Response of forest aquatic ecosystems to riparian canopy modifications

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Experiment made feasible due to Green Diamond's aquatic HCP (experimental watersheds and incidental take) and BOF VTAC

REVIEW DRAFT

Site-Specific Riparian Zone Management:

Section V Guidance Document

Anadromous Salmonid Protection Rule Section V

Technical Advisory Committee (VTAC)

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Sacramento, California

Current Collaborators

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- Dr. Ken Cummins, private consultant
- Dr. Lee Benda, private consultant (Earth Systems Institute), Mount Shasta, CA
- Dr. Caren Goldberg, Research Scientist, Washington State University, Pullman, WA
- Dr. Trent McDonald, statistician, WEST, Inc., Cheyenne, WY


Riparian Functions
• LWD recruitment
• Water temperature control
• Microclimate buffering
• Sediment control
• Nutrient input

Historical Timber Harvesting Practices

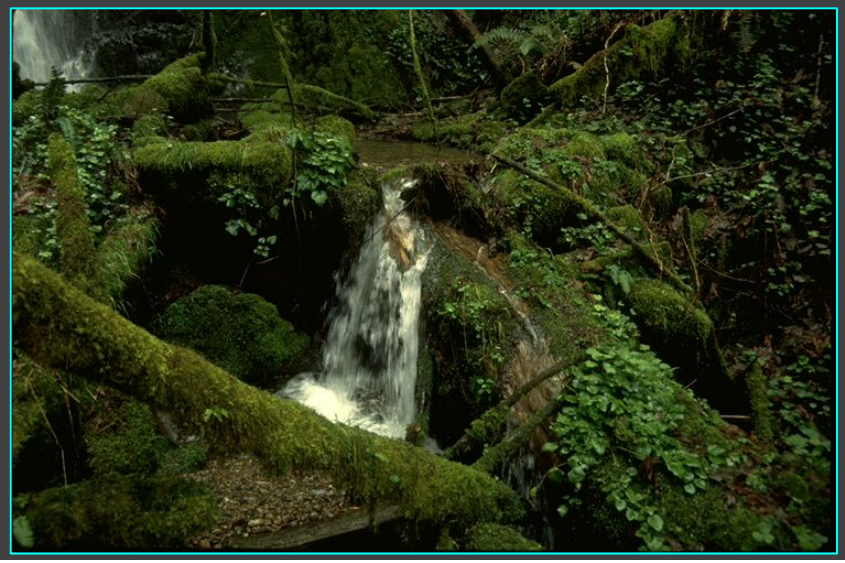
Union Logging Co., Pudding Creek, Mendocino Co., 1921

