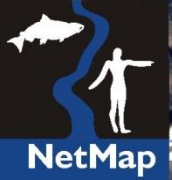




# NetMap

Desktop watersheds and analysis tools

**Earth Systems Institute**  
**Seattle/Mt. Shasta/Fort Collins**



# *A Collaborative Enterprise since 2007*

- National Forests (WA, OR, NCA, AK, ID, MT)**
- Forest Service Research: PSW, PNW; RMRS**
- NOAA**
- BLM**
- EPA**
- Oregon Dept. Forestry**
- NGOs**
- Watershed Councils**
- Universities**
- Private timber**

# Applications

## Roads



## Restoration



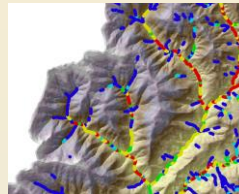
## Forestry: Timber harvest riparian management



## Conservation



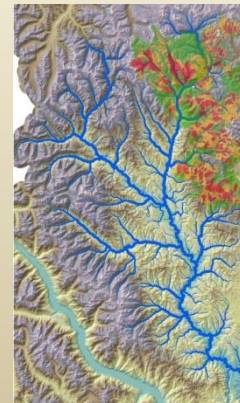
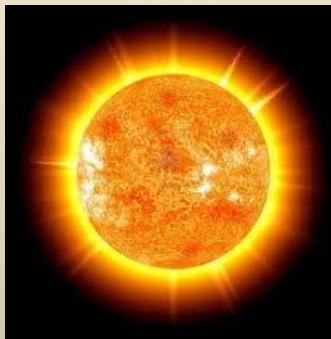
## Aquatic Habitats



## Pre-fire planning

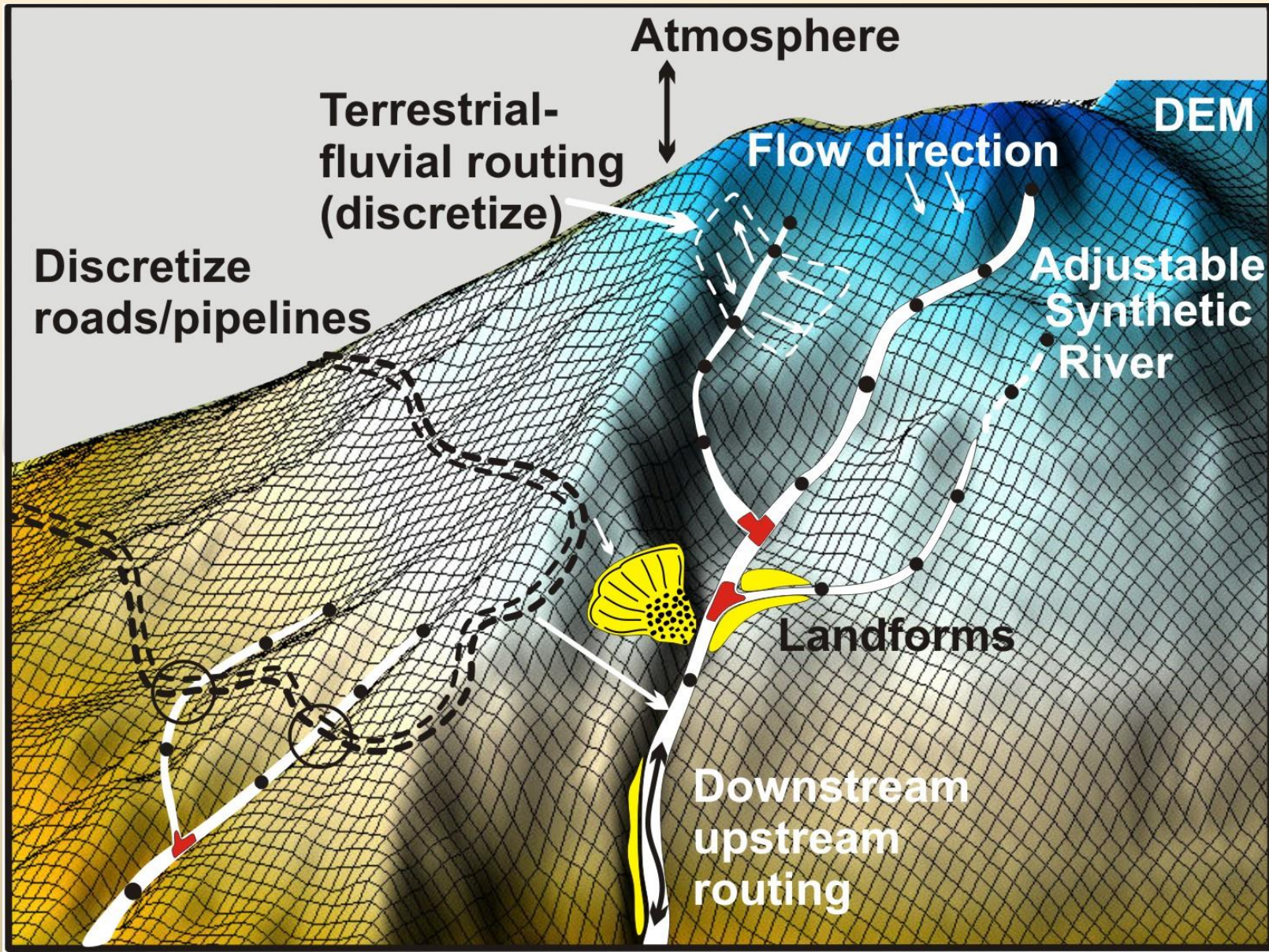


## Climate change

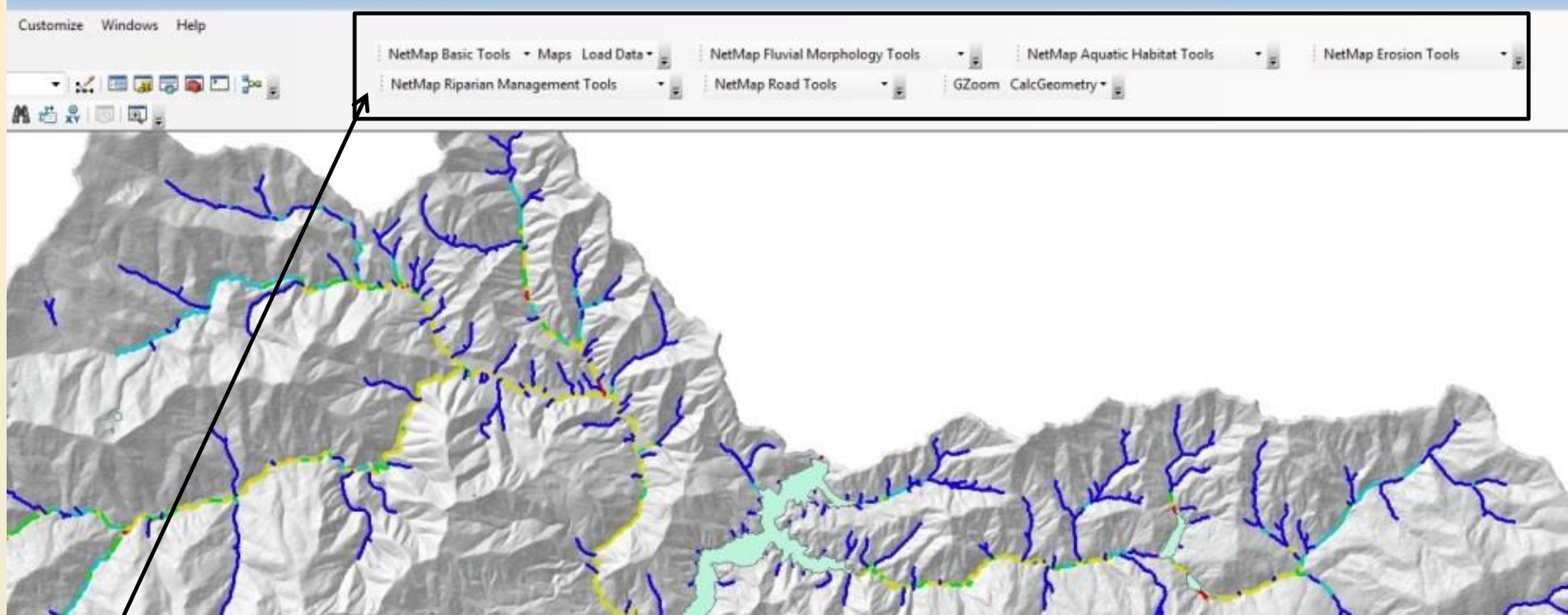


## Post-fire (BAER) planning

*A desktop watershed is a virtual environment where landforms and physical and biological processes are placed in context with spatial patterns of human activities and infrastructure*



# *NetMap in ArcMap 10/10.1*



*~70 tools/100+ parameters*

*-River Builder (create your own)*

*-Basic Tools*

*-Fluvial Morphology*

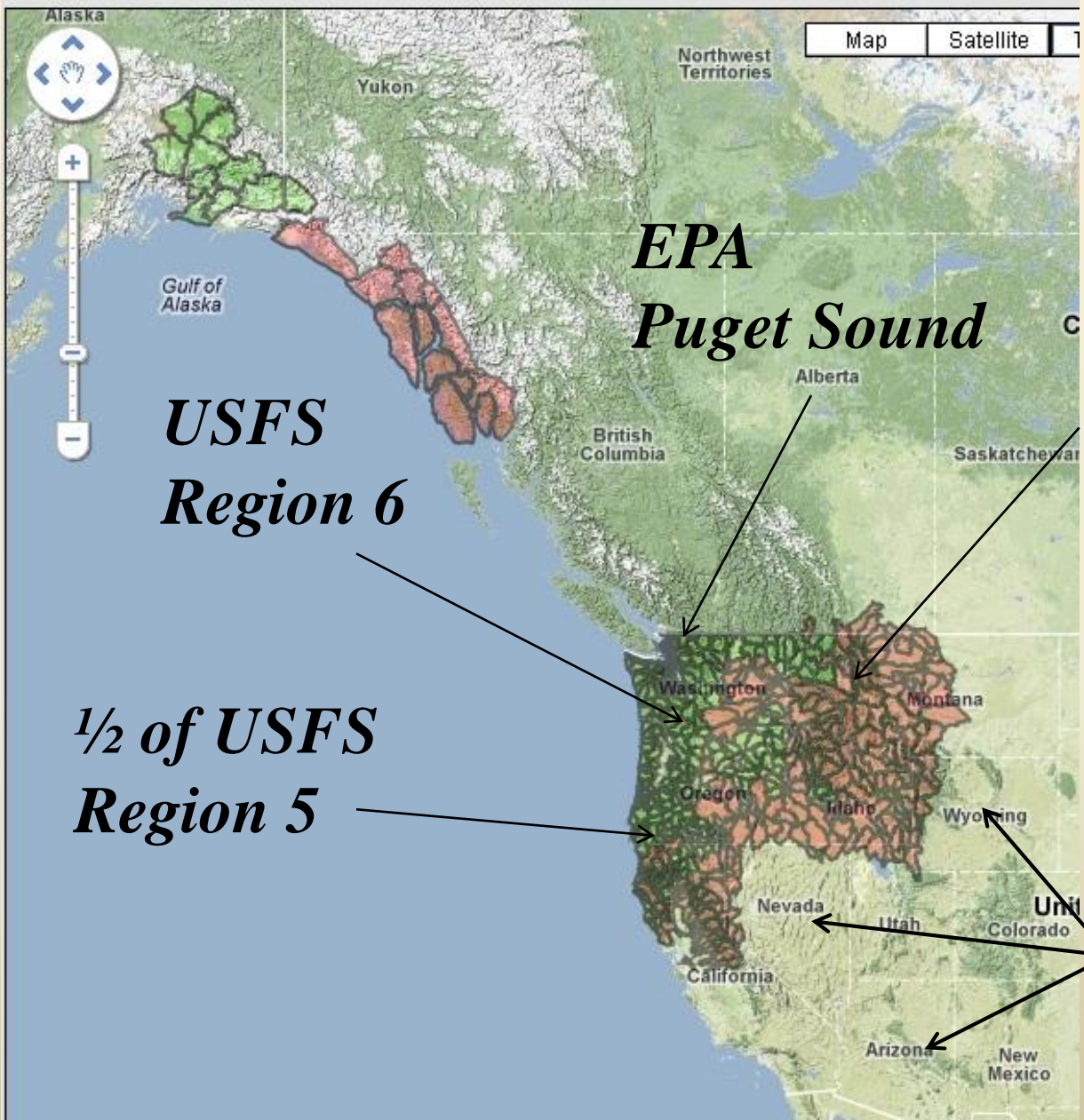
*-Aquatic Habitat*

*-Erosion*

*-Riparian Management*

*-Transportation/Energy*

# *Current and Pending Coverage*



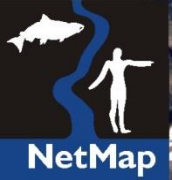
***EPA  
Puget Sound***

***USFS  
Region 6***

***USFS  
Region 1***

***1/2 of USFS  
Region 5***

***2013/14***

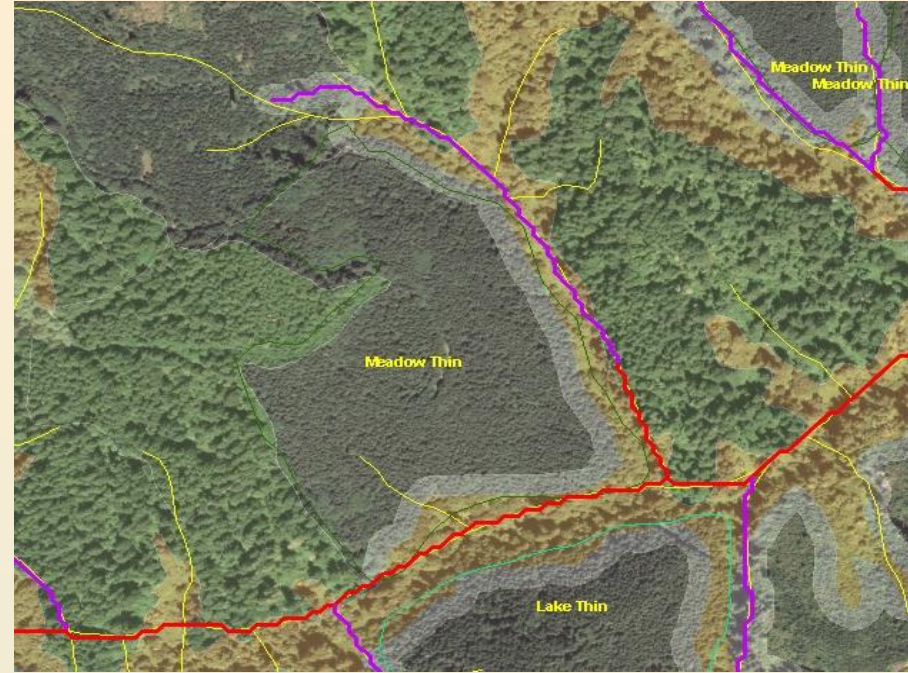


# NetMap Tools

Over to Sam...

