Riparian Corridors, the Link Between Upland and Instream Restoration

A Concurrent Session at the 40th Annual Salmonid Restoration Conference held in Fortuna, California from April 25–28, 2023

Session Coordinators:

- Tom Leroy, Pacific Watershed Associates
- Elise Ferrarese, Trout Unlimited
- David Roon, Oregon State University

Riparian corridors are a crucial component of a healthy ecosystem and provide a link between upland and instream watershed processes. Riparian forests, within coastal streams of the Pacific Northwest, significantly influence the stream morphology and overall productivity of aquatic habitat which can, in turn, provide a basis for the health of salmonids throughout their range. Aquatic habitat conditions and associated riparian ecosystem functions needed by salmon and steelhead are diverse and perhaps only marginally understood, but it is clear that restoring disturbed riparian zones to conditions where they can provide multiple ecosystem services is critical to recovering threatened salmon populations resulting from past anthropogenic disturbances, including industrial logging and development. Riparian forests contribute to bio-fluvial-geomorphic processes and overall productivity of a watershed in myriad ways, including: stream bank stability, instream large wood recruitment, stream shading and temperature regulation, nutrient cycling, sediment capture and filtering, food web productivity, carbon dynamics, flood and drought attenuation, and providing floodplain dead standing and downed large wood. In this session we invite speakers to present research and case studies related to riparian forest restoration, and linkages between riparian conditions and salmonid life-cycle requirements. We encourage speakers to create presentations that allow the audience to understand the importance of characterizing existing riparian conditions, evaluating and determining desired future conditions, and developing action plans for riparian forests that allow them to reestablish fully functioning ecosystem services.

Presentations

- Slide 4, **Redwoods Rising: Resetting the Standard of Parks Management**, Andrew Morin, *National Park Service*
- Slide 37, **Incorporating Invasive Species Management into Riparian Restoration Design and Implementation at the Redwood National and State Parks Visitor Center and Restoration Project**, Amy Livingston, *McBain Associates*
- Slide 59, **Evaluating the Effects of Riparian Forest Thinning on Stream Ecosystems in Coastal Northern California Watersheds**, David Roon, Post-doc, *OSU*
- Slide 107, **Is More Light Good for Fish?: Results from a Riparian Buffer Manipulation on Private Timberland in the Oregon Coast Range**, Ashley Sanders, *OSU*
- Slide 141, **Effects of Experimental Riparian Canopy Gaps on Fish, Salamanders, Biofilms and Ecosystems Processes in Headwater Streams**, Dana Warren, *OSU*
- Slide 200, **Riparian Canopy Modification Experiment: Lessons Learned and Results from Salmonid and Coastal Giant Salamander Monitoring in an Experimental Watershed in Northwestern CA**, Mathew Nannizzi, *Green Diamond Resource Company*
- Slide 223, **Effectiveness of Meadow and Wet Area Restoration as an Alternative to Watercourse and Lake Protection Rules**, Christopher Surfleet, Cal Poly, *SLO*

Resetting the Standard of Parks Management

REDWOODS RISING™

Andrew Morin – National Park Service

Marisa Parish Hanson – CA Dept of Parks and Recreation

NATIONAL PARK SERVICE

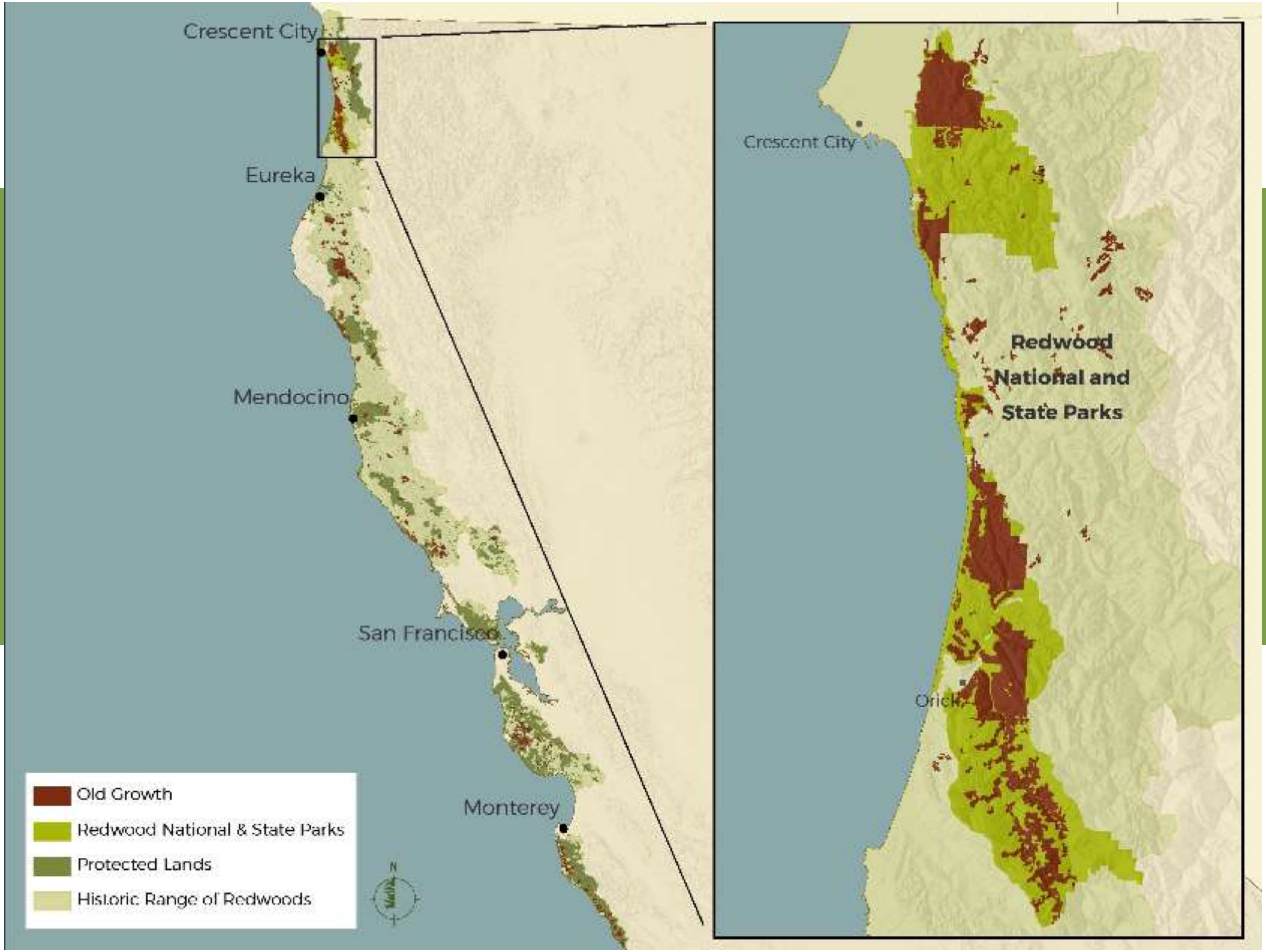
Save The Redwoods LEAGUE

CALIFORNIA STATE PARKS SINCE 1864

Overview

- Prairie and Mill Creek Histories
- Redwood Rising Project Background
- Mill Creek current and future work
- Prairie Creek current and future work
- Monitoring

Project Area



Historic Actions




Redwood National and State Parks

Restoration work began in the 1980s

Thinning of previously clearcut forest

Rehabilitation of stream channels

Logging Road removal

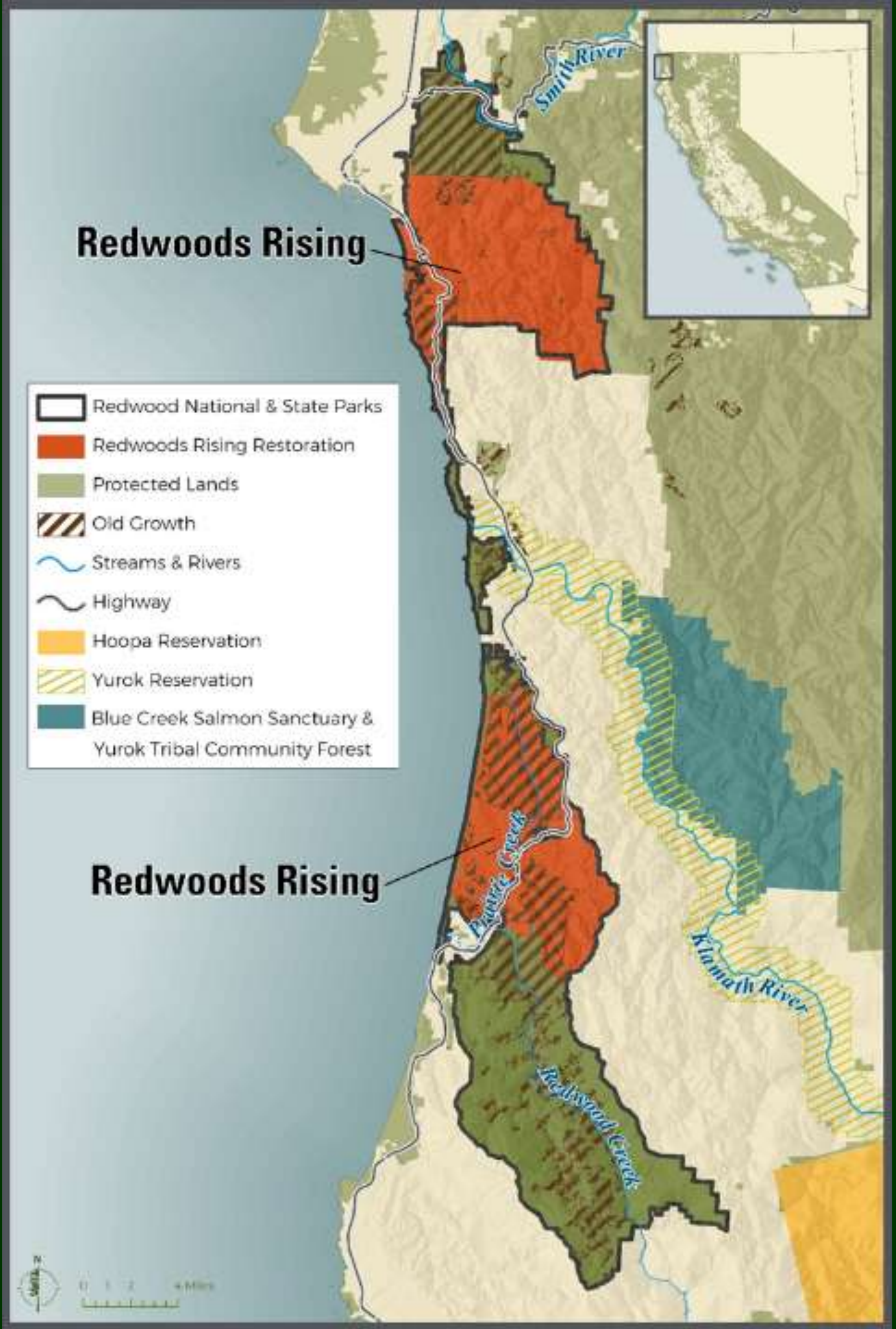
Redwoods Rising Restoration Goals

Accelerate the recovery of previously logged forests to mature forest structure and function

Create connectivity between the remaining fragments of ancient coast redwood forest

Improve stream habitat, reduce erosion, & restore hydrology

Enhance landscape resiliency to a changing climate

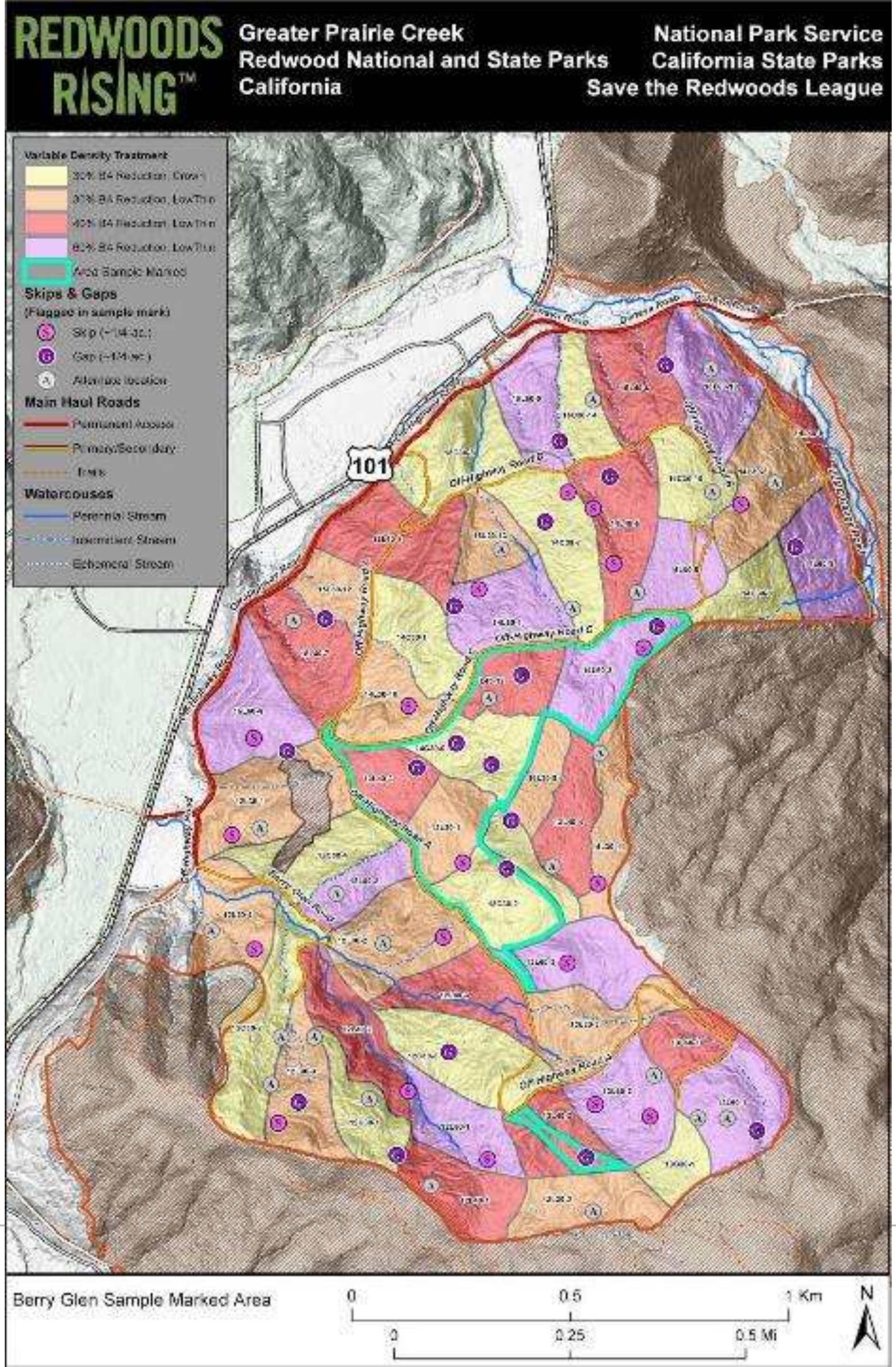


Variable-Density Thinning

Young stands are overly dense
- Improve Tree growth
- Promote forest floor plant diversity

Uniform spacing
- Spatial diversity

Timber valued species
- Species composition



Forest Restoration: Variable Density Thinning

Before

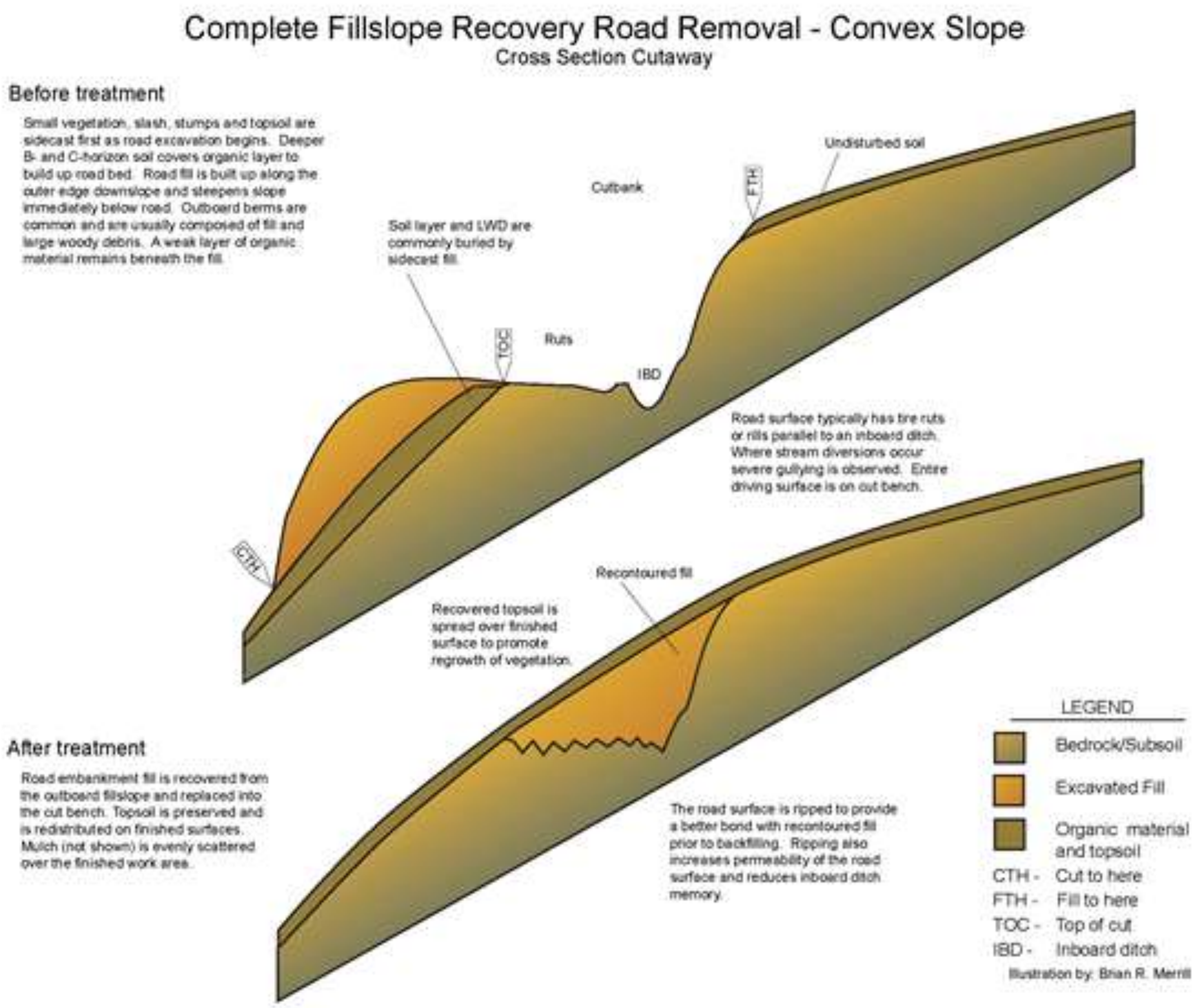
After

5 Years After

Road Removal

Impacts:
Buried streams at crossings
Buried floodplains
Compacted soils

- Improve natural hydrologic connectivity
- Reduce sediment delivery
- Improve vegetation growth



Road Reoccupation and Removal

Road removal at Larry Dam Creek in Redwood National Park

Riparian and Stream Restoration

- Large wood installation
- Riparian planting
- Promote conifer growth
- Daylighting streams

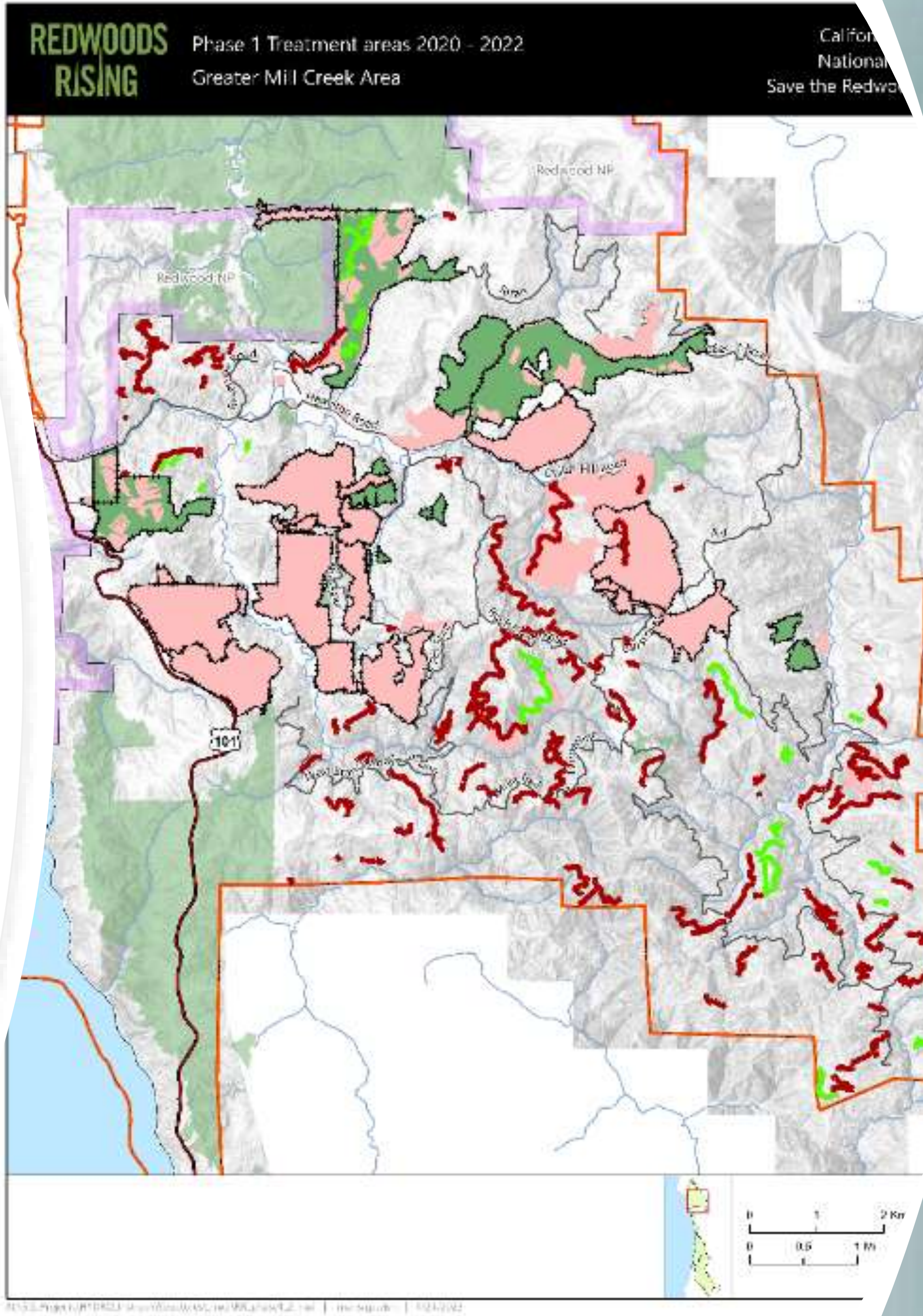
Large wood installation in the Mill Creek Watershed

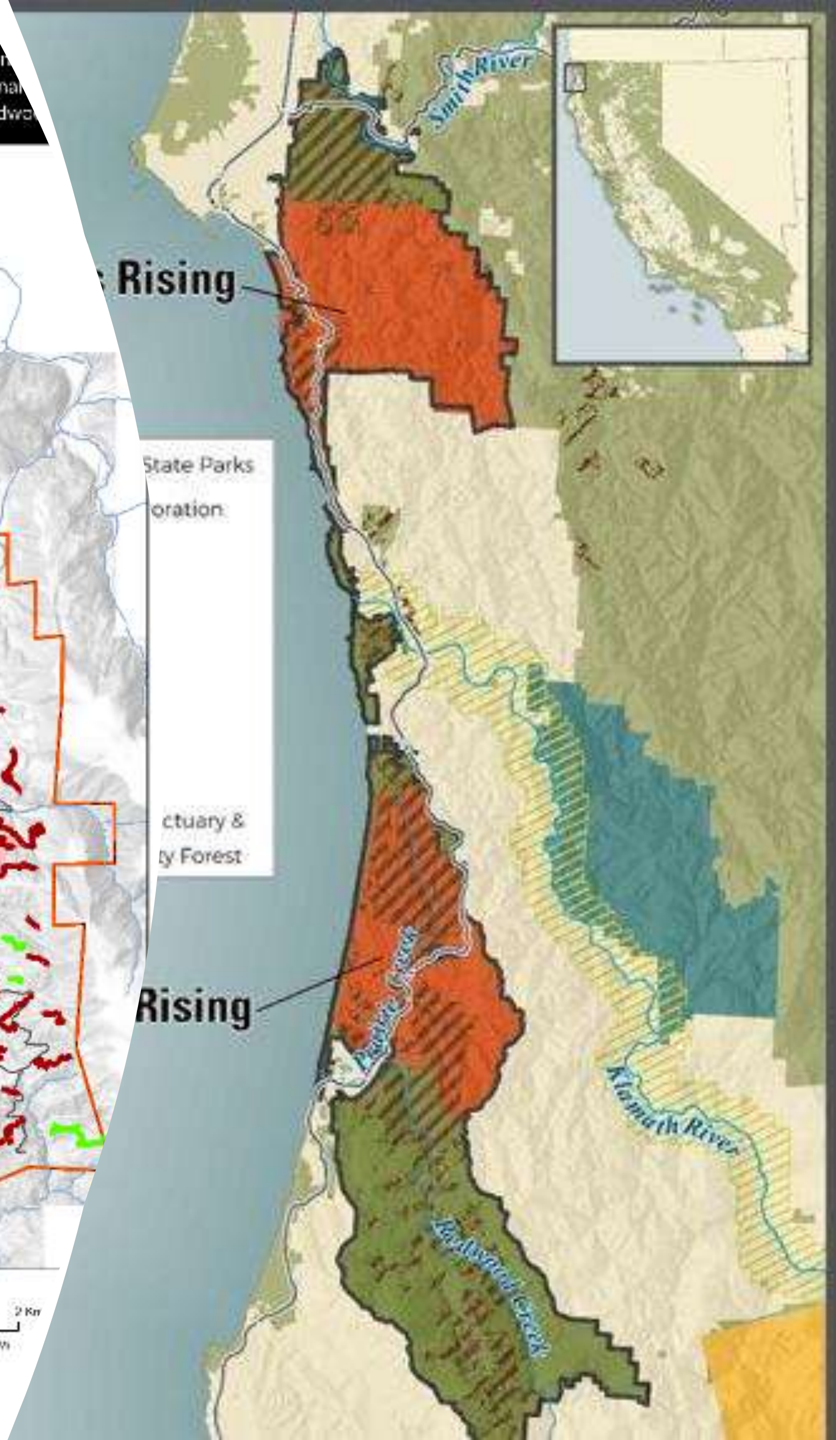
Watershed Facts- Mill Creek

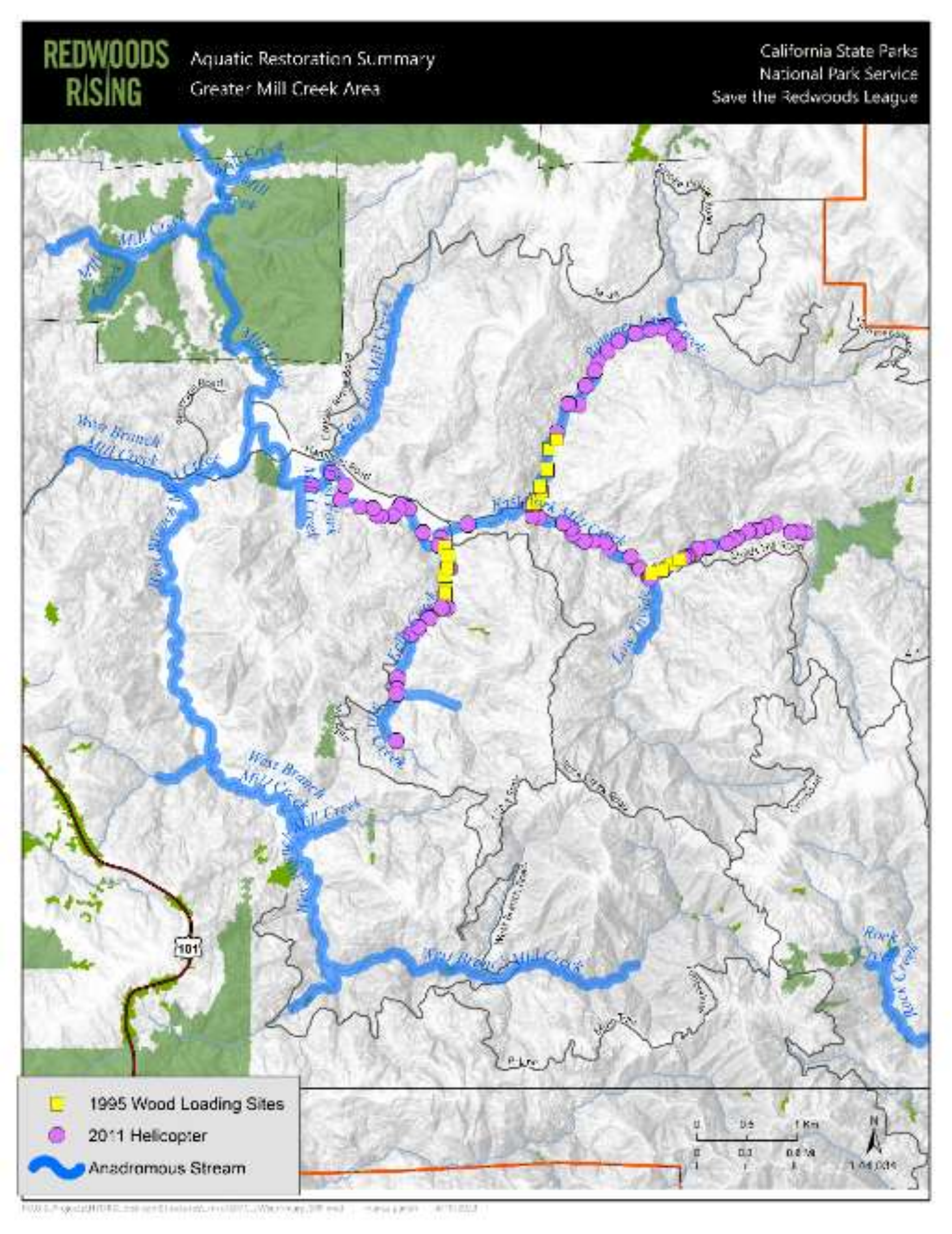
- 37 sq mile watershed
- Logging started in 1853
  - Extensive logging from 1908 – 1939 and 1954 - 2000
- DNCRSP formed in 1927 and expanded (25,000 acres) in 2002
- 120 acres of OG remain

<u>Redwood Rising</u>

- 28,000 acres to treat



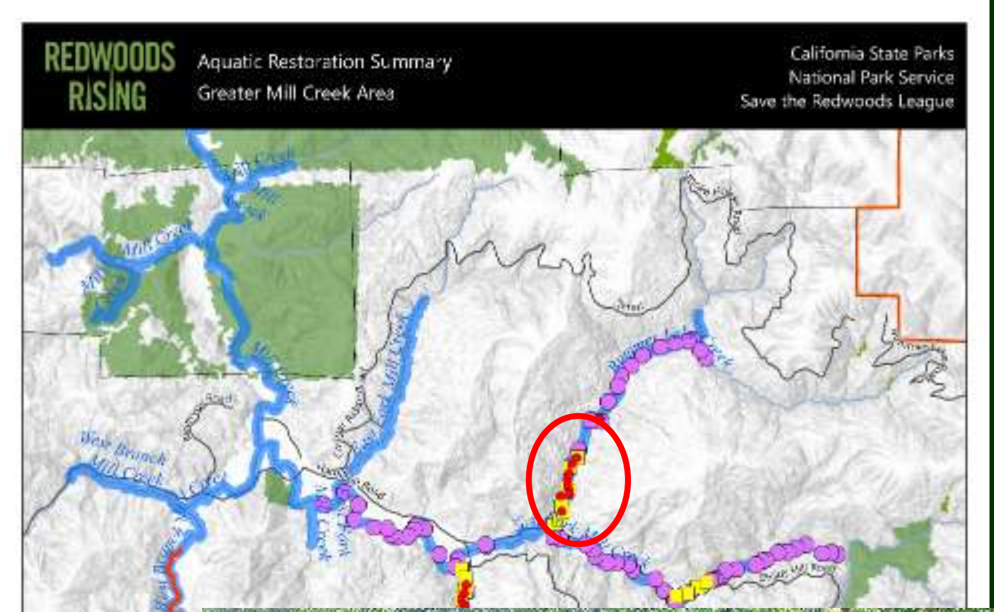




Mill Creek Background

- 1995: 49 LWD sites
  - 1- 4 log ballasted and anchored with rocks
- 2006: 12 LWD sites
  - 1 - 4 logs intertwined with and anchored to riparian tree
- 2008: 14 sites
  - Pieces with RW, buried and woven between trees without anchoring
  - Mobile pieces incorporated
- 2011: 13 sites (2 were augmentation sites)
  - Use of helicopter
  - 2 – 4 logs per site

Mill Creek - Aquatic Restoration



2022 – Bummer Lake Creek

- 10 sites with 63 trees along 3,600 feet of stream

Mill Creek - Aquatic Restoration

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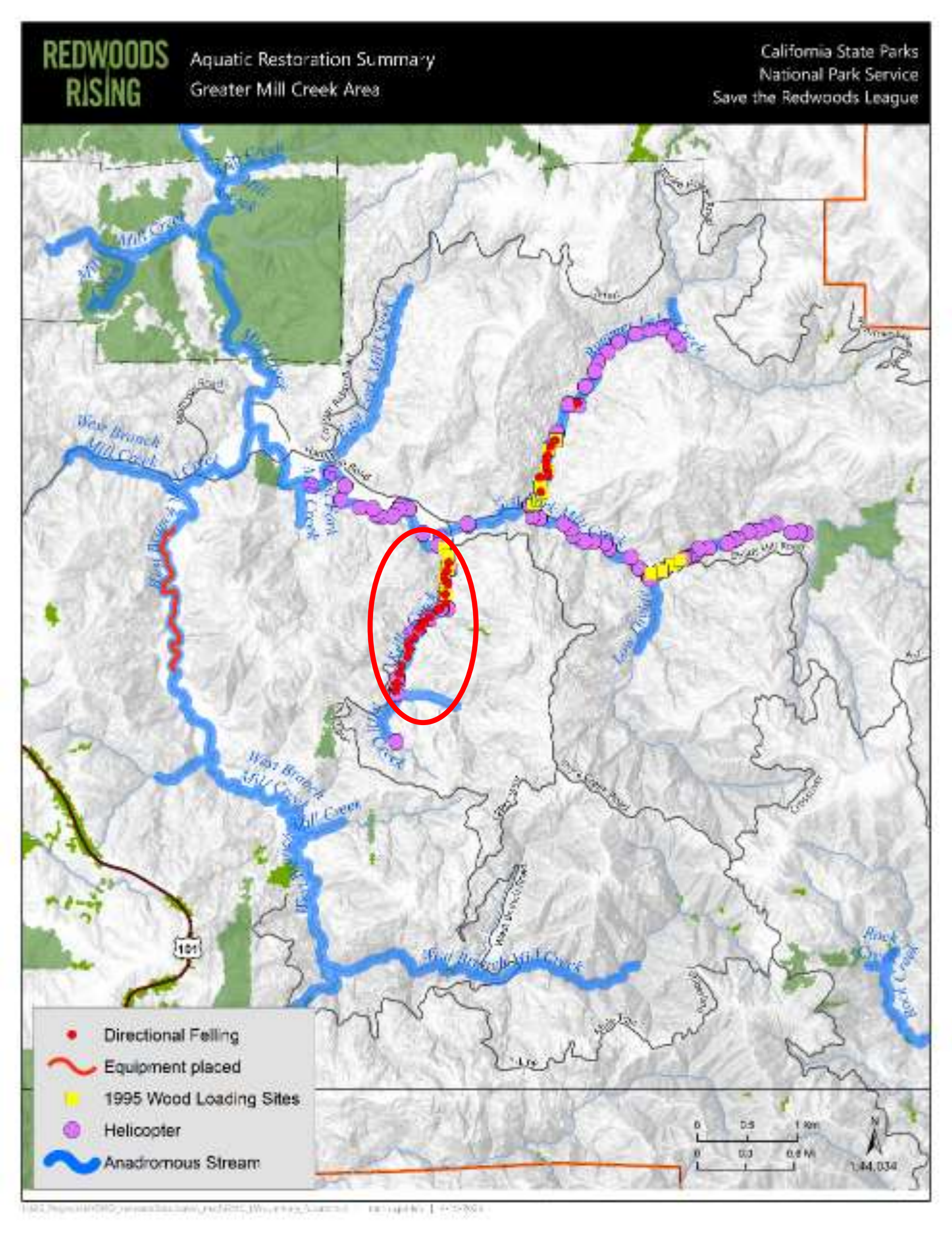
Mill Creek - Aquatic Restoration

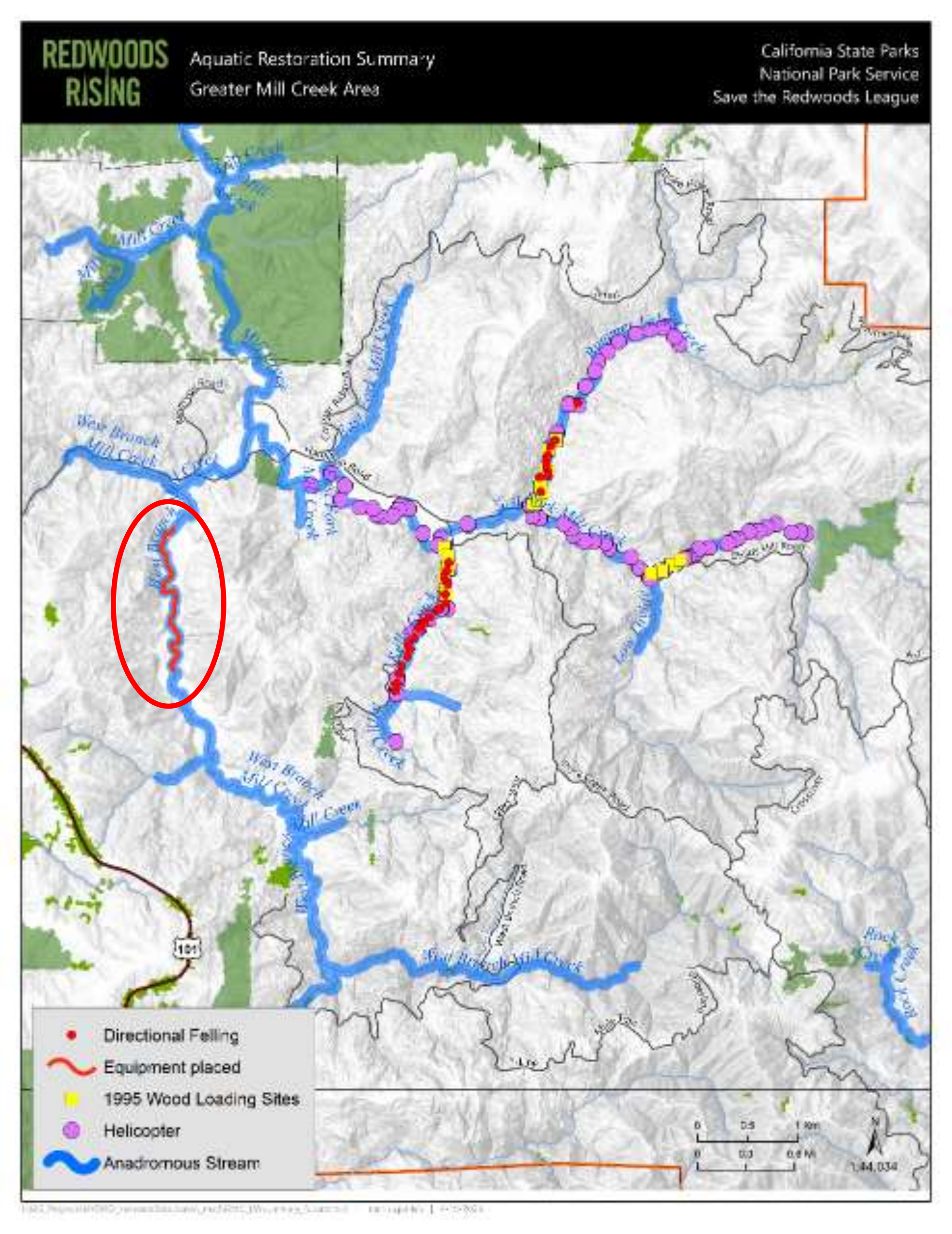


2023 – Kelly Creek

- 20 sites with 85 trees along 4,900 feet of stream

Large wood installation in the Mill Creek Watershed

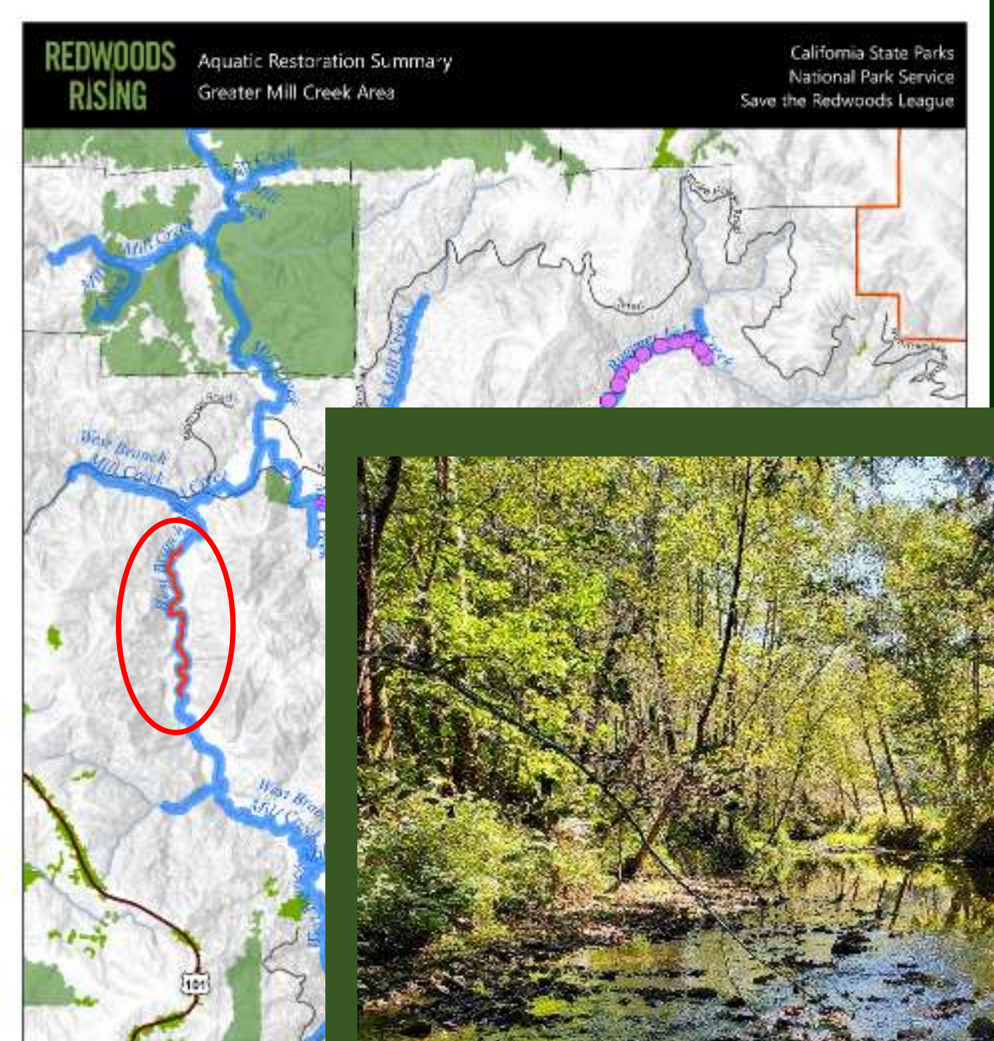
Mill Creek - Aquatic Restoration



2024 – West Branch Mill Creek

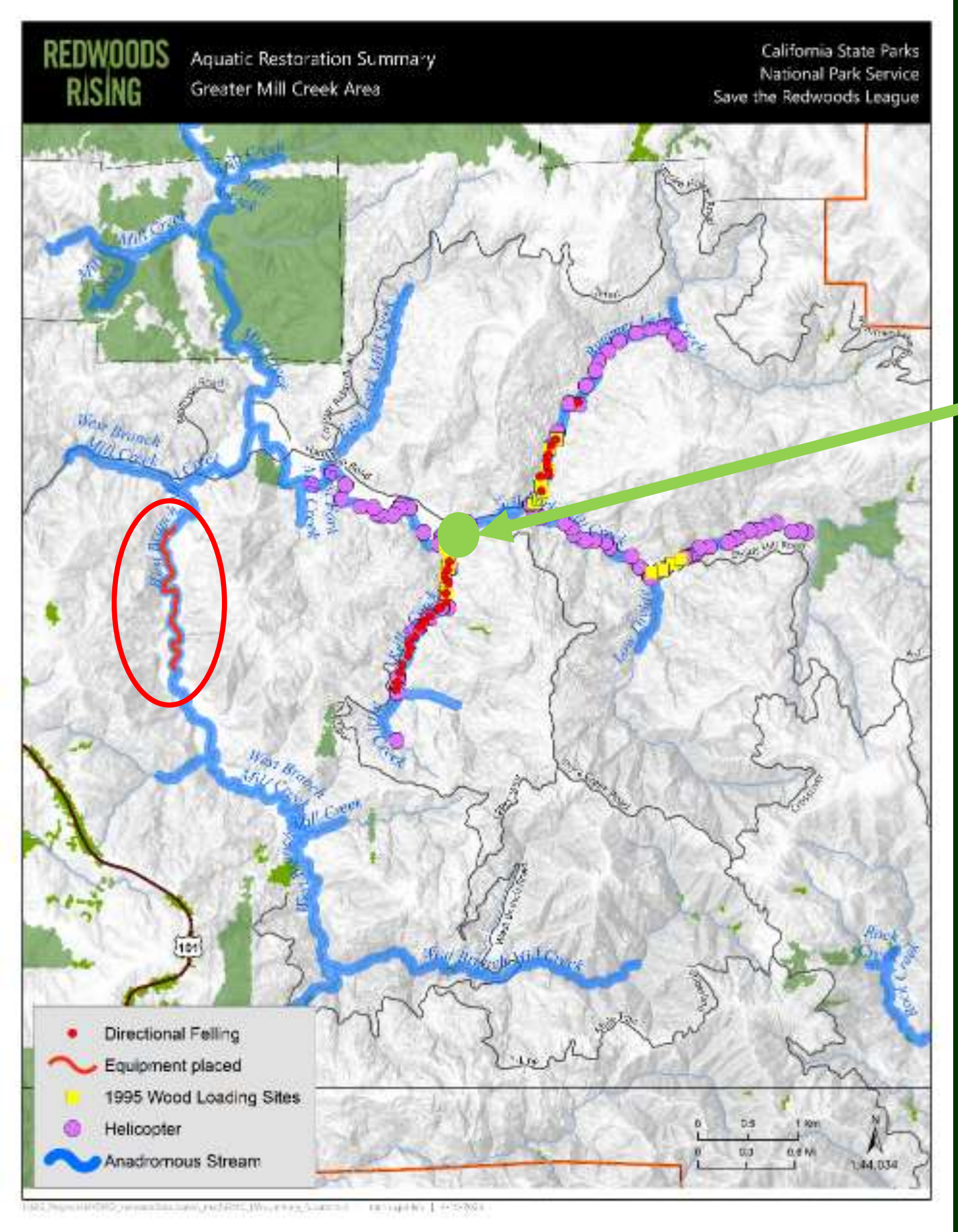
- 20 sites with ? trees along 5,000 feet of stream

Mill Creek - Aquatic Restoration



2024 – West Branch Mill Creek

- 20 sites with ? trees along 5,000 feet of stream



Mill Creek - Aquatic Restoration

2024 – West Branch Mill Creek

- 20 sites with ? trees along 5,000 feet of stream

2024 – East Fork Mill Creek Floodplain

- Relocating bridge, enhancing connection to 7 acres of floodplain habitat and installation of 45 pieces of LW with RW

Beyond – Heli-wood loading and expanding into Rock Creek watershed

Watershed Facts- Prairie Creek

- 39.8 sq mile watershed
- Upper headwaters protected in 1925 by founding of Prairie Creek State Park.
- 19 sq miles of old-growth forest remain
- Most of the remaining watershed was logged between 1930-1978
- Estimated 45 miles of stream in second growth, of which an estimated 29 miles are buried.
- Purchased by NPS in 1968 and expanded in 1978.

<u>Redwood Rising Phase I</u>

- 9,200 acres to treat
- Road-Shed approach
- Road removal daylighting buried streams

Prairie Creek - Aquatic Restoration

- 25 Large wood structures along 0.8 miles of mainstem Prairie in 2021
- Riparian planting along this stretch in 2022-2024 to expand riparian zone.
- Development of a mainstem floodplain model to highlight future potential work.

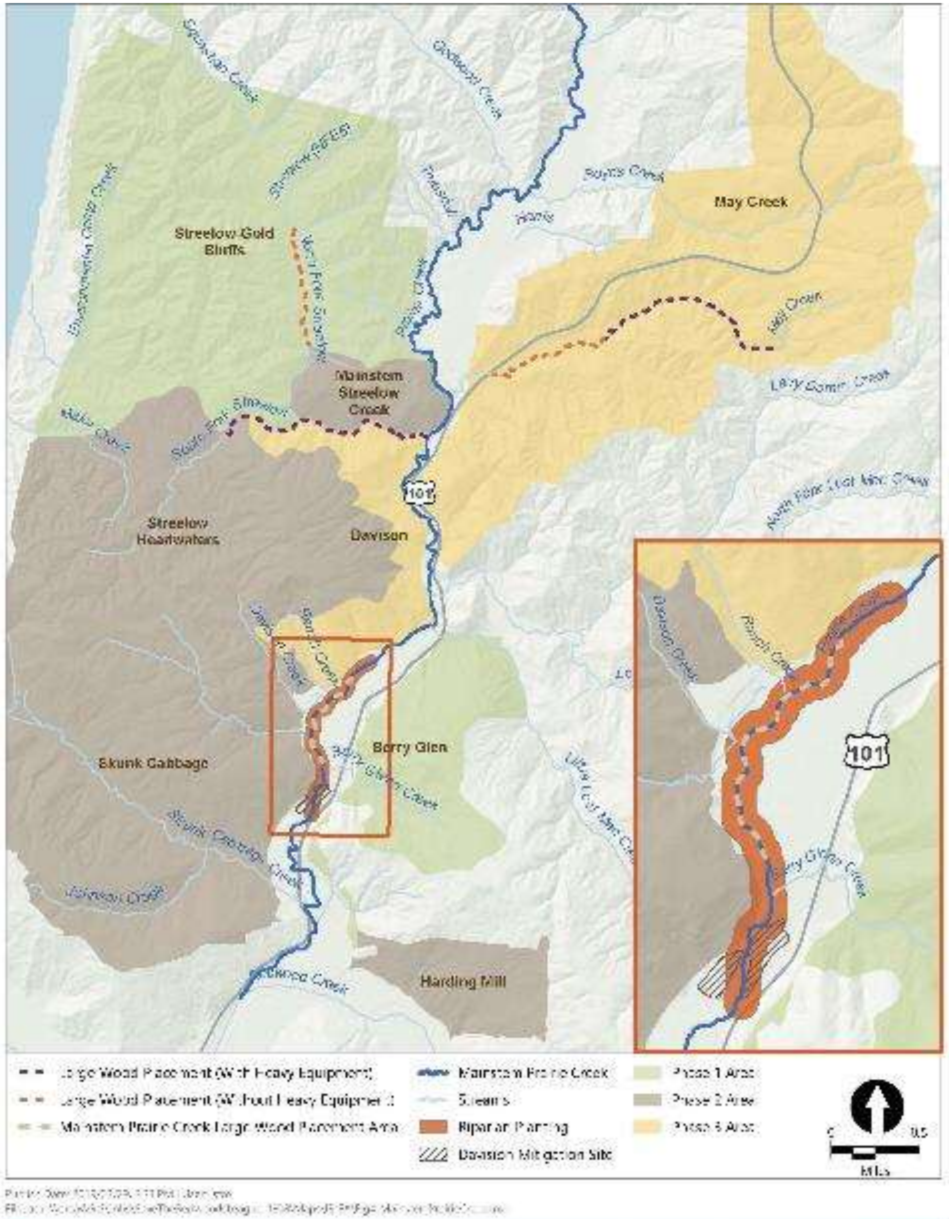
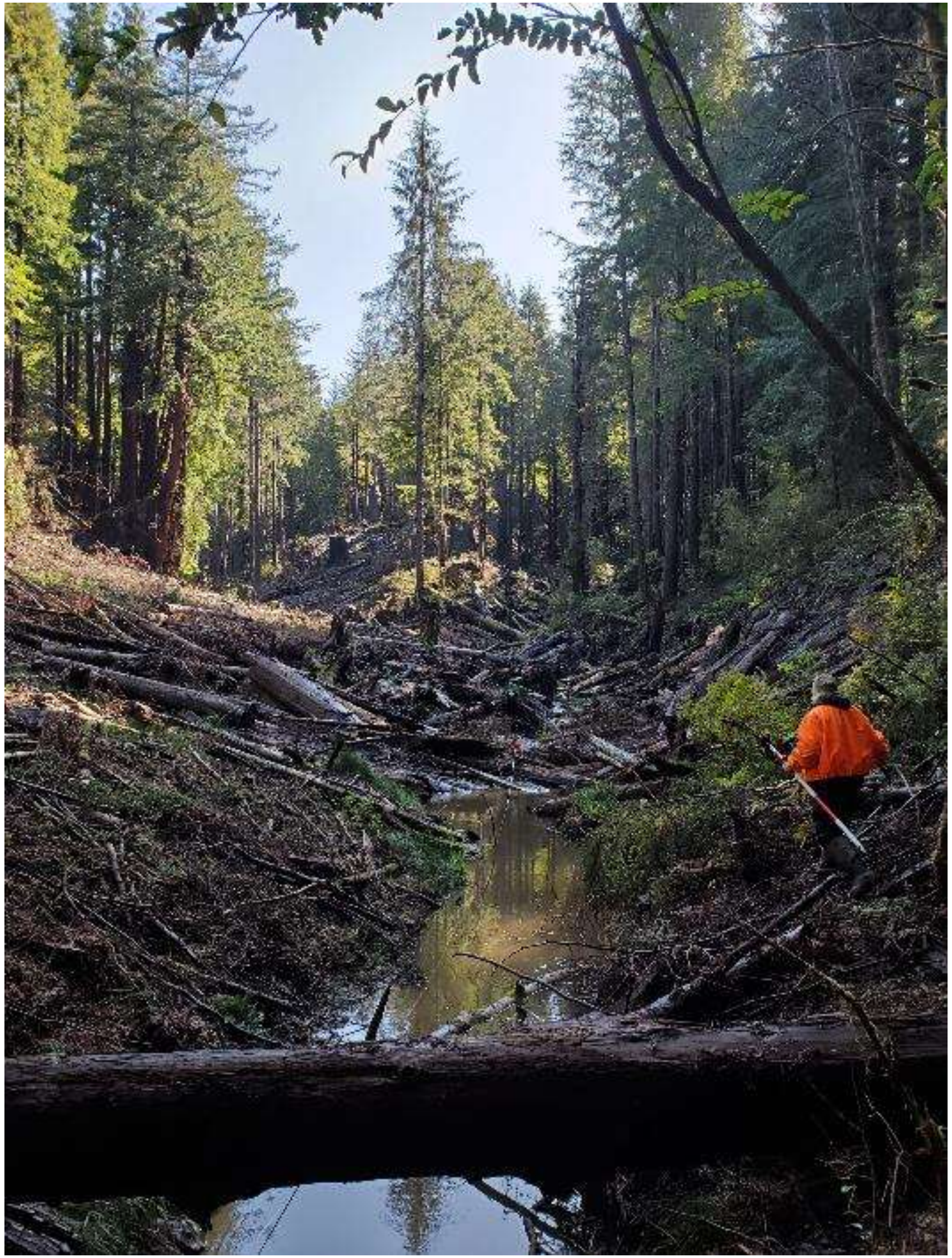


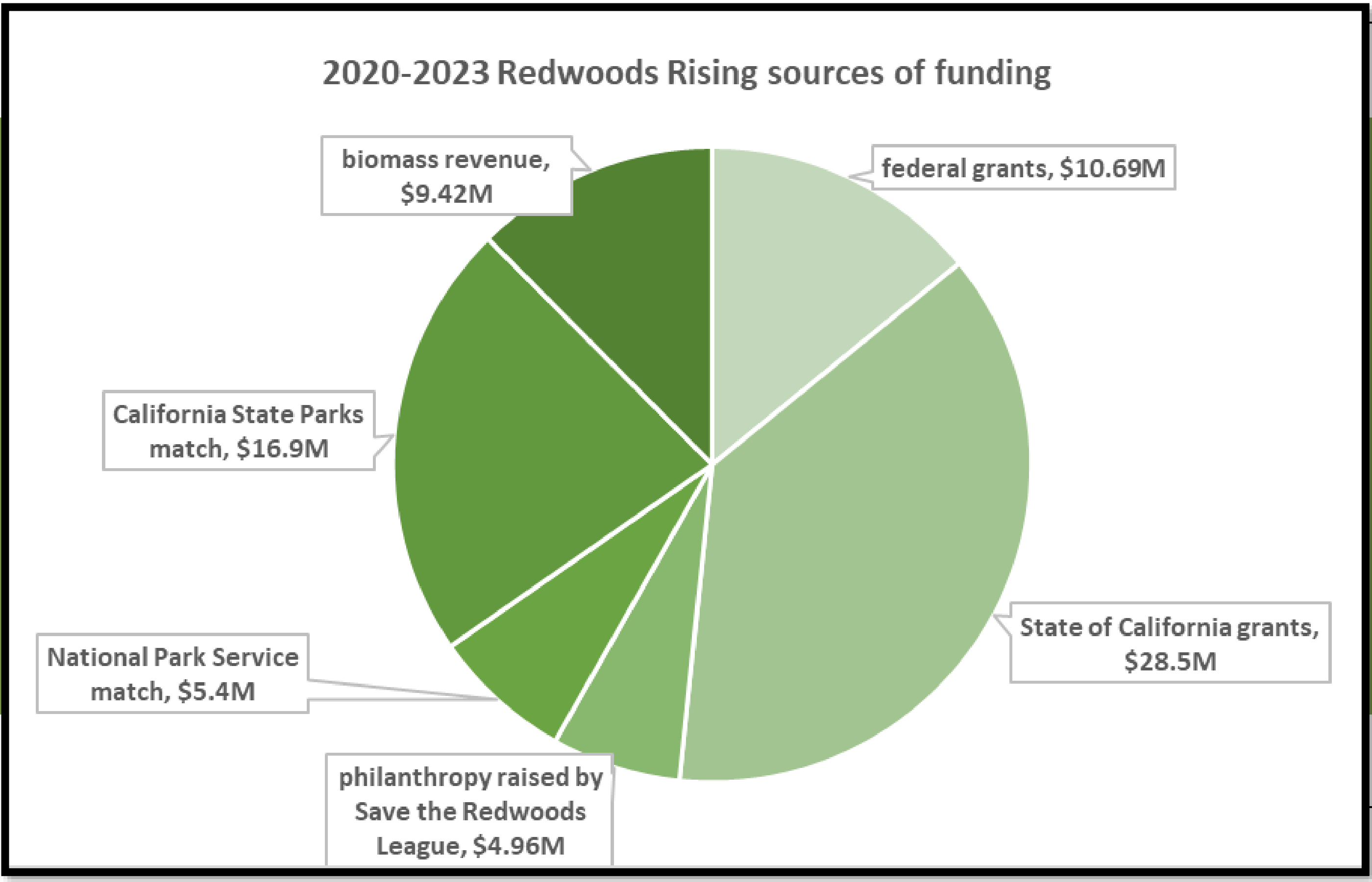
Figure 4
Aquatic Restoration Activities
Greater Prairie Creek Ecosystem Restoration Project



Save The Redwoods League

STAND FOR THE FUTURE

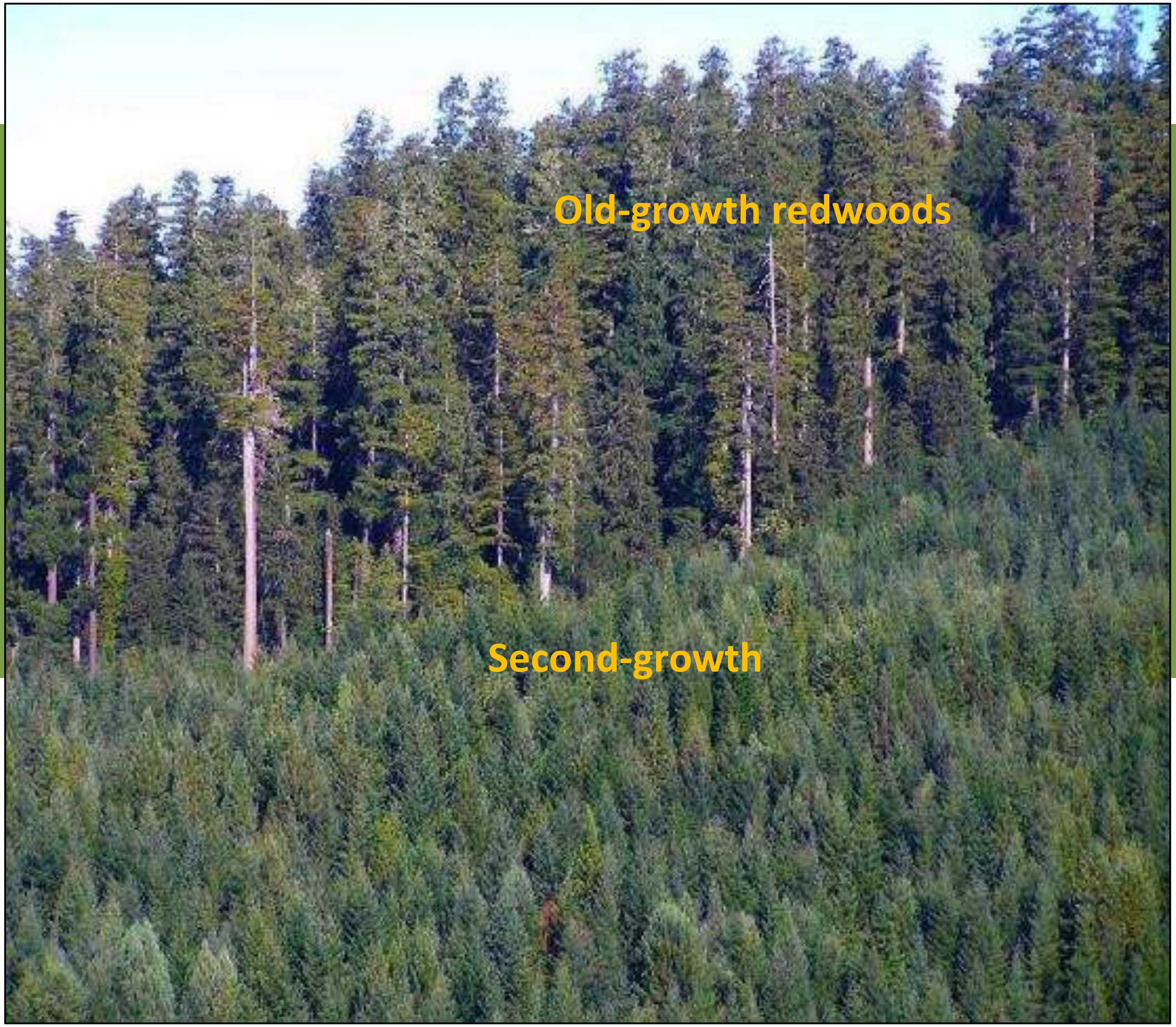
How we are doing it…



- MOU signed in 2018 between NPS, CDPR, and SRL
- Combination of federal and state grants and funding.
- Separate NEPA/CEQA documents for Mill and Prairie Creeks.
- Combination of programmatic and adaptive permits. Pre and Post Implementation reporting each year.

2020-2022 Implementation

- Forest thinning (2,660 acres):
  - Greater Prairie Creek - 1,439 acres
  - Greater Mill Creek - 1,201 acres
- Road removal: 22 miles
- Channel Restored: 3 miles
- Complete by March 2023



2023 Proposed Implementation

2019 brush clearing along main access

- Estimated 6 miles of road removed with 29 stream crossings
- Approximately 600 acres of forest thinning.
- 4900 ft of stream restoration
- Expanded aquatics monitoring.

Monitoring

- Compliance monitoring- Turbidity monitoring for NMFS
- Physical habitat monitoring at large wood loading sites
- Expansion of stream health monitoring looking at physical, chemical, and biological characteristics.