Courtesy Fritz-Metcalf Collection


Salmon Creek in
Headwaters Forest

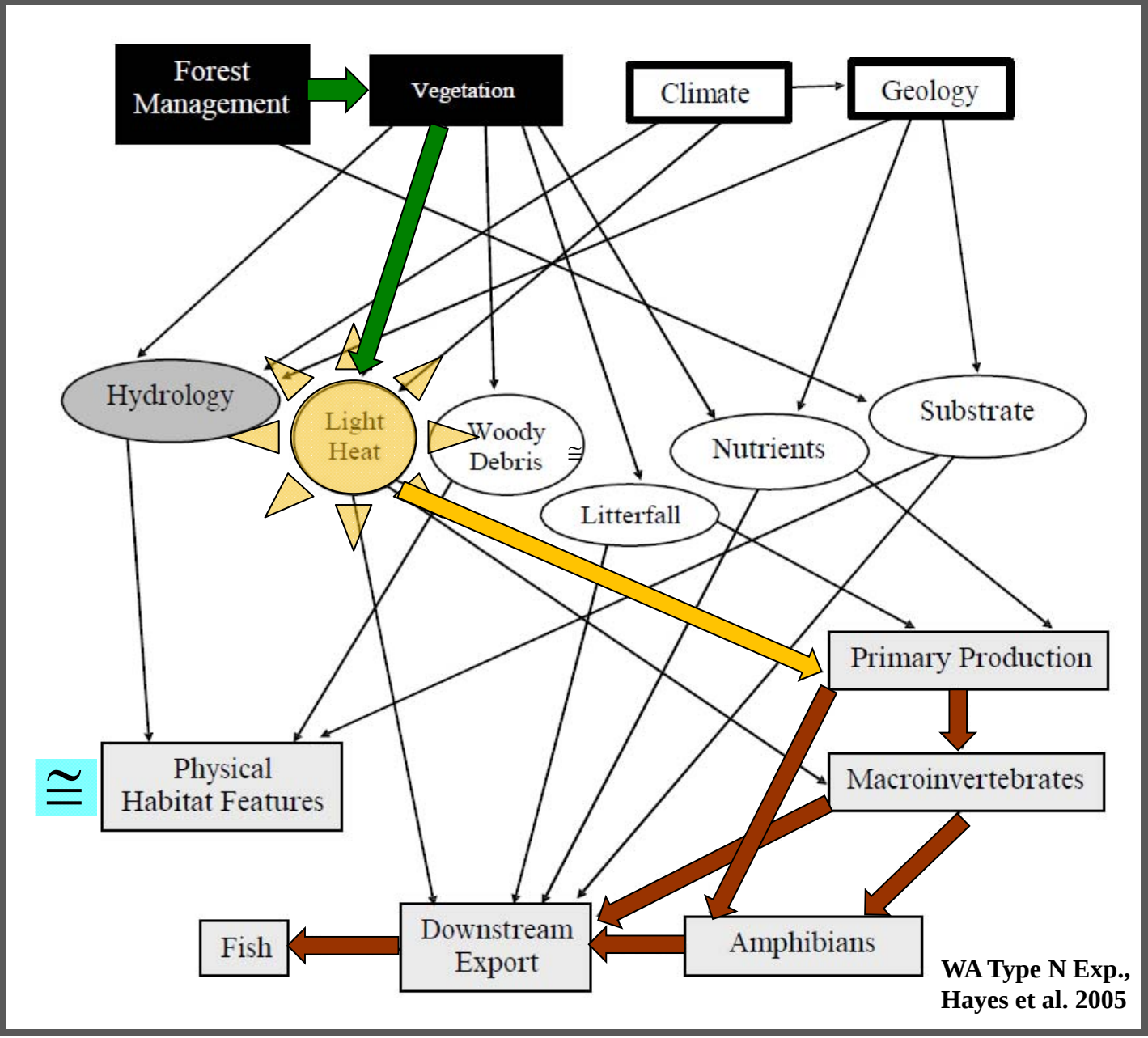
Trend in Riparian Management

Riparian policies promoting large conifers adjacent to all streams may not be scientifically supportable (Burnett et al. 2006)




Factors limiting stream productivity
• Hydrology
• Habitat/LWD
• Water temperature
• Nutrients
• Sunlight – may be most limiting in small forested NW streams

Watershed Interactions: Energetics vs Disturbance



Previous experiments to test the effects of canopy manipulations

Results of riparian canopy opening and salmon carcass addition experiment (Wilzbach et al. 2005 and Harvey and Wilzbach 2010)

- Effects of riparian canopy opening and addition of salmon carcass on biomass, density and growth rates of juvenile salmonid in SF Rowdy, Savoy, Little Mill, Peacock, Tarup and Tectah Creeks.
- 100-m reach with all hardwoods removed, and on the same stream, 2nd 100-m control reach with an intact canopy.
- Salmon carcasses added to half of the cut and uncut reaches
- Cutthroat and rainbow trout responded positively to canopy removal but there was no measureable effect from carcass addition.
- 100-m openings only had minor effects on water temp

"Stream-associated Amphibian Response to Manipulations of Forest Canopy Shading", (MacCracken et al. *In review*)

- Using a BACI design, manipulated vegetation cover, retaining ≈ 0%, 30%, and 70% canopy on 50-m treatment reaches separated by >50m with a paired reference reach where cover was near 100%.
- Study 2004-2007 in 26 headwater streams in NW Oregon and W Washington, each with a paired reference reach
- **Conclusion**: Intermediate levels of canopy openings appear to be either benign or beneficial for most taxa as long as potential other stressors (increased fine sediment delivery or water temperature) are minimized
- Saw a 2-4^0 C increase in water temp (max and 7-day moving mean) in the lowest canopy retention levels, but did not detect any obvious negative effects on any taxa (increases exceeded regulatory thresholds)

Reference looking into 0% canopy retention

30% canopy retention looking into reference reach

"TYPE N Experimental Buffer Treatment Study", (Hayes et al. *In progress*)

- Using a BACI design with 4 experimental treatments and 5 replicates per treatment for a total of 20 sites
- Two years pre and post-treatment with study conducted from 2005-2011 (budgeted for $3.4 million)
- Treatments included: no buffer, a Forest & Fish Rules (FFR) buffer (50% of the stream has a 50' buffer), a full 50' buffer stream, and an unharvested reference site
- Critical Question: What is the magnitude, direction and duration of change in riparian-related inputs and the response of amphibians and their habitat associated with treatments relative to untreated reference conditions?

Type N 100% 50-foot buffer

Type N 50% 50-foot (FFR) buffer

Type N 50% 50-foot (FFR) buffer

Type N 0% buffer

Response of Forest Aquatic Ecosystems to Riparian Canopy Modifications

- Previous riparian experiment on Green Diamond was restricted to inferences on stream reaches.
- The proposed experiment will start with a similar stream-reach approach on a single stream and transition into watershed level inferences

Study Objective

Study is designed to evaluate the response in terms of growth and abundance of selected key aquatic organisms including juvenile salmonids, a headwater amphibian (coastal giant salamander) and macro-invertebrates to modifications of the riparian canopy.