# Spatially Explicit Riparian Management

A stepwise procedure for riparian management planning based on:



- ❖ fish habitat distribution,
- ❖ debris flow risk & upslope wood recruitment,
- ❖ streamside mortality wood recruitment
- ❖ thermal loading



# Example area: Lake Creek, a tributary to the Alsea River



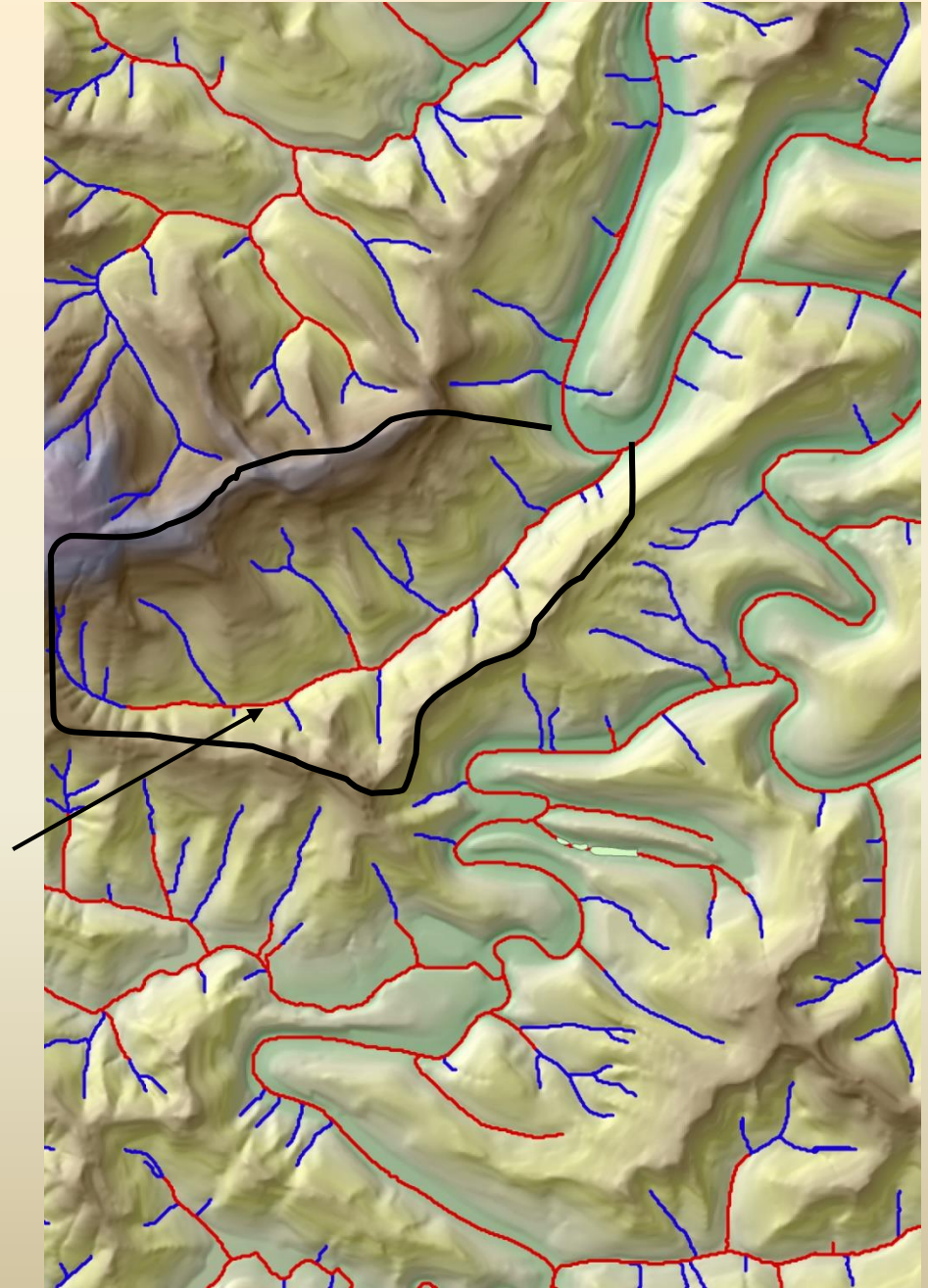
Alsea River

Lake Creek basin (5 km<sup>2</sup>)

# Step 1 – Define fish habitat distribution and quality



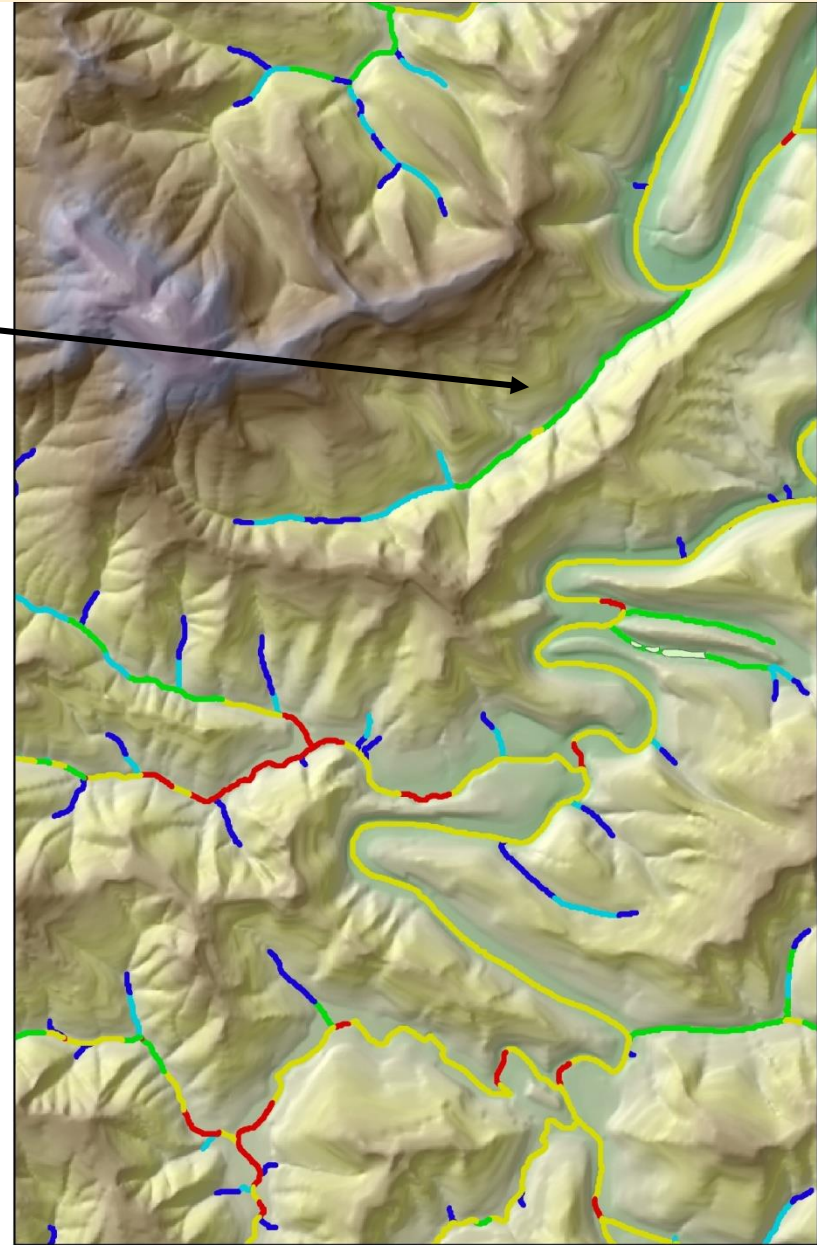
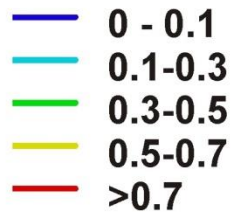
Define fish-bearing streams:  
e.g., Coho habitat (gradient  
< 8%; in red)



## Step 2 – Define habitat distribution and quality by species

Lake creek is a moderate value Coho stream with Intrinsic Potential = 0.1 – 0.5

Coho  
Intrinsic Potential

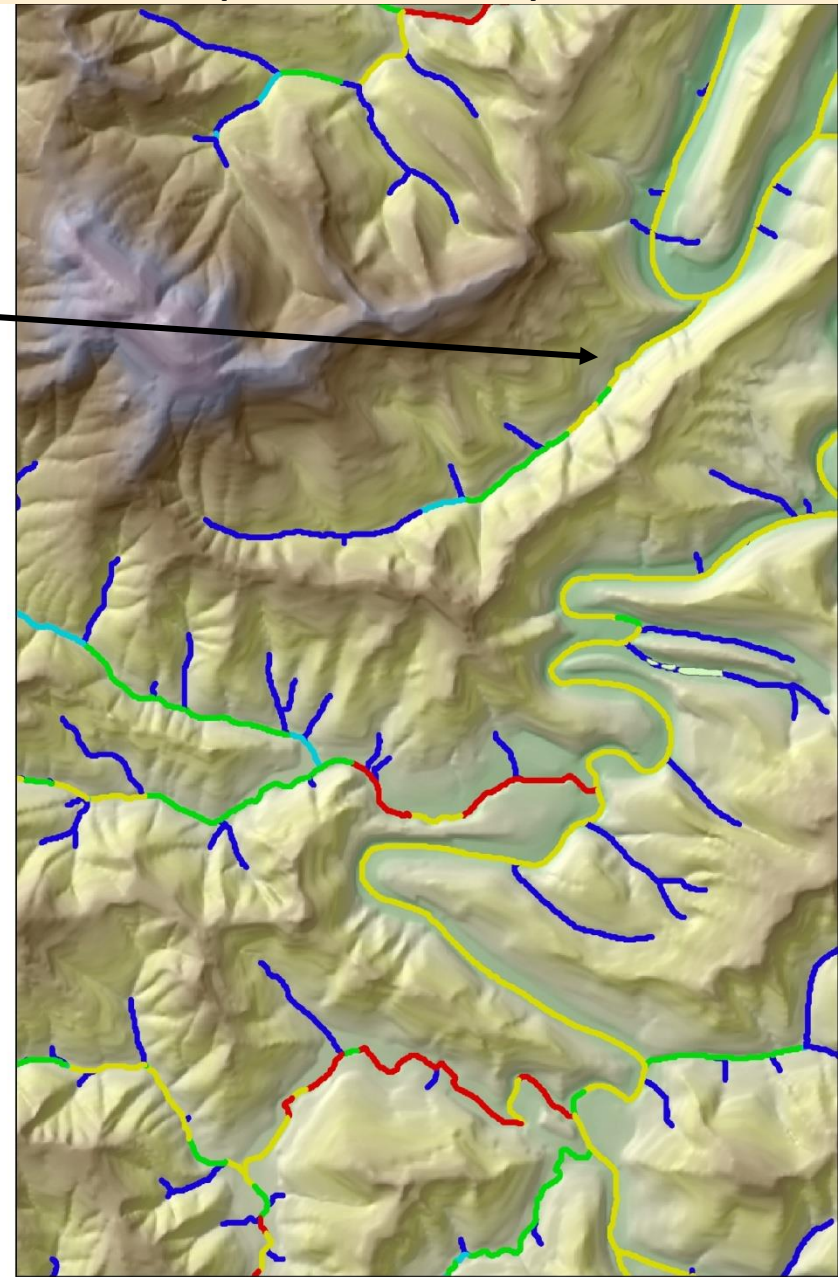
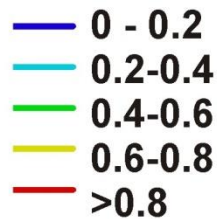


0 0.5 1 2 Kilometers

## Step 3 – Identify other species of concern (steelhead)

Lake creek is a better steelhead (than Coho) stream:  
IP values up to 0.8

Steelhead  
Intrinsic Potential

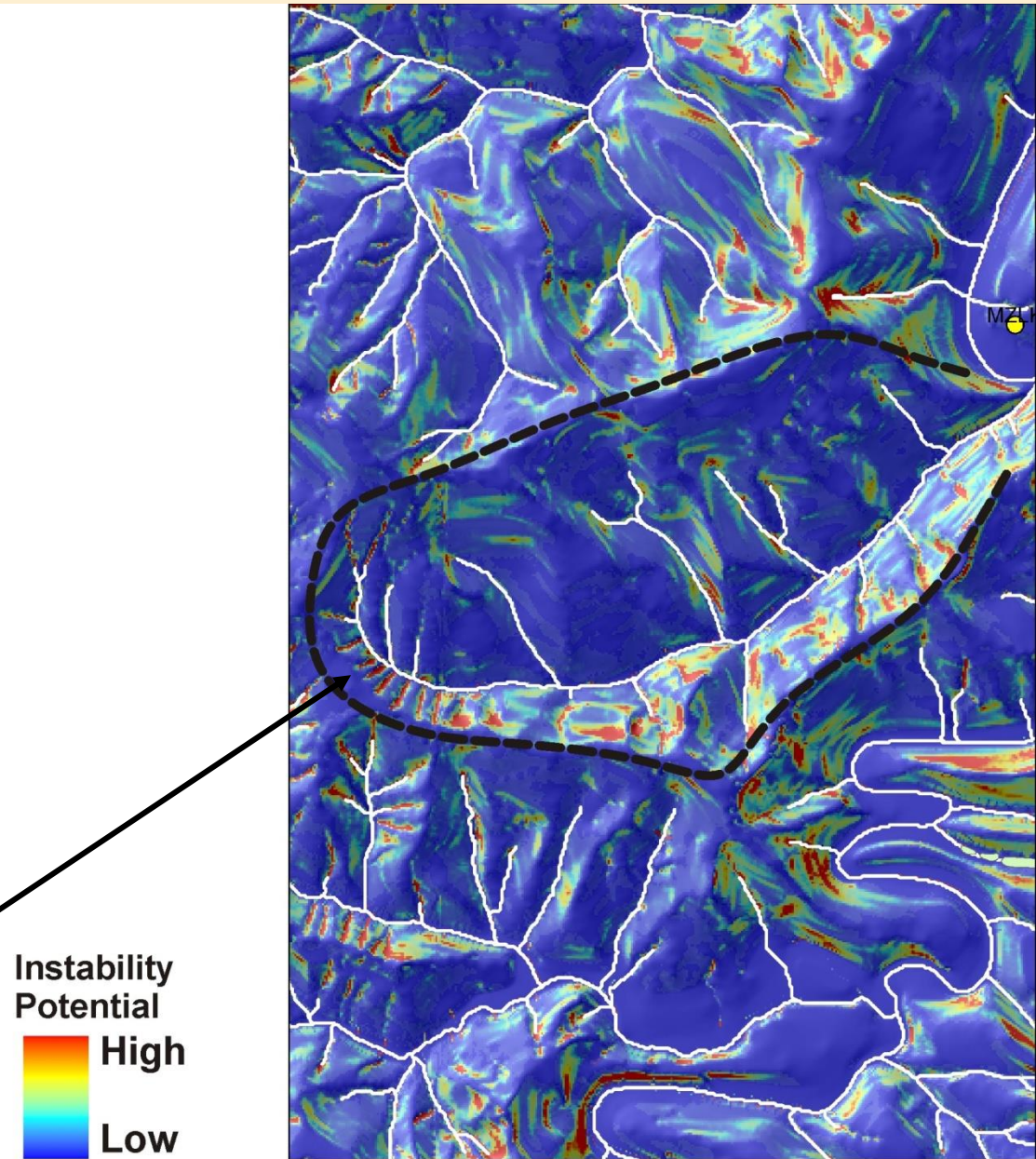


0 0.5 1 2 Kilometers

# Step 4 – Determine slope stability concerns, including landsliding

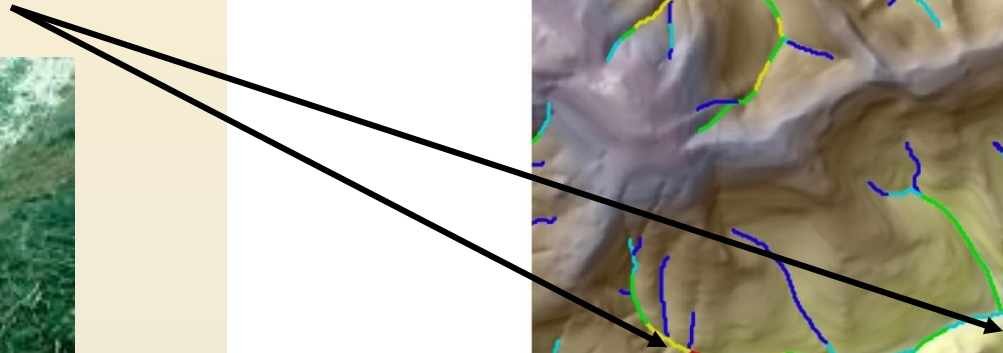


Certain areas in the Lake Creek basin are potentially unstable (in red)



