**Fish and Wildlife Habitat in Managed Forests**

1. **Project Title:**  *How do riparian forest gaps affect macroinvertebrates and fish diet in headwater streams*
2. **List of Principal Investigators**

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| --- | --- | --- | --- |
| Role | First | Last | Affiliation |
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| CoPI |  |  |  |
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1. **Project Duration**

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| --- | --- |
| Start Date | End Date |
| 07-01-18 | 06-30-19 |

1. **Budget Summary**

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| --- | --- | --- | --- |
| Year 1 | Year 2 | Year 3 | Total |
| $12,468 | $ | $ | $ |

***How do riparian forest gaps affect macroinvertebrates and fish diet in headwater streams***

**Dana R. Warren, Oregon State University**

**Project Description**

1. ***Relevance of topic to program mission and program priority areas***

The links between forests and adjacent stream environments inextricably tie forest management in the terrestrial environment to stream habitat, water quality and biota in adjacent aquatic ecosystems. The proposed study will explore how changes in the streamside forest cover affect water quality, stream food webs and ultimately fish in managed forest landscapes of western Oregon. This study will focus in particular on stream macroinvertebrates because they are a key conduit through which changes in stream light and stream primary production translate to changes in stream fish. They are also commonly used in biological integrity indices to assess stream water quality.

The information we will learn from this proposed study will complement a larger effort to assess other food web and ecosystem responses to canopy gap formation. Through a series of correlative studies, we have found strong relationships between riparian forests, stream light and aquatic food webs (Kaylor and Warren 2017a, Kaylor and Warren 2017b, Kaylor et al. 2017, Heaston et al. *in press*). By studying demographic responses, community change and the connections between macroinvertebrate communities and fish diet, we will develop a mechanistic understanding of how stream ecosystems as a whole (which support healthy fish populations) respond to modification of the riparian forest. With correlations, we are regularly warned not to extrapolate results beyond the range of conditions in the data set used to create a given relationship. However, with an understanding of the mechanisms for change, we are more capable of creating a rigorous set of expectations about how other systems will behave, even if they differ somewhat from our initial system. Therefore the proposed work on macroinvertebrates and fish diet will help us to meet the FWHMF Research Program’s mission goals by providing “*information needed by forest managers to guide responsible stewardship of fish and wildlife habitat resources consistent with land management objectives.”*

Beyond a greater mechanistic understanding of food web connections, quantifying macroinvertebrate abundances as well as community composition will allow us to assess potential forest management impacts on water quality using an index of biological integrity (IBI). Assessing water quality is particularly relevant to forest management because there have been, and continue to be, a number of key forest management regulations that are built around water quality. Indeed, according to the Oregon Department of Forestry’s own accounting of the Oregon Forest Practices Act (FPA): “*A large portion of the FPA rules are aimed at the protection of water sources. Regulations require landowners to leave forested buffers and other vegetation along streams, wetlands, and lakes to protect water quality and fish and wildlife habitat*.” Water protection and regulations for aquatic biota also factor in significantly in the Northwest Forest Plan, which regulates forest management on federal lands across Oregon and Washington. In the headwaters where the proposed project is located, and where much of the logging across Oregon occurs, water quality is generally high with invertebrate IBI scores that reflect high dissolved oxygen content and few pollutants. Given the high initial water quality and the small size of proposed riparian forest manipulations, I do not actually expect the creation of localized canopy gaps in the proposed study to substantially affect macroinvertebrate IBI scores. However, I believe that assessing responses to individual riparian forest gaps is a critical first first-step before one can argue that it is reasonable to explore larger riparian forest management initiatives.

1. ***Objectives***

In a number of recent publications, we have shown that headwater streams running through mid-seral forests have a high degree of canopy closure, which in turn correlates with low light levels, low rates of primary production, low macroinvertebrate biomass, and ultimately lower abundance of fish relative to comparable streams with more complex riparian forests. The role of light as a fundamental control on bottom-up processes in streams, and ultimately as a key driver of trout biomass in forested headwaters, was further corroborated by an experimental shading study in 2016 (Heaston et al. *in press*). Based on these cumulative findings, the FWHMF program funded a study on managed forestlands to test how creating canopy gaps in the riparian forest affect primary production, fish, temperature and nutrient dynamics in streams. This new project has important implications for potential riparian restoration along heavily shaded stream corridors in sites with regenerating forests. It also provides important information on how streams will respond to the creation of localized areas of increased light that would occur under implementation of variable retention riparian buffers.

The currently funded FWHMF project evaluates many aspects of stream ecosystem responses to local riparian gaps, however, it does not address stream macroinvertebrates. Rigorously quantifying macroinvertebrate responses was beyond the scope of the initial project given logistic and personnel constraints. However, macroinvertebrate responses are a critical link in the proposed effects on fish. Therefore, **the first two objectives of this proposed study are (1) to characterize macroinvertebrate community responses to riparian gap implementation and (2) to compare invertebrate communities to fish diets.** In quantifying stream macroinvertebrate communities, we will also be able to determine an Index of Biological Integrity (IBI) score for our sites. Invertebrate IBI’s are commonly used to assess water quality in streams and our third objective would be **(3) to determine if the gaps affect invertebrate IBI assessments of water quality.** As noted above, I do not expect our gap experiments to impact invertebrate IBI scores, however, confirming this hypothesis is important as we move forward with plans for future riparian restorations that use gaps or in experiments of variable retention buffers.