Special Considerations

- NetMap will be used to guide the type, extent and spatial distribution of canopy manipulations that are likely to have positive benefits to the selected aquatic organisms without causing adverse impacts to other aquatic resources.
- If deemed necessary, potential future loses in wood recruitment will be mitigated by tipping trees into the treated streams following completion of the study.

Biological Response Variables

- Fish-bearing reaches
  - Estimate abundance and growth of juvenile salmonids and larval coastal giant salamanders through capture, PIT-tagging and recapture
  - Macro-invertebrate functional groups estimated by food habits of fish and giant salamanders

Biological Response Variables

- Headwater reaches
  - Abundance and growth of giant salamanders is the primary response variable – measured the same as in lower reaches
  - Will also monitor distribution and occupancy using eDNA and population genetics (i.e., changes in effective population size and genetic connectivity) of coastal tailed frogs and southern torrent salamanders

Physical Response Variables

- Thermal loading/Water temperature – NetMap will be used to evaluate radiation inputs (watts/m^2) to stream reaches. Predictions will be made for existing forest conditions and those anticipated following forest openings. Data loggers will be placed at top and bottom of treatment reaches plus 150-300m downstream; expect minor localized effects, but no cumulative effects
- Sediment – NetMap with LiDAR data will predict unstable slopes to avoid or minimize openings. Site inspections will document and direct erosion and TTS station at the mouth of each watershed to monitor cumulative effects.

Physical Response Variables Continued

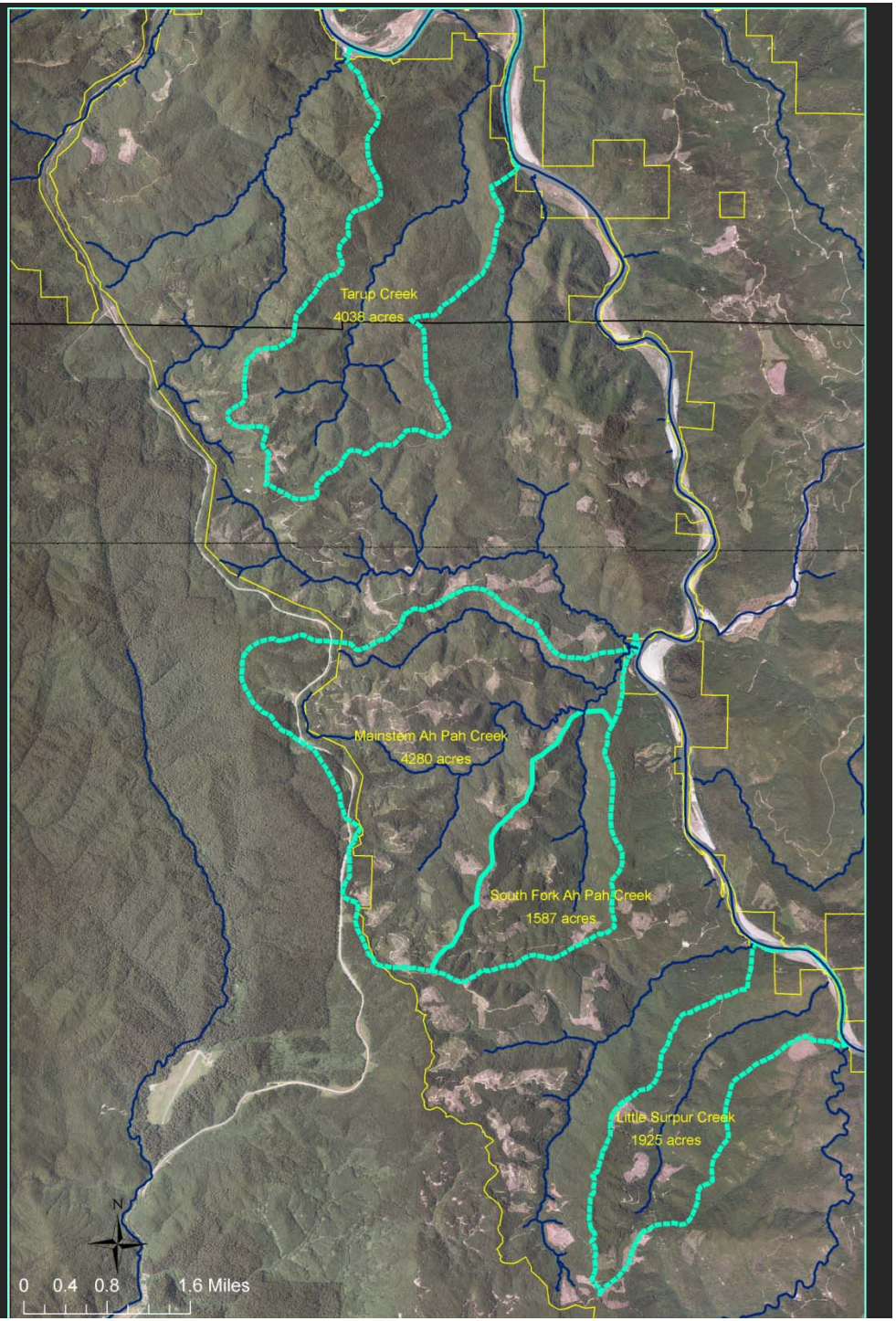
- LWD – Conduct wood budget surveys to quantify the rates of tree mortality and bank erosion that supplies wood to streams. Wood recruitment model in NetMap will be used to predict future recruitment for the study reaches.
- Tree tipping will be used to mitigate any potential "significant" loss in LWD . Tipping will be accomplished by falling trees into channel where possible or using cable yarding system to transport trees into the channel