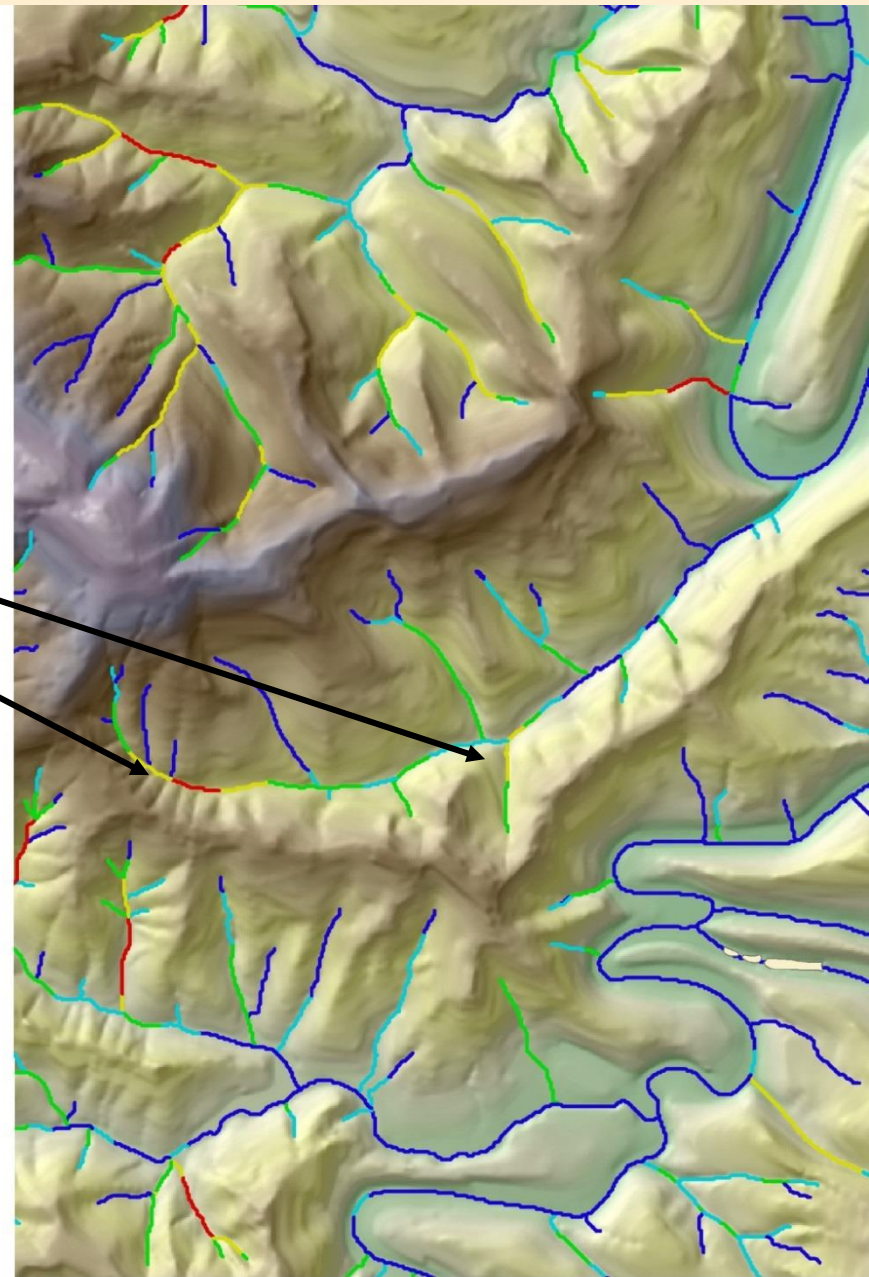
# Step 5 – Predict debris flow risk

Only a few tributaries in Lake Creek basin are very prone to debris flows



Debris flow potential

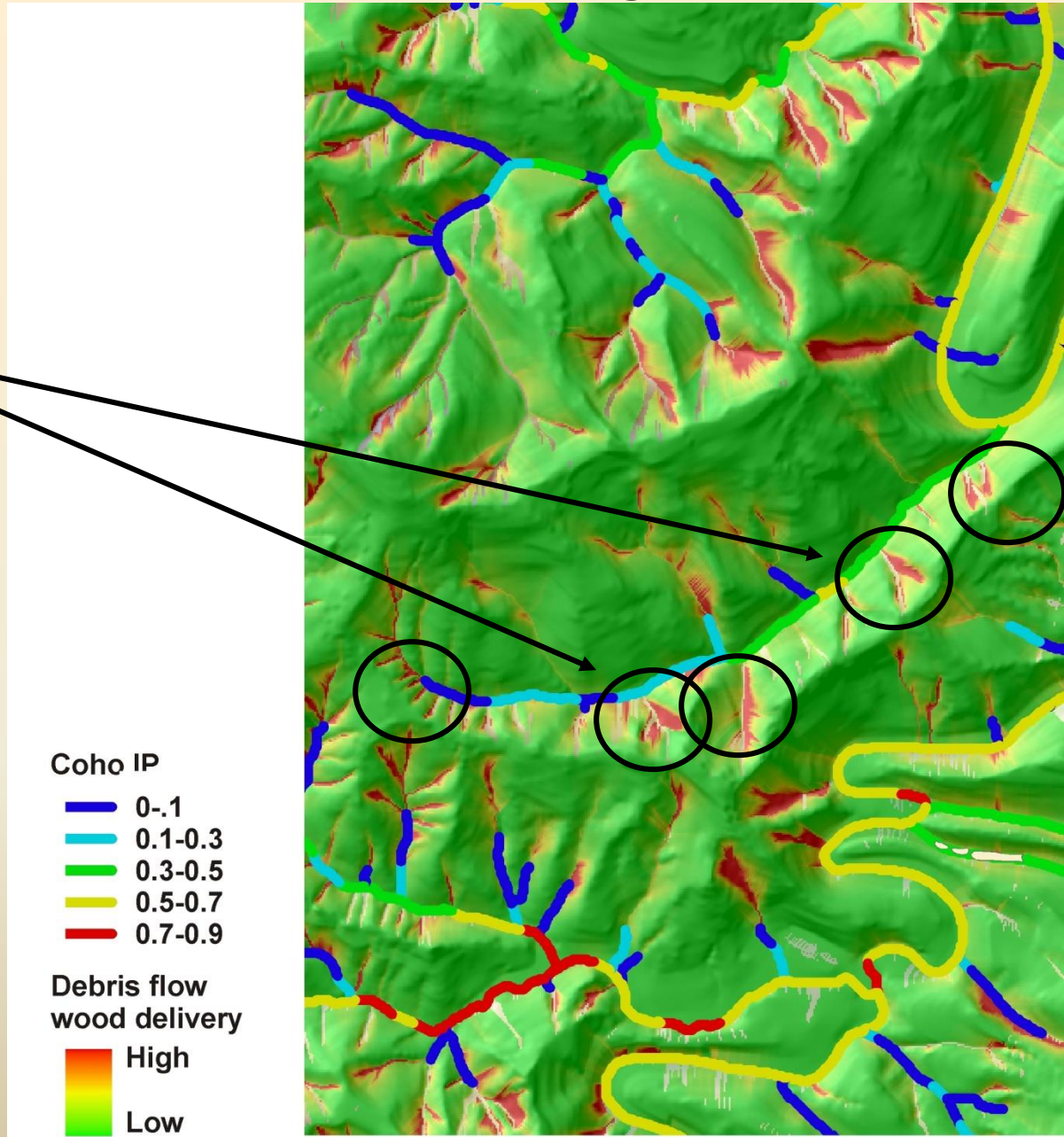
-  Low
-  Medium
-  High
-  Very High



0 0.35 0.7 1.4 Kilometers

# Step 6 – Predict debris flow contribution of large wood to streams

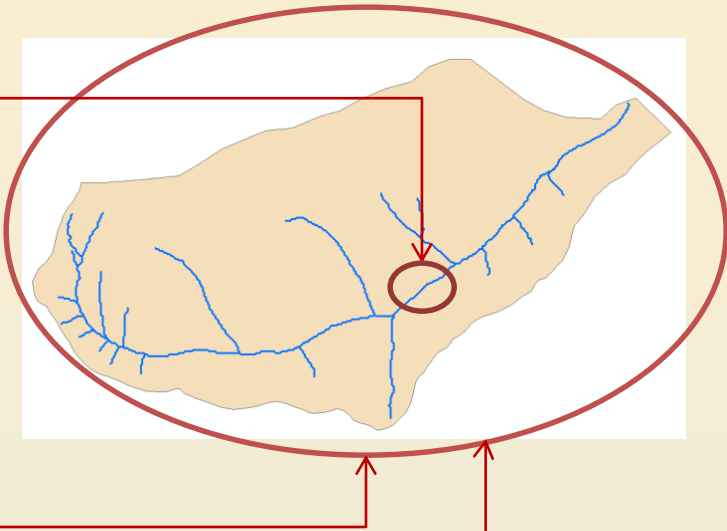
Identify likely sources of large wood to anadromous fish bearing streams from shallow failures & debris flows



- Coho IP
  - 0-.1
  - 0.1-0.3
  - 0.3-0.5
  - 0.5-0.7
  - 0.7-0.9
- Debris flow wood delivery
  - High
  - Low

# Steps 7,8,9 – Evaluate effects of thinning on in-stream wood recruitment

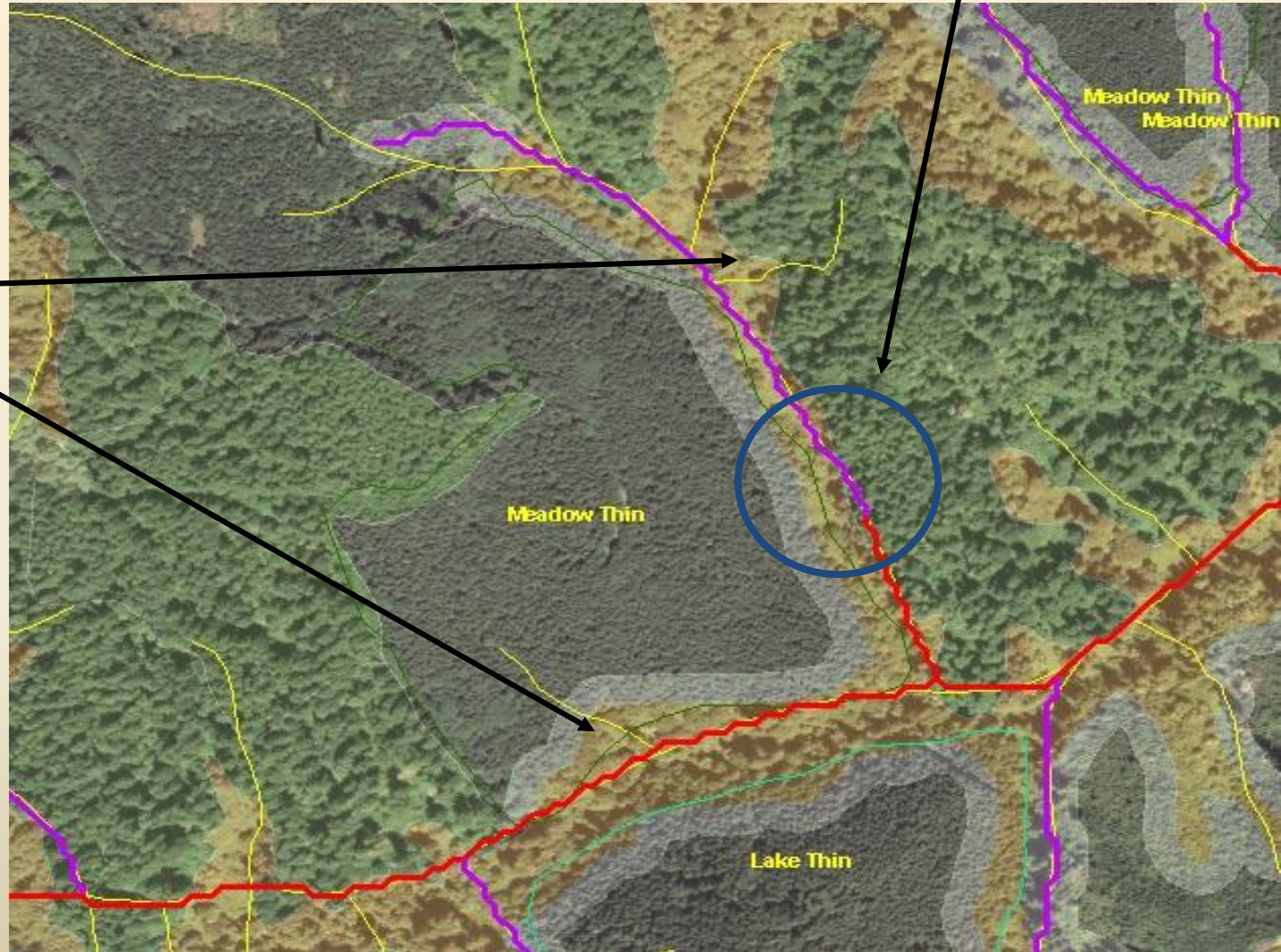
- Reach scale
  - Per 100m reach or project
  - For selected piece sizes
  - Temporally and spatially explicit
  - Up to 3 stands on each bank
  - Plots of volume and number of pieces
- Watershed scale
  - Temporally and spatially explicit
  - CE analysis of management scenarios
  - Based on RSWM technology
  - Plots and maps available
- SnapShot scale
  - Spatially explicit
  - Uses GNN tree data





# Project analysis

30-100ft  
deciduous  
stand



Meadow Thin

Meadow Thin  
Meadow Thin

Lake Thin

Thinning in uplands and in riparian areas

# Reach Scale Wood Model (RSWM)

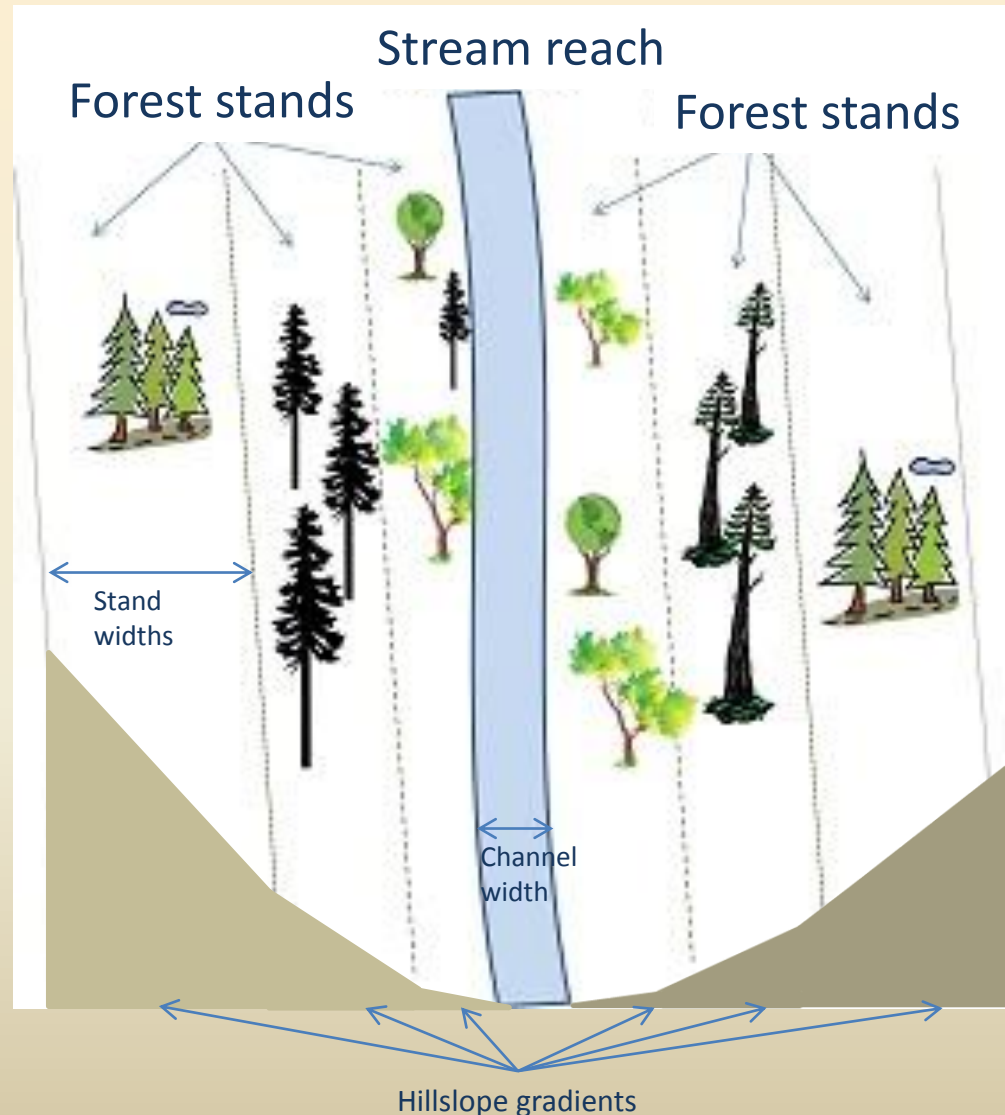
Mortality types include suppression, fire, insect, disease, & wind-throw.

