ Andrews, OR

- 0.1 km^2 headwater catchment
- 450 year-old conifer forest
- Clearcut in 1975
- Stream discharge data 1969-present



Watershed 10, HJ Andrews, OR

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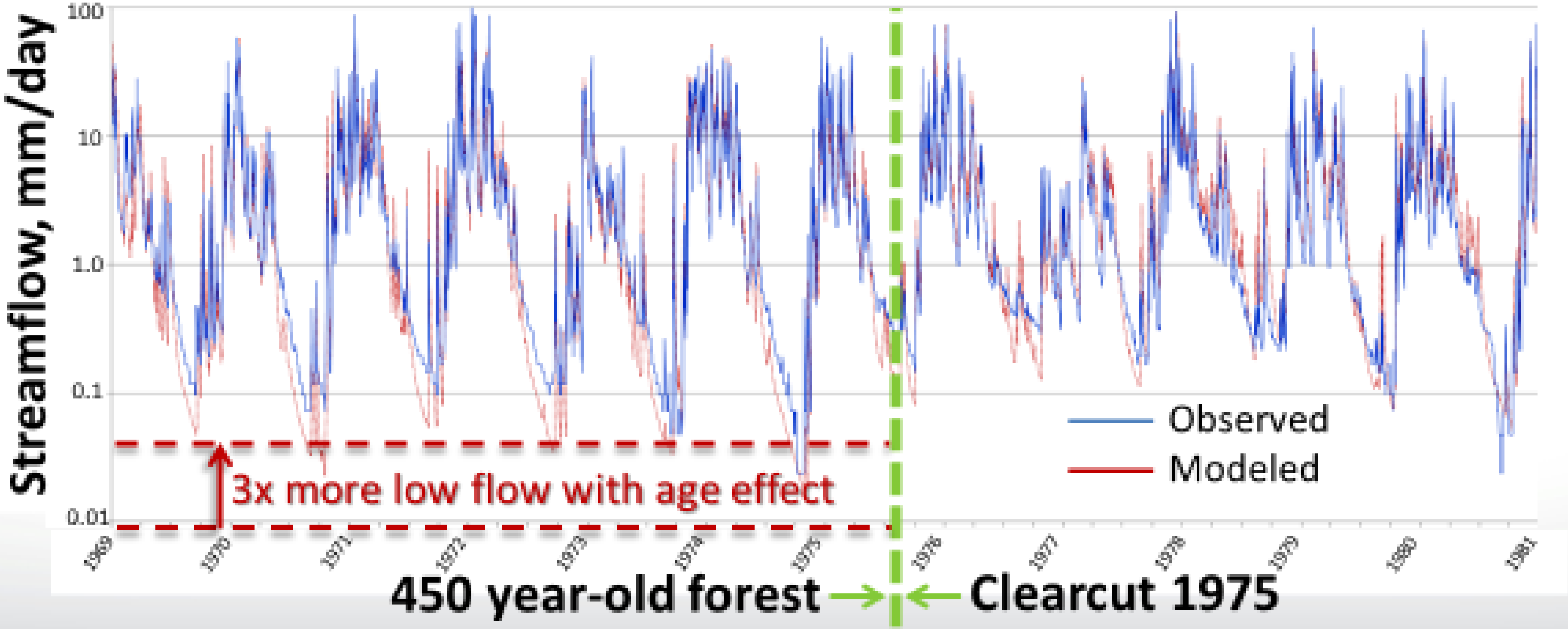
Forest age effect turned ON



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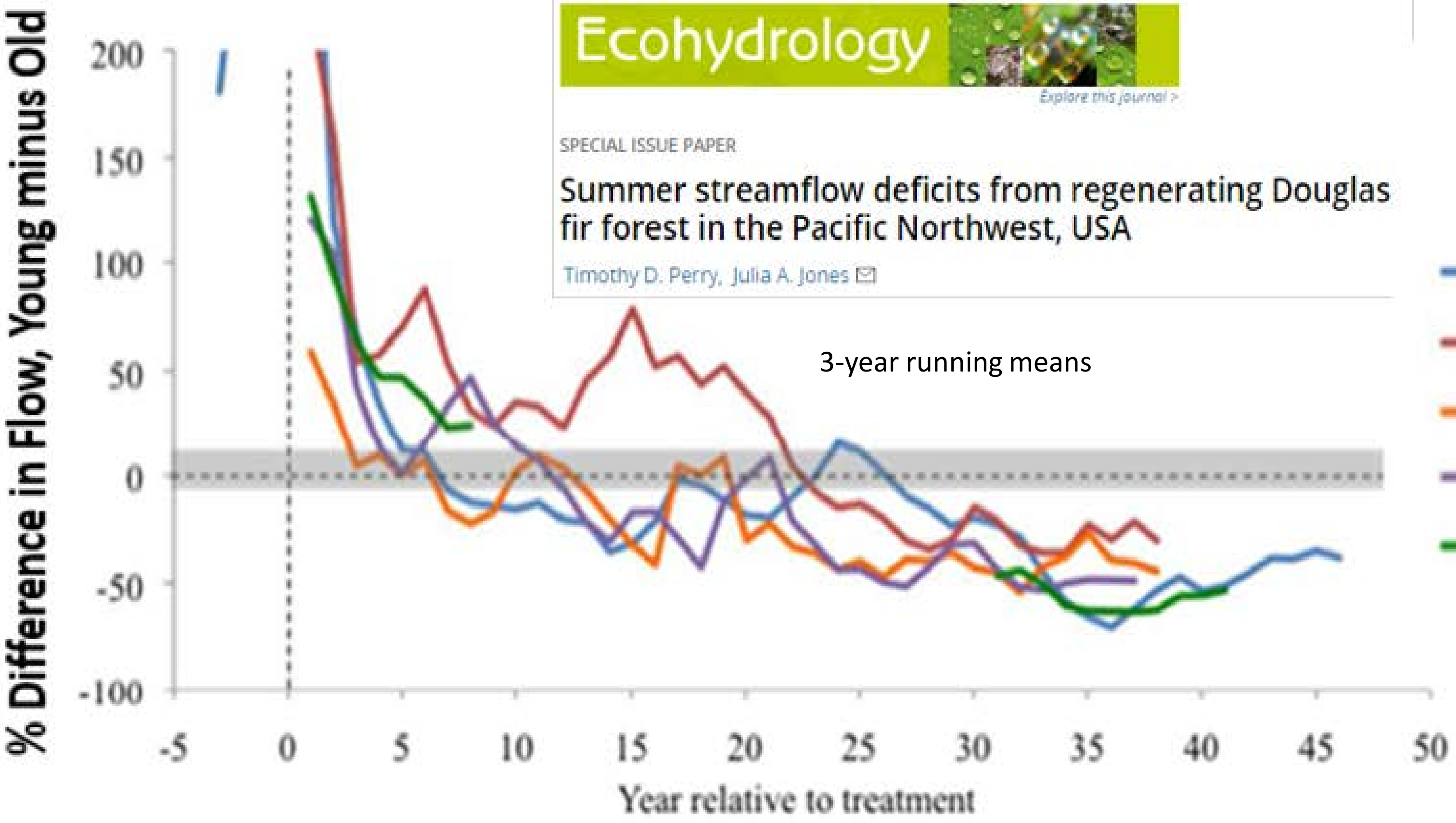

