College of Agriculture and Life Sciences
Proposal for Research Funds
Administered by the Office of Academic Programs
And the Cornell University Agricultural Experiment Station

Cover Sheet

STUDENT INFORMATION:

Student's Name: Jennifer Moslemi Cornell I.D.#: xxxxxxx
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RESEARCH INFORMATION:

Research Title: Linking hydrologic regime and stoichiometric imbalance in streams

NAME OF FUNDING PROGRAM(S) APPLYING TO:

Undergraduate:

☐ Hatch/Multistate Supplement

☐ Other *(includes: Jane E. Brody Undergrad Research; CALS Charitable Trust Research Grants; Dextra Undergraduate Research Endowment Funds; Morley Student Grants)*

Graduate:

☐ Arthur Boller Apple Research Grants ☒ Andrew W. Mellon Student Research Grants

☐ Kieckhefer Adirondack Fellowships

Previous CALS Awards *(indicate fund name, year and amount received):* ______

DEGREE STATUS:

Undergraduate:

Current Class: ______

Major(s): ______

Graduate:

Degree currently pursuing: PhD

Number of years already completed in current program: 3

FACULTY RESEARCH MENTOR:

Name: Alex Flecker
Department: Ecology and Evolutionary Biology
Email: asf3@cornell.edu

Faculty Research Mentor *(Signature):* ______

Please send completed cover sheet and proposal electronically to:
Sharon Loucks, CALS OAP, 173 Roberts Hall, sh51@cornell.edu.

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ABSTRACT

Human use of freshwater resources has altered the dynamics of hydrologic regimes in rivers around the world. Frequency, timing, and periodicity of extreme fluctuations in water flow have been modified, disrupting the flow regimes to which lotic biota have adapted over evolutionary time. The goal of the proposed research is to increase our understanding of how the hydrologic regime modulates links between biological communities and cycling of chemical elements, and by extension, to improve our predictions of ecosystem-scale consequences of alterations to flow regimes. I will use the theoretical framework of ecological stoichiometry to measure the relative incongruence of elemental ratios of biological supply and demand in the benthos of streams, and assess how these patterns are related to water flow characteristics. I will generate a comprehensive measurement of hydrologic disturbance that includes actual and potential substrate movement, and determine the stoichimetric relationships between benthic consumers and their resources in streams with distinct hydrologic regimes. The proposed research will integrate the traditionally disparate fields of organismal biology, community ecology, and ecosystem ecology to increase mechanistic understanding of dynamics operating at the levels of communities and ecosystems.

INTRODUCTION

Human impacts on water flow patterns of rivers are global in extent, and human-mediated change in water retention, land use, and climate can have often unanticipated consequences for lotic communities and ecosystem processes (Poff et al. 1997). Extreme fluctuations in flow and the accompanying movements of substrate are one of the primary sources of hydrologic disturbance in rivers and streams (Poff and Ward 1989) and are widely regarded as an important driver of community structure (Resh et al. 1988, Lake 2000). Given the knowledge that streams are hydrologically dynamic, studies of interactions between lotic communities and ecosystem processes should incorporate the importance of extreme flow variation. *The overarching goal of my research is to increase our understanding of how hydrologic regime modulates links between aquatic communities and cycles of biologically important chemical elements.* The proposed research will use the theoretical framework of ecological stoichiometry to integrate community and ecosystem processes in streams.

BACKGROUND AND LITERATURE REVIEW

Ecological stoichiometry and the balance of resource supply and demand

Stoichiometry is the measurement of quantitative relationships between chemical constituents that are involved in, and produced by, chemical reactions. In ecological stoichiometry it is the balance between biologically important chemical elements in ecological interactions that is of interest. Ecological stoichiometry has been put forth as a conceptual framework that increases mechanistic understanding of complex ecological dynamics by distilling them into mass balance relationships (Elser et al. 1996, Sterner and Elser 2002). Using ecological stoichiometry, for example, food web interactions can be examined by congruence of elemental ratios of biological supply and demand, and causes and consequences of a lack thereof (Sterner et al. 1996, Schade et al. 2005). Under stable conditions a species in relative stoichiometric balance with a given resource supply will have fewer food quality constraints on growth and reproduction, and thus gain a competitive advantage over other species within a functional group (Sterner and Elser 2002). Yet conditions are not often stable in natural systems, and temporal and spatial heterogeneity can alter supply ratios at different scales. Factors external to communities—such as temperature, disturbance regime, and solar radiation—provide a "stoichiometric template" (Schade et al. 2005), defining the range of stoichiometric responses of communities to supply ratios (Elser et al. 2000, Woods et al. 2003). Such factors may drive and/or maintain stoichiometric imbalances, acting against forces such as natural selection that over evolutionary time should bring organisms towards stoichiometric balance with their food (Redfield 1958, Sterner et al. 2004). Despite the influence of these external factors on elemental cycles in ecosystems, their identities and importance are often unclear.