Bells and Whistles:

- ❖ channel width,
- ❖ stand width,
- ❖ hillslope gradient,
- ❖ bank erosion,
- ❖ wood decay,
- ❖ taper equations,
- ❖ thinned trees that are tipped, and
- ❖ size of resulting wood pieces

Inputs: stand tables from forest growth models

Outputs: 10 types of plots



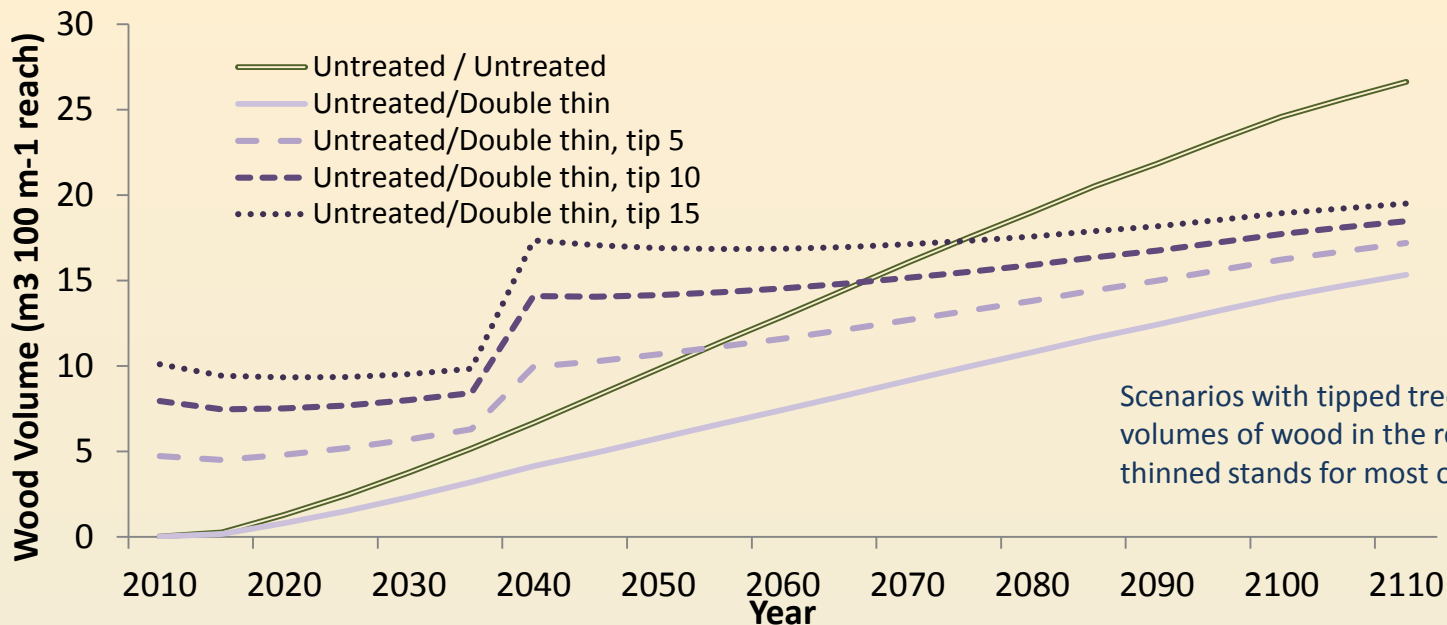
# RSWM Scenarios

- Left bank is always no action scenario (70 m)
- Right bank treatment scenarios (11) with and without a no action buffer
- Double entry thin, 70 TPA: 2010, 2040
- All other parameters held constant (bank erosion, channel width, gradient, taper equations)

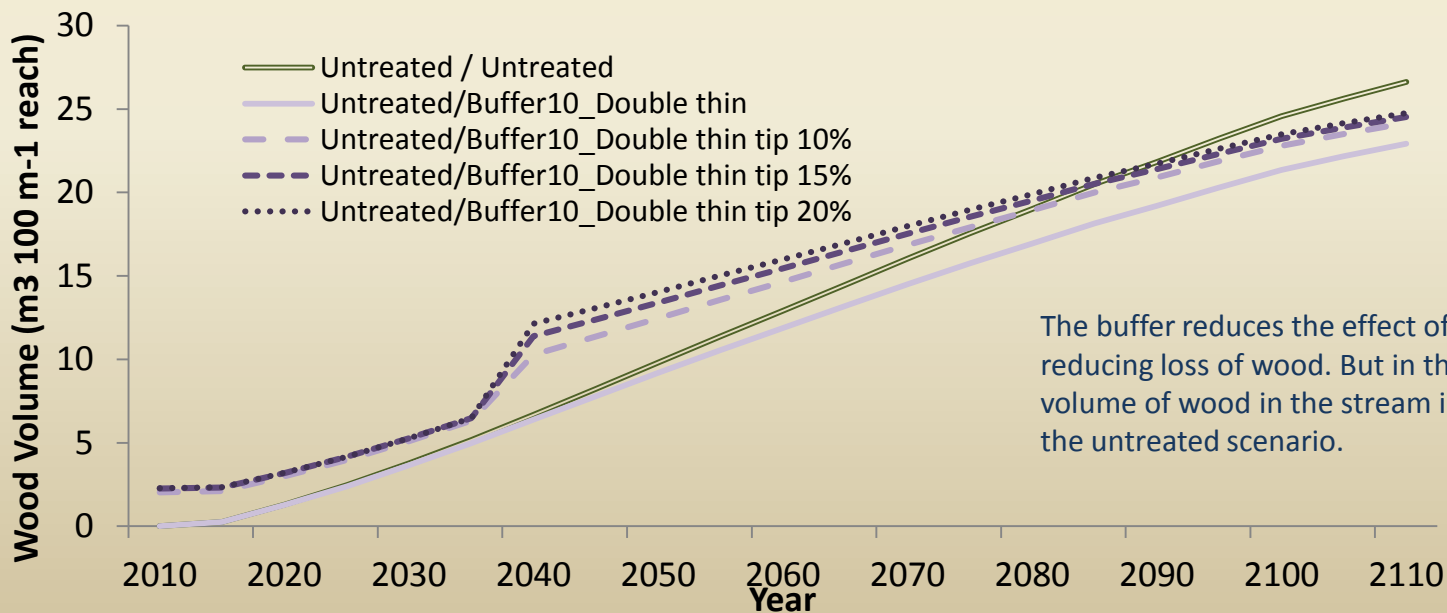
## Right bank scenarios

Stand1	Stand2
No action buffer ( <b>10 m</b> )	No action ( <b>60 m</b> )
No action buffer	Thinned
No action buffer	Thin & tip 5%
No action buffer	Thin & tip 10%
No action buffer	Thin & tip 15%
No action buffer	Thin & tip 20%
Thinned ( <b>70 m</b> )	
Thin & tip 5%	
Thin & tip 10%	
Thin & tip 15%	
Thin & tip 20%	

## Cumulative wood volume using 2 bank scenarios, no buffer



## Cumulative wood volume using 2 bank scenarios, 10 m buffer



# Total volume of cumulative wood over time

(sorted by increasing volume)

	Volume (m <sup>3</sup> 100 m <sup>-1</sup> reach) (percent change from reference )
Total cumulative wood	
Untreated/Double thin	156 (-42%)
Untreated/Double thin, tip 5%	232 (-14%)
Untreated/Buffer10_Double thin	243 (-10%)
Untreated/Untreated (reference condition)	271
Untreated/Double thin, tip 10%	284 (5%)
Untreated/Buffer10_Double thin tip 10%	288 (6%)
Untreated/Buffer10_Double thin tip 15%	299(10%)
Untreated/Buffer10_Double thin tip 20%	305 (13%)
Untreated/Double thin, tip 15%	324 (20%)

Tree tipping from thinning operations combined with riparian buffers offer the highest volumes of wood loadings

# Step 8. Watershed Scale Wood Model

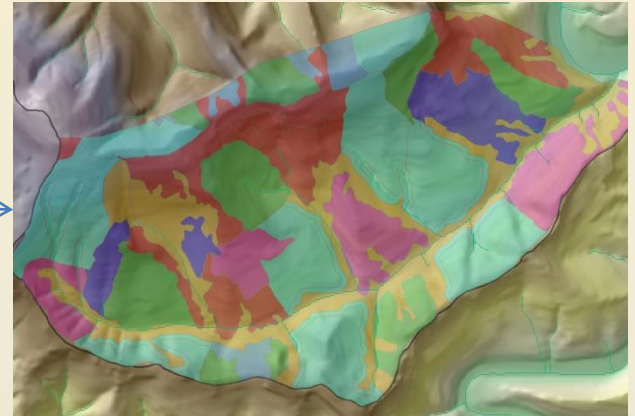
Stand tables from forest growth models (FVS, Organon, Zelig) pre-processed in RSWM



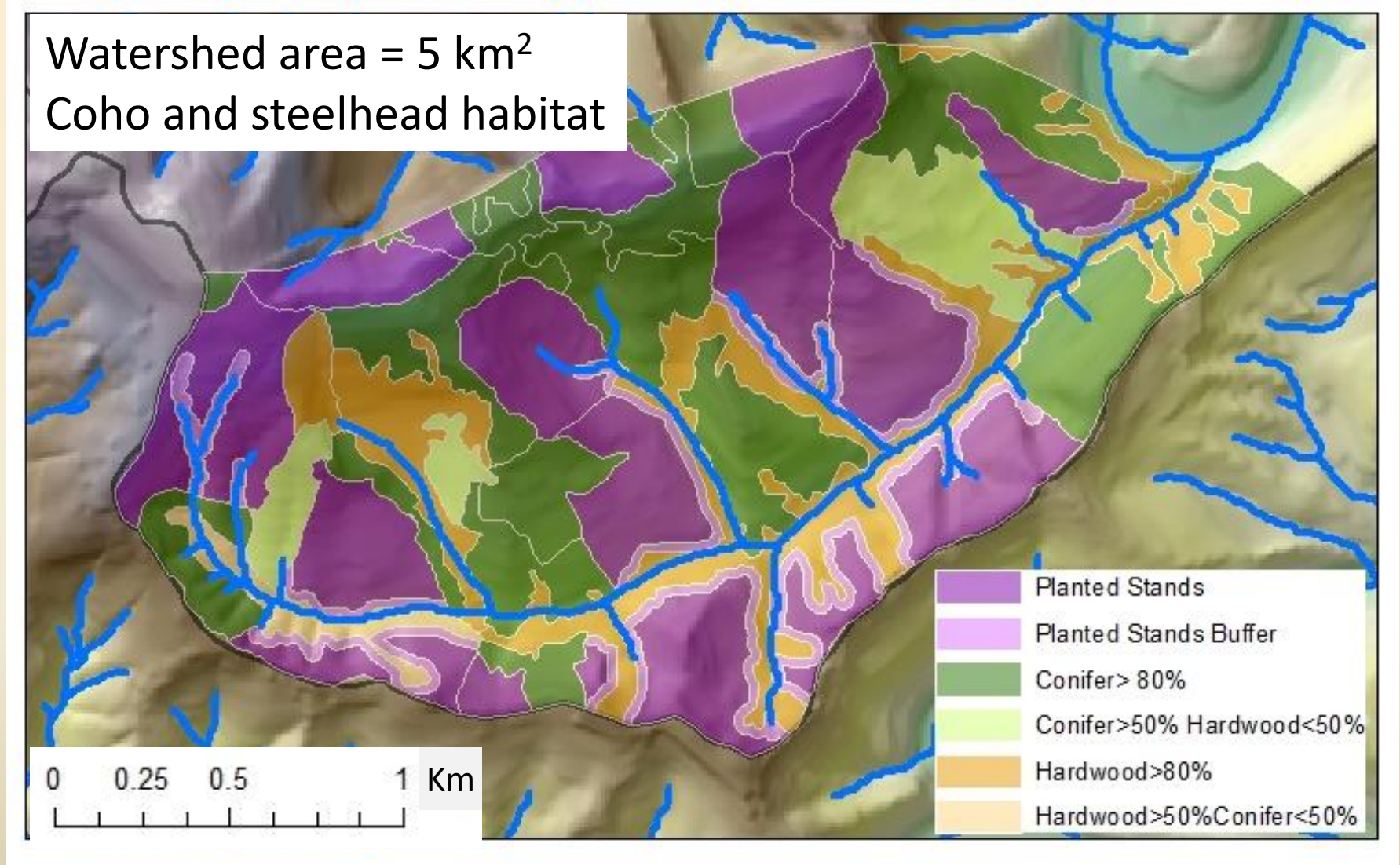
Tabular data integrated with GIS: stream segments, stands, and DEM