Paired HJA Watersheds:

Young	Old
1	2
6	8
7	8
10	2
3*	4*

*Coyote Creek, OR

Watershed 10, HJ Andrews, OR

- 0.1 km^2 headwater catchment
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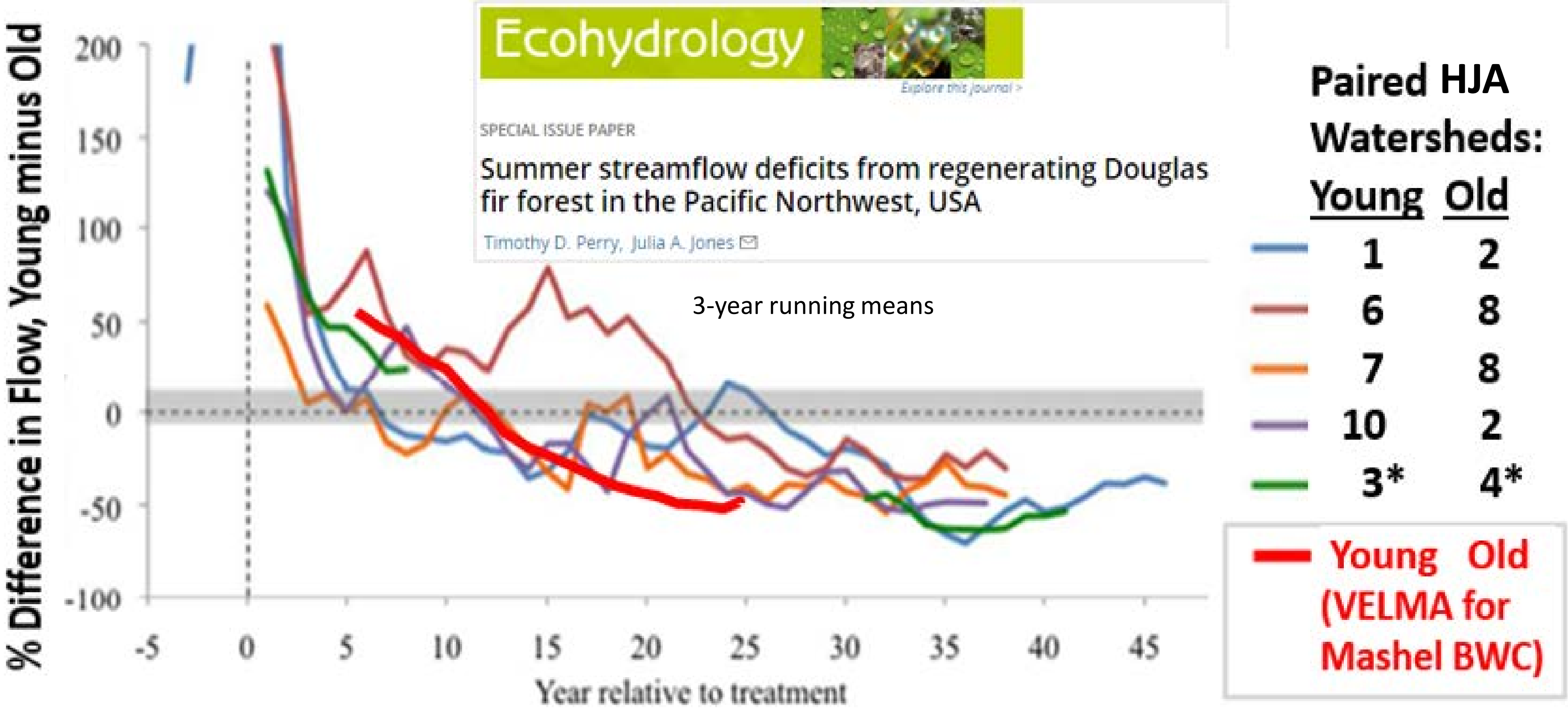


Watershed 10, HJ Andrews, OR

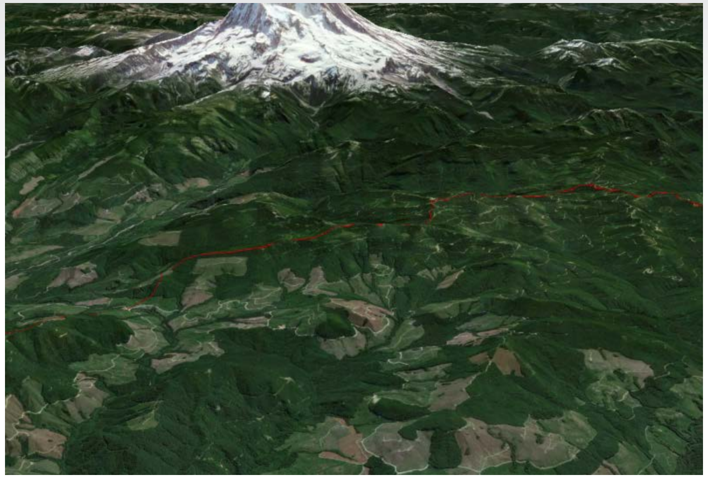
- **0.1 km² headwater catchment**
- **450 year-old conifer forest**
- **Clearcut in 1975**
- **Stream discharge data 1969-present**