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Incorporating Invasive Species Management into Riparian Restoration to Promote Quality Habitat for Salmonids at Prairie Creek



Amy Livingston, Riparian Botanist and John Bair, Senior Riparian Ecologist
amy@mcbainassociates.com and john@mcbainassociates.com

McBain Associates
APPLIED RIVER SCIENCES

April 28, 2023

Prairie Creek Project Setting

- Lower watershed Prairie Creek, near confluence with Redwood Creek
- Identified as important opportunities to restore Coho habitat
- Orick valley, surrounded by RNP and ancestral territory of the Yurok tribe
- Former Orick Mill, purchased by Save the Redwoods League 2012
- Large, multiple phase project, combines restoration of Prairie Creek with a trails gateway for RNSP

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Existing Conditions

- Re-connect Prairie Creek to floodplain
- Create off-channel rearing habitat for salmonids

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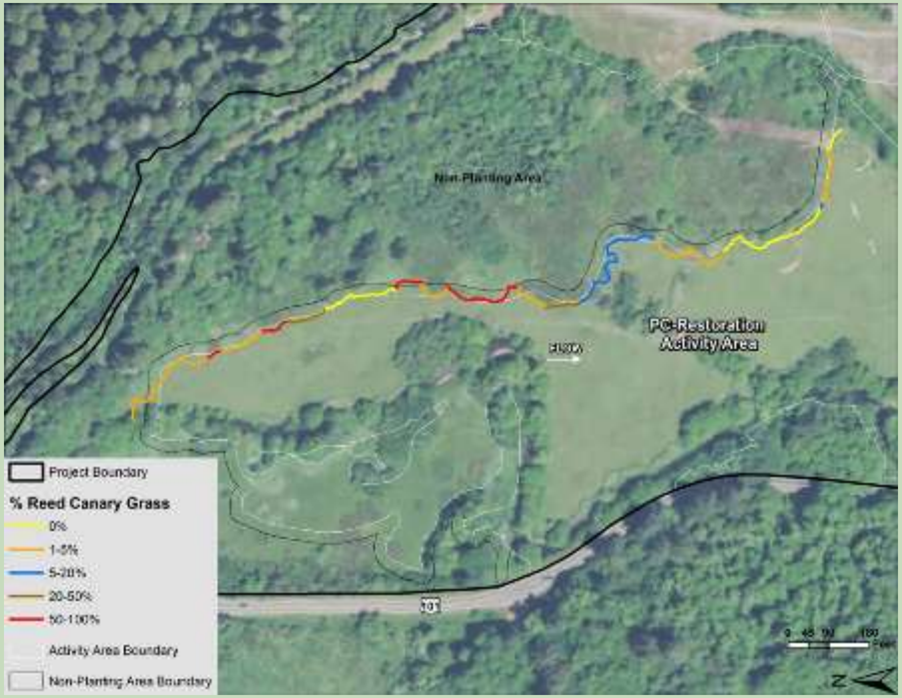
Revegetation Goals

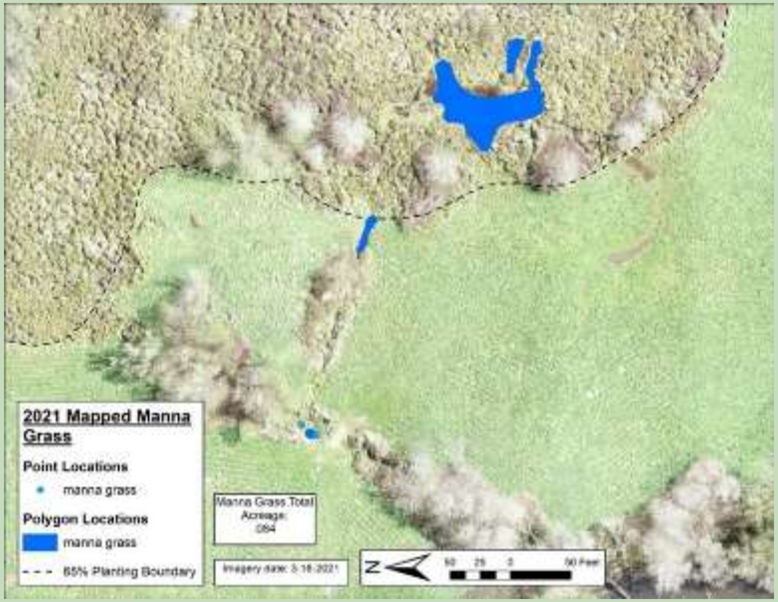
- Create species-rich, structurally complex, self-maintaining riparian vegetation and minimize invasive species

Reed Canary Grass (*Phalaris arundinacea*)



- RCG in Prairie Creek controlled by velocity and water depth and shade from mature vegetation
- Project pulls back banks, create shallower channel and aquatic habitats including side channels, backwater ponds, and wetlands, disturbing existing vegetation
- Slower moving water for Coho rearing
- Upstream and on-site propagule sources

Water manna grass (*Glyceria fluitans*)



- Isolated occurrence of water manna grass in wetland adjacent to project boundary
- Capacity to form aquatic mats 2-4 feet thick

Threats to Salmon

- Potential fish passage issue, potential to limit mobility at low flows
- Can alter hydrology by trapping silt and constricting or choking stream channels
- May lower dissolved oxygen as mats of vegetation decay
- Thick and dense floating mats create very poor fish habitat, limiting sunlight and primary productivity
- Can slows flow causing sediment to drops from water column, and cover spawning gravel
- Complicates establishment of revegetation efforts by shading out young plants

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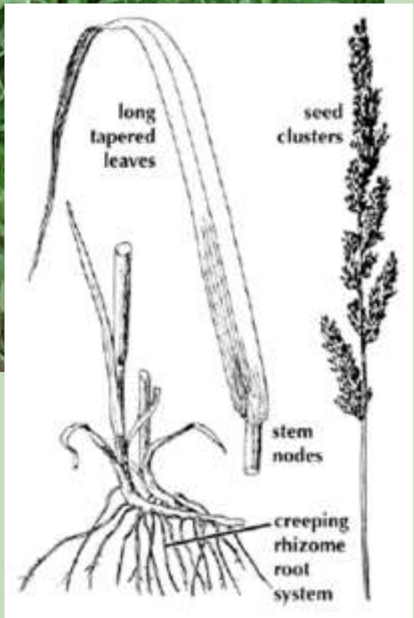
RCG Biology and Management



- Perennial, rhizomatous species spreads by stem, root fragments, and seed
- Competitive advantage: emerges early in spring shading out native species that emerge later
- Mowing may stimulate stem production
- Can excavate but entire rhizome must be removed
- 3-5 years generally needed for effective herbicide treatment of well-established populations
- Does not germinate under dense shade, <u>does not tolerate year-round shade</u>

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Local and Regional Projects Reviewed

Five Mile Bell Siuslaw National Forest

- Stage zero project that created slow moving aquatic habitat for Coho across entire alluvial valley
- Excavated RCG
- Raised water at surface year round, long periods of inundation have kept RCG in check
- Intensive revegetation

City of Arcata Flood Control Project, Janes Creek

- High density planting most successful strategy combined with manual removal as trees matures
- Multi-story riparian vegetation lacking under dense tree canopy with was controlling RCG

- *How do we balance control with shade with desire to have some light near aquatic features for primary productivity and also for restoration of multi-layered riparian habitat?*

Strawberry Creek

- Tributary to South Slough/Redwood Creek estuary
- Conversion of floodplain and wetlands to pasture along Strawberry Creek lead to RCG invasion and water manna grass invasion, very difficult conditions for restoration
- Several restoration projects over a decade including NOAA, RNP

Strawberry Creek Revegetation Strategies-What Worked

- Very dense revegetation favoring conifers, competitive evergreen species
- “Lasagna mulch”: cardboard overlaid with burlap and covered with shredded redwood bark, covering all exposed ground surfaces

Photo from Lower Strawberry Creek Restoration and Planning Report Mike Love & Associates 2008

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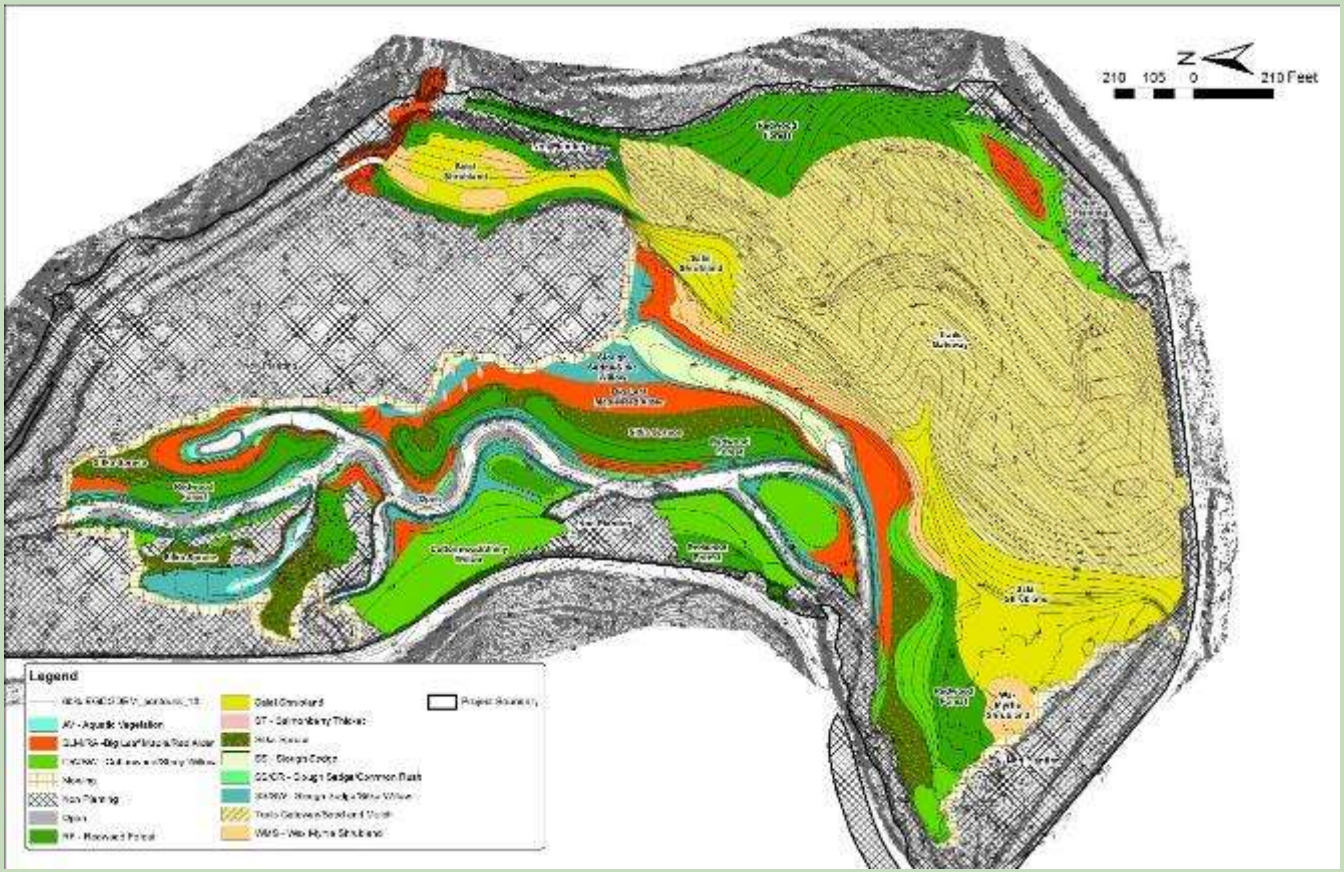
Prairie Creek- Revegetation Design Strategies



- Ground Surface Treatments 3 types
- Construction buffers
- High density planting in vulnerable areas
- Multi-layered plant groups
- Conifers and evergreen species favored, but not exclusively

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Ground Surface Treatments

Ground Surface Treatments

- Two-layer fine weave coir fabric with redwood mulch

Eight Months Later (July 2022)

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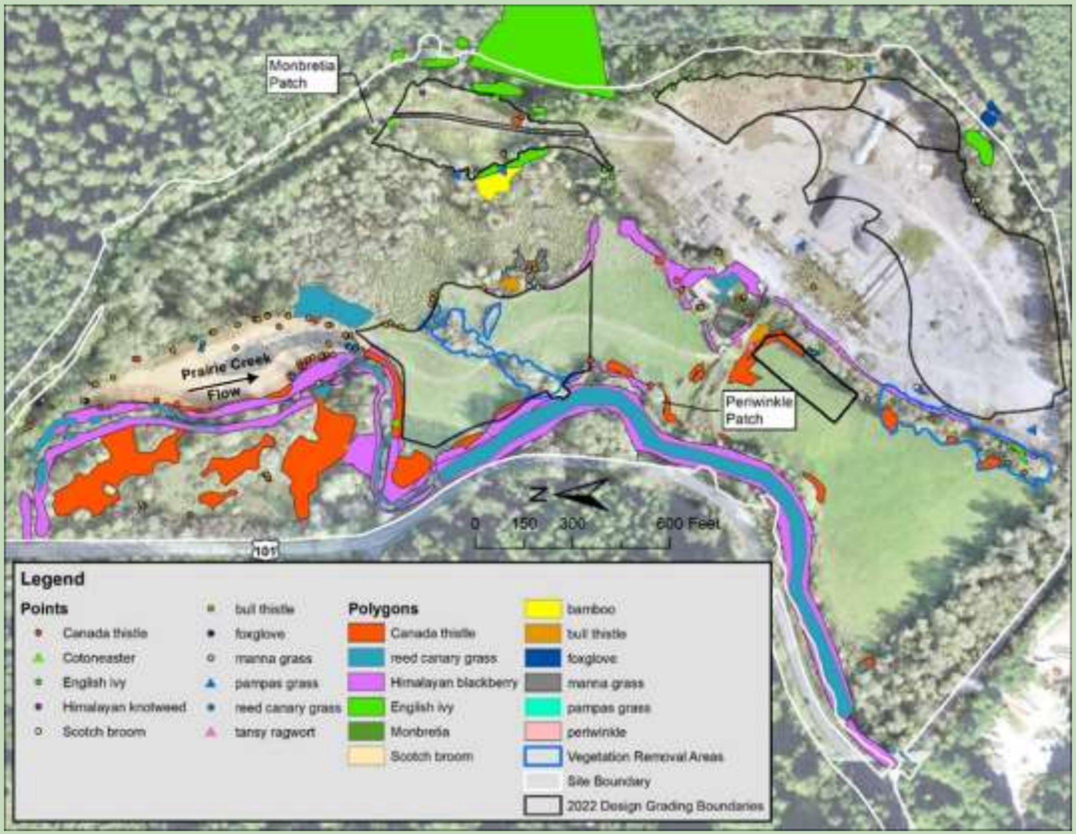
Construction Buffers

- Manage space; provide revegetation time and space, 25’ mowed construction buffer, maintain buffers with mowing, equipment use, and mulch

Invasive Plant Treatment Plan



- 14 high priority species, plus lower priority species
- Species specific strategies
- Input from future landowner (RNP)
- Primary strategy excavate and bury
- Manual control
- Limited herbicide use, two species
- Monitoring and reporting to an Adaptive Management Team

Emphasis on species that:

- Threaten aquatic habitat goals
- Threaten revegetation goals

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Primary Strategy: Mechanical Removal

- Excavate entire root systems of most problematic species

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Stewardship

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January 2023 (14 months)

- Seining Phase 1 pond captured 165 coho salmon

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Acknowledgements

- National Oceanic and Atmospheric Administration (NOAA)
- State Coastal Conservancy
- Save the Redwoods League
- CalTrout
- Wildlife Conservation Board
- USFWS Partners Program
- Redwood National and State Parks
- Yurok Tribe- Construction Crew, Fisheries Dept, Youth Crew
- Northern Hydrology and Engineering
- GHD
- SHN
- Redwood Community Action Agency
- John Northmore Roberts & Associates

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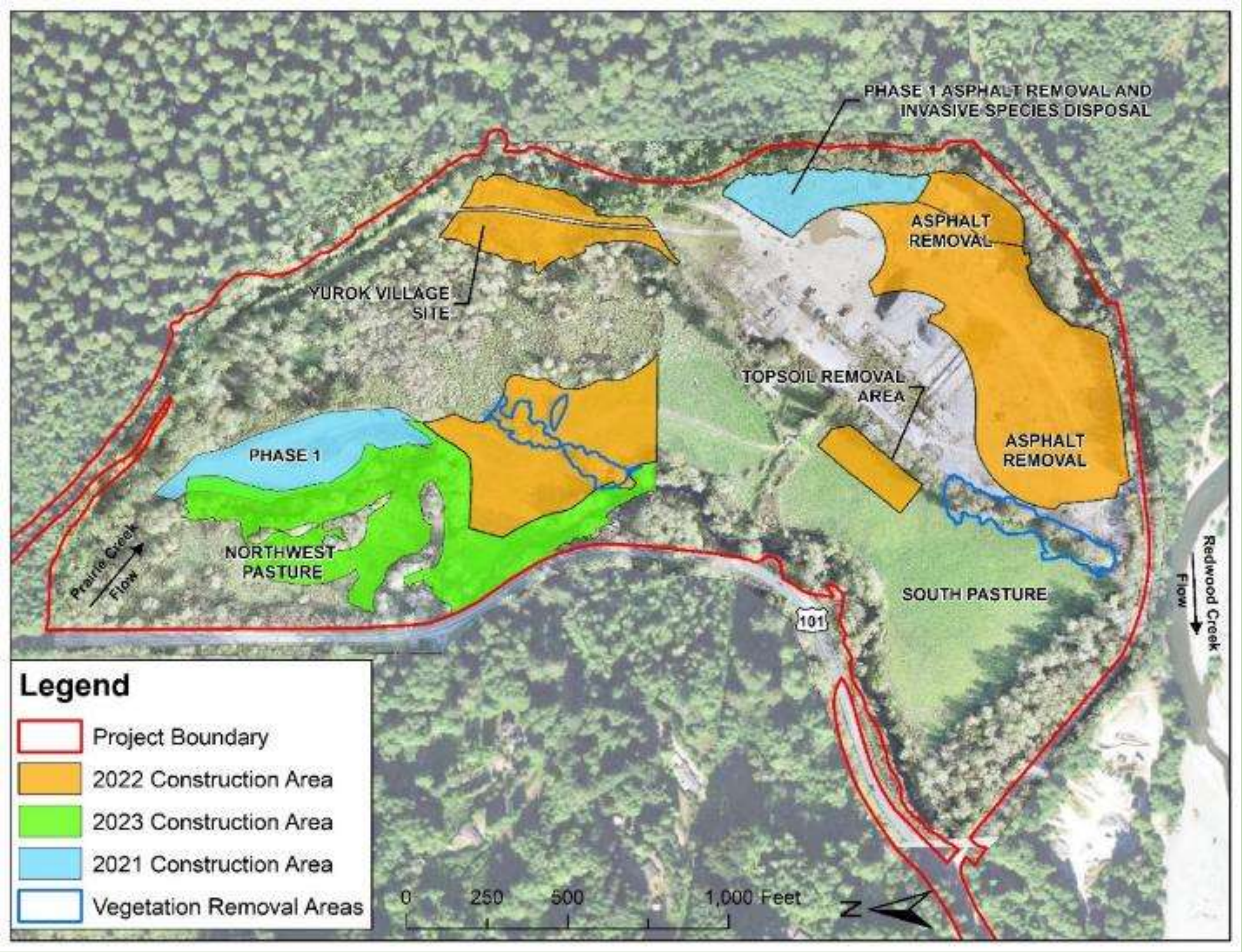
Implementation 2021, 2022, 2023



Evaluating the effects of riparian thinning on stream ecosystems in second-growth redwood forests of northern California

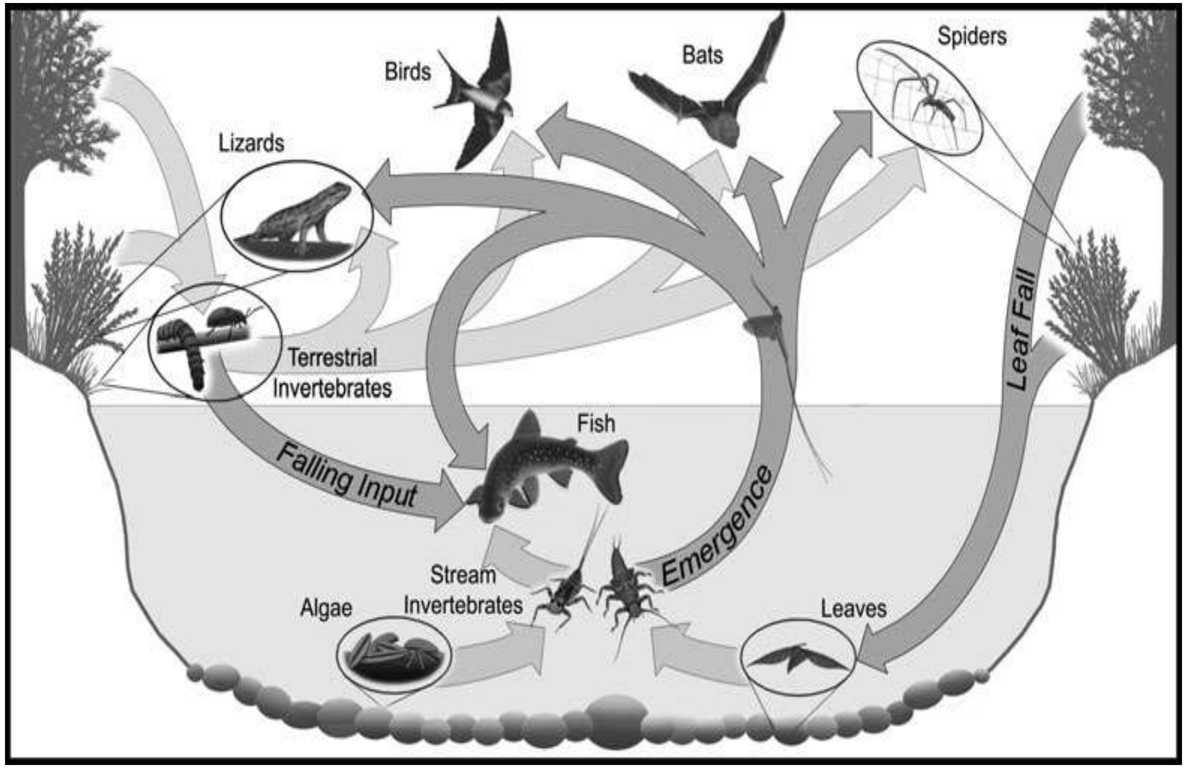
SRF Presentation 4/28/2023

David Roon, Jason Dunham, Dede Olson, Bret Harvey, Ryan Bellmore, Joe Benjamin, Jeremy Groom, and Christian Torgersen

OSU Oregon State University · USGS science for a changing world · Forest Service U.S. Department of Agriculture · Green Diamond Resource Company · National Park Service · Save The Redwoods League

Riparian forests provide a wide array of ecological functions for streams

- Riparian canopies control stream temperature and primary production
- Large wood structures aquatic habitats
- Roots filter sediment and nutrients
- Riparian canopies contribute inputs of leaf litter and insects



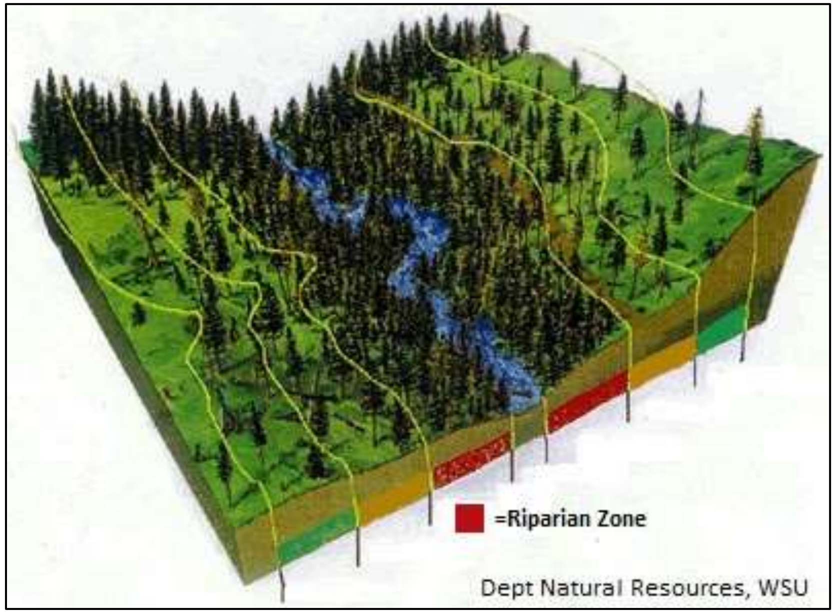
Baxter et al. 2005

Key idea: changes in riparian forests can affect streams via aquatic-terrestrial linkages

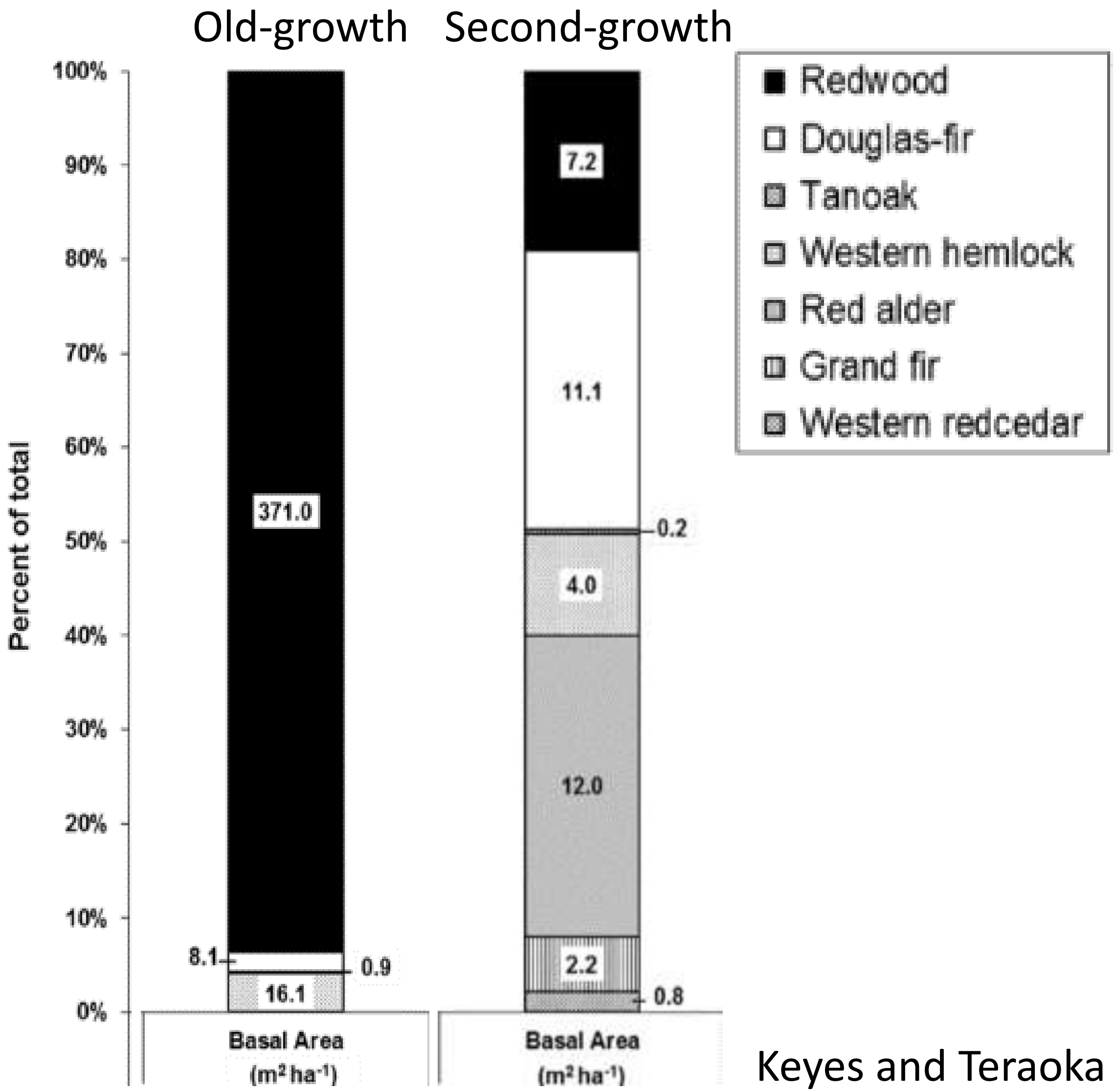
Timber harvest has profoundly altered riparian forests in PNW

Historical practices

Contemporary practices



In redwoods, second-growth differs from old-growth



Keyes and Teraoka 2014

Thinning a solution for second-growth riparian forests?

- Accelerate recovery of old-growth forests
- Shift successional trajectory to provide future source of large wood
- Strike balance between stream temperature and aquatic productivity
- However, immediate effects unknown…

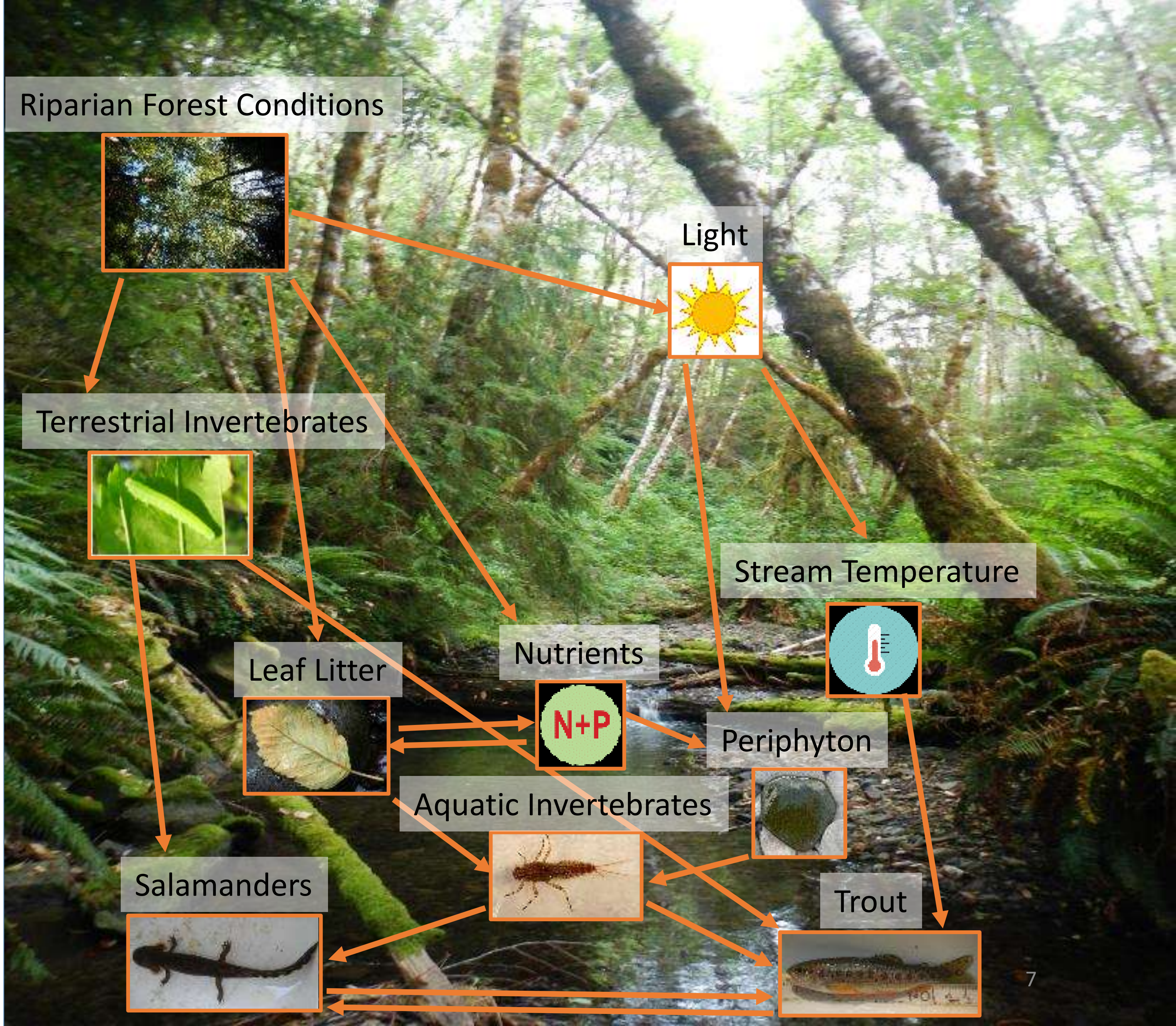
Riparian Summit – April 2015

Convened meeting with stakeholders from multiple agencies to develop study plan

- Private timber companies
- Redwood National Park
- Federal and State Researchers
- Regulatory Agencies

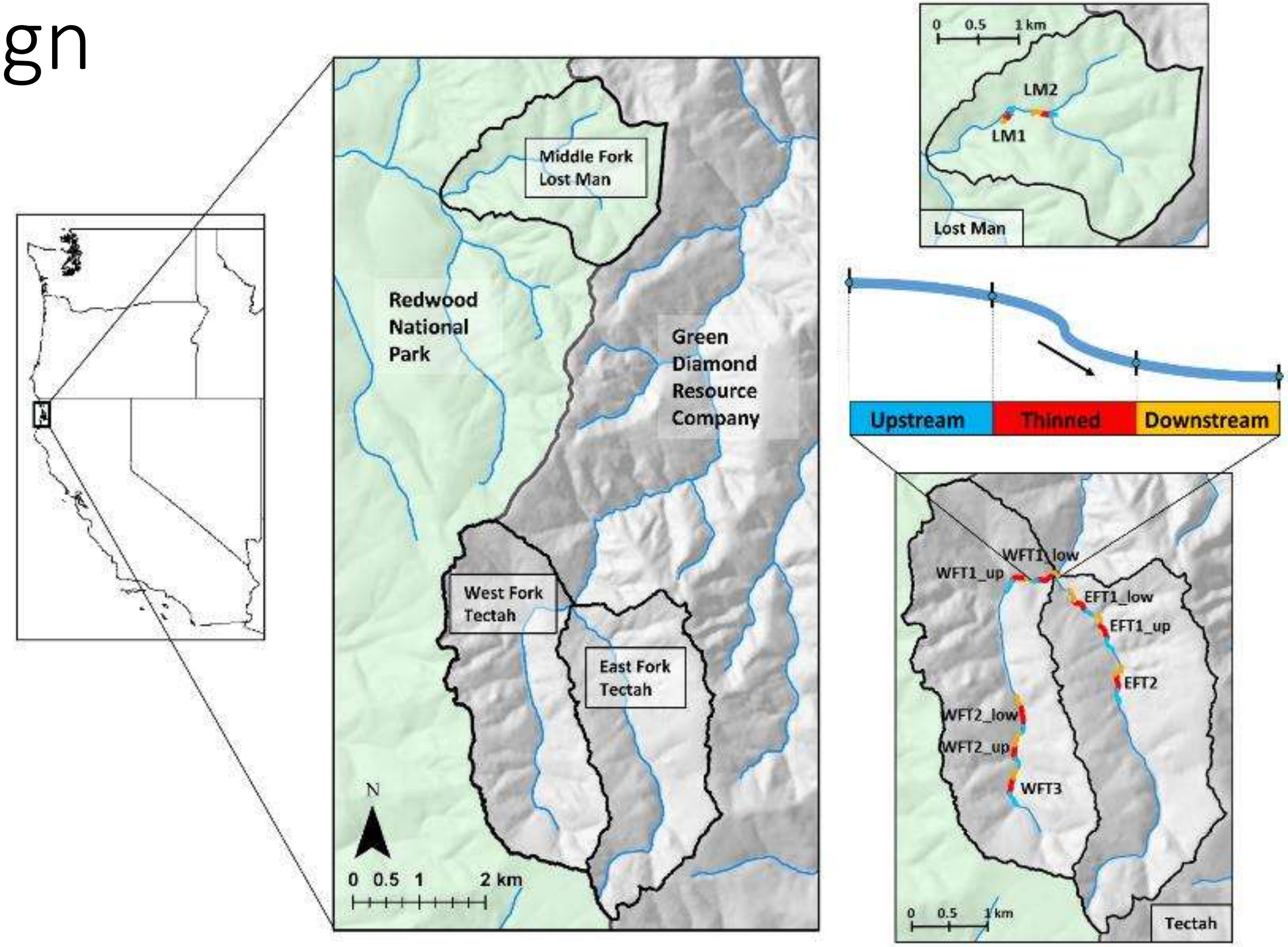
Research objectives

1) Riparian shade, light, and stream temperature
2) Stream food webs
3) Cutthroat trout



Experimental design

- BACI design
  - Upstream reference, thinned, and downstream reaches
  - Before and after thinning
- Replicated at 10 locations across 3 watersheds
- Data collection occurred seasonally (Spring, Summer, Fall)

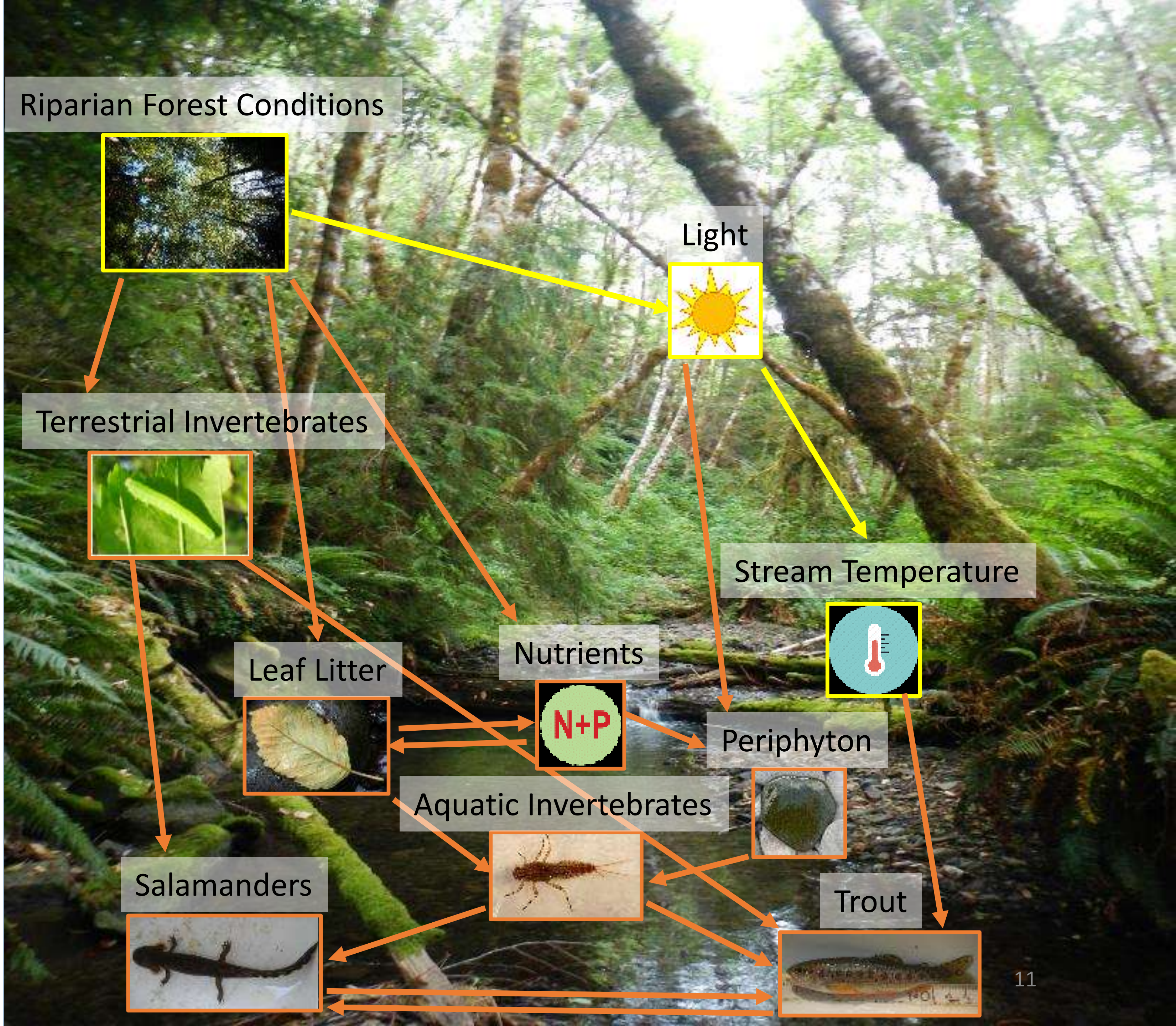


Thinning Treatments - Lost Man

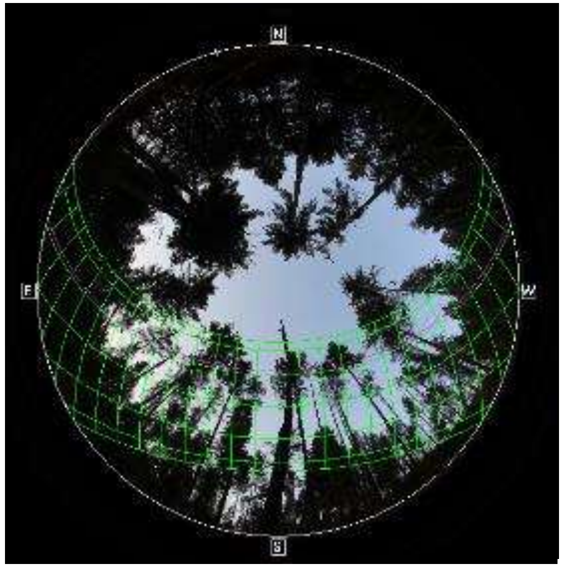
Thinning Treatments - Tectah

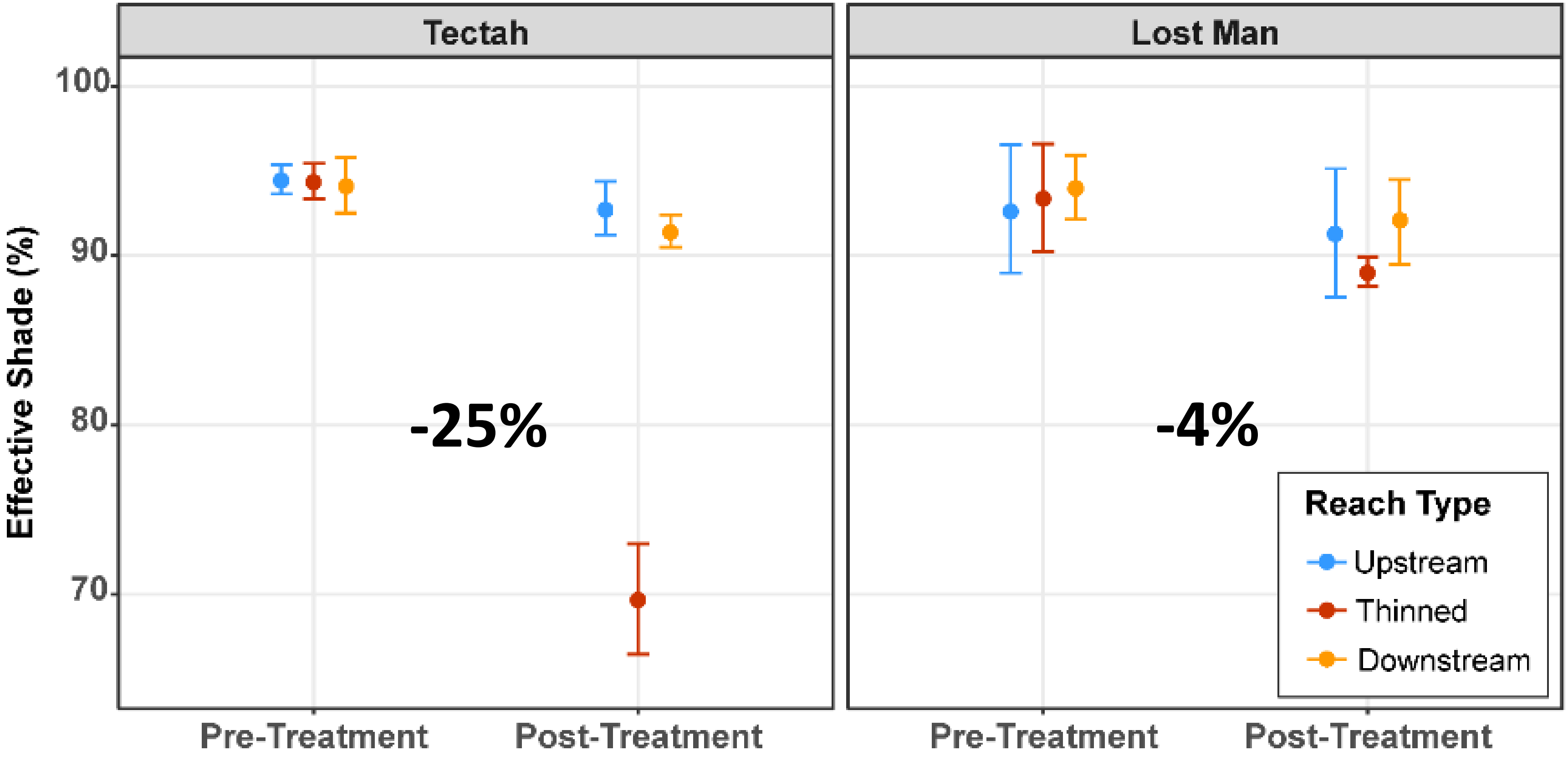
Part 1

How does riparian thinning influence shade, light, and stream temperature?

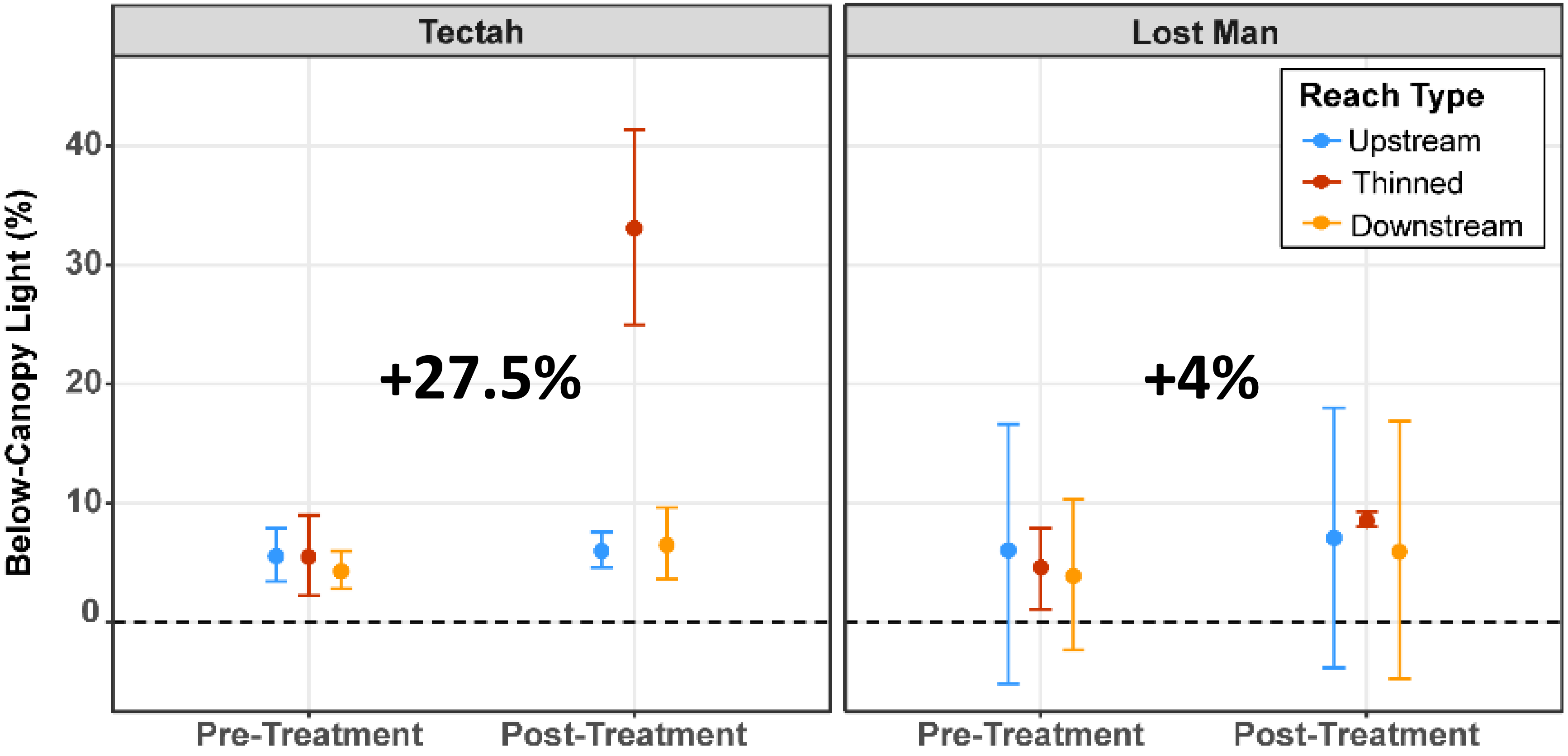


Thinning reduced riparian shade…

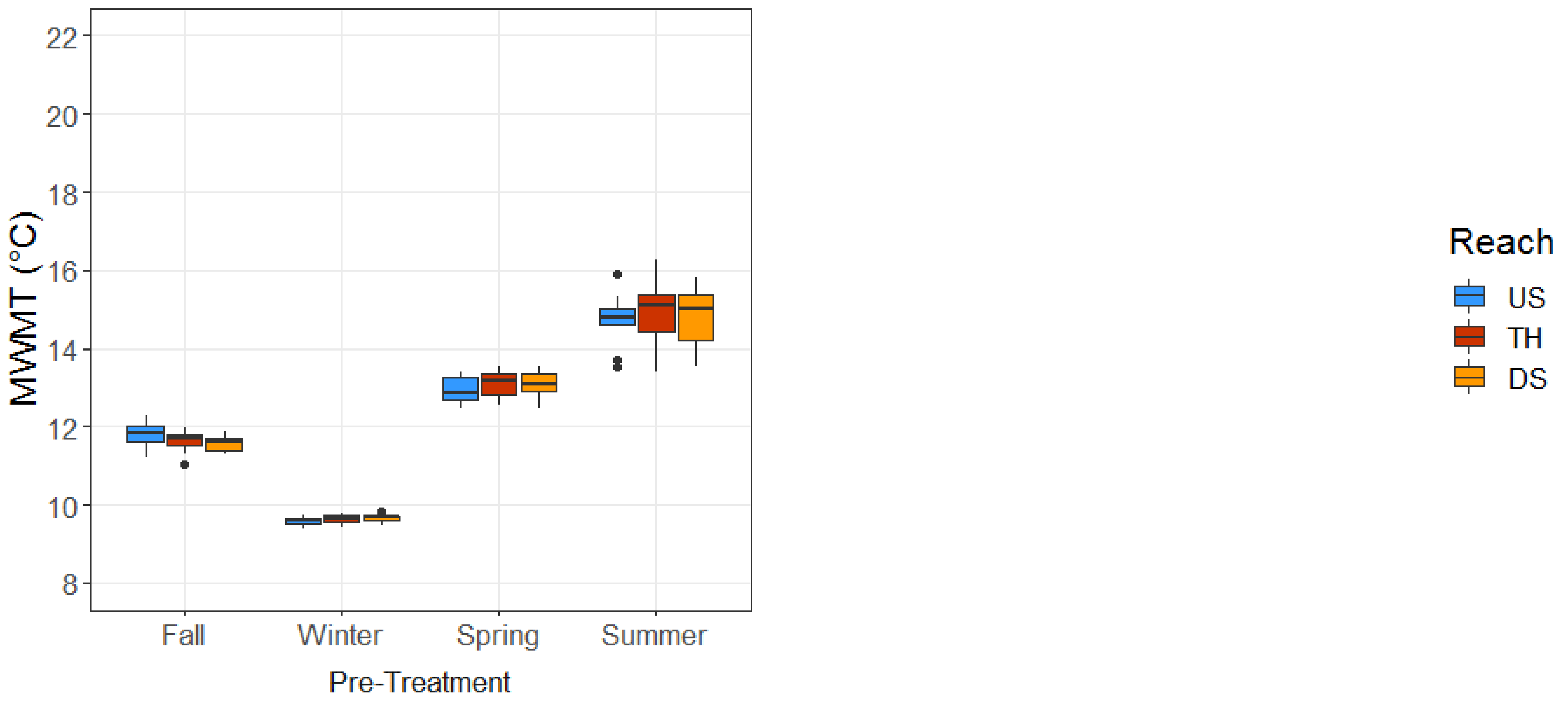




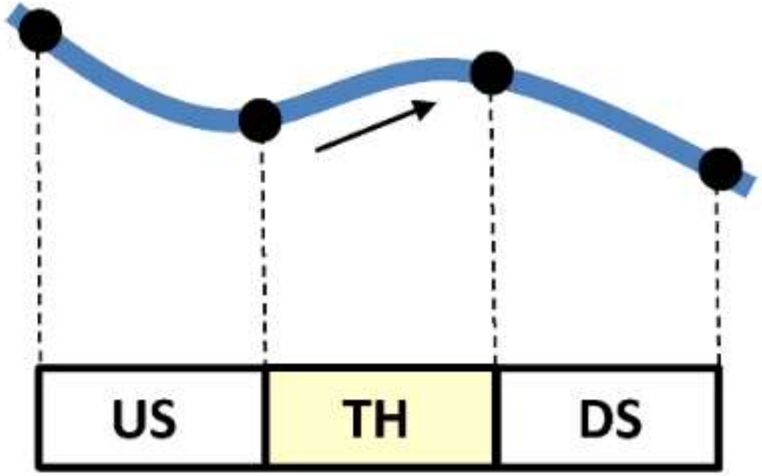
Thinning increased light to stream…

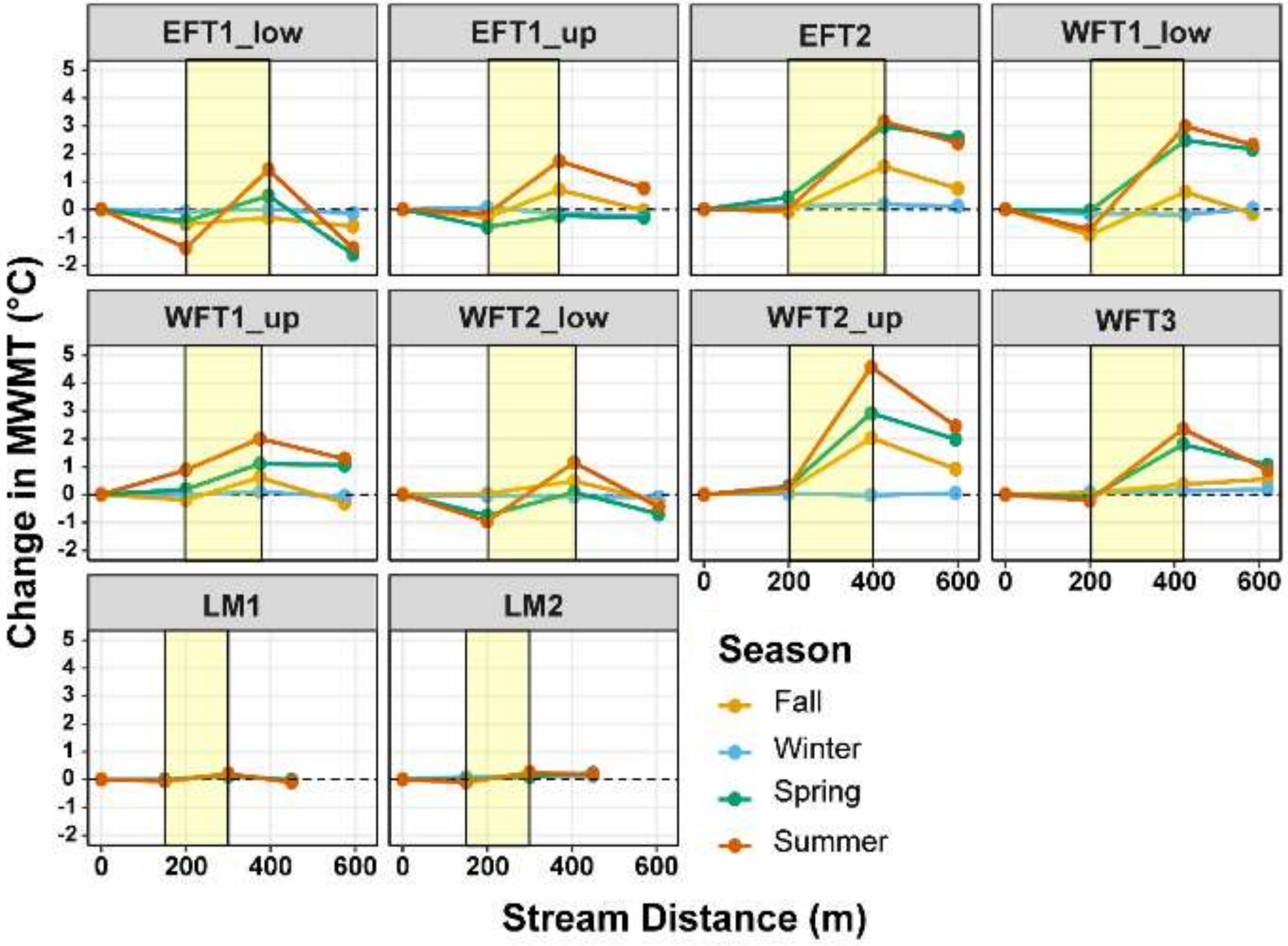


Thinning increased maximum stream temperatures, especially in summer months

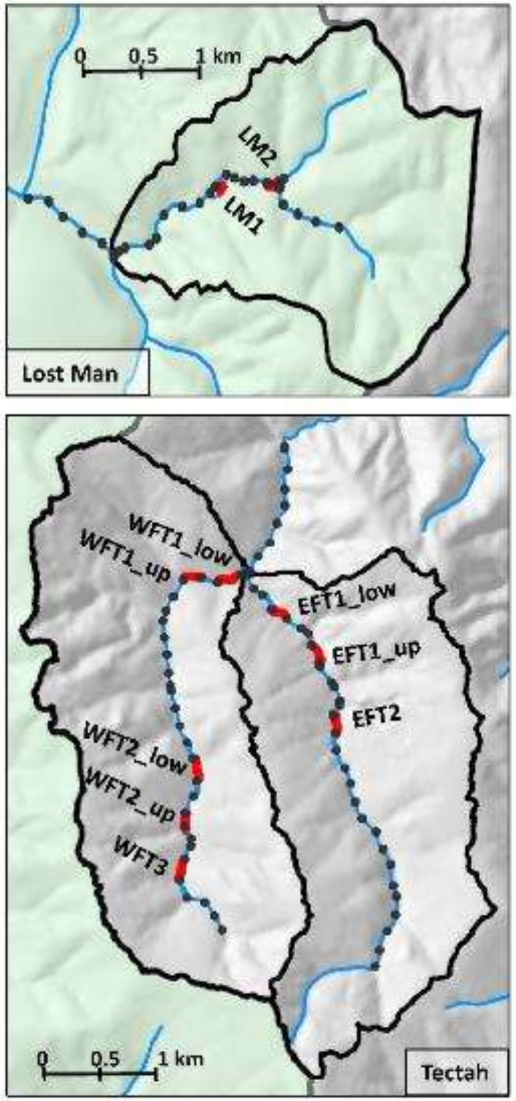


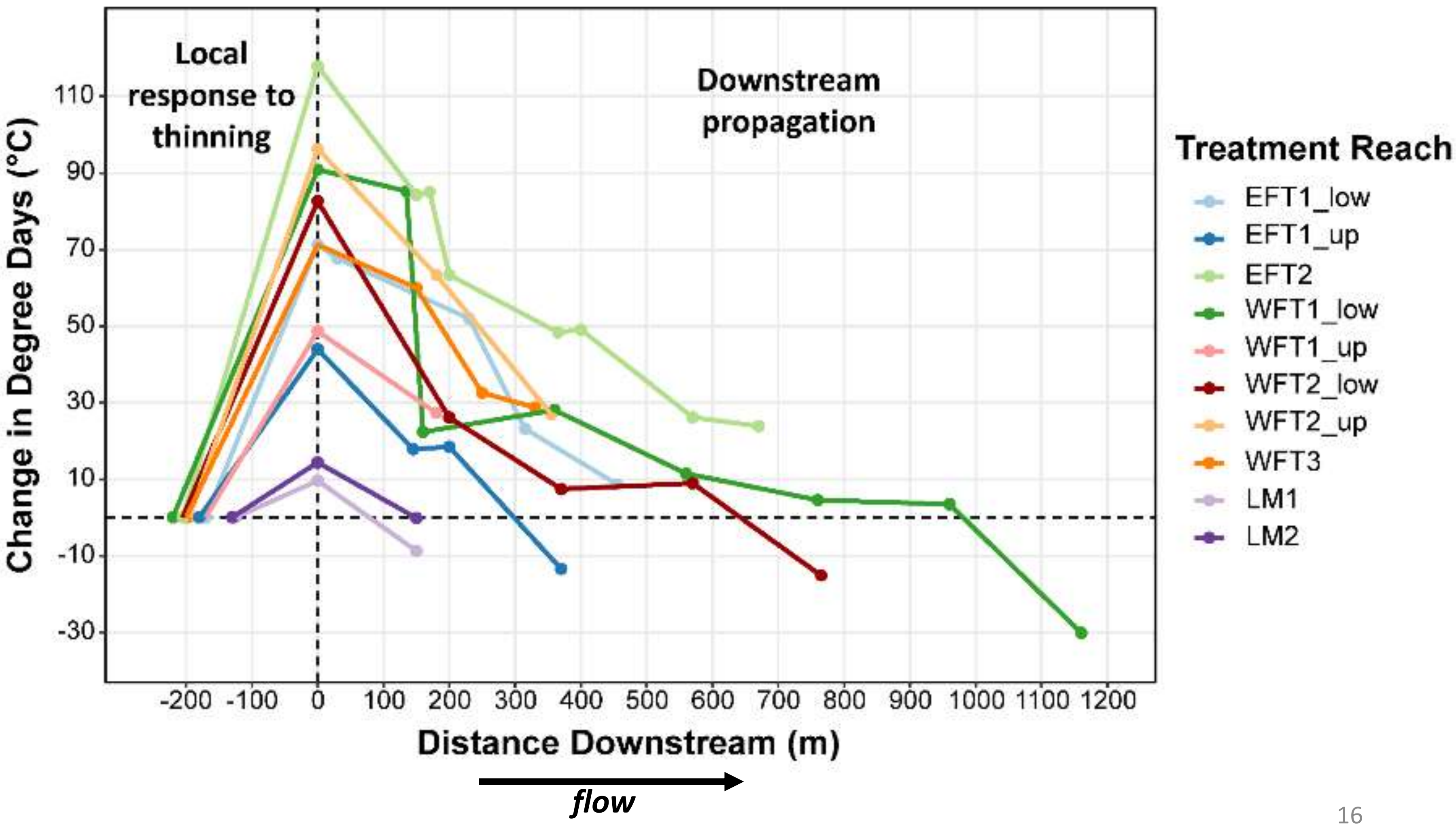
Local changes in temperature propagated downstream





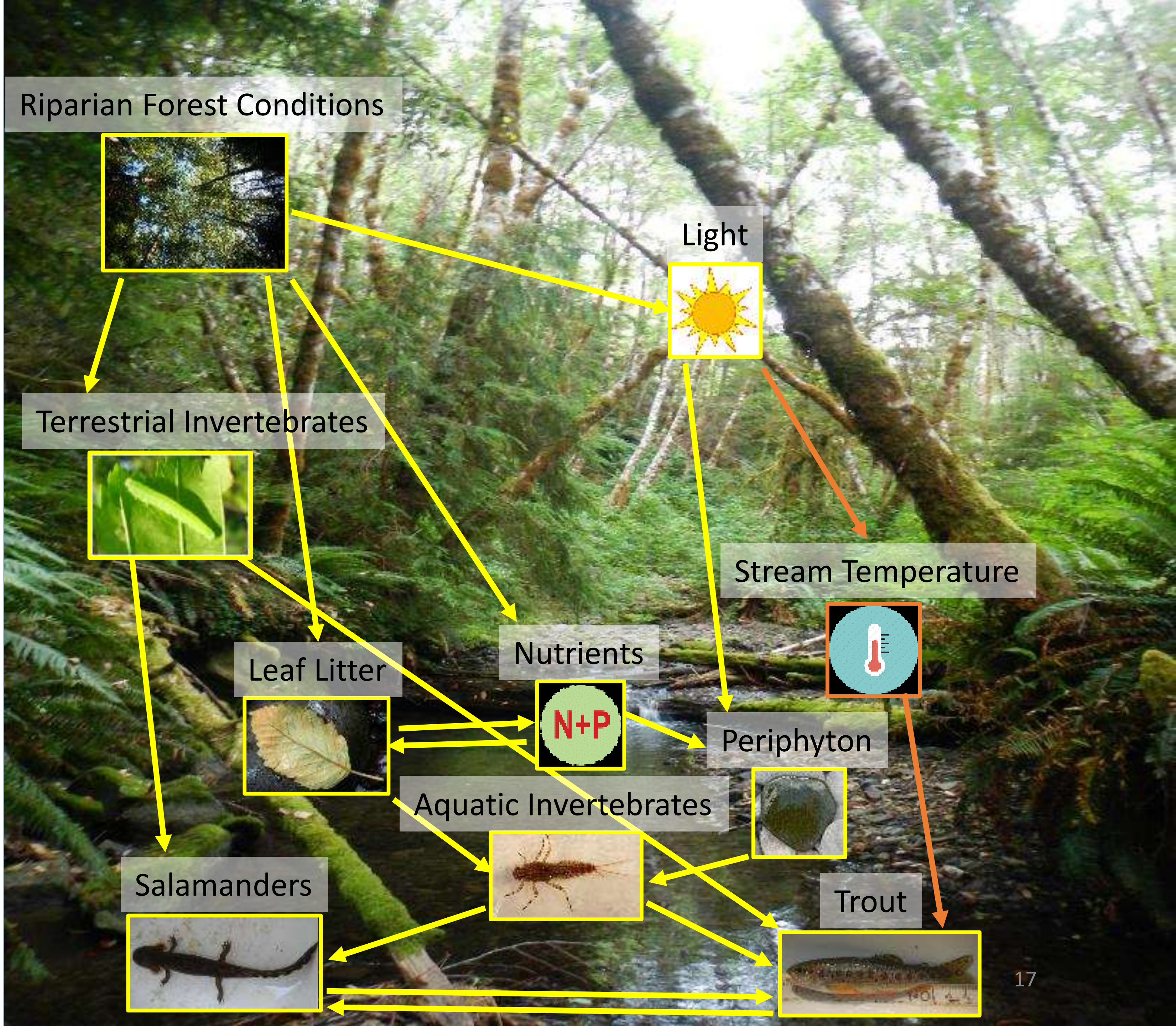
Watershed-scale downstream propagation of local responses extended 100-1000m



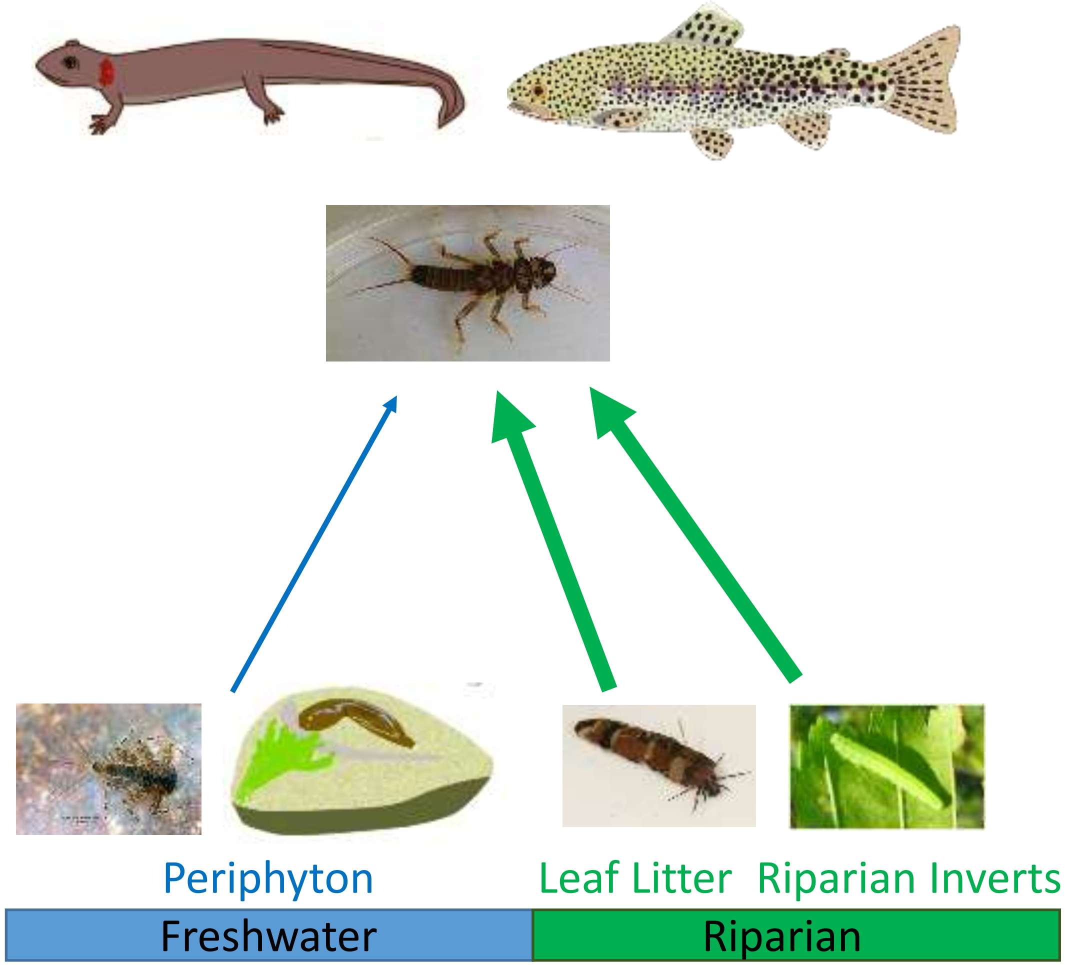


Part 2

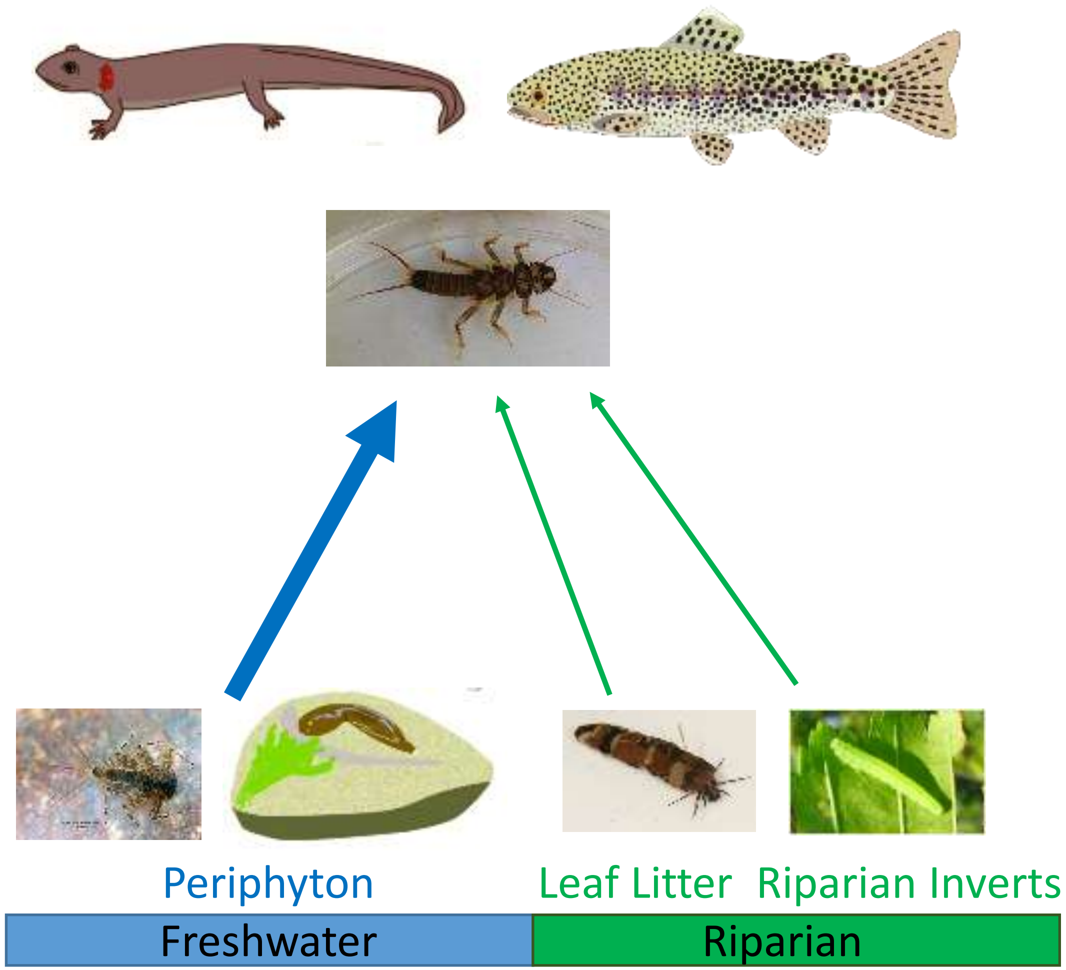
How does riparian thinning influence stream food webs and aquatic productivity?