Generate output: plots and maps

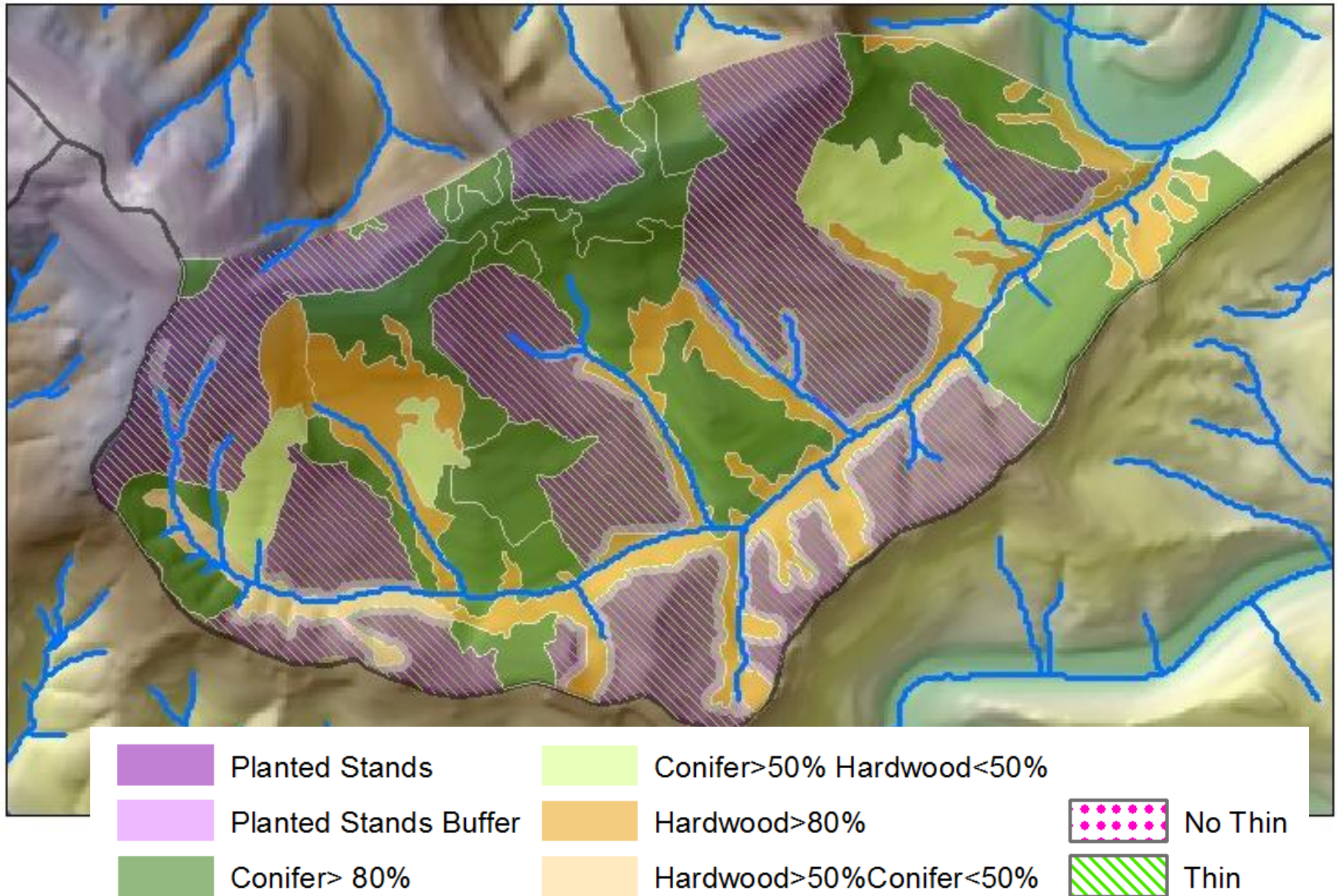


Step 11 - Consider 'cumulative effects' of thinning at watershed scale (example, wood recruitment) – a key part of the analysis (not complete)



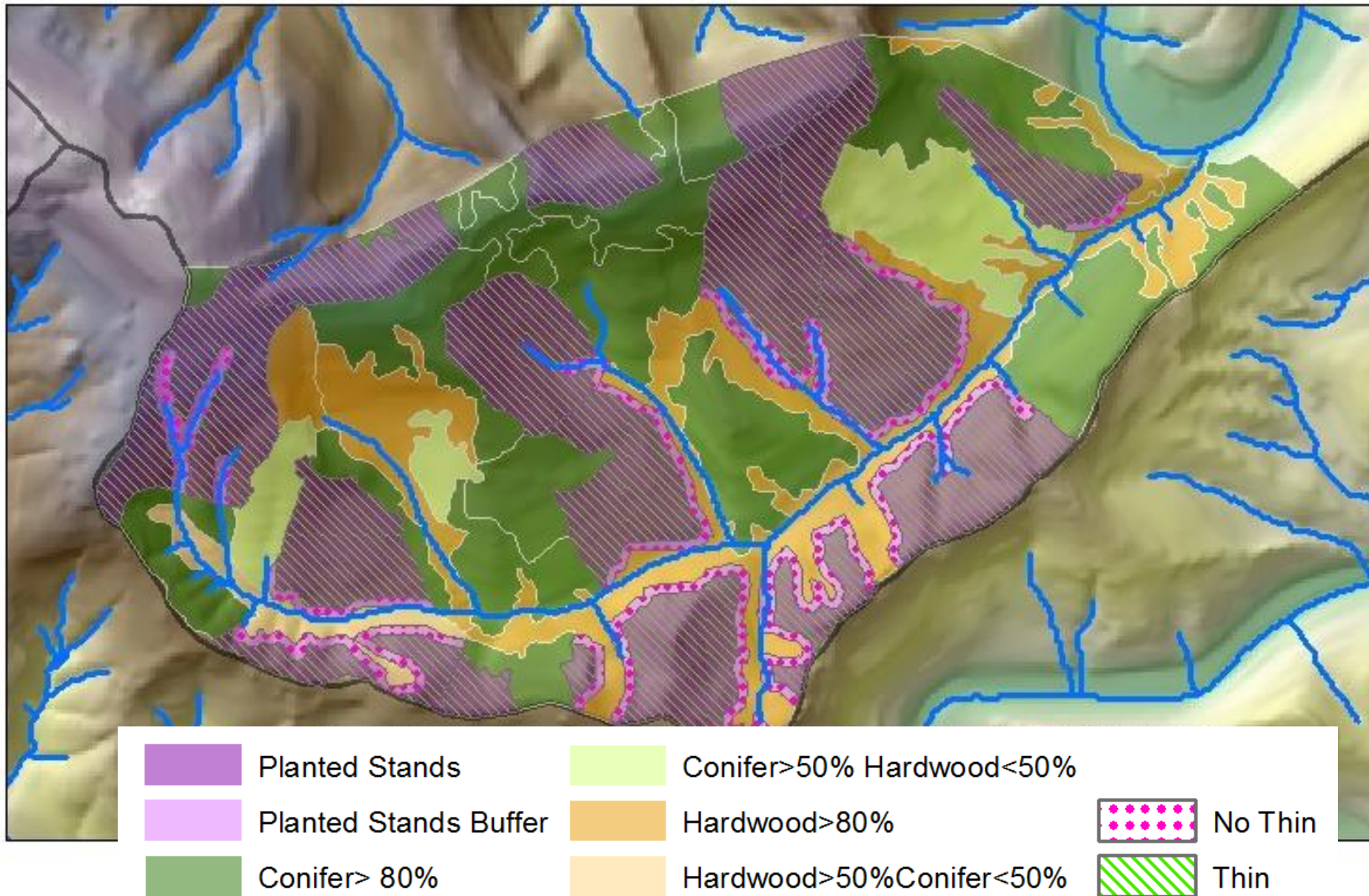
Parameters: variable age stands, variable thinning timing and location over 30 years, numerous stream segments, 100 years

# Stand treatments – thin to 70 TPA from the bottom (47% of watershed thinned)





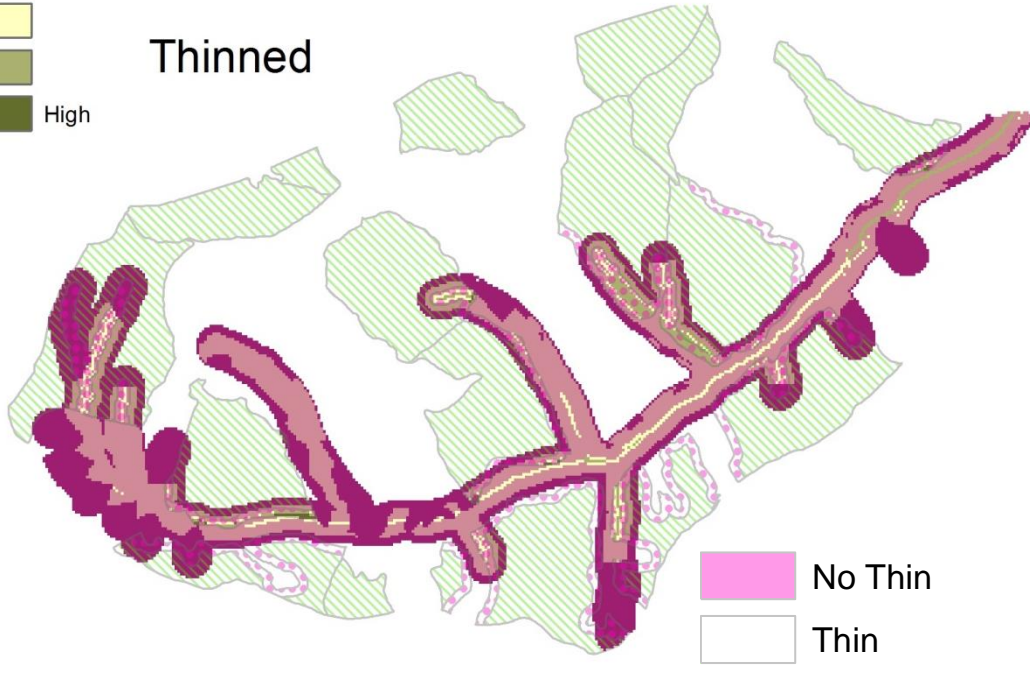
# Stand treatments – no action buffer & thin (39% of watershed thinned)



Wood Volume

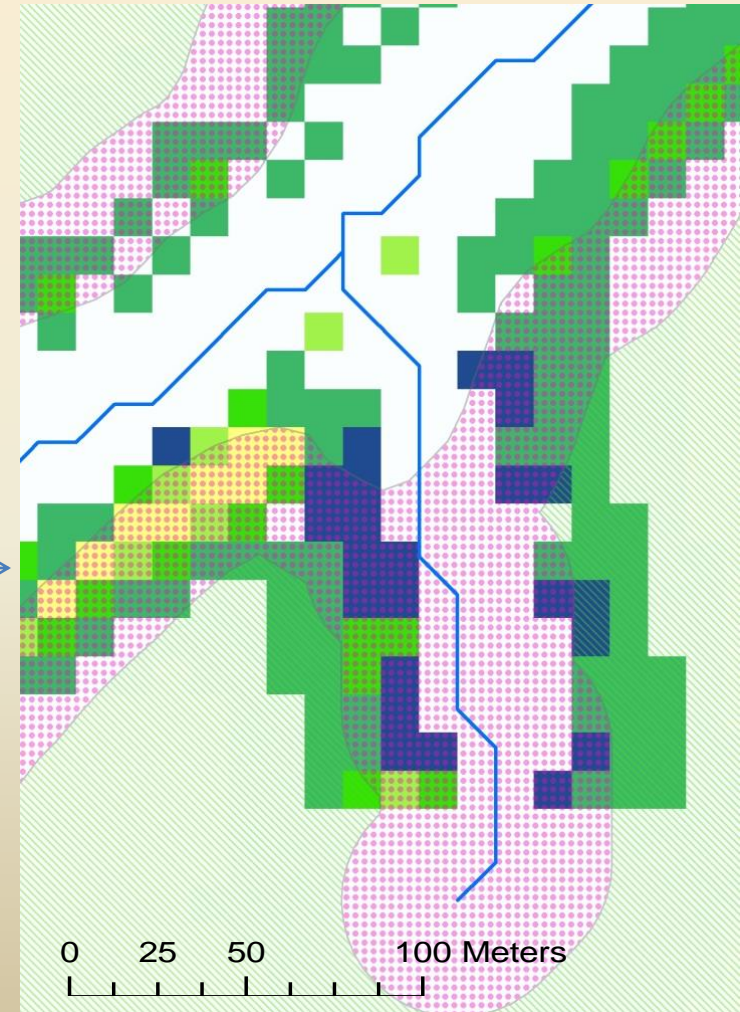
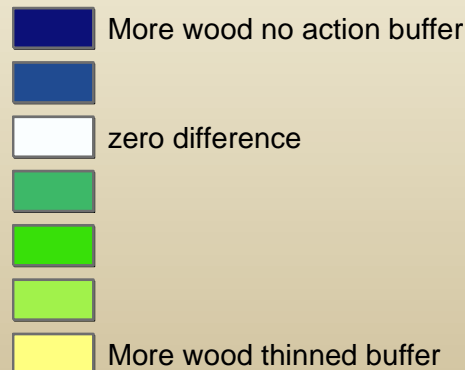


Thinned



Spatial distributed sources of wood volume, year 2055

Difference between wood volumes, thinned and no action buffers, year 2055.

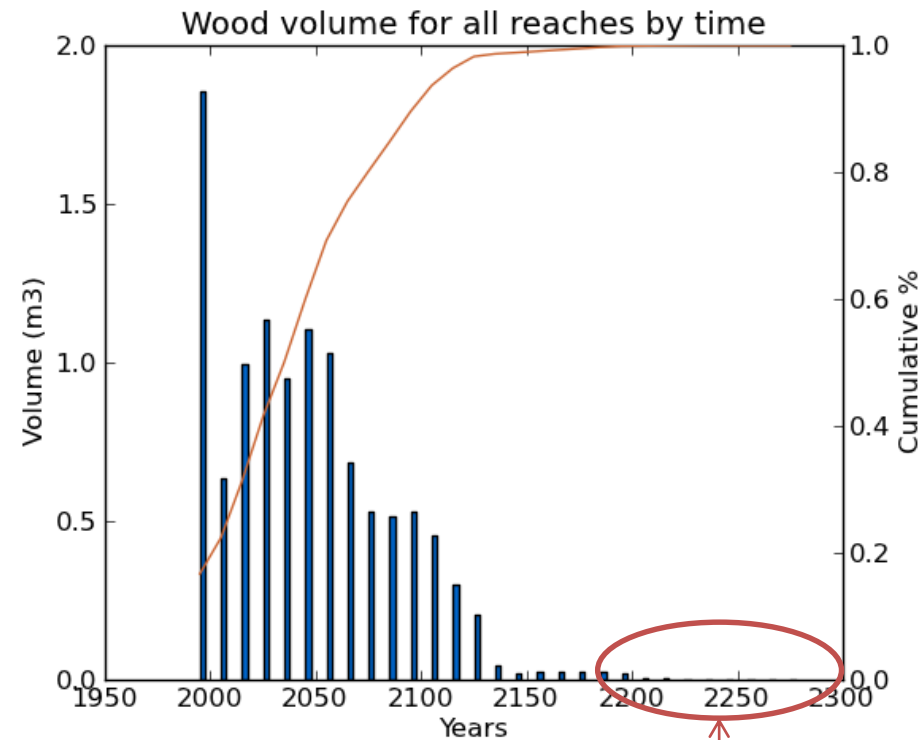
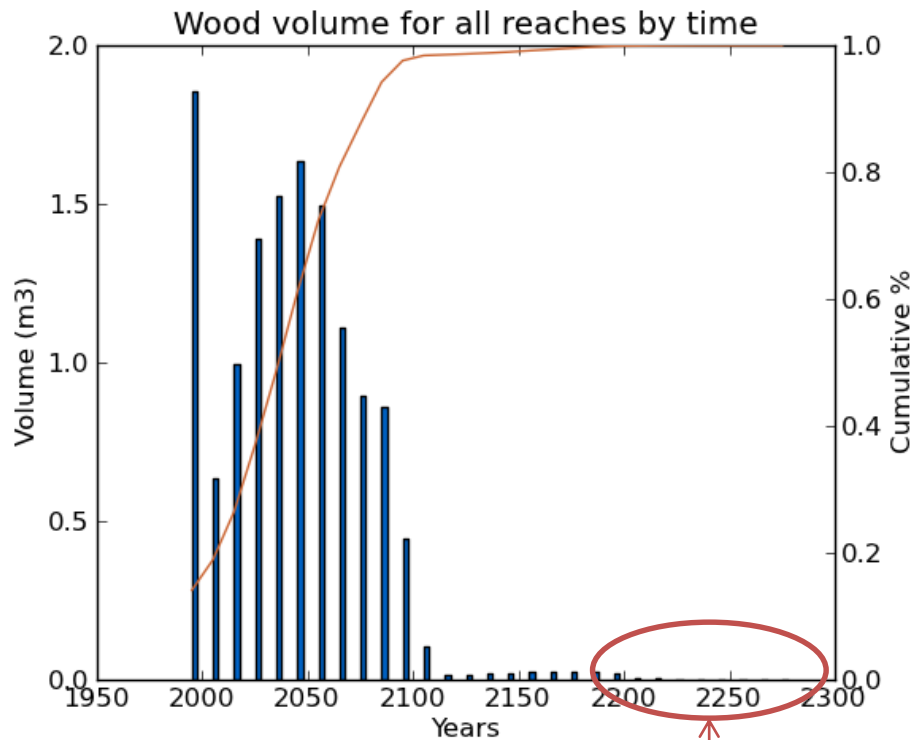