Effect of forest age on summer low flow scales up very well from

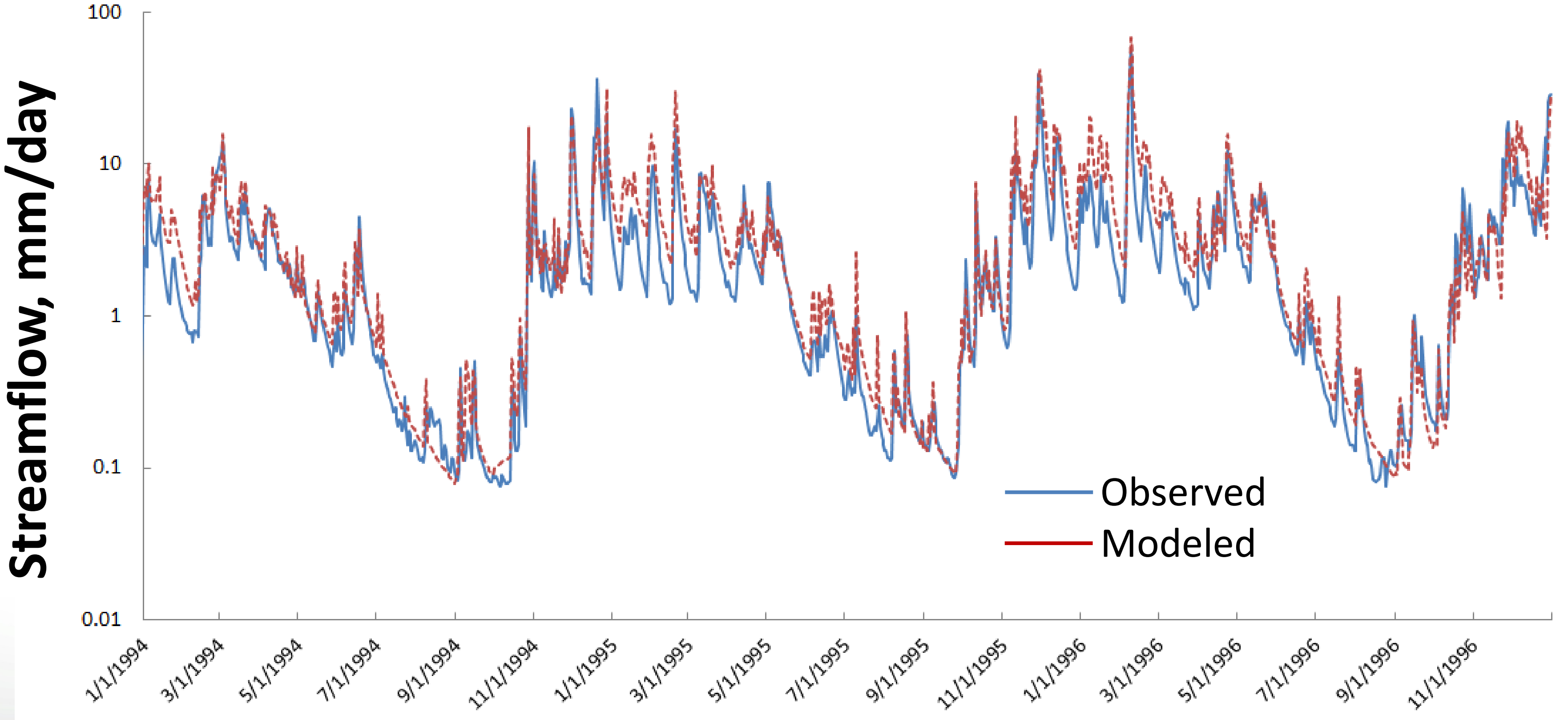
$$\underbrace{\text{tree} \rightarrow \text{stand}}_{\textit{Moore et al 2004}} \rightarrow \underbrace{\text{small catchment}}_{\textit{This study}}$$

(and Perry & Jones 2016)

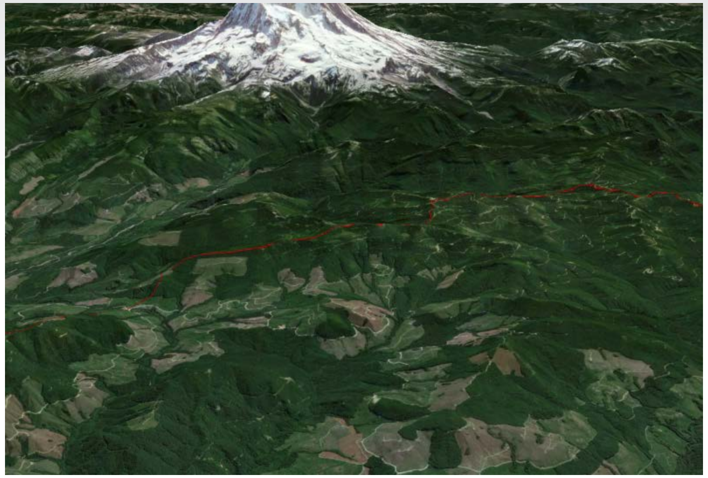
Mashel River Watershed, WA



- 209 km^2
- Mixture of forest stand ages, most less than 60 years-old
- Stream discharge data, 1992-present



Mashel River Watershed, WA



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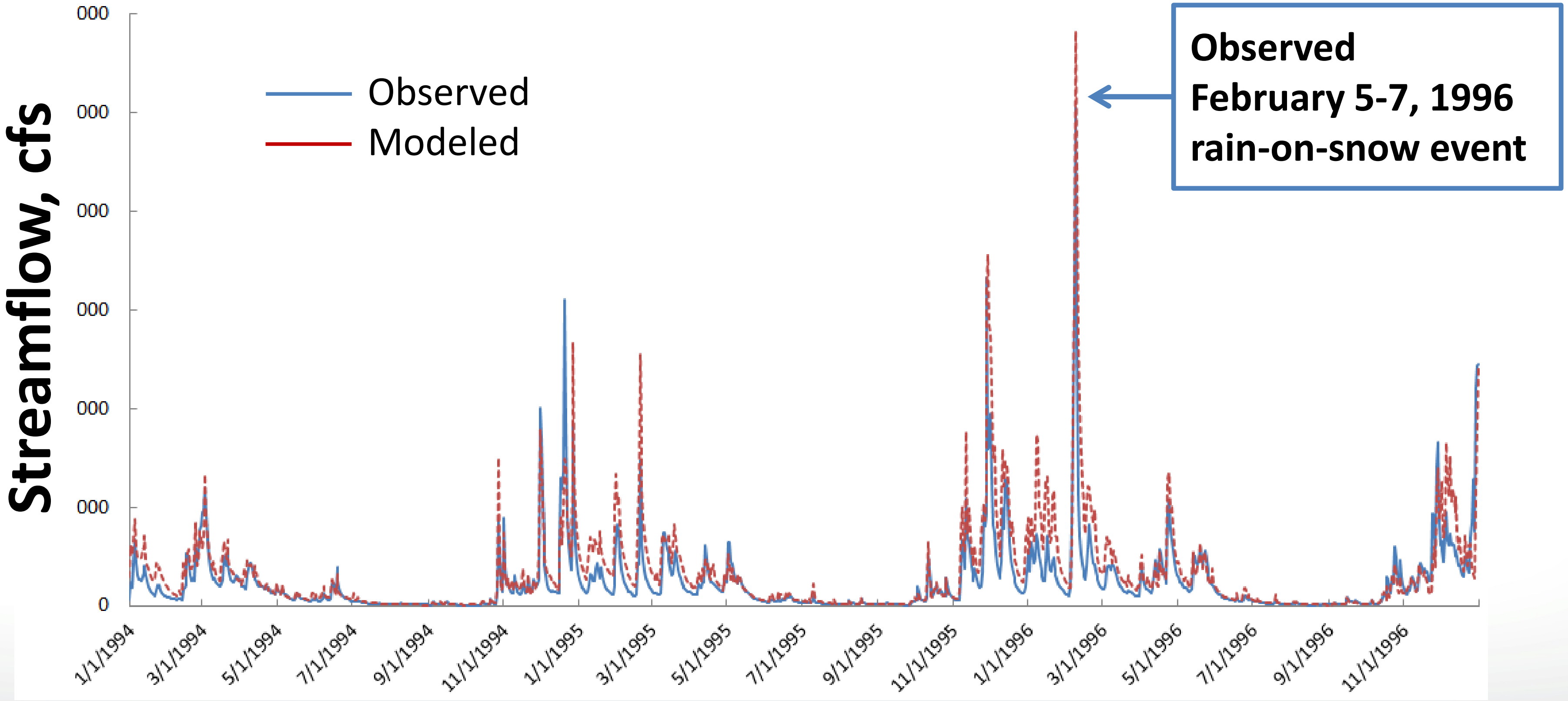
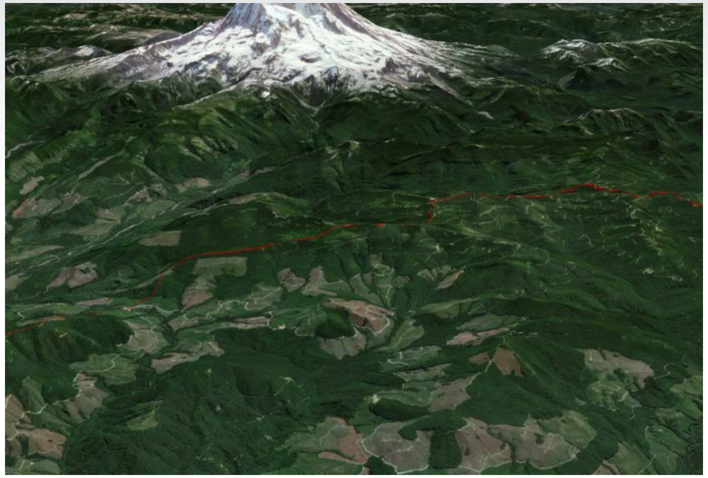