Stream food web conceptual model

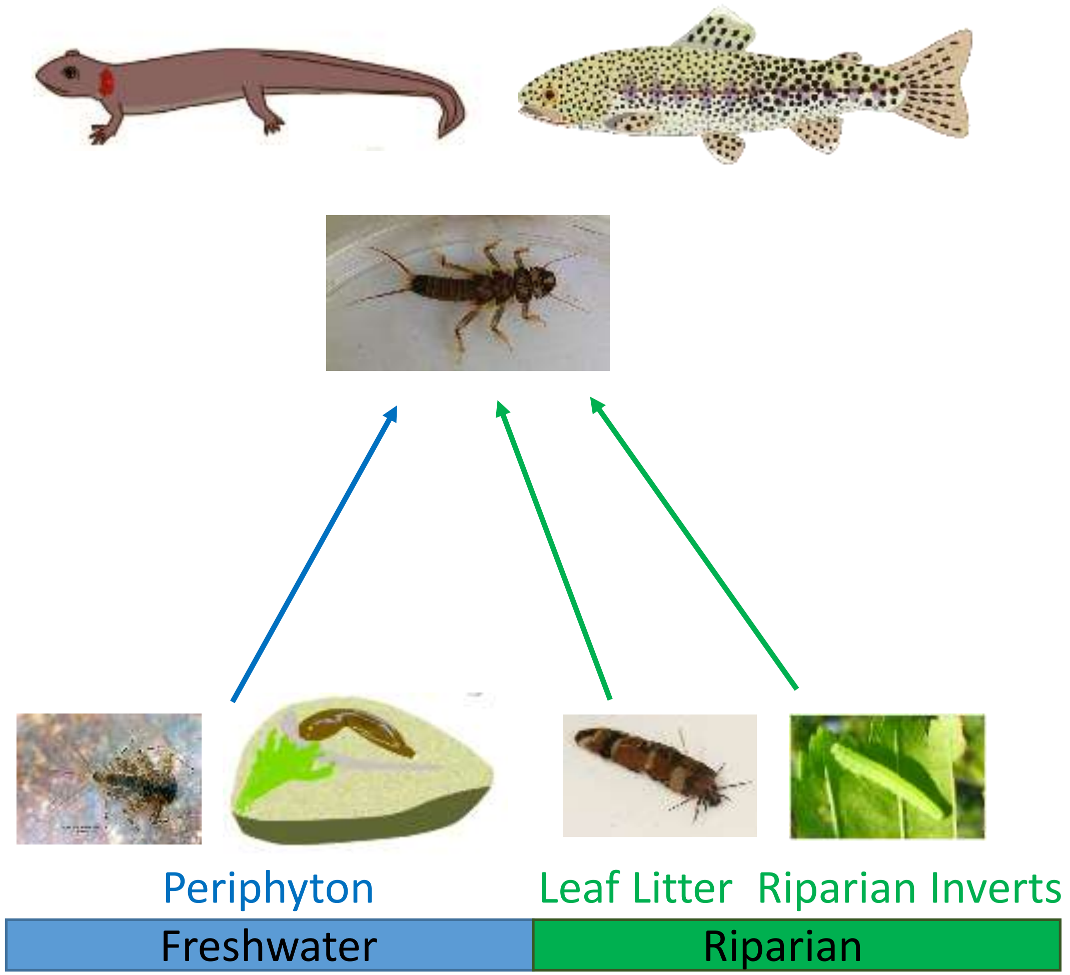


Stream food web conceptual model



Does thinning enhance aquatic productivity?

- **Stream periphyton**
- **Prey in diets of top predators**
- Stable isotopes



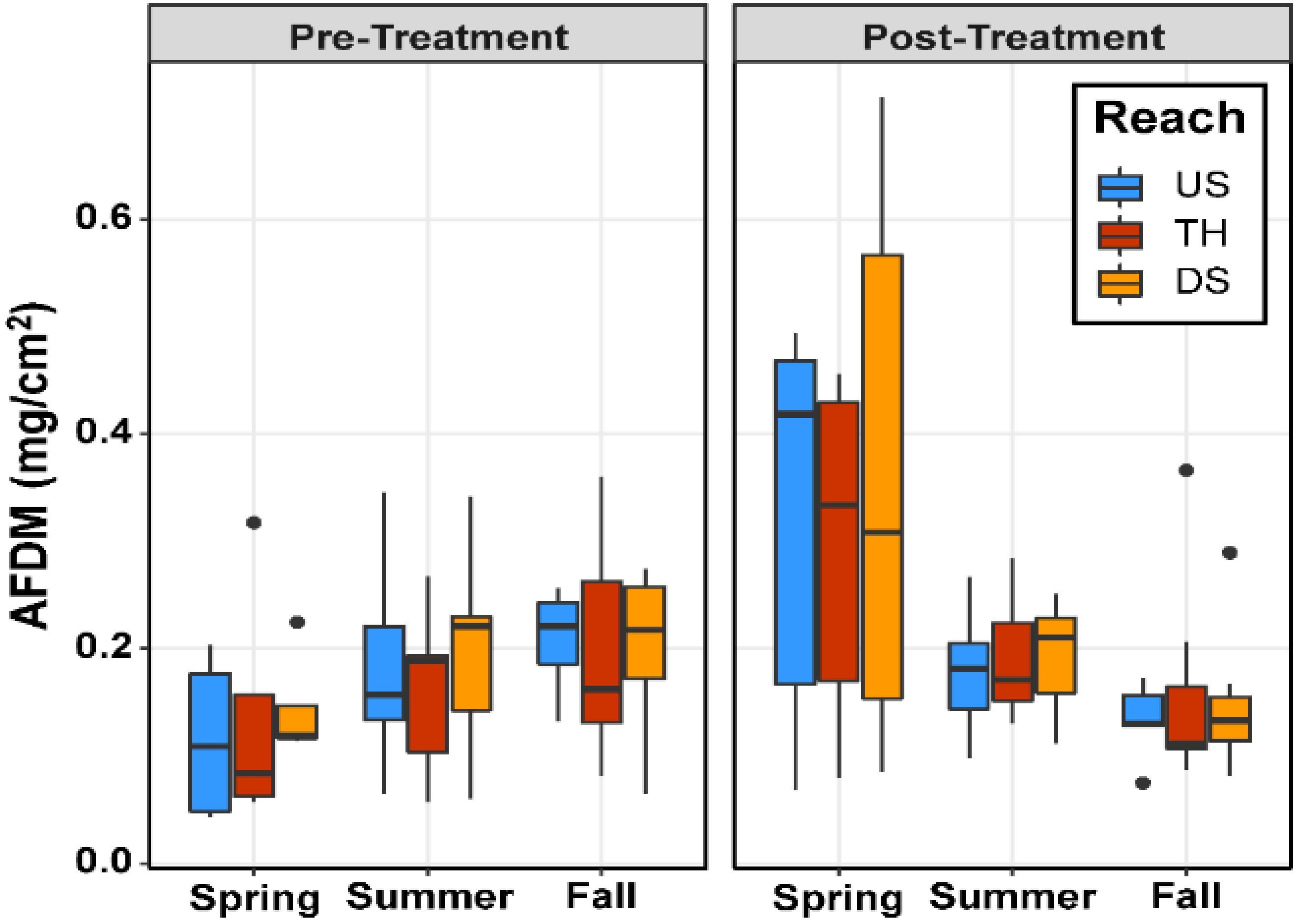
Stream periphyton

Hypothesis: thinning will increase abundance of periphyton

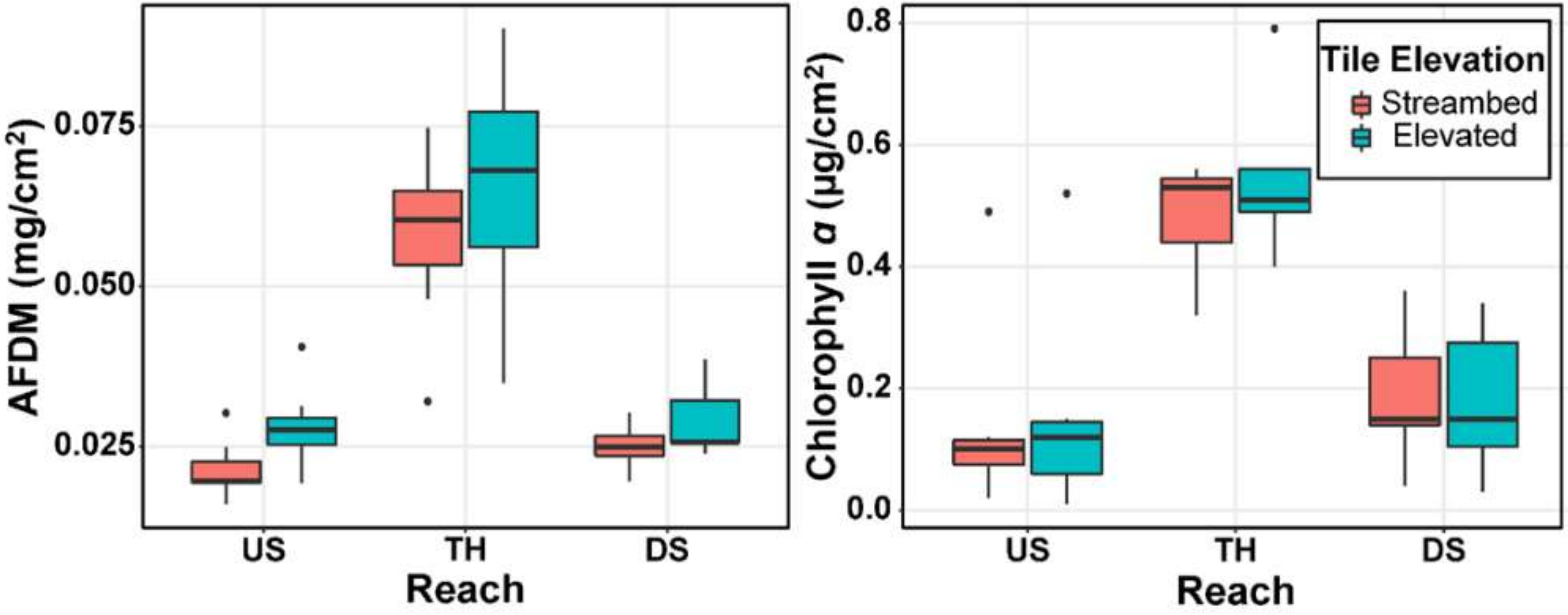
Methods:

- Standing stocks on natural substrates
- Accrual on experimental tiles

No effect of thinning on periphyton biomass on natural substrates



Thinning increased periphyton accrual on tiles



Diet analysis

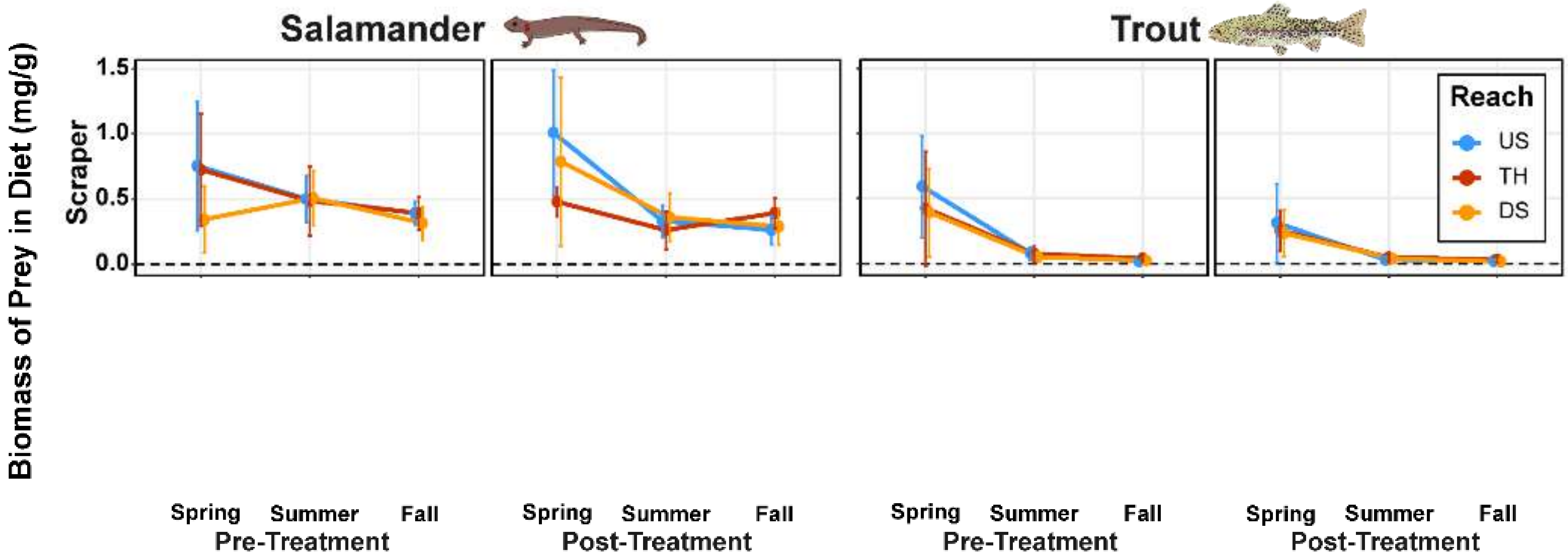
Hypothesis: thinning will:

- increase biomass
- shift composition

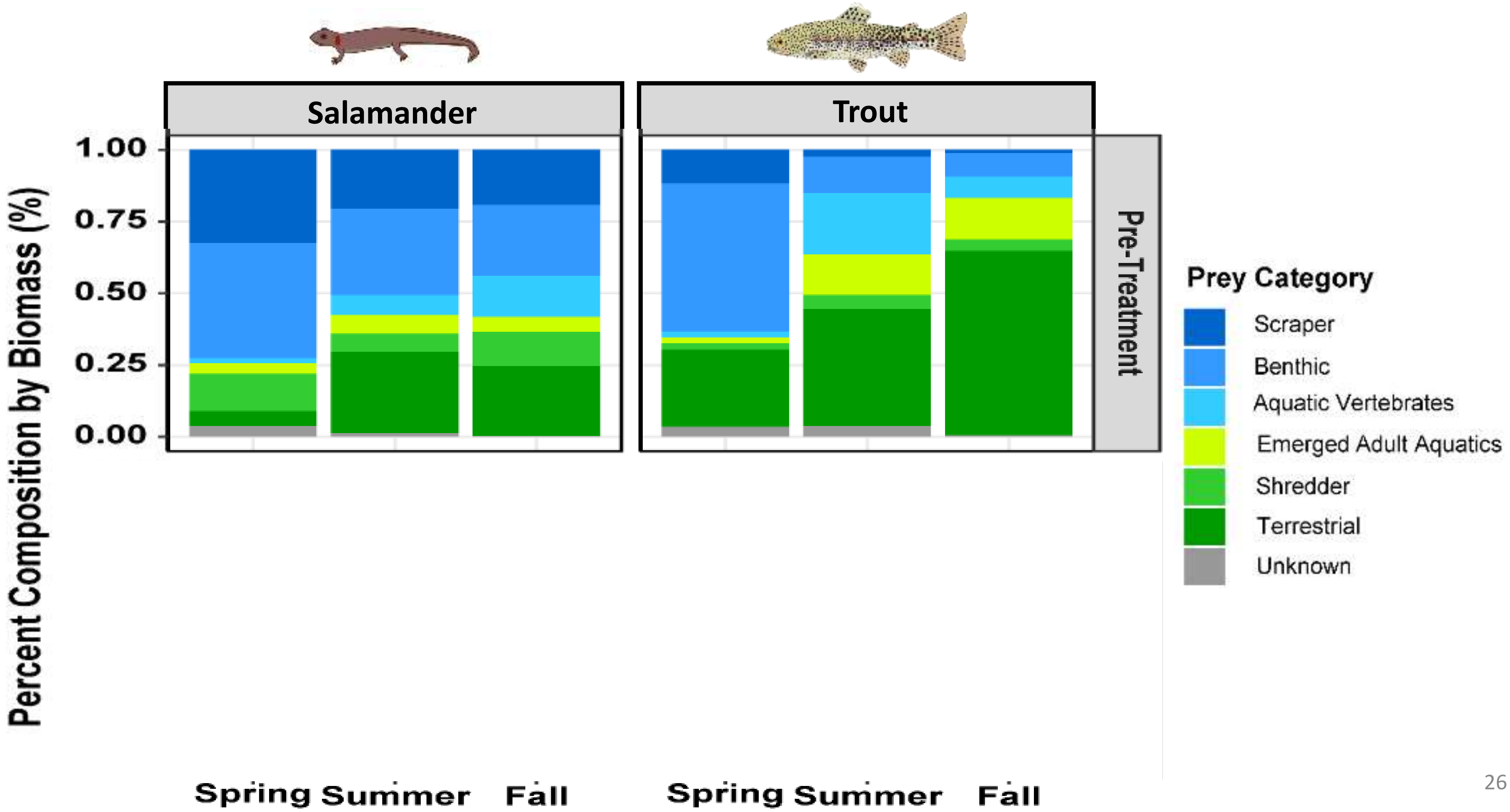
Methods:

- Non-lethal gastric lavage (n = 2498 samples)

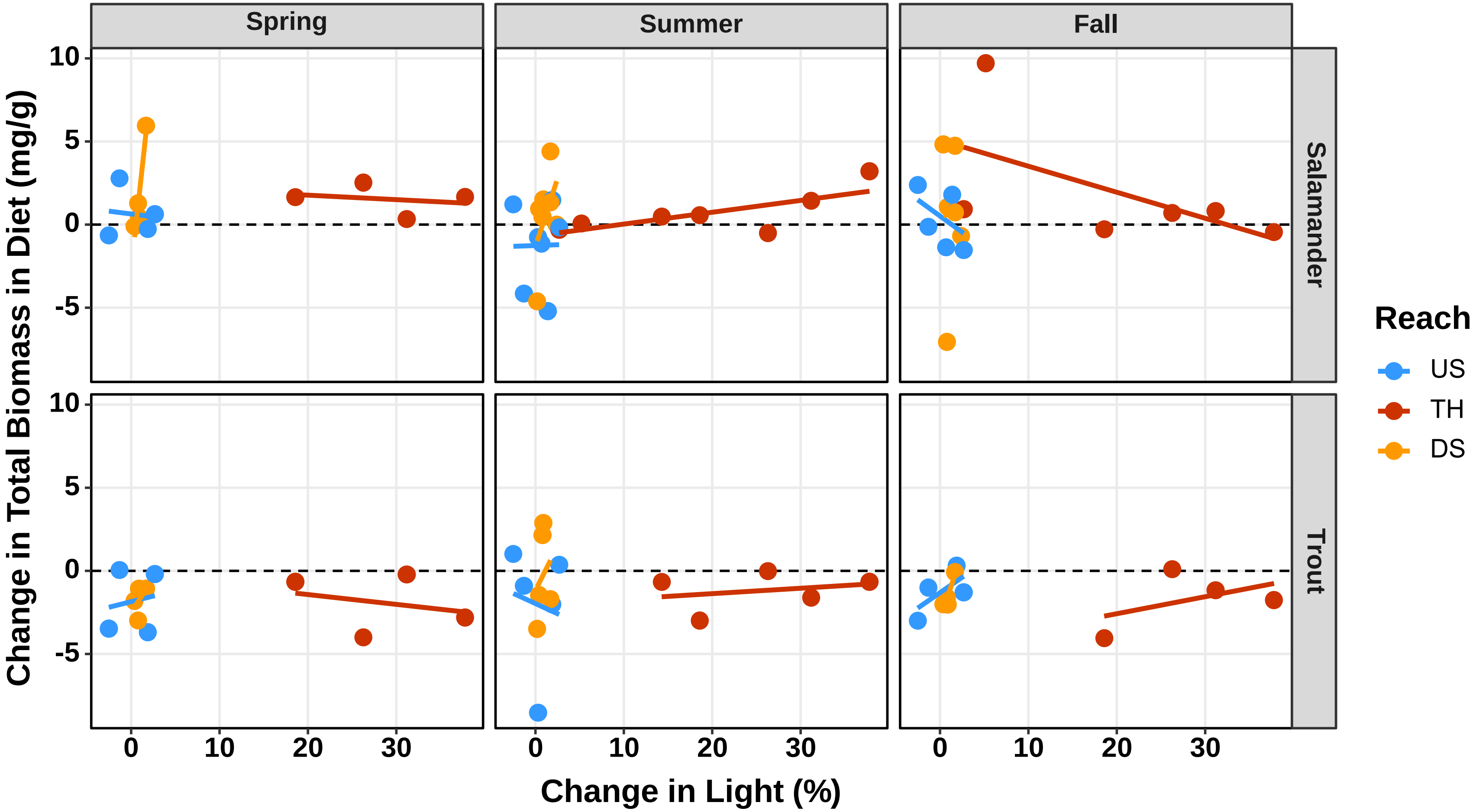
Thinning did not increase the biomass of prey in the diets



Prey composition in diets varied more seasonally and between predators than due to thinning



Pretty remarkable given the intensity of thinning treatments

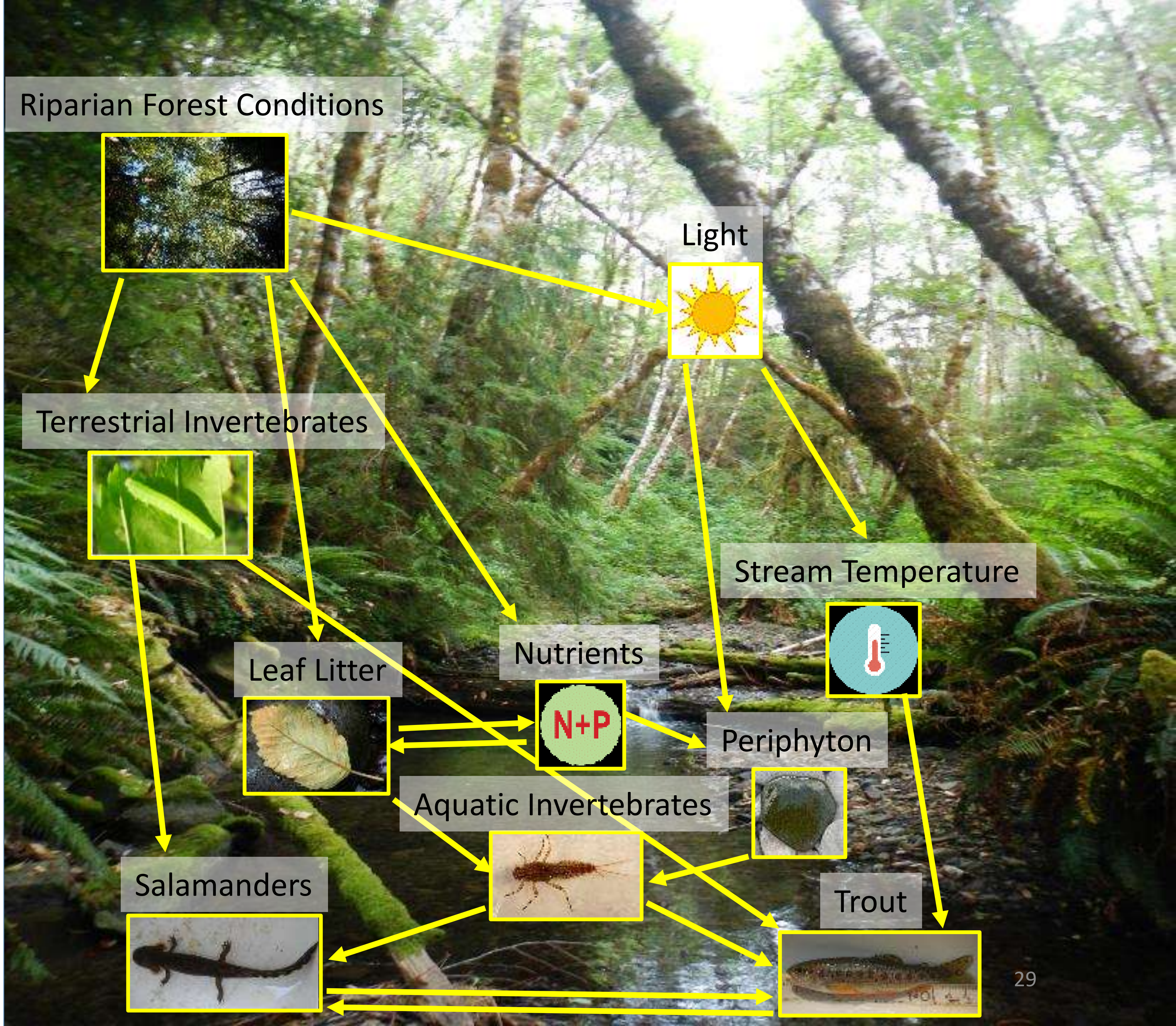


So what's going on?

- Change in light sufficient to increase periphyton, but not enough to influence higher trophic levels
- Other limiting factors in watersheds (e.g. nutrients)
- Scraping taxa only made up small portion of diets, and didn't change with thinning
- Importance of terrestrial prey items continued after thinning
- Only examined responses 1 year after treatment

Part 3

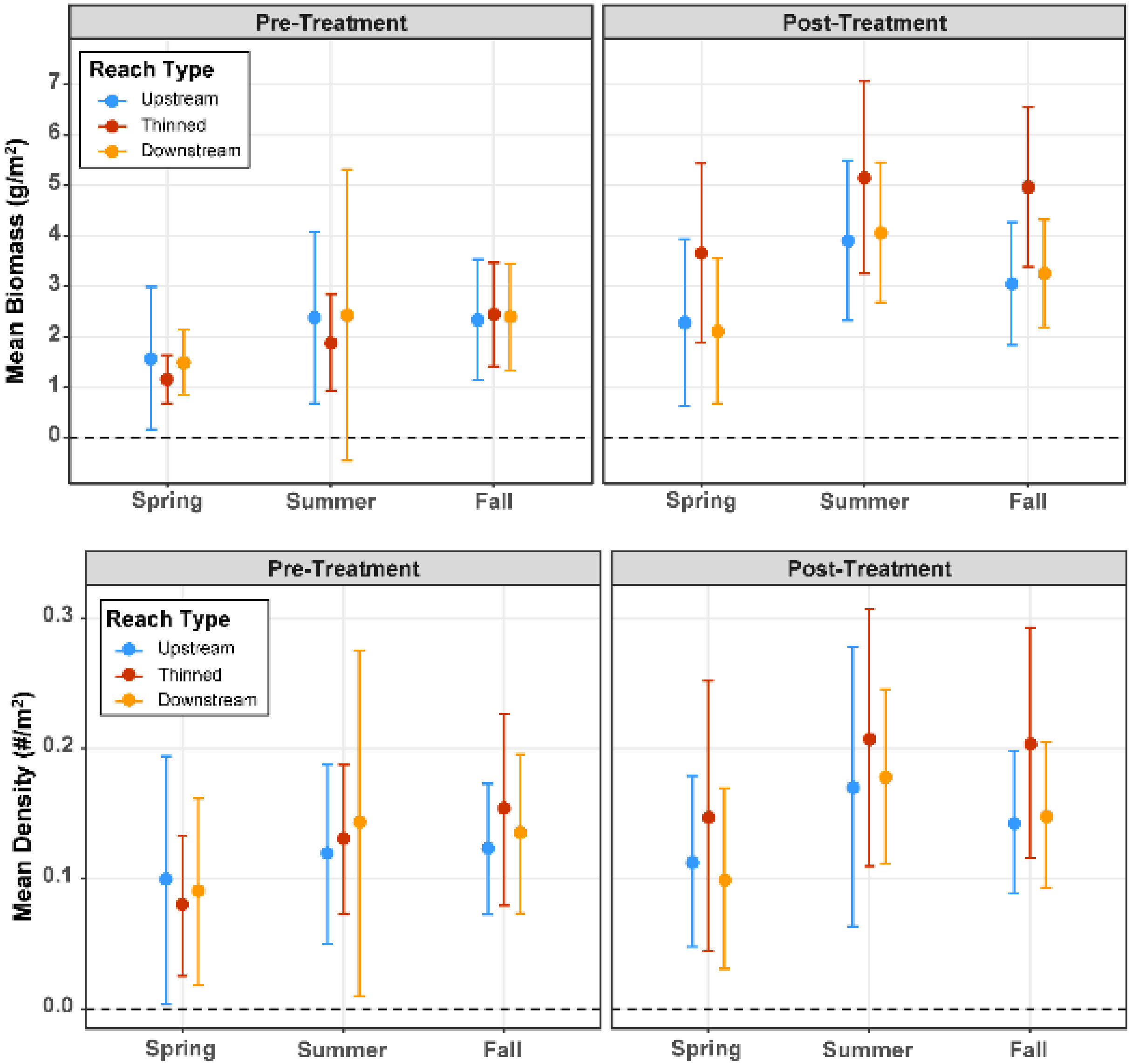
How does riparian thinning influence the cutthroat trout in the study watersheds?



So how did cutthroat trout respond to riparian thinning?

- Backpack electrofishing
- Measured density, biomass, and growth
- Bioenergetics modeling
  - Provides a way to understand how temperature and prey interact to affect growth
  - Growth = Consumption - Metabolism – Waste
  - Consumption = Growth – Metabolism - Waste

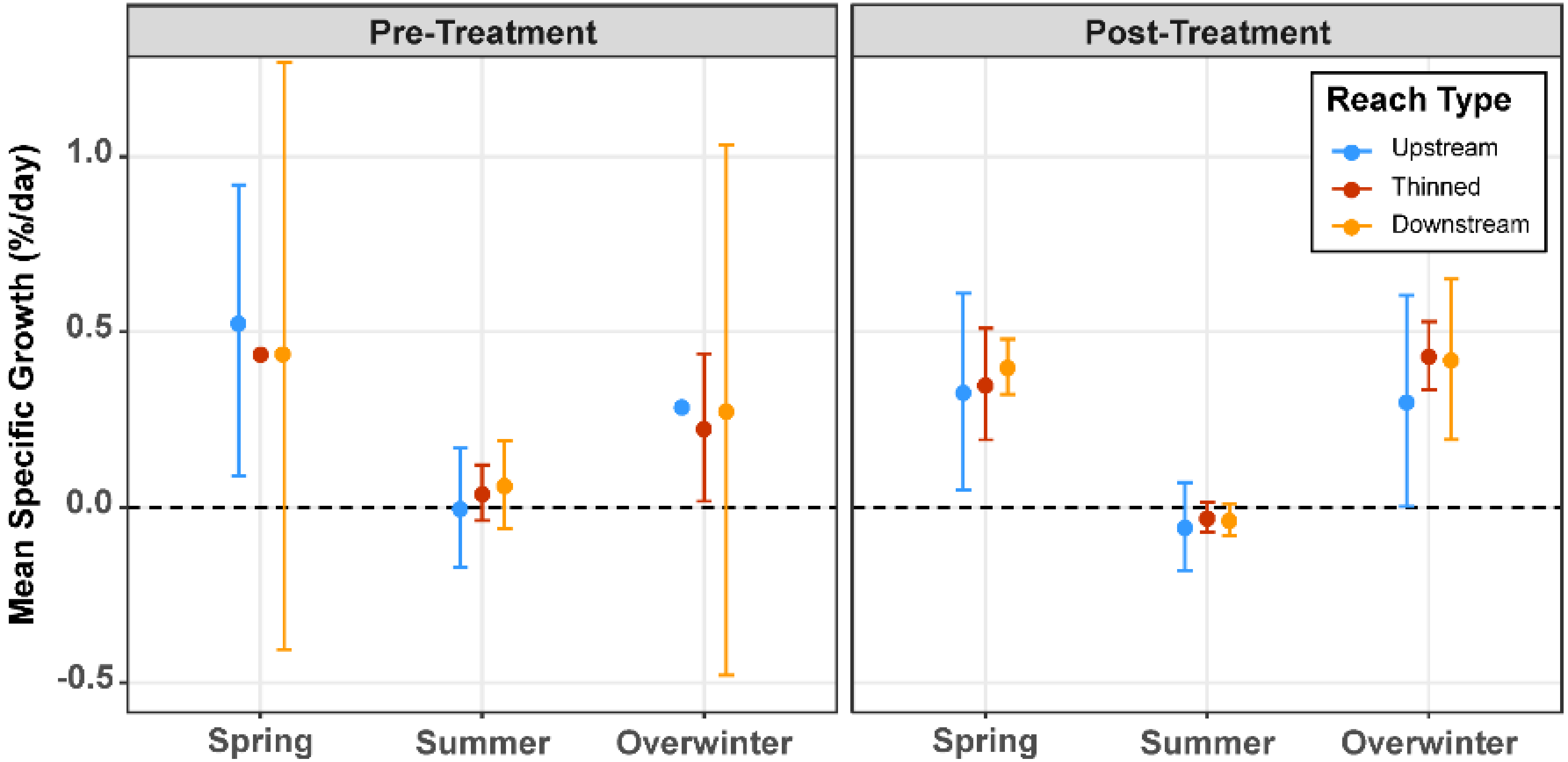
Cutthroat trout biomass increased to thinning treatments more than density, but a lot of variation across sites



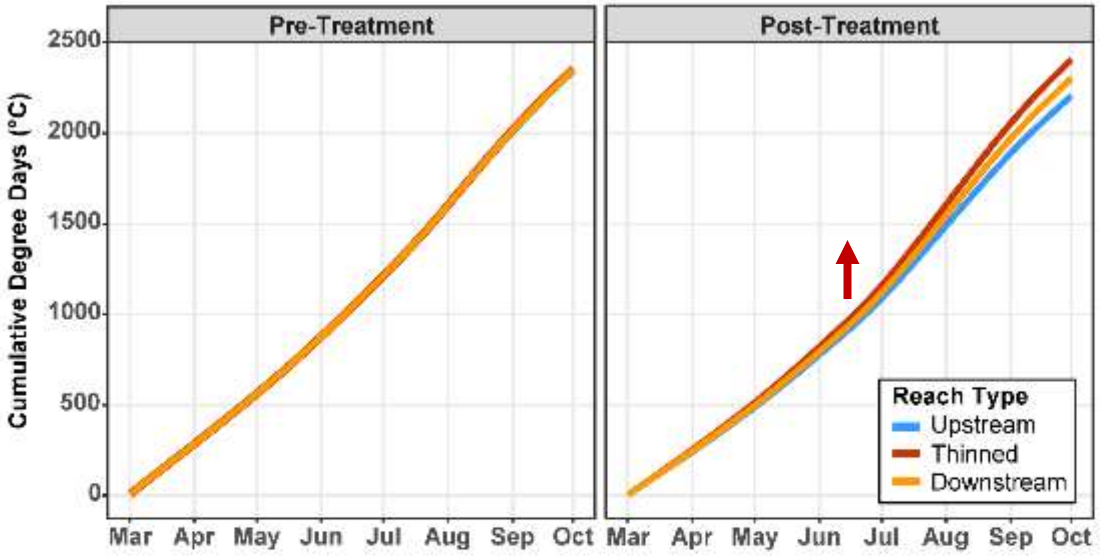
+50-75%

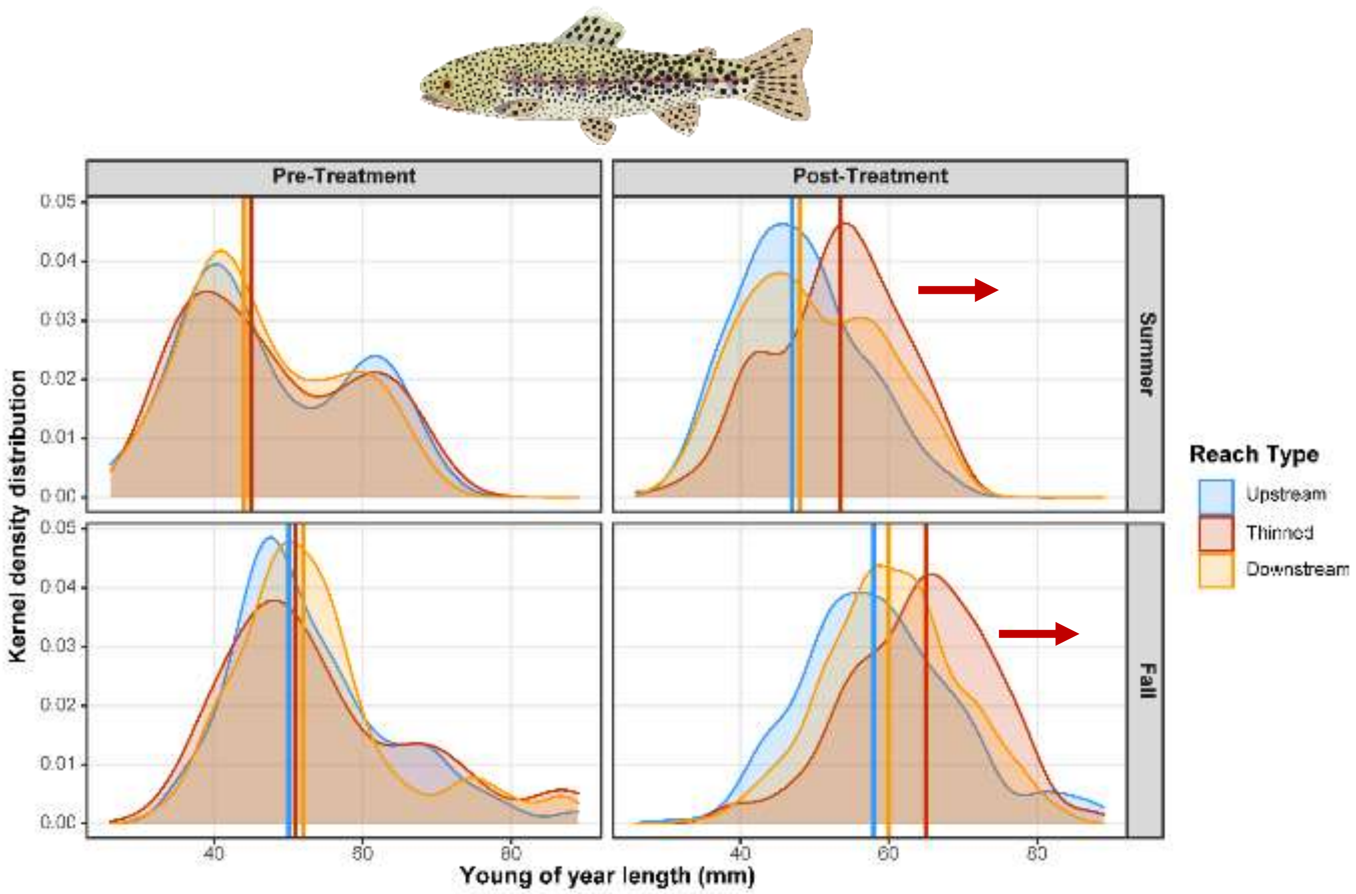
+15-25%

Cutthroat trout growth varied more seasonally than due to thinning

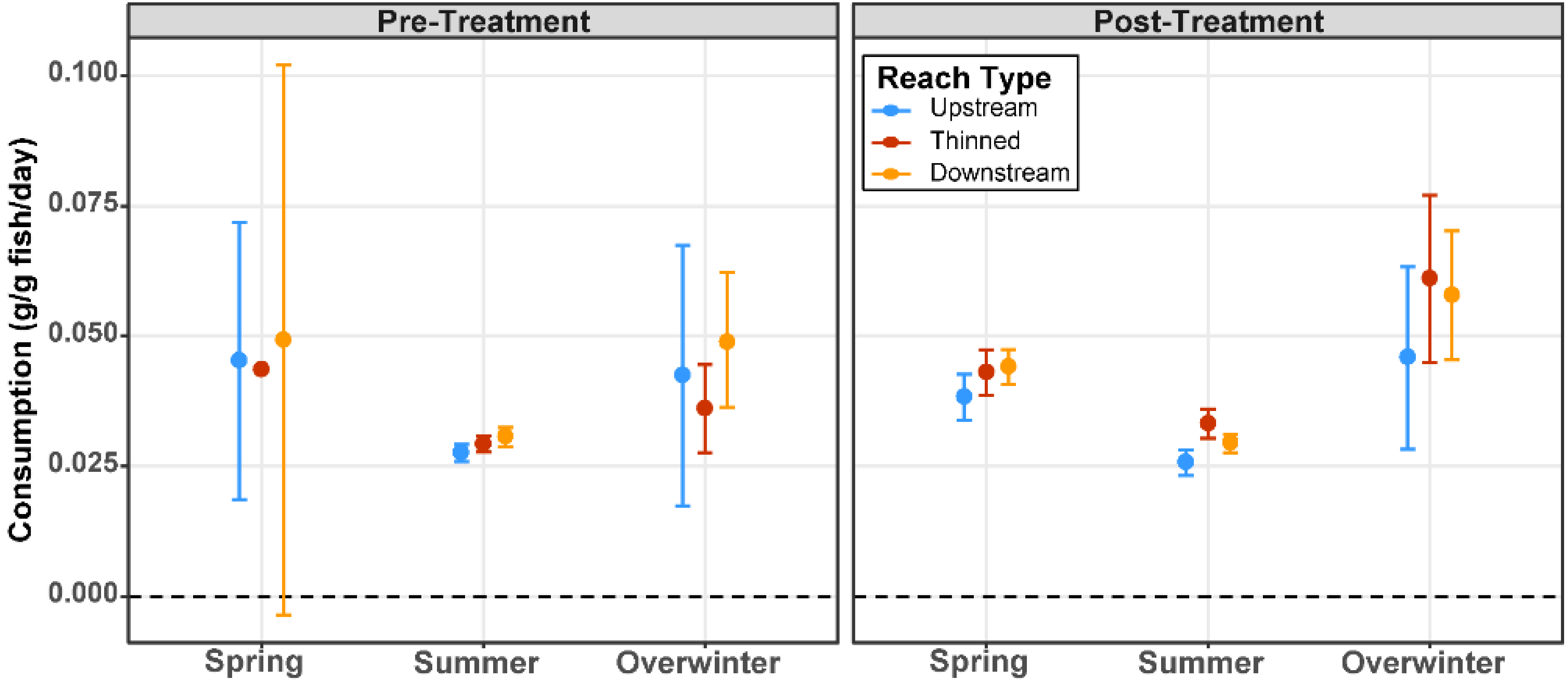


Increases in biomass likely due to small increases in temperature that led to early emergence leading to larger fish

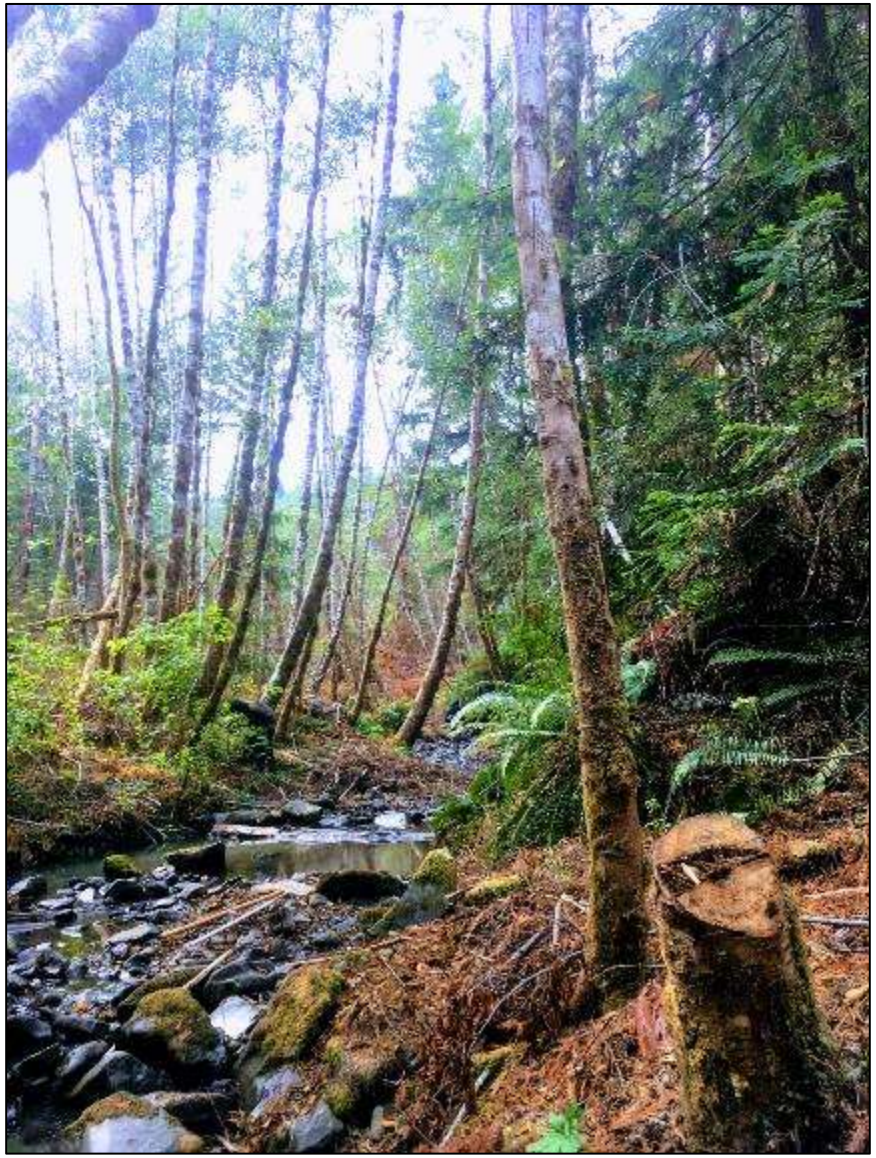




Bioenergetics modeling suggests cutthroat trout dealt with increases in temperature through increased consumption



General conclusions



1) Riparian shade, light, and stream temperature

- Stream temperatures increased locally and downstream, but responses depended on treatment intensity

2) Stream food webs

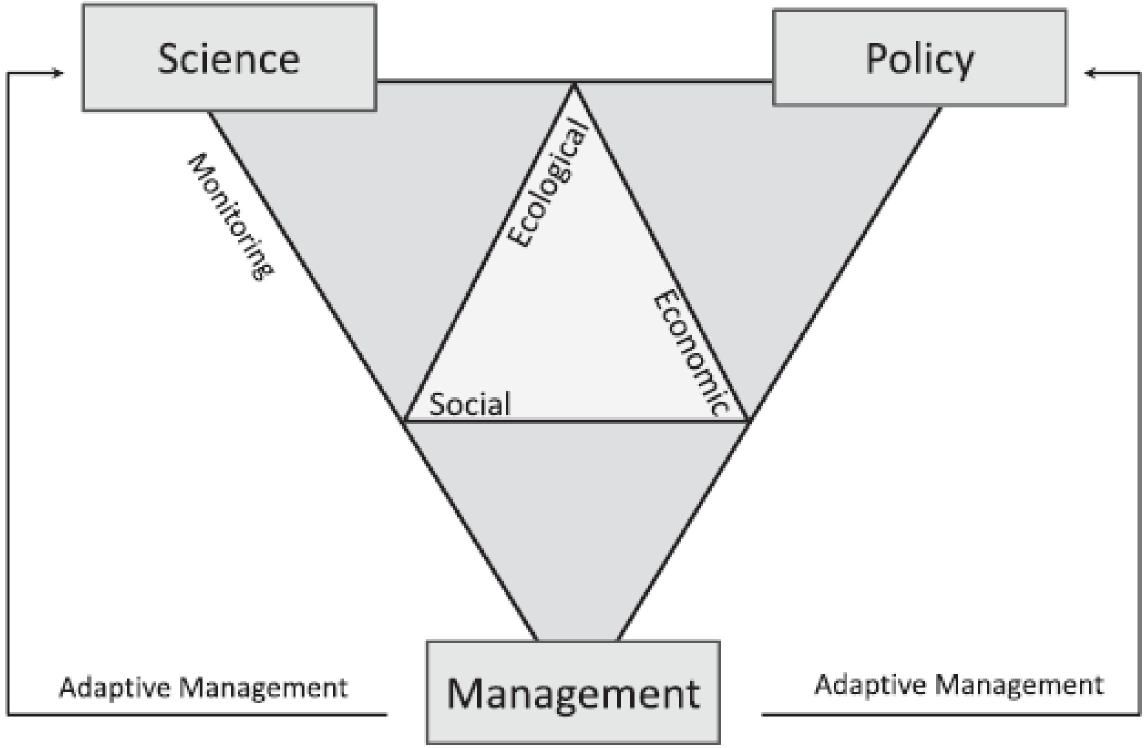
- Limited influence on stream food webs; responses largely confined to lower trophic levels

3) Cutthroat trout

- Biomass increased more than density, possibly due to small increases in temp that led to earlier emergence
- Growth varied more seasonally than due to thinning
- Cutthroat trout dealt with increased temperatures via increased consumption rates

Implications for resource managers interested in riparian thinning

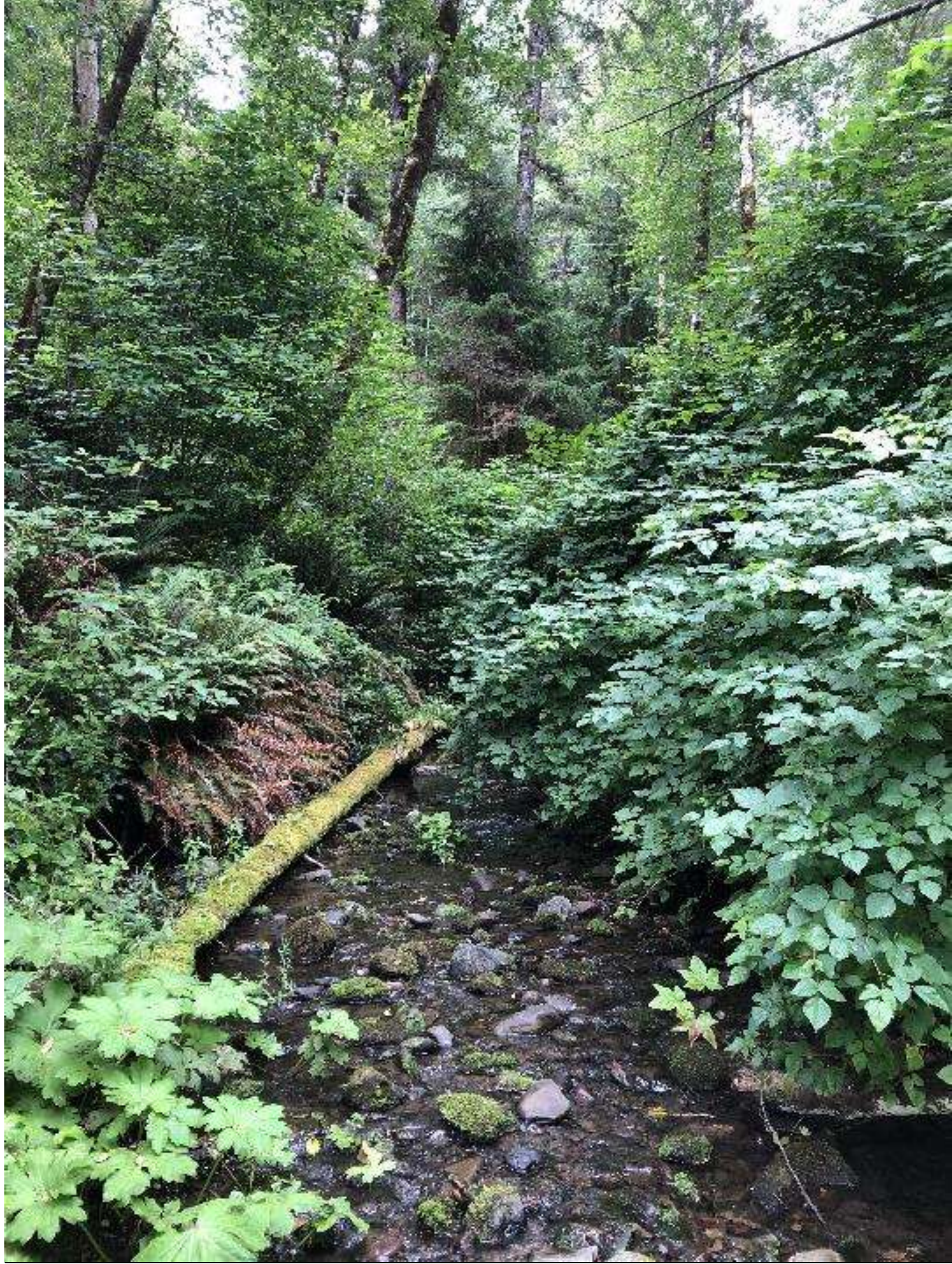
- Stream temperatures
  - Could thin less intensively or thin shorter reaches
  - Could space treatments further apart to avoid downstream effects
- Stream food webs
  - Increases in light don't always translate to increased aquatic productivity of entire food web
- Cutthroat trout
  - Fish largely resilient; increases in temperature likely small enough that did not stress fish
  - But will depend on context
- Other attributes we didn't measure
  - Heterogeneity of riparian vegetation
  - Large wood



Sibley et al. 2012

Future directions / next steps

- Longer-term evaluations needed
  - How long do initial responses last?
- Consider broader range of thinning intensities
  - (e.g., one-sided treatments at lower intensities that may be easier to implement)
- Repeat in other locations under broader range of contexts
  - Different watersheds, positions within a watershed



Acknowledgements

- Collaborative Effort: OSU, USGS FRESC, USFS PNW Research Station, USFS Redwood Sciences Lab, Green Diamond Resource Company, Redwood National Park
- Funding Sources: OSU Department of Fisheries and Wildlife, USFS, USGS FRESC, Green Diamond, Save the Redwoods League
- Green Diamond Resource Company: Lowell Diller, Matt House, Keith Hamm, Pat Righter, Matt Nannizzi, everyone on Aquatics Team
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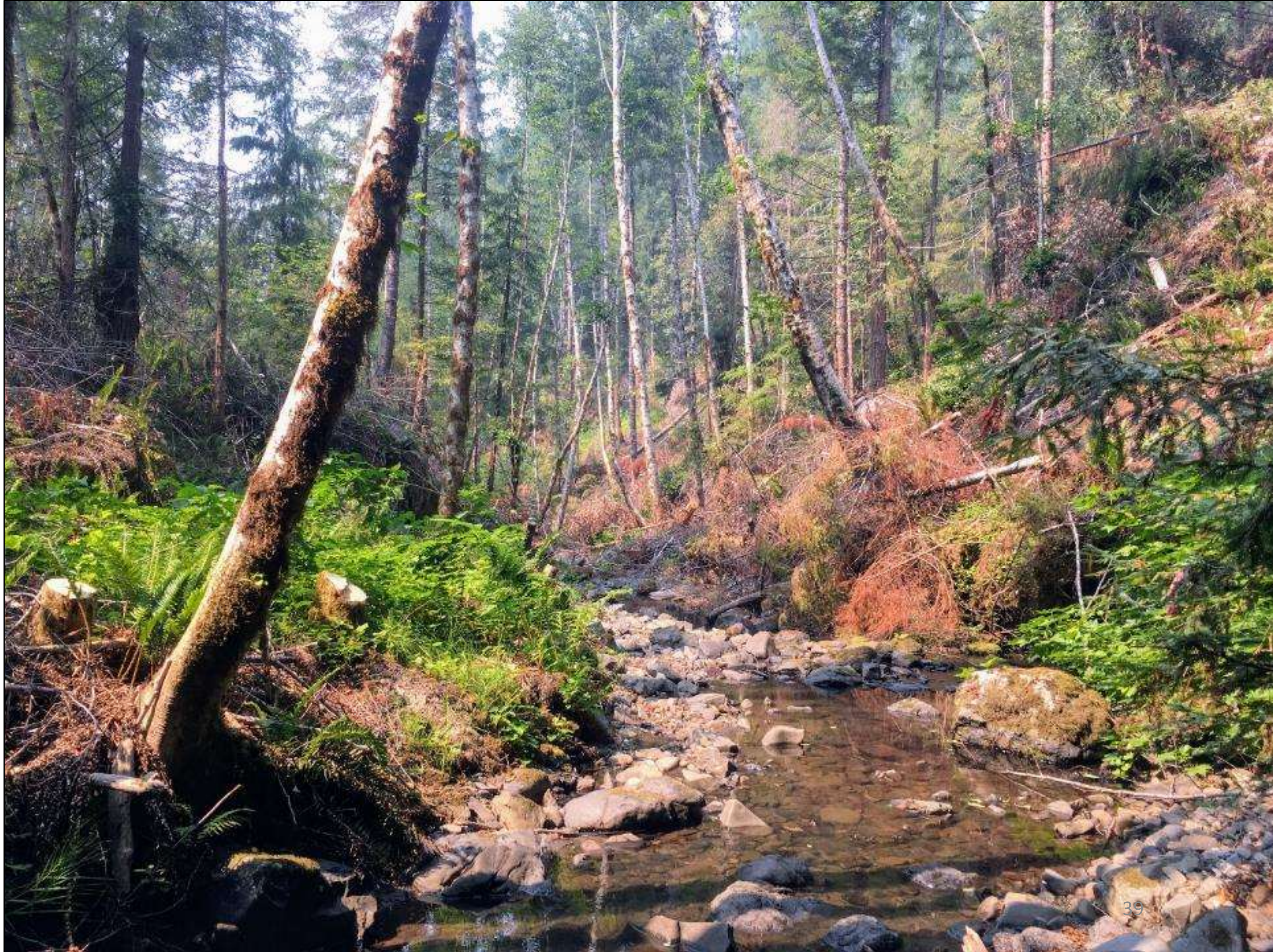
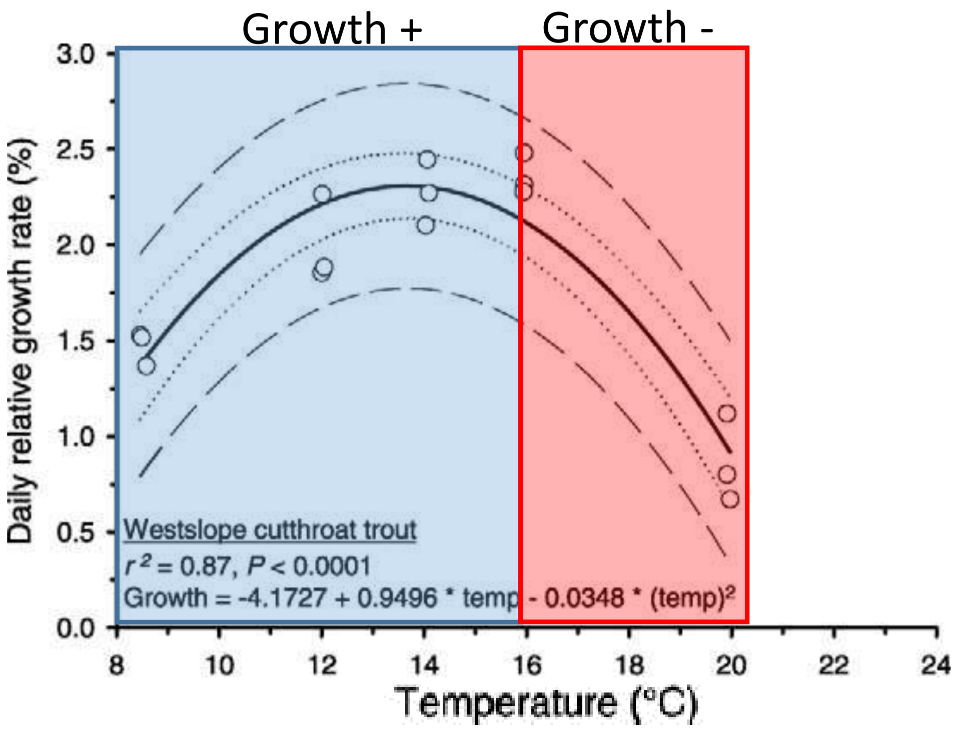
- Lab technicians: Ashley Sanders, Cedar Mackaness, Laura Nepstad, Alex Scharfstein
- USFS PNW Research Station and USGS FRESC
- Warren lab

Questions?