Physical Response Variables Continued

- Allochthonous inputs – We considered measuring litterfall, but rejected it because it is too difficult to quantify and would not provide data useful to our primary objectives.
- Primary production – Rather than estimating primary production through estimates of periphyton biomass, we will estimate it directly through changes in dissolved oxygen levels.

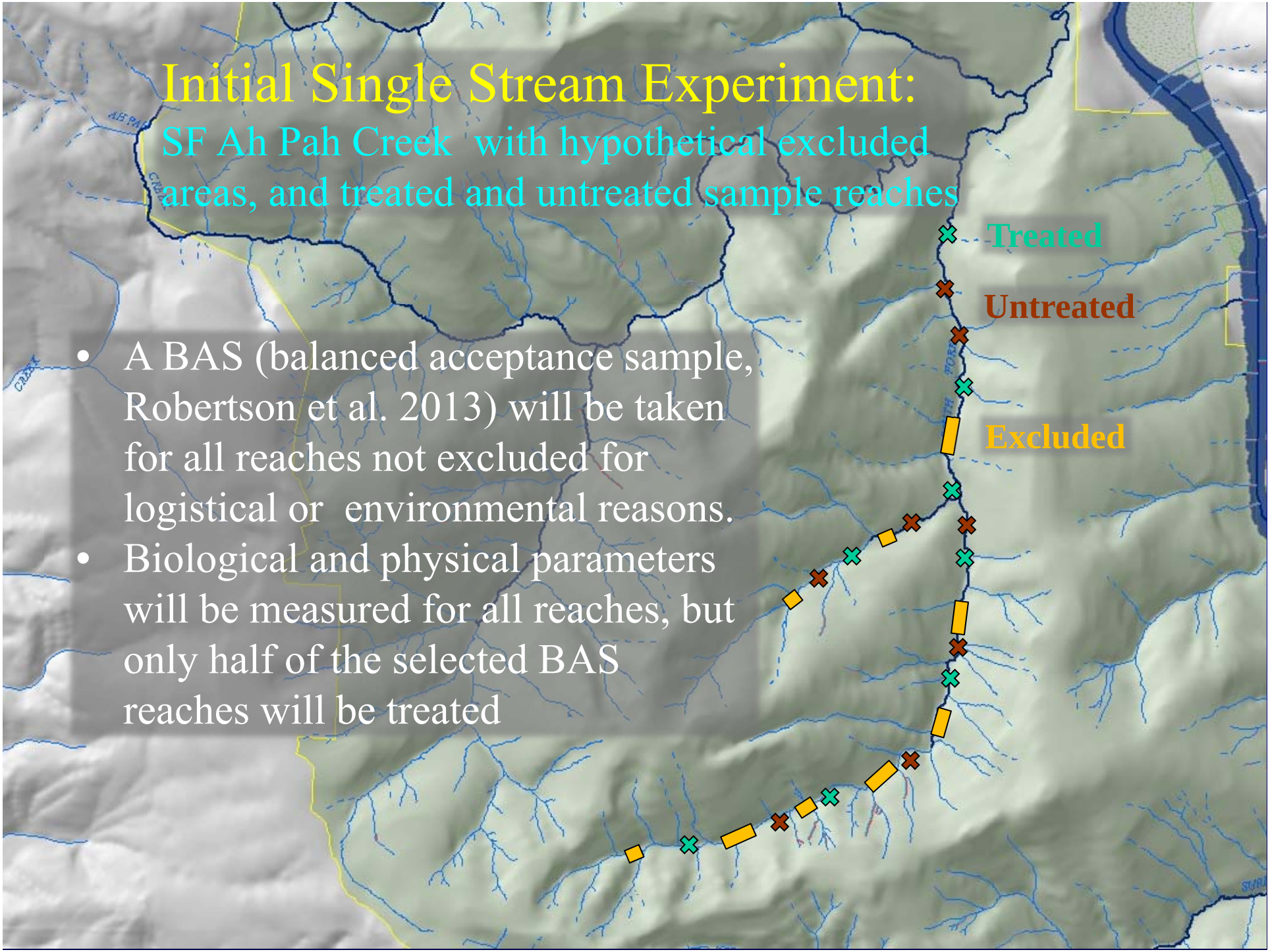
Proposed Study Area

- Tarup Creek (4038 acres)
- Mainstem Ah Pah Creek (4280 acres)
- South Fork Ah Pah Creek (1587 acres)
- Little Surpur Creek (1925 acres)