# Wood volume by time ( $\text{m}^3 100\text{m}^{-1} \text{yr}^{-1}$ )

## Thinned 2015

No action buffer

Thinned buffer



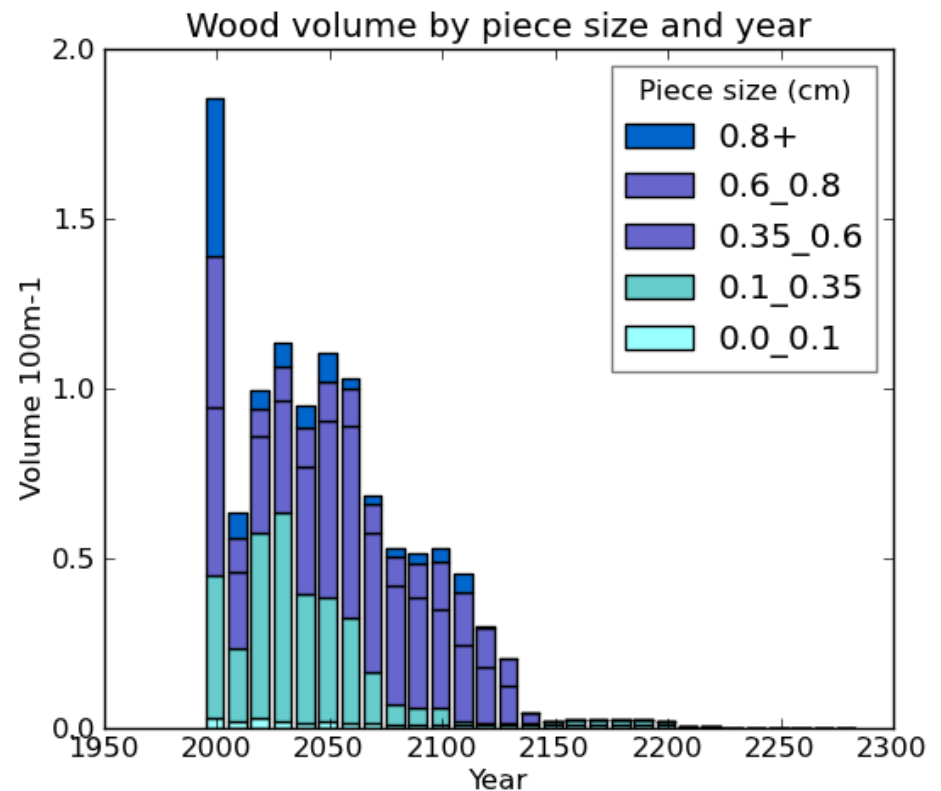
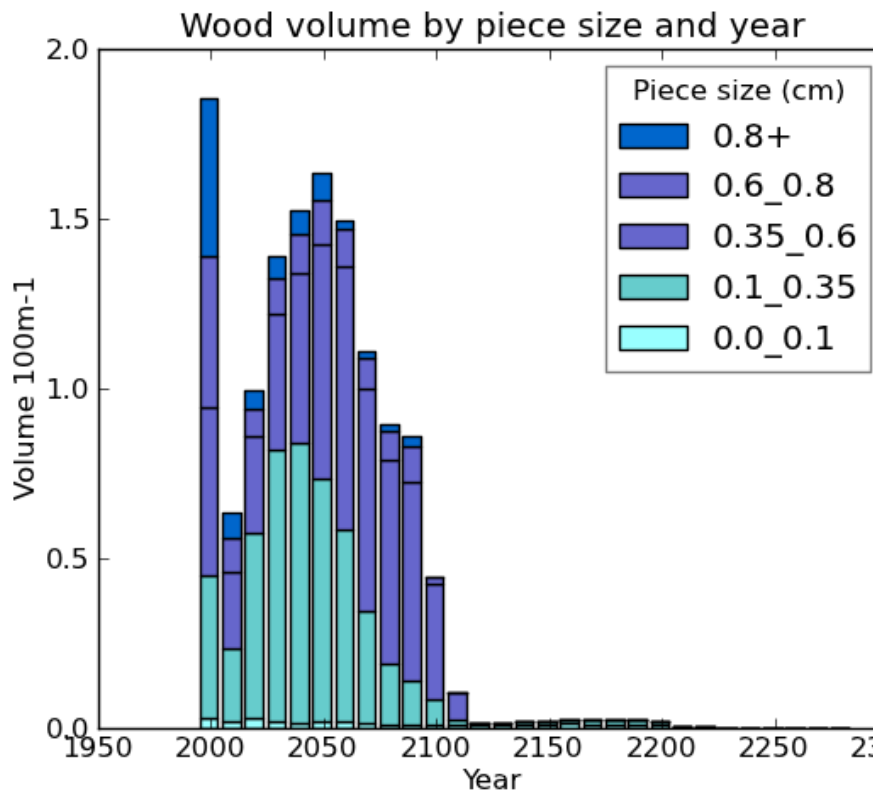
1995: high initial mortality – result of FVS model parameters  
2015: thinned  
2025 – 2085: no action buffer produces more wood  
2095+ : thinned buffer scenario produces more wood

Only one stand had data to 2295, others ended at 2195, hence the low values after 2195

# Wood volume by piece size and time ( $\text{m}^3 \text{100m}^{-1} \text{yr}^{-1}$ ), thinned 2015

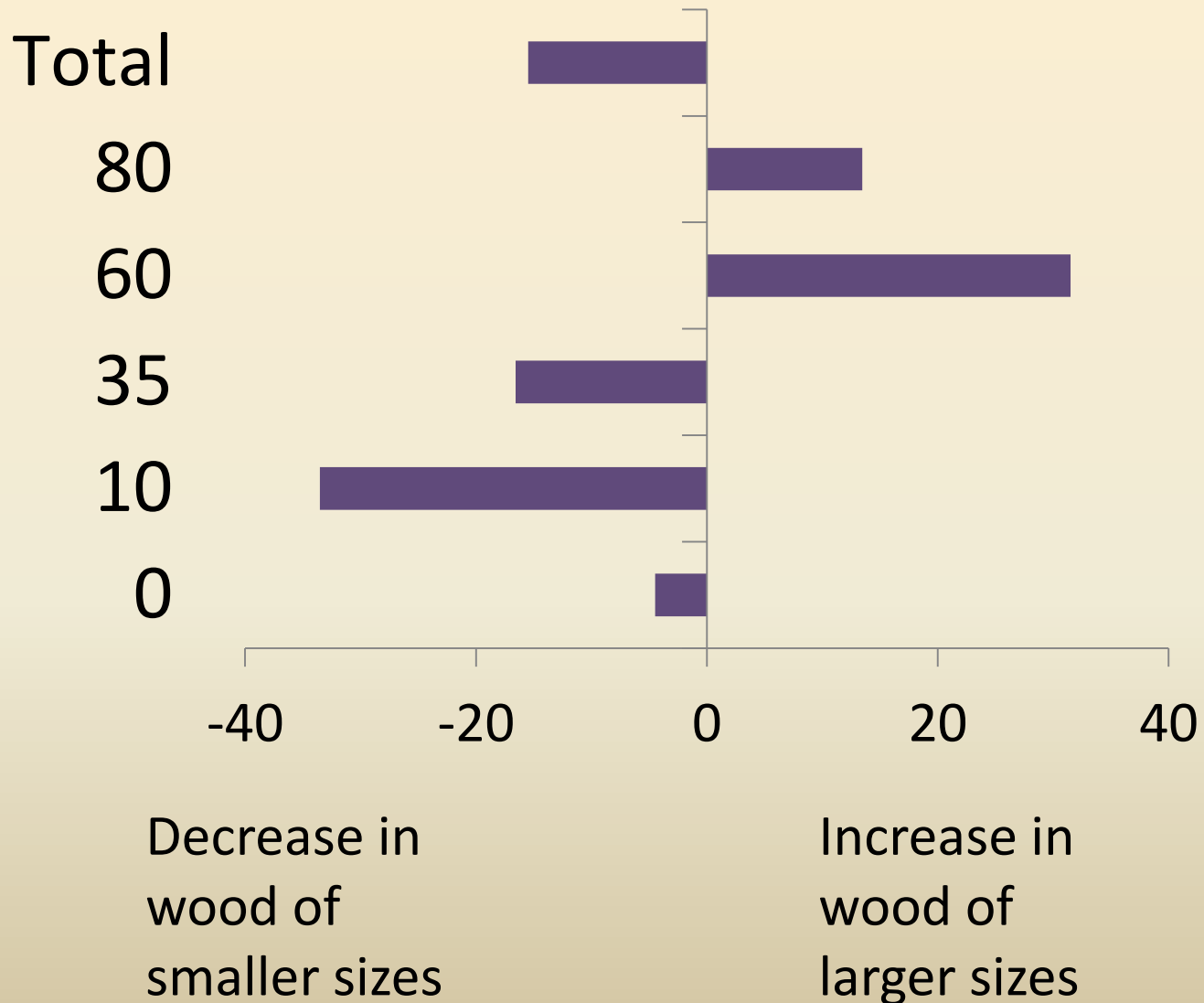
No action buffer

Thinned buffer

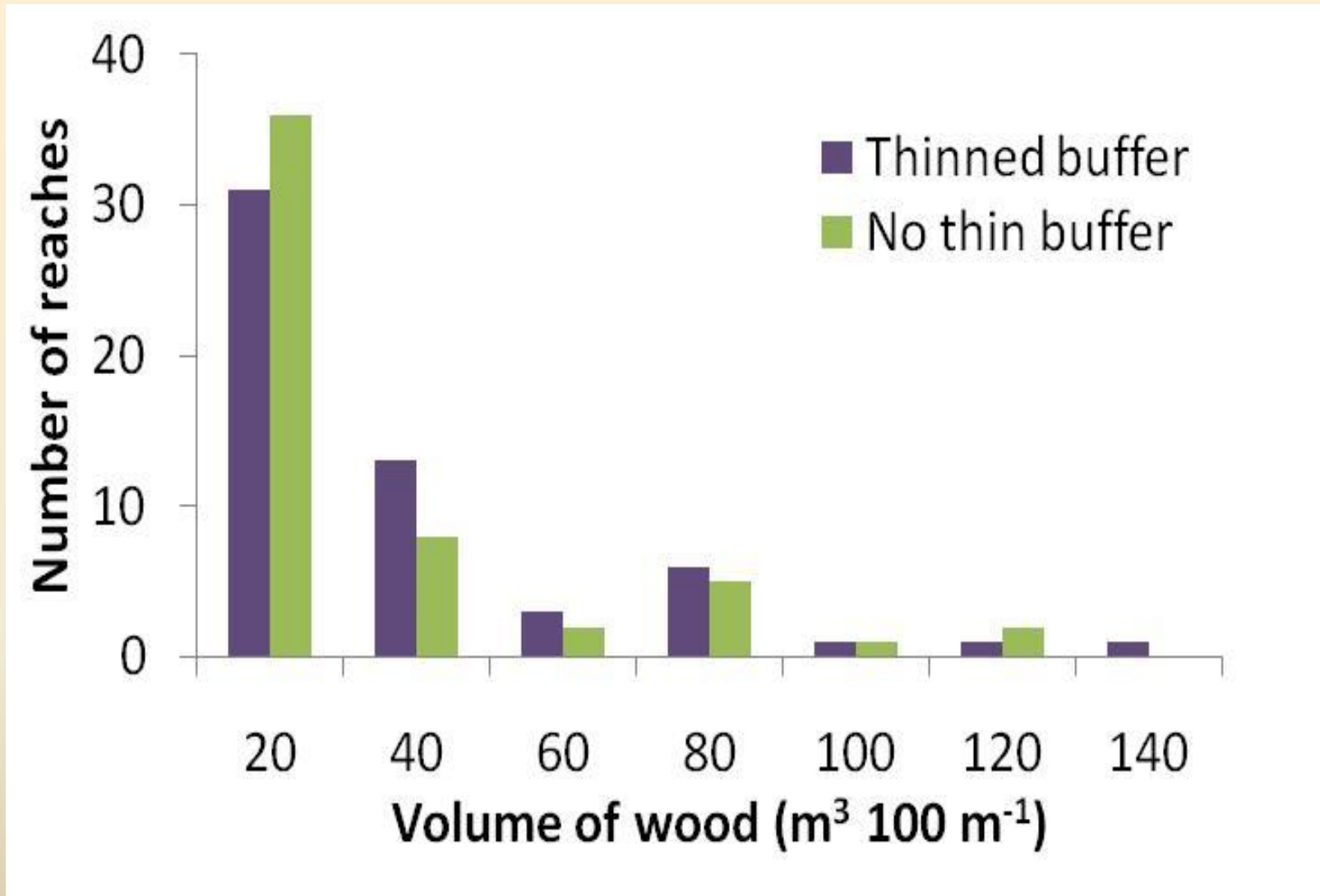


Thinned buffers resulted in a 15% decrease in wood volume

# Percent changes in wood volume by piece size (cm) from no action to thinned buffer

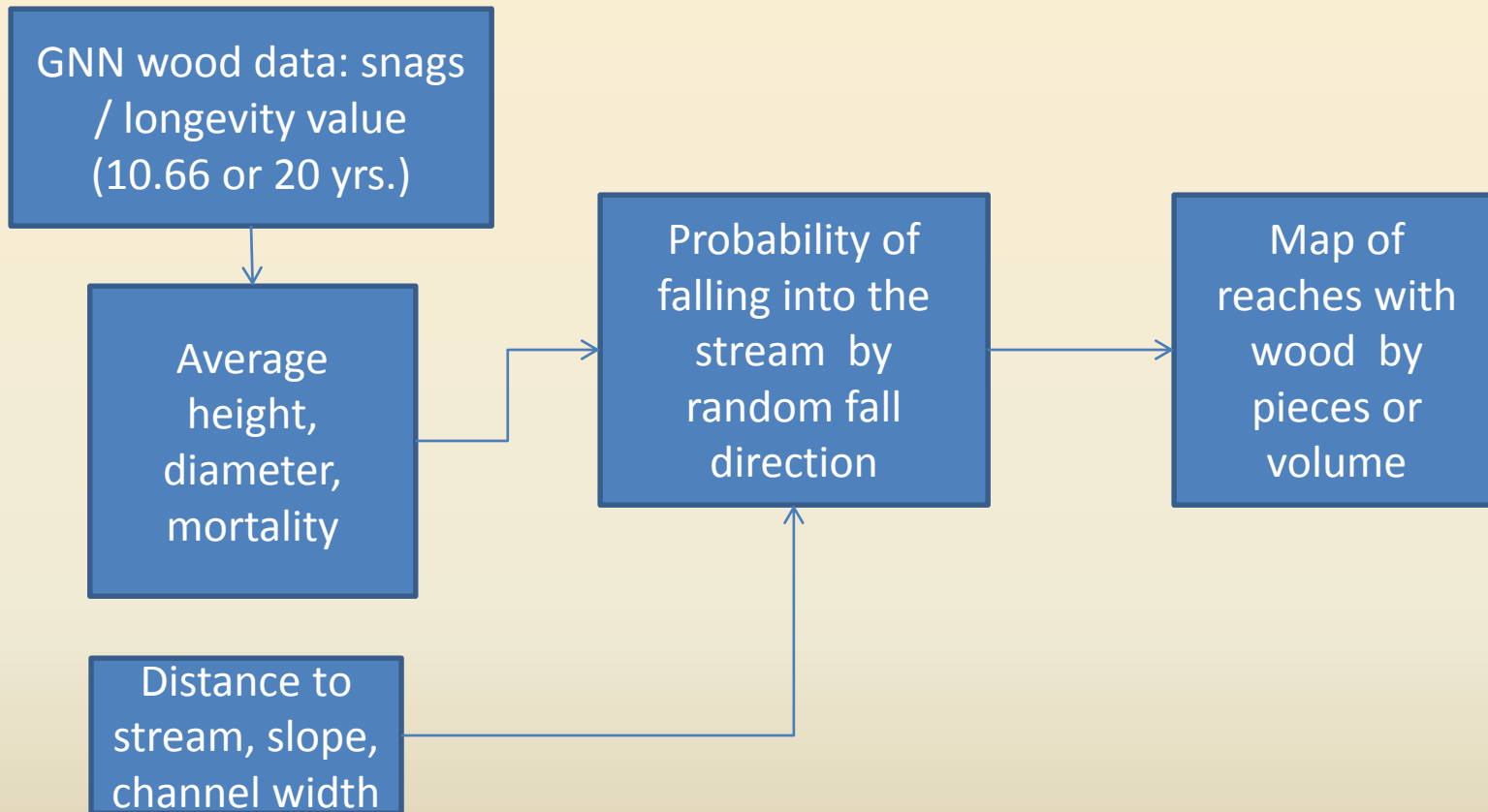


Small reduction in the smallest volumes of wood in storage w/ thinning, increases in larger volumes of stored wood w/thinning

