The Effects of Mountain Pine Beetle Induced Forest Mortality on Headwater Aquatic Macroinvertebrate Communities

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March 21, 2011

Project Description

This project will assess the response of headwater stream macroinvertebrate communities to inputs of whitebark pine duff induced by mountain pine beetle invasion. To do this, I will conduct a field survey in conjunction with laboratory experiments to determine the behavioral and life history responses of dominant leaf-consuming benthic invertebrates and the associated changes in organic matter processing to whitebark pine duff inputs. Functions provided by benthic macroinvertebrates in headwaters provide important ecosystem-level functions, the impacts of which are propagated to downstream reaches. This project will be mentored by Dr. Laurie Marczak and will be conducted in conjunction with another, larger study being led by a graduate student in her lab. The larger project focuses on the effects of whitebark pine mortality on nutrient dynamics and ecosystem function in headwater stream food webs. Field sites and data may be shared between projects and both projects will have the potential to inform and complement each other.

Problem Being Addressed

In recent years, the forests of the Rocky Mountain West have been greatly affected by climate change. Strong evidence supports the probability that warmer summer and winter temperatures in the Northern Rockies are facilitating an extensive outbreak of the mountain pine beetle (Aukema et al., 2008; Raffa et al., 2008; Carroll et al., 2006), causing widespread mortality of the keystone whitebark pine stands of the Greater Yellowstone Ecoregion. Though research has been and continues to be widely conducted on the effects of this large-scale mortality on soil communities and terrestrial ecosystems (e.g. Arno 1986, Ellison et al. 2005, Bentz and Schen-Langenheim 2006), essentially no research has yet been conducted on the effects of this outbreak on headwater stream communities. Marczak et al. (2007) found that cross-boundary resource subsidies, such as leaf litter entering a stream, can significantly affect the food web dynamics in headwater ecosystems. In the case of whitebark pine mortality, large pulses of stoichiometrically novel litter entering headwater communities at the trophic base of the food web may be fundamentally altering aquatic community structure and function on those sites. This study will fill a current gap in our understanding of this outbreak through the assessment of the response of benthic macroinvertebrates to mountain pine beetle induced whitebark pine litter inputs.

What I Hope to Accomplish

I hope to expand our understanding of the effects of large-scale terrestrial community change on adjacent aquatic ecosystems through the study of the dramatic mountain pine beetle-influenced whitebark pine mortality in Western Montana. The field of aquatic-terrestrial boundary ecology is a largely understudied realm of ecological theory, although ecosystem boundaries are known to play a significant role in riparian and aquatic ecosystem structure and function. Small headwater stream communities, more than communities lower in a river system, depend on allochthonous inputs of organic matter for most of their production, as *in situ* primary production in these systems is limited. Insights gained from this study have the potential to further our understanding of the complexity of large-scale, climate-induced landscape changes on associated aquatic communities. Impacts from mountain pine beetle invasion may be propagated from high elevation terrestrial systems to river mainstems through organic matter processing loops and food web changes in small headwater streams. Understanding the basic dynamics of food web structure in these small headwater systems can be of critical importance to managers whose primary concern is with the management of important fisheries in larger river segments downstream.

Methods

In coordination with researchers investigating nutrient dynamics in headwater streams affected by whitebark pine mortality, I will conduct a broad scale survey to quantify the benthic aquatic invertebrate community composition in six streams near Daisy Pass, MT in the Custer National Forest outside Yellowstone National Park. Using standard surveying techniques – benthic surber samples replicated across microhabitats along a 200 m reach – I will collect macroinvertebrates for later identification in the lab. Preserved invertebrates will be identified to the lowest taxonomic level possible and assigned to functional feeding groups using data from Merritt and Cummins (1996). I will assess dominance of invertebrates in the shredding functional group based on abundance and biomass. Once I have identified community dominants in this functional group I will conduct a series of feeding and performance trials with these organisms. Dominant shredding invertebrates will be grown in the lab on a diet of green, red and grey phase whitebark pine needles (corresponding to the different stages of mountain pine beetle infestation). I will use statistical modeling (ANOVA approaches) to determine whether rate of growth and survival in these organisms is altered by stage of whitebark pine needle decay. I will determine decomposition rates of needles included in feeding trials by fitting a negative exponential function to ash-free dry mass (AFDM g) remaining at the conclusion of the experiment. Using an algebraic model and data collected during field surveys I will scale the results of my laboratory experiments to estimated functional changes at the reach scale (10^{10} m).

Relation To Climate Change

It is widely accepted that the mountain pine beetle epidemic being experienced throughout much of the West can be attributed to the warmer and drier summers and winters of recent years (Aukema et al., 2008; Raffa et al., 2008; Carroll et al., 2006). Climate change induced insect outbreaks are likely to continue or increase in coming decades. Since headwater streams are innately connected to their watersheds, alterations of terrestrial habitats by climate change will necessarily result in alterations of associated aquatic systems. Climate change will affect headwater systems in many unpredictable ways. The cumulative effects of a changing climate may reduce the resiliency of aquatic ecosystems to further variability in the future. Climate change may also limit the capacity of aquatic systems to provide crucial ecosystem services and functions within the landscape. Without stronger, more holistic understandings of the threats climate change plays for ecosystems, there will be no way for managers to best mitigate degradation.

Timeline

Early June	Initial Site Assessment and Macroinvertebrate Sampling
June-August	Laboratory Experiments and Continued Site Monitoring
September-November	Data Analysis and Written Summary Completed

Budget

I am requesting funds for wages of $10.00 per hour for 300 hours of work, for a cumulative salary of $3000.00 for the summer. Dr. Marczak has agreed to cover all research, travel, and supply costs associated with this project.

Literature Cited

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