Hydrologic disturbance and stochiometric balance in benthic systems

Ecologists are just beginning to recognize external factors that form the stoichiometric template at broad scales in streams (e.g anthropogenic nutrient enrichment; Bowman et al. 2005). Hydrologic regime is likely a significant determinant of the stoichiometric template because of its influence on community structure and dissolved nutrient availability on broad scales. During floods, high discharge can suspend sediments, reduce nutrient availablity, move and redistribute benthic material, remove algae by scouring the streambed, and kill or displace biota (Lake 2000, Holmes et al. 1998). By subjecting organisms to a harsh environment characterized by scouring, extreme flow events can alter relative densities of consumers and their prey (Peckarsky 1983). Since benthic species often differ in elemental composition (Cross et al. 2003, Evans-White et al. 2005), hydrologic events that drive the identity and relative densities of biota can change system-wide stoichiometric patterns of resource supply and demand (Schade et al. 2005). Hydrologic disturbance can also reduce dissolved nutrient availability, which can change the stoichiometry of benthic producers that serve as food resources to higher trophic levels (Holmes et al. 1998).

The hydrologic regime has the potential to alter elemental patterns in benthic systems by mediating community structure and dissolved nutrient availability, but links between stoichiometric imbalance and hydrologic disturbance have not been examined. The proposed research would provide information to improve our ability to predict consequences—ranging from impacts on biogeochemical cycles to food quality constraints on individual organisms—of human modification of hydrologic regimes.

RESEARCH OBJECTIVE AND HYPOTHESIS

Objective: Identify watershed-scale relationships of hydrologic disturbance regime and stoichiometric imbalance between resource supply and demand in benthic communities.

Hypothesis: Relatively high levels of hydrologic disturbance will be associated with increased stoichiometric imbalance between consumers and resources in benthic systems.

Rationale: Communities associated with relatively harsh hydrologic regimes experience a reduction in resource availability due to the scouring caused by flood events. These organisms may be forced to draw from lower quality food patches, likely increasing stoichiometric imbalance between resource supply and demand relative to systems associated with more physically benign conditions.

STUDY SYSTEM

I will work in the East River drainage basin near the Rocky Mountain Biological Laboratory (RMBL) in western Colorado. This is an excellent site for an analysis of water flow effects on stoichiometric imbalance because: (1) hydrologic regime varies across streams throughout the drainage basin and has been recorded in a subset of streams continuously over the past three years, (2) benthic communities in these high altitude systems have moderate biodiversity, making them feasible candidates for comprehensive stoichiometric analysis, (3) differences in plant and invertebrate community composition are associated with variation in hydrologic characteristics, and (4) streams in this region are likely to experience altered precipitation patterns—and therefore altered hydrologic regime—due to climate change (Hauer et al. 1997, Inouye et al. 2000). It is therefore imperative to increase our ability to predict consequences of climate change-mediated impacts to these benthic systems.

METHODOLOGY

I will examine patterns of hydrologic disturbance and biotic stoichiometry across the East River watershed. I will work in 10 streams previously determined to be phosphorus limited (Moslemi, *unpublished data*), and that reflect a gradient of hydrologic variability (Peckarsky, *unpublished data*).

Characterization of disturbance regime

Together with collaborators at the RMBL, I will characterize the hydrologic regime of the 10 study streams using three indices: (1) discharge variability, (2) potential substrate movement, and (3) actual substrate movement. Discharge variability will continue to be calculated from information provided by TruTrack stage height data loggers. Year-round data from loggers will enable a comparative analysis of magnitude, frequency, duration, timing, and predictability of high and low flow events among streams (Lytle and Poff 2004), and subsequent classification of streams on a continuum of stable to highly variable using a principle components analysis (*sensu* Taylor and Warren 2001). Actual substrate movement will be measured using a technique combining photography of stream beds and GIS technology to determine particle movement into and out of established transects (Peckarsky, *unpublished data*). Potential substrate movement will be estimated from tractive force and particle size distributions (*sensu* Giberson and Caissie 1998, Parker and Huryn 2006).

