**dDRAFT 1**

Journal

© 2019 Cedar Mackaness

Cedar Mackaness

College of Earth, Ocean & Atmospheric Sciences, Oregon State University

[mackanec@oregonstate.edu](mailto:mackanec@oregonstate.edu)

**Introduction**

Streams and their biota are inherently linked to riparian vegetation in forested systems. In the Pacific Northwest (PNW) region of North America, riparian forests have undergone a drastic shift in the past half century with decades of heavy harvesting resulting in a landscape dominated by dense second-growth vegetation. For streams that run through these forests, dense vegetation decreases light availability and limits light availability for benthic primary production. In many systems, higher trophic levels can be disproportionately supported by algae, and a shift in this basal resource can have substantial effects on stream biota.

To understand how aquatic food webs respond to an increase in light associated with canopy gaps, we investigate the response of macroinvertebrates and fish feeding to canopy-opening manipulations.

Earlier research has shown that relieving light limitation by clear-cutting riparian forests can result in an increase in stream primary and secondary productivity, but clear cutting along streams is no longer a common practice in the Pacific Northwest. Even in managed landscapes riparian buffers are left. Unmanaged forests and these riparian forest buffers are in the early stages of stand regeneration with dense homogenous canopy cover and low stream light. As forest succession continues natural disturbances and tree mortality will increase canopy heterogeneity through the introduction of gaps. While studies on forest clearing demonstrate a clear response in benthic primary producers, invertebrates and fish to release from light limitation throughout a stream reach, the effects of localized light patches – that reflect a more realistic picture of future stream conditions in forested landscapes – have not been evaluated.

Stream light availability is an important factor affecting aquatic food webs through its controls on stream primary production. In the PNW, stream algal production is highly light-limited, and an increase in light often enhances benthic algal growth, which in turn increases food availability for secondary consumers in the stream such as macroinvertebrates. Such changes in resource availability can cascade through trophic levels resulting in changes in selective pressures dependent on the relative abundance of resources.

Evidence of this – example?

Stream secondary production is dominated by aquatic macroinvertebrates, which obtain resources from both allocthonous litter originating outside the stream and in-stream production. Sentence about disproportionate quality or representation of algae in bugs. Etc etc etc for a few sentences Macroinvertebrates play an important role in assimilating and transducing energy to higher trophic levels such as insectivorous fish and other vertebrate predators. Because macroinvertebrates play such a crucial role in mediating food web interactions, understanding their community dynamics can provide insight into broader ecosystem functioning.

Clear cutting has been shown to have a definite impact on stream food webs, but local changes in light availability (on the meter scale) have much more variable impacts on trophic interactions. Light can enhance algal growth, acting as a bottom-up driver of secondary production, but it can also increase foraging efficiency of fish, imposing a top-down pressure on macroinvertebrates.

Understanding the impacts of small canopy gaps, rather than large clear cuts, will be important for dictating future management practices.

**Methods**

*Study location*

The study consists of 5 reach pairs on five separate streams in the western Cascade Mountains of Oregon. Two of the reach pairs (W-100, W-113) are located on private Weyerhaeuser Co. land, and three (LOON, CHUCK, MCTE) are located on U.S. Forest Service land, one of which (MCTE) is situated in the HJ Andrews Experimental Forest. Stream reaches were 90 meters in length and treatment gaps were 40 to 60 meters in diameter situated approximately in the middle of treatment reaches. Reach pairs were spaced x meters apart to minimize any effects of the upstream reach on downstream conditions.

Sampling lasted two years with pre-treatment data gathered during summer 2017 and post-treatment data gathered during summer 2018. Canopy gaps were cut in the treatment reach during the winter of 2017-18 to permit adequate time for response to the canopy manipulation. The reach pair design with pre and post treatment years is intended to account for inherent environmental variation among streams and between years.

All of the streams are wadeable, fish-bearing streams with bankfull widths of 1-8 meters. Fish-bearing streams were purposefully selected to provide management-relevant results for protecting salmonids. Small streams were chosen for ease of sampling and to maximize the effect of a canopy opening manipulation since smaller streams can be more heavily shaded. The streams run through 40-60-year-old forests that had previously been harvested without leaving a riparian buffer. The result is a forest stand homogenous in age with a homogenous canopy structure, as defined by its early seral development stage. Stream-side vegetation predominantly consists of red alder (*Alnus rubra*) and douglas fir (*Pseudotsuga menzesii*) which provide shade and allocthonous carbon inputs to the streams.

*Data Collection*

Three benthic invertebrate samples were taken at each stream reach at meters 15, 45, and 75, or the closest area with non-boulder substrate. Samples were collected once per year over the course of one week using a Surber sampler with a .09 m2 sampling area. Substrate was disturbed to a depth of approximately 4 inches for one minute. The sample was then preserved in 95% ethanol for identification and enumeration in the lab. Fish diets were collected during three-pass depletion of fish standing stock and were only taken from a subset of fish greater than 100 mm in length. Fish were gastro-lavaged, and stomach contents were collected in filter paper and preserved in 95% ethanol for lab processing. In order to measure the response of primary producers to the canopy gap, three tiles were set out every ten meters for two weeks for each stream and Chlorophyll values were measured using a Bentho Torch™.

*Data Preparation and Adjustments*

*Benthic Data Analysis*

*Trout Diet Data Analysis*

*Regressions*

**Results**

*Light Response*

*Algal Response*

*Benthic Community Differences*

*Trout Diets*

*Regressions*

**Discussion**

**Acknowledgments**

This study was conducted in conjunction with Allison Swartz’s Masters’ project, and any future publications would include her, Dana Warren, Dave Roon and Matt Kaylor. Alvaro Cortez, Brook Mackaness, Nate Day and Cory Colp helped with data collection, and the HJ Andrews Experimental Forest and its staff provided lodging and accommodations. Dave Lytle provided lab space and equipment for invertebrate identification.

**References**

Bilby, R. E., and Bisson, P. A. 1992. Allochthonous versus autochthonous organic matter contributions to the

trophic support of fish populations in clear-cut and old-growth forested streams. Canadian Journal of Fisheries and Aquatic Science 49: 540-551.

Kaylor, M. J., and Warren, D. R. 2017. Linking riparian shade and the legacies of forest management to fish and

vertebrate biomass in forested streams. Ecosphere 8(6):e01845.

Kruskal, J.B. 1964. Nonmetric multidimensional scaling: a numerical method. *Psychometrika* 29:115-119.

McCune, B., and Grace, J.B. 2002. Analysis of Ecological Communities. MjMSoftware, Gleneden Beach, OR,

USA.

McCune, B., and Mefford, J. M. 2016. PC-ORD. Multivariate analysis of ecological data. MjMSoftware, Gleneden Beach, OR,

USA.

Nakano, S., Miyasaka, H., Kuhara, N. 1999. Terrestrial-aquatic linkages: riparian arthropod inputs alter trophic

cascades in a stream food web. Ecology, 80(7): 2435–2441.

Wilzbach, M., Cummins, K., & Hall, J. 1986. Influence of habitat manipulations on interactions between cutthroat trout and invertebrate

drift. *Ecology,* *67*(4), 898-911.

Wootton J. T. 2012. River Food Web Response to Large-Scale Riparian Zone Manipulations. *PLoS ONE*

7(12):e51839.