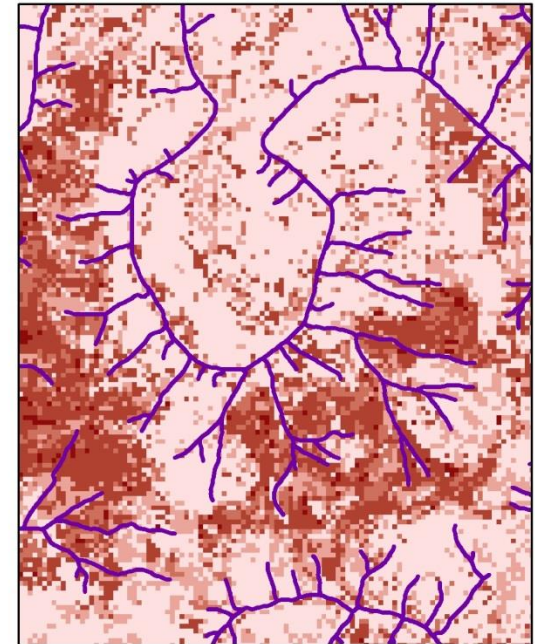


Compare the cumulative distributions of total wood storage, 1000 stream segments over 100 years – not available.

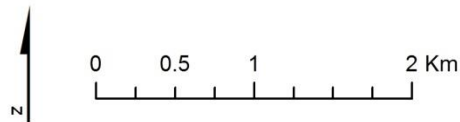
# Step 9. SnapShot wood model (coming summer 2013)



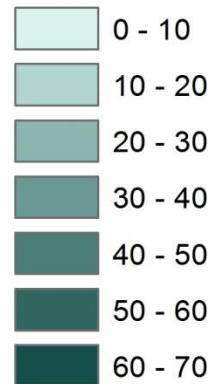
# SnapShot wood model – data availability (coming summer 2013)



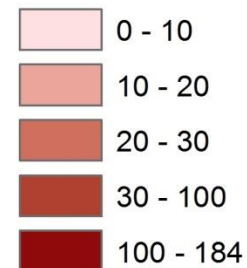
Drainage wings



Stand Height (m)



Snag TPH DBH  $\geq$  25 cm





# Applications for land management

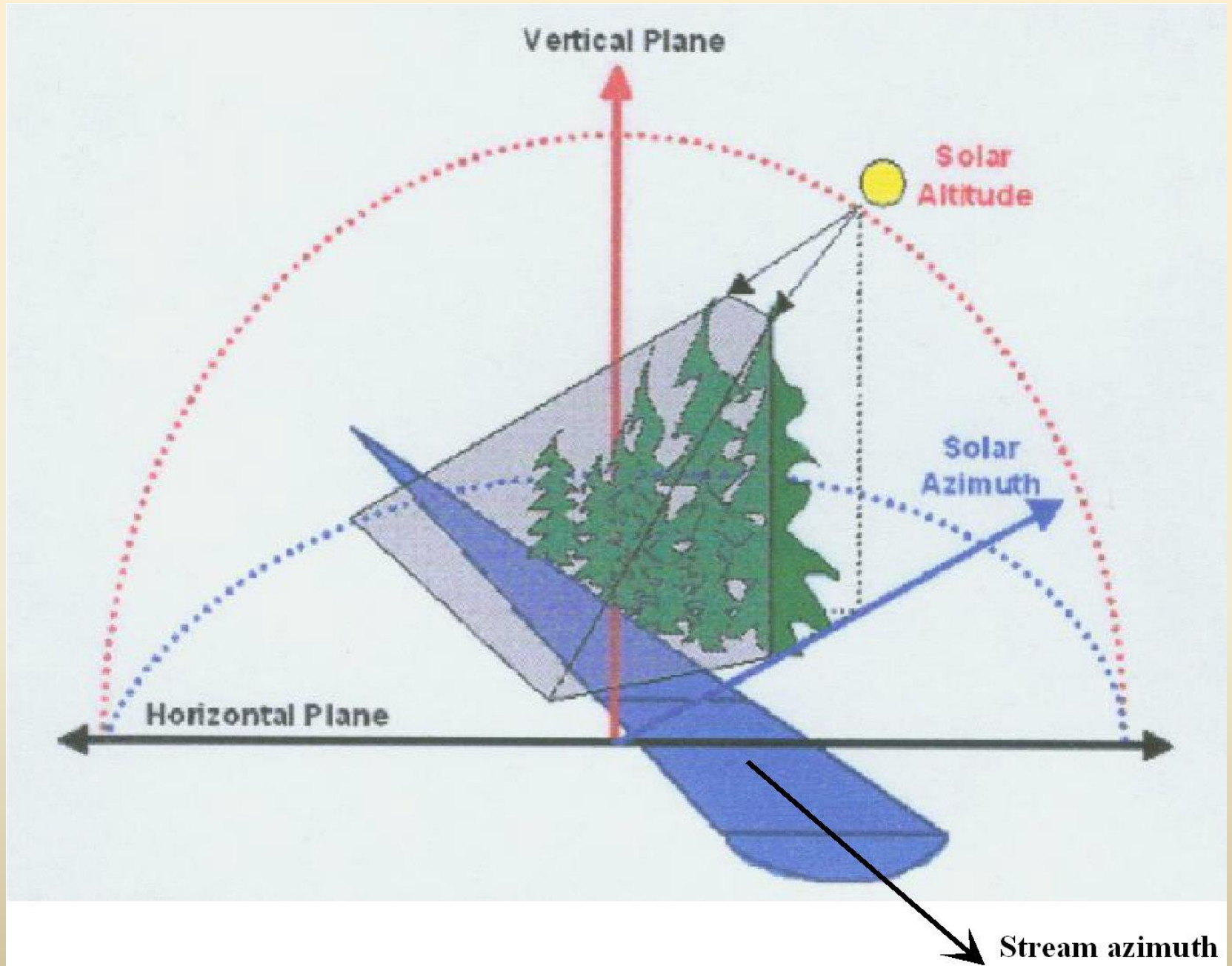
- Multi-scale: reach or project scale v. watershed scale management and analysis;
- Enables spatially variable approach and analysis;
- Designs for riparian treatments – thinning, buffers, habitat;
- Designs for mitigation, enhancement, tree tipping



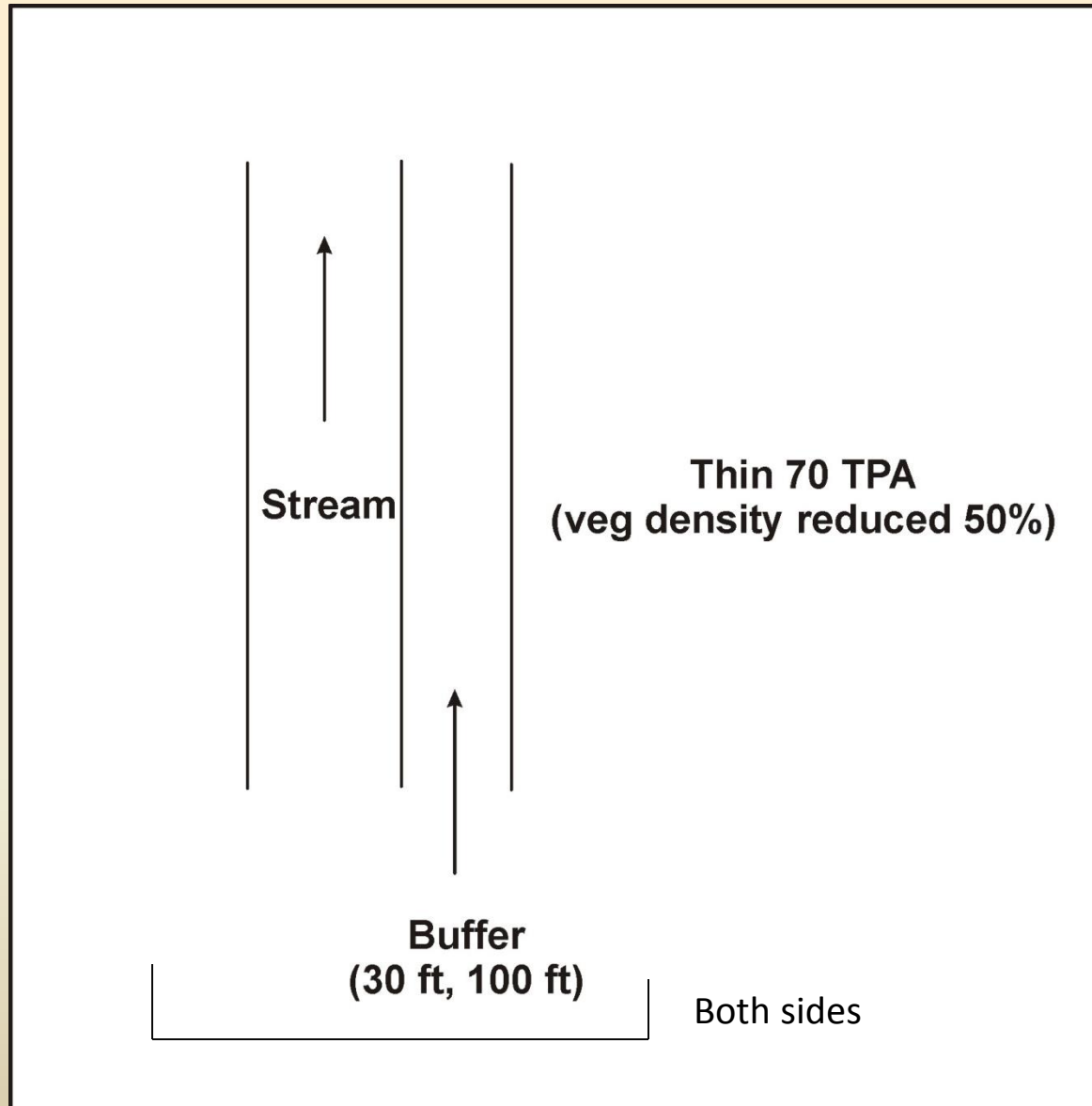


Step 10. Modeling  
stream thermal  
loading for varying  
forest conditions

# Examine the effect of thinning on thermal loading




# Evaluate buffer designs



# NetMap: Thermal Tool Interface

NetMap: Thermal loading tool

The thermal loading tool calculates incoming solar radiation for July 20th which is the hottest day of the year on average. Solar radiation is calculated for bare earth and for forest conditions in riparian and outer stands, on each stream bank; the difference between the two conditions is also calculated. Solar radiation is attenuated by forest stand conditions (average tree height, stand width, and vegetation density) using Beer's Law. Channel aspect is used to determine the solar direction relative to stream banks. Hillslope gradients are assumed to be a constant 10%. Stream left and right banks are determined looking downstream. After the calculations are complete, maps may be displayed to show solar radiation in Watts / m2.  
Note: Future development of this tool will enable the use of spatially explicit hillslope gradients in calculations.



1. Average tree height (m) Left: 48 Right: 48

2.  Selected reaches only

3. Riparian Buffer Forest

Left Right

Buffer Width, m 200 200

Veg Density (0 to 1) 0.70 0.70

4. Outer Forest

Set density to 0 to ignore.

Left Right

Buffer Width, m 20 20

Veg Density (0 to 1) 0.00 0.00

**Run** **Help**

**WARNING:** This tool, when run at the watershed scale, may require several hours processing time. Time required will depend on the number of reaches selected. A few reaches may take only a few seconds but the time involved increases linearly with increasing number of stream segments.