By using three indices to characterize hydrologic regime I will generate a robust estimate of relative impacts experienced by benthic communities. If water flow variability were the sole estimate of disturbance, for example, I may not adequately capture stability of the benthos if particle size varies between streams. This comprehensive approach and use of novel techniques will move closer to solving the inherently difficult problem of defining disturbance in streams.

Collection of food web components

Basal resources (algae and detritus) will be collected biweekly for a total of 8 weeks in each study stream for analysis of stoichiometric composition. I will collect samples at three randomly chosen transects within each 50m study reach. Periphyton will be removed from 5 rocks and algal and detrital fractions separated at each transect. Within the algal fraction, filamentous algae will be separated from diatoms by creating a density gradient with colloidal silica following Hamilton et al. (2005). Biomass of primary producers and detritus will be estimated by measurements of ash-free dry mass, obtained by combusting samples in a muffle furnace at 500° C (*sensu* Wallace et al. 2006). I will identify benthic macroinvertebrates to species and estimate densities biweekly using a modified box sampler (D. Hoffman, U. of Wisconsin). Classifying organisms by species allows for finer detection of stoichiometric differences that may be lost if lumped into broader categories. I will use established length to mass ratios to estimate biomass of consumers (Benke et al. 1999). Six samples of each food web component will be collected for transport to Cornell University where C:N:P ratios will be analyzed using standard methods. I will also collect water samples at each study stream to analyze relative dissolved C, N, and P availability using equipment available at Cornell University.

Analysis of stoichiometric imbalance and construction of trophochemical food webs

Elemental composition data will enable me to determine stoichiometric imbalance within food webs across streams of varying hydrologic regimes. I will construct trophochemical food web diagrams (*sensu* Sterner et al. 1996; Fig 1) to represent and evaluate imbalances. The utility of this technique is its graphic expression of several chemical substances simultaneously within webs of interacting species—a representation of stoichiometric patterns at the community level. Species will be plotted on axes representing concentrations of N and P, and C abundance will be given by the size of the circle centered on coordinates generated by N and P data. For each consumer-resource pair, the size of the angle created by two rays emerging from the origin will be analyzed as a measure of imbalance. In this way I will be able to both quantify and visually represent which trophic interactions are imbalanced for consumer growth and relate occurrence and magnitude of imbalances to characteristics of the hydrologic regime.

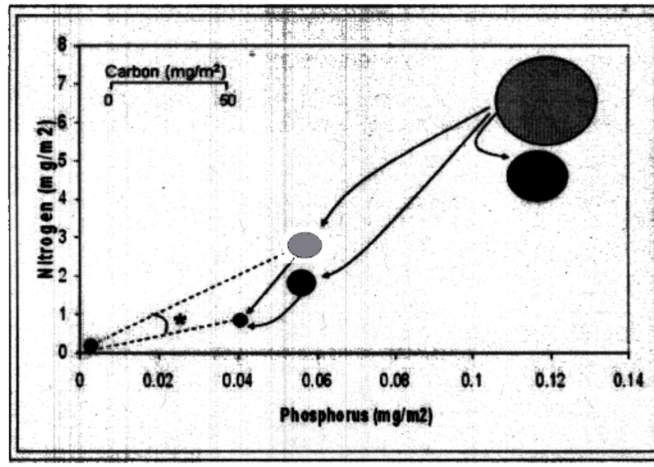

Fig. 1. Hypothetical example of a simple trophochemical food web diagram indicating amounts of C, N, and P within benthic species in the East R basin. The predator is represented by the black circle, grazers by dark shading, and algae by light shading. Dashed lines signify N:P ratios of a predator-prey pair, and stoichiometric imbalance between the two species is given by the angle formed by the lines (indicated by a (*)). Feeding relationships are represented by arrows.

SIGNIFICANCE

The proposed research will integrate the traditionally disparate fields of organismal biology, community ecology, and ecosystem ecology to increase our understanding of the processes that drive patterns of biologically important elements in ecosystems. It one of the first attempts to examine influences of disturbance on stoichiometric imbalances between resource supply and demand. Stoichiometric imbalance impacts organizational levels ranging from the organism (by affecting growth rates and reproductive success), to the ecosystem (by affecting nutrient cycling). Study of the factors that shape patterns and magnitudes of imbalances will increase our mechanistic understanding of community and ecosystem dynamics.