Mashel River Watershed, WA

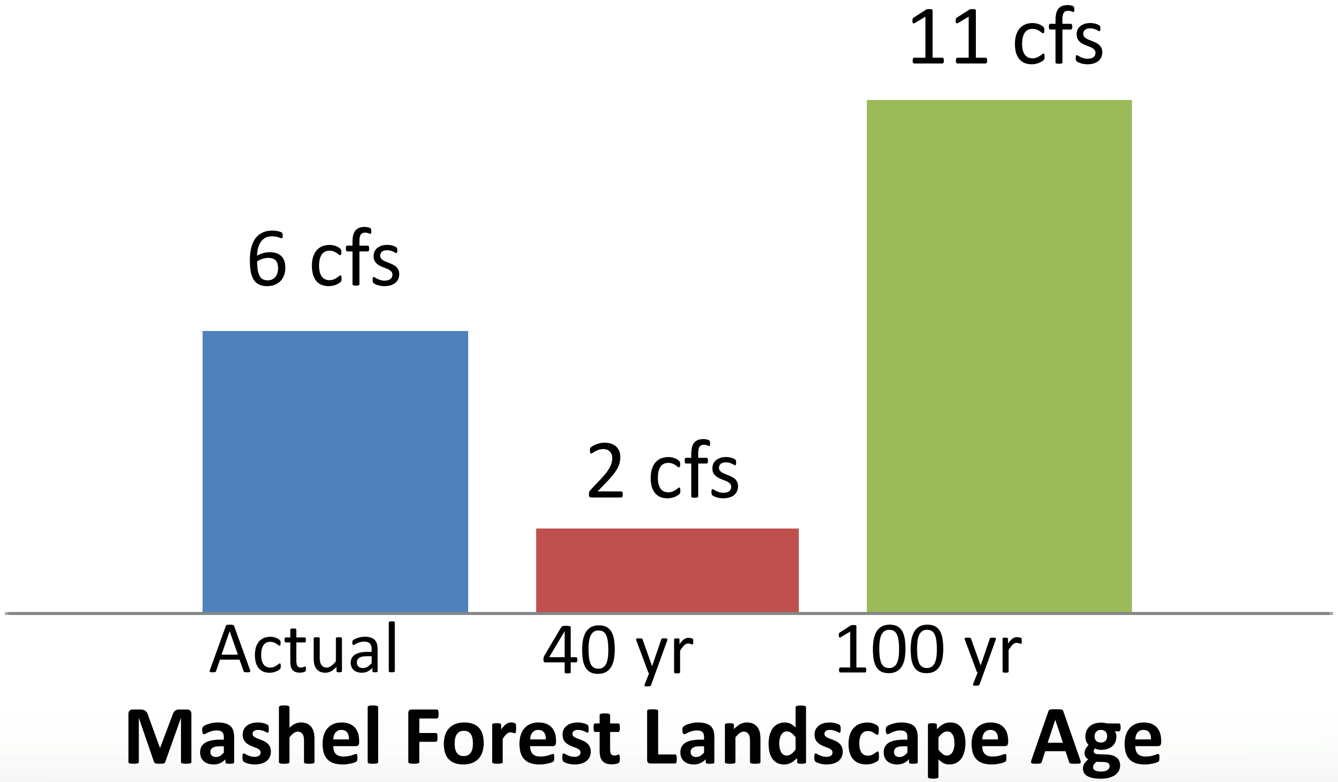
- 209 km^2
- Mixture of forest stand ages, most less than 60 years-old
- Stream discharge data, 1992-present

Effect of forest age on summer low flow scales up well from a headwater catchment in Oregon to the 2,000x larger, mixed-age Mashel watershed ***(no parameters were changed, only drivers)***

Can longer forest harvest intervals increase summer streamflow for salmon recovery?

Simulated September Minimum Daily Flow

Average for 2006-2014



Can longer forest harvest intervals increase summer streamflow for salmon recovery?

Yes, VELMA results indicate that establishment of older (>80 yr?) forest landscapes could substantially increase summer low flows compared to the present-day Mashel watershed