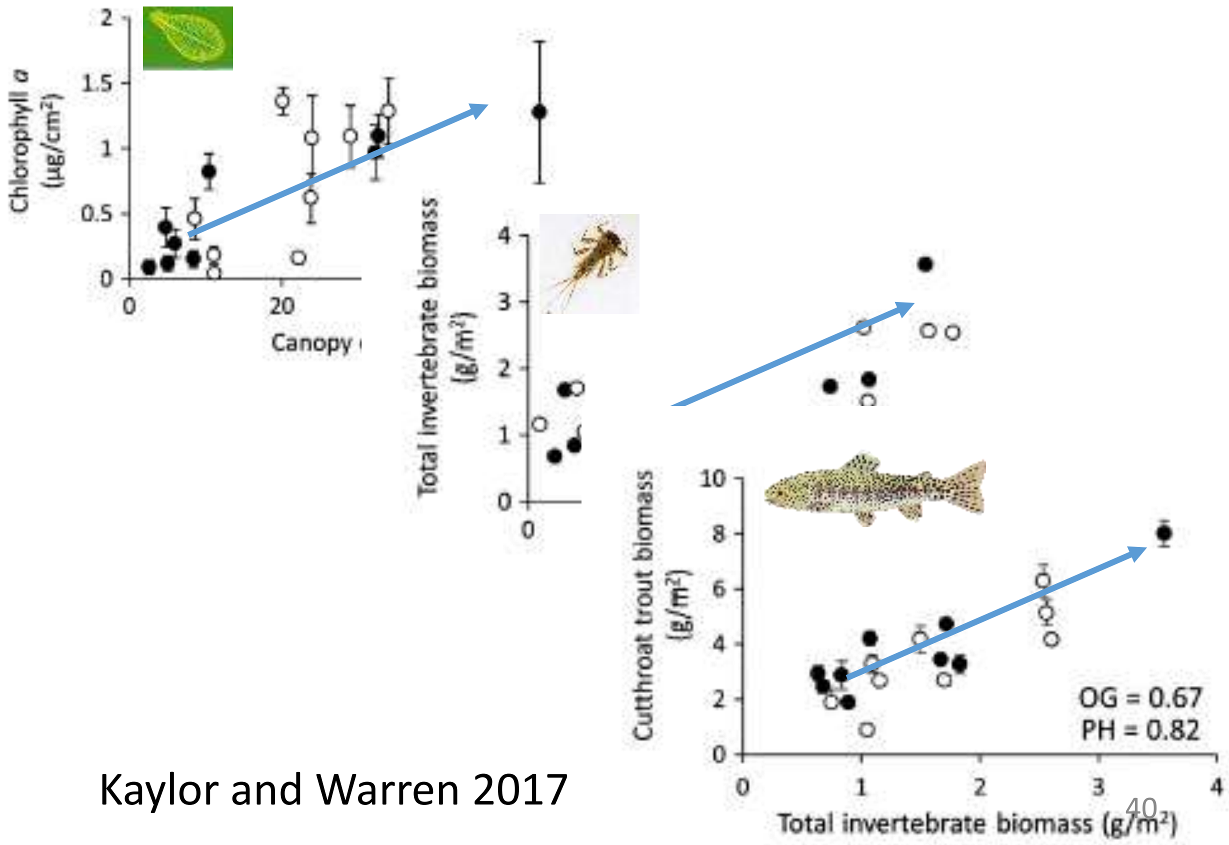
Changes in riparian canopies can result in ecological trade-offs for streams

- Increases in stream temperature (-)



Bear et al. 2007

- Increases in aquatic productivity (+)



Kaylor and Warren 2017

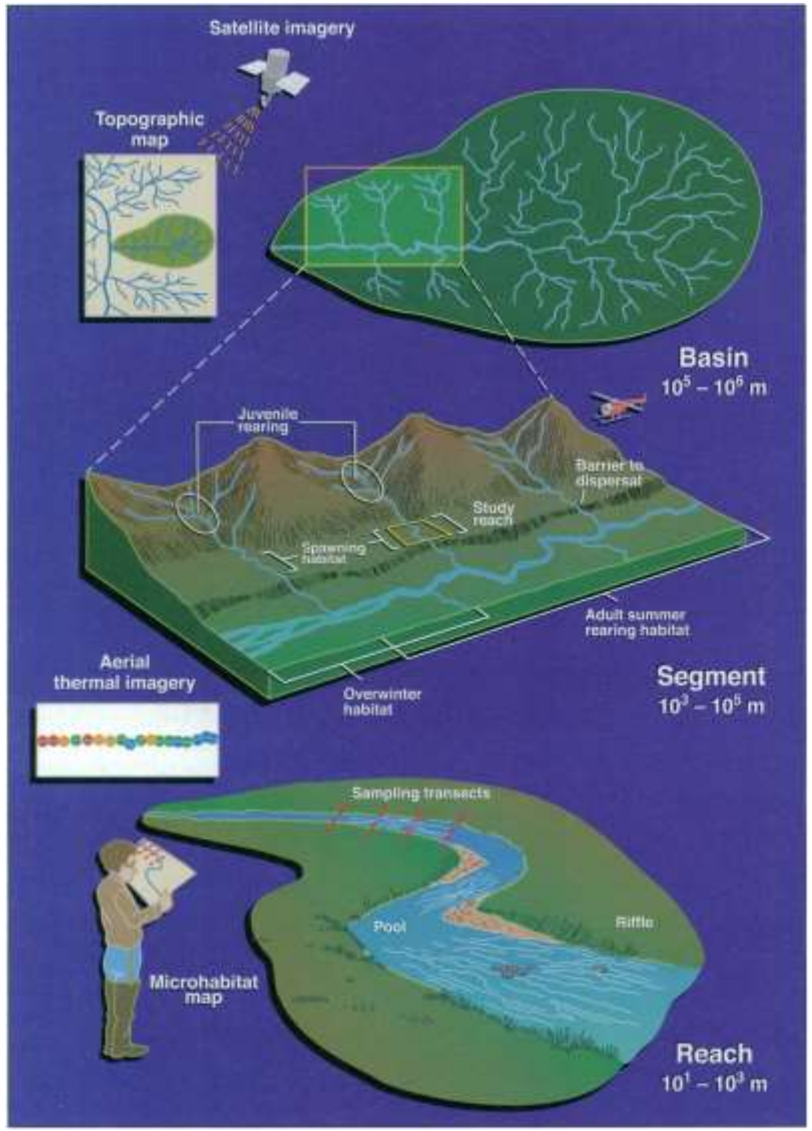
Knowledge gaps

Previous research has focused on:

- Dramatic changes in riparian forests
- Summer conditions
- Local, reach-scale responses
- Patterns

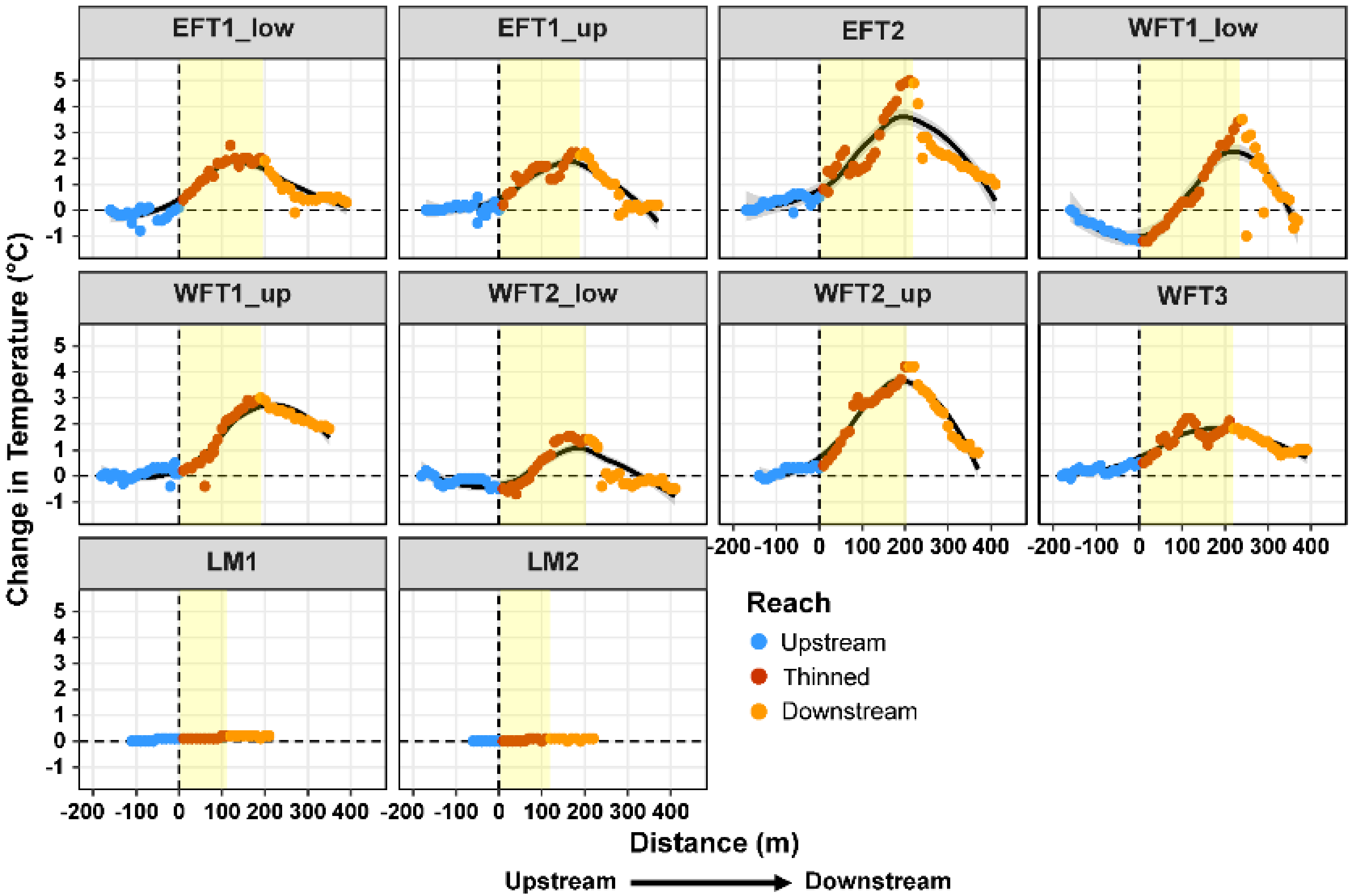
We know far less about:

- Smaller changes in riparian forests
- Seasonal variation
- Broader spatial extents such as entire watersheds
- Underlying processes

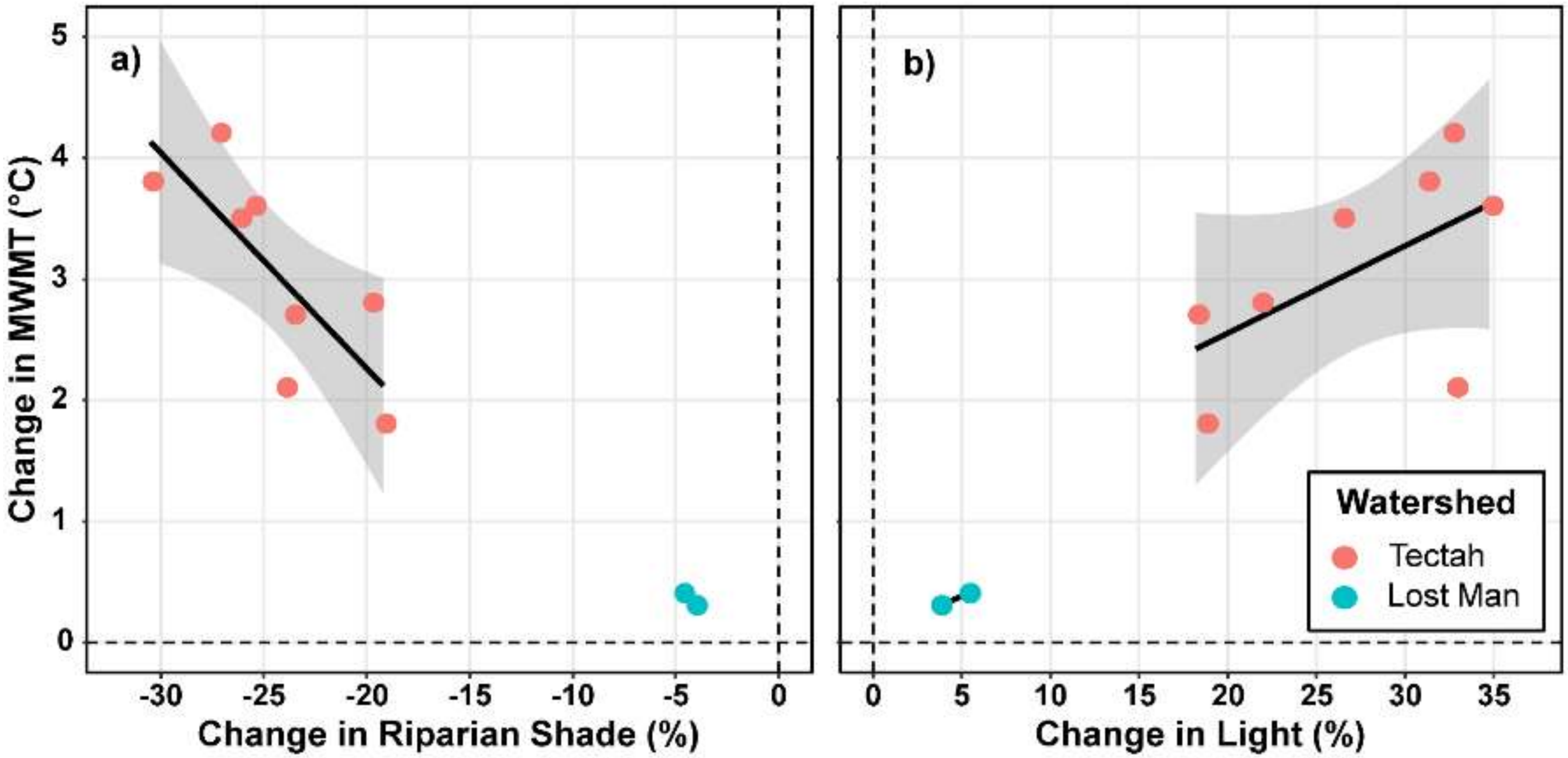


Fausch et al. 2002

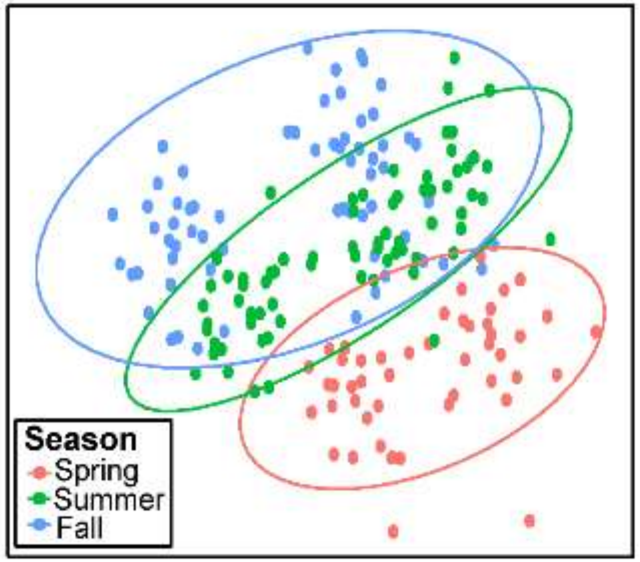
Fine-scale longitudinal temperature patterns



Temperature responses highly correlated with changes in shade and light



Prey community structure varied more seasonally and between predators than due to thinning



NMS Axis 2

NMS Axis 1

Stable Isotopes

Hypothesis: thinning will shift pathways of energy flow supporting aquatic consumers

Methods:

- Carbon $\delta^{13}C$ can track energy sources = “you are what you eat”
  - Basal resources
  - Primary consumers
  - Top predators

Perlid stoneflies

Giant salamanders

Cutthroat trout

Heptageniid mayflies

Tailed frog tadpoles

Uenoid caddisflies

Juga snails

Stream periphyton

Stable isotopes indicated shifts in energy flow associated with thinning limited to lower trophic levels

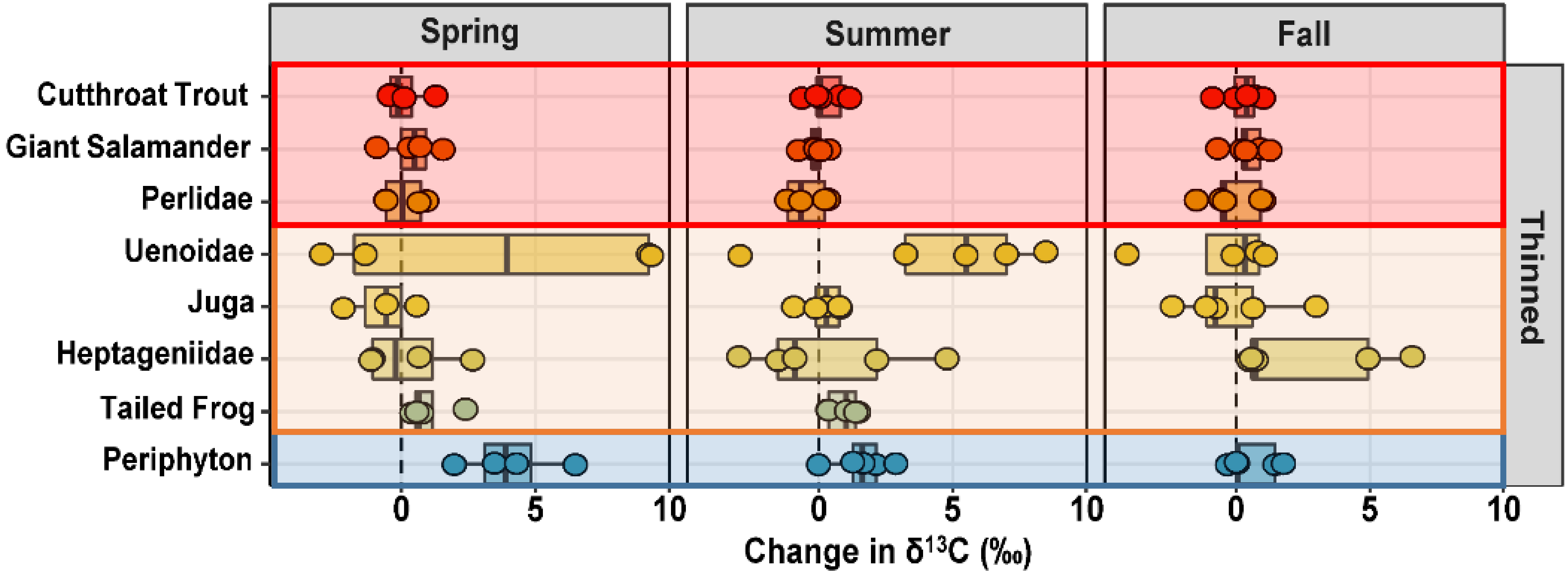
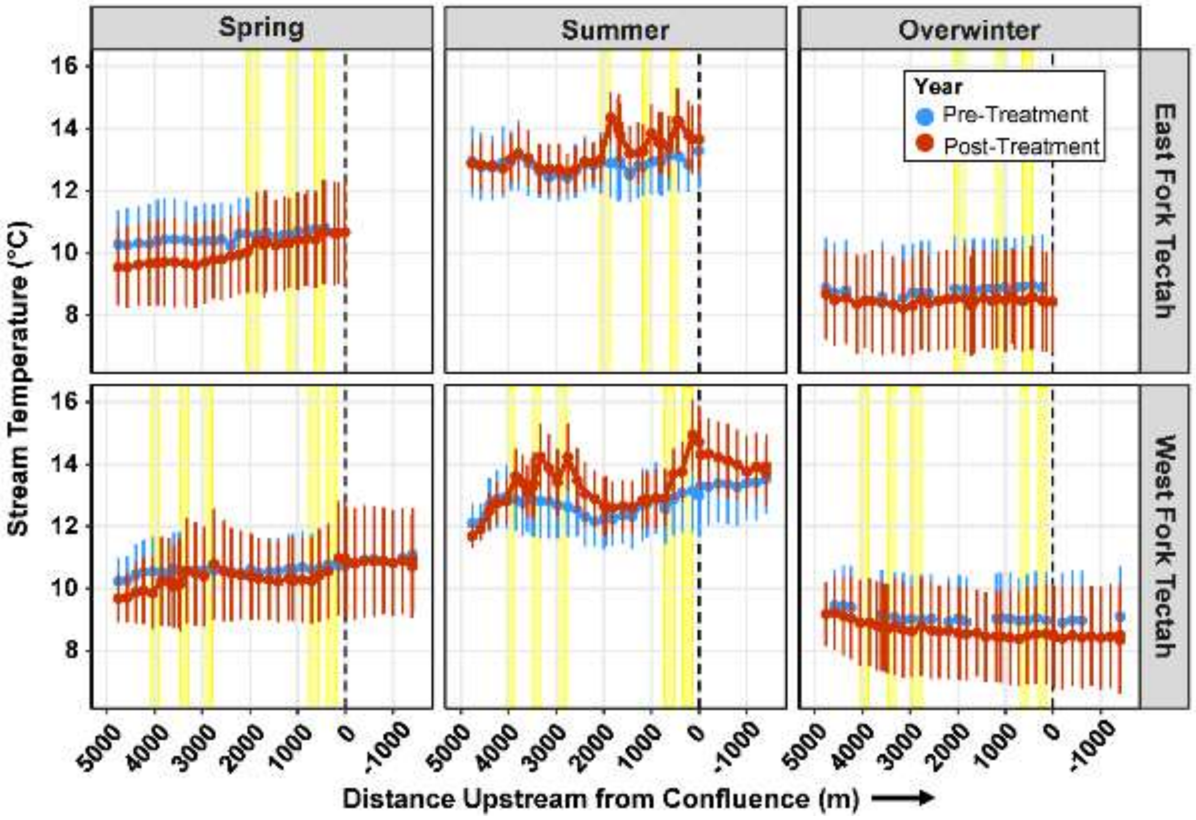
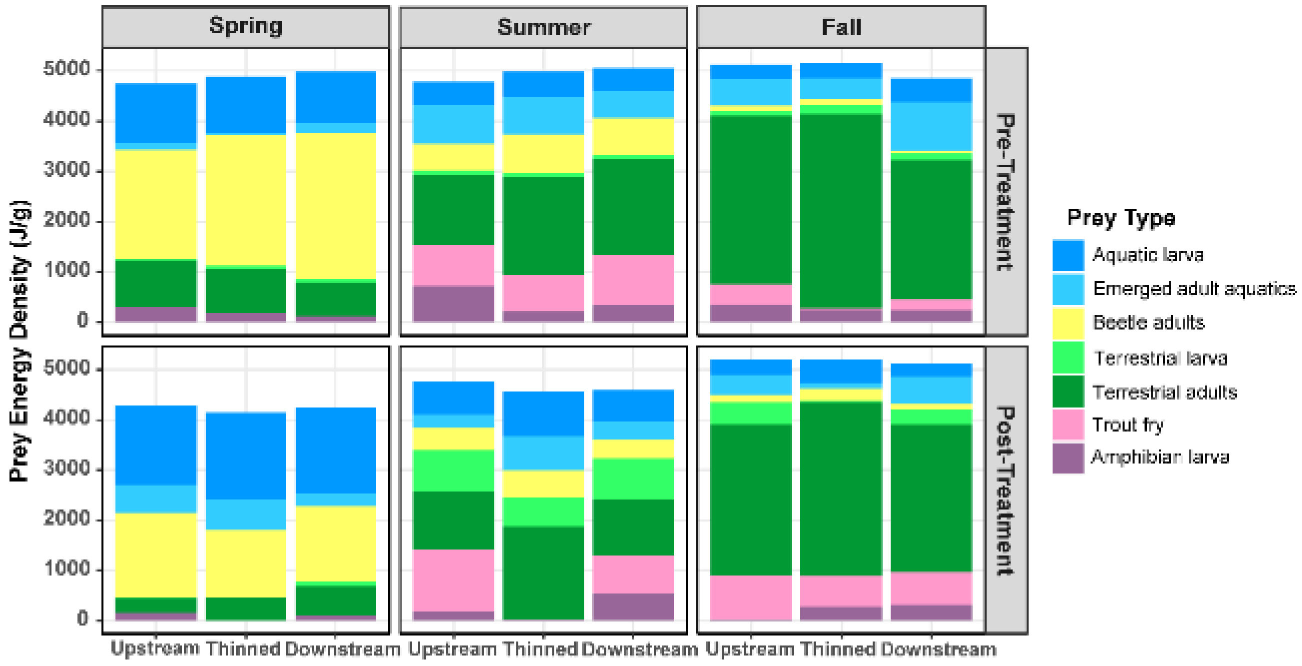


Figure 4. Thermal and trophic resources in study watersheds

Thinning increased stream temperatures esp. in summer



Prey in diets varied more seasonally than due to thinning



Influx of slash immediately after thinning…

How does light effect cutthroat trout populations in low-order streams in the Oregon Coast Range?

Ashley Sanders

MSc Student, Forest Ecosystems and Society,
Oregon State University

Dr. Dana Warren (OSU) and Dr. Ashley Coble (NCASI)

SRF 2023

NCASI IMPACT. SCIENCE. SOLUTIONS.

Oregon State University College of Forestry

Manulife Investment Management

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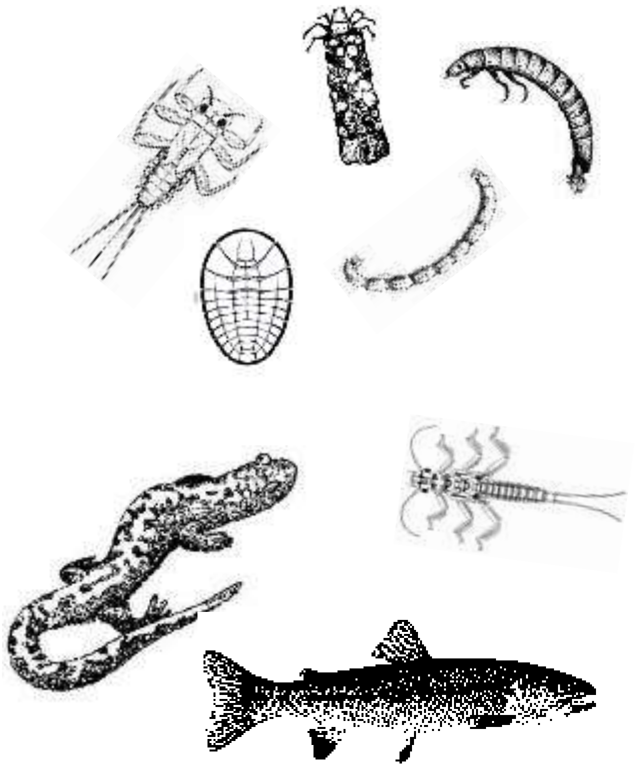


“increased food hypothesis” (Bisson and Sedell 1984)

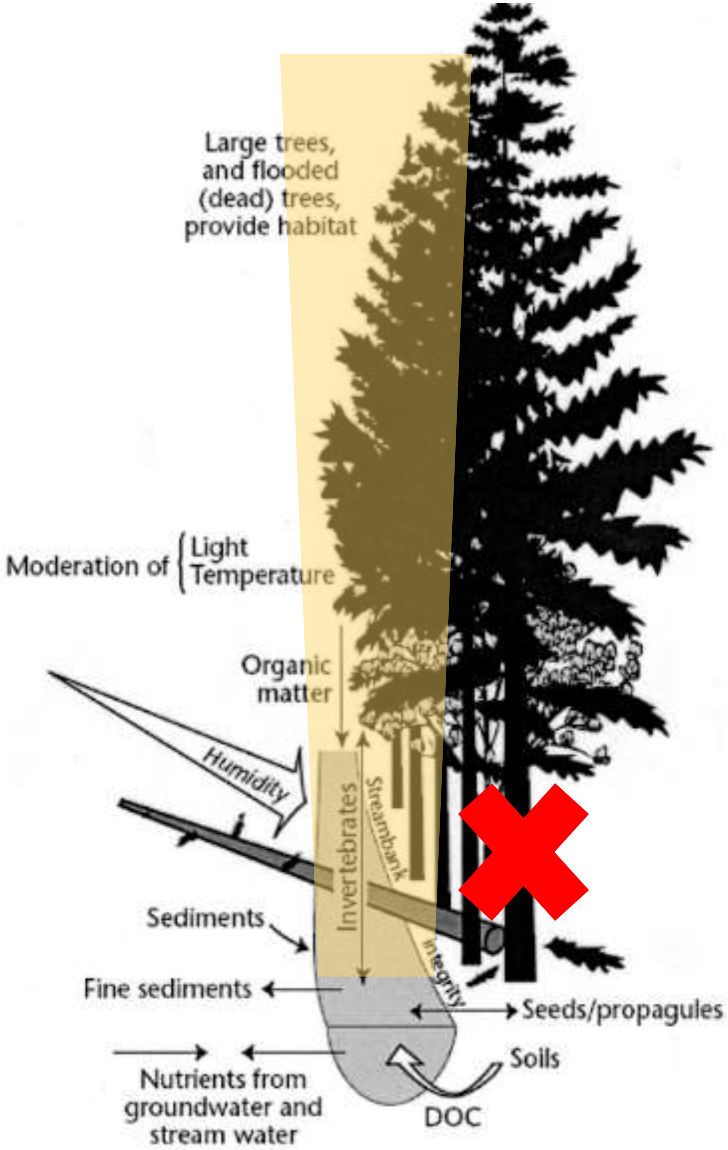
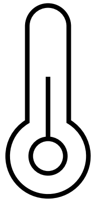
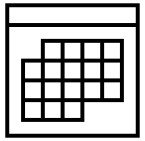


Figure 2. Schematic Drawing of Some of the Processes Linking the Forest and Stream Across the Riparian Zone.

Richardson et al. 2005





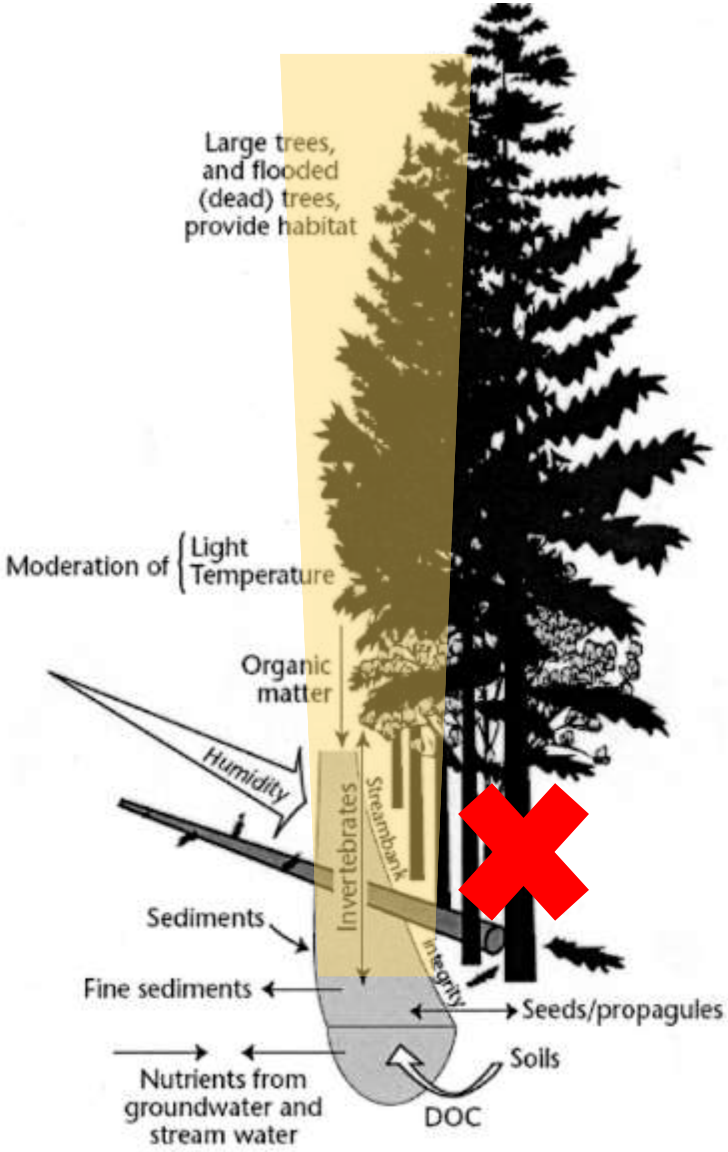


Figure 2. Schematic Drawing of Some of the Processes Linking the Forest and Stream Across the Riparian Zone.

"increased temperature hypothesis" (Bisson and Sedell 1984)

Richardson et al. 2005

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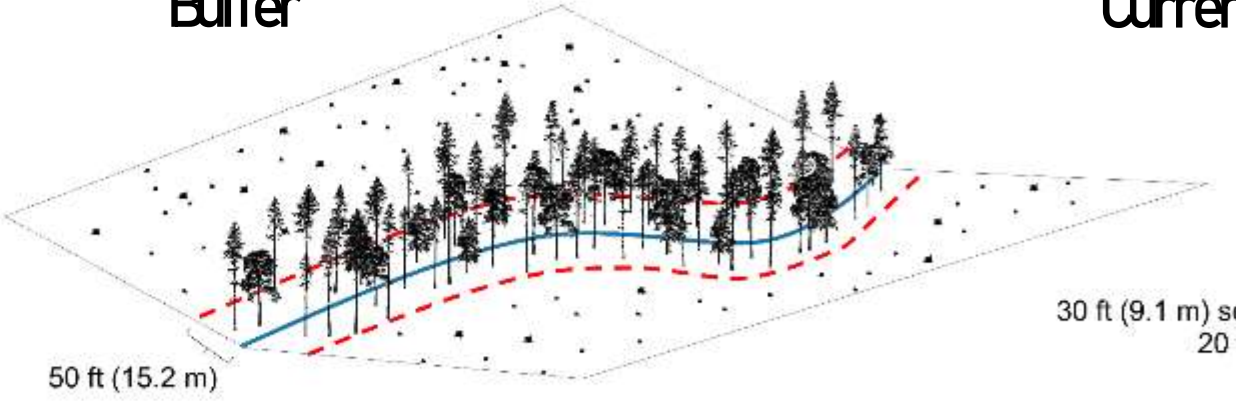
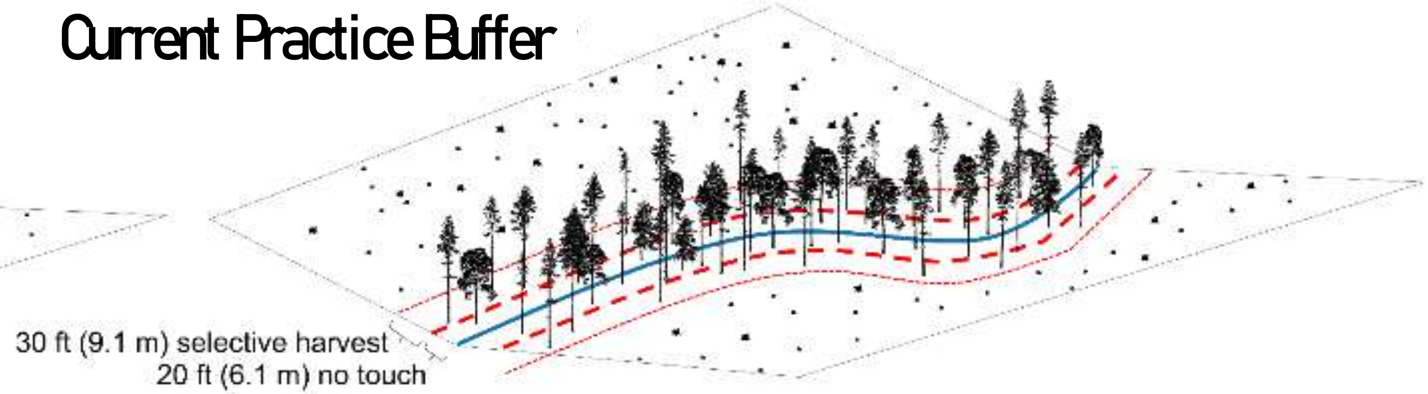
Study Design: Before-After Control-Impact (BACI)

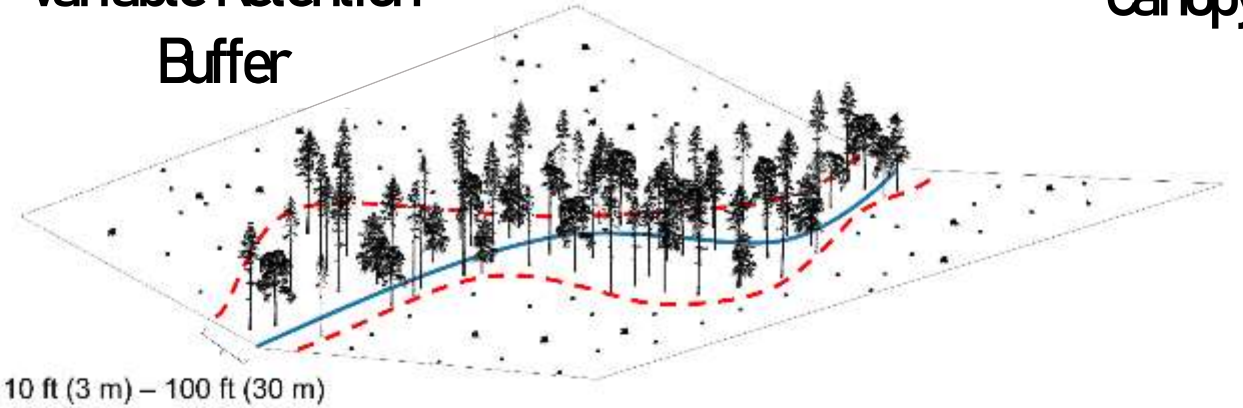
Fixed-Width Buffer



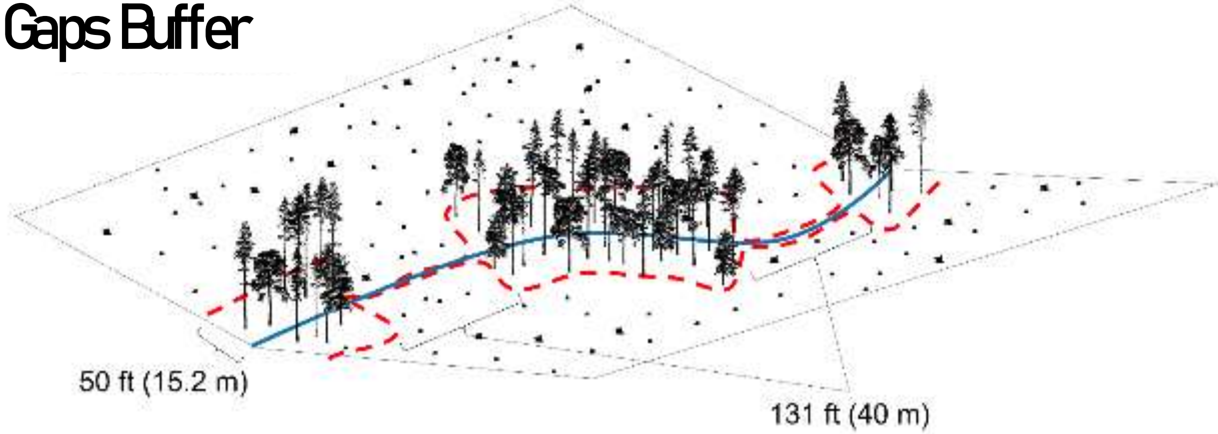
Current Practice Buffer

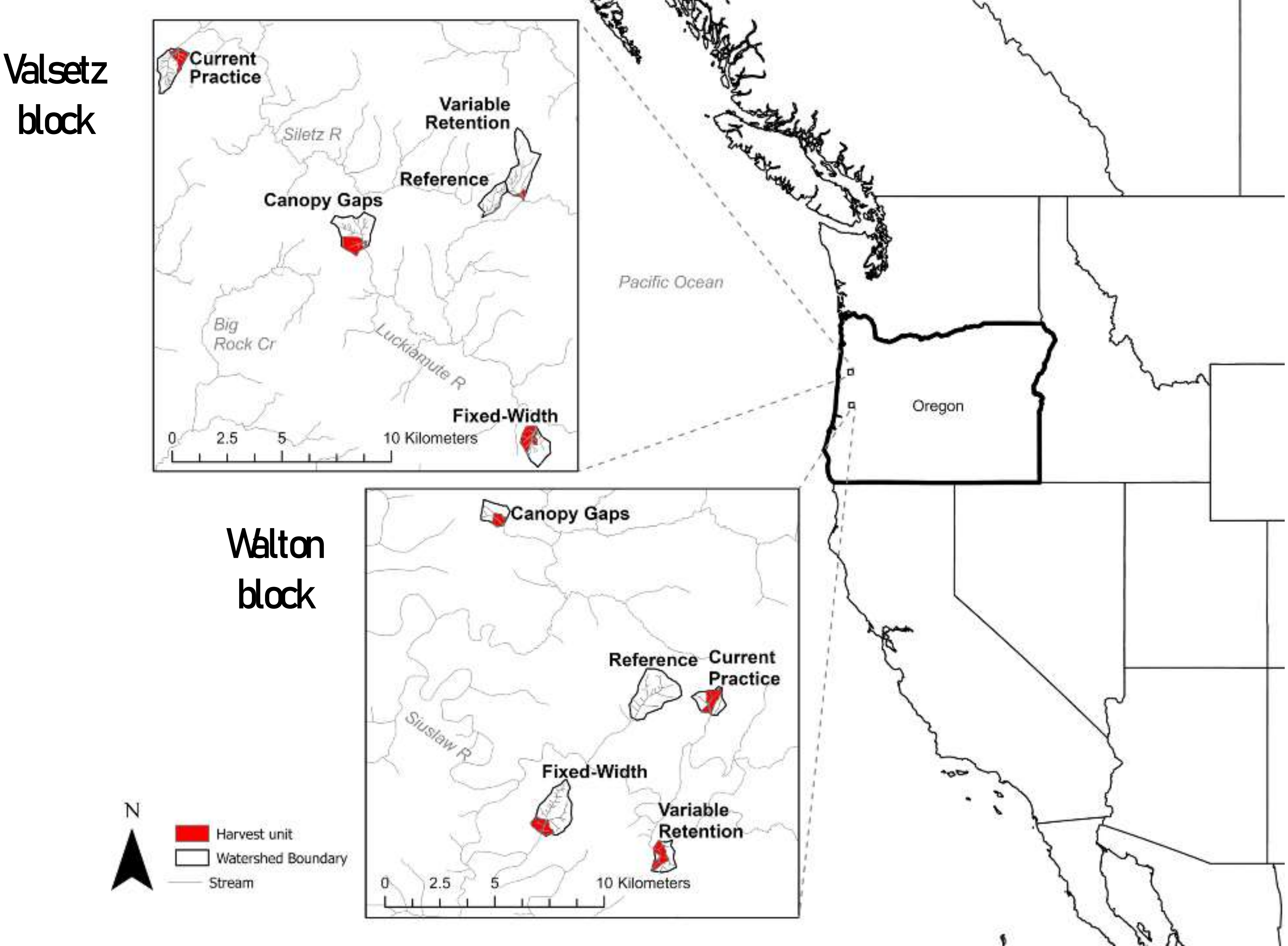


Variable Retention Buffer



Canopy Gaps Buffer

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Current Practice
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0 2.5 5 10 Kilometers
N
Harvest unit
Watershed Boundary
Stream

Research Question:

Do changes in light, imposed by alternative riparian buffer designs, affect fish in low-order headwaters of the Oregon Coast Range?

H1a: Increased food hypothesis

- More basal resources, more/larger fish
- Fish are eating more, resulting in positive or no change in growth depending on temperature

H1b: Increased temperature hypothesis

- Higher temperatures, larger juveniles that hatched earlier

H1c: Increase in fish metrics from… something else

H2: No change – treatment isn't strong enough

H3: Changes in habitat conditions that caused extirpation or movement out of study reach

Stream Sampling:

Stream light measurements

- Continuous light intensity at 4 locations per stream
- Summarized as mean of total daily PAR in August

Canopy cover measurements

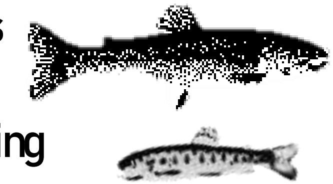
- Hemispherical photos every 20 m
- Summarized as mean canopy closure

Stream Sampling:

https://

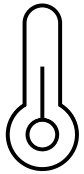
E-fishing surveys

- Twice per summer, 90 m reach
- Estimates of population density, biomass density of coastal cutthroat trout
- Estimates of summer growth by PIT tagging larger individuals
- Gastric lavage for diets in post-treatment



Stream temperature measurements

- Continuous temperature at 1 mid-reach location per stream
- Summarized MWMT for July and August



Benthic periphyton standing stock sampling

- During e-fishing event
- 5 locations per stream
- Estimates of chl *a* and AFDM

Benthic macroinvertebrate sampling

- During e-fishing event
- Surber sampler, composite of 5 samples
- Proportion of chironomids and scraping taxa

Data Analysis

Post-pre difference = $(Response_{post} - Response_{pre})$ *all sites presented together

Double difference =

$(Treatment_{post} - Treatment_{pre}) - (Reference_{post} - Reference_{pre})$

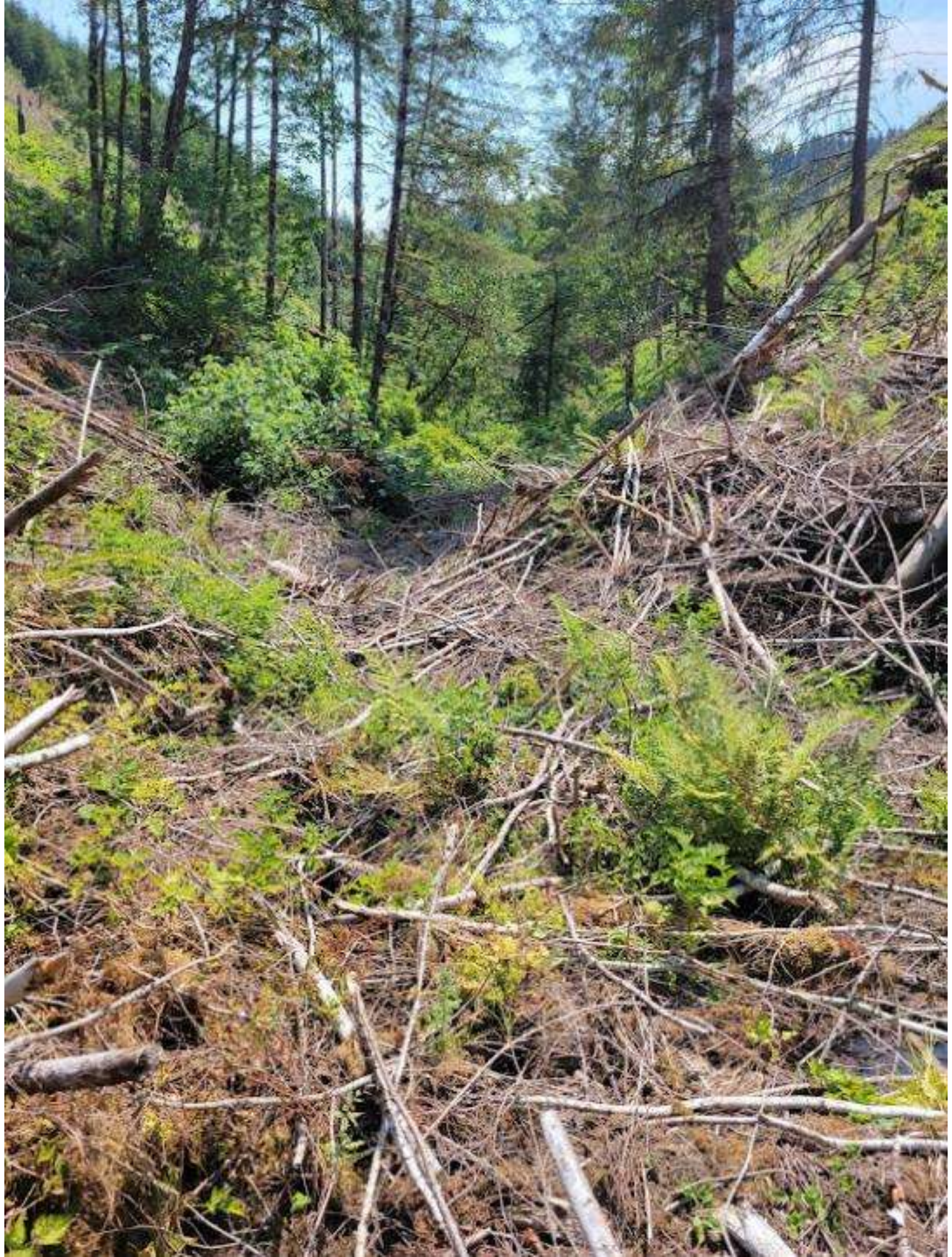
Bioenergetics Modeling: FishBioenergetics 4.0 in R

Input: fish growth, fish diet composition, temperature, literature values for prey energy density and predator energy density

Output: Proportion of maximum consumption (P)

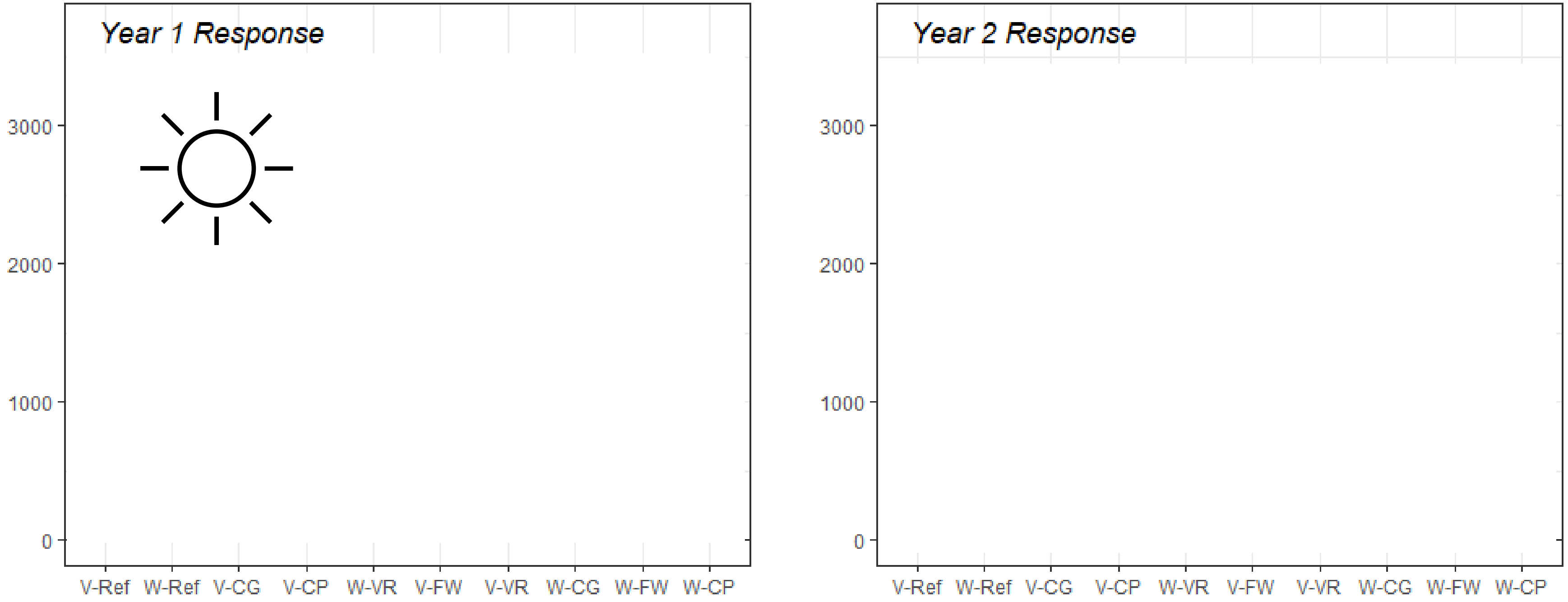
Results – (notes before we dive in)

- Harvests were successfully completed, but not always as expected
- Harvests caused lots of slash and blowdown, which complicated sampling




Light and Canopy

Post-pre difference in total daily PAR ($\mu mol\ m^{-2}\ s^{-1}$)

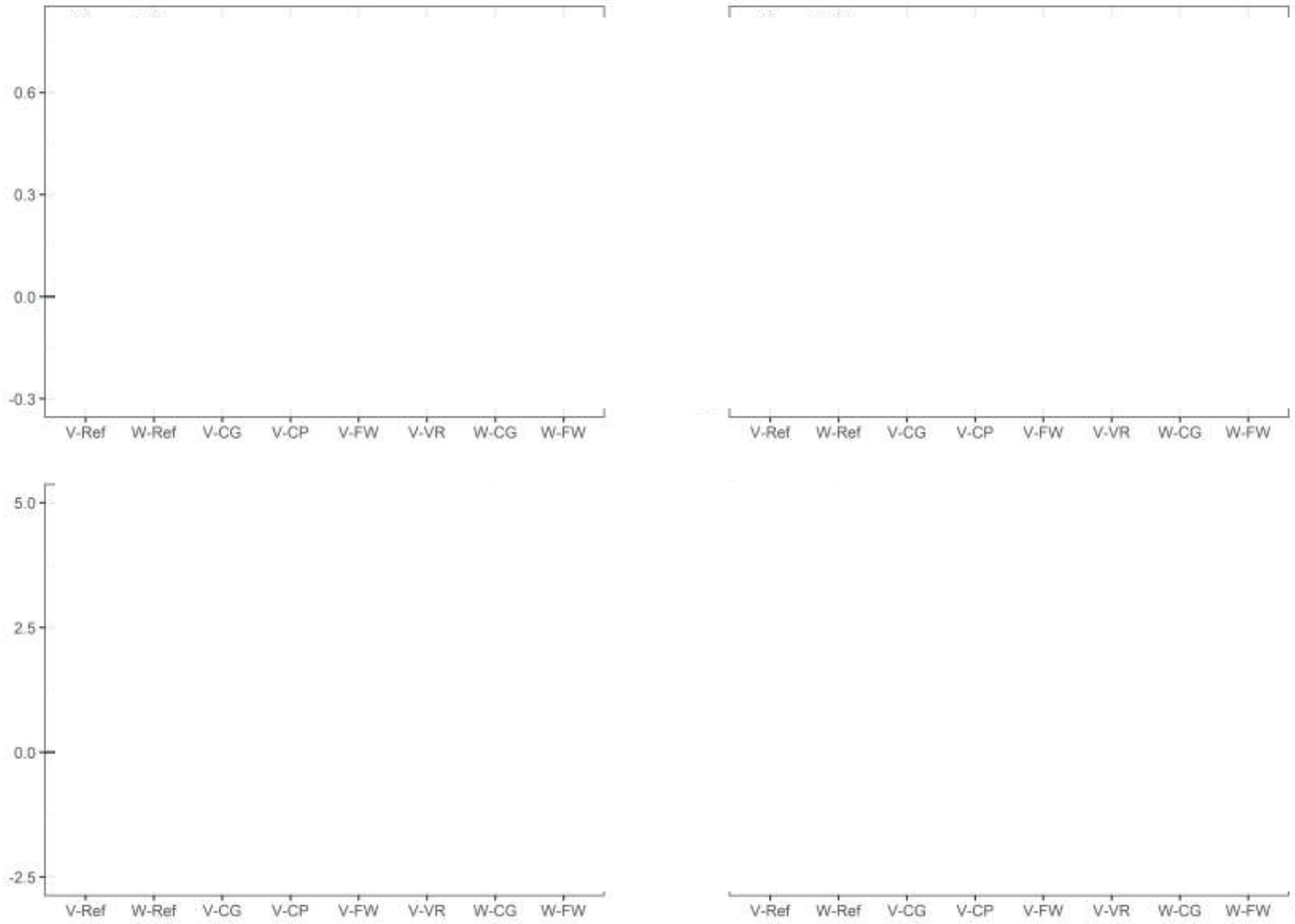


Post-pre difference in canopy cover (%)

Fish Density and Biomass Density

Post-pre different in density (# m-2)

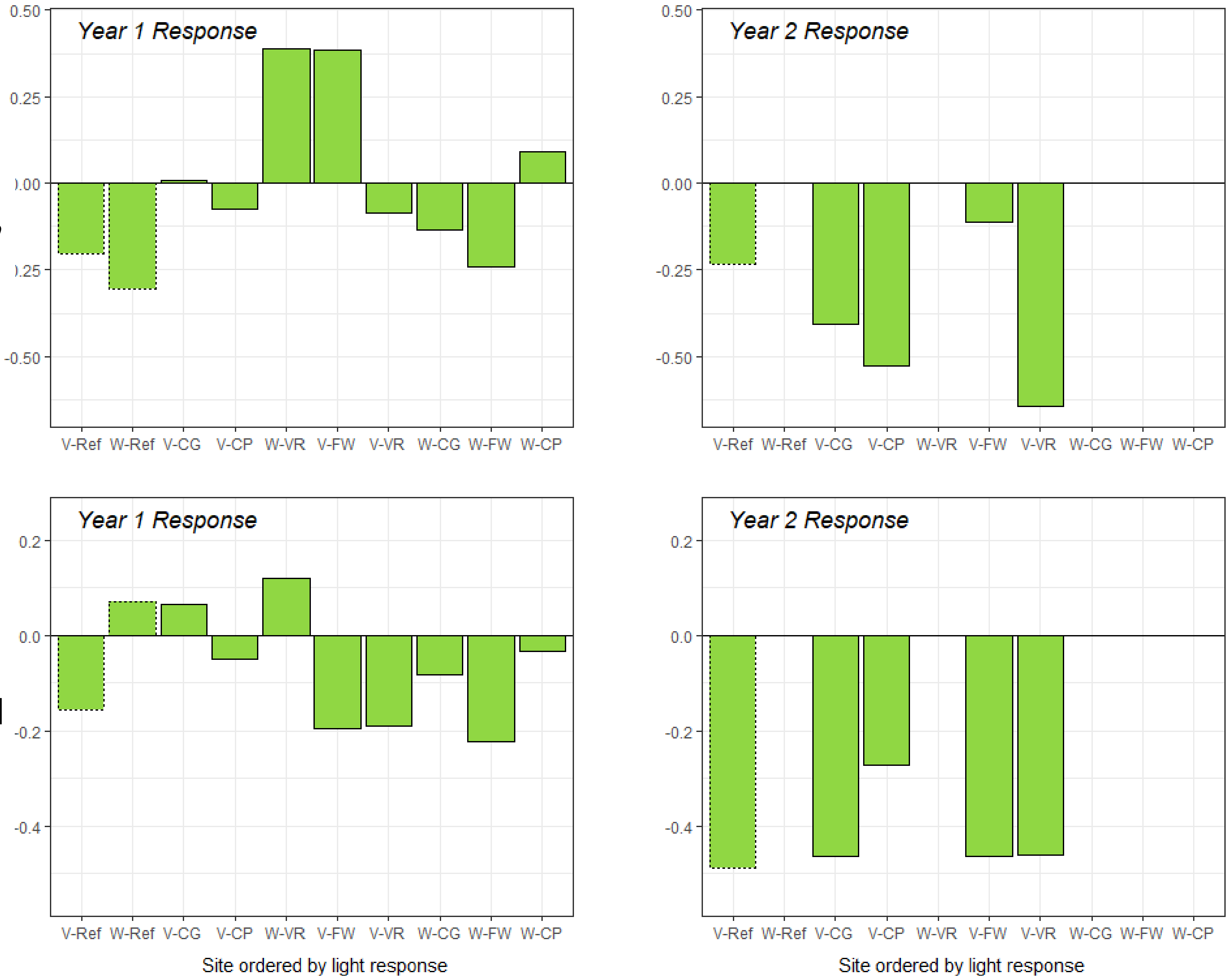
Post-pre different in biomass density (g m-2)

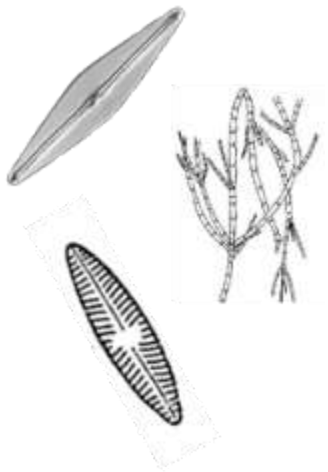


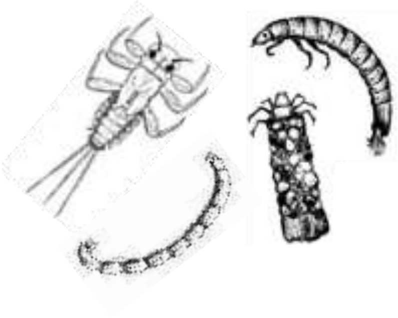
Basal Resources and Macros

Post-pre difference in periphyton chl *a* (µg cm⁻²)

Post-pre difference in periphyton AFDM (mg cm⁻²)

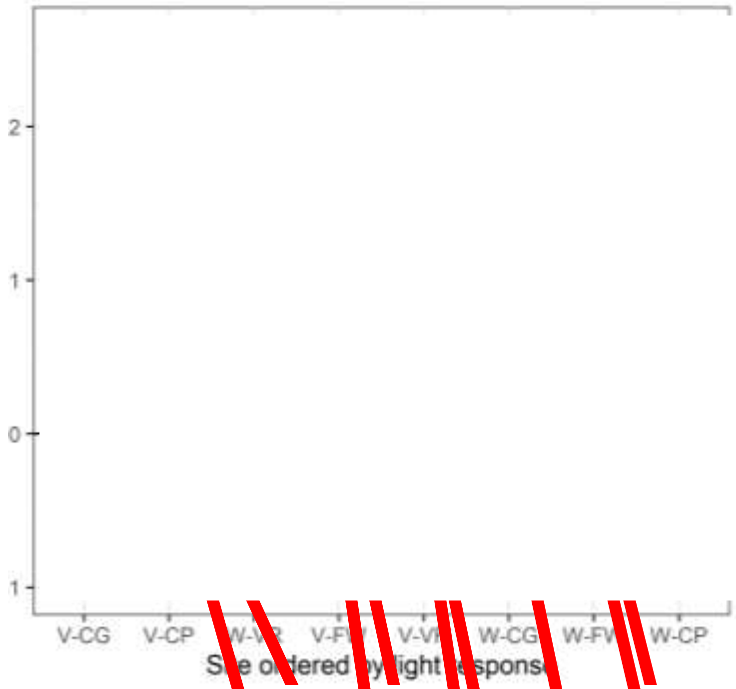


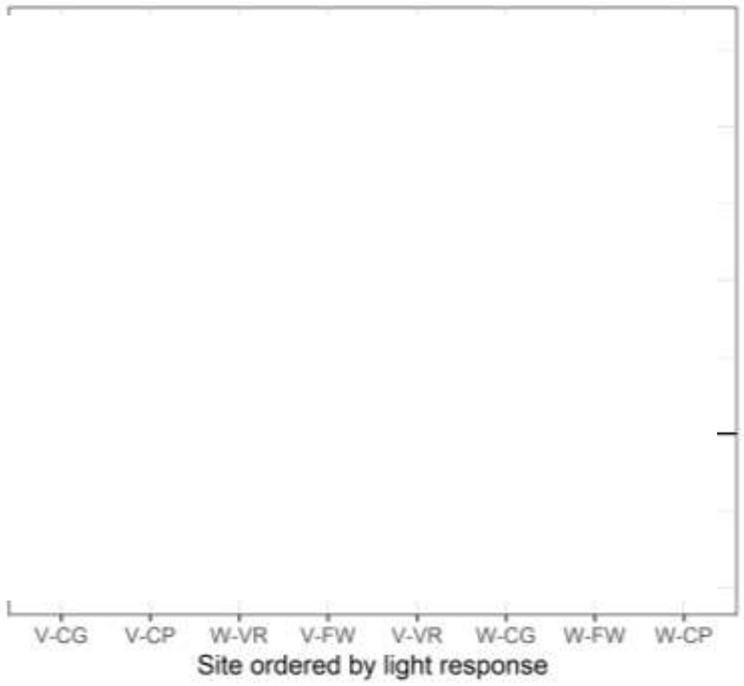




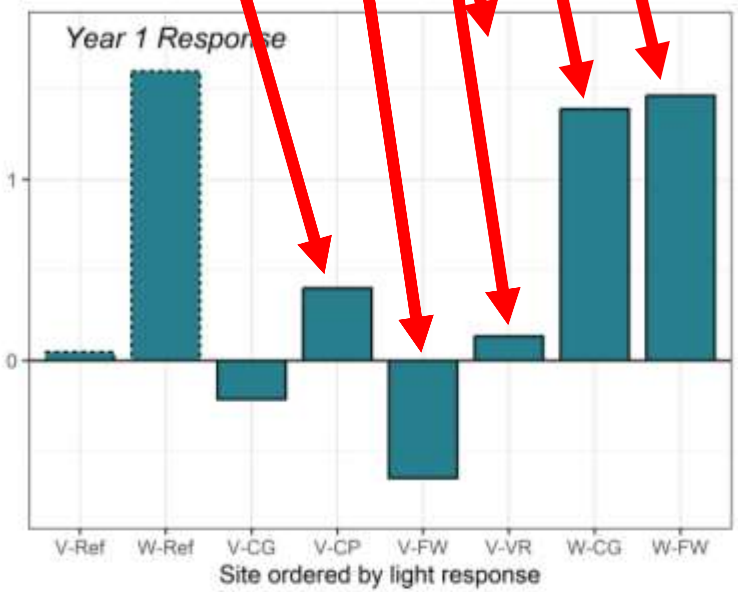
Temperature

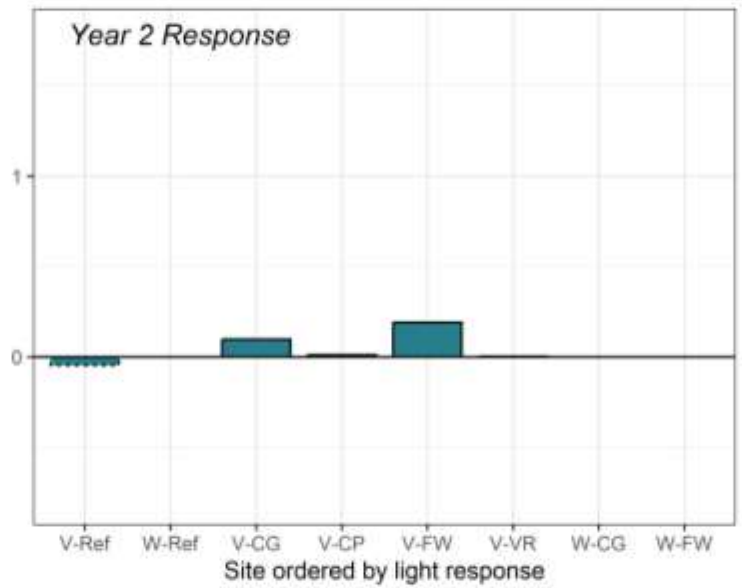
Double difference in MWMT (°C)





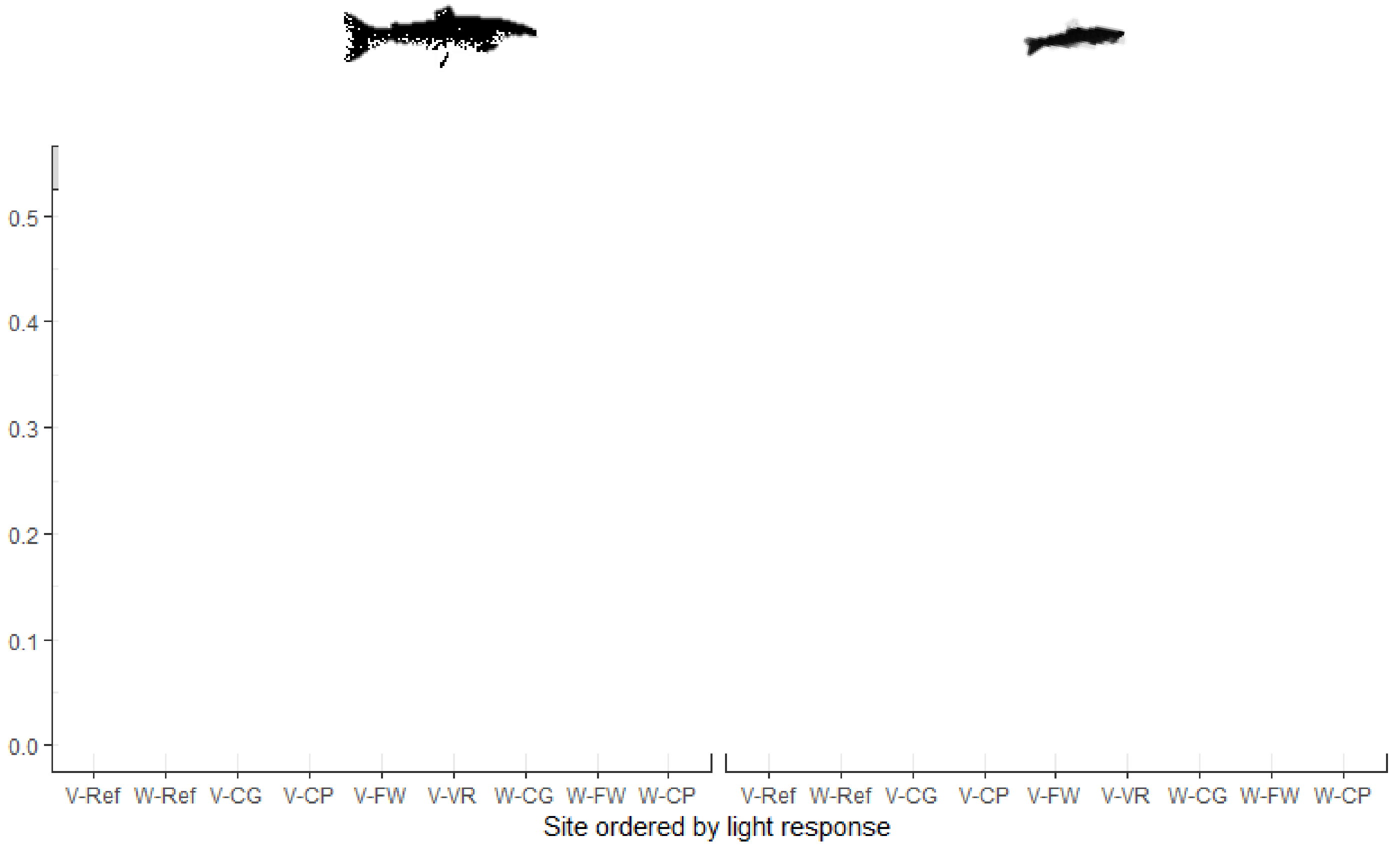
Post-pre difference in density (# m-2)





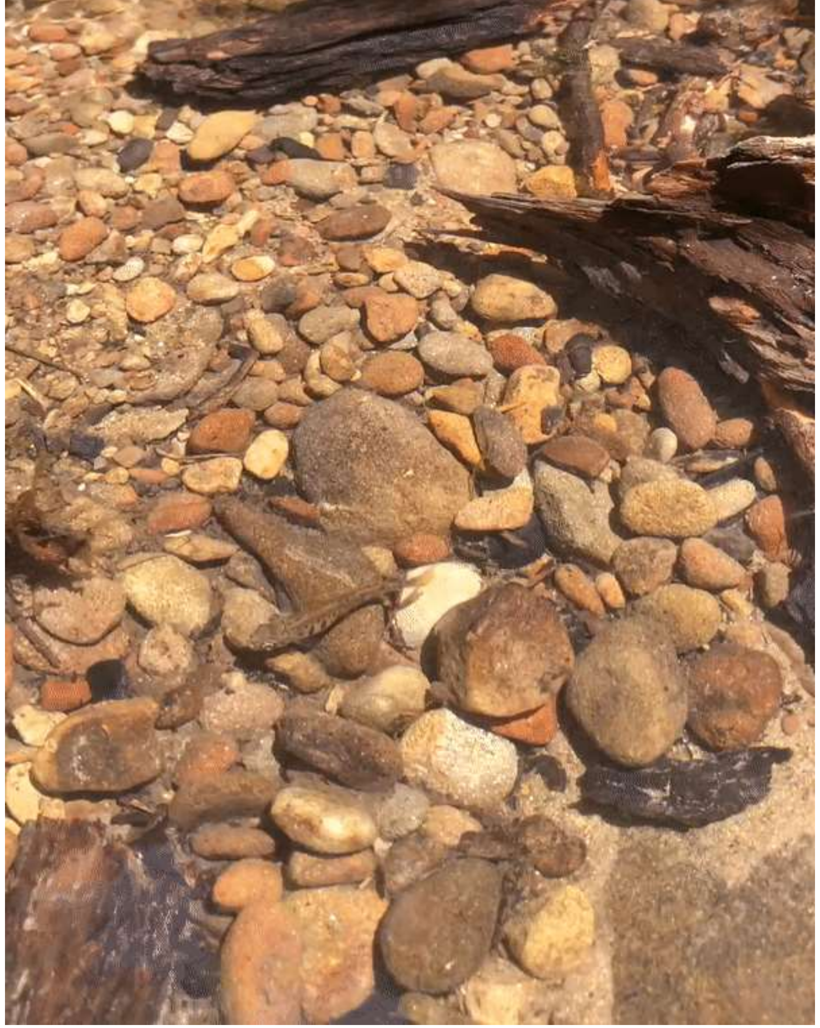
Bioenergetics

Proportion of maximum consumption (P)



So, what's going on with the YOY response?

- Change in shallow water habitat (Scrivener and Anderson 1984, Bisson and Sedell 1984)
- Lack of Spring storms in 2021
- More adult female spawners in the reach
- Increase in food but we didn't observe it



Conclusions

- We caused a range of increases in light, but it didn't correspond with canopy cover
- We observed a population-level response in cutthroat trout YOY
  (more YOY that aged to adults)
- We did not find support for the increased food or temperature hypotheses, or for compensatory consumption
  H1c: Increase in fish metrics from... something else
- Small streams may respond differently to riparian change than other "headwaters"

Is more light "good" for fish?

- In some systems, yes, if you're managing for fish production in the short-term
- In small streams where we work, we don't understand mechanism
- Providing more heterogeneity in the riparian canopy for other purposes is likely not catastrophic to streams in the short-term
- But, it depends on what you're managing for!

Questions?

Acknowledgements:
Landowners: Manulife Investment Management and Roseburg Forest Products

Field crews 2019-2022: Alex Boe, Molly Hamilton, Zowie DeLeon, Rylee Rawson, Annika Carlson, Nathan Maisonville, Will Johnstone, Rory Corrigan, Nate Neal, Maya Greydanus, Jacqui James, Tyler Parr, Nicole Miller, Brenna Cody, Alex Foote, and Ciana David

Funding:
OSU FWHMF grant and NCASI, Inc.

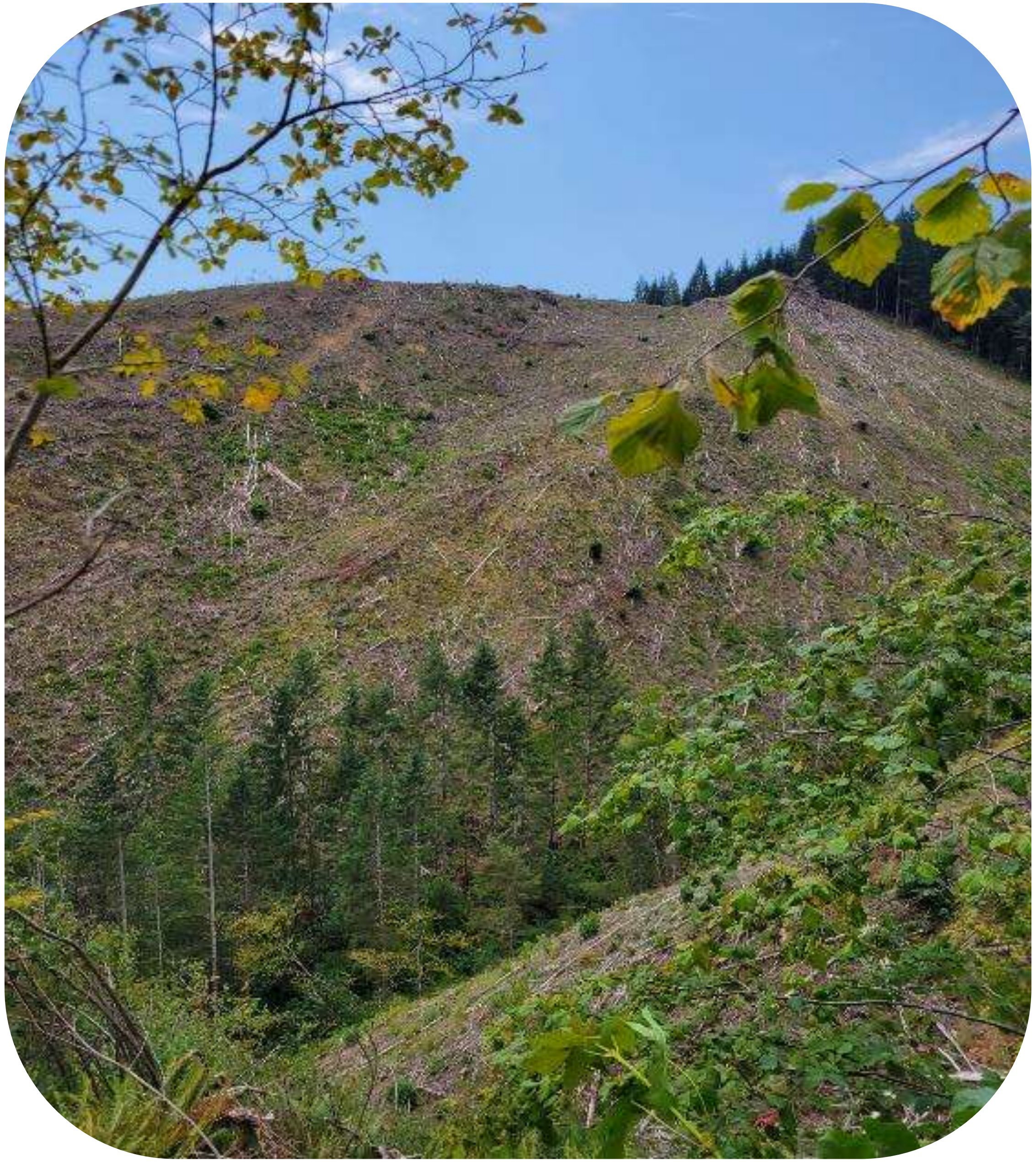
Contact:
ashley.sanders@oregonstate.edu

NCASI
IMPACT. SCIENCE. SOLUTIONS.