In lotic systems around the world, and in Colorado in particular, natural flow regimes continue to be modified due to human demand for water (Lytle and Poff 2004). These modifications are likely to increase as a result of population growth and global climate change (Inouye et al. 2000). Understanding the effects of hydrologic regime on the flow of energy and nutrients on broad scales is critical to inform mitigation efforts and appropriate management strategies. The implications are far-reaching: benthic systems have direct economic and social relevance as the resource base for organisms that provide important protein sources to humans.

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BUDGET

I am requesting $1,500 from the Andrew W. Mellon Foundation. In addition, I have been awarded $2,000 from the IGERT in Biogeochemisty and Biocomplexity for this project and have requested $700 from the Cornell University Graduate School. These three sums will allow me to fund the proposed research in its entirety, as I will have access to equipment at the RMBL.

Travel to the RMBL (RT airfare from Syracuse, NY to Gunnison, CO)	$700
Room at the RMBL (9.5 weeks; incl. housing, station fees, shared lab rental)	$1,930
Supplies (sample bottles, vials, sampling syringes, whirlpaks etc.)	$500
Dissolved C, N, and P analysis (4 samples in each of 10 streams @ $3/sample)	$120
C:N:P analysis of consumers and resources (150 samples @ $3/sample)	$450
Truck rental (portion owed for shared use between 3 graduate students)	$500

	Arrive at the RMBL at set up lab, housing
	Discharge data on TruTrac loggers and collect geomorphology data for potential substrate movement calculations. Set up camera for actual substrate movement analysis.
June 22-Aug 17, 2007	Sample water, epilithon, benthic invertebrates biweekly. Photograph substrate 4 times for analysis of actual substrate movement.
Aug 21, 2007	Return to Cornell University
Aug 22-Nov 22	Analysis of stoichiometric and hydrologic disturbance data; creation of trophochemical webs

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Education

2003- present PhD Candidate, Ecology and Evolutionary Biology, Cornell University
Advisor: Alex Flecker

1996-2001 BS in Biology, University of Washington, *cum laude*,
1999 Universidad de Cadiz (Spain)

Research & Professional Experience

2004-present "Stoichiometric imbalance between resource supply and demand in benthic systems", Cornell University
2002-2003 Fisheries ecologist, National Oceanic Atmospheric Administration
2001-2002 Field ecologist, Magellanic Penguin Project, Argentina
2000-2001 Participant, Field Ecology and Ethology Course, University of Washington
2000 Field assistant for PhD candidate Wendy Palen, "UV impacts on alpine amphibians", University of Washington
1999-2000 Undergraduate research assistant, Dr. Shahid Naeem, University of Washington
1999 Summer internship with Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica.

Teaching Experience

2005 Stream Ecology Teaching Assistant, Cornell University
Lectured on disturbance in stream systems; developed laboratory exercise on analysis of stream water chemistry

Publications

Hoekstra, J. H., K. K. Bartz, M. H. Ruckelshaus, J. M. Moslemi, and T. Harms. Quatitative threats analysis for management of an imperiled species - Chinook salmon (*Oncorhynchus tshawytscha*). Ecological Applications. *In review*.

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Fellowships and Grants

2009	Cornell University Fellowship
2005-2008	National Science Foundation Graduate Student Fellowship (2005-2008)
2006	Program in Biogeochemistry and Biocomplexity Small Grant
2003-2005	National Science Foundation IGERT Fellowship (2003-2005)
2004	Andrew W. Mellon Student Research Grant
2004	Program in Biogeochemistry and Biocomplexity Small Grant

Service

2004-present	Graduate student committee member, Cornell University
2005-present	Biogeochemistry and Environmental Biocomplexity Graduate Student Assoc. Active Member, Graduate student manuscript coordinator
2004-2006	Workshop leader, Expanding Your Horizons, a conference for high school girls designed to nurture interest in science and math
	Biogeochemistry and Environmental Biocomplexity Small Grant Review Panelist
	Workshop leader, 4-H Environmental Appreciation Days, a hands-on nature and ecology program for local 4th-6th graders

Memberships

Ecological Society of America
Society of Conservation Biology
North American Benthological Society
American Institute of Biological Sciences
International Society of Ecological Economics