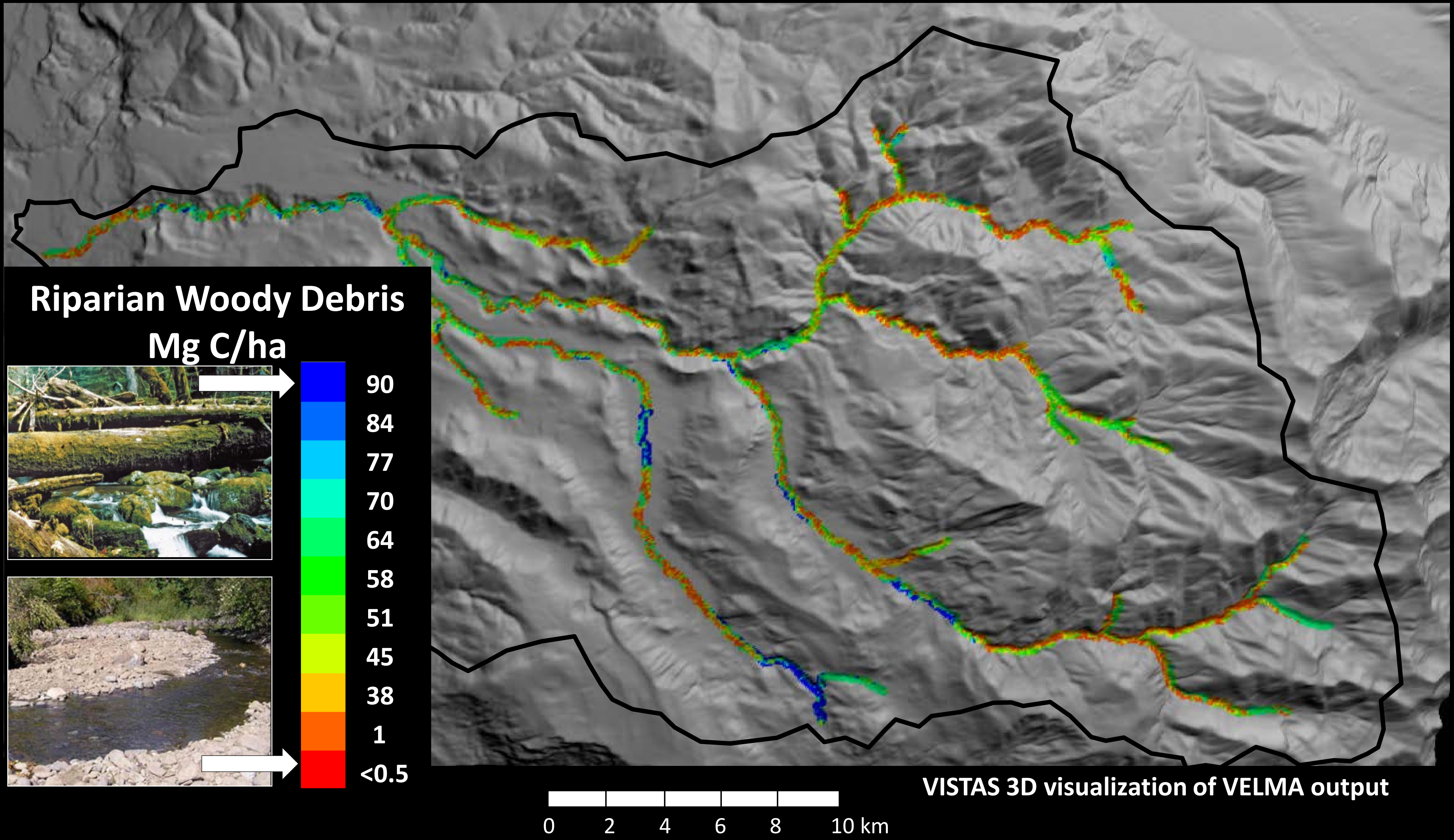
- **Long harvest rotations: up to 80 years, with thinning → maximize timber value**
- **1936: 110 acres of Coast Range second-growth**
- **Now: 86,000 acres of standing timber (growth exceeds harvest)**
- **Sustainably harvesting 15 million to 20 million board-feet per year**
- **About $15 million in annual sales**
- **Fish passage (culverts) & habitat improvement**
- **Water quality protection (skyline logging, road maintenance)**

VELMA

Large Woody Debris

Riparian Large Woody Debris

Mashel Basin – VELMA Simulation, Year 2000

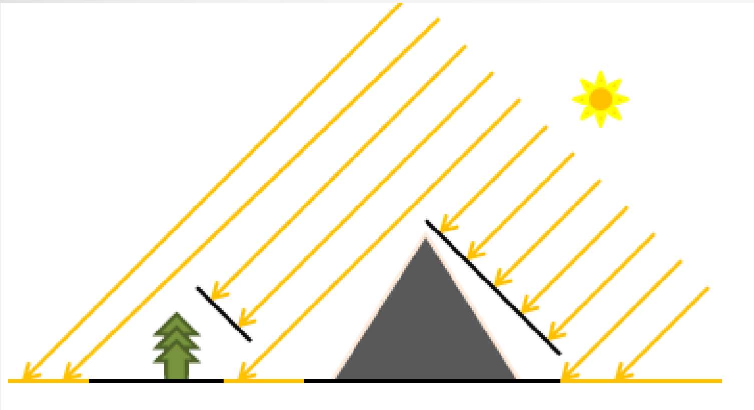


VISTAS 3D visualization of VELMA output

Penumbra

Stream Shade & Temperature

Penumbra: Stream Shade & Temperature Model

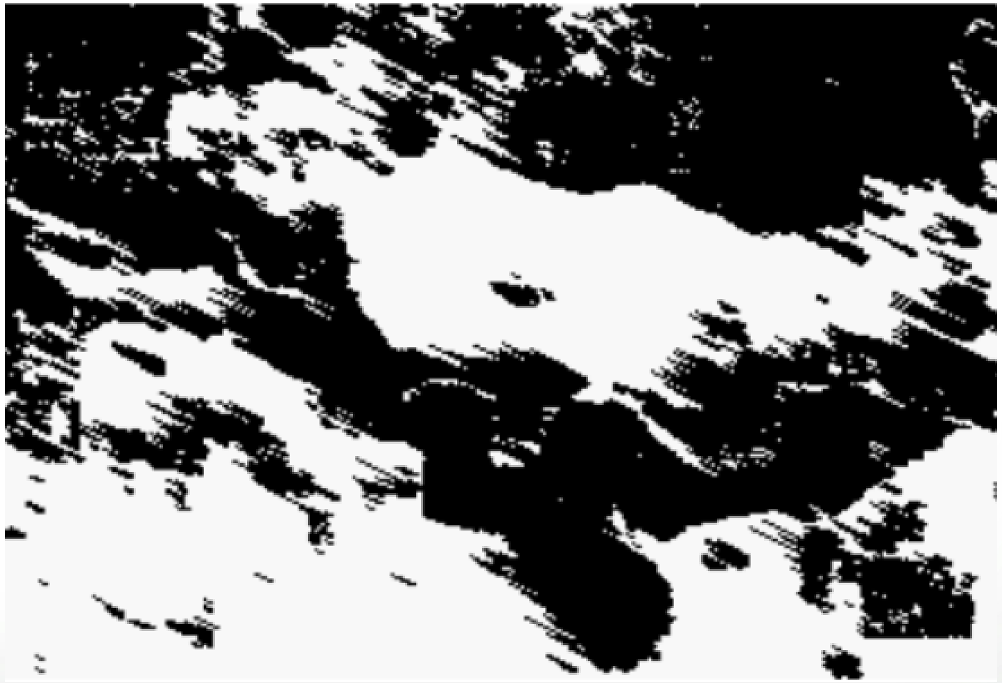


Developer: Jonathan Halama

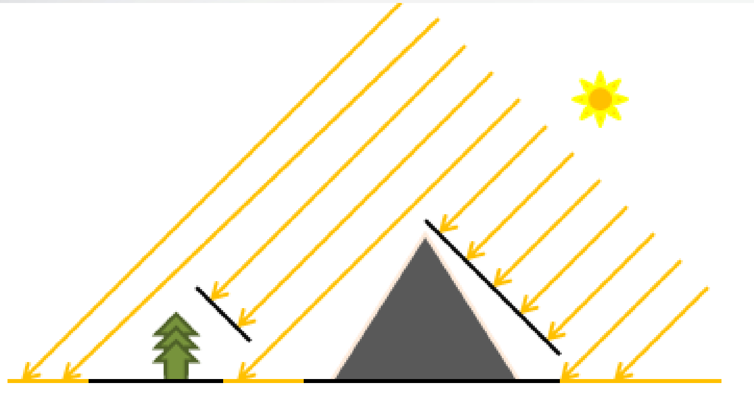
- Stream shade component (done)
- Integrate with VELMA for dynamic vegetation (done)
- Stream temperature (draft)

