Riparian forest structure and bottom-up drivers of fish production in headwater streams – Final Report

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Study Objectives:

• Understand how riparian forest structure influences bottom-up drivers of fish abundance and growth in headwater streams

• Set up preliminary data set for experiments exploring whether selective thinning in the riparian zone to create a more complex canopy structure influences fish in headwater streams
Stand development (*simplified*)

**Relative Light Index value on the forest floor**

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**Phases**

- Stand initiation
- Stem-exclusion
- Understory reinitiation
- Gap-dynamic

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Donato et al. 2012

% canopy openness versus stand age across the Pacific Northwest

% open canopy

Age of dominant canopy trees ("stand age") in the riparian forest (years)

Warren et al. in prep

% canopy openness versus stand age across the Pacific Northwest

% open canopy

Stand initiation (<10 yrs)
Early stem-exclusion (10-40 yrs)
Late stem-exclusion (40-80 yrs)
Mature (understory regeneration) (80-170 yrs)
Old Growth (>170 yrs)

War. + al. in review

Forest age class comparison

Stream 1: upper third-order McRae Creek
• 6.6 m bankfull width
Forest age class comparison

Stream 2: McRae Creek Tributary – West
• ~4 m bankfull width
(a) McRae Trib – West (4.4 m bankfull)

(b) McRae Trib – East (3.1 m bankfull)
Conceptual model for changing *stream light* over time in a forested headwater stream.

- **Dense, closed canopy**
- **Complex canopy with patchy openings**

Y-axis represents average light to stream benthos.
Is periphyton accrual affected by local light?

McRae Creek

Fluorescein decay (ppb)

Increased Light ----->

Transect Distance (m)

0 50 100 150 200 250 300 350 400 450

Buffer

Old-Growth

Second-Growth

Fluorescein decay (ppb)

Increased Light ----->

Distance (m)

0 10 20 30 40 50 60 70

McRae Creek

Fluorescein decay (ppb)

Increased Light ----->

Distance (m)

0 10 20 30 40 50 60 70
Is periphyton accrual affected by local light?

Fluorescein decay (ppb) 

Increased Light ---->

Distance (m)

0 100 200 300 400 500

μg chl. a/cm²

0.00 0.01 0.02 0.03 0.04 0.05

Old-Growth

R² = 0.6586

Second-Growth

Fluoroscein decay (Δppb)

(more loss = more light)

0 100 200 300 400 500

Is periphyton accrual affected by local light?

R² = 0.6586

Old-Growth

Second-Growth

Fluorescein decay (Δppb)

(more loss = more light)
Conceptual model for changing *periphytion* (GPP?) over time in a forested headwater stream
Conceptual model for changing predator biomass over time in a forested headwater stream.
Why would a small change in periphyton matter to stream predators?

- Algal material is “higher quality” food that most allochthonous material that enters streams (i.e. leaves)
- Therefore relatively small increases in primary production have the potential to disproportionately impact secondary production
Specific study hypotheses

**H1:** Stream reaches with complex riparian forests will have more light, more primary production and ultimately more trout and total vertebrate biomass than stream reaches with uniform closed-canopy riparian forests.

Figure: Warren et al. in review
“A strategy for managing streamside areas for long-term fisheries values would be to keep the large woody materials in the stream during harvest, leave large coniferous trees to serve as a future source of instream debris, and selectively thin dense second-growth stands along the stream to provide a mix of food resources, including algae”

Sedell and Swanson (1984)
Study Design:

Set up reach pairs to evaluate relationships among the following metrics compare across streams for each stand type.

- Light/canopy cover
- Stream habitat
- Background nutrient concentrations
- Primary production (chlorophyll $a$)
- Macroinvertebrate biomass and community composition
- Fish abundance and biomass
- Salamander abundance and biomass
Methods

We hypothesized that changes in canopy coverage both temporally and associated with differences in forest structure will be important predictors of predator biomass via bottom-up processes.

- **Canopy**: Spherical Densiometer
- **Periphyton chl a**: 10 tiles/reach
- **Invertebrates**: 6 surber samples/reach
- **Fish and Salamanders**: Mark-Recapture
- **Habitat Surveys**
- **NO₃ + PO₄**
Study Design

H.J. Andrews Experimental Forest, OR

- Old-growth
- Previously Harvested

9 Total Pairs
18 Total reaches

Surveyed in Murphy and Hall 1981

2014 Fish Data from Gregory et al.
Results: Bottom-up Drivers?

Increased Solar Radiation → Increased Primary Production → Greater Invertebrate Biomass → Greater top consumer abundance, biomass and/or growth rates

NOTE: The sequential regressions between light, chl a, invertebrates and fish have been excluded from this report. Those data are part of an MS thesis and the student has not yet defended. I apologize for the omission of information here, but it is important to protect the research of students in our program and allow them ample time to publish before widely distributing their results. The student will defend in Spring 2016 and we anticipate manuscript submission by July 2016.

-Dana Warren
YoY Mean Length
Early and mid-summer

* Error bars indicate 2 standard errors of the mean

P-Value: 0.011
P-Value: 0.0004
P-Value: 0.088
P-Value: 0.613

(n=9, 12) (n=11, 14) (n=27, 21) (n=24, 41)
Take Home Messages

1. Light availability appears to have strong bottom-up controls on trout and vertebrate biomass.
2. Large wood and pool area surprisingly were not correlated with trout biomass - *likely a result of the higher gradient basalt-dominated systems in which we worked.*
Next steps- *Experimental Canopy Gaps*

![Graphs showing loss of fluorescein over 24 hrs for upstream and downstream distances with control and manip conditions.](image)

**Next steps**

- Experimental Canopy Gaps
Next Steps - Creating Canopy Gaps

McRae Trib – East (3.1 m bankfull)
Conceptual model for changing vert. biomass over time in a forested headwater stream

Murphy et al. 1981

- Dense, closed canopy
- Complex canopy with patchy openings

Years since stand replacing event

Fish Biomass

Average light to stream benthos

Periphyton stocks
Conceptual model for changing **vert. biomass** over time in a forested headwater stream

Kaylor et al. *In prep.*
Riparian forest age class

McRae Creek Tributary Day/Night nutrient releases in a reach with an old growth riparian forest versus a reach with a second-growth riparian forest.

Uptake Velocity (mm*s⁻¹)

Mean Δ in Fluorescein concentration (greater change = more light)

Riparian forest age class

- **DAY**
- **NIGHT**
- Mean Fl loss in vials
Thank you

Acknowledgements

Funding:
• CoF Forestry’s Fish and Wildlife in Managed Forests Research Program
• OSU’s Dept. of Fisheries and Wildlife & Dept. Forest Ecosystem and Society

Fieldwork and data collection:
• Matt Kaylor
• Brian VerWay

Other intellectual contributions:
• Lina DeGrigorio
• Ivan Arismendi
• Cheryl Friesen
• Stan Gregory
• Kathy Keable
• Julie Pett-Ridge
• Mark Shultz
• USFS/BLM fisheries research team
• Theresa Vallentine
• Randy Wildman