Initial Single Stream Experiment:

SF Ah Pah Creek with hypothetical excluded areas, and treated and untreated sample reaches



- A BAS (balanced acceptance sample, Robertson et al. 2013) will be taken for all reaches not excluded for logistical or environmental reasons.
- Biological and physical parameters will be measured for all reaches, but only half of the selected BAS reaches will be treated

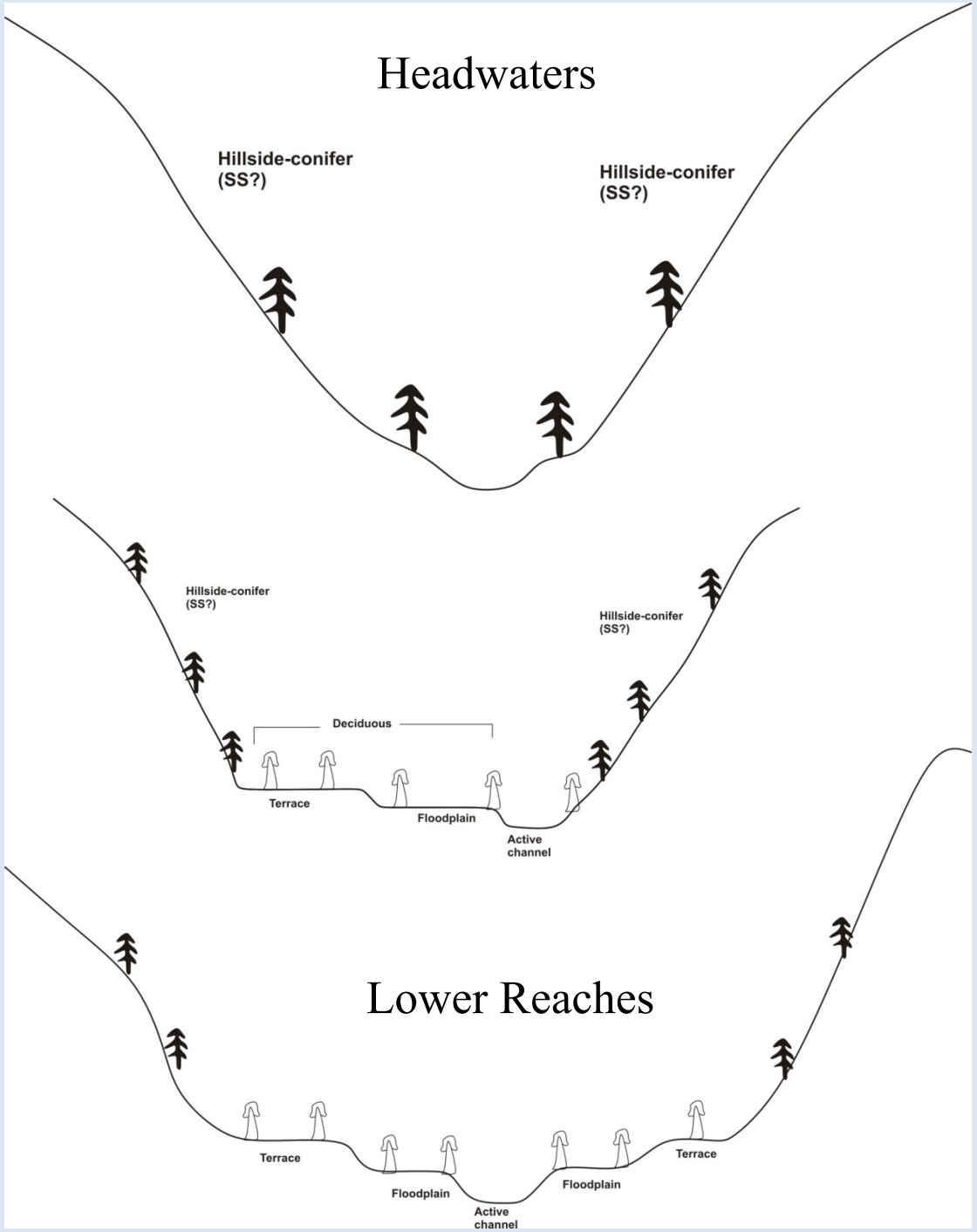
Multiple Watershed-Level Experiment

- Assuming no environmental concerns from the single stream experiment, the experiment will be expanded to all 4 watersheds.
- We will use the same BAS approach to select treated and untreated reaches.
- Little Surpur Creek will get AHCP timber harvesting but no riparian treatments. Technically it will not be a “control”, but it will provide a baseline for physical and biological parameters.
- Trent describes it as a "repeated measures with a randomized complete block design at the reach level".