Calapooia River, OR

Stream shade, 6am June 15



Penumbra: Stream Shade & Temperature Model

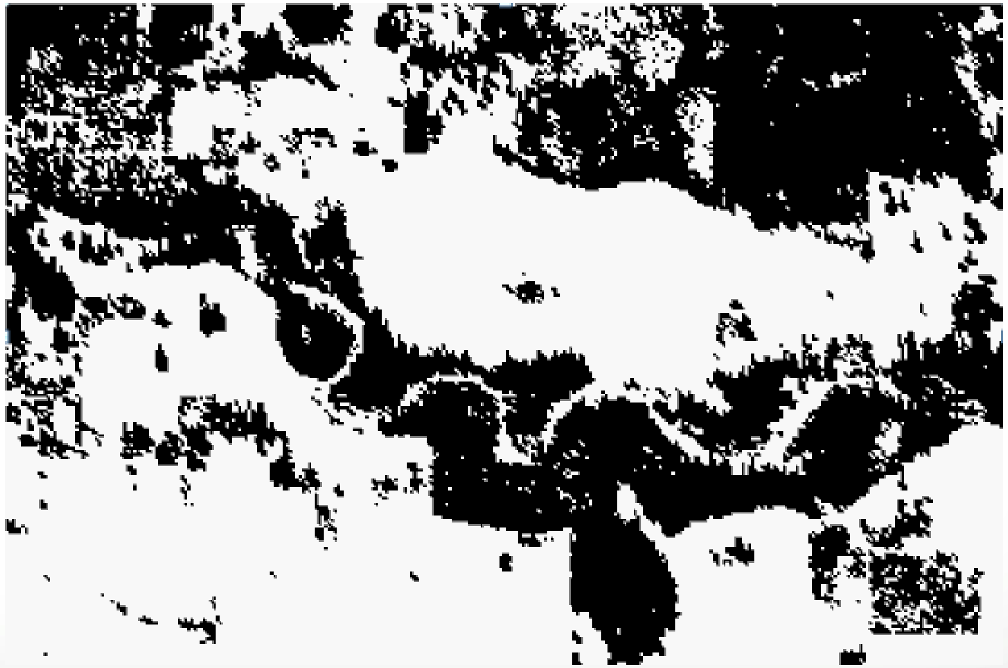


Developer: Jonathan Halama

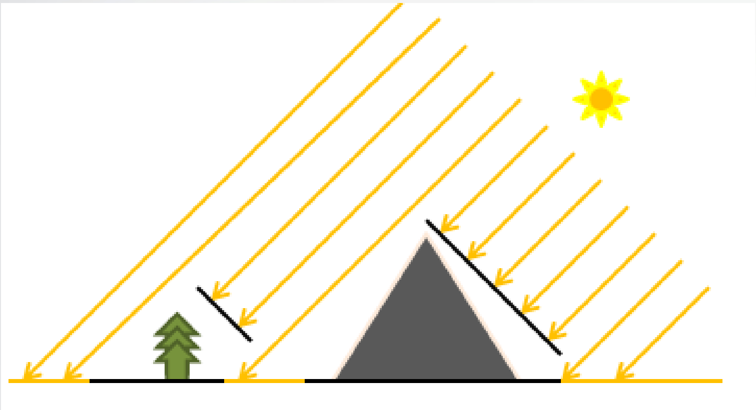
- Stream shade component (done)
- Integrate with VELMA for dynamic vegetation (done)
- Stream temperature (draft)

Calapooia River, OR

Stream shade, 12pm June 15



Penumbra: Stream Shade & Temperature Model

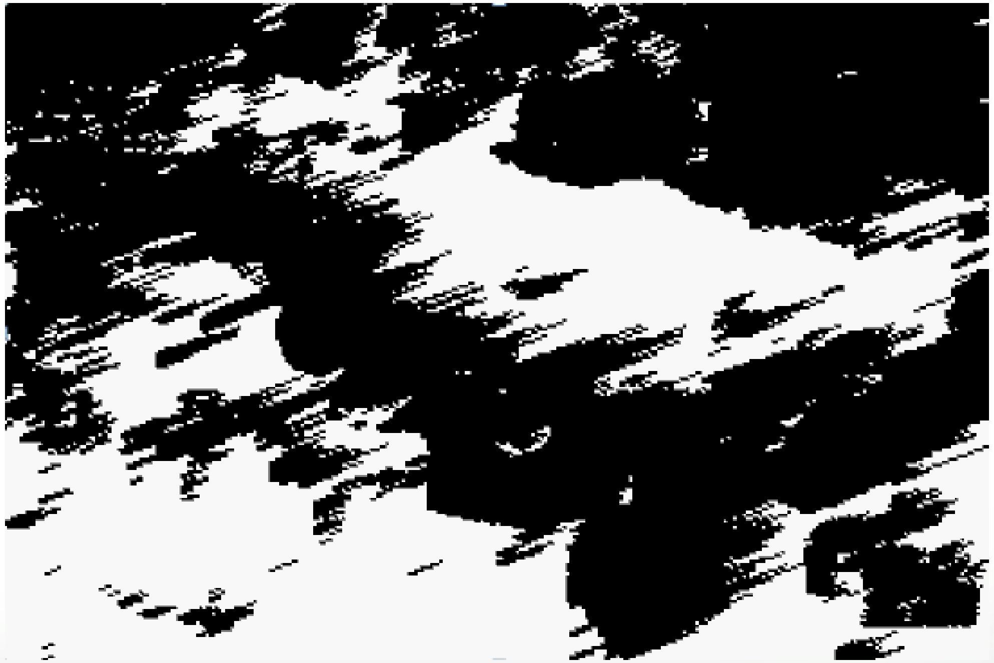


Developer: Jonathan Halama

- Stream shade component (done)
- Integrate with VELMA for dynamic vegetation (done)
- Stream temperature (draft)

