1 Faculty Research Grant, Kenneth Fortino

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Grant Sought: Faculty Research Grant

Grant Period: 2 - 3 years

Amount Requested: $8300

Date of Submission: January 2013

Applicant (Kenneth Fortino)

Department Chair (Mark Fink)

Dean (Chuck Ross)

II. Project Abstract

Small ponds are one of the most abundant types of aquatic habitat, and due to human pond construction, are increasingly abundant in regions that lack natural lakes and ponds. Furthermore, pond sediments house diverse animal (mainly larval insect) communities and are highly active systems for the breakdown of organic carbon. When organic carbon is broken down by pond microbes, stored carbon is released into the atmosphere as CO_2 where it can accelerate climate change. Despite this, man-made ponds are understudied, and the interaction between biodiversity and ecosystem function in ponds is poorly understood. The goal of the proposed research is to evaluate the impact of sediment insect functional diversity on the breakdown of organic carbon in man-made ponds. We propose to accomplish this goal through 1. the characterization of sediment insect functional diversity in man-made ponds near Longwood University, and 2. experimental analysis of the effect of functional diversity on the breakdown of organic carbon in the pond sediments. The proposed project is designed to establish a research program based in ponds near Longwood University that will further our understanding of the interactions between biodiversity and ecosystem function in aquatic systems, as well as increase our knowledge of the role man-made ponds play in climate change. The proposed research program will provide opportunities to train undergraduate research students, and offer potential for collaboration both within and outside of the university.

III. Narrative Description of the Project

The impact of biodiversity on ecosystem function: effects of functional diversity on organic carbon breakdown in pond sediments.

A. Rationale Human activities have resulted in dramatic changes to many of the Earth's ecosystem processes. Forest clearing and the burning of fossil fuels have altered the carbon cycle and changed the climate (Tranvik et al. 2009). Simultaneously human land-use has altered the distribution of many species and overall reduced the biodiversity of the Earth (Hooper et al. 2012). One striking example of a human activity that affects both biodiversity and carbon cycling is the construction of ponds. The number of man-made ponds is increasing exponentially (Downing et al. 2006) and in regions without abundant natural lakes, such as Virginia, man-made ponds represent a dominant habitat for freshwater biodiversity. Ponds are highly active sites of organic carbon breakdown and therefore have the potential to release stored carbon into the atmosphere as CO_2, where it can accelerate climate change. Nonetheless, the impact of man-made ponds on climate change and biodiversity remains poorly understood.

The proposed project will evaluate the impact of biodiversity on the breakdown of organic carbon in the sediments of man-made ponds. This project expands on my past work (Tranvik et al. 2009, Fortino 2010) and will allow me to continue to develop my investigations into the factors controlling carbon cycling in aquatic systems. This research will benefit the field of aquatic ecology, since man-made ponds are understudied systems (Tranvik et al. 2009) and the relationship between biodiversity and ecosystem functioning is a fundamental question in ecology and environmental science (Hillebrand and Matthiessen 2009, Hooper et al. 2012). Addressing these questions through research done at Longwood University will contribute to the strong program in environmental science that is being developed in the Department of Biological and Environmental Sciences (BES). BES has several faculty

who specialize in aquatic systems, and thus the department has the potential to become a strong focal point of aquatic biology and environmental science. Establishing research projects in local systems will provide the foundation for the continued development of aquatic environmental science research at Longwood and provide opportunities for collaboration within BES and with researchers at other universities.

The proposed project has been designed from the ground up to incorporate undergraduate research students. The project builds off of preliminary research that was begun at DePauw University using only undergraduate researchers, and which resulted in 2 student poster presentations at DePauw's Research Symposium, plus I will present the results at the national meeting of the Society for Freshwater Science this year. The project described in this proposal is designed to lay the foundation of a research program that will provide extensive undergraduate research opportunities. Furthermore, the data collected will be valuable for developing laboratory and classroom exercises for upper level ecology and environmental science courses in BES.

B. Goals The principle goal of the proposed research is to *elucidate the effect of insect functional diversity on organic carbon breakdown in the sediments of man-made ponds*. The importance of biodiversity on ecosystem processes is a fundamental question in ecology and environmental science (Hillebrand and Matthiessen 2009, Hooper et al. 2012), and the role of man-made ponds in carbon cycling and climate change is poorly understood (Tranvik et al. 2009). In order to accomplish the above goal, the project is divided into 2 objectives:

Objective 1: Characterize the functional diversity of sediment insect communities in local ponds.

Pond sediments contain diverse communities of aquatic insects. Prior work by myself (K. Fortino, unpub. data) and others (Boyero et al. 2007, Hunting et al. 2012) have found that these aquatic insects interact with their environment in different ways (e.g., tube-builders, predators, collectors, etc...),

producing functional diversity in addition to species diversity. Objective 1 is designed to describe the patterns of functional diversity in the sediments of ponds near Longwood University, which will provide valuable information on the biodiversity in man-made ponds. Furthermore, when correlated with data collected about the physical environment of the ponds, the characterization of functional diversity will provide insight into the factors that control biodiversity in man-made systems. Finally, the description of pond functional diversity is essential for the development of the experiments in the second objective. The data collected as part of objective 1 will be used to frame the hypotheses about how the observed functional diversity affects sediment organic carbon breakdown (objective 2).

Objective 2: Test the effect of observed functional diversity on the breakdown of sediment organic carbon.