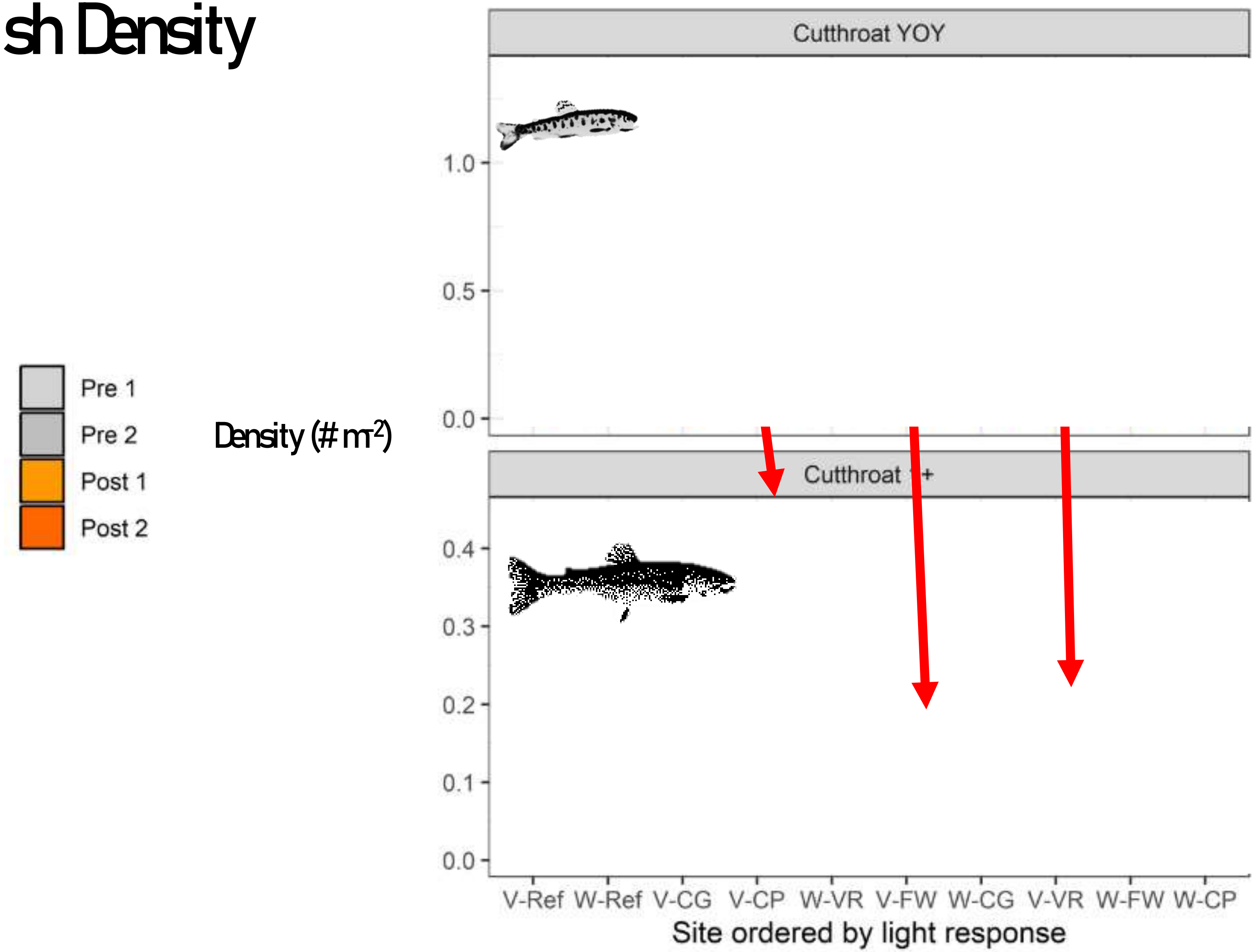
Manulife
Investment Management

Oregon State University
College of Forestry

Roseburg
A Forest Products Company



Fish Density

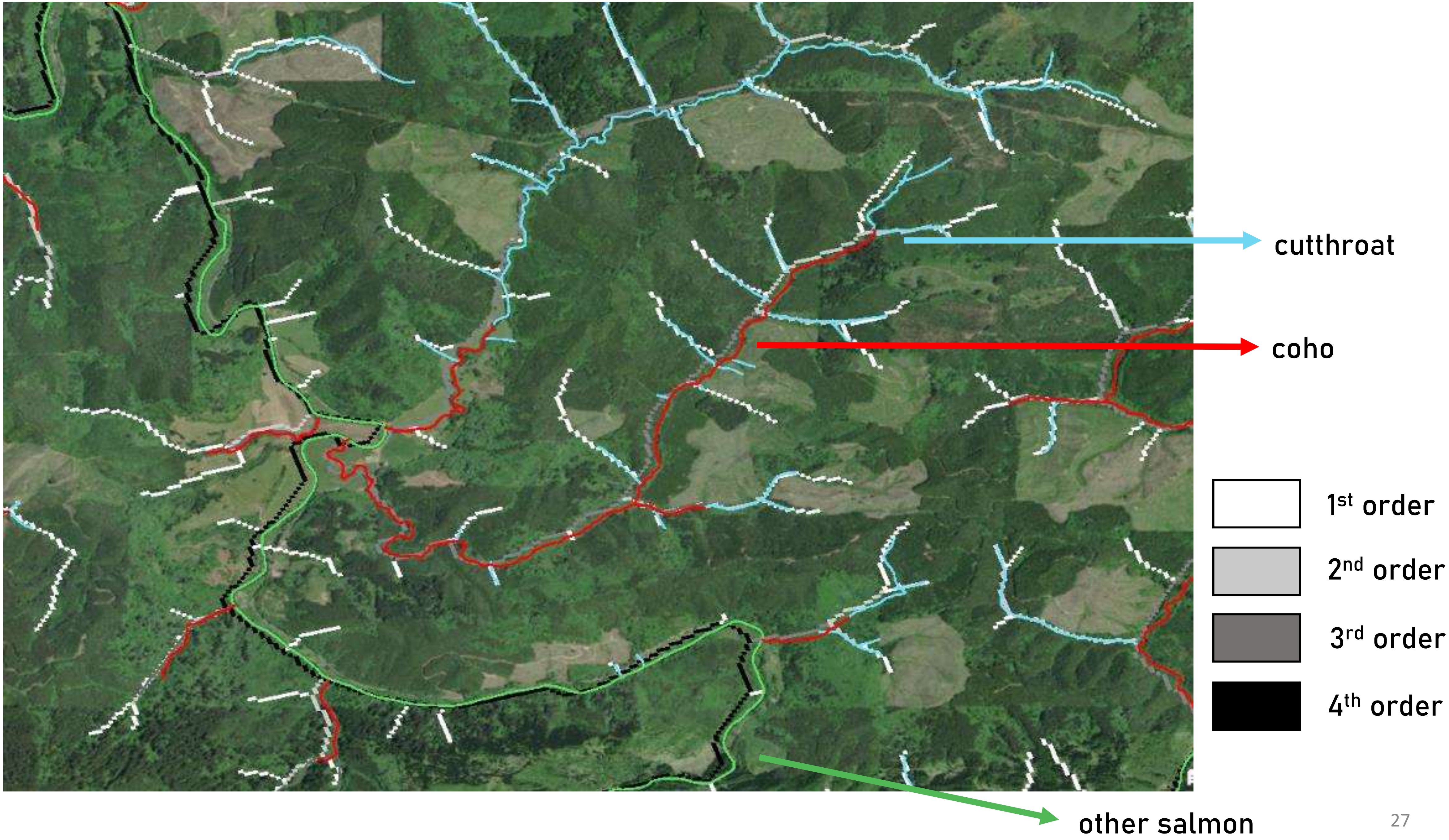


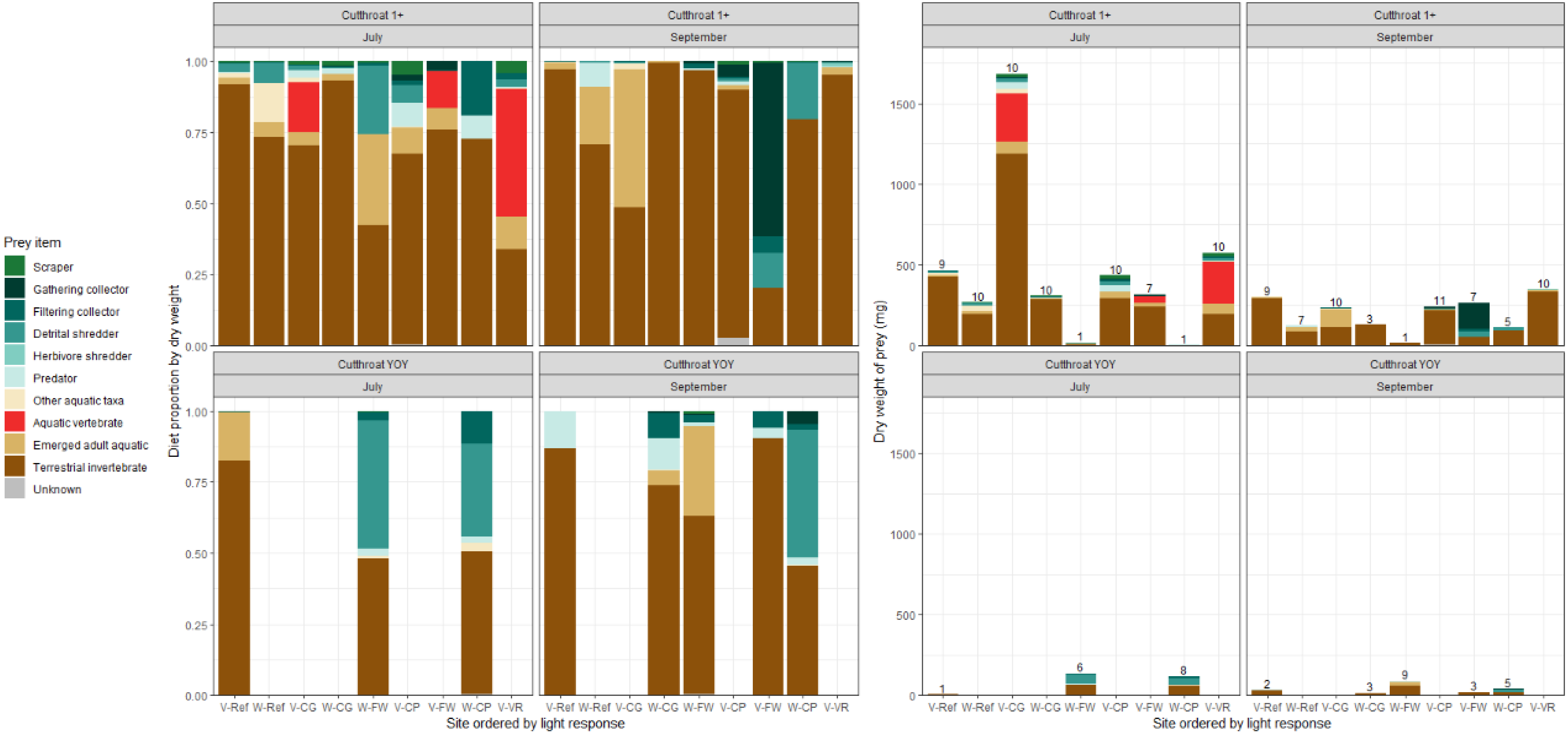
Hypotheses could *not* be supported in small streams because:

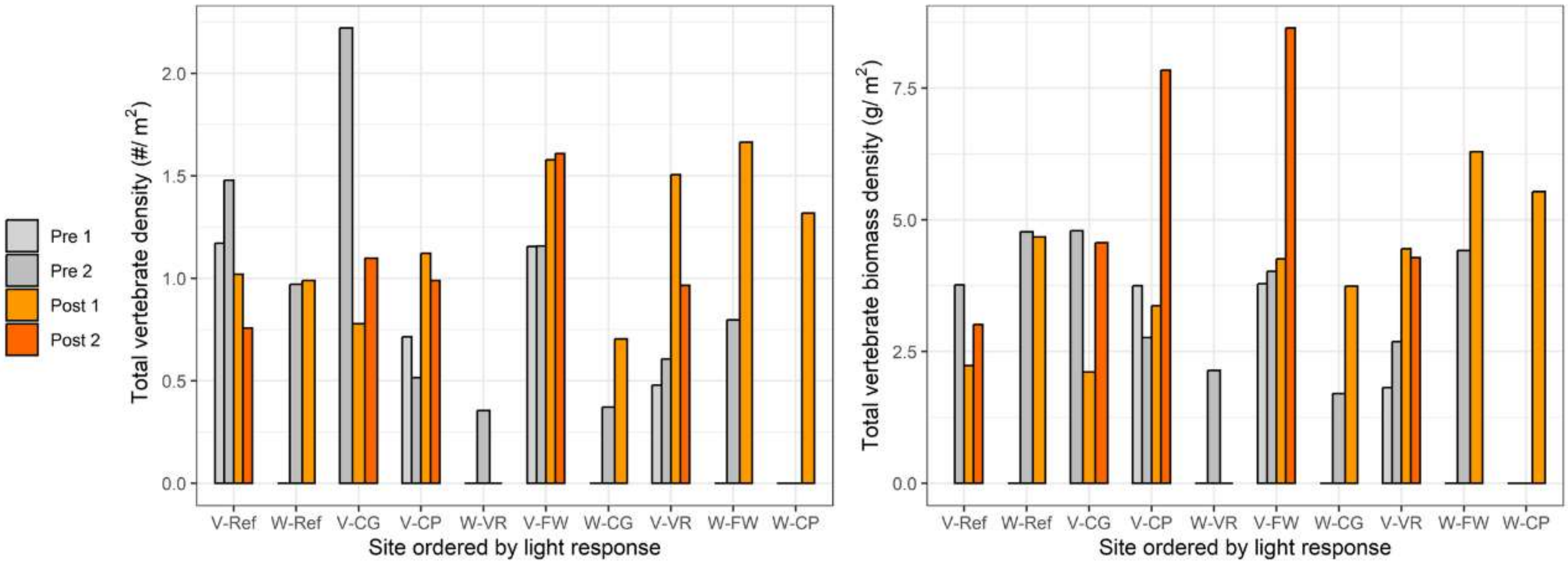
- Alternative modes of stream shading
- Trout are drift feeders and may rely more on terrestrial sources
- Fish may be limited by habitat
- Algal assemblages may be dominated by diatoms, not green algae
- Small streams could stay cold because they are groundwater-fed

Hypotheses could be supported in small streams because:

- They are light-limited
- Fish could use more food!
- Oregon Coast Range streams are not as nutrient-limited as Cascade streams, and harvest may increase nutrients
- Small streams are cold, fish are below their thermal optimum
- Small streams have lower thermal mass


cutthroat
coho
other salmon
1st order
2nd order
3rd order
4th order


Prey item
Scraper
Gathering collector
Filtering collector
Detrital shredder
Herbivore shredder
Predator
Other aquatic taxa
Aquatic vertebrate
Emerged adult aquatic
Terrestrial invertebrate
Unknown
Cutthroat 1+
July
Cutthroat 1+
September
Cutthroat YOY
July
Cutthroat YOY
September
Diet proportion by dry weight
0.00
0.25
0.50
0.75
1.00
V-Ref W-Ref V-CG W-CG W-FW V-CP V-FW W-CP V-VR
Site ordered by light response
Dry weight of prey (mg)
0
500
1000
1500
9 10 10 10 1 10 7 1 10
9 7 10 3 1 11 7 5 10
1 6 8
2 3 9 3 5


Pre 1
Pre 2
Post 1
Post 2
Total vertebrate density (#/ m2)
2.0
1.5
1.0
0.5
0.0
V-Ref W-Ref V-CG V-CP W-VR V-FW W-CG V-VR W-FW W-CP
Site ordered by light response
Total vertebrate biomass density (g/ m2)
7.5
5.0
2.5
0.0
V-Ref W-Ref V-CG V-CP W-VR V-FW W-CG V-VR W-FW W-CP
Site ordered by light response

Vaired Effects of Clear-cut Logging on Predators and Their Habitat in Small Streams of the Cascade Mountains, Oregon[1]

Michael L. Murphy[2] and James D. Hall

HJ Andrews Experimental Forest, Blue River, OR

1981

A Population Study of the Cutthroat Trout in an Unshaded and Shaded Section of Stream

by

Richard Stanley Aho

1976

Density of Fish and Salamanders in Relation to Riparian Canopy and Physical Habitat in Streams of the Northwestern United States[1]

Charles P. Hawkins[2]

Department of Entomology, Oregon State University, Corvallis, OR 97331, USA

Michael L. Murphy[3]

Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331, USA

N. H. Anderson

Department of Entomology, Oregon State University, Corvallis, OR 97331, USA

and Margaret A. Wilzbach

1983

1969

1971 Forest Practices Act Passed

Alsea Watershed Study, Alsea, OR

James D. Hall

Department of Fisheries and Wildlife
Oregon State University, Corvallis, Oregon

and

Richard L. Lantz

Oregon State Game Commission
Corvallis, Oregon

Effects of Logging on the Habitat of Coho Salmon and Cutthroat Trout in Coastal Streams[1]

1984

Carnation Creek Study, BC, Canada

Logging Impacts and Some Mechanisms that Determine the Size of Spring and Summer Populations of Coho Salmon Fry (*Oncorhynchus kisutch*) in Carnation Creek, British Columbia

J. C. Scrivener and B. C. Andersen

Department of Fisheries and Oceans, Fisheries Research Branch, Pacific Biological Station, Nanaimo, B.C. V9R 5K6

Western WA 1984

SALMONID POPULATIONS IN STREAMS IN CLEARCUT VS. OLD-GROWTH FORESTS OF WESTERN WASHINGTON

Peter A. Bisson

Weyerhaeuser Company Technology Center, Tacoma, Washington 98477

James R. Sedell

USDA Forestry Sciences Laboratory, 3200Jefferson Way, Corvallis, Oregon 97330

1994 NWFP

1986 Humboldt, CA

INFLUENCE OF HABITAT MANIPULATIONS ON INTERACTIONS BETWEEN CUTTHROAT TROUT AND INVERTEBRATE DRIFT[1]

Margaret A. Wilzbach and Kenneth W. Cummins

Center for Environmental and Estuarine Studies, Appalachian Environmental Laboratory, University of Maryland, Frostburg, Maryland 21532 USA

and

James D. Hall

Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon 97331 USA

1986 SE Alaska

Effects of Clear-cut Logging with and without Buffer Strips on Juvenile Salmonids in Alaskan Streams[1]

Michael L. Murphy, Jonathan Heifetz, Scott W. Johnson, K V. Koski, and John F. Thedinga

1992

Allochthonous versus Autochthonous Organic Matter Contributions to the Trophic Support of Fish Populations in Clear-Cut and Old-Growth Forested Streams

Robert E. Bilby and Peter A. Bisson

1994 NWFP

1998

SE Alaska

Effects of Canopy Removal on Invertebrates and Diet of Juvenile Coho Salmon in a Small Stream in Southeast Alaska

N. J. Hetrick[1] and M. A. Brusven
Department of Plant, Soil, and Entomological Sciences
University of Idaho, Moscow, Idaho 83844-2339, USA

T. C. Bjornn*[2] and R. M. Keith[3]
Idaho Cooperative Fish and Wildlife Research Unit
University of Idaho, Moscow, Idaho 83844-1141, USA

W. R. Meehan[4]
U.S. Forest Service, Pacific Northwest Research Station
Juneau, Alaska 99801, USA

1999

Malcolm-Knapp Research Forest
BC, Canada

Status of Resident Coastal Cutthroat Trout and Their Habitat Twenty-Five Years after Riparian Logging

Kyle A. Young*
Center for Applied Conservation Biology and the Department of Forest Sciences,
University of British Columbia, 3004-2424 Main Mall,
Vancouver, British Columbia V6T 1Z4, Canada

Scott G. Hinch and Tom G. Northcote
Westwater Research Unit in the Institute for Resources and Environment,
and the Department of Forest Sciences, University of British Columbia,
3004-2424 Main Mall, Vancouver, British Columbia V6T 1Z4, Canada

2005

Effects of riparian canopy opening and salmon carcass addition on the abundance and growth of resident salmonids

Margaret A. Wilzbach, Bret C. Harvey, Jason L. White, and Rodney J. Nakamoto

2007

Effects of Logging Second-Growth Forests on Headwater Populations of Coastal Cutthroat Trout: A 6-Year, Multistream, Before-and-After Field Experiment

Jennifer D. De Groot
Centre for Applied Conservation Research and Department of Forest Sciences, University of British Columbia, 2424 Main Mall, Vancouver, British Columbia V6T 1Z4, Canada

Scott G. Hinch*
Centre for Applied Conservation Research and Department of Forest Sciences, University of British Columbia, 2424 Main Mall, Vancouver, British Columbia V6T 1Z4, Canada; and Institute for Resources, Environment, and Sustainability, University of British Columbia, 2202 Main Mall, Vancouver, British Columbia V6T 1Z3, Canada

John S. Richardson
Centre for Applied Conservation Research and Department of Forest Sciences, University of British Columbia, 2424 Main Mall, Vancouver, British Columbia V6T 1Z4, Canada

2010

The influence of partial timber harvesting in riparian buffers on macroinvertebrate and fish communities in small streams in Minnesota, USA

Christopher J. Chizinski[a,*], Bruce Vondracek[b,1], Charles R. Blinn[c], Raymond M. Newman[a], Dickson M. Atuke[a], Keith Fredricks[a], Nathaniel A. Hemstad[a], Eric Merten[a], Nicholas Schlesser[a]

Canopy closure after four decades of postlogging riparian forest regeneration reduces cutthroat trout biomass in headwater streams through bottom-up pathways

Matthew J. Kaylor and Dana R. Warren

Influence of riparian thinning on trophic pathways supporting stream food webs in forested watersheds

David A. Roon[1,2] | Jason B. Dunham[3] | J. Ryan Bellmore[4] | Deanna H. Olson[5] | Bret C. Harvey[6]

2022

2018

Fish response to contemporary timber harvest practices in a second-growth forest from the central Coast Range of Oregon

D.S. Bateman[a,*], R.E. Gresswell[b], D. Warren[c], D.P. Hockman-Wert[d], D.W. Leer[a], J.T. Light[e], J.D. Stednick[a,f]

Swartz dissertation

Studies on riparian removal and fish

- Historic clearcuts with no buffer

(Hall and Lantz 1969, Holtby 1988)

- Observations several years after clearcuts compared to second growth and old growth

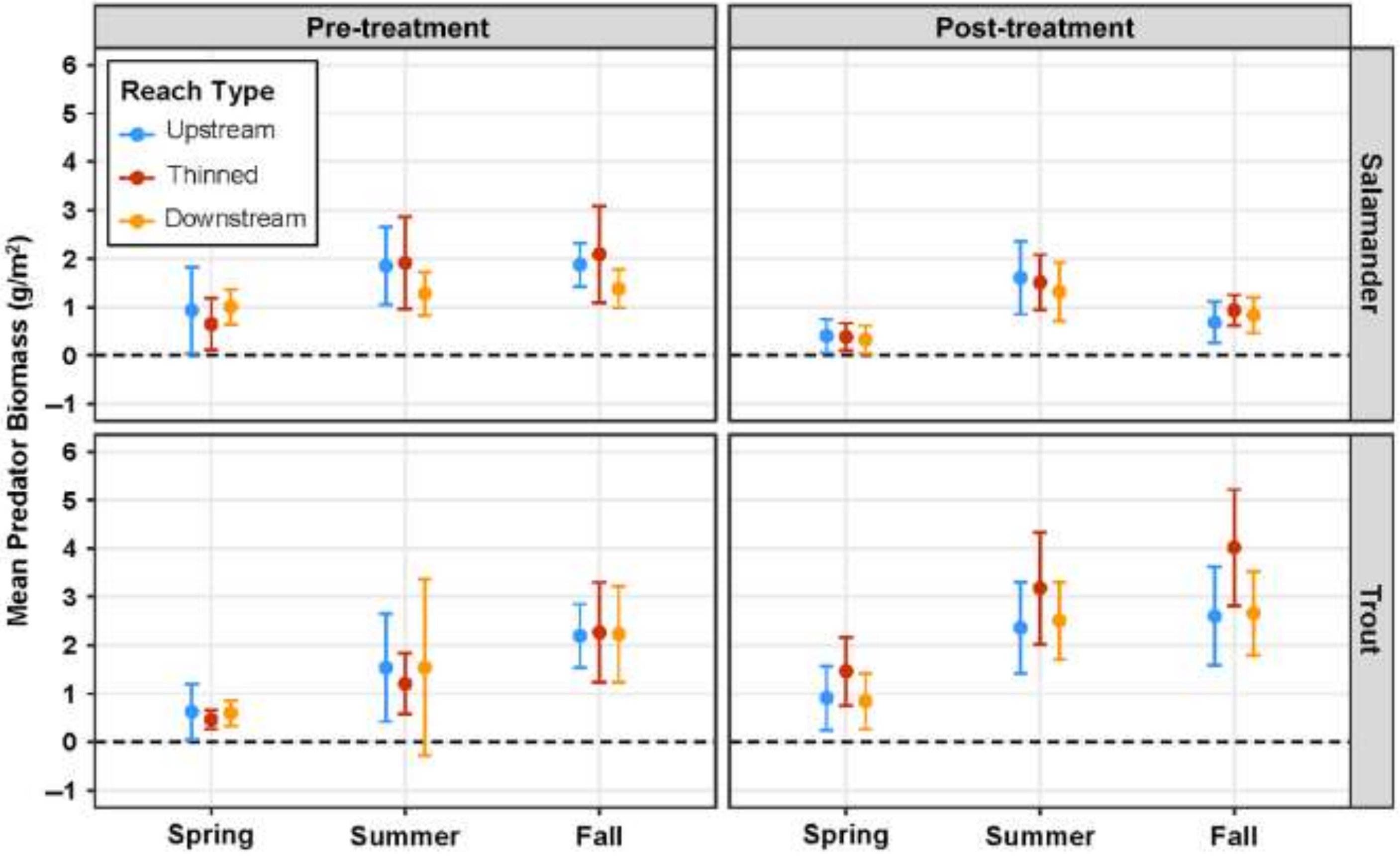
(Murphy and Hall 1981, Kaylor and Warren 2017, Young et al. 1999, Bilby and Bisson 1992)

- A few experiments with modern BMPs

(DeGroot et al. 2007, Bateman et al. 2018)

- A few experiments are explicit about light effects on fish

(Roon et al. 2022, Wootton 2012, Swartz 2022, Wilzbach et al. 2005)



or clear-cut sites ($P < 0.005$), and lower insect density than clear-cut sites ($P < 0.05$. Mann–Whitney U test).

https://www.rrnw.org/wp-content/uploads/Invited-Speaker-4-RRNW-Peter-Tschaplinski-2019.pdf

Effects of Experimental Riparian Canopy Gaps on Fish, Salamanders, Biofilms and Ecosystems Processes in Headwater Streams

Dana Warren
Allison Swartz

Dept. Forest Ecosystems and Society
Oregon State University

Why a focus on riparian forest gaps?

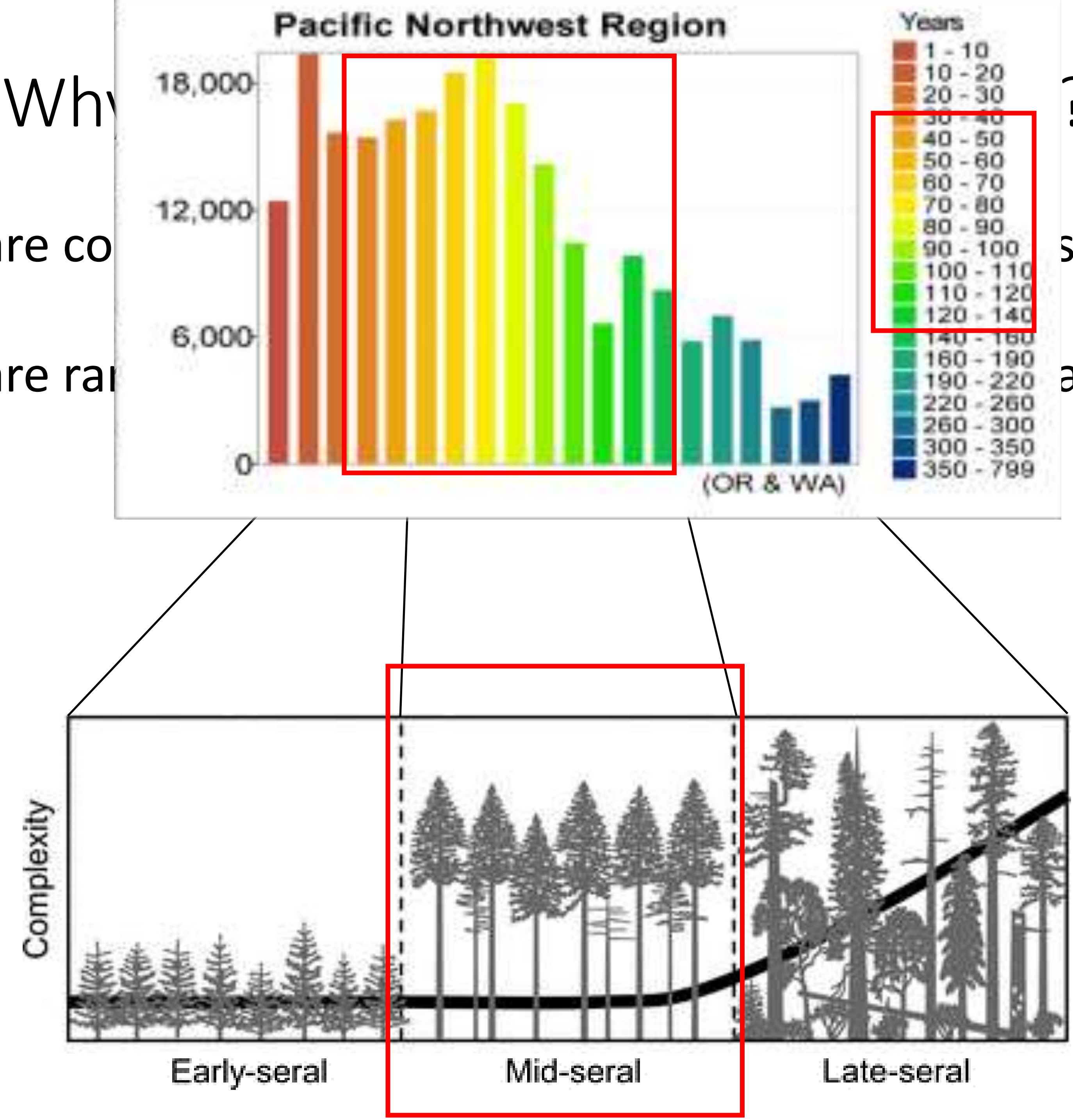
- Canopy gaps are common in late succession/old-growth forests

- Canopy gaps are rare in the mid-succession forests that dominate western OR, WA, CA

Why ... ?

- Canopy gaps are co ... s

- Canopy gaps are ra ... ate western OR, WA, CA



Pan et al. 2011

Donato et al. 2012

Why a focus on riparian forest gaps?

- Canopy gaps are common in late succession/old-growth forests
- Canopy gaps are rare in the mid-succession forests that dominate western OR, WA, CA

Gaps create spatial heterogeneity in the forest – and so may be a desired restoration tool for terrestrial biota.

Forest Ecology and Management 473 (2020) 118280

Environmental drivers of forest biodiversity in temperate mixed forests – A multi-taxon approach

Dima [c], Ildikó Király [d], Gergely Kutszegi [e], Ferenc Lakatos [f],
renc Samu [j], Irén Siller [k], Győző Szél [l], Péter Ódor [a]

Chapter 10
Bats and Gaps: The Role of Early Successional Patches in the Roosting and Foraging Ecology of Bats

Susan C. Loeb and Joy M. O'Keefe

Bark beetle infestation spots as biodiversity hotspots: Canopy gaps resulting from insect outbreaks enhance the species richness, diversity and abundance of birds breeding in coniferous forests

Fabian Przepióra [a], Jan Loch [b], Michał Ciach [a,*]

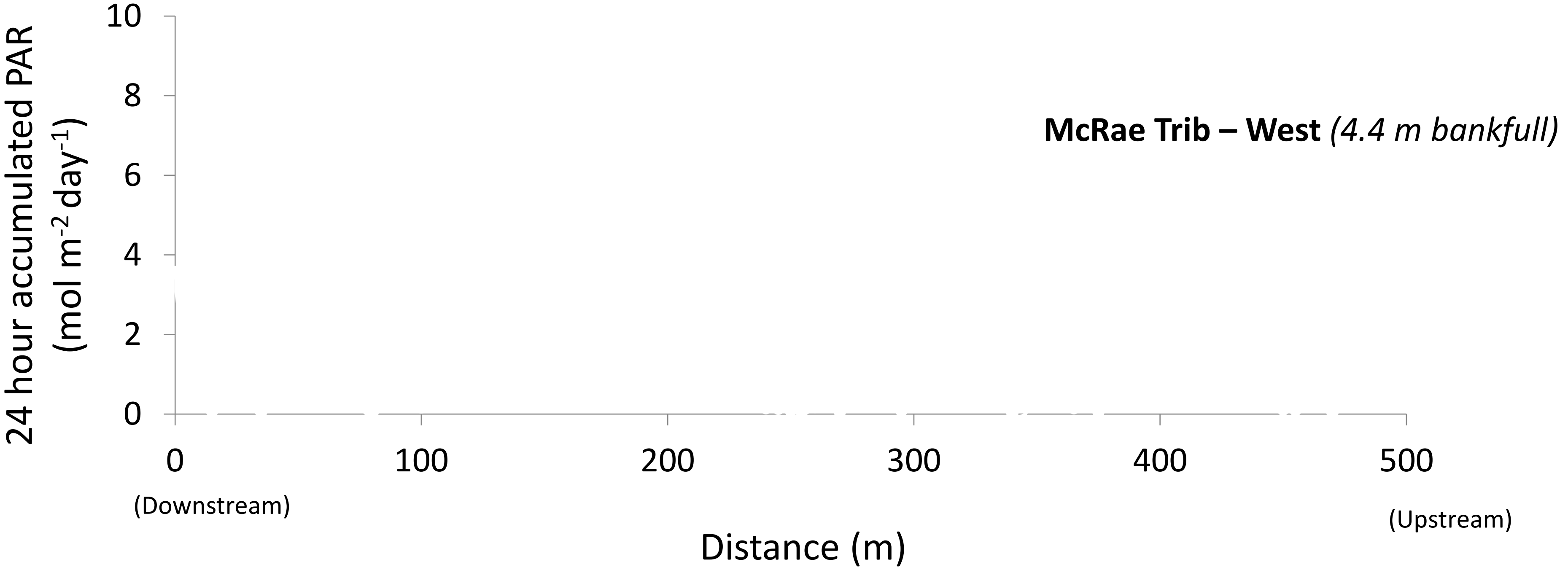
[a] Department of Forest Biodiversity, Faculty of Forestry, University of Agriculture, al. 29 Listopada 46, 31-425 Kraków, Poland
[b] Gorce National Park, Poręba Wielka 590, 34-735 Niedźwiedź, Poland

(Anecdotally) – concerns over any cutting in riparian zones have hamstrung efforts to create complex habitat for terrestrial biota

Why a focus on riparian forest gaps?

- Canopy gaps are common in late succession/old-growth forests
- Canopy gaps are rare in the mid-succession forests that dominate western OR, WA, CA
- Gaps create spatial heterogeneity in the forest – and so may be a desired restoration tool for terrestrial biota

Gaps also create spatial heterogeneity in the light environment of associated streams



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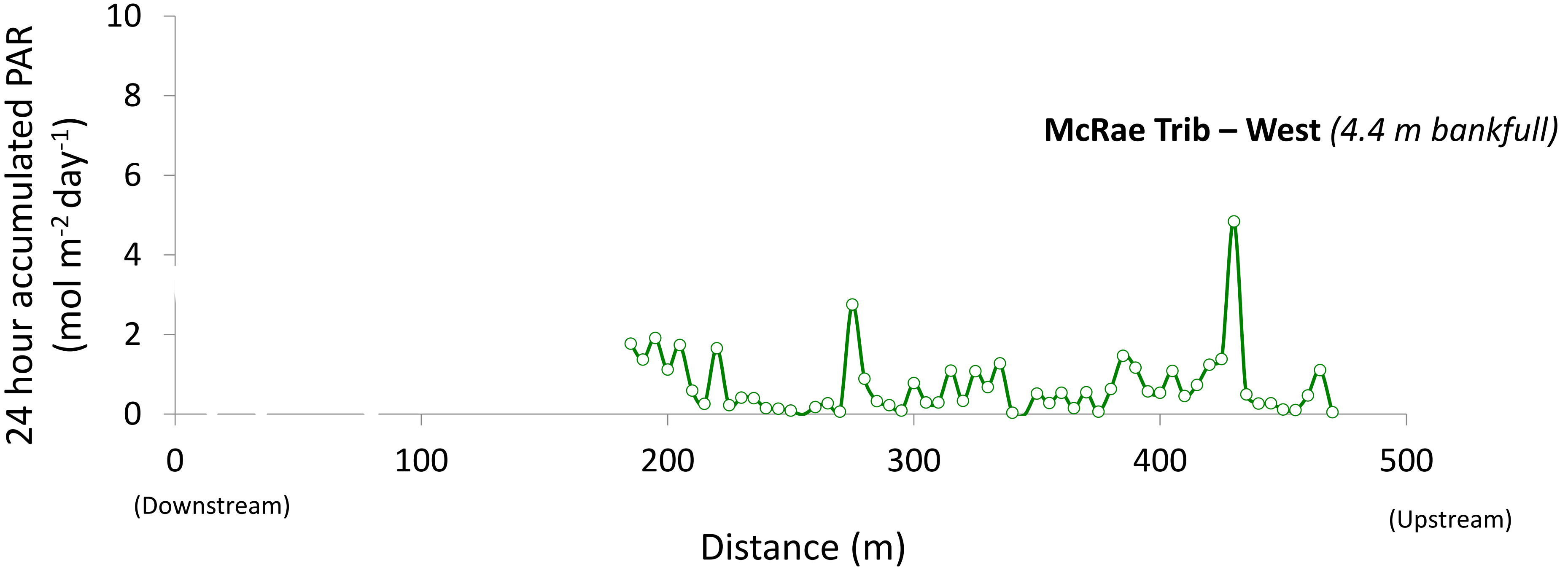

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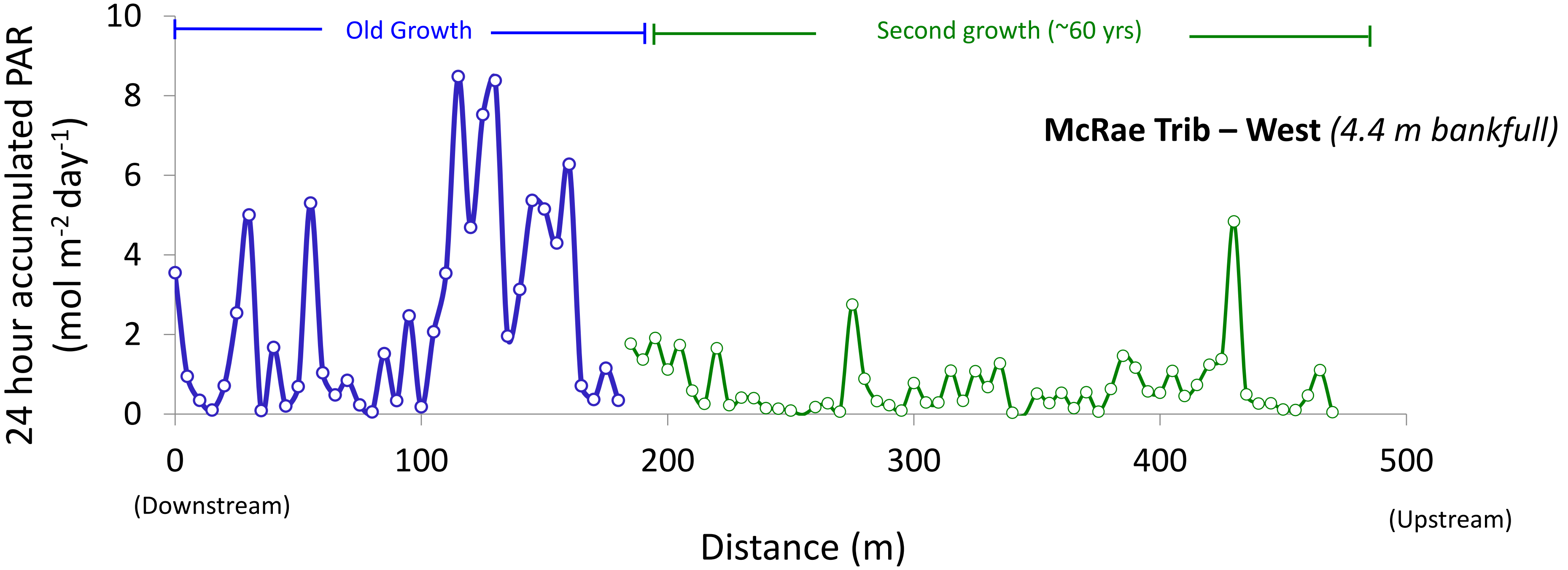
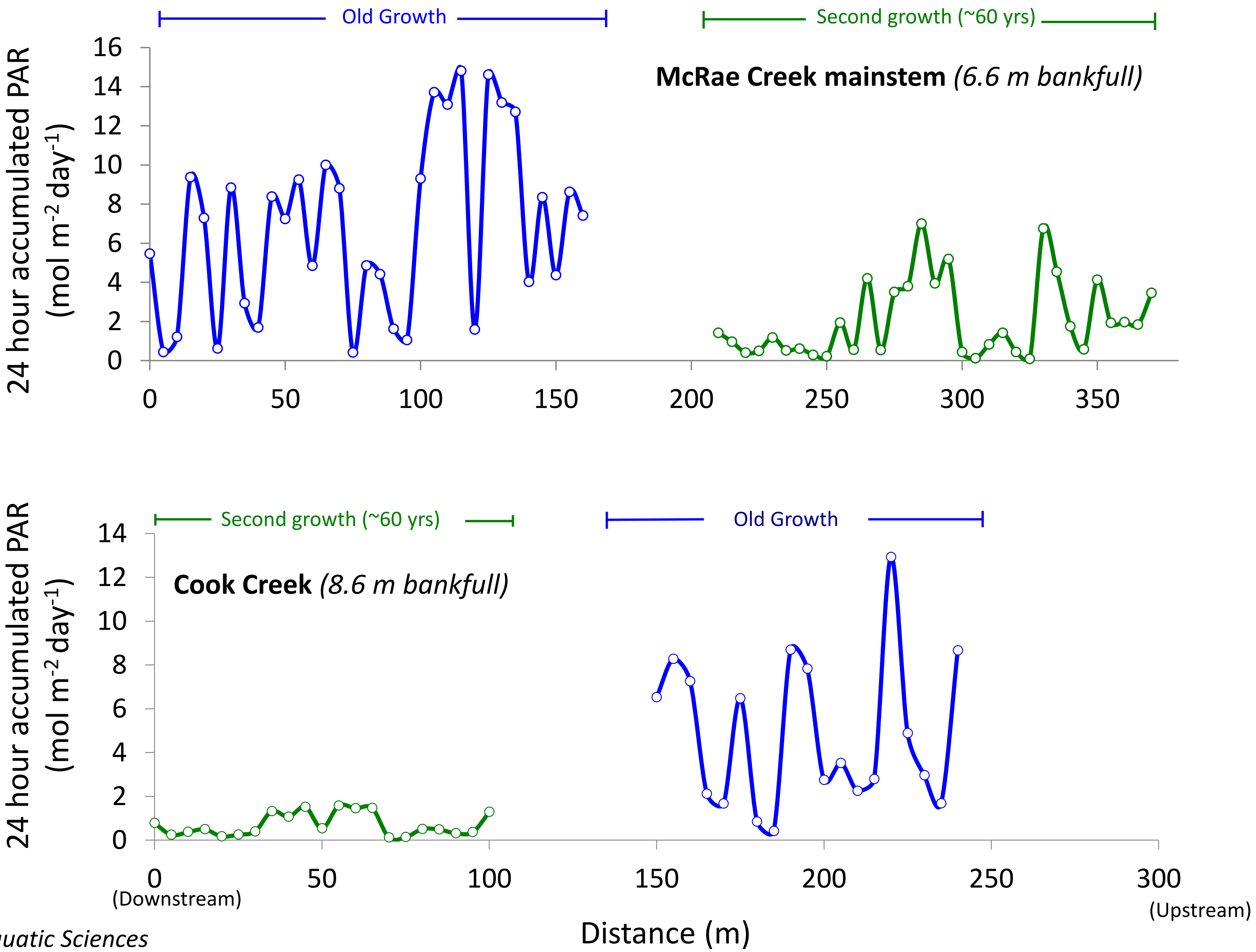




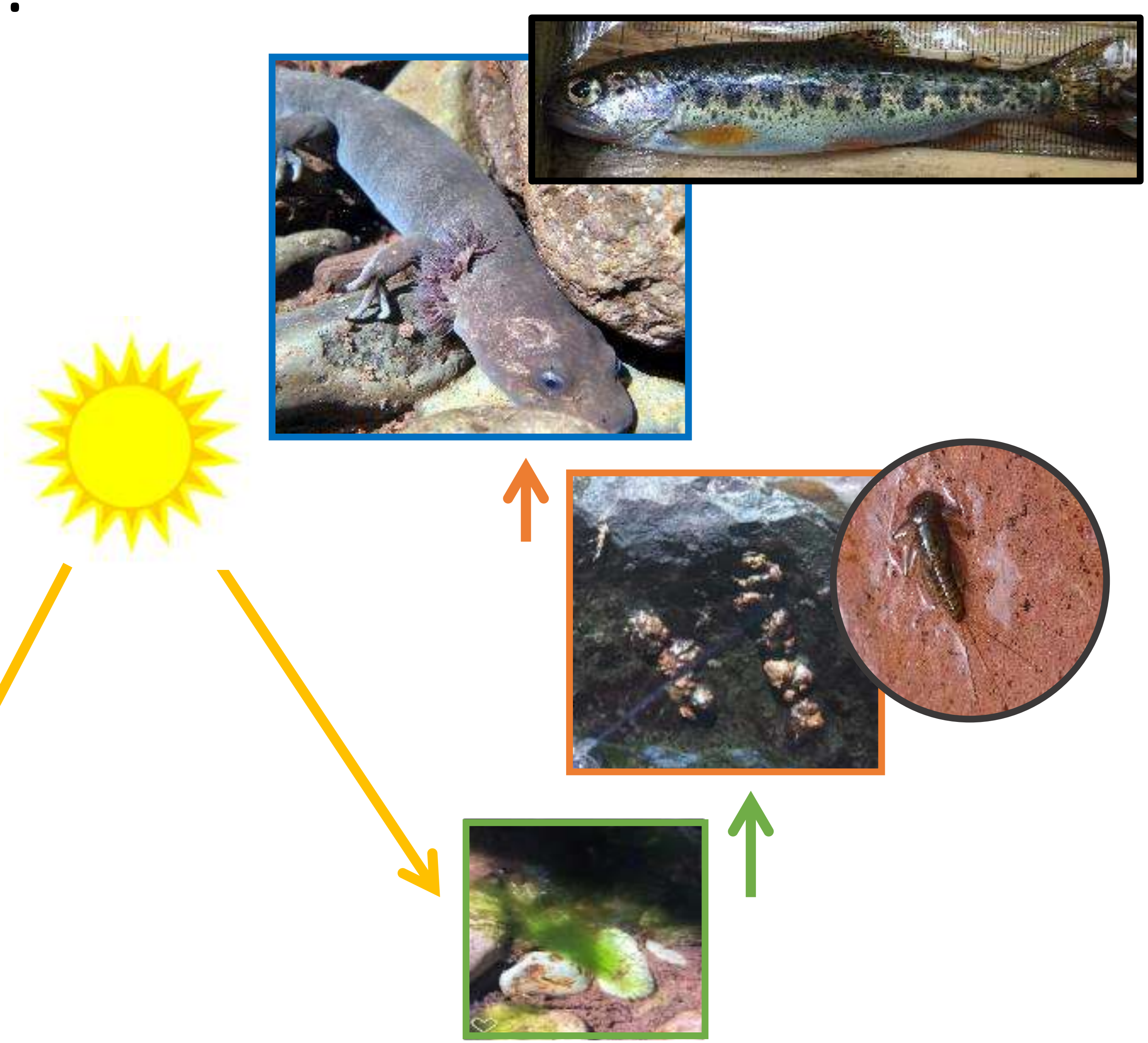
Warren et al. 2013 – Aquatic Sciences

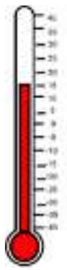
Why does Light matter?

- Primary production is often ***light-limited*** in forested headwater systems

- Food availability for consumers is often ***limited*** in these systems

- Stream biofilms are a disproportionately important food source





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- Primary production is often ***light-limited*** in forested headwater systems

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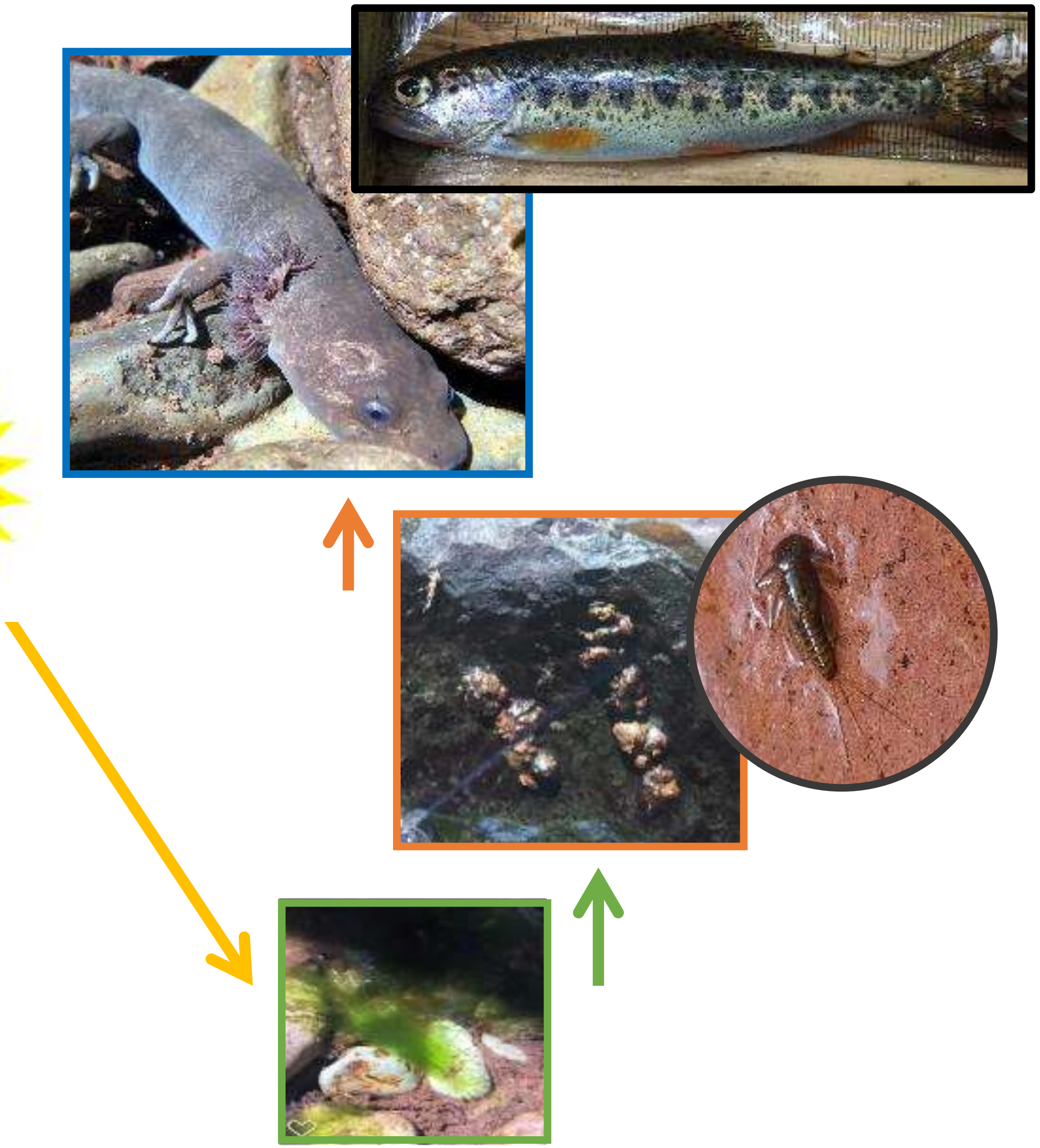

- Light drives stream temperature

- Temperature affects biota and all ecosystem processes

Why a focus on riparian forest gaps?

- Canopy gaps are common in late succession/old-growth forests
- Canopy gaps are rare in the mid-succession forests that dominate western OR, WA, CA
- Gaps create spatial heterogeneity in the forest – and so may be a desired restoration tool for terrestrial biota
- Gaps also create spatial heterogeneity in the light environment of associated streams

We are already creating gaps when we implement wood addition studies

Lawrence Creek – National Fish Habitat Partnership

Garcia River – North Coast Coho project

Why a focus on riparian forest gaps?

- Canopy gaps are common in late succession/old-growth forests
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- Gaps create spatial heterogeneity in the forest – and so may be a desired restoration tool for terrestrial biota
- Gaps also create spatial heterogeneity in the light environment of associated streams

We are already creating gaps when we implement wood addition studies

- **Are the responses we're seeing to wood additions just due to wood?**
- **Or is there also a bottom-up effect that drives responses?**
- **Or is the response dominated by bottom-up processes *instead* of habitat processes?**

Garcia River – North Coast Coho project

Riparian gap experiment

Cut small gaps into riparian zones with close-canopy second-growth forest

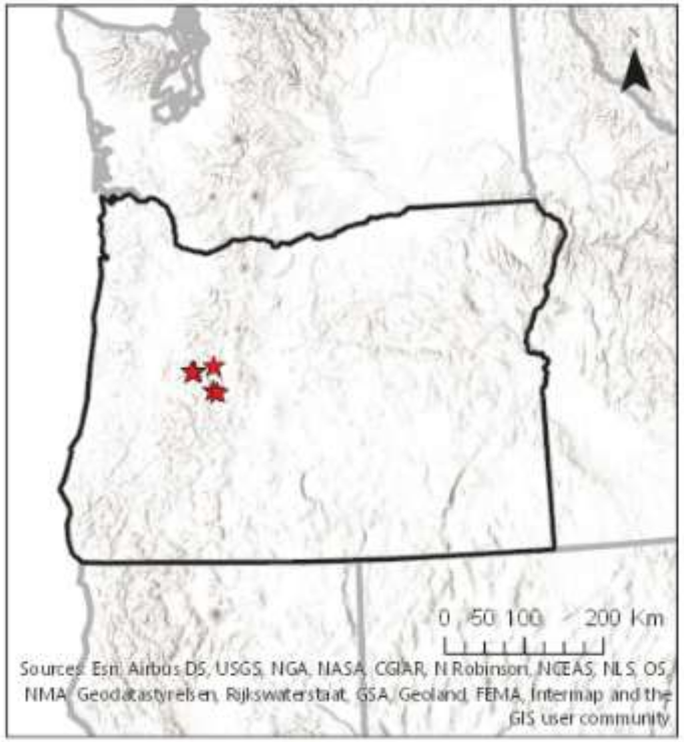
Study Question

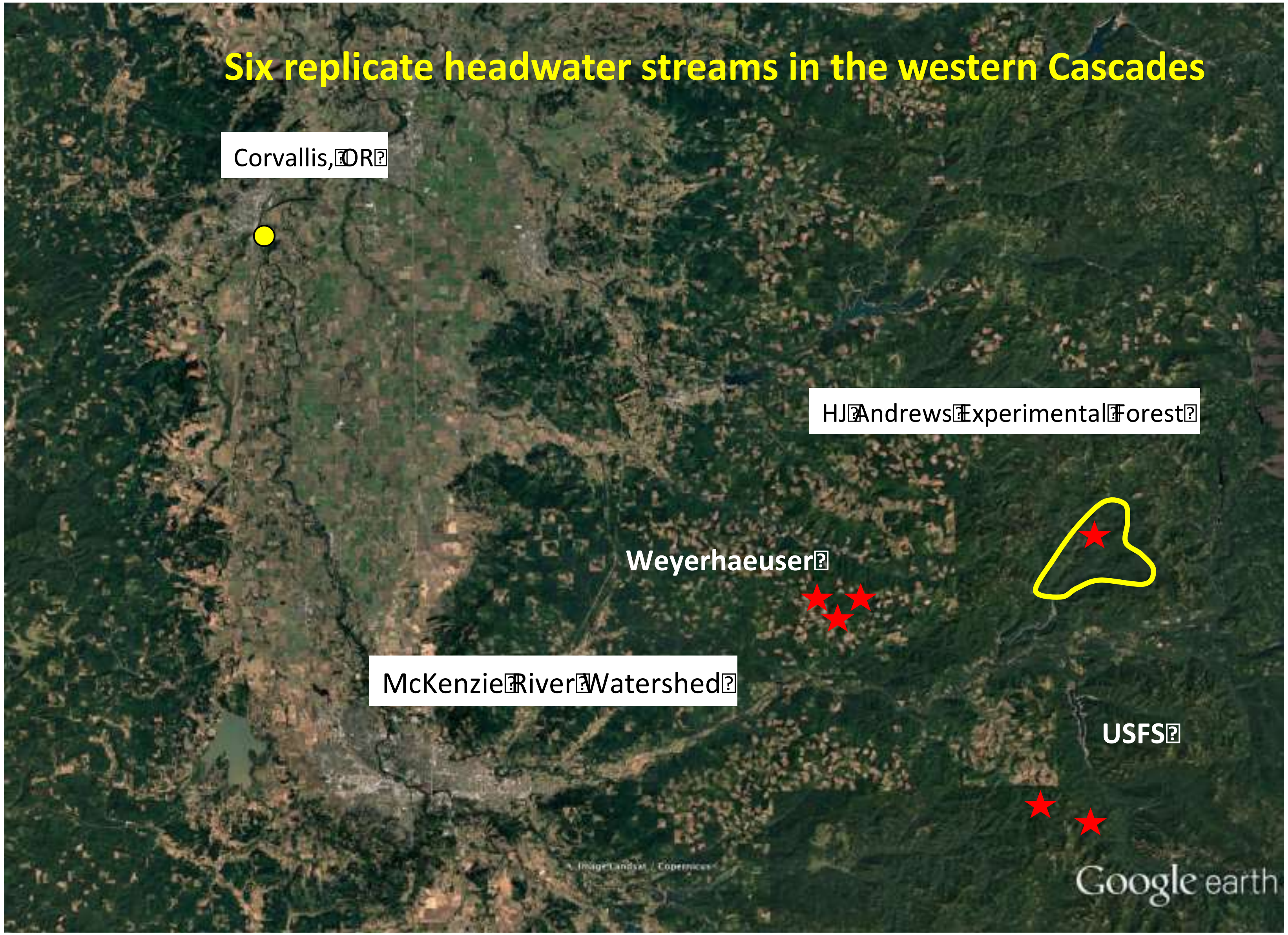
How do localized canopy gaps affect the biomass of apex predators at the reach scale?