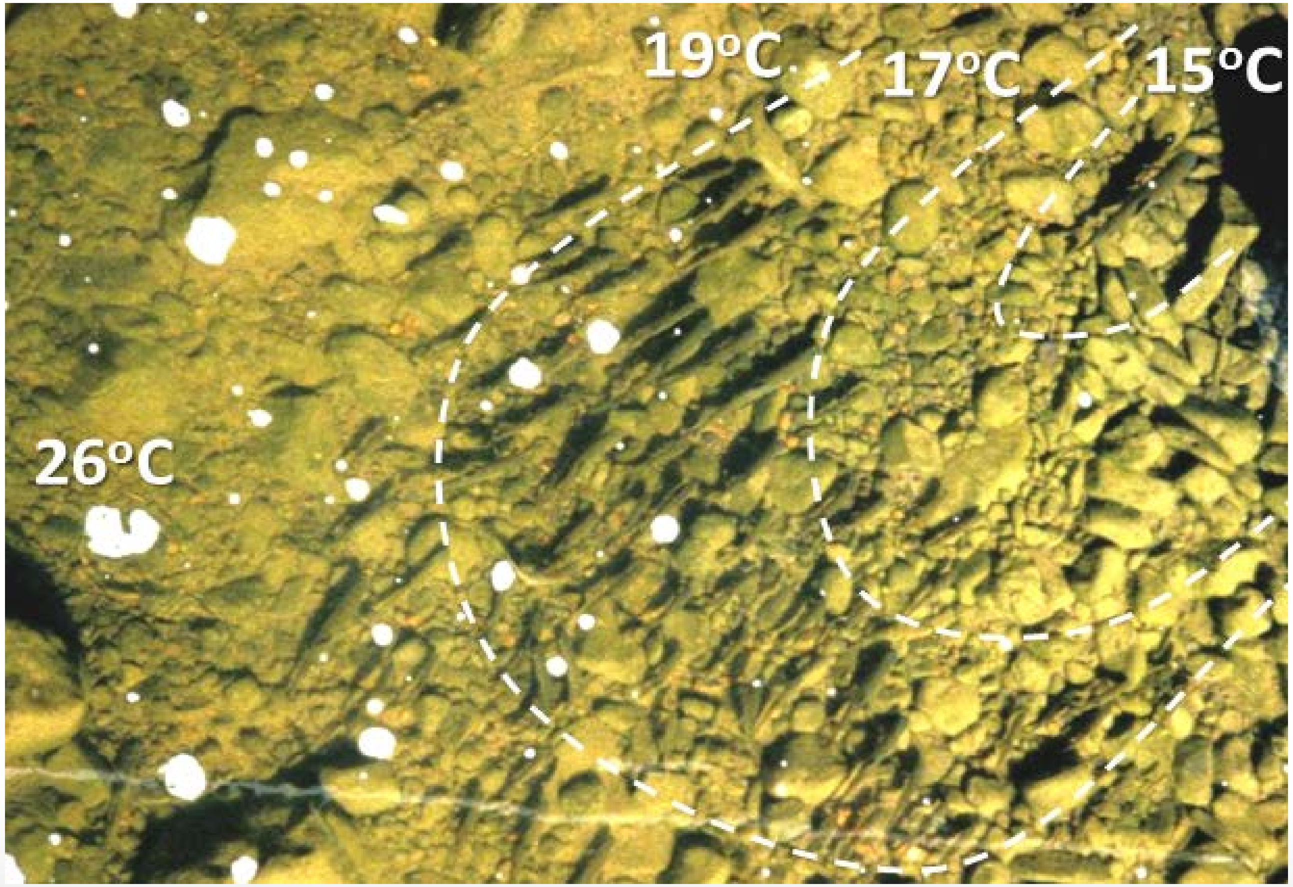
Calapooia River, OR

Stream shade, 8pm June 15



Climate Refuges

Where and what type of restoration practices can help establish cold water refuges for salmon?



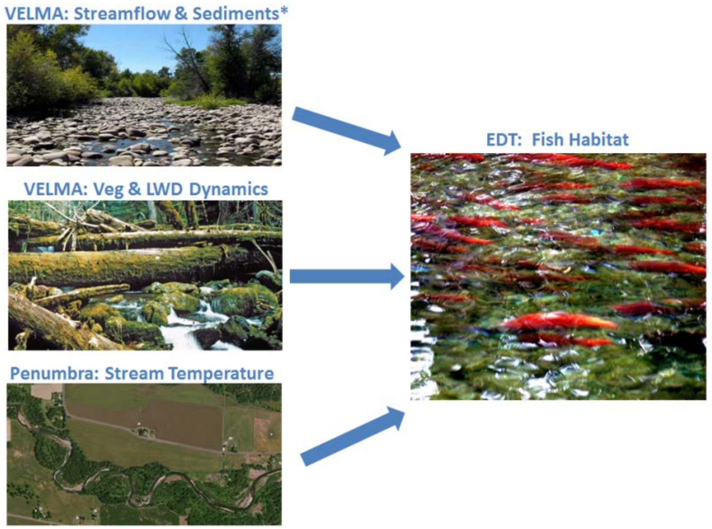
Joe Ebersole, EPA

- Riparian Shade
- Snowpack
- Groundwater
- Hyporheic flow
- Large wood

EDT
Fish Habitat

Fish Habitat Modeling:
Ecosystem Diagnosis & Treatment (EDT) Model

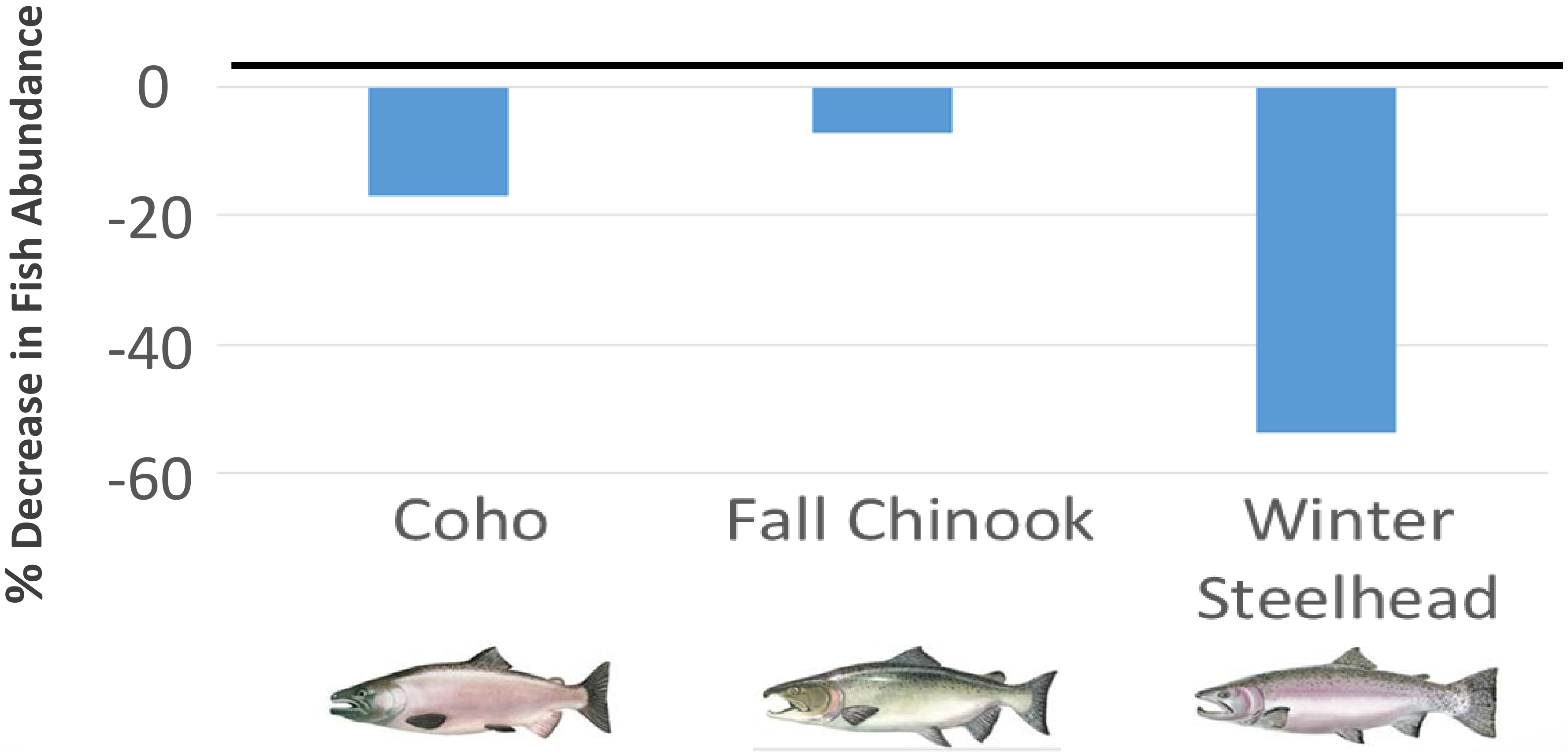
- ❖ EDT is a <u>fish life-cycle habitat</u> model
  - ✓ Synthesize available information
  - ✓ Identify limiting habitat factors
  - ✓ Prioritize habitat restoration needs
  - ✓ Help managers design restoration solutions to meet recovery targets