What do the treatments look like?

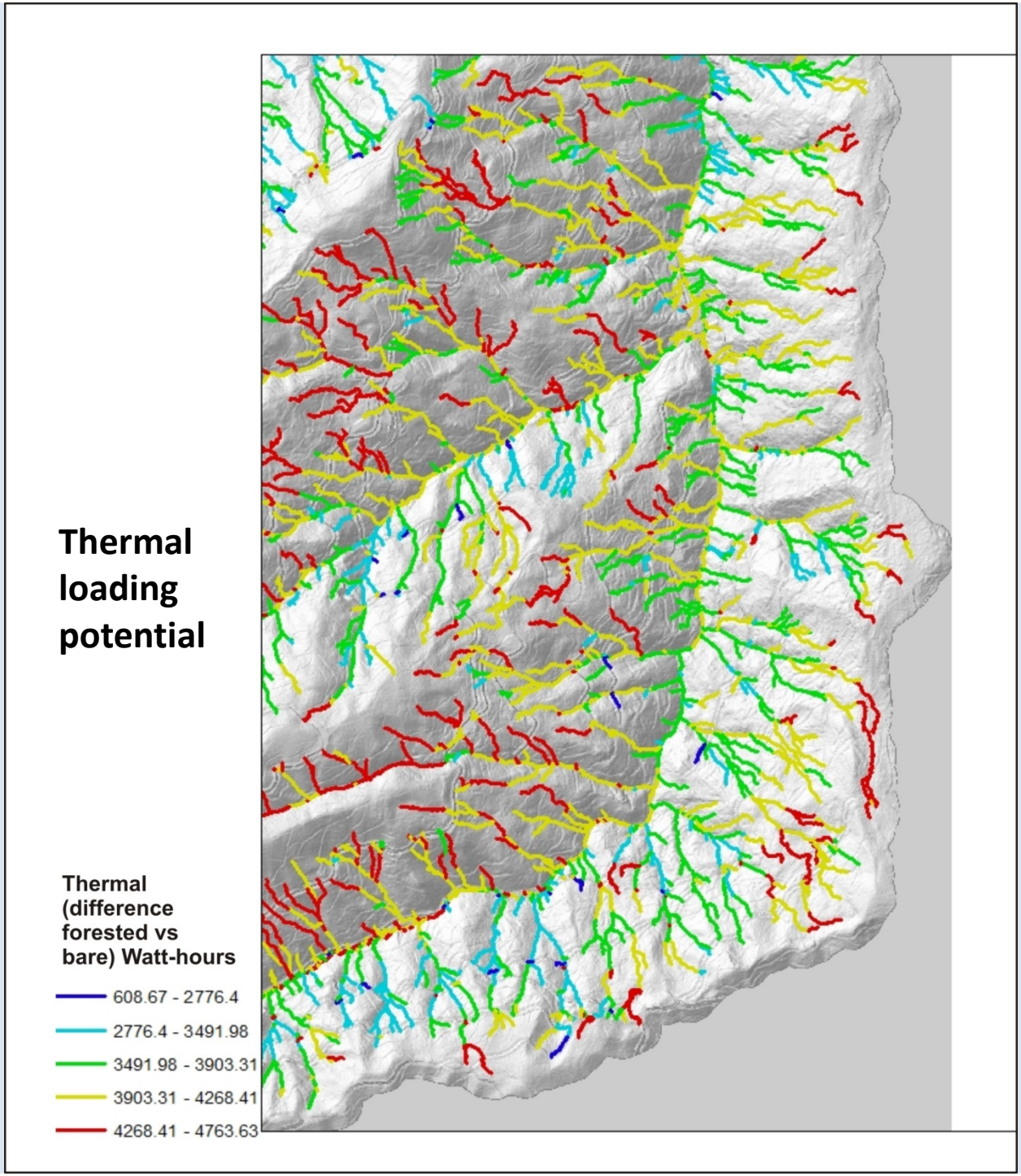
- Goal is to increase solar radiation similar to Wilzbach et al. (2005), but using techniques applicable to timber management
- Treatments will be guided by NetMap to minimize adverse impacts benefits
- Treatments will vary from 200m with 50-60% canopy removal in lower reaches to 50m with same removal in upper reaches
- Use wood recruitment model in NetMap to minimize loss of potential LWD
- If judged to be significant, tree tipping will occur following completion of the experiment.