1. ***Basic approach overview***

Study design and data collection details: The study design for this project is established. We are implementing a set of replicated experimental forest manipulations across private and federal ownership that create individual canopy gaps, and therefore patches of elevated light on the stream. All of the wood felled in creating the gaps is being left outside the stream to isolate light effects. By assessing a single gap, we can better understand the impact of a small change in light on the larger system. We are working on six streams in the McKenzie River basin, draining the western slope of the Cascade Mountains in central Oregon. Three sites are on the Willamette National Forest, and three sites are on private timber land (Weyerhaeuser Co.). The project follows a before-after control-impact (BACI) design. Each of the six streams contains two study sections (one reference reach and one treatment reach) approximately 100 m in length.

Recognizing the importance of macroinvertebrates to stream fish, we collected stream insects in summer 2017, prior to cutting riparian gaps. Three pre-treatment samples were collected in all reaches (two per stream) in summer 2017. Gap manipulations were conducted at 4 sites in 2017 and the final two gap manipulations will be implemented in March 2018. In this coming summer (post-treatment), we will again collect 3 samples per reach (in approximately the same locations) in all 12 reaches. All samples will be stored in 90% ethanol in the field. Per methods in Kaylor and Warren (2017a), for samples with fewer than approximately 250 individuals, all invertebrates will be sorted and identified to family. For larger samples, we will use a plankton splitter to sub-sample until we have approximately 250 individuals and then all invertebrates in the sub-sample will be sorted and identified to family. Invertebrate communities will be compared using a Nonmetric Multidimensional Scaling (MDS) ordination, analysis tool to quantitatively assess overlap among communities within and across sites.

While having only one year before and one year after manipulation is not ideal, in this case, I believe that it is fully adequate to address our study questions. With reference reaches on the same streams as treatment reaches, they function well as a control for (1) annual climate variability, (2) disturbance effects (e.g. flood or drought), and (3) the seasonal emergence of macroinvertebrates that can affect the benthic community at any given point in the summer. Given the life history – many living for a bit less than a year – and the mobility of stream macroinvertebrates, I expect that if a change in the local community does occur as a result of the gap, it would manifest within a short timeframe (a year or less). Further, given that the gaps we are creating are relatively small, this first summer after gap formation will likely be the time period when gap effects, if present, will be largest.

We will use results from the macroinvertebrate sampling to complete the Streamkeepers Benthic Index of Biological Integrity (B-IBI) (<http://www.clallam.net/SK/biologicalmonitoring.html>). Indices of biological integrity are regionally specific. This B-IBI has been developed for western Washington – a region with comparable geology and climate – and is widely used and cited. We will analyze changes in the difference in stream IBI scores in reference and treatment reaches from before versus after the gap manipulations.

Fish collections will occur once at each site throughout the month of August within two weeks after the macroinvertebrate sampling at a given reach. At each site, we will use gastric lavage to non-lethally collect fish stomach contents. In this method, water is gently pumped into the fish’s stomach with a small tube and a syringe. When the stomach is full of water, the tube is removed and water rushes back out of the fish’s stomach, bringing with it the gut contents. The stomach samples from each fish will be stored in 90% ethanol in the field. Back in the lab, samples will be sorted and then identified to lowest taxonomic level possible based on the condition of the diet items. We do not have trout diets from before the gaps are implemented, so this aspect of the study will focus on how fish diets match up with available prey in the benthic invertebrate community, and then whether differences in community or total abundance manifest in fish gut contents as a result of the gap cut. We will evaluate whether trout diets differ between paired reaches and between streams overall, but comparative results will be placed in the context of general differences in stream light, substrate and habitat, rather than attributing any specific differences to the creation of the gaps.

Planned outcomes and deliverables: I will mentor and undergraduate OSU honors student for this project. As part of an honors thesis, the student will produce results from each of the three analyses discussed above (invertebrate community changes, IBI score changes, and diets differences). The OSU honors thesis, will then be developed into a manuscript that will be published in a peer-reviewed journal. The student will make presentations at Oregon State University, at state scientific meetings (e.g. ORAFS), and I will present any relevant results at stakeholder meetings.

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| Activity | Year 1 | | | |
| Sum | Fall | Win | Spr |
| Collect post-treatment data on stream communities and fish diet | X |  |  |  |
| Analyze/ID samples | X | X |  |  |
| Data analysis | X | X |  |  |
| Writing (unfunded; will occur through student honors thesis) |  | X | X | X |

1. ***Timeline***
2. ***Diversity, Equity, and Inclusion (DEI)***

In the proposed study I will hire one undergraduate student. Independent of the student’s background or gender, I will address DEI by providing basic DEI education as part of the student’s summer research experience. Whether the student comes from an underrepresented group or not, there is value in increasing the education and awareness of students around DEI issues. By educating the student we will impact DEI not only for that individual, but it will hopefully have a further reach as it will allow that student to recognize, engage with, and hopefully affect change on DEI issues throughout their life. I will provide for this student (and all of my field crews) a short set of readings (3 articles, one about the value of diversity in general, one about diversity in the sciences, and one about gender issues in field ecology) that we will read and discuss early in the field season. I will also have this student (and all of the field crew) take one of the simple online tests for unintended biases. Awareness is a key first step to addressing any issue. We all have unintended biases and these tests, while not perfect, help make us aware of what they are.

**Bibliography & References Cited** - (1 page max)

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