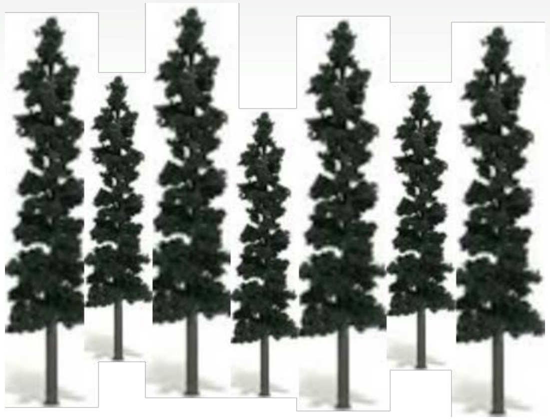
Greg Blair, ICF International

Modeled effects of summer low flows on Mashel adult salmonid abundance

% Decrease in Fish Abundance: Young Forest Fish Abundance – Old Forest Fish Abundance



Results <u>do not</u> yet include harvest effects on stream temperature, large woody debris, or sediments



Old Forests

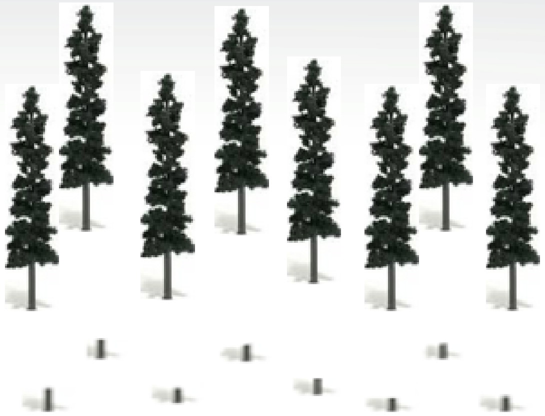
Prevailing Forest Mgmt

Young forests, Short rotations

- **Higher ET**
- **Lower low flow**
- **Higher peak flow**
- **Higher temps**
- **More sediment**

- **Less large wood detritus for spawning and rearing habitat, prey species**

Nisqually Community forest



Long rotations with thinning

Young forests, Short rotations

- Lower ET
- Higher low flow
- Lower peak flow
- Lower temps
- Less sediment

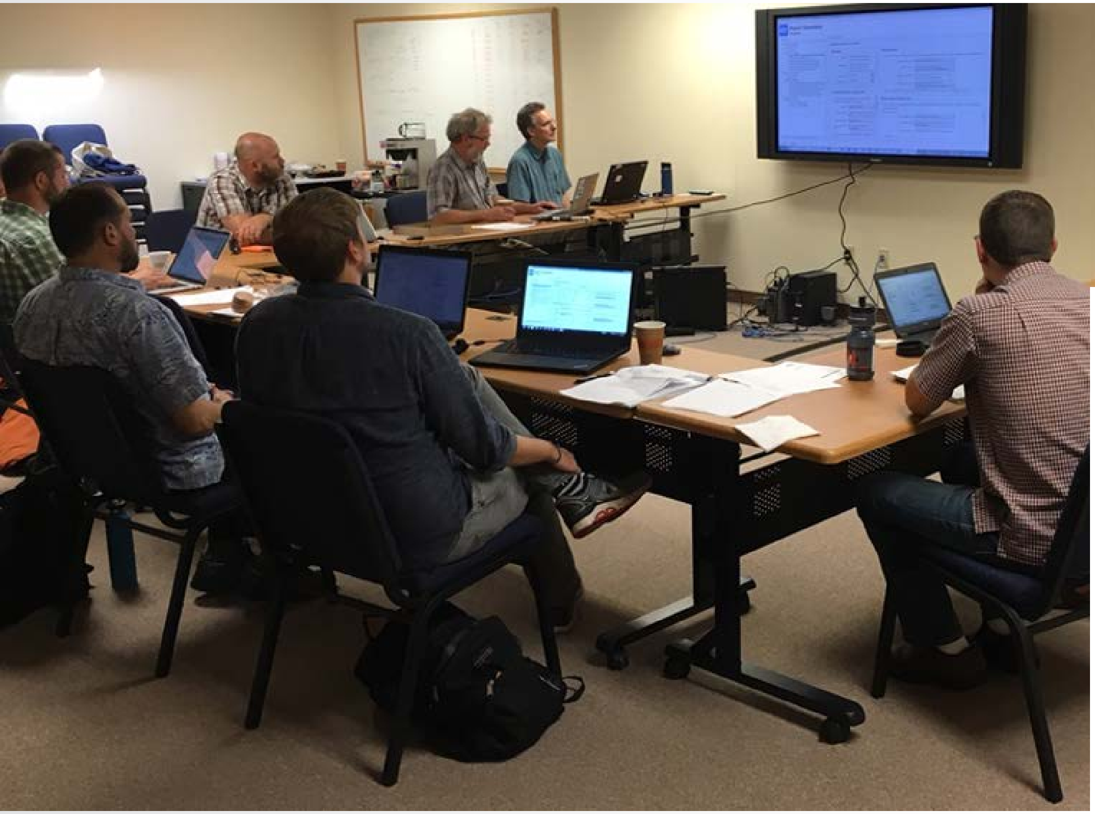
- More large wood detritus for spawning and rearing habitat, prey species

Salmon recovery model scenarios

- **Identify salmon habitat restoration priorities:** Streamflow, LWD, temperature, sediments?
- **How much restoration & where?**
- **How long for restoration to have an impact?**
- **Can restoration help mitigate effects of climate extremes & long-term trends?**
- ***Scenarios for balancing diverse objectives:*** salmon, timber, drinking water quality & quantity, carbon sequestration, local forest sector jobs…

Key goal: tool transfer to communities, tribes, states

Workshops



Online training and downloads

https://www.epa.gov/water-research/visualizing-ecosystem-land-management-assessments-velma-model-20

Visualizing Ecosystem Land Management Assessments (VELMA) Model - 2.0

Version 2.0 – Enhanced to address engineered and natural applications of green infrastructure for reducing nonpoint inputs of nutrients, and contaminants

Description

VELMA can be used to help improve the water quality of streams, rivers, and estuaries by making better use of both natural and engineered green infrastructure (GI) to control loadings from nonpoint sources of pollution. It is designed to help users assess green infrastructure options for controlling the fate and transport of water, nutrients, and toxics across multiple spatial and temporal scales for different ecoregions and present and future climates.

Thanks!

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