Hypothesis: ↑ **LIGHT** = ↑ Biofilm = ↑ Macroinvertebrates = ↑ Fish/Sal

Riparian gap experiment

Study site – Wester Cascade Mountains of central Oregon



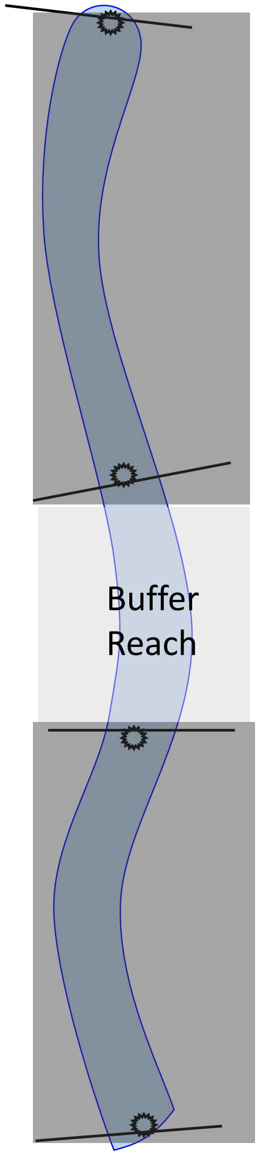


Riparian gap experiment

Study design

Before- After-
Control- Impact

Pre-year



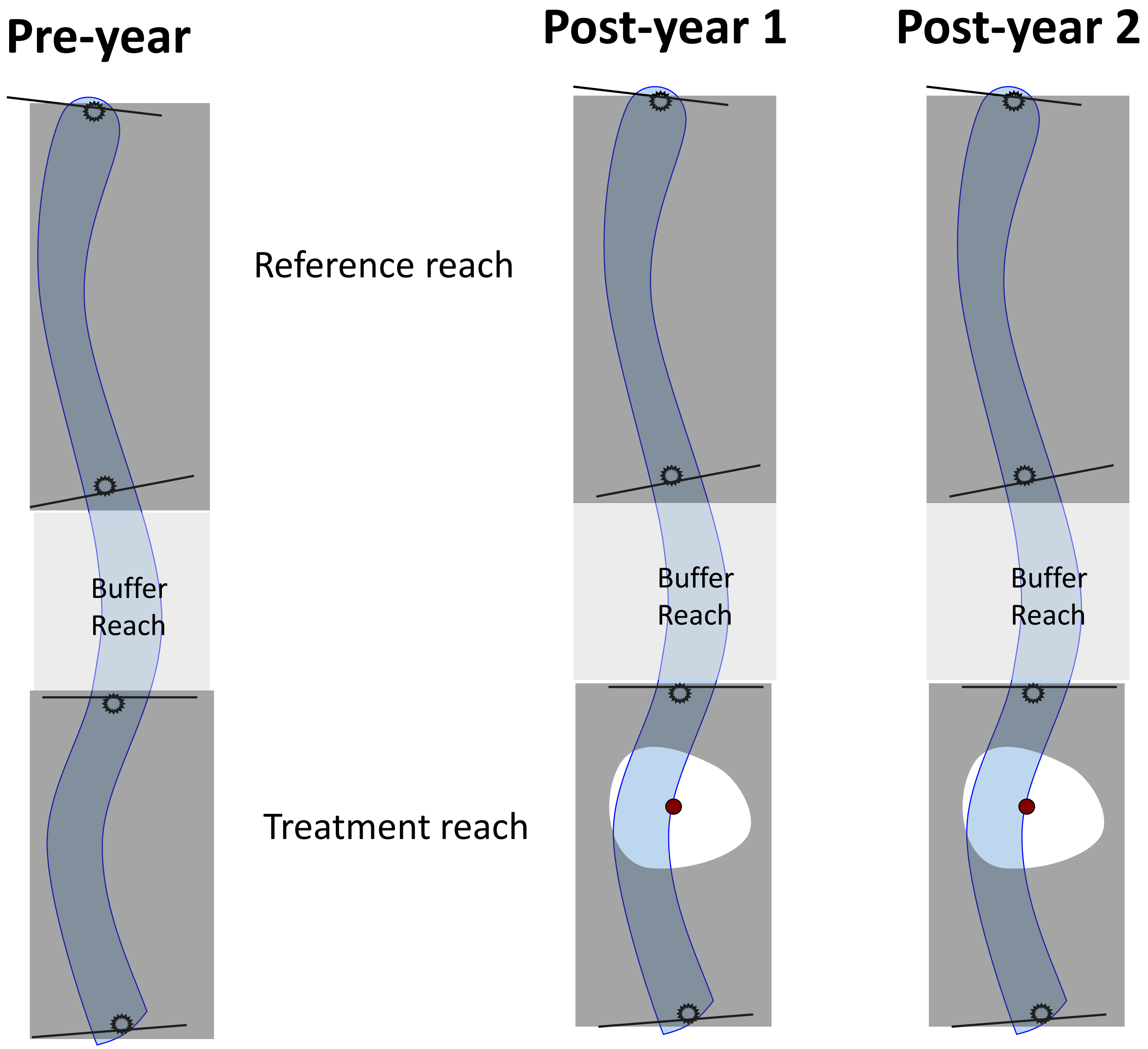
Reference reach

Treatment reach

Riparian gap experiment

Study design

Before- After-
Control- Impact



Riparian gap experiment

Pre-treatment

W-113

W-100

W-122

Riparian gap experiment

Pre-treatment

W-113

W-100

W-122

Post-treatment

Riparian gap experiment

Before

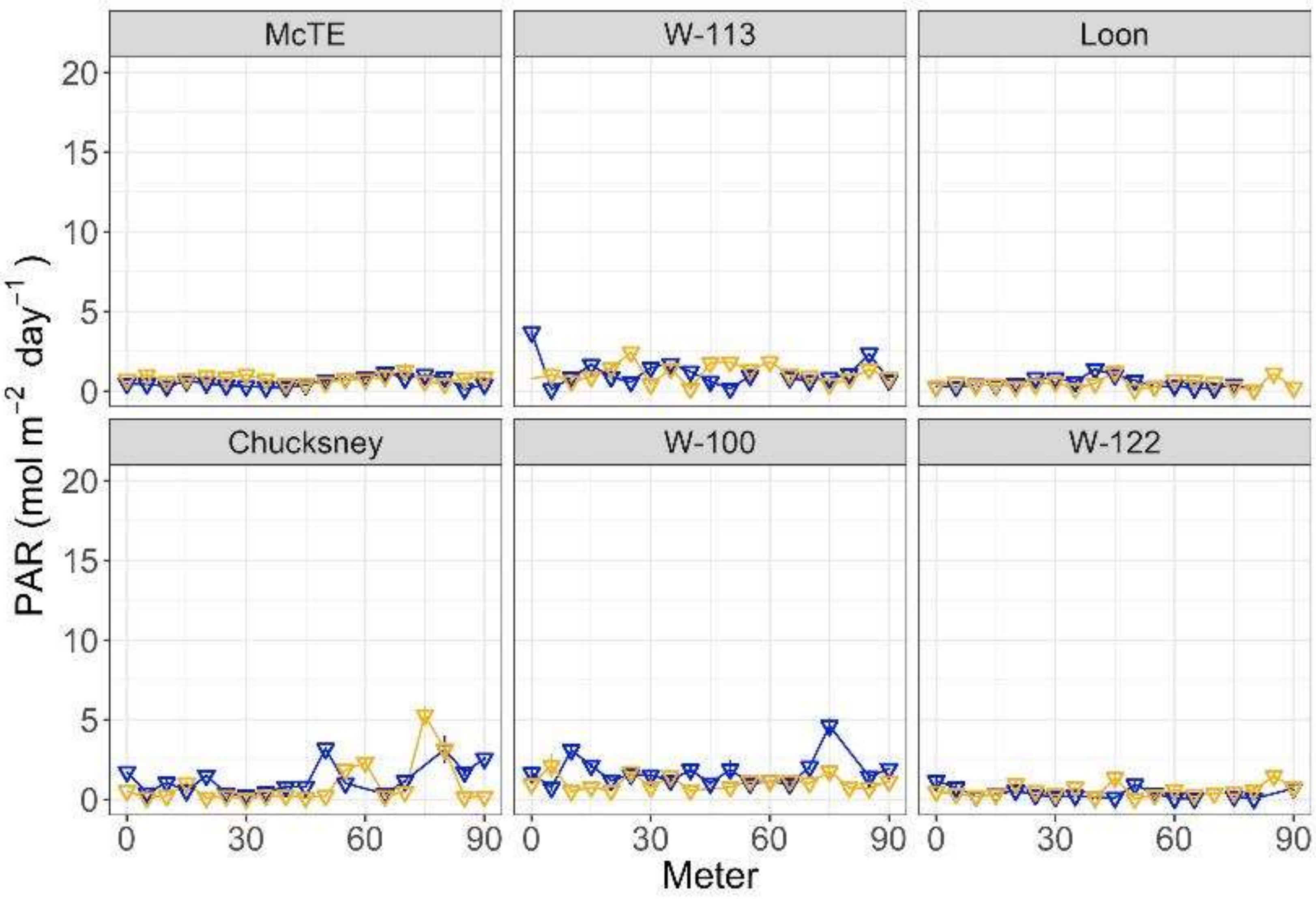
After

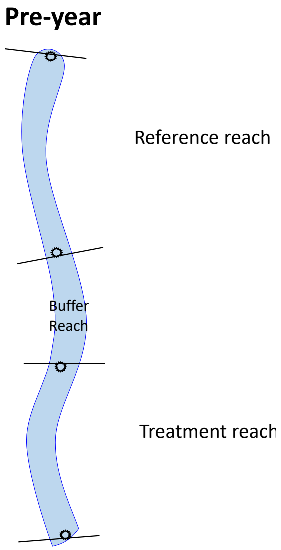
McTE

Loon Creek

Riparian gap experiment

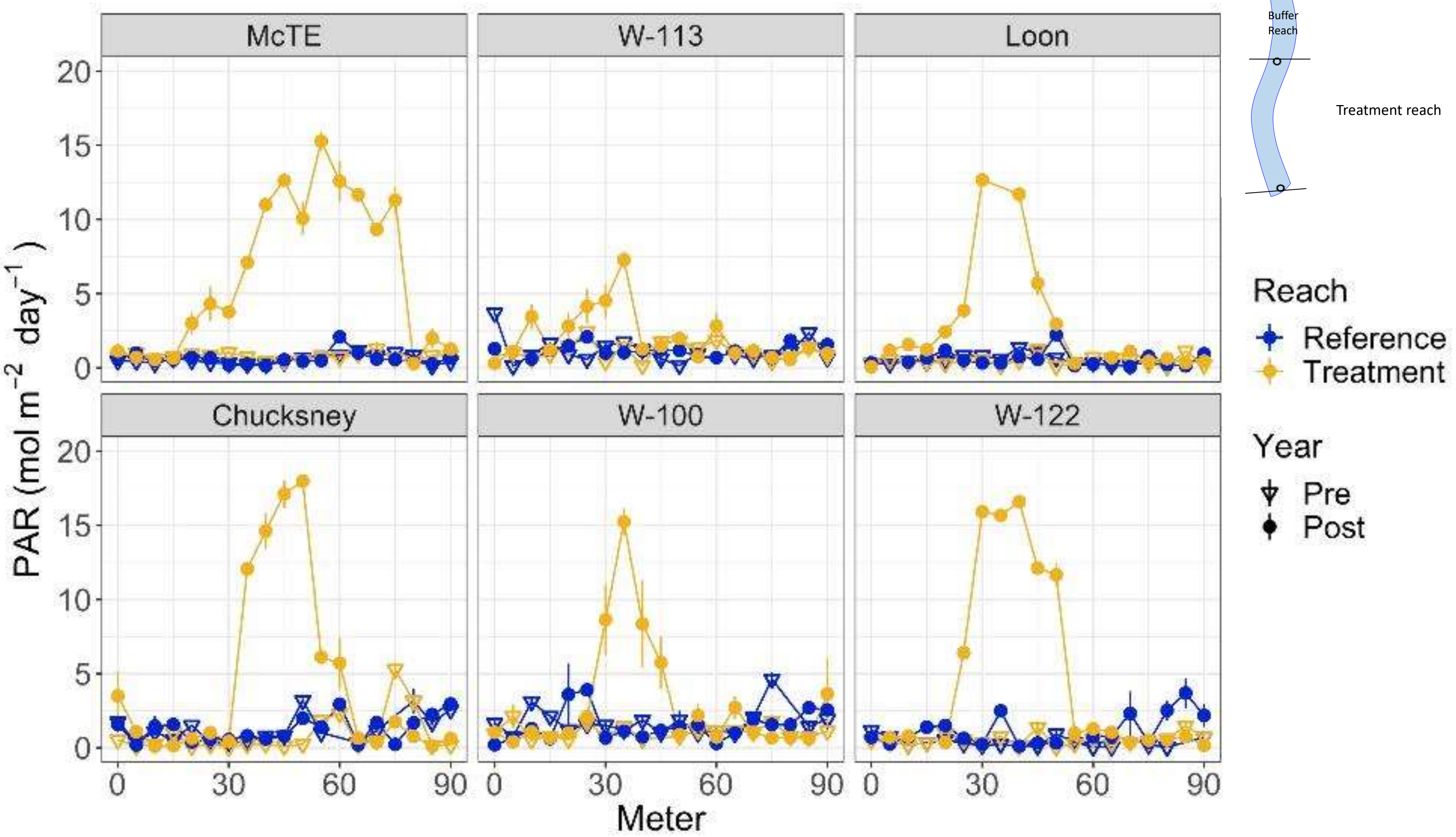
Stream Light

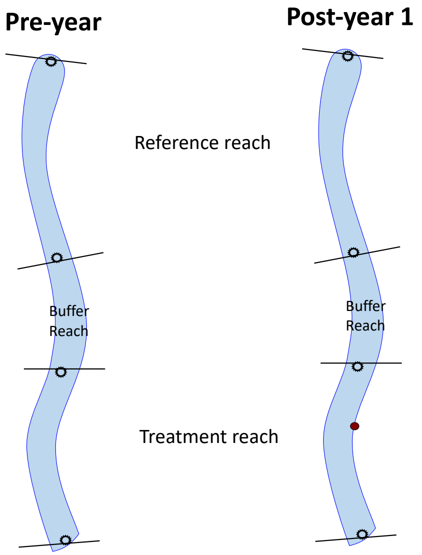




Riparian gap experiment

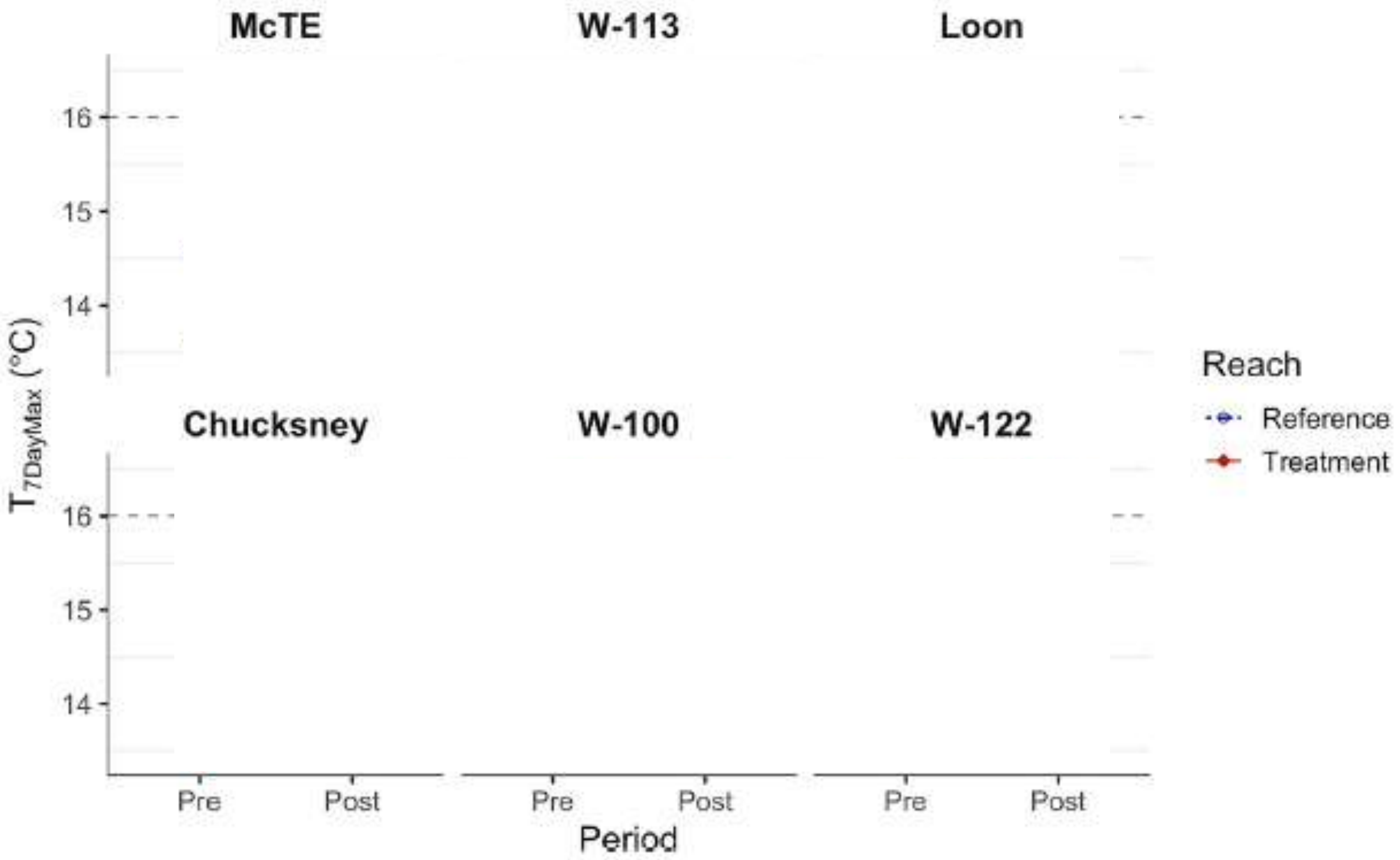
Stream Light





Riparian gap experiment

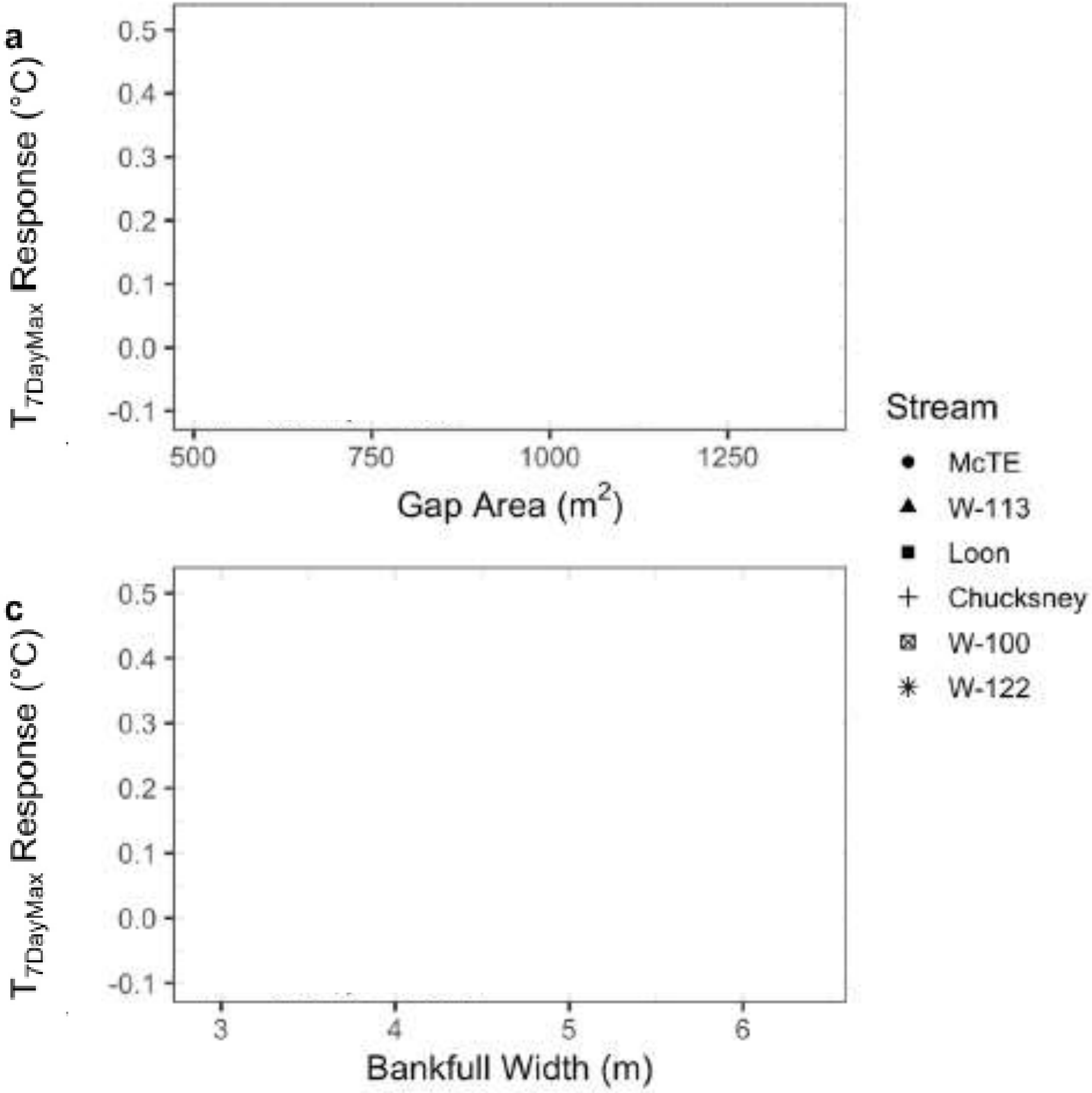
Stream Temperature



Swartz et al. 2020

Riparian gap experiment

Stream Temperature

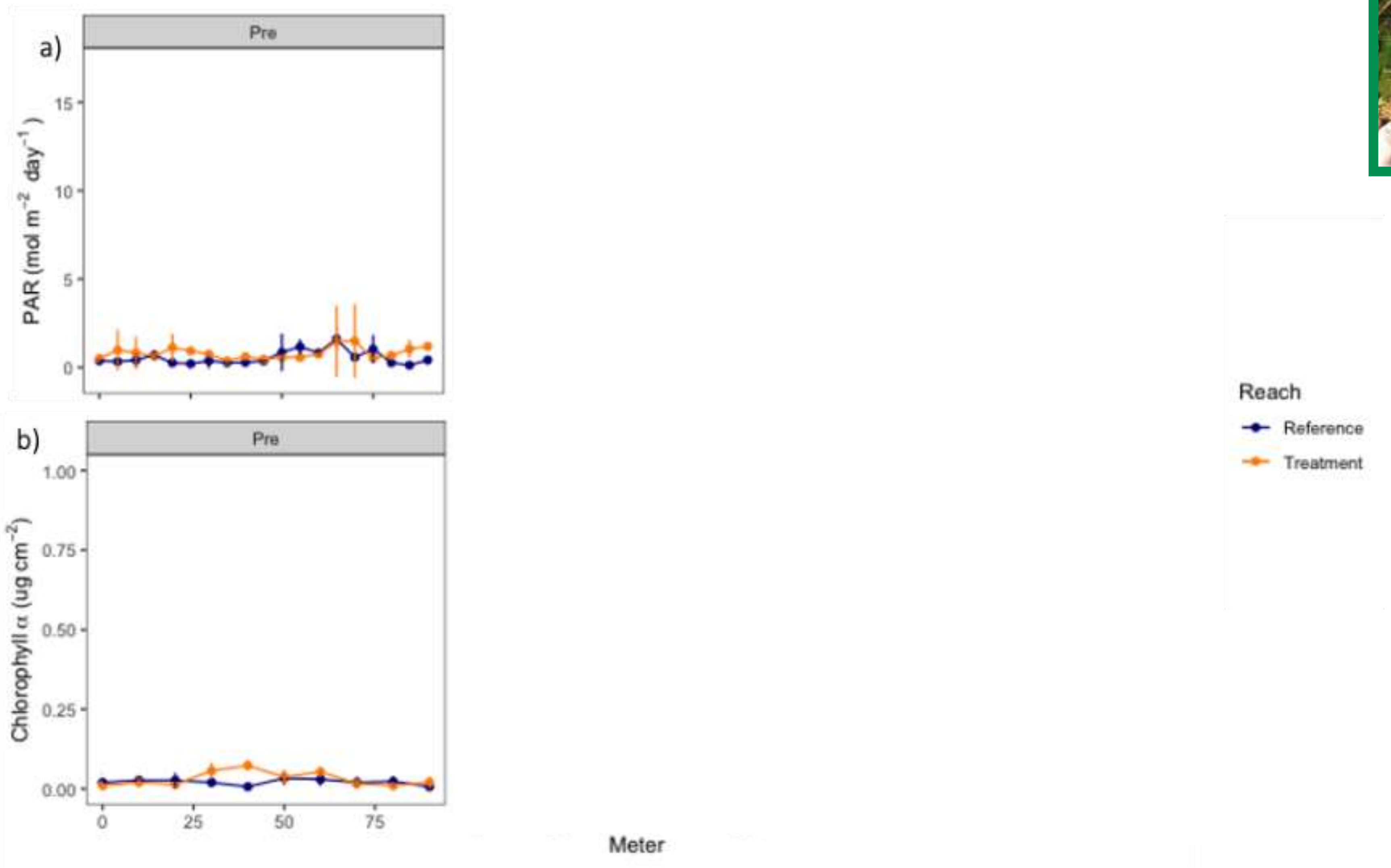


Swartz et al. 2020

Riparian gap experiment

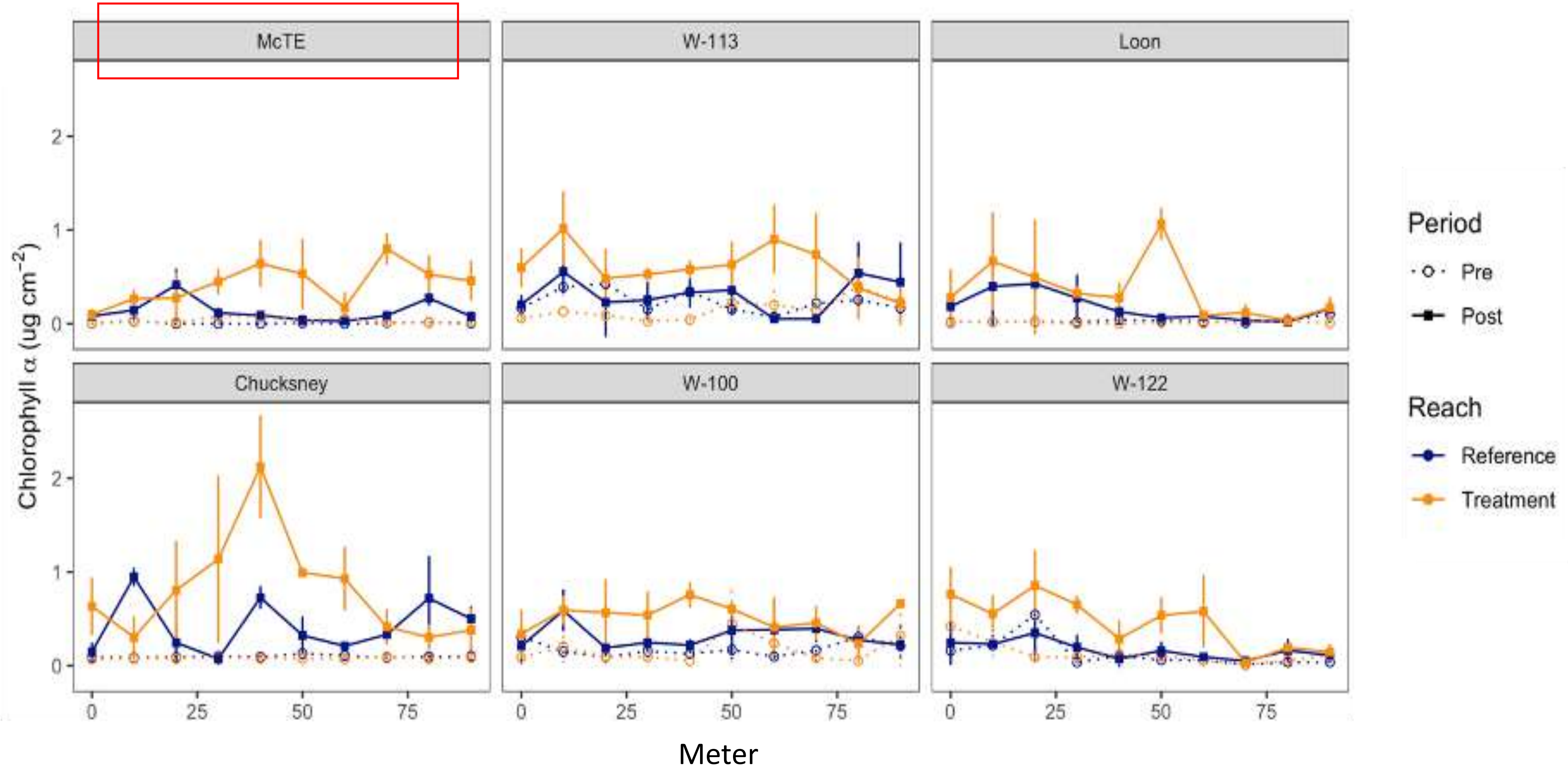
Local primary production

Stream: MCTE

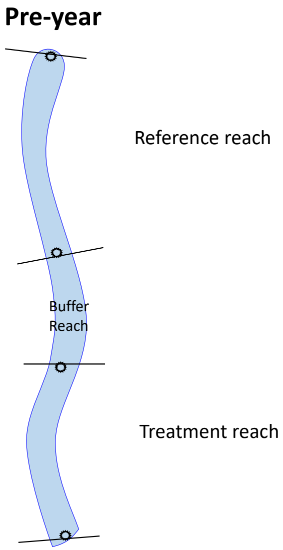


Riparian gap experiment

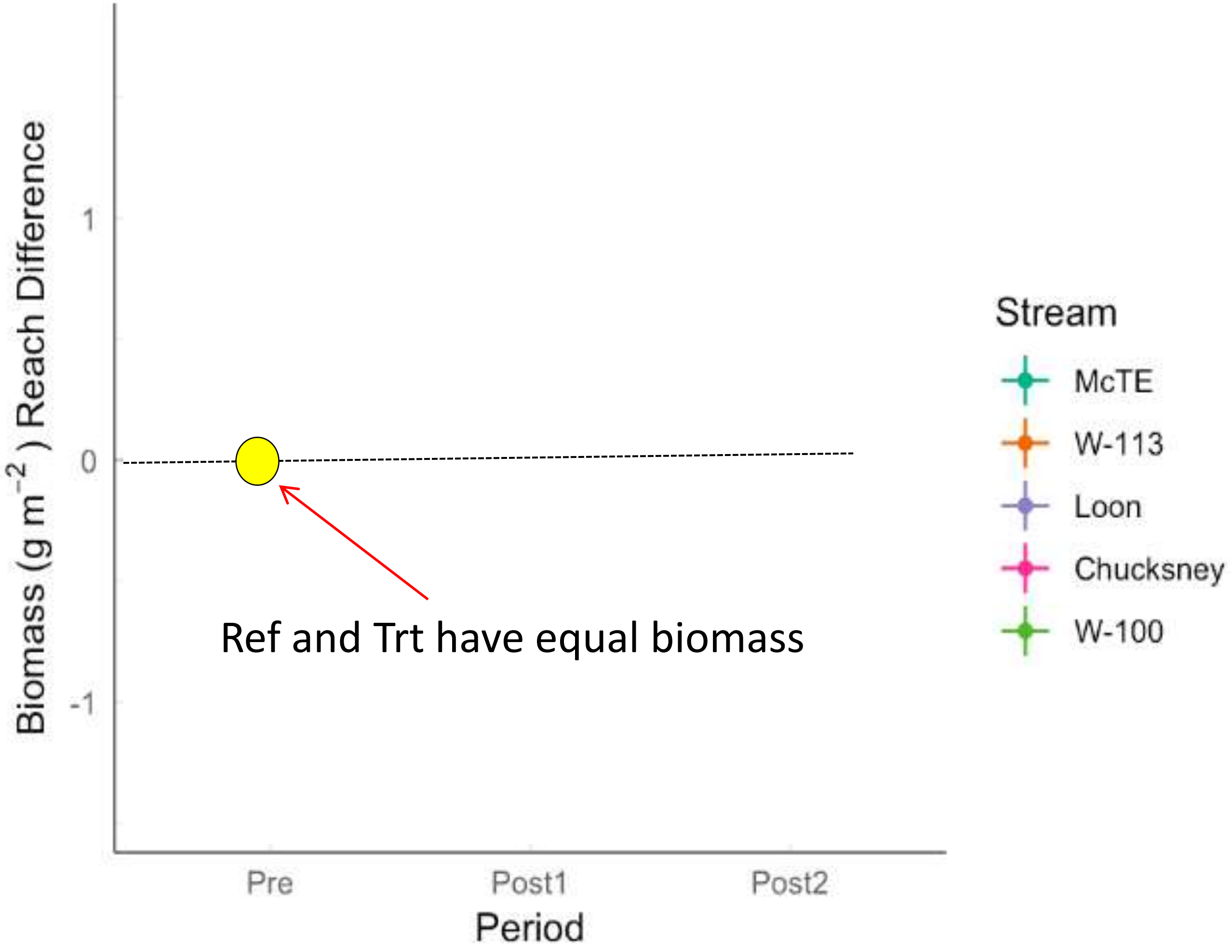
Local primary production



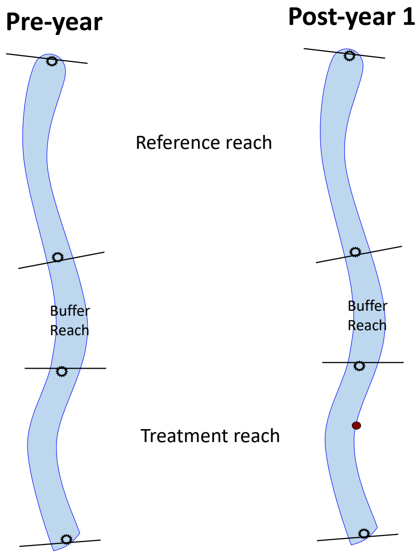
Riparian gap experiment



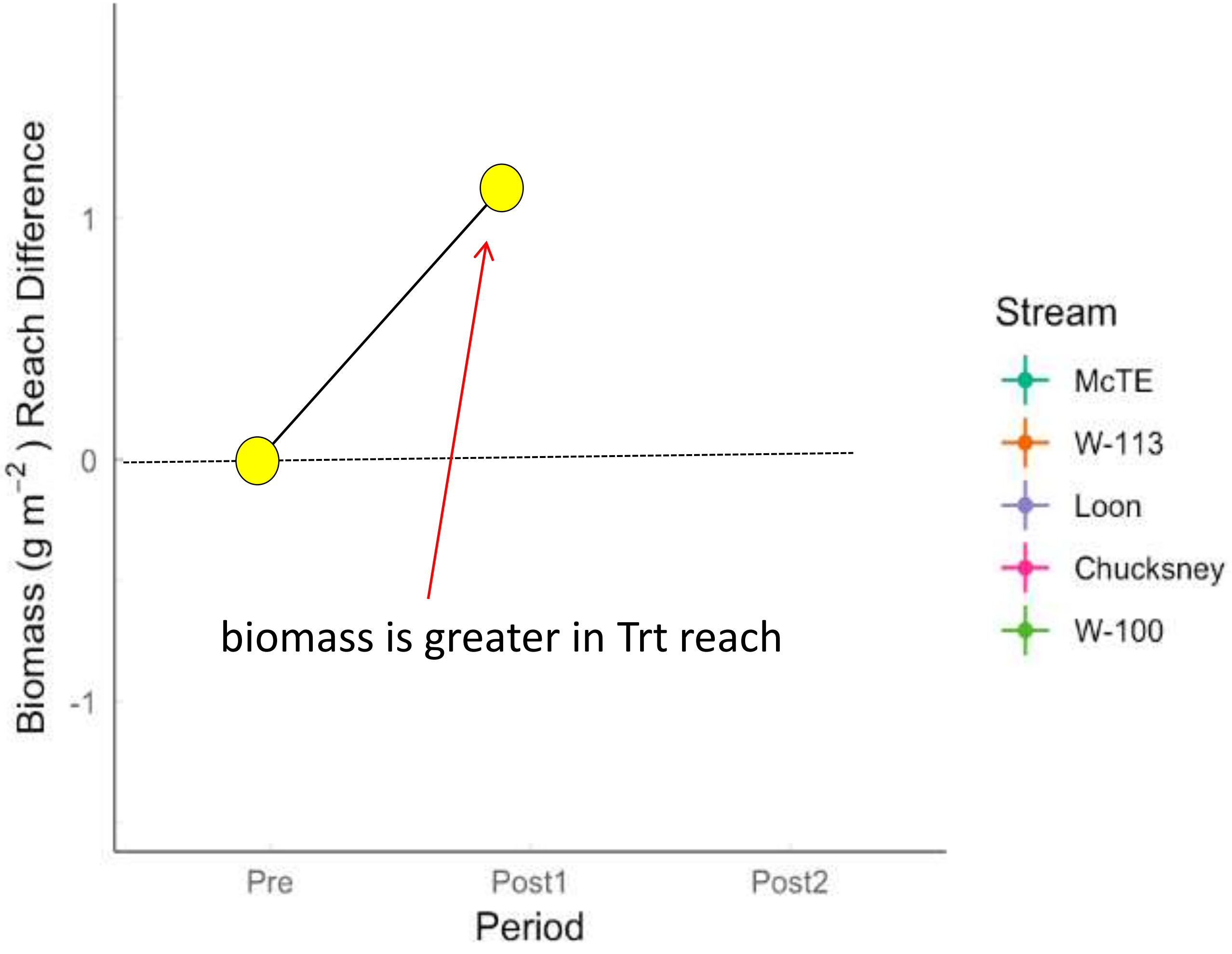
Hypothetical Results – normalized to ref reaches



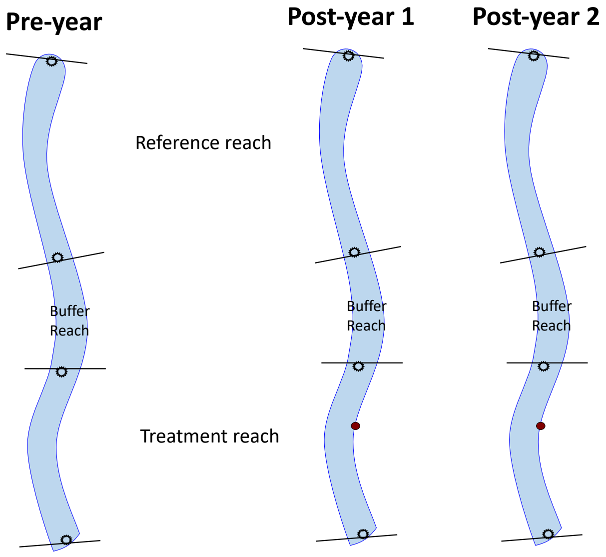
Riparian gap experiment



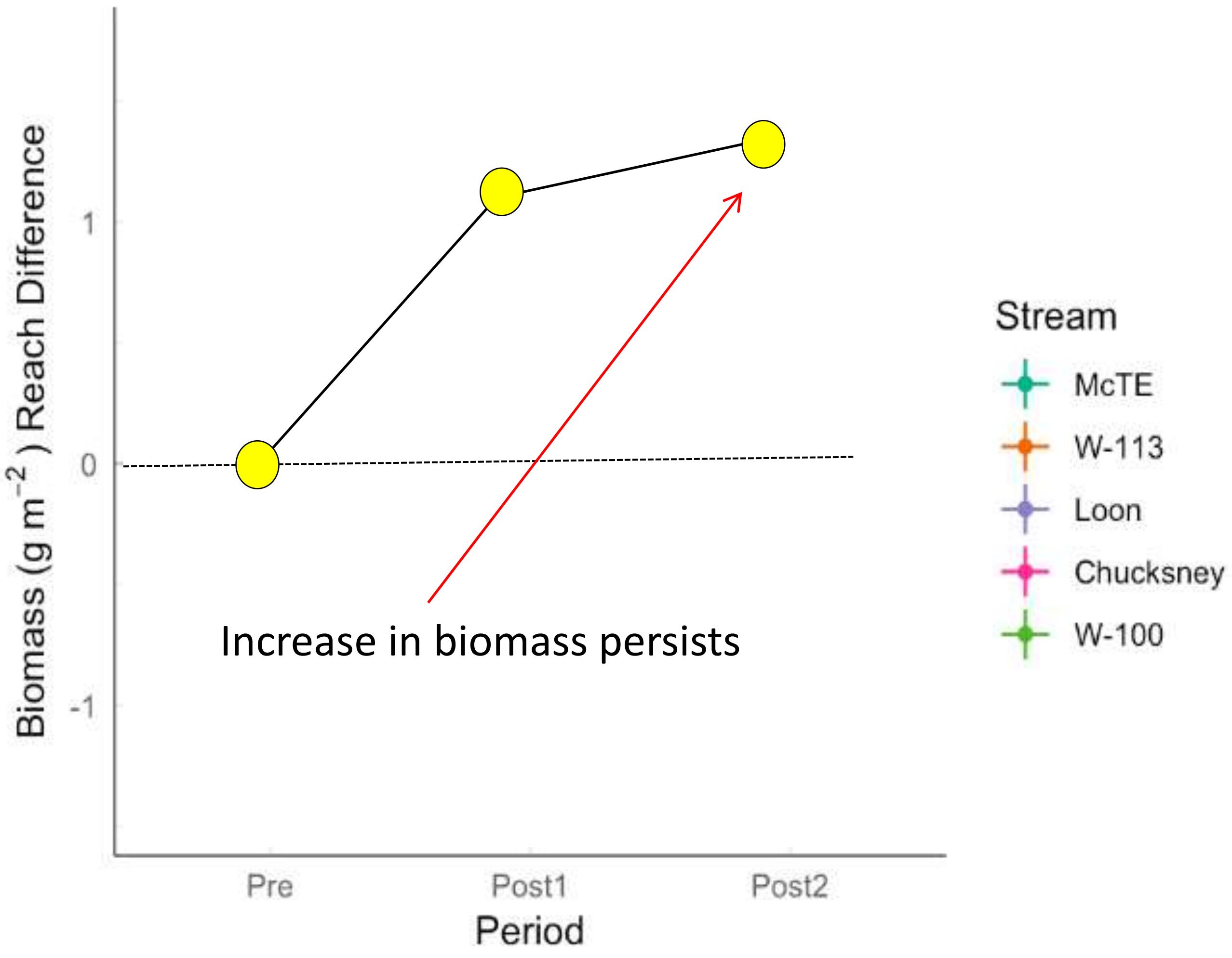
Hypothetical Results – normalized to ref reaches



Riparian gap experiment

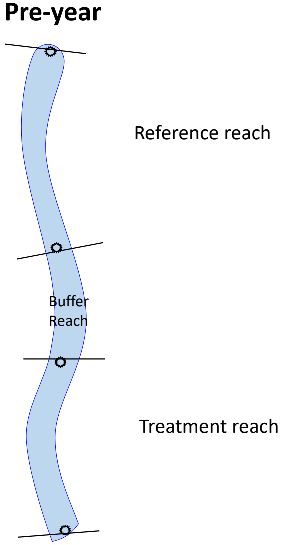


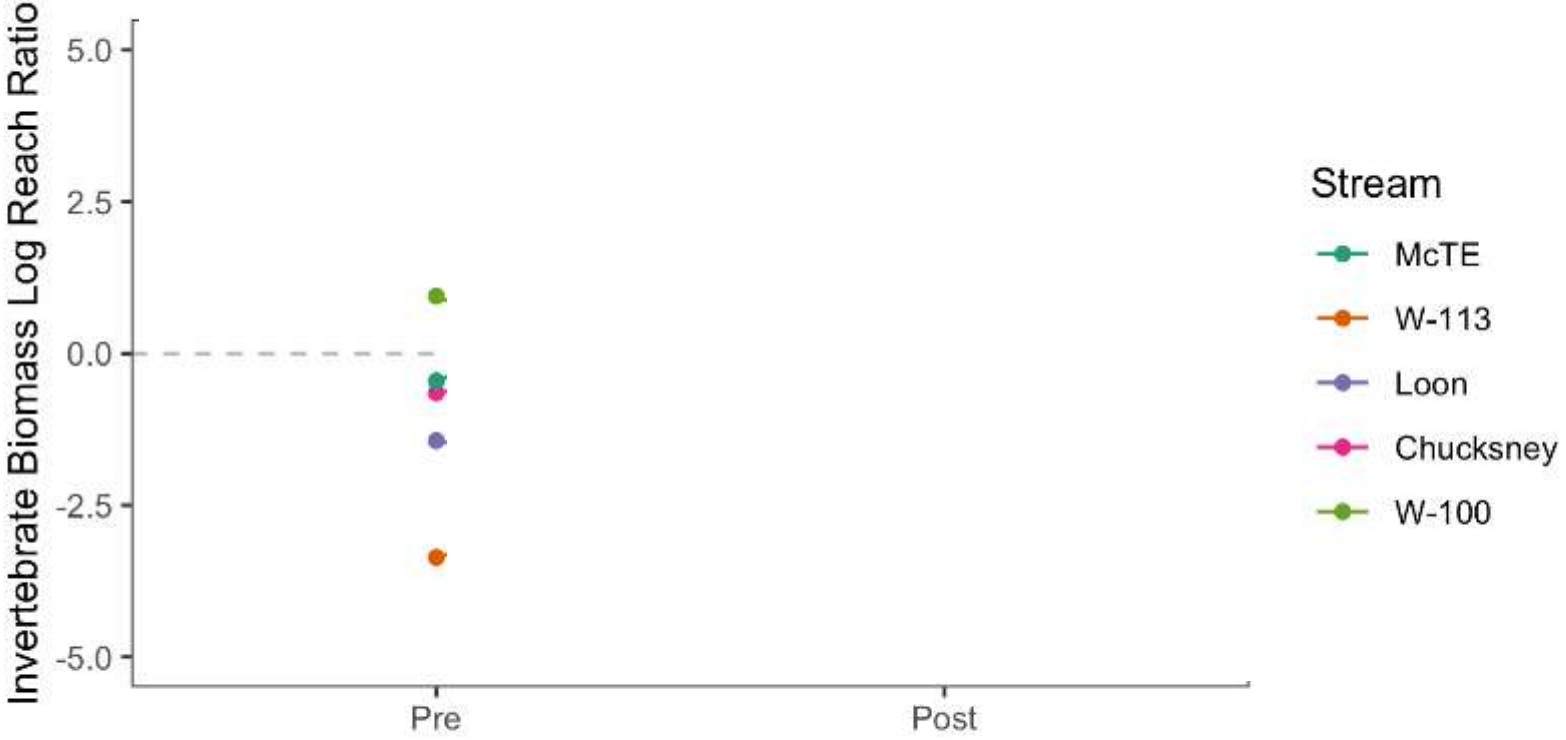
Hypothetical Results – normalized to ref reaches



Riparian gap experiment

Macroinvertebrates

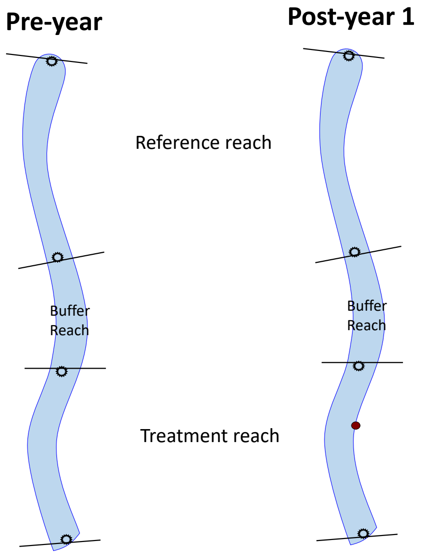


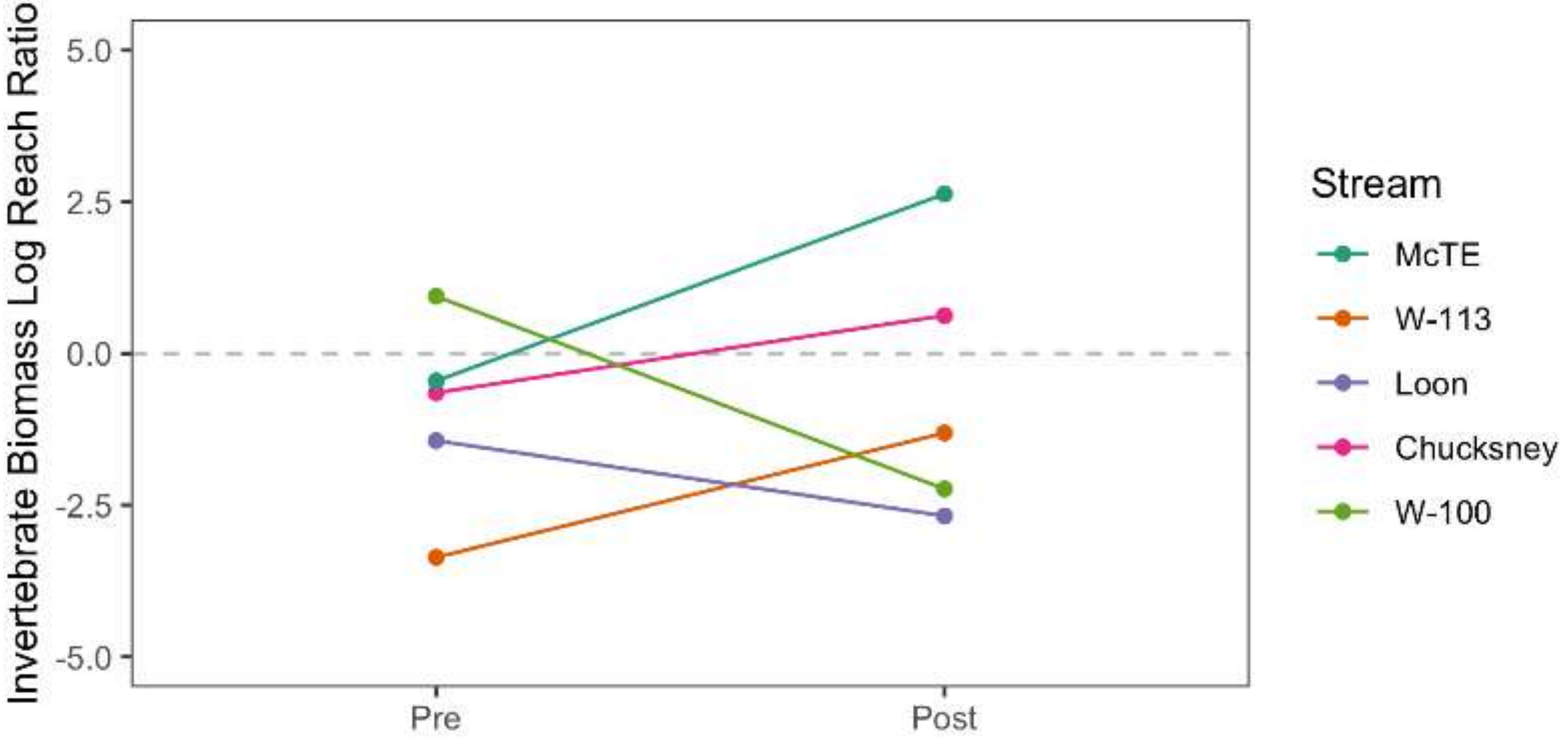


Riparian gap experiment

Macroinvertebrates

- **Increases in 3 of 5 sites**
- **Decreases in 2 of 5**



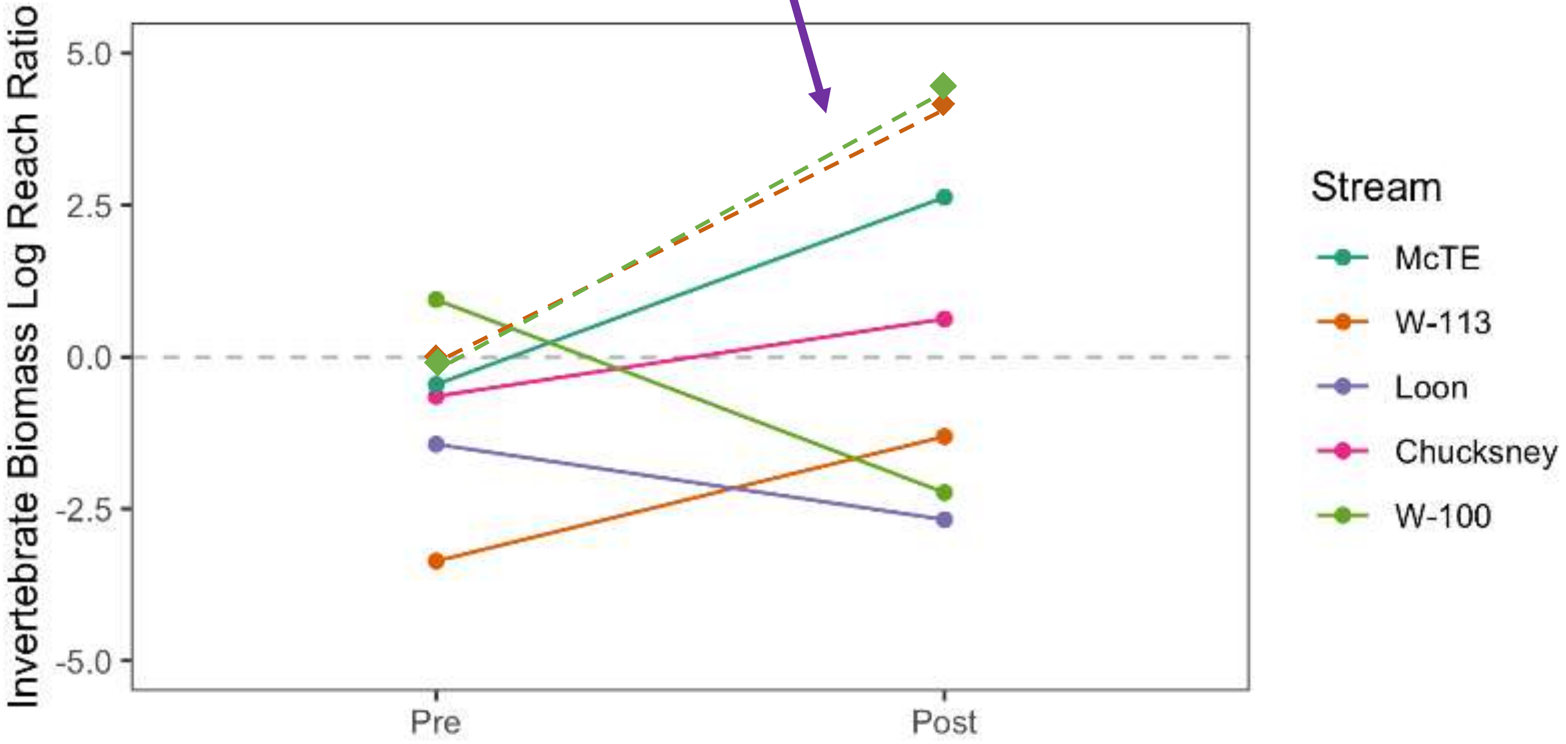


Riparian gap experiment

Macroinvertebrates

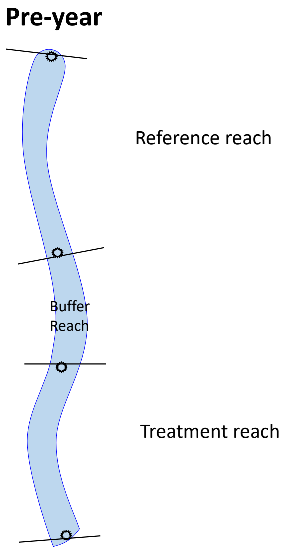
Inedible scrapers

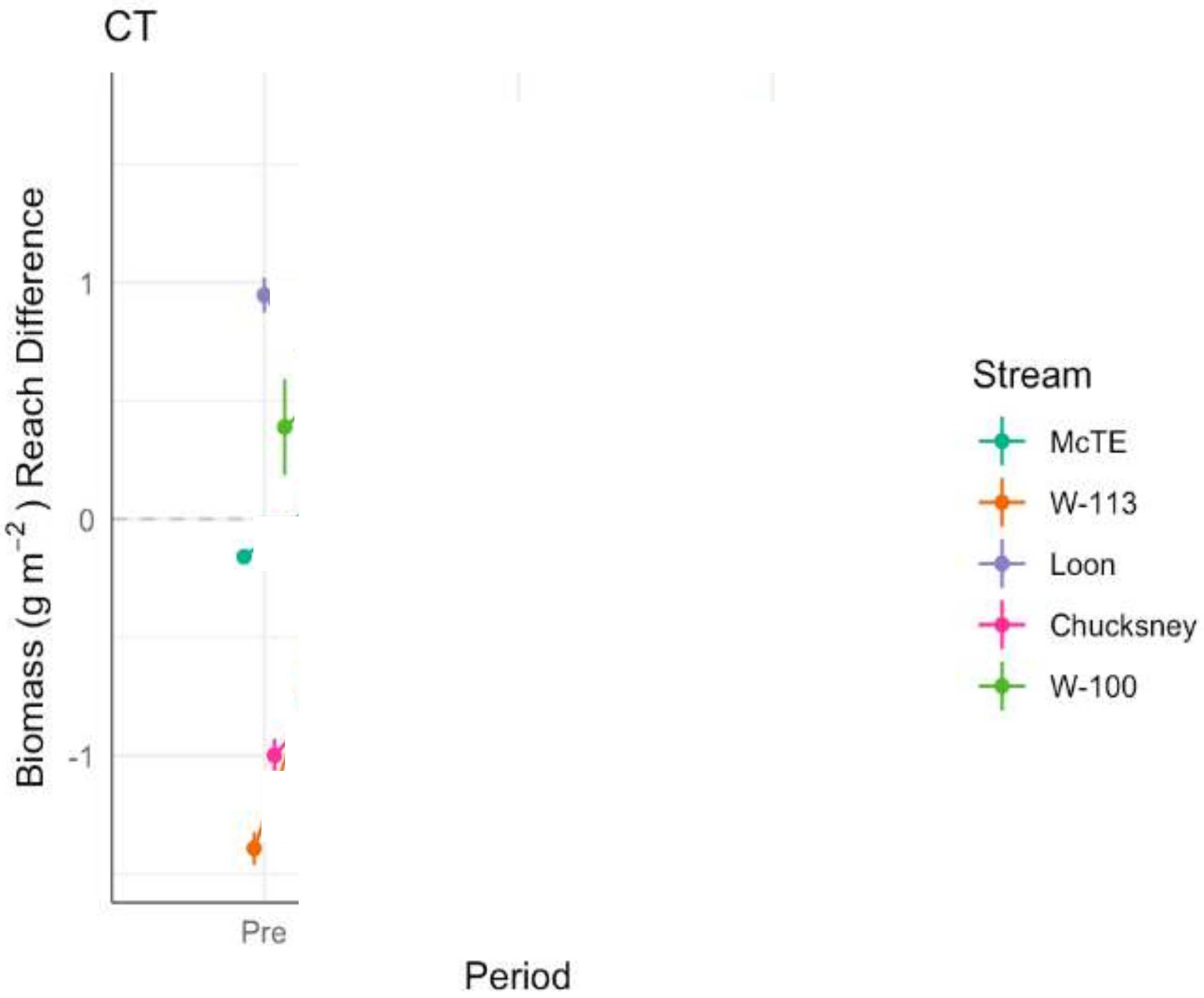
- **Increases in 3 of 5 sites**
- **Decreases in 2 of 5**
- **Very strong responses in snails (where present)**



Riparian gap experiment

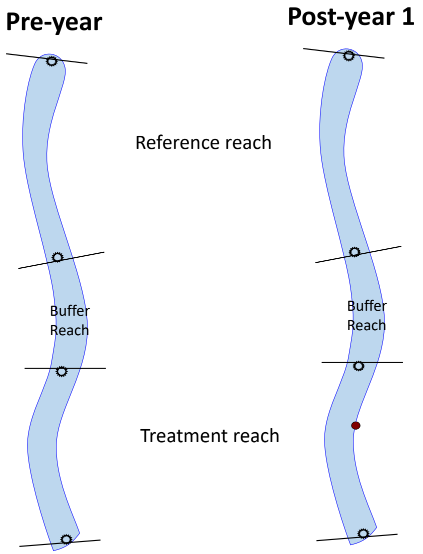
>1+ Cutthroat Trout

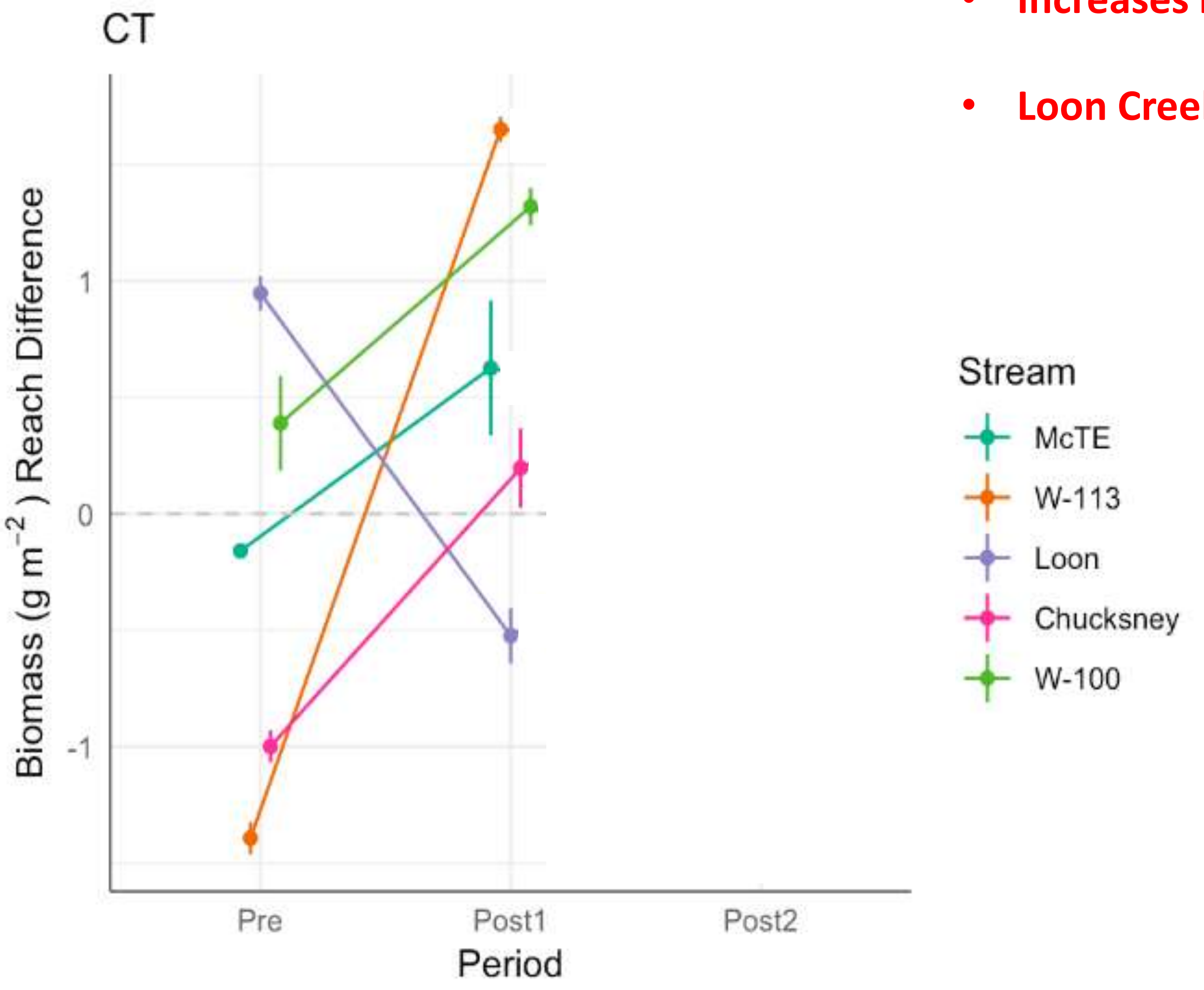




Riparian gap experiment

>1+ Cutthroat Trout

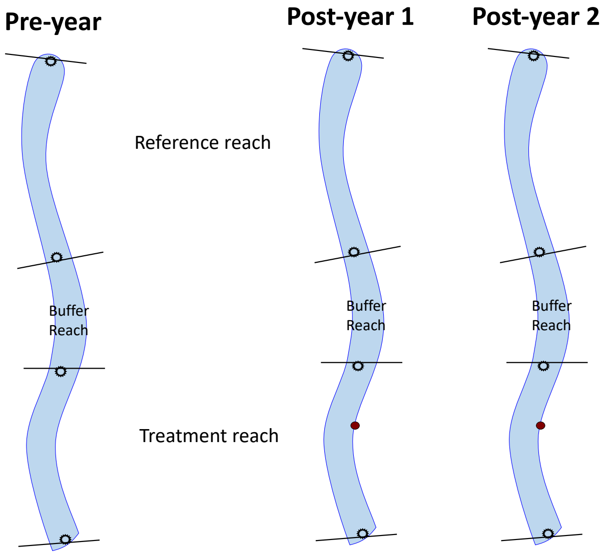


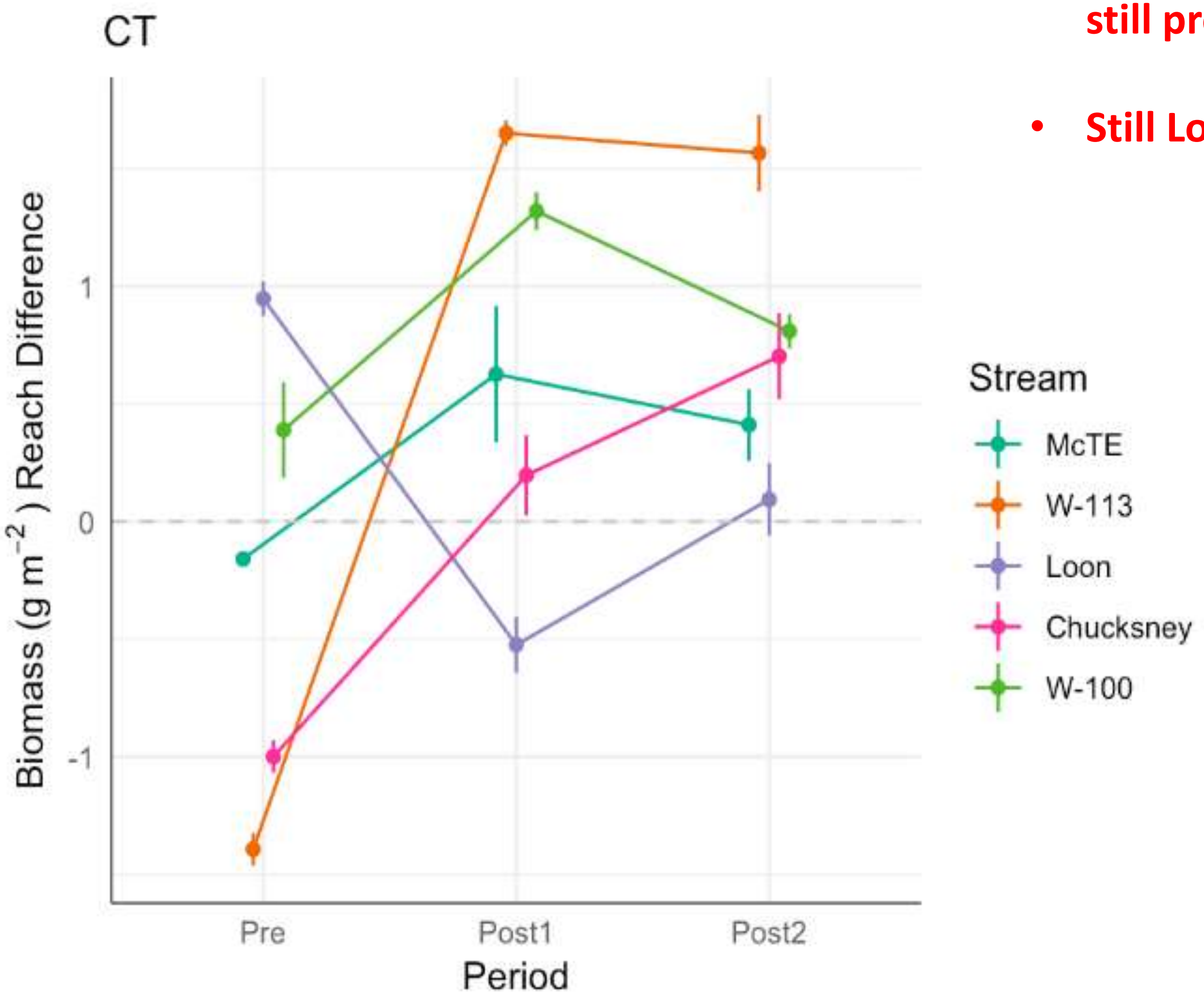


- **Increases in 4 of 5 sites**
- **Loon Creek??**

Riparian gap experiment

>1+ Cutthroat Trout



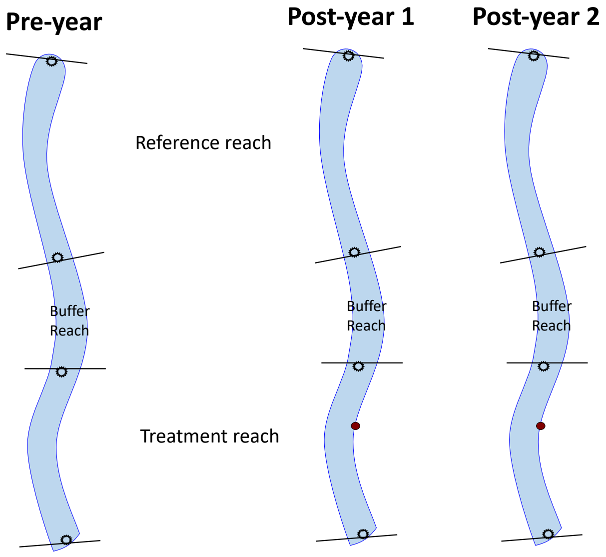


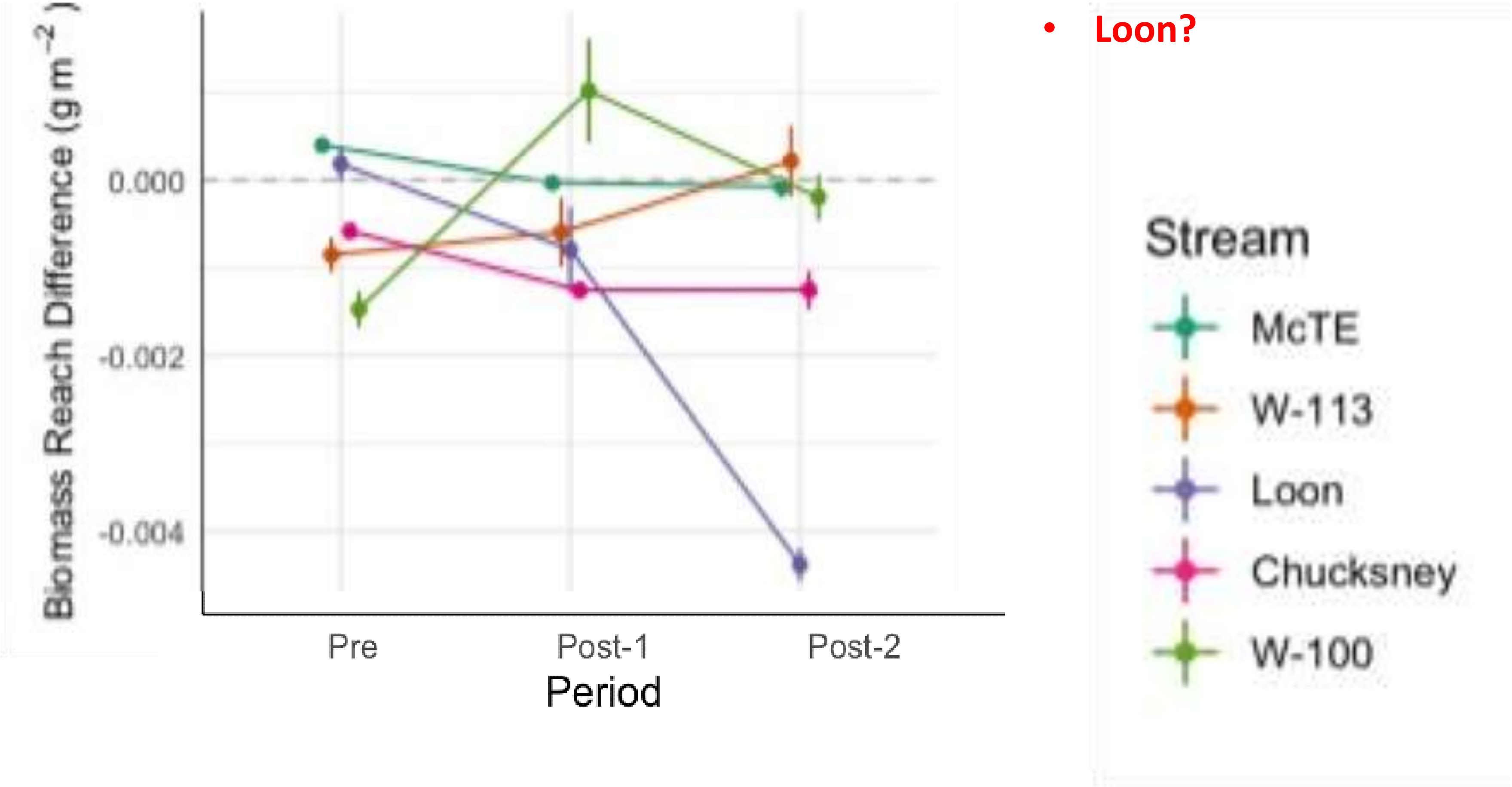
- **Increases mostly still present**
- **Still Loon Creek??**

Riparian gap experiment

0+ Cutthroat Trout

- **2 increase**
- **1 about the same**
- **2 decrease**
- **Loon?**





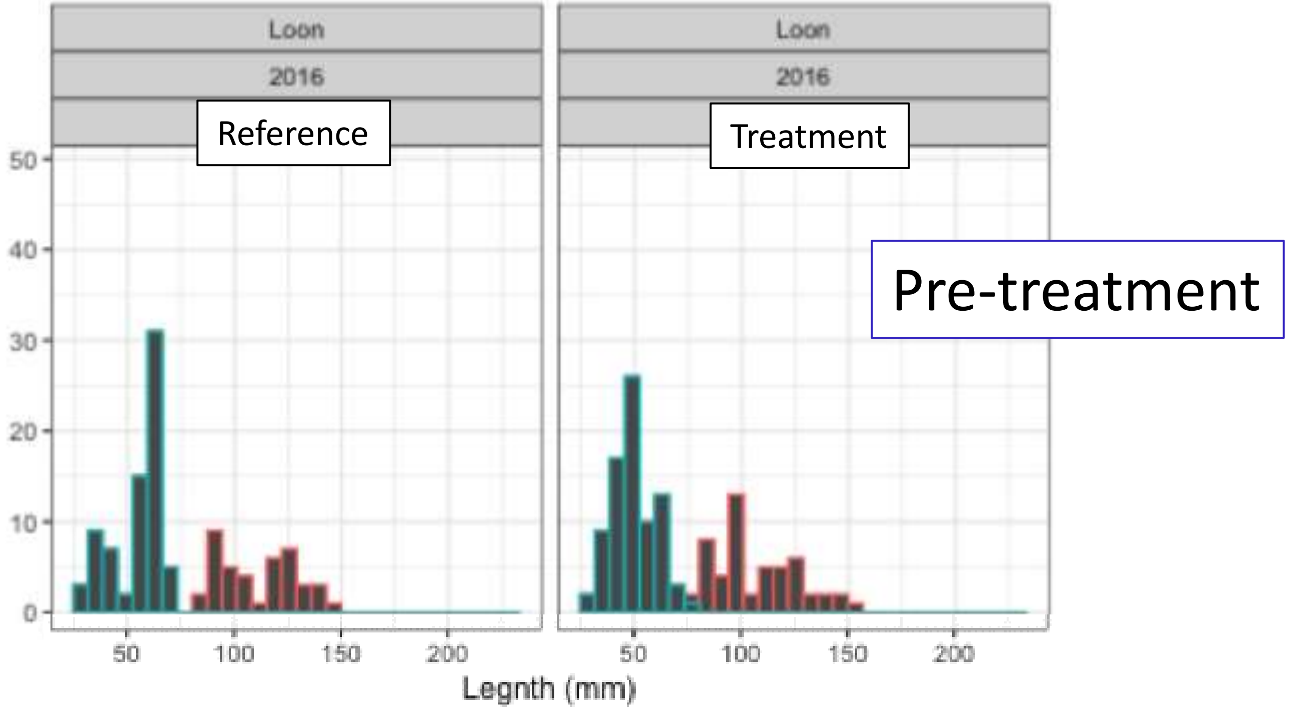
Loon Creek??

Smallest Gap

Loon Creek??

Smallest Gap

Responses in a system that already has high CT densities

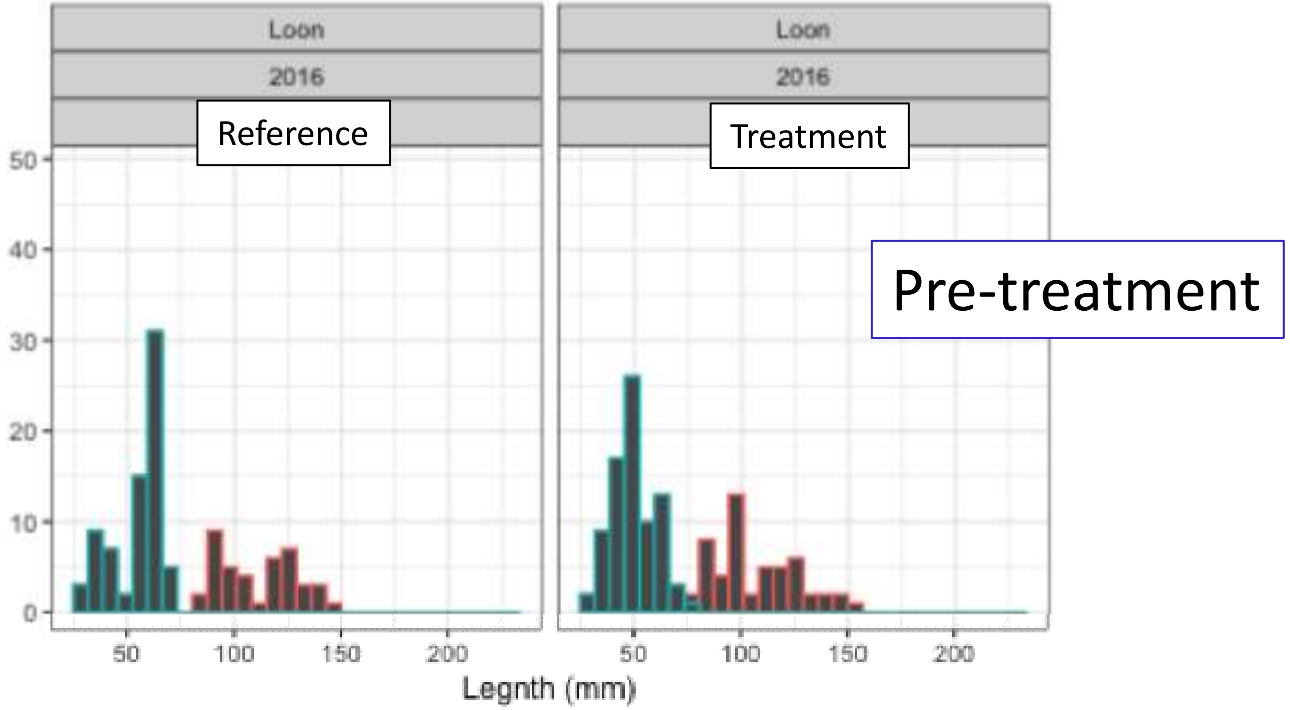


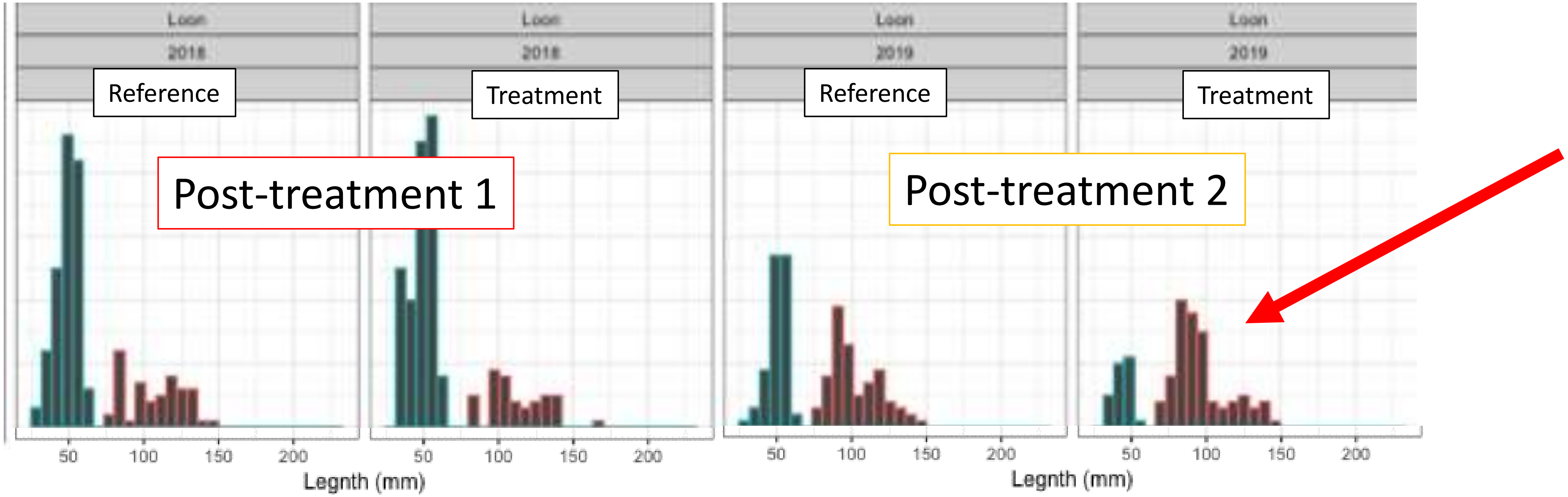
Loon Creek??