Channel Types



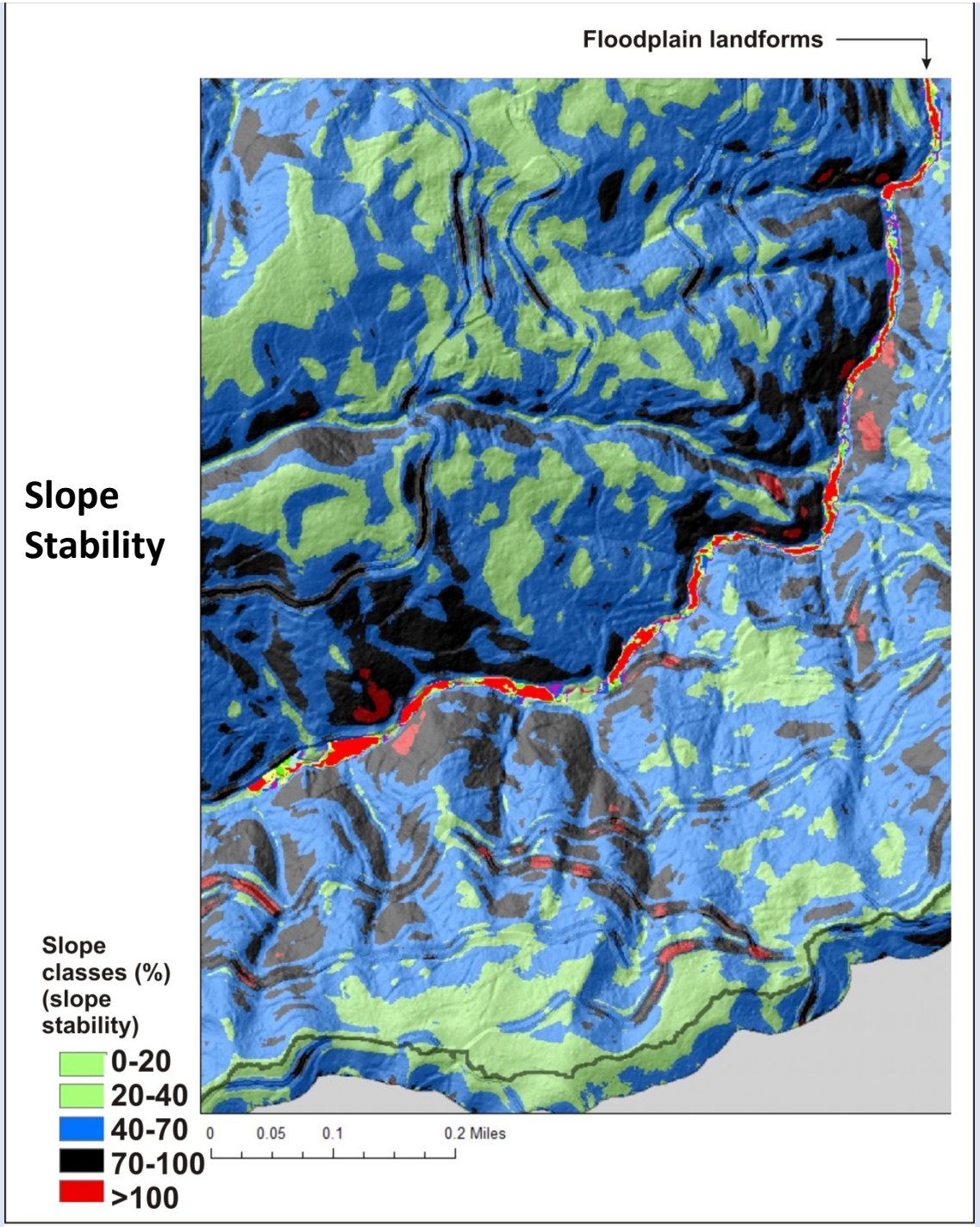
NetMap Analysis

Suite of models developed by Lee Benda to predict reaches sensitive to temp, erosion & LWD recruitment