Map options for displaying output (Watts / m2):

Total radiation, vegetated conditions  Total radiation, bare earth  Difference between bare earth and vegetated

Fish-bearing reaches only **Display Results**

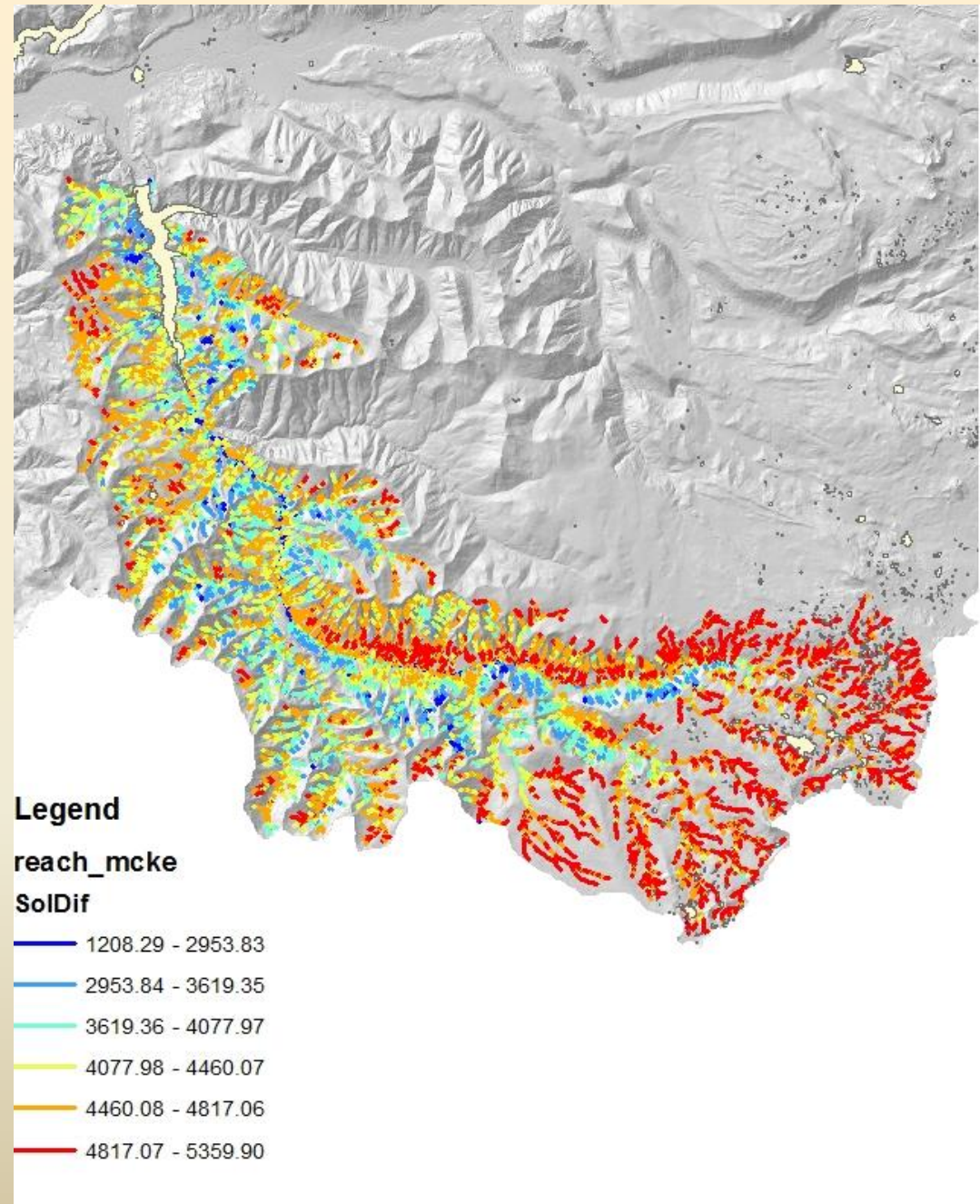
Utilities

Save current input values as default Save reach selection

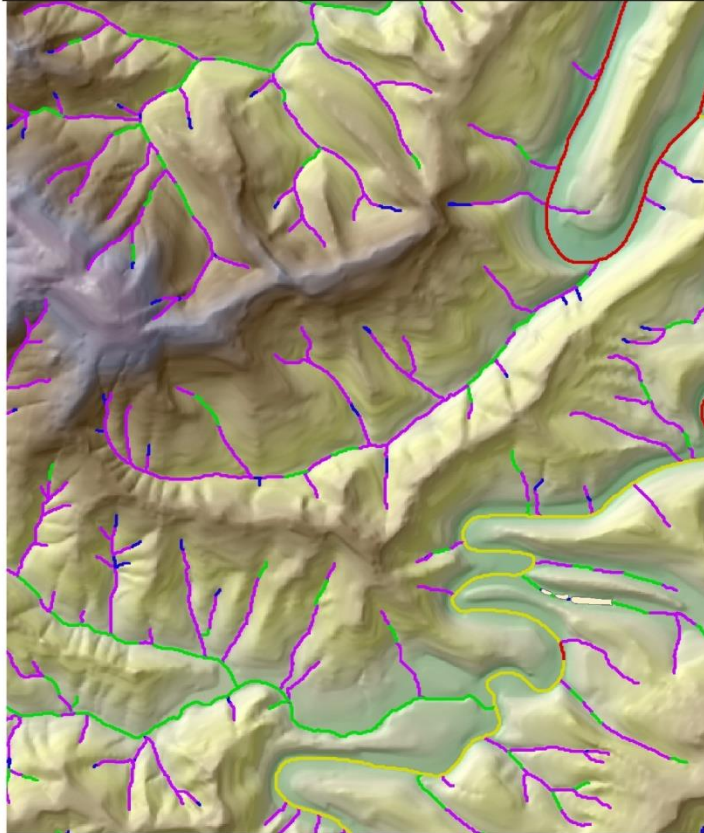
Reset all results to 0 Clear reach selection

Display All Reaches Load reach selection **Close**

Thermal tool sensitivity analysis:  
difference between fully vegetated  
and bare earth



Thermal load (watts/m<sup>2</sup>)  
no action, 0.8 veg density



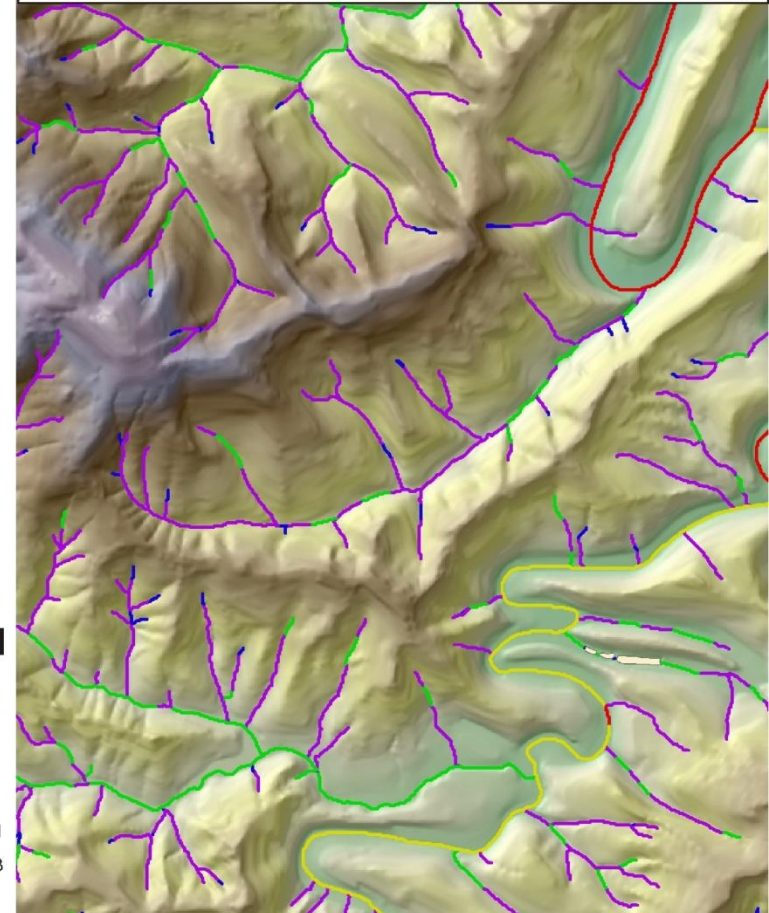
Thermal load  
(watts/m<sup>2</sup>)

- 22.47 - 269.57
- 269.57 - 573.63
- 573.63 - 1196.42
- 1196.42 - 2295.91
- 2295.91 - 4112.63

0 0.4 0.8 1.6 Kilometers

No thermal effect with  
100 ft buffers w/thin beyond

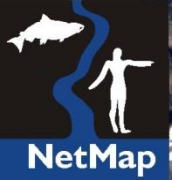
Thermal load (watts/m<sup>2</sup>)  
100 ft buffer, thinning beyond  
to 0.4 veg density



Thermal load  
(watts/m<sup>2</sup>)

- 22.47 - 269.64
- 269.64 - 573.71
- 573.71 - 1196.42
- 1196.42 - 2295.91
- 2295.91 - 4112.63

0 0.4 0.8 1.6 Kilometers



# NetMap Tools

[Back to Lee ...](#)



# Step 12 - Assemble the pieces and design forest management and watershed restoration (one hypothetical example)

No coho/steelhead habitat  
thin to deciduous band  
(no buffer, thin) - target:  
larger trees riparian avian, mammal

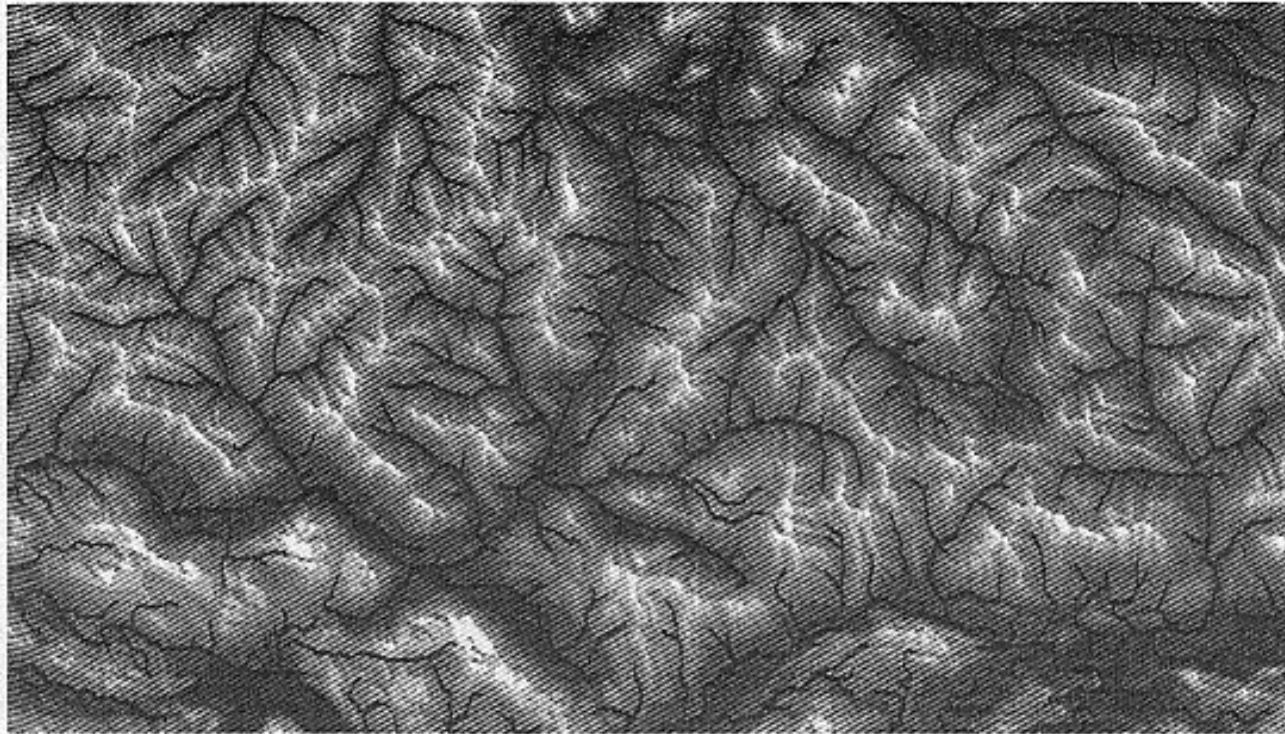
Best coho/steelhead habitat  
(100' buffer, thin beyond) - target: no stream  
effect or longitudinally variable  
buffer (30-100') to increase  
large wood to habitat (marginal  
effect on all wood loading,  
increase in large wood loading)



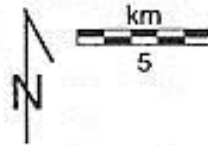
Debris flow delivery of  
large wood to fish habitat  
(incl. coho/steelhead),  
thin in some swales or/and upper mainstem,  
no buffer - target: increase large wood to fish habitat  
via landslides/debris flows

Add road restoration  
activities to reduce  
mass wasting & surface  
erosion

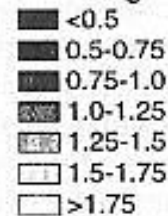
# Spatially variable fire frequency based on landscape position



Tilton-Mineral



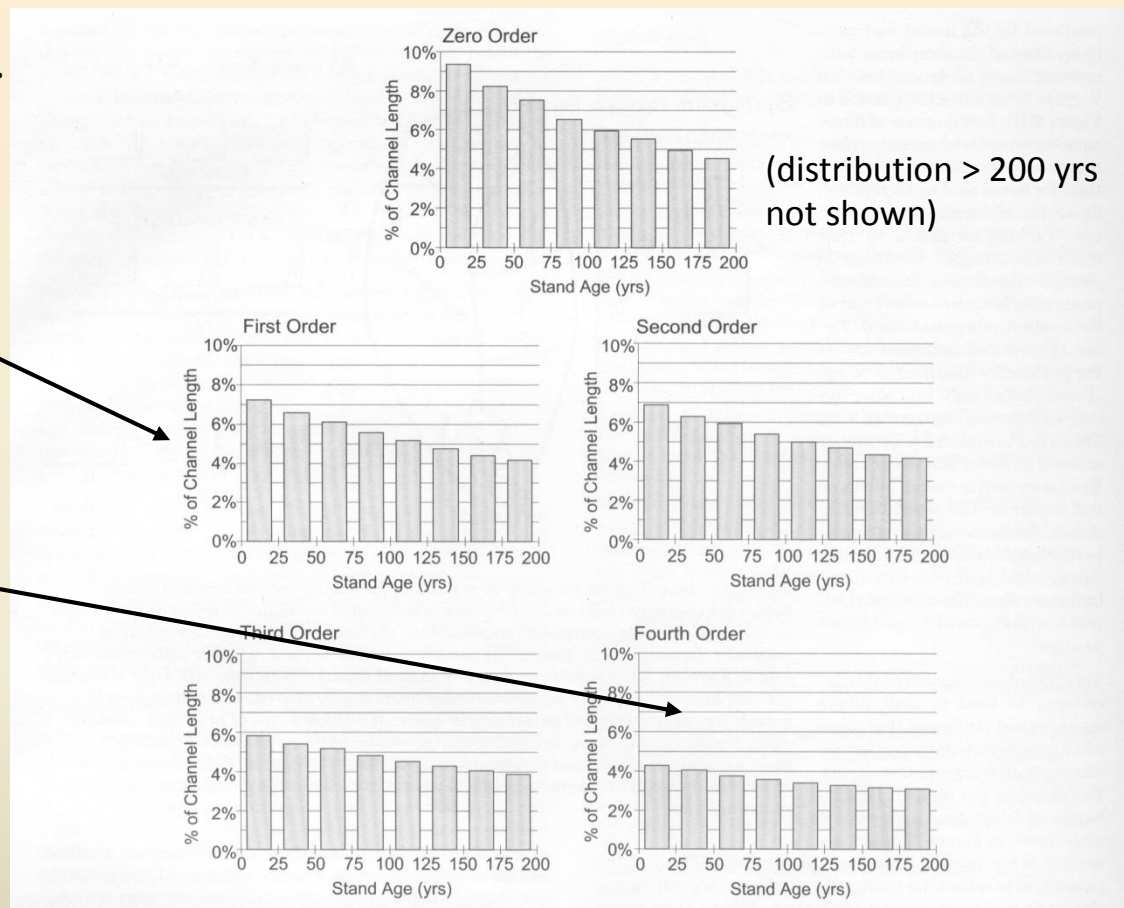
Relative Probability  
of Burning



# Step 13: (optional): Run forest fire simulation models (with topographic dependency on fire frequency) to predict spatially heterogeneous nature of forest ages, including in riparian zones

On average, over time, approx. 14% of the total length of first-order streams are predicted to have forests less than 50 yrs old

Drops to 8% along larger valley floors



(distribution > 200 yrs not shown)

Figure 11. Probability distributions of riparian forest ages, including for landslide sites. The average proportion of channel length with forest stands of a particular age, using 25-year bins up to 200 years (forests greater than 200 years not shown) was tabulated for zero-order (i.e., landslide sites) through fourth order. These predicted histograms indicate, that on average, the proportion of the channel length containing trees less than 100 years old varies from 30% (zero order), 24% (first-order), to 15% (fourth order). The decreasing amount of young trees with increasing stream size is a consequence of the field estimated susceptibility of fires. Fire frequency was the highest on ridges and low-order channels (~175 yrs) and the lowest (~400 yrs) on lower gradient and wide valley floors.

Results from southwest Washington (GTR-101-CD, 2002)



# NetMap

Community Digital Watersheds & Shared Analysis Tools

[www.netmaptools.org](http://www.netmaptools.org)

Earth Systems Institute  
[www.earthsystems.net](http://www.earthsystems.net)  
Seattle/Mt. Shasta/Fort Collins