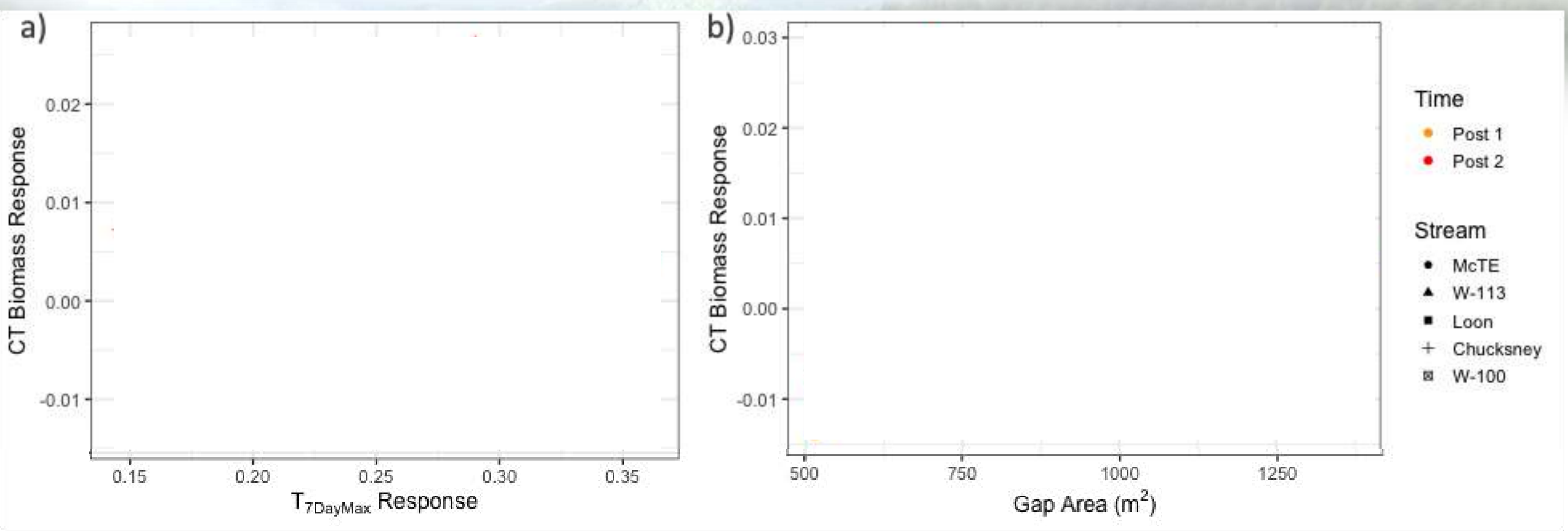
Smallest Gap

Responses in a system that already has high CT densities

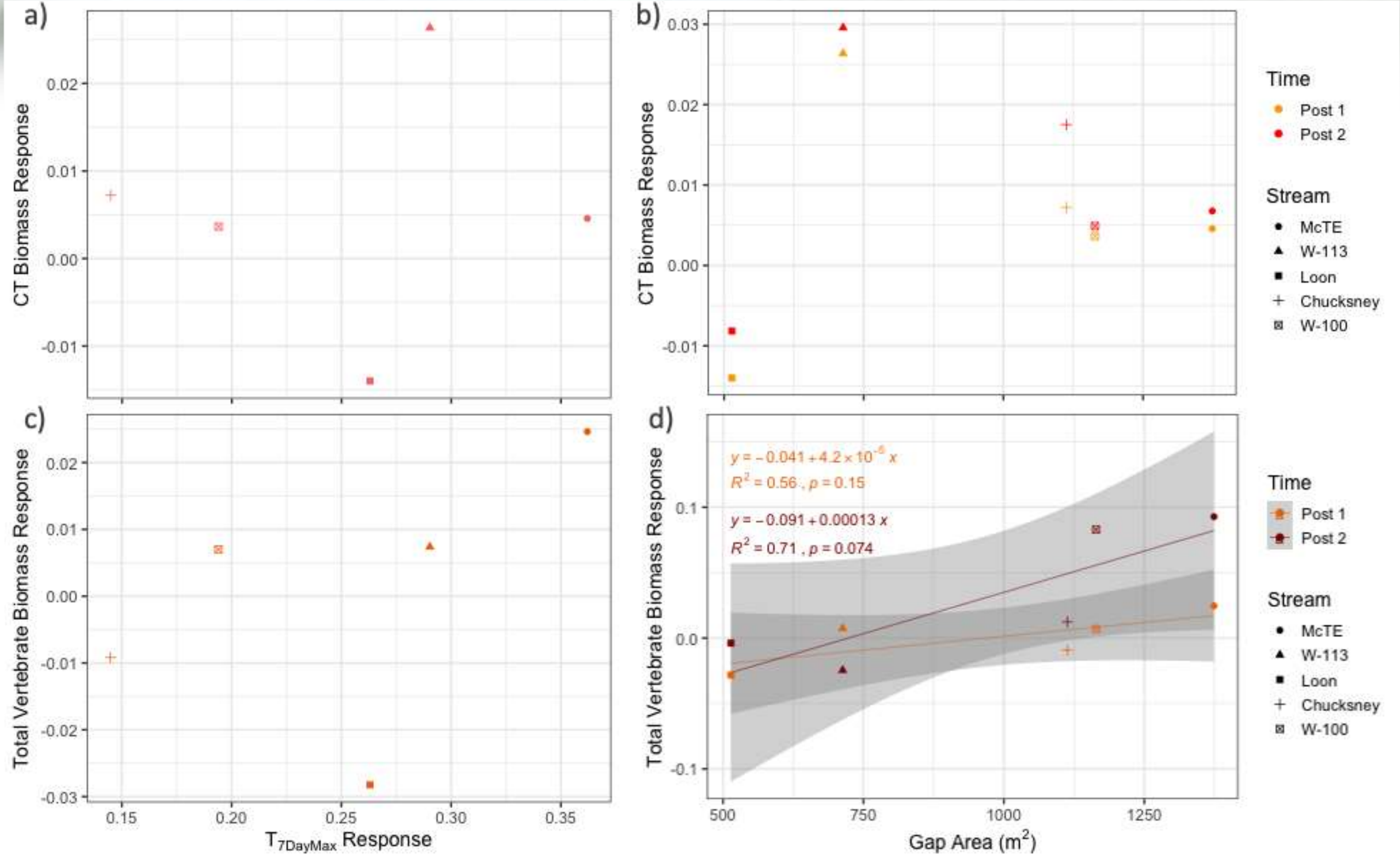
Post-2 YOY response due to competition with age 1+?







Were responses related to temperature or gap area?



a)
b)
c)
d)
CT Biomass Response
Total Vertebrate Biomass Response
T7DayMax Response
Gap Area (m2)
y = −0.041 + 4.2 × 10-5 x
R2 = 0.56 , p = 0.15
y = −0.091 + 0.00013 x
R2 = 0.71 , p = 0.074
Time
Post 1
Post 2
Stream
McTE
W-113
Loon
Chucksney
W-100

Conclusions

- Gaps created local increases in benthic primary production and nutrient demand

Riparian gap experiment

Conclusions

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- No consistent declines in fish
- Generally consistent but small ↑ in adult fish

Riparian gap experiment

Conclusions

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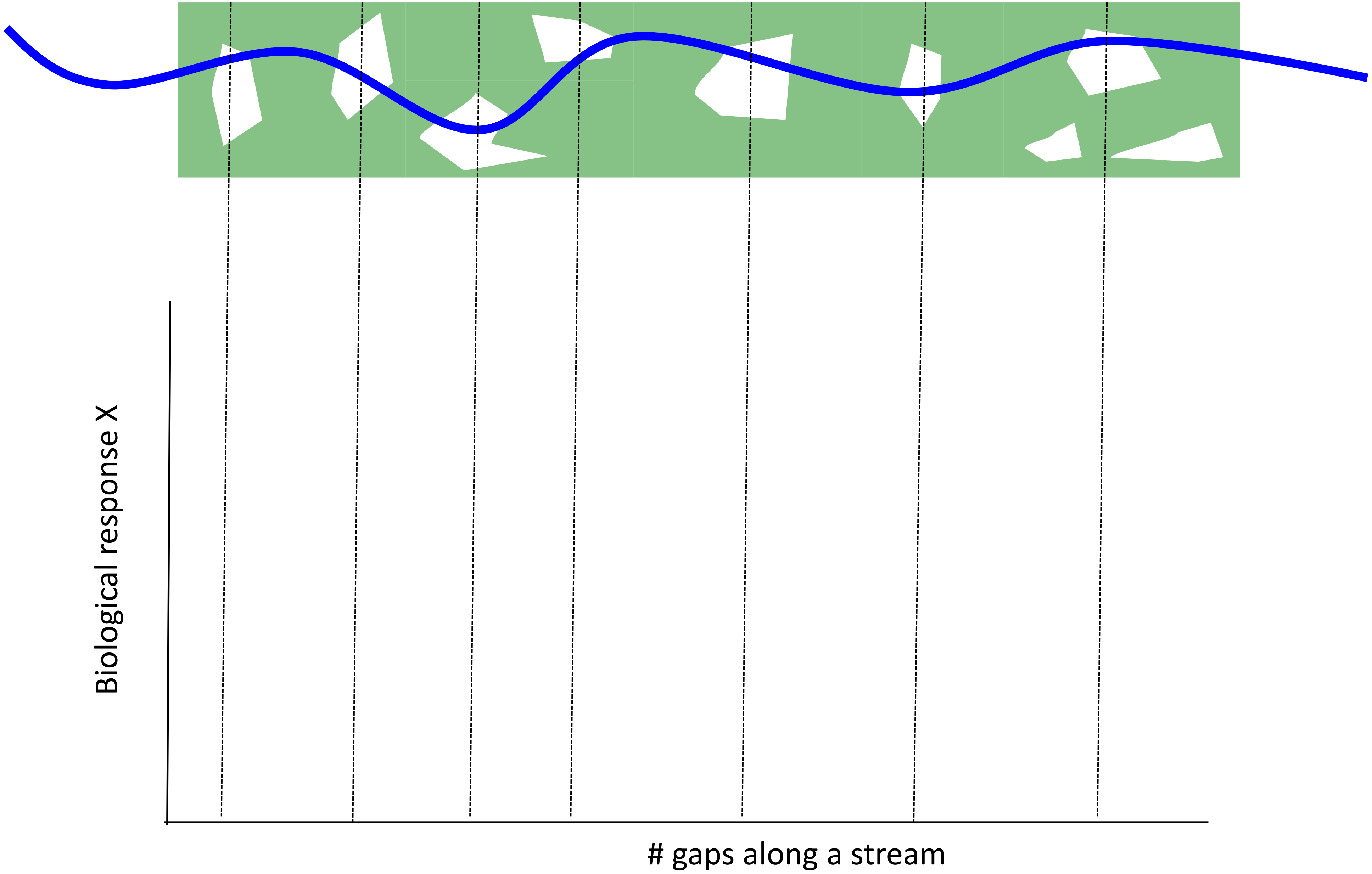
- Single gap reach **is** viable tool for increasing spatial heterogeneity with out negatively impacting aquatic environment
- Single gap alone **is not** enough to be a viable tool to meaningfully increase total vertebrate production in streams

Riparian gap experiment

Conclusions

- Gaps created local increases in benthic primary production and nutrient demand
- No consistent declines in fish
- Generally consistent but small ↑ in adult fish
- Single gap reach **is** viable tool for increasing spatial heterogeneity with out negatively impacting aquatic environment
- Single gap alone **is not** enough to be a viable tool to meaningfully increase total vertebrate production in streams
- Future research should look at the effect of multiple gaps

What if we have multiple gaps along the stream?



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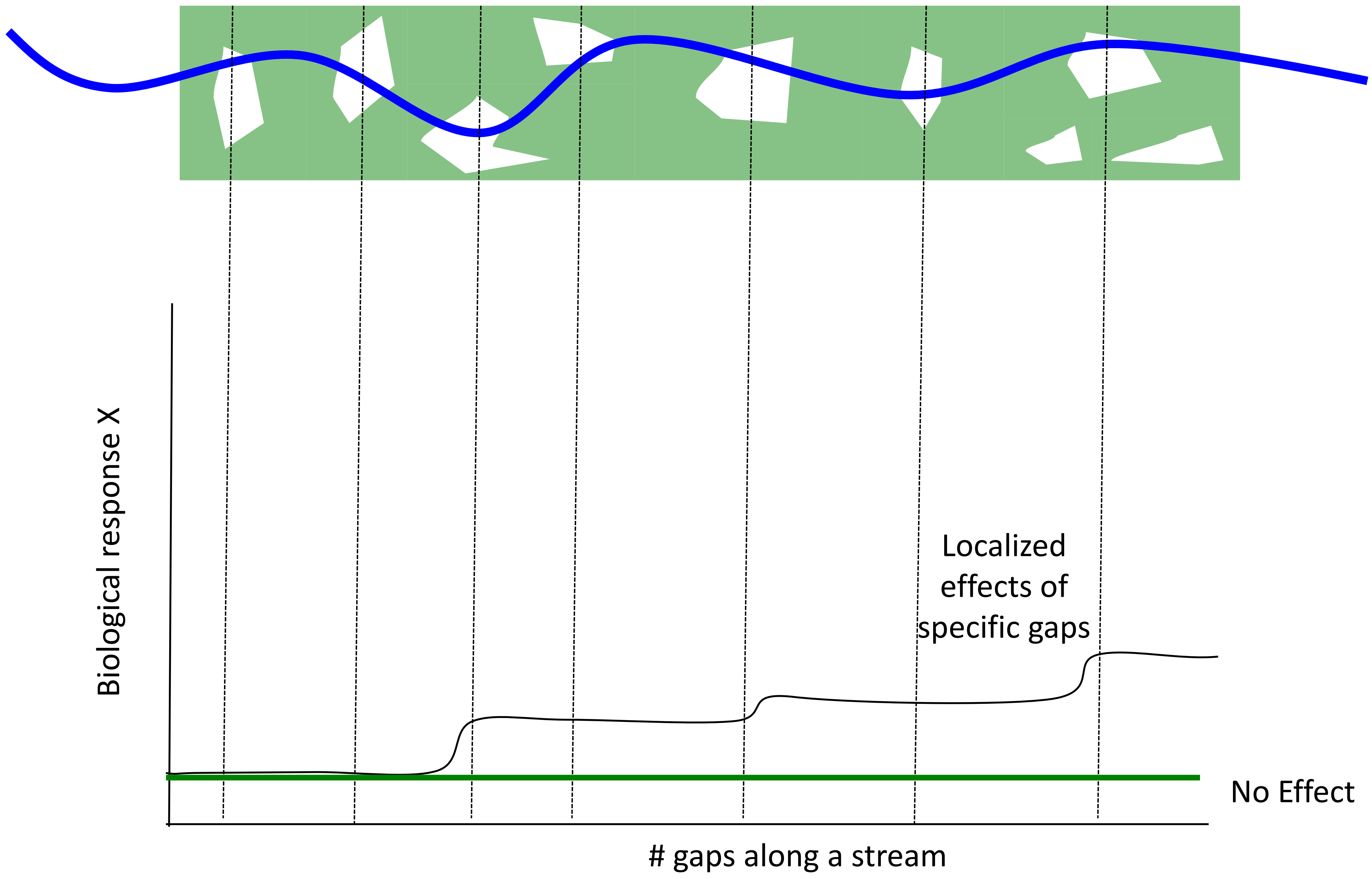

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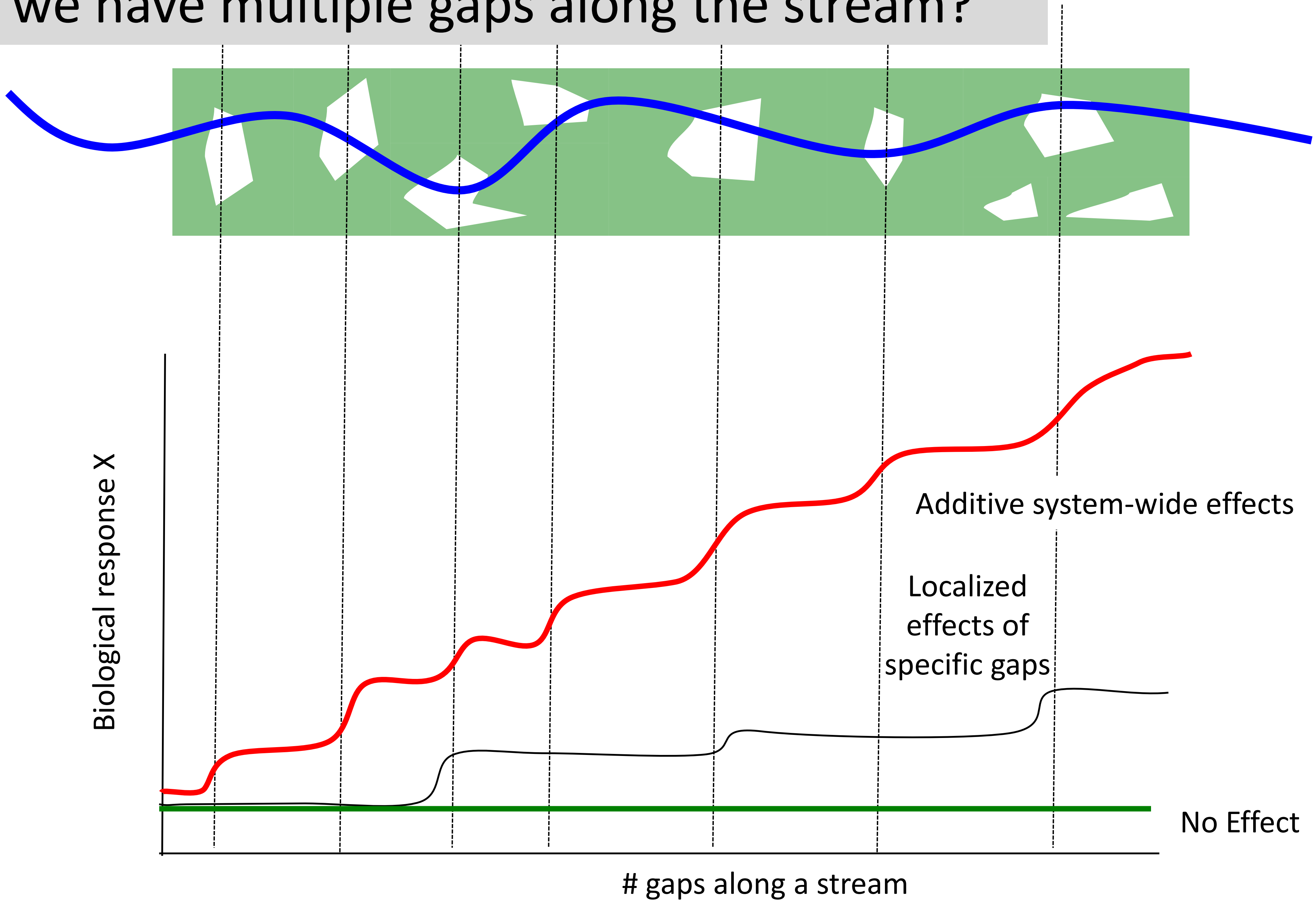

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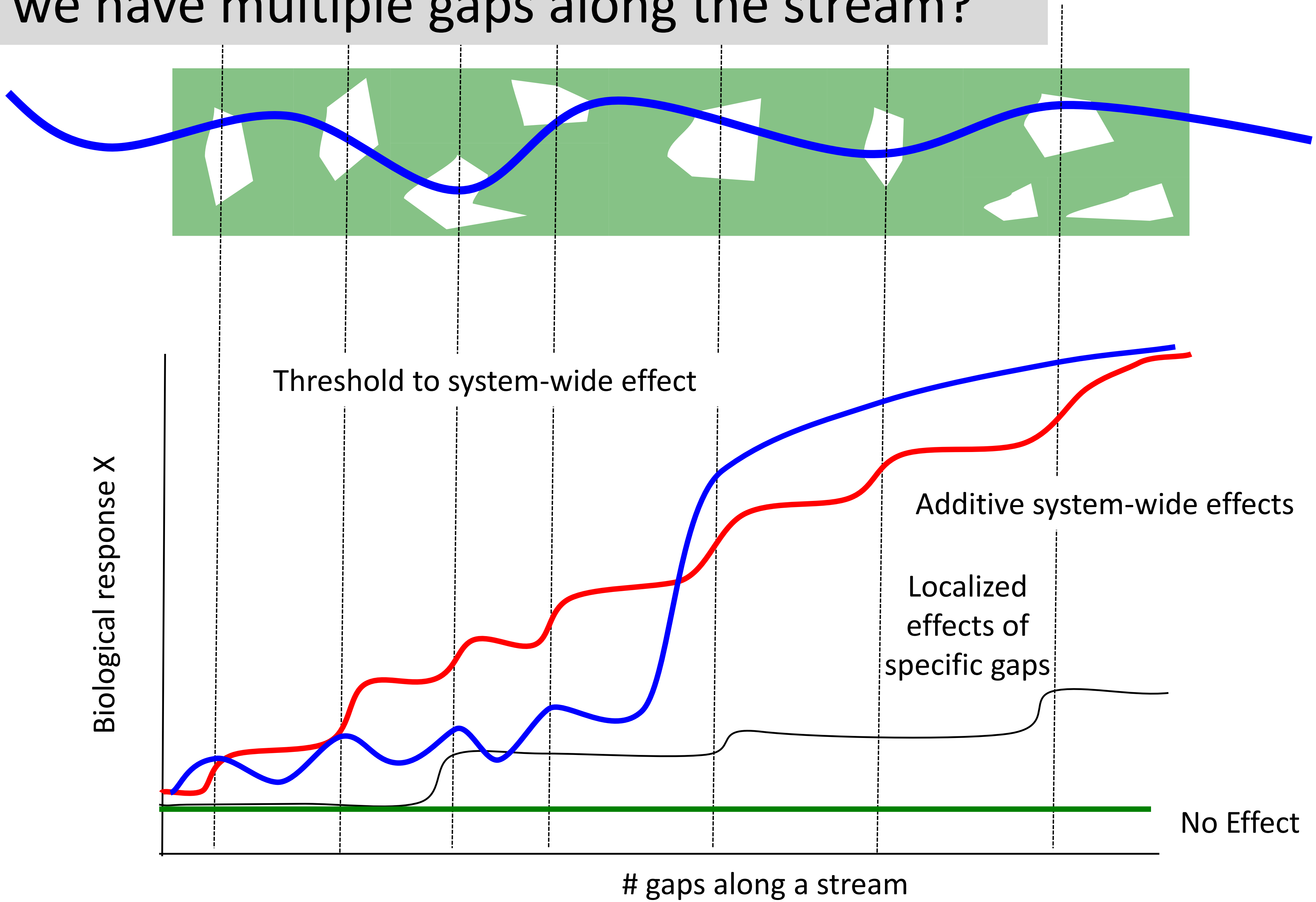

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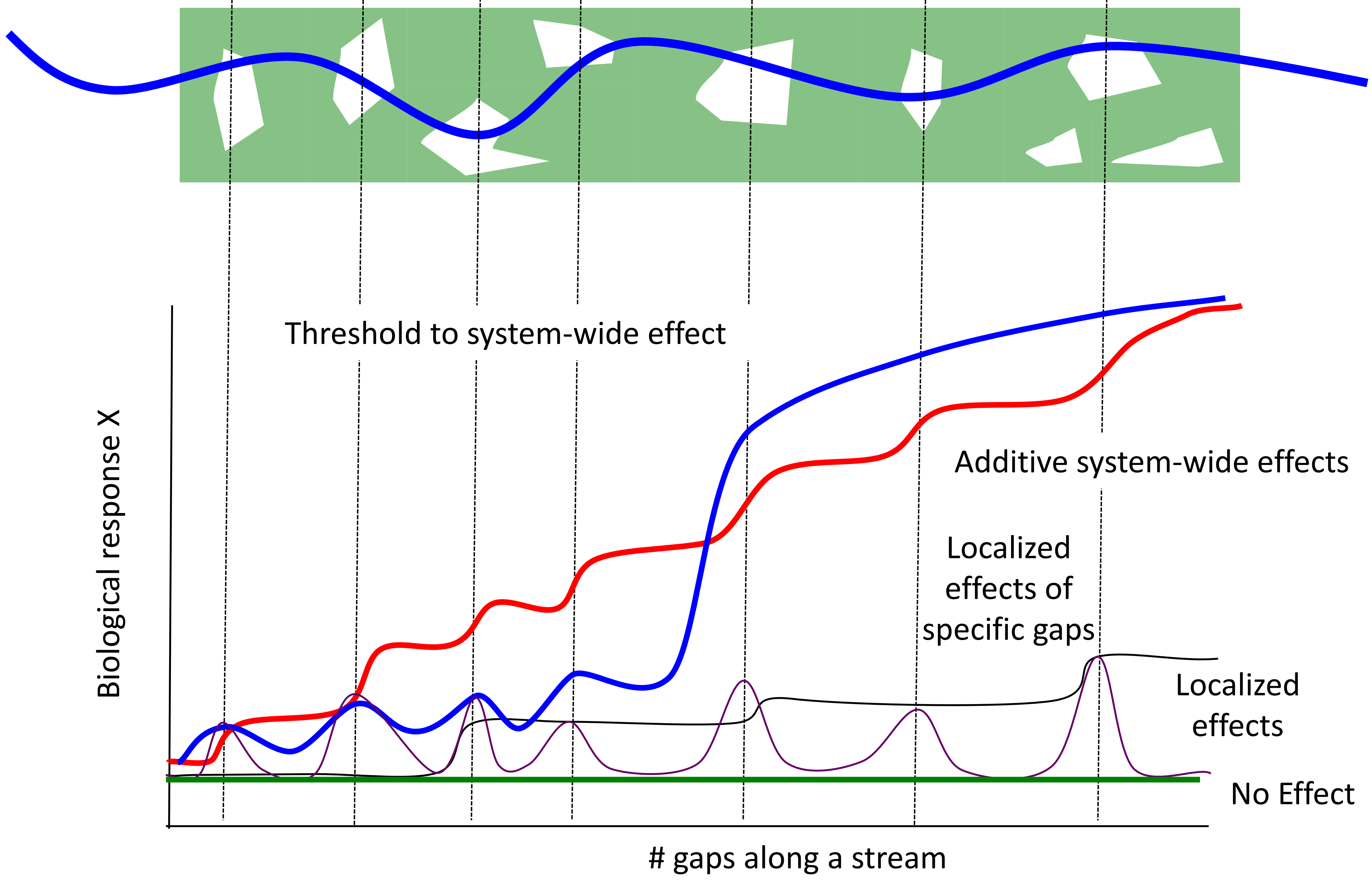
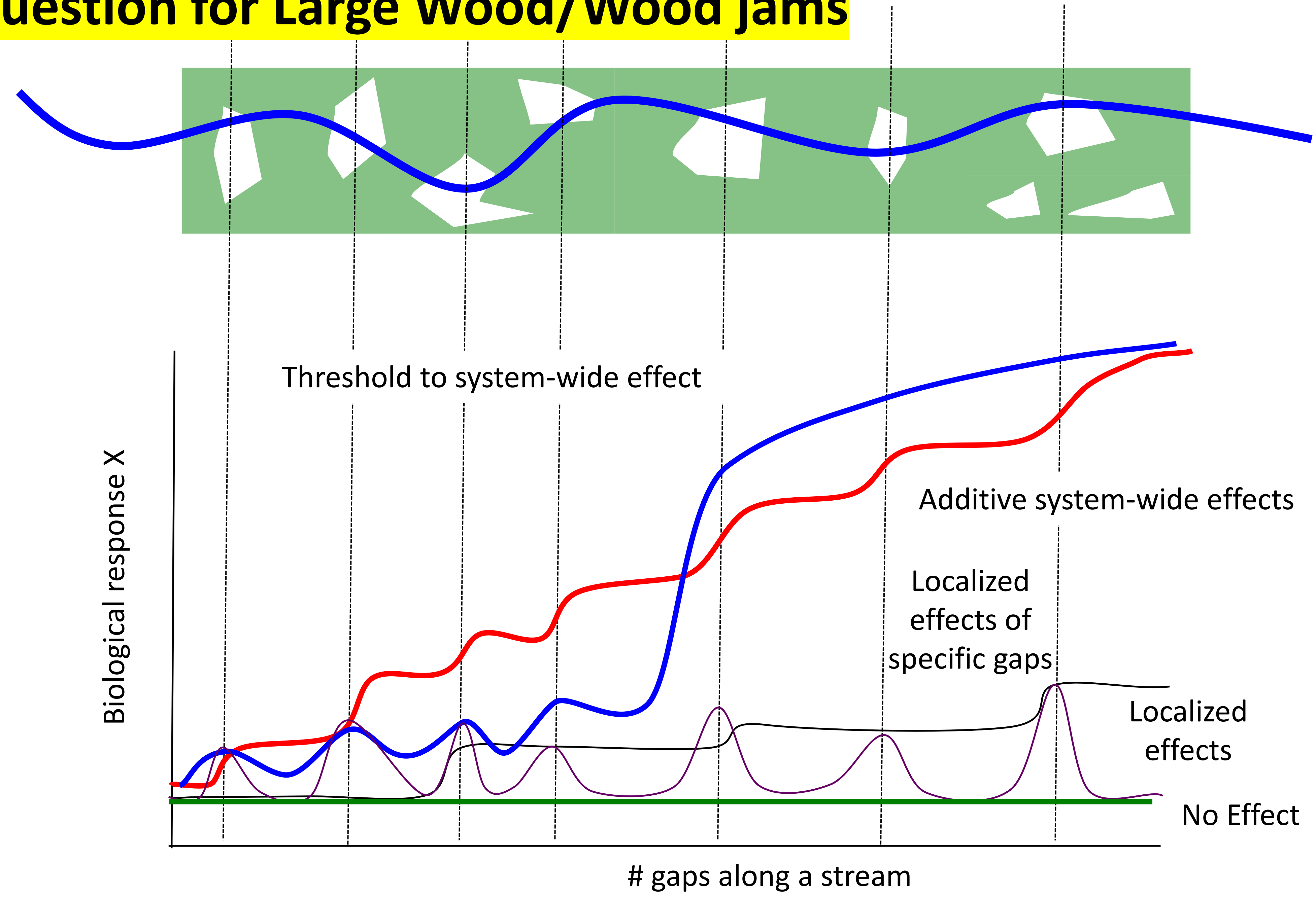


Same question for Large Wood/Wood jams



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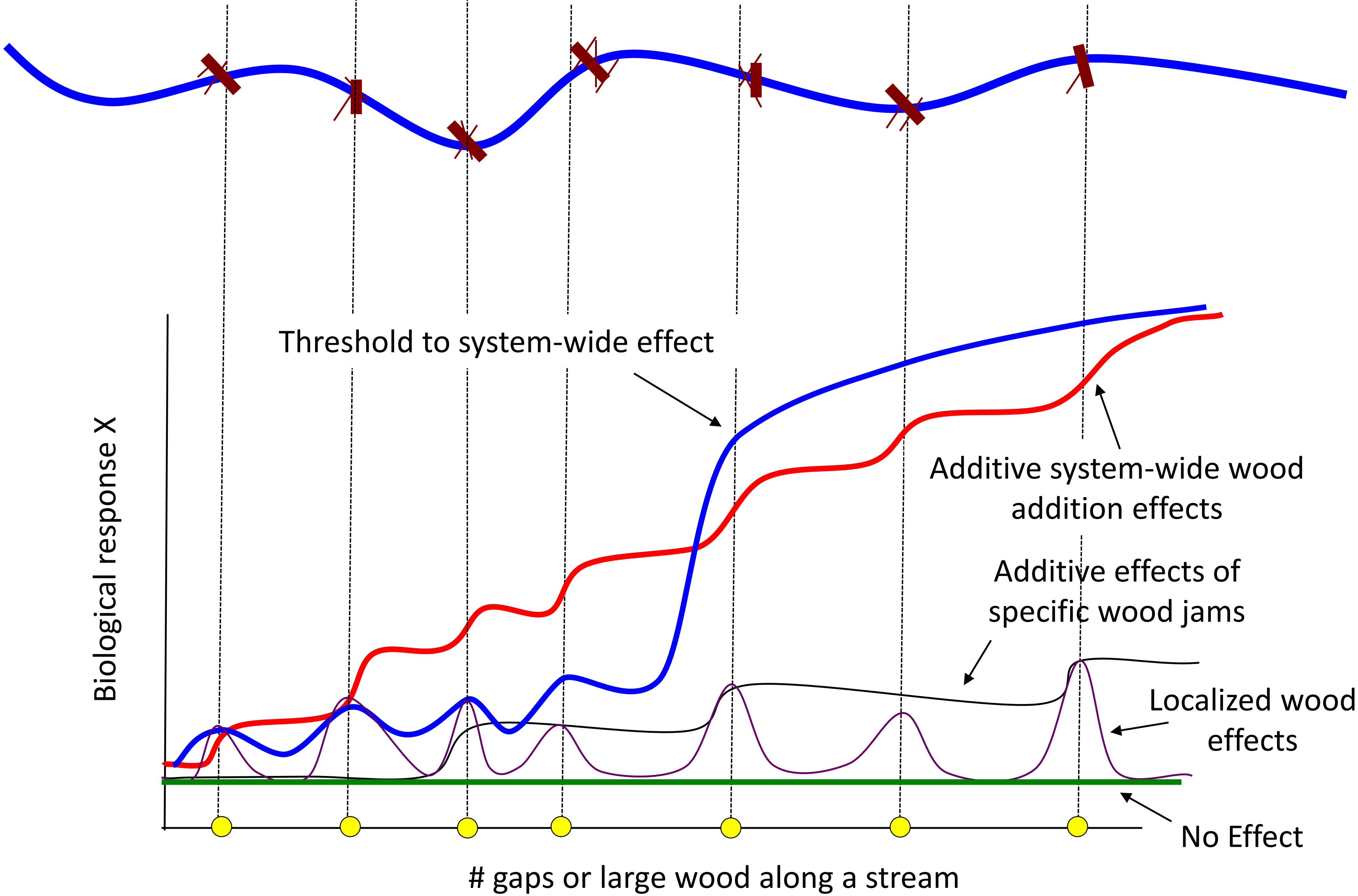
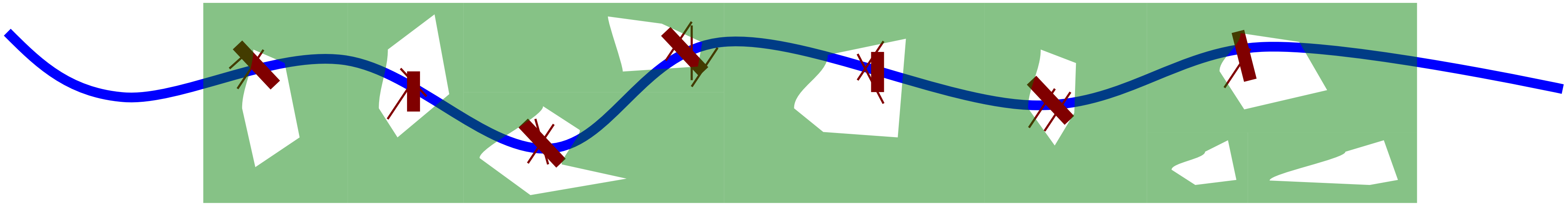
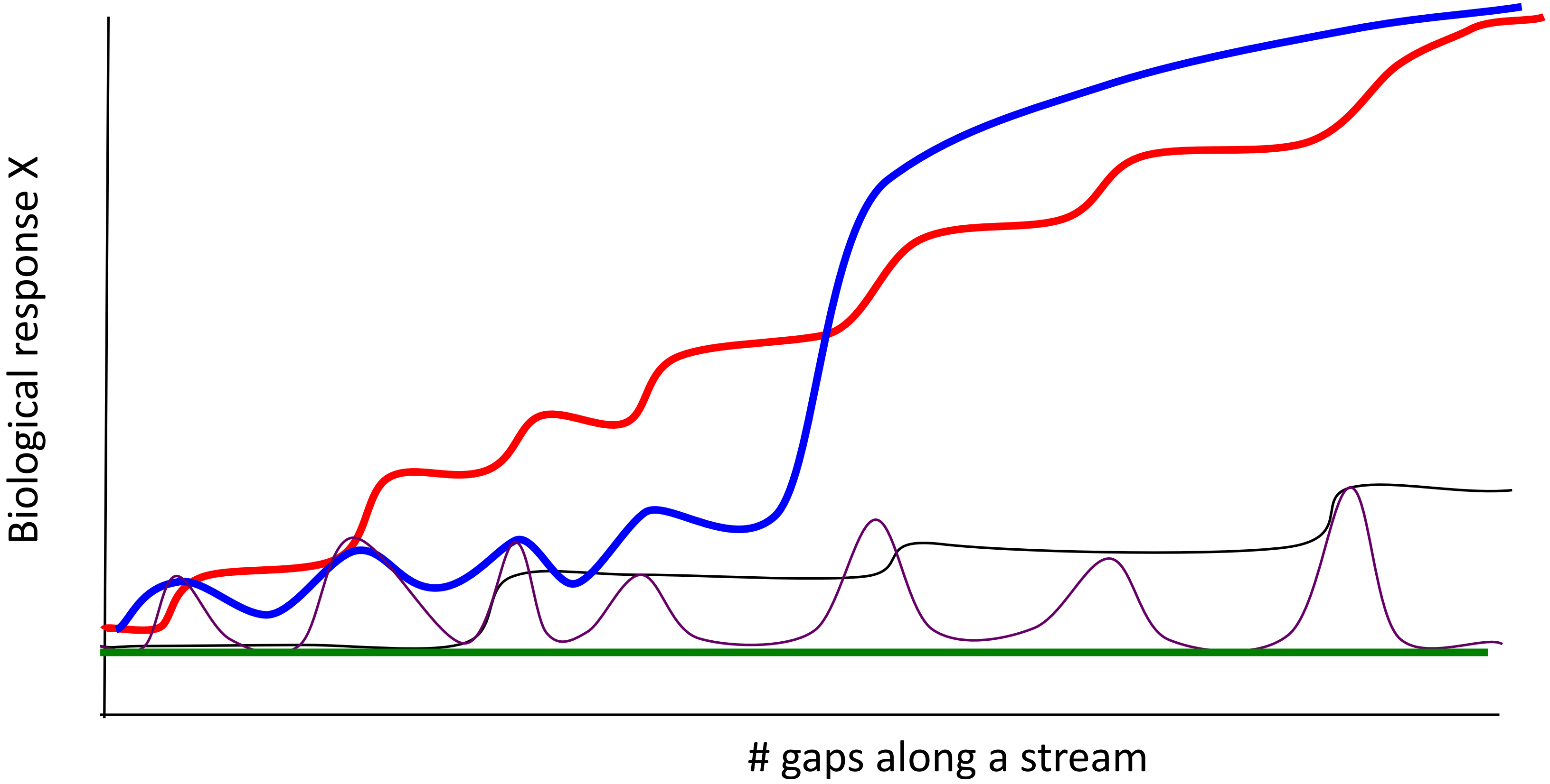


Wood + Gaps?

This is what we get with most chop-and-drop wood additions. . .





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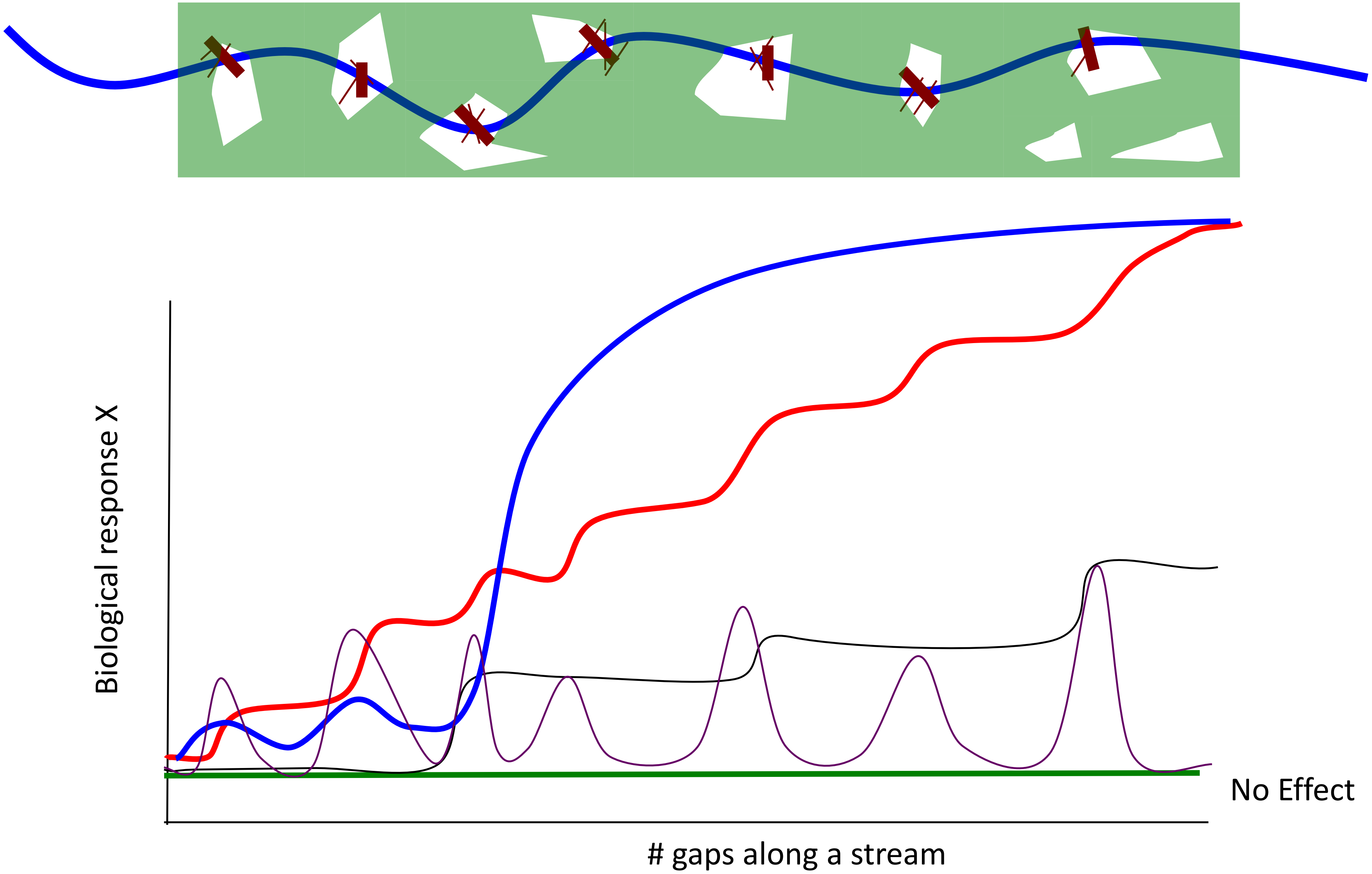
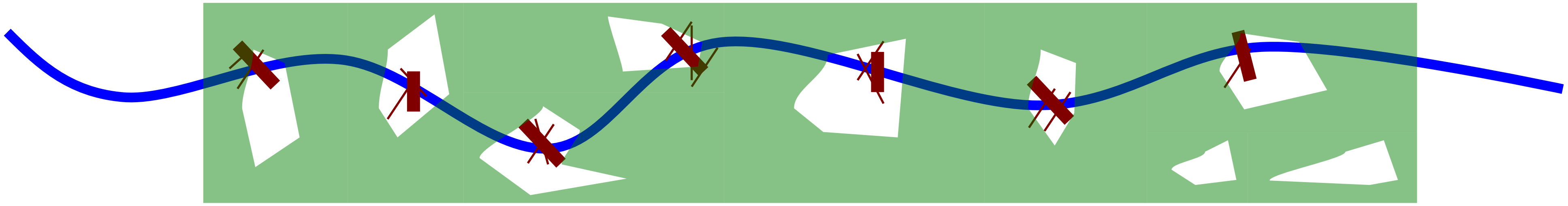
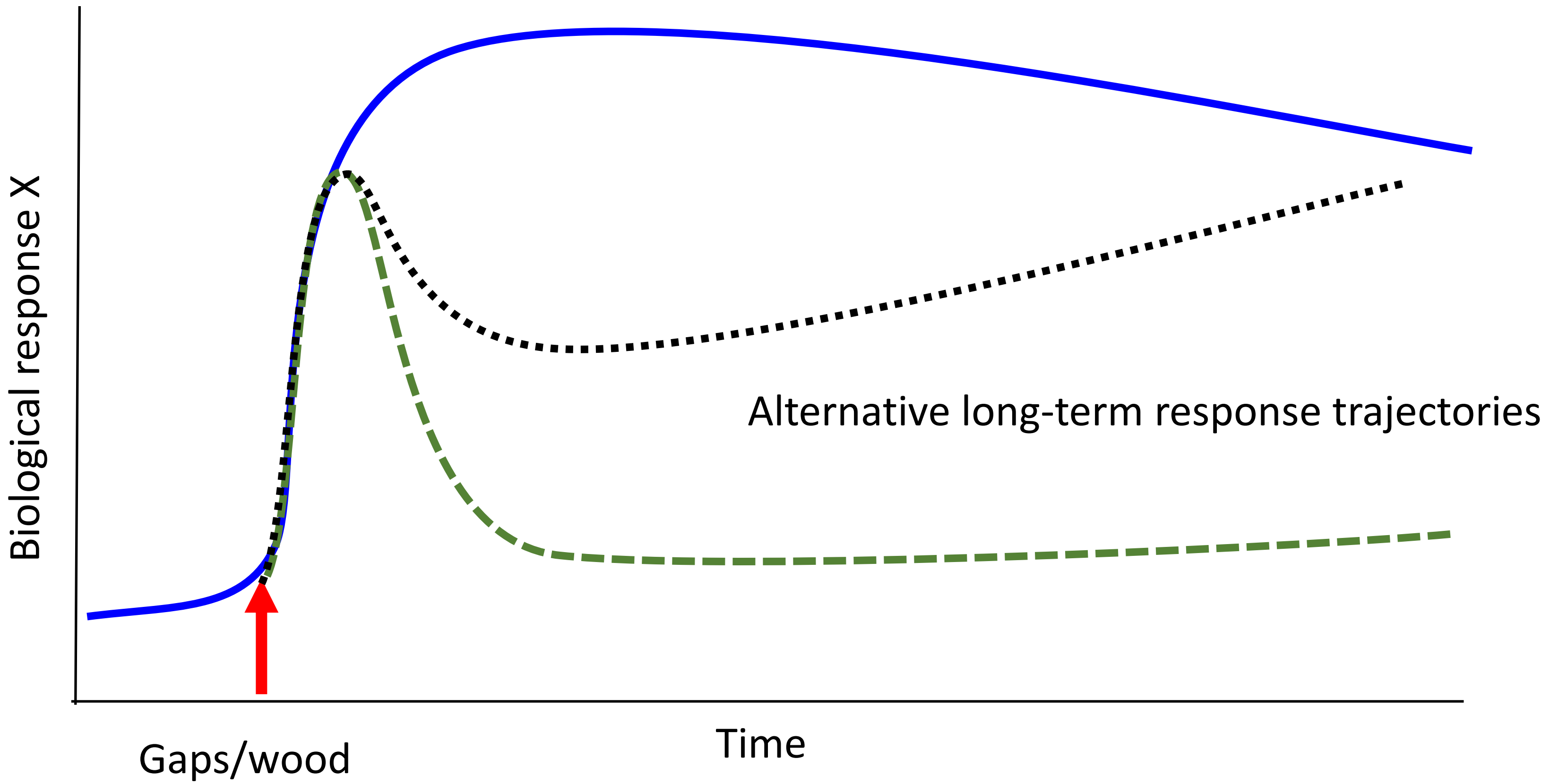


Effect Persistence?





Thank you

Acknowledgements

Funding:

- HJ Andrews LTER
- NSF – Div. Env. Biol. (Ecosystems)
- Fish and Wildlife Habitat in Managed Forests Grant Program
- USFS Willamette National Forest (McKenzie Ranger District)

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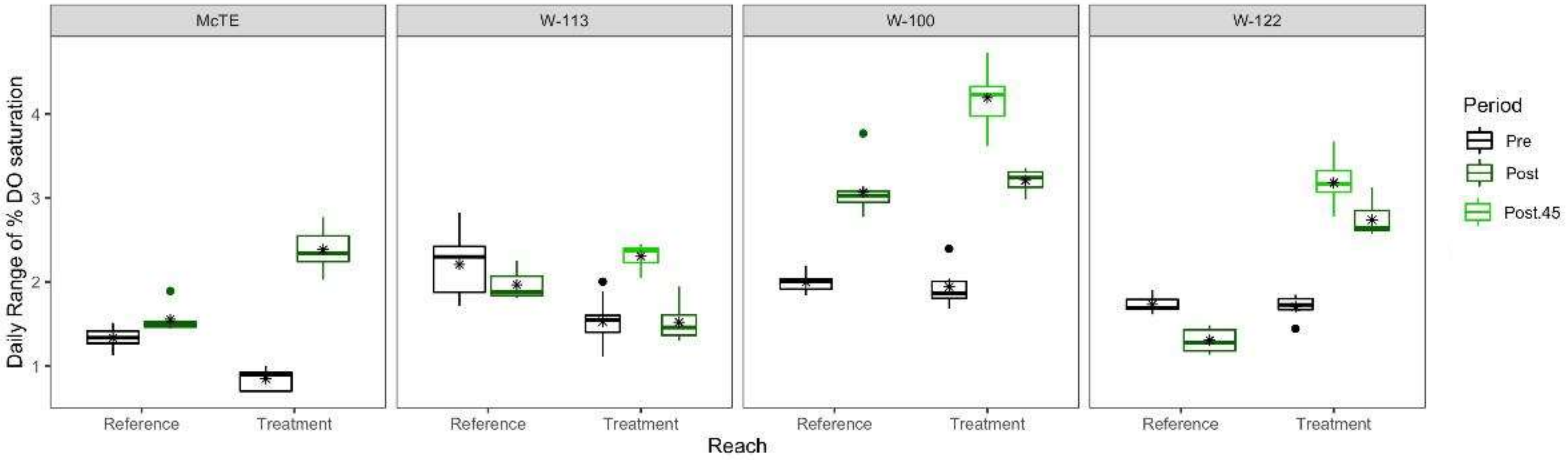
- Matt Kaylor, Emily Heaston, Brian VerWey, MaCedar Mackeness, Alvaro Cortes, Claire Hacker, Lauren Still, Gavin Jones, Greg Downing, Jay Sexton

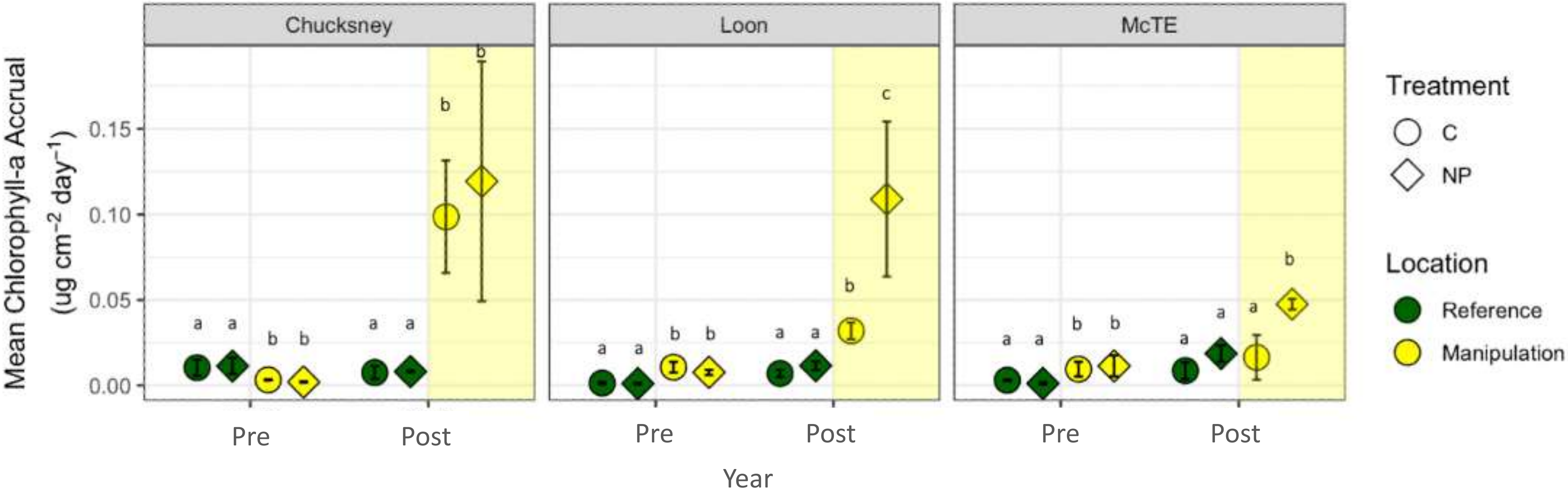
Site access, permitting and other help:

- Ray Rivera
- Maryanne Reiter
- Mark River
- Brett Bloundon
- Cheryl Friesen
- Mark Shultz
- Lina DeGregorio

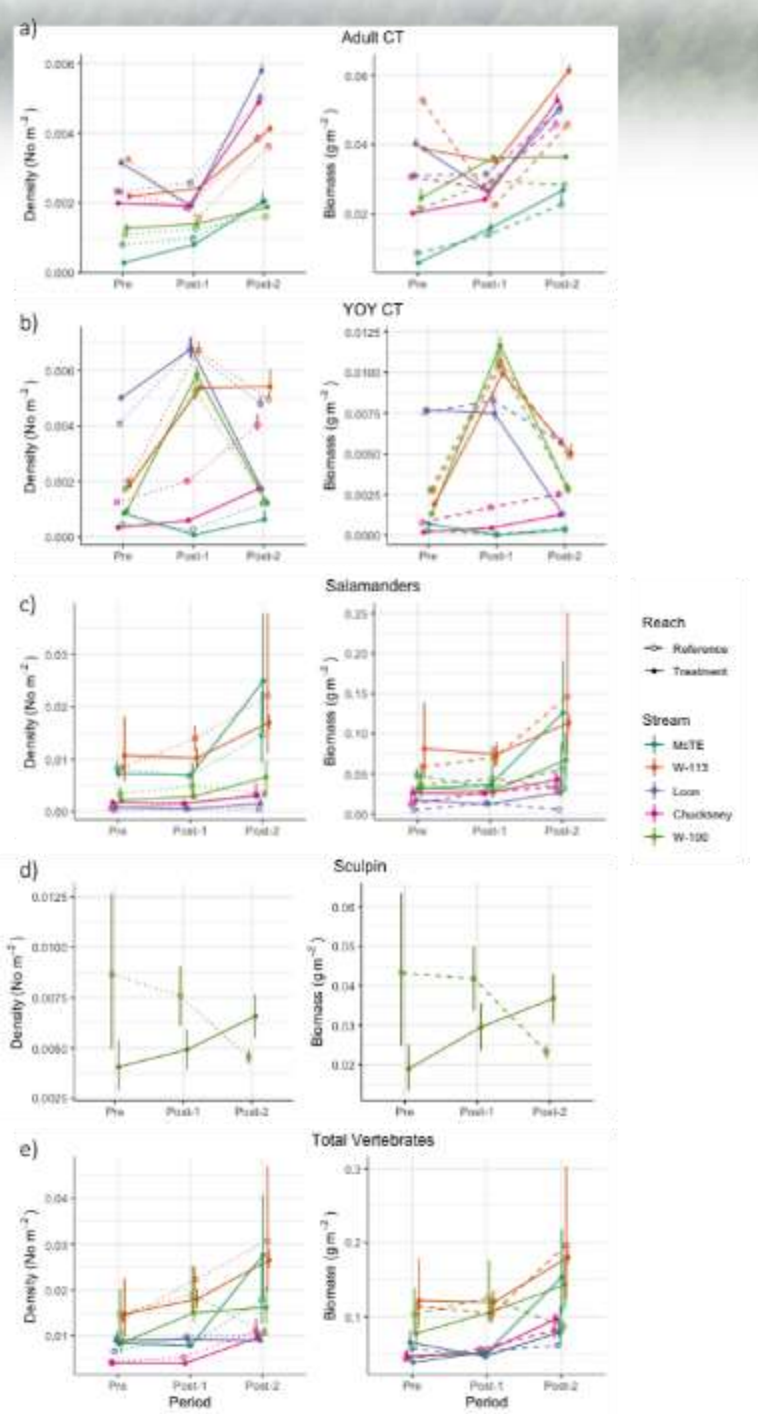
Reach scale ecosystem responses



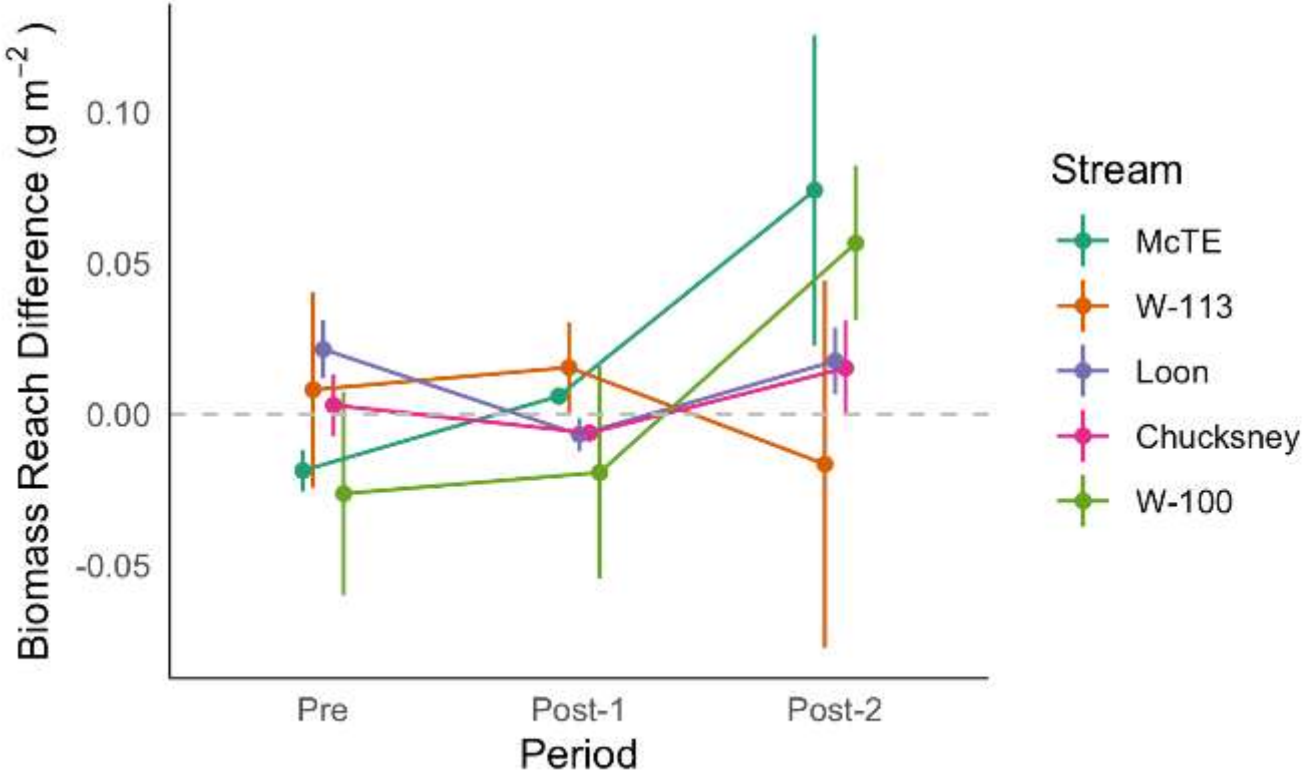
Local Nutrient Demand



All vertebrates



Total vertebrate responses

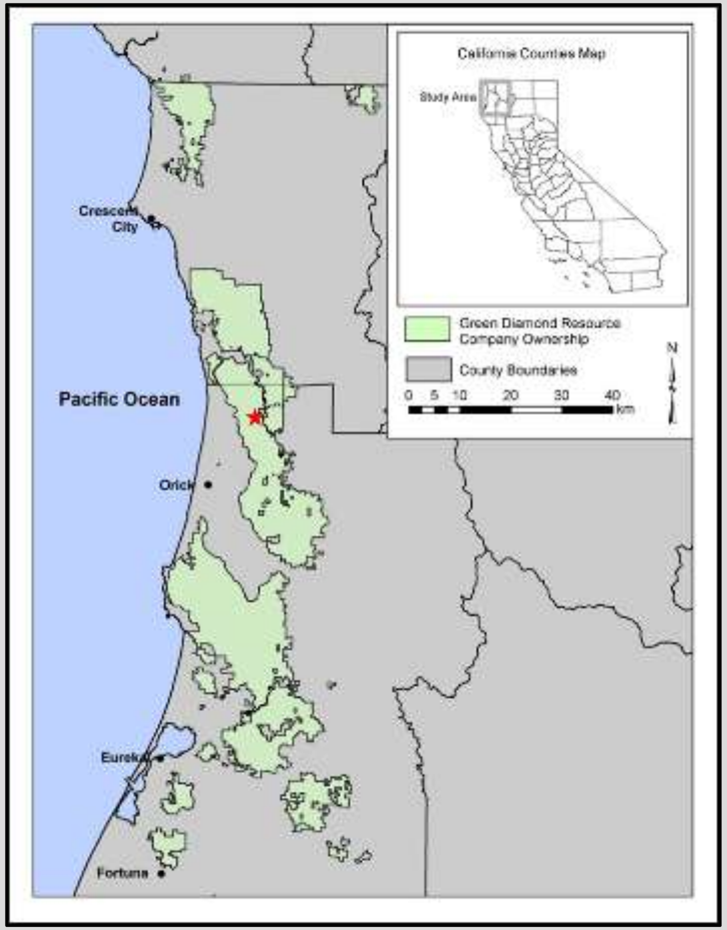


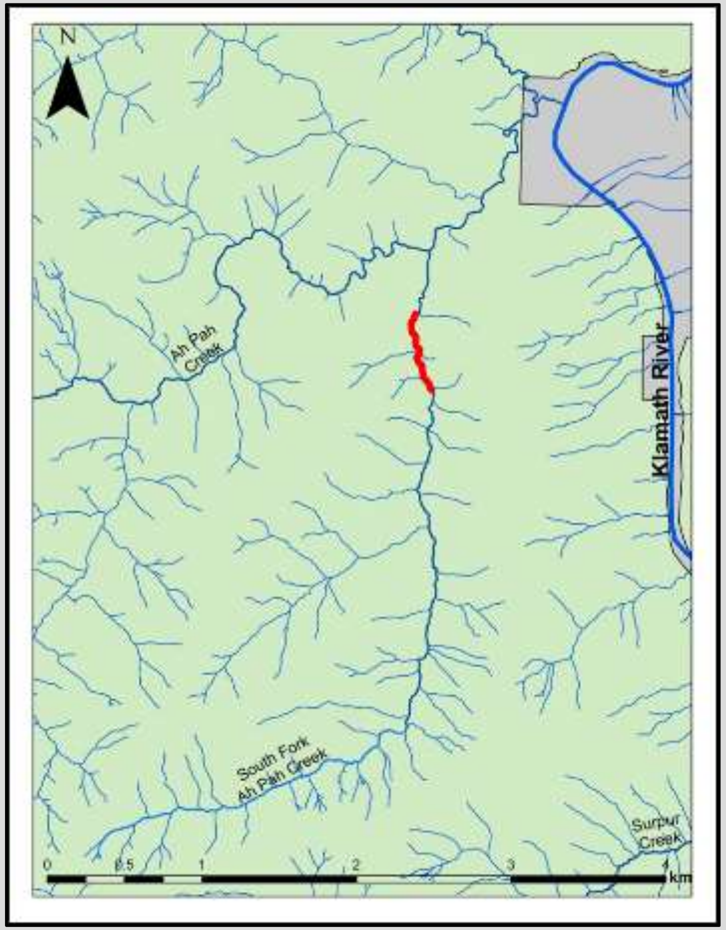
Riparian Canopy Modification Experiment: Lessons Learned and Results from Salmonid (*Oncorhynchus* spp.) and Coastal Giant Salamander (*Dicamptodon tenebrosus*) Monitoring in Northwestern California

Matt Nannizzi, Matt R. Kluber and Matthew R. House
Green Diamond Resource Company
Trent McDonald
West Inc.