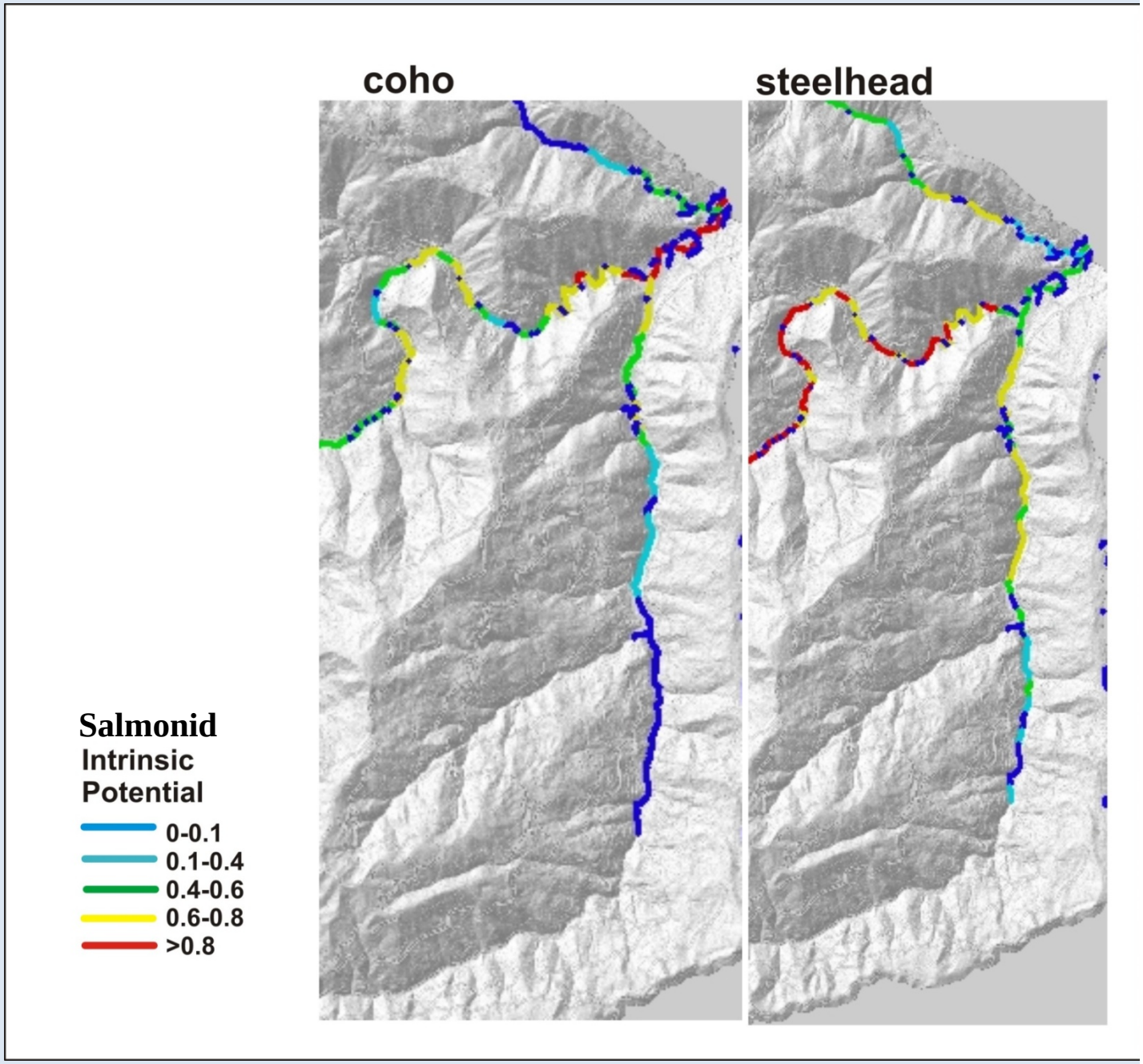
NetMap Continued

Treatments will be laid out to minimize cutting trees on steep and unstable slopes



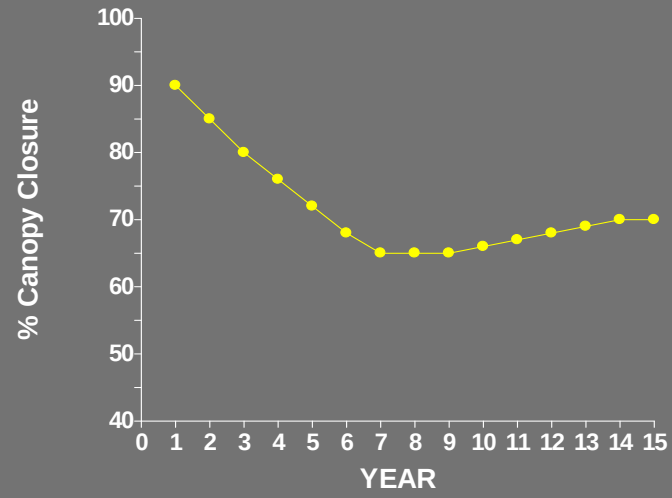
NetMap Continued

With other constraints, we may not be able to use salmonid IP as a selection criterion, but it will be useful as a covariate in the analysis of the results



Watershed Canopy Response

Winter 2002



Fall 2012

Future Application of NetMap

- Experiment is not specifically designed to test NetMap, but the results of the experiment will help refine the predictive ability of the models
- Refined model will allow application of the experimental results to other areas where canopy modifications would likely result in overall beneficial effects without cumulative negative impacts to other aquatic resources.

Potential Timeline for Experiment

- 2012-13: Initial pre-treatment data collected (water temp., turbidity monitoring and juvenile salmonid estimates)
- 2014: First SF Ah Pah treatments implemented; pretreatment data for all the response variables in all the watersheds.
- 2015-17: Expand treatments in SF and mainstem Ah Pah – continue pretreatment data collection in Tarup
- 2018-22: Completion of treatments
- Probably 2024 before the results can be used to make management recommendations

Implications for Future Management

- Past studies have already shown that light is important to forest streams
- There is increasing evidence that healthy and productive forest stream ecosystems should be viewed as dynamic where heterogeneity of riparian forests is generally beneficial
- Assuming positive results from this experiment, future management of riparian forests in coastal redwood forests and potentially other areas include active management to maintain some proportion of openings.