STUDY AREA

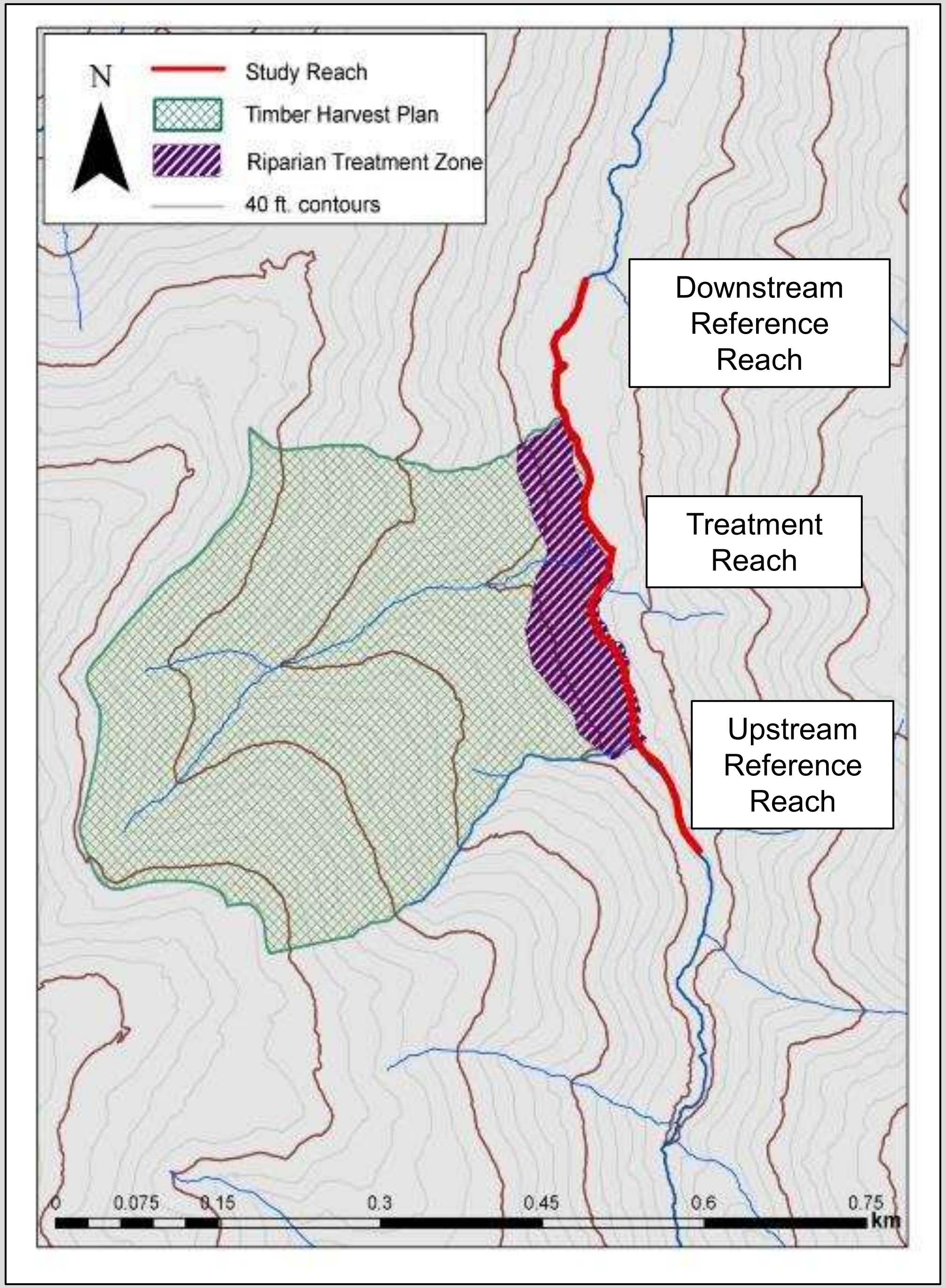
- Private timberlands in NW CA
- Forest stands dominated by:
  - Coast Redwood (*Sequoia sempervirens*)
  - Douglas-fir (*Pseudotsuga menziesii*)
  - Red Alder (*Alnus rubra*) dominated riparian areas
- SF Ah Pah Creek
  - Experimental watershed
  - Tributary to Ah Pah Creek, which is a tributary to the lower Klamath River





Study Area

- 600 m study reach
  - 100 m downstream reference reach
  - 300 m treatment reach
  - 200 m upstream reference reach



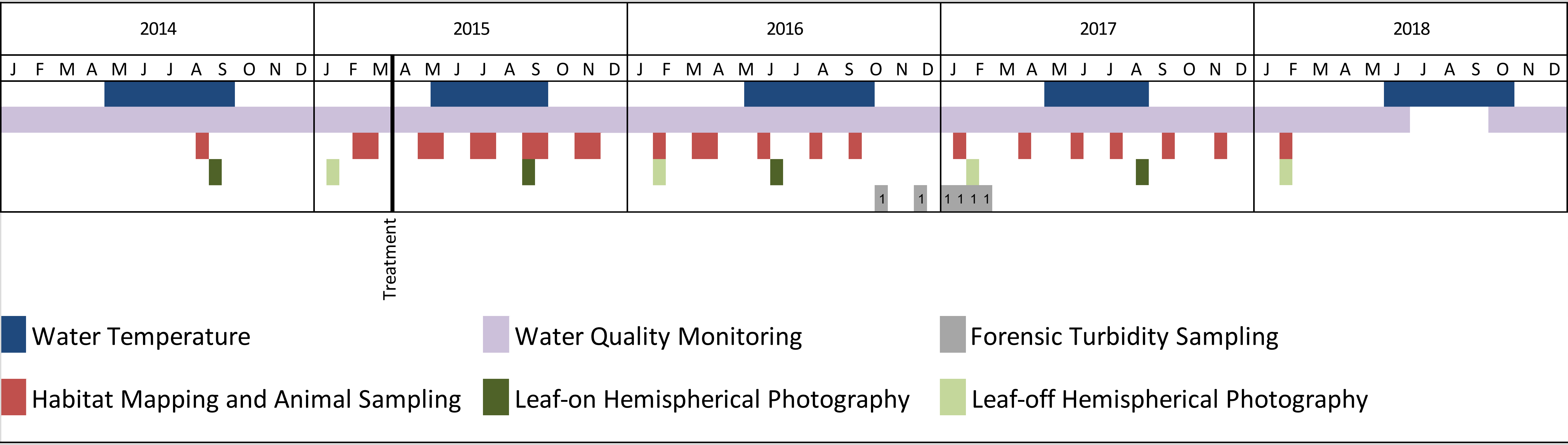
Primary Objectives of Pilot Project

- Receive an approved THP that included a riparian zone thinning experiment
- Test the feasibility of extracting trees from the riparian zone
- Monitor potential effects of a riparian thinning experiment
  - Hydrological
  - Biological – Salmonid and amphibian growth and movement

Topics For Today:

- Implementing a riparian thinning project presents significant operational and permitting challenges.
- What happens when we reduce canopy in the riparian?
- Statistical: How do we assign growth to a specific reach?
  - In an open system where individuals have free range
  - When we obtain locations of individuals only during capture events

PROJECT TIME LINE

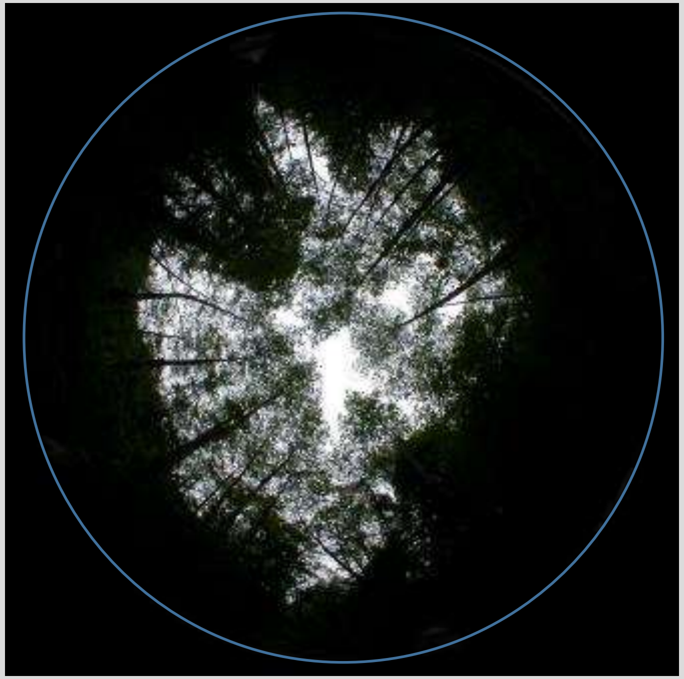


Permitting and Operational Challenges

- Project was performed under the Experimental Watersheds Program of the AHCP.
- Riparian tree harvest was authorized under an approved Timber Harvest Plan (THP). Section V (additional information) of the THP.
- Forester and aquatic biologist had a difficult time deciding which trees to select for harvest and ultimately ended up not marking enough trees.
- Directional felling of trees was difficult due to the dangerous nature of red alder.
- Yarding of trees out of the riparian zone was challenging. Additional settings were required to access all of the trees and limiting the damage to the existing stand was tough requiring additional settings,

Methods: Canopy Closure

- Hemispherical photo monitoring
  - 18 locations (4 in the DSR, 10 in the TRT and 4 in the USR)
  - Locations established in center of bankfull channel
  - 4’ long, ½” rebar pounded into the substrate.
- Targeted for low-light conditions for photos
  - During four leaf-on and leaf-off periods from 2014 to 2018
- HemiView 2.1 software (Delta-T Devices) used for analysis.



Results: Canopy Closure

- Max canopy reduction over stream ~ -6.6%
  - ~60% canopy closure achieved in middle of 150' riparian buffer

Before

After

Methods: Animal Sampling

- Target Species
  - Steelhead trout (*Oncorhynchus mykiss*)
  - *Coastal Cutthroat Trout (*Oncorhynchus clarkii clarkii*)
  - *Larval Coastal Giant Salamanders (*Dicamptodon tenebrosus*)
- Animal Sampling
  - Fish and amphibian sampling bi-monthly (FEB 2015-FEB 2018)
  - Electrofishing & rubble rousing
- Marking
  - Trout >70mm fork length = PIT tags
  - Coastal Giant Salamanders
    - <45 mm SVL = Visible Implant Elastomer (VIE)
    - >45 mm SVL = PIT tags

Methods: Growth Rate Estimation

- Total growth of individuals calculated between capture intervals

- Total growth was allocated to season and reach using weighted values derived from the Brownian Bridge distributions

- Average growth rate for all combinations of season and reach was calculated by averaging over an individual’s capture intervals

- Variation was calculated using a bootstrap method

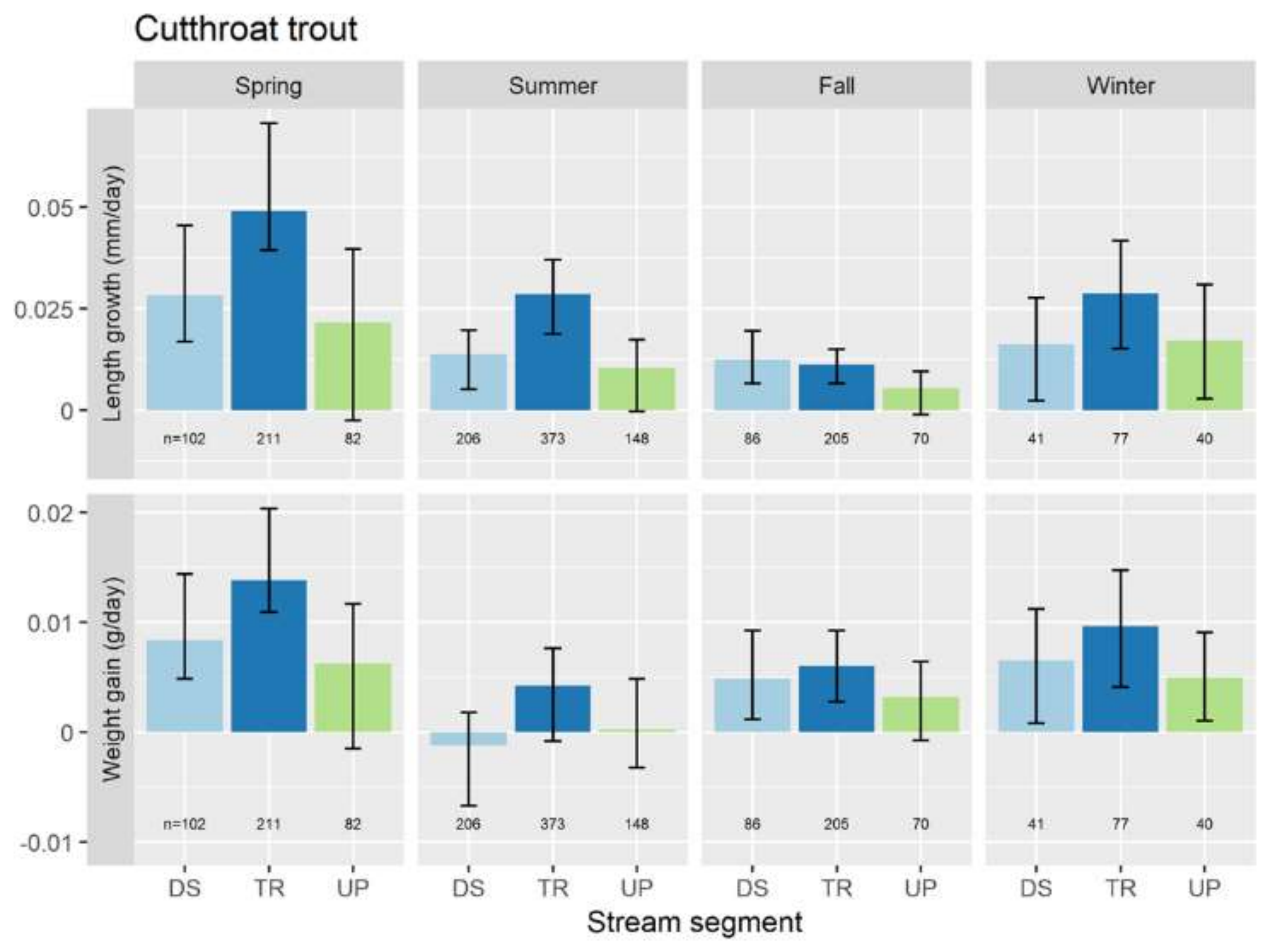
Results: Captured and Marked

Total Marked Animals

	Species				
Reach	CU	CGS	SH	TR	Totals
DSR	76	558	25	57	716
TRT	220	1382	52	221	1875
USR	49	441	27	41	558
Totals	345	2381	104	319	3149

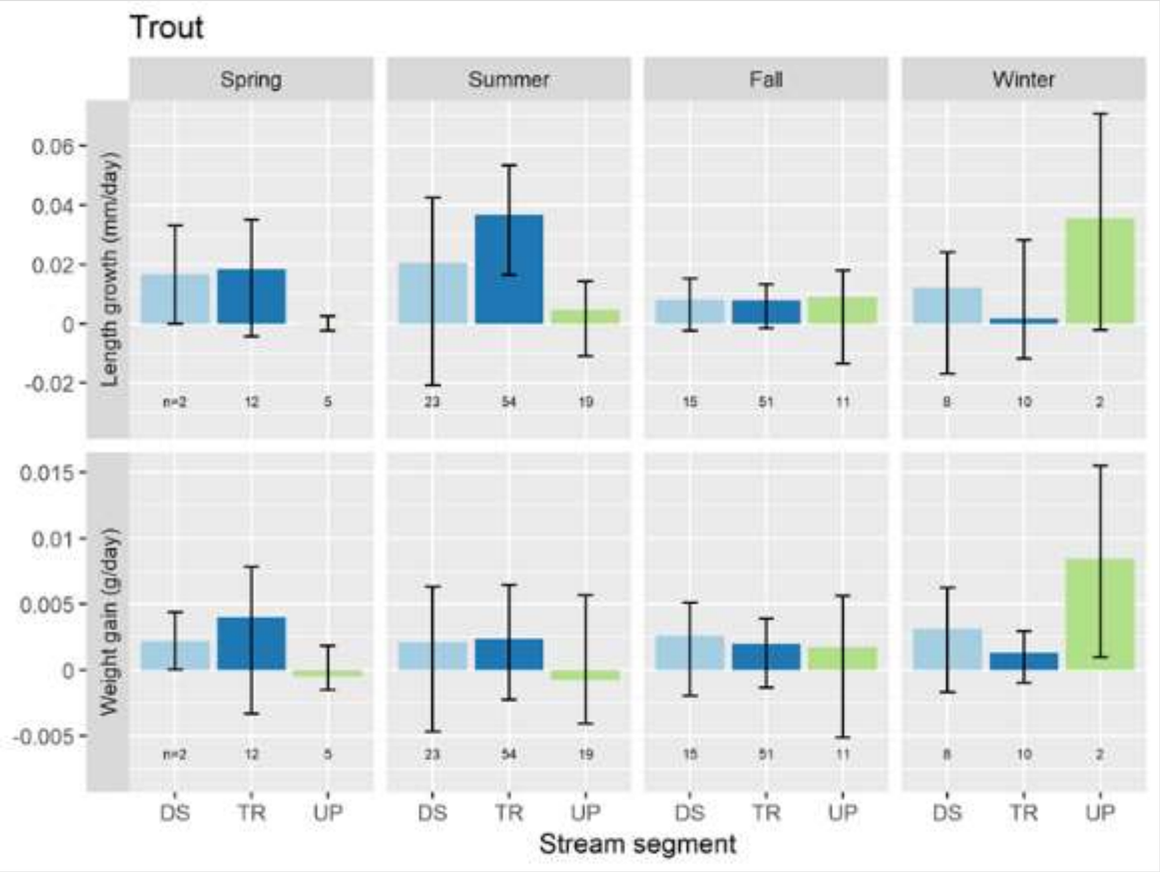
RESULTS: CUTTHROAT TROUT GROWTH

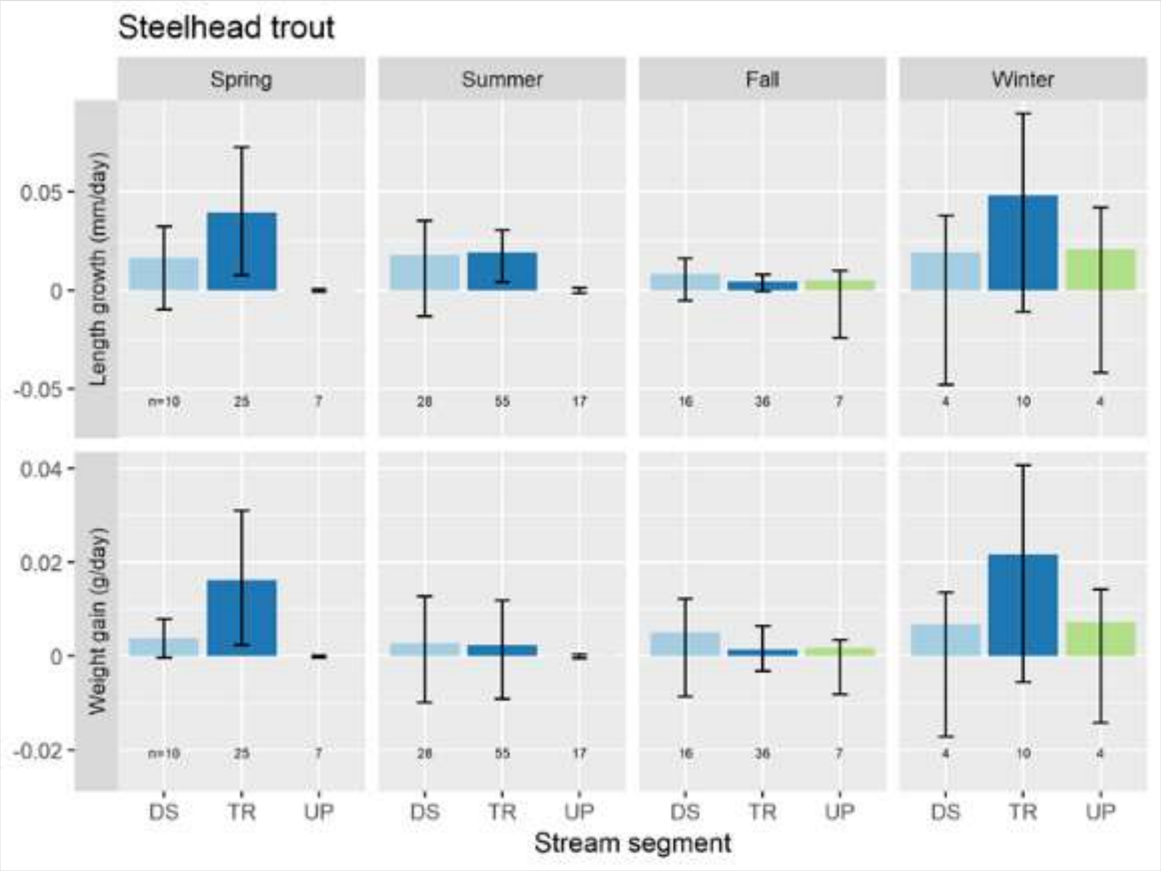
- CV's: 50% to 100%
- Equivalent or higher growth rate in treatment
- Highest growth rate seasonally in Spring



Results: Trout spp. and Steelhead Growth

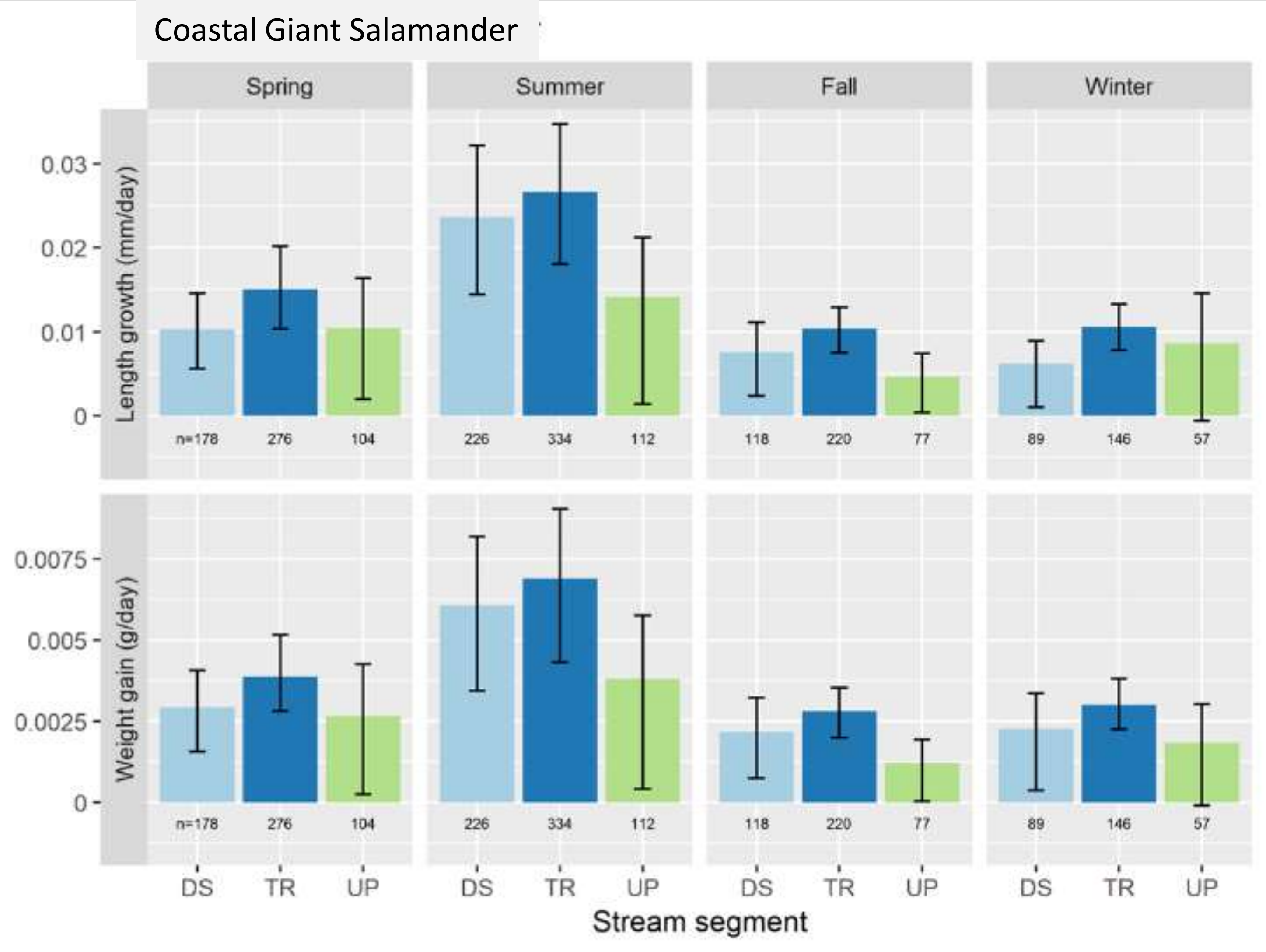
- CV's: 100% to 250% (low sample sizes)
- Mostly equivalent or higher growth in treatment reach





Results: Coastal Giant Salamander Growth

- CV's: 25% to 100%
- Equivalent or higher growth rate in treatment reach



In Summary…

- Generally higher growth rates observed in treatment reach when compared to reference reaches
- Cutthroat
  - Higher growth in treatment during spring, summer and winter
  - Highest seasonal growth during spring
- Coastal Giant Salamanders
  - Higher growth rates observed in treatment across all seasons
  - Highest seasonal growth during summer
- Upstream reference reach generally had lower overall growth compared to downstream reference and treatment reaches

Discussion: Two Explanations

- <u>Maybe:</u> Treatment reach was great habitat to begin with
  - Removing trees lowered growth rates in treatment but not below that of reference reaches
  - Canopy removal over stream was slight (~3%)
    - More removal could cause more significant effects
- <u>More likely:</u> Individuals in treatment benefitted (at least not negatively affected) in short term by riparian tree removal
  - One possibility: Flow increased following tree removal and increased light lead to increased macroinvertebrate populations benefitting fish and amphibians

Thank You!

mnannizzi@greendiamond.com

- **References**

- Horne, J. S., E. O. Garton, S. M. Krone, and J. S. Lewis. 2007. Analyzing animal movements using Brownian bridges. Ecology 88:2354–2363.

Results: Captured and Marked

Total Marked

	Species				
Reach	CU	DITE	SH	TR	Totals
DSC	76	558	25	57	716
TRT	220	1382	52	221	1875
USC	49	441	27	41	558
Totals	345	2381	104	319	3149

Total Recaptures

	Species				
Reach	CU	DITE	SH	TR	Totals
DSC	154	150	19	10	333
TRT	339	259	53	52	703
USC	55	57	1	9	122
Totals	548	466	73	71	1158

Includes multiple recaptures of same animal

Results: Captured and Marked

Total Marked

Reach	CU	DITE	SH	TR	Totals
	Species				
DSC	76	558	25	57	716
TRT	220	1382	52	221	1875
USC	49	441	27	41	558
Totals	345	2381	104	319	3149

# of Individuals Recaptured

Reach	CU	DITE	SH	TR	Totals
	Species				
DSC	71	121	11	10	213
TRT	179	233	33	45	490
USC	32	49	1	9	91
Totals	282	403	45	64	794

Total Recaptures

Reach	CU	DITE	SH	TR	Totals
	Species				
DSC	154	150	19	10	333
TRT	339	259	53	52	703
USC	55	57	1	9	122
Totals	548	466	73	71	1158

Includes multiple recaptures of same animal

Methods: Overview

- Fall 2014, Riparian Canopy Modification Experiment (RCME) was established
- Prior to tree felling, a variety of monitoring activities were initiated:
  - Hydrologic
    - Water temperature
    - Turbidity
    - Suspended sediment concentration
  - Habitat typing
  - **Canopy closure**
  - **Salmonid growth**
  - **Amphibian growth**

Methods: Overview

- Tree felling occurred March 2015
  - 220 hardwoods (mostly Red Alder)
    - Felled and yarded from riparian zone along left bank
      - Trees removed in association with a THP approved by CA Dept. of Forestry and Fire Protection
  - Goal was to reduce riparian canopy by 50%

Effectiveness of meadow and wet area restoration as an alternative to watercourse and lake protection (WLPZ) rules

Christopher G. Surfleet

Professor of Watershed Management and Hydrology

40th Annual Salmonid Restoration Conference

April 28, 2023

LEARN BY DOING
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Natural Resources Management & Environmental Sciences
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PROBLEM

- Meadow habitat has been decreasing in the Sierra Nevada and Cascades.
- Fire suppression, poor grazing practices, and climate change has accelerated encroachment of conifers (*specifically Pinus contorta*) into meadow habitat.
- Many meadows, floodplains, and stream channels are degraded.
- Hydrologic improvement in managed forest lands is an important land management activity to increase landscape resilience to climate change.

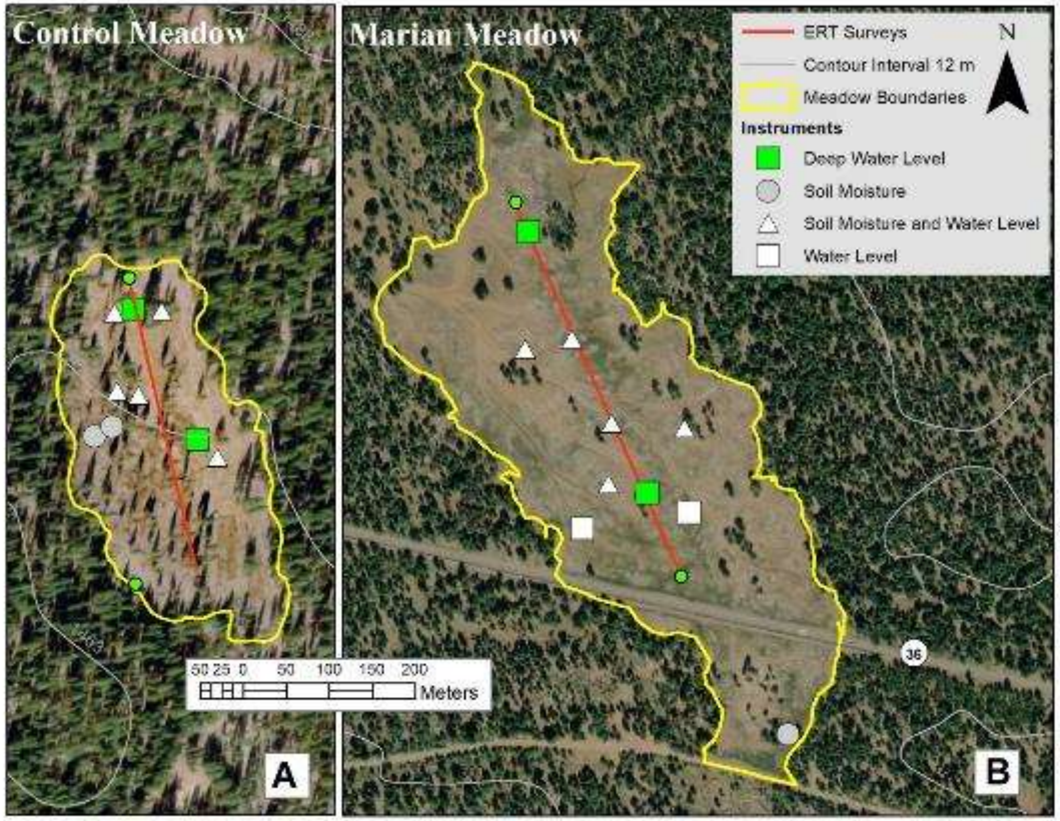
CCR § 933.4 [e] states:

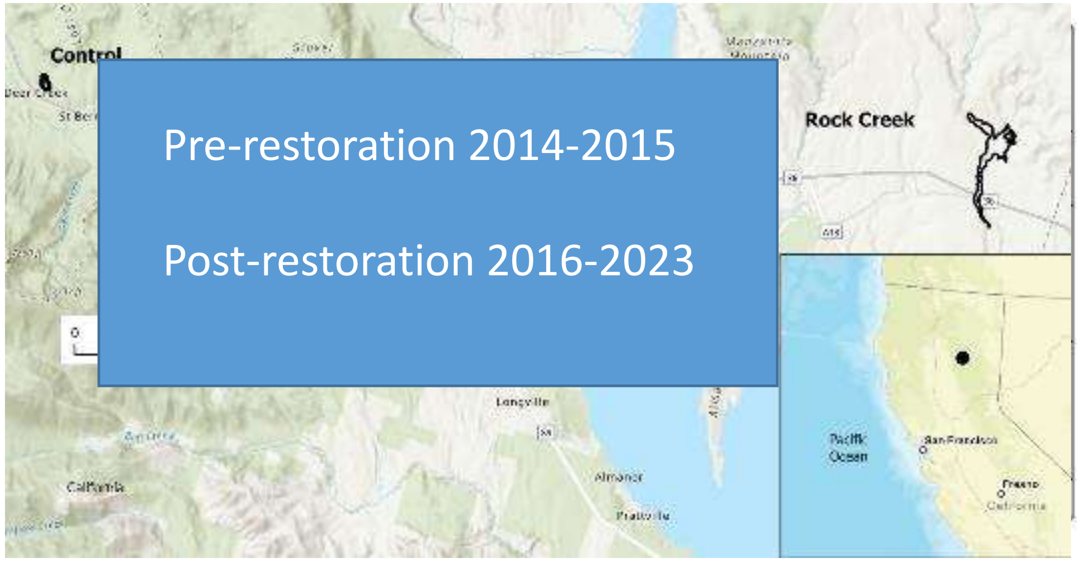
> **All trees within aspen stands, meadows and wet areas may be harvested or otherwise treated in order to restore, retain, or enhance these areas for ecological or range values.**

Research Objectives

- Objective 1. Quantify the hydrologic and vegetation response of meadow habitat restoration from removal of encroached *Pinus contorta.*

- Objective 2. Determine if the disturbance from the removal of encroached conifer trees from meadows or WLPZ reduce the environmental benefit.

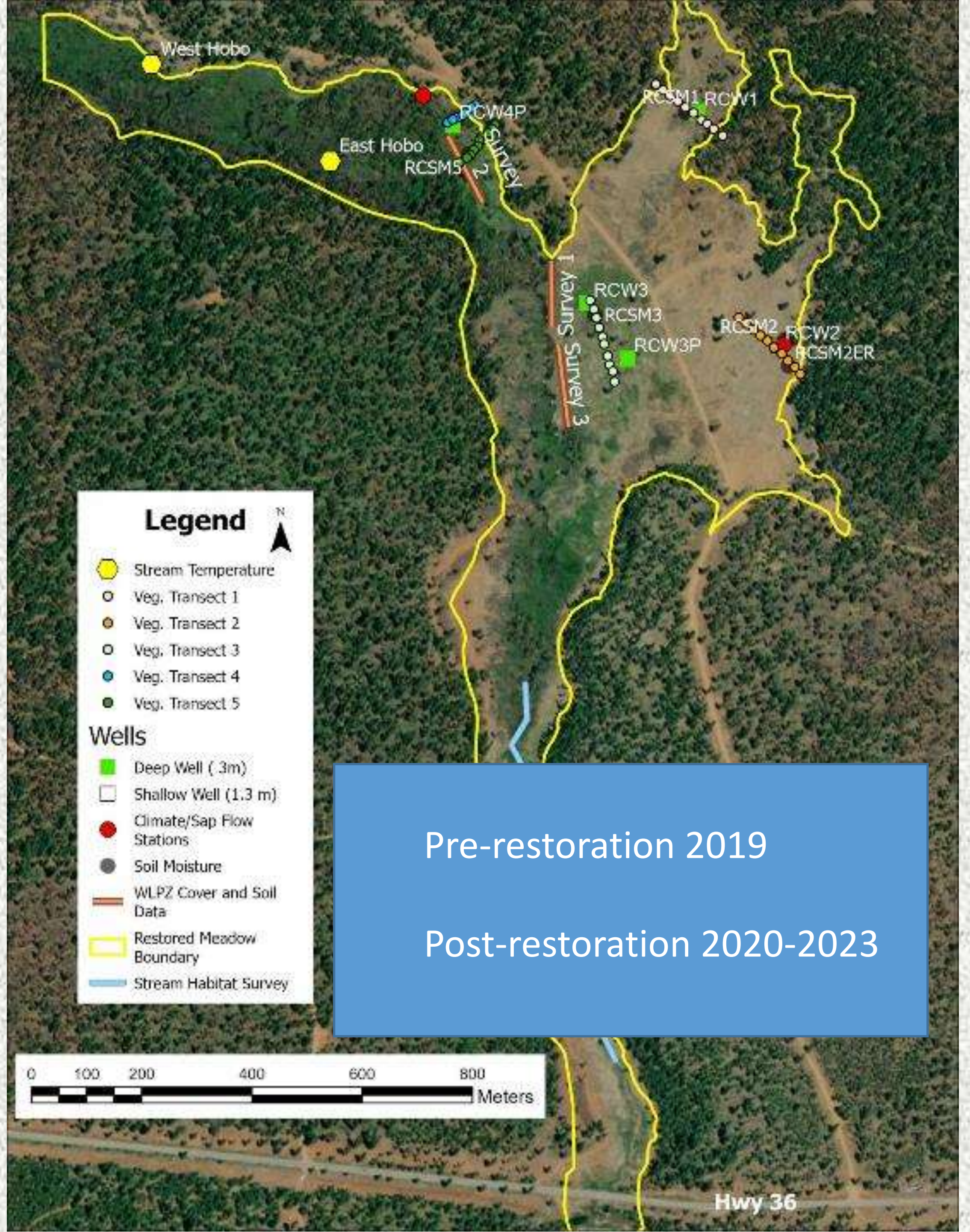




Pre-restoration 2014-2015

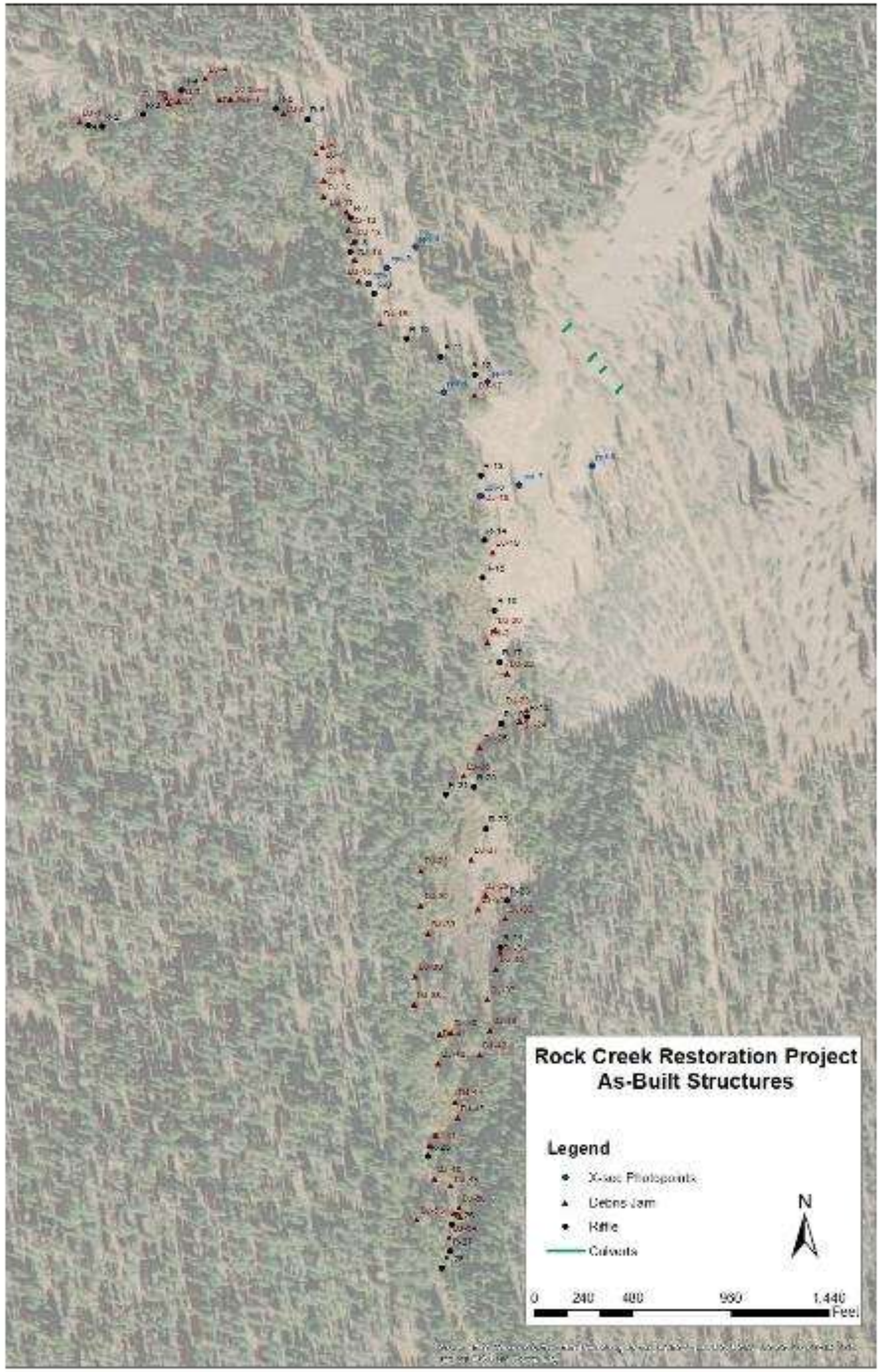
Post-restoration 2016-2023

Study Areas



Pre-restoration 2019

Post-restoration 2020-2023



Instream Restoration Work at Rock Creek by Plumas Corporation

- Permitting done through the Timber Harvest Plan process.
- Completed in 2021; just before the Dixie Fire.

Adverse Effects of Restoration?

4 locations – 500 feet long

Transects at 30, 50 and 75 feet from watercourse to determine ground cover disturbance

Randomly selected soil bulk density samples at transects at all 4 locations.

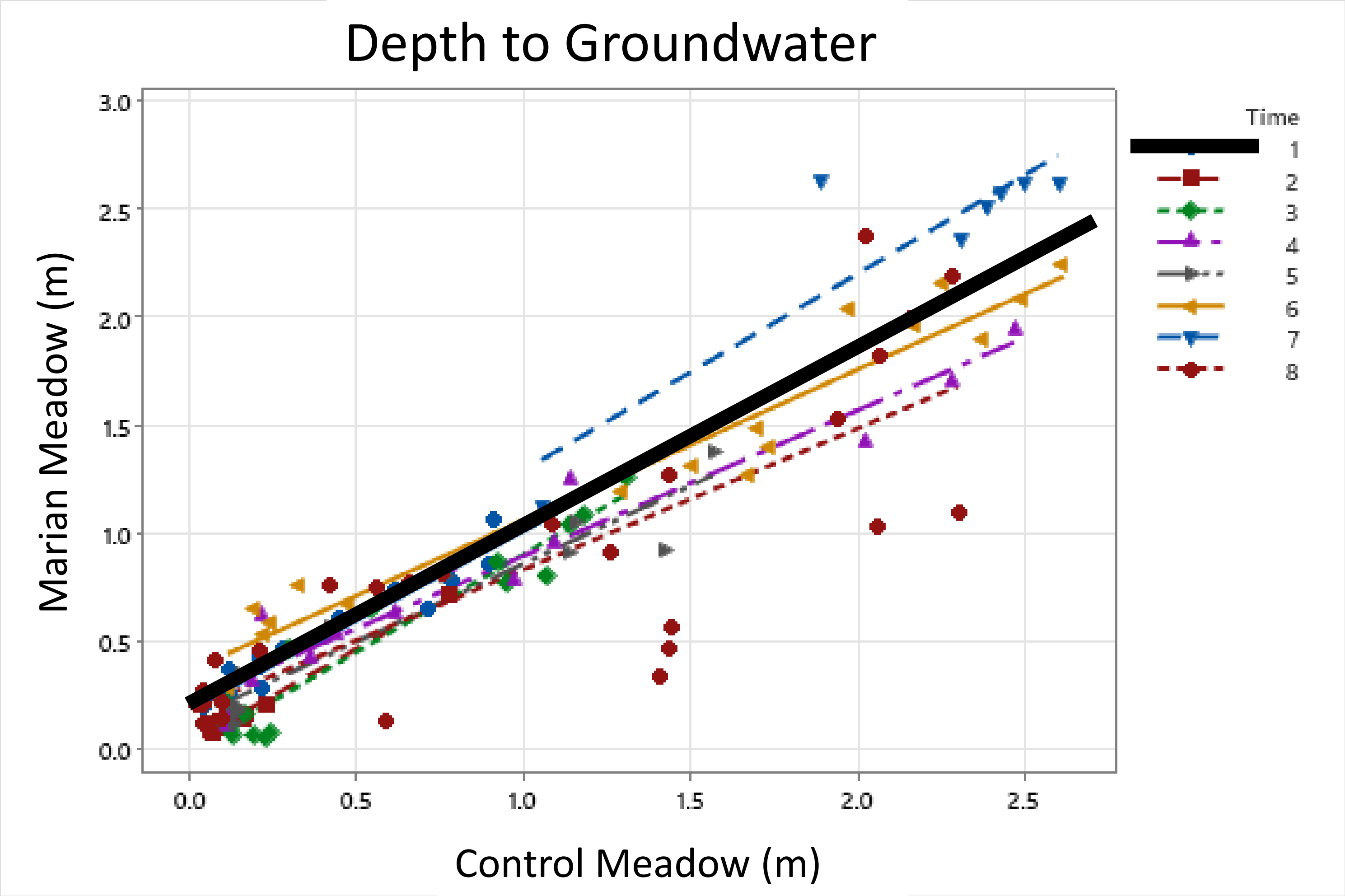
Lower Rock Creek - changes in stream bed, pool and riffle, temperature. (2019-2022)

Encroached Conifer Marian Meadow Basal Area 2014-2016
110 (ft^2/ac)

Post Restoration Marian Meadow 2016-2023

Marian Meadow Study

- Increase in groundwater in Marian Meadow following conifer removal, except for 2020-2021.
- Average 0.15 m increase in groundwater depth (Surfleet et al. , 2020)
- Increase attributed to loss of interception from removal of encroached conifer.

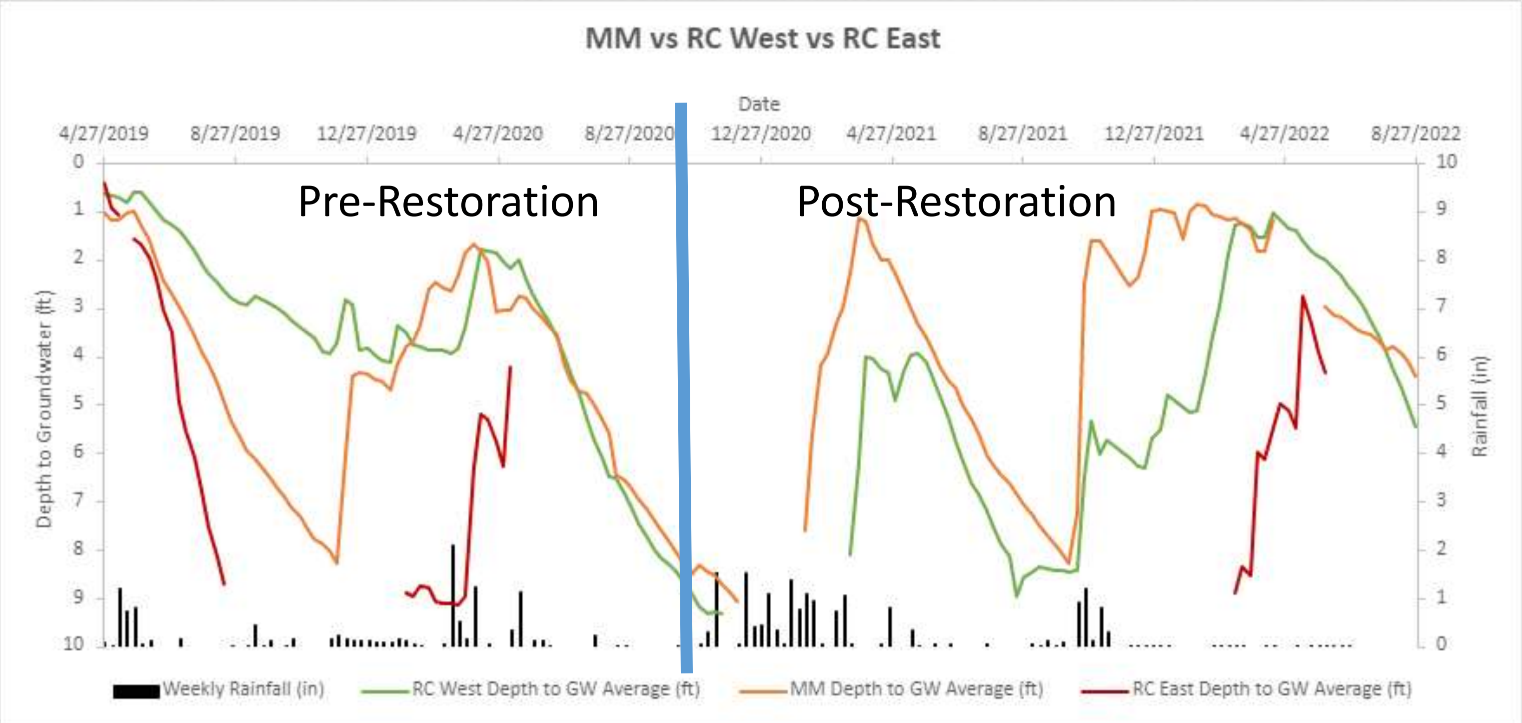


Surfleet.C., Fie, N., and J. Jasbinsek. 2020. Hydrologic response of a montane meadow from conifer removal and upslope thinning. *Water 12*(1), 293; **https://doi.org/10.3390/w12010293**

Rock Creek Meadow Study

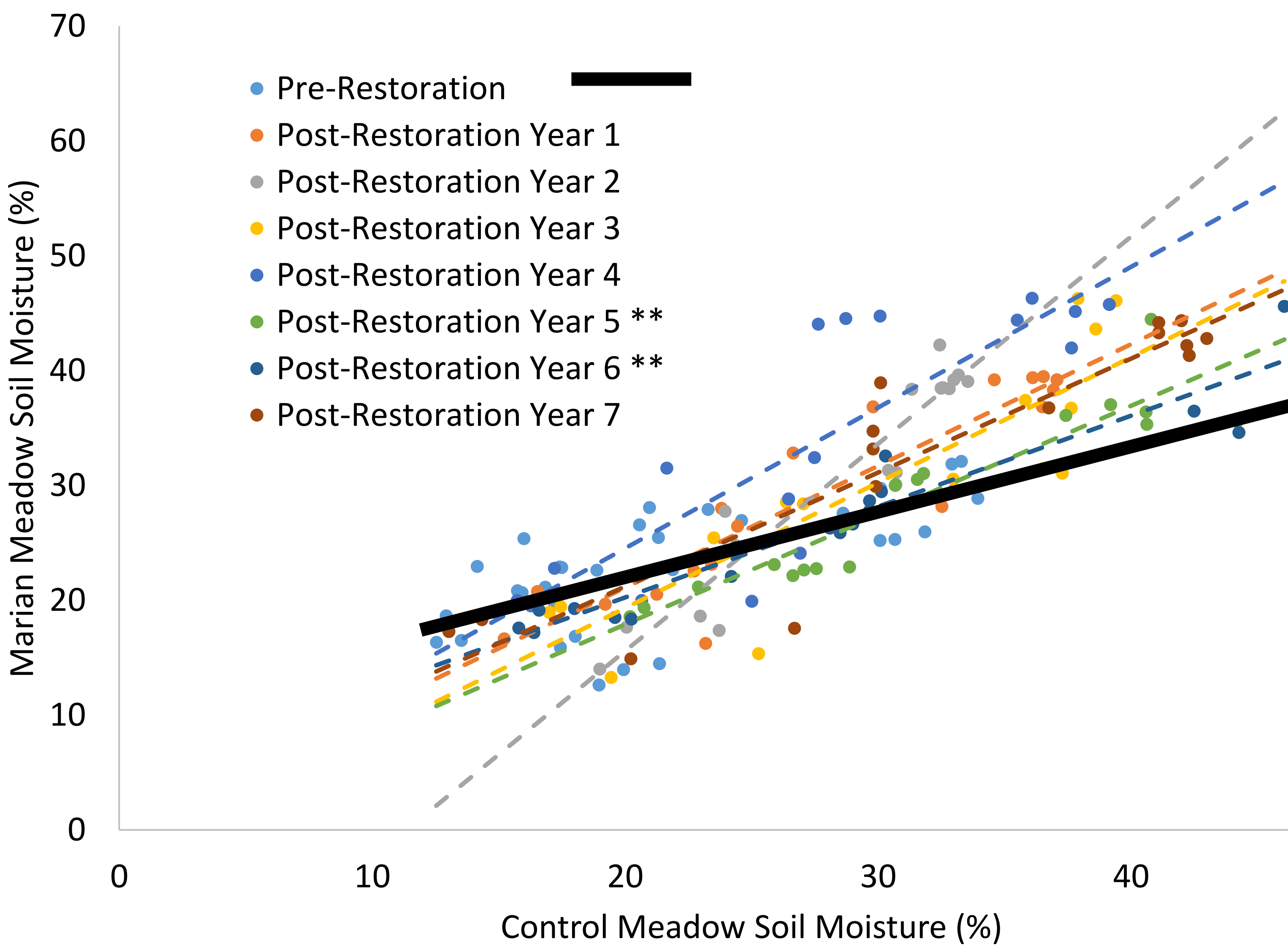
- Small increase in groundwater 2nd year following restoration.
- First year was a drought year

Preliminary Results



Marian Meadow Study

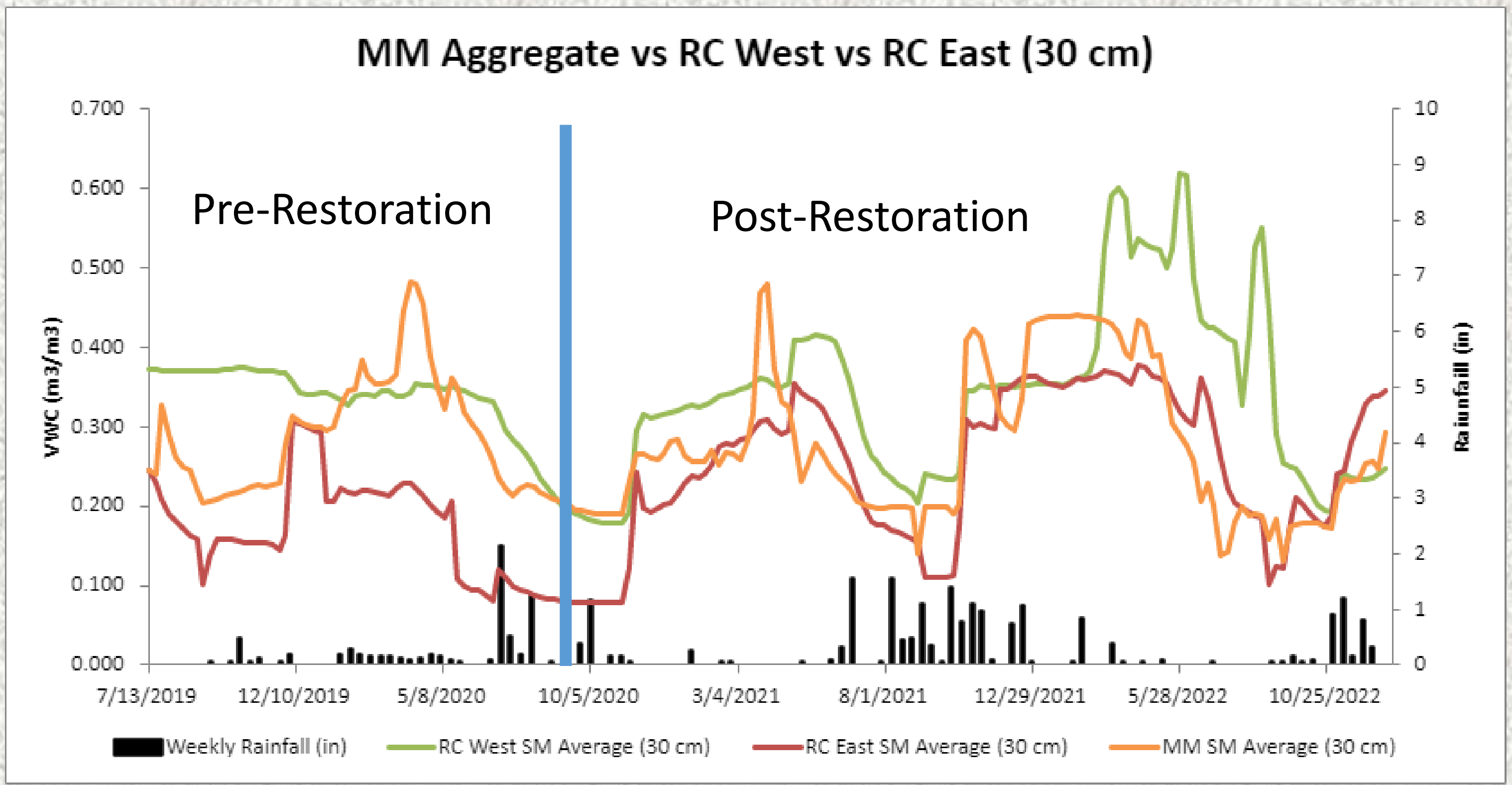
- Increase in shallow soil moisture in wet season.
- Decrease in soil moisture in dry season in years directly after tree removal.
- Decrease attributed to loss of shade cover or increased transpiration of meadow vegetation from removal of encroached conifers.



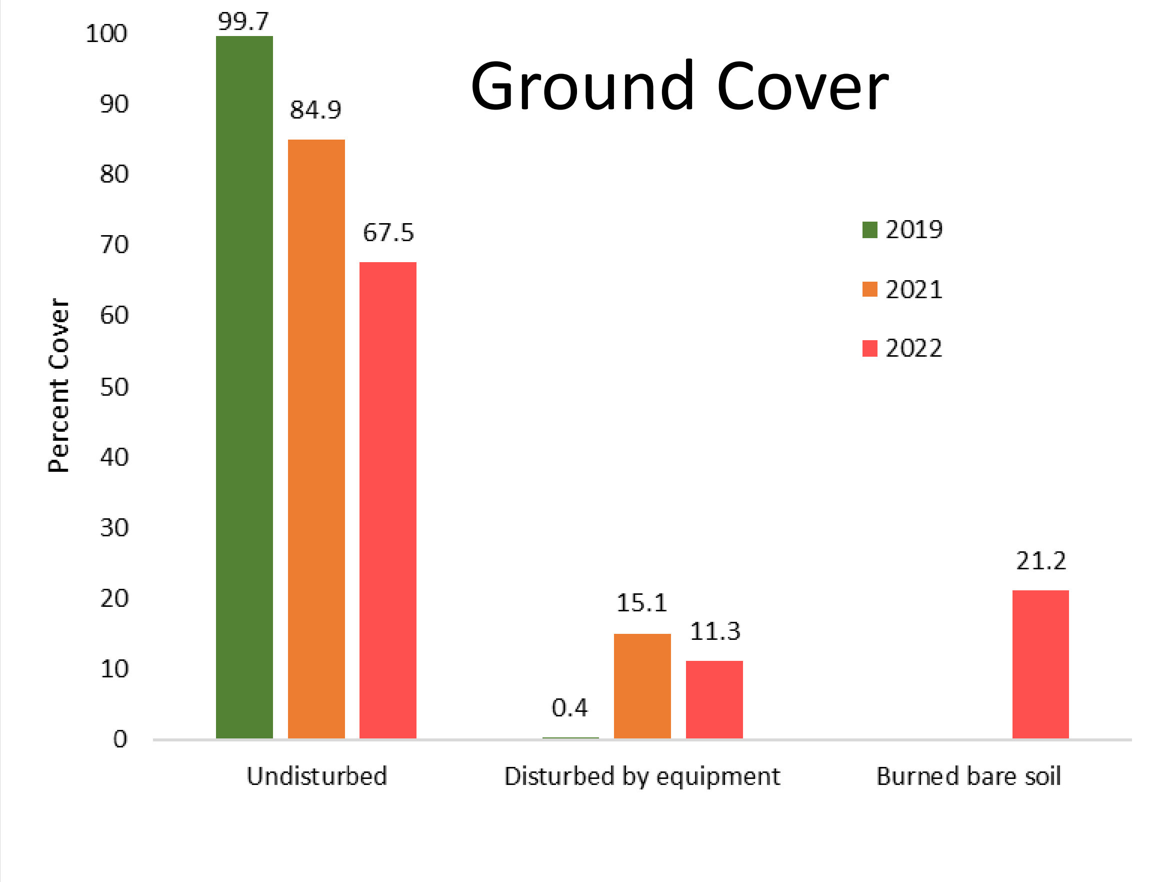
Rock Creek Meadow Study

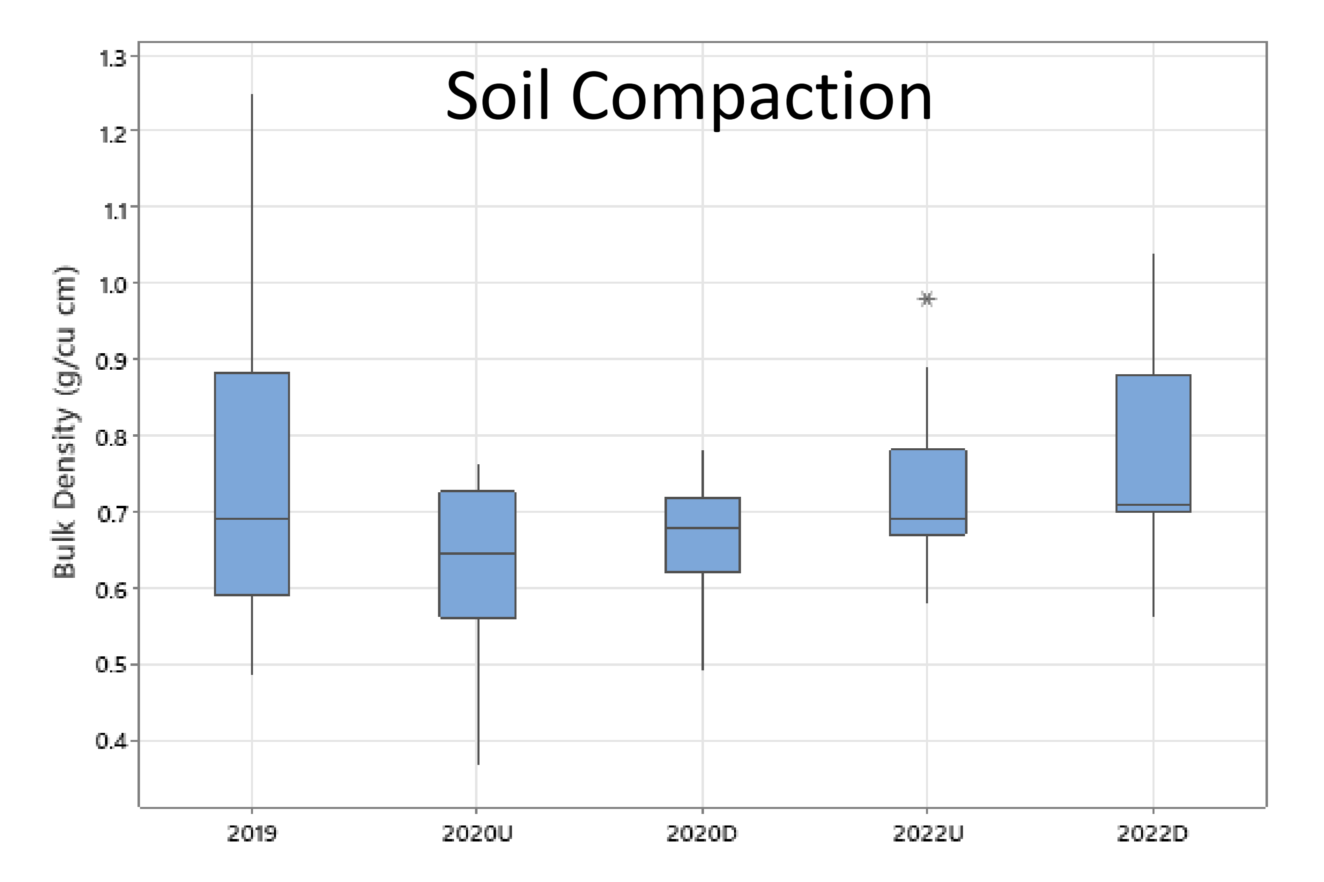
- Increased soil moisture in Rock Creek following *Pinus Contorta* removal.
- *Pinus Contorta* transpiration 200-300 mm/yr.

Preliminary Results



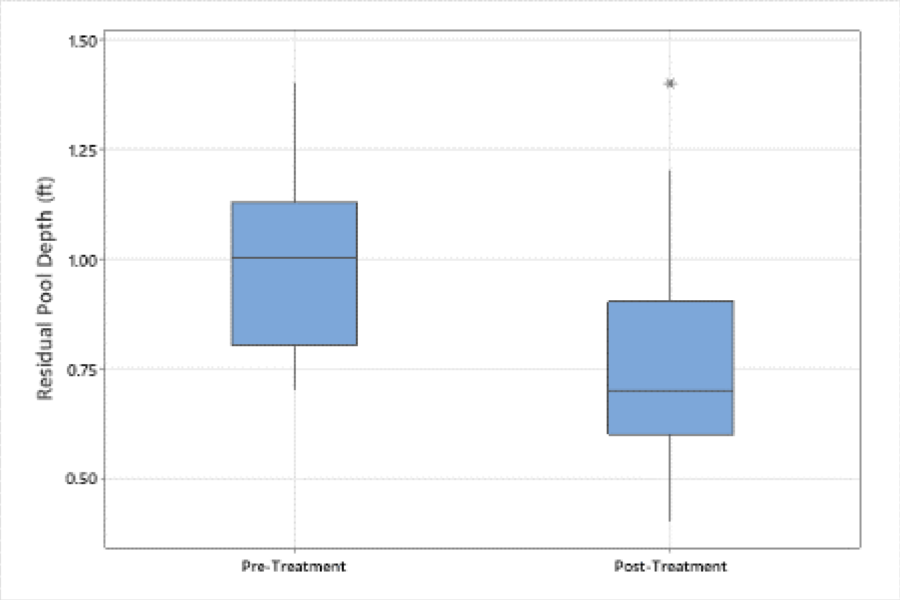
WLPZ Disturbance from *Pinus contorta* Removal



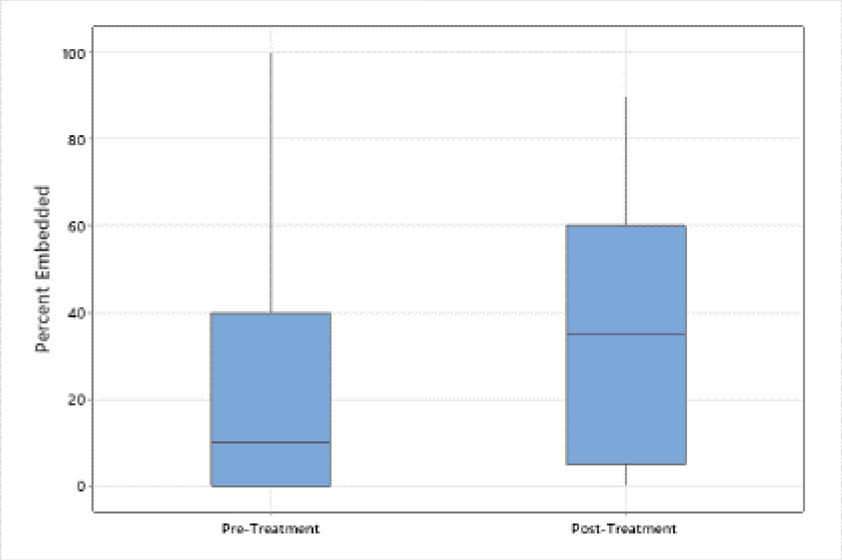


Stream Habitat Response

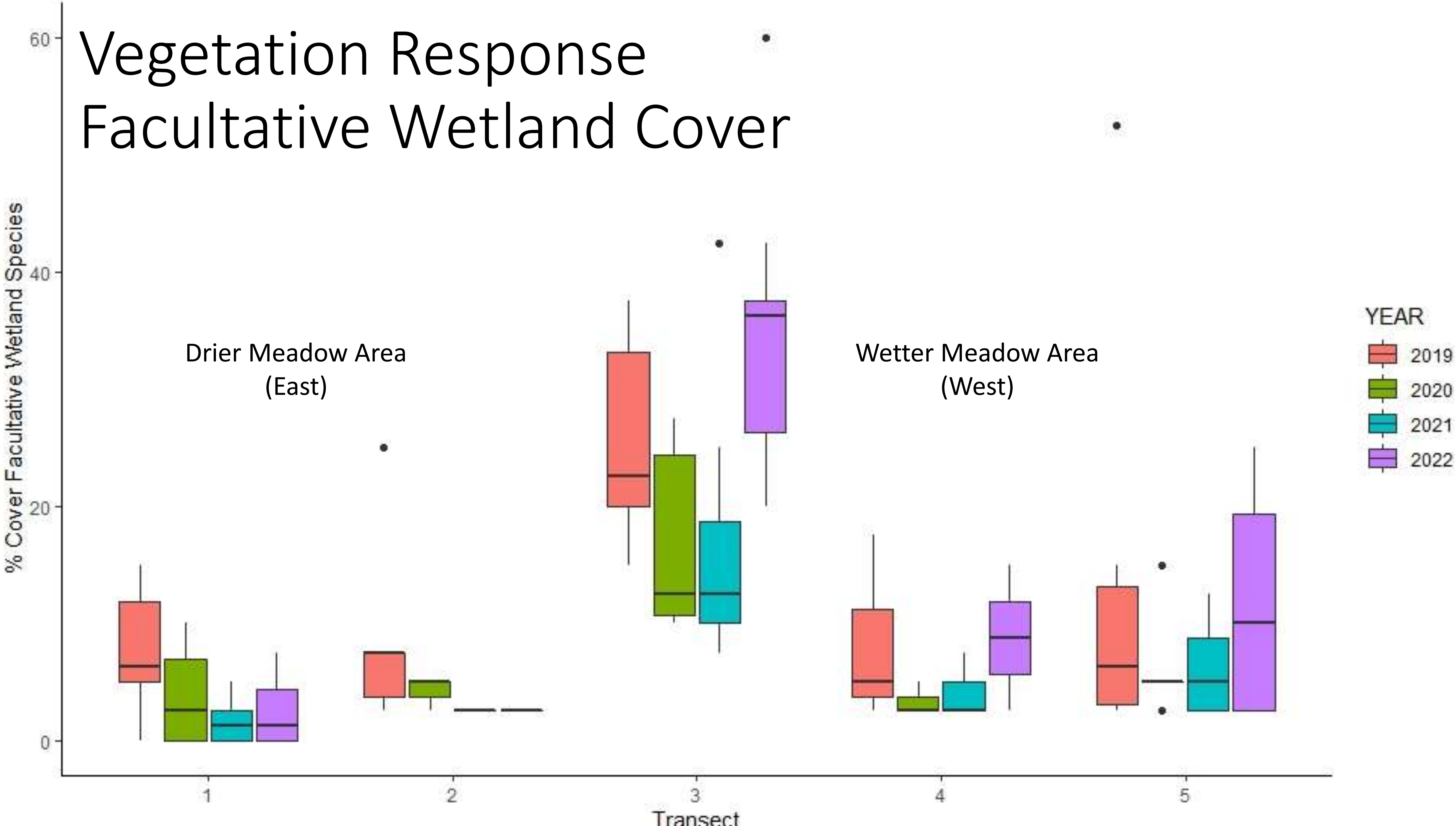
Slight decrease in pool habitat and pool depths following restoration and fire.



Stream bed had greater embeddedness following restoration and fire



Vegetation Response
Facultative Wetland Cover



Conclusions

- Groundwater and soil moisture increased in the meadows following removal of *Pinus contorta*. Except for drought years.

- Disturbance in the WLPZ was minimal, there was a small increase in disturbed ground, but no increase in soil compaction.

- The Dixie Fire disturbed more WLPZ ground cover than the removal of *Pinus contorta*. This resulted in slightly lower stream habitat conditions.

- Meadow vegetation recovery was observed in transects in the wetter areas of Rock Creek meadow, not in the drier areas.

Restoration Perspectives (observations from the field)

- THP umbrella for permitting stream work created problems.
  - State regulators would no allow stream work until after all vegetation removal was completed.
  - This delayed implementation by over a year.
  - Made for ineffective stream structure implementation.
  - Confusion between State and Federal permits (e.g. US Army Corp)
- Greater oversight of the logger to reduce impacts.
  - Good job in WLPZ, not so good outside of the WLPZ.
- Fire roads in meadows?

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Marian Meadow at Sunrise
January 2023