The research that I completed for my doctoral dissertation (Fortino 2010), as well as the work of other researchers (Hargrave 1969, den Heyer and Kalff 1999) have shown that the rate of organic carbon breakdown in lake sediments is primarily controlled by factors local to the patch of sediment being observed (e.g., temperature, oxygen availability, etc...). The activity of sediment insects can alter these local environmental factors and affect the rate of organic carbon breakdown in the sediments where they occur (Harrault et al. 2012). Most of the previous work on the effect of sediment-dwelling insects on sediment processes has evaluated the effect of a single insect species at a time (Hunting et al. 2012). The experiments associated with objective 2 are designed to explicitly evaluate the effects of the interactions between insects in functionally diverse sediment communities. There is very little existing research on how interactions between co-occurring sediment-dwelling insects affect ecosystem processes, especially in man-made ponds. The data collected through this objective will provide essential information on how the insect communities of man-made ponds alter the role ponds in carbon cycling and climate change.

Taken together the two objectives will provide valuable information about the biodiversity and function of man-made ponds in the Southeast, a region virtually devoid of natural ponds and lakes. Furthermore, the results of these objectives will inform our understanding of the role of man-made ponds in a changing climate.

C. Subjects The only organisms used in this research will be the sediment-dwelling macroinvertebrates collected from the pond sediments. Upon completion of the proposed collections or experiments, all organisms will be sacrificed and preserved in 70% ethanol.

D. Procedures

Objective 1: I propose to characterize the functional diversity of the sediment insect communities of 3 - 6 ponds in the vicinity of Longwood University. The exact number of ponds used will depend on the density and diversity of the communities that we find, and thus the amount of time required to process the samples. At a minimum we will sample Wilck's Lake - located in Wilck's Lake Park on Third St. in Farmville, and 2 ponds located in the wetland area associated with Lancer Park. These 3 ponds will provide a gradient in size and degree of human impact. Sediment insect communities will be collected from a representative sample of habitat locations within each pond throughout the year. Sediment collection will begin this spring as part of the research responsibilities of 2 research students (BIO 496/497) working in my lab and continue approximately monthly through the year.

In each pond the sediment animal communities will be sampled using an Ekman dredge. The collected sediments will be washed through a 250 μm mesh net to remove fine sediment, and the remaining sample will be preserved in 70% ethanol. Preserved insects will be sorted from the surrounding sediment and counted using a dissecting microscope. My lab is already equipped to collect and sort the sediment insects. However, to identify the insects and assign them to functional groups we will need to mount the insects on microscope slides and observe them under a compound light

microscope. The proposed budget contains money to acquire a microscope and a portion of the lab consumables budget will be for the mounting materials. In addition to the insect collections, basic environmental information will be collected from each pond on each sampling date.

Objective 2: To test the effect of functional diversity on the breakdown of sediment organic carbon, my students and I will conduct a series of sediment incubation experiments. When sediment microbes break down organic carbon into CO_2 they consume oxygen. Therefore, sediment oxygen demand (SOD) is a measure of the amount of sediment organic carbon breakdown. Experiments will be conducted in containers (approx. 500 ml) containing lake sediments and overlying water from the lake. Each experiment will consist of a manipulation of insect functional diversity and the simultaneous measurement of SOD.

Sediment oxygen demand will be measured using the Winkler titration method (Carpenter 1965). To perform Winkler titrations I will need the digital buret, reagents, and biological oxygen demand (BOD) bottles indicated in the budget. Furthermore, the budget contains money for the construction of the incubation chambers. These chambers are constructed from mason jars that have been modified to allow for the removal of water samples without the introduction of air.

Timeline for Completion of the Project: The lake sampling to characterize the functional diversity of the sediment community will begin this spring and continue for approximately 1 year. The SOD experiments will be conducted during the summer of 2013 with a summer research student from the PRISM program, and with the plan of continuing in the summer of 2014. The analysis of the experiments will be complete by the end of the summer of 2014 and the manuscript preparation will begin during the fall of 2014 with plans to submit for publication by the end of the 2014. Since this project is designed to provide a foundation for continuing studies of the interaction between biodiversity

and ecosystem function in ponds, new project planning based on the findings of the summers of 2013 - 2014 will begin during the fall of 2014.

E. Expected Outcomes The principle expected outcome of this project is the establishment of a program of research in pond biodiversity and biogeochemistry that will provide scholarship opportunities for myself and research experience for Longwood students. The materials requested in this proposal will provide my lab with the equipment needed to train research students and develop collaborations with researchers both at Longwood and other universities.

F. Current Status of the Project The proposed project builds off of work that I conducted as part of my doctoral dissertation, as well as a research project performed at DePauw University. My dissertation research found that the major factors affecting organic carbon breakdown in lake sediments were temperature and oxygen availability (Fortino 2010). My work at DePauw showed that different functional groups of insects (predators and collectors) varied in their effect on SOD (K. Fortino, unpub. data). Collector insects increased SOD in the sediments of a shallow quarry pond, yet there was no effect of the presence of predatory insects. These results are intriguing because they suggest that alterations to the insect community can affect the ability of ponds to store organic carbon in their sediments, however these results are from a unique system (i.e., a shallow quarry pond) and may not be representative of more typical man-made ponds. I am working with 2 research students this spring to initiate the pond sampling and one of these students will likely be continuing to work on this project this summer as part of the PRISM program.

G. Personnel Most of the techniques required for the completion of this project were utilized in the completion of my dissertation research and I have approximately 13 years of experience performing research in aquatic systems. Furthermore, I have experience collecting and identifying aquatic insects from the southeastern United States.

IV. Budget

To acquire the materials needed for the completion of this project I will need $8300. The majority of the budget is for the compound microscope needed to identify the insects collected from the pond sediments. The remaining items will be used to set up the necessary apparatus to incubate the sediments and measure SOD. The digital burette, BOD bottles, and reagents are needed for the Winkler titration.

Compound Microscope	$4300
Digital Buret	$1000
BOD Bottles	$800
Reagents	$500
Incubation Chambers	$200
Lab Consumables	$1500
Total	$8300

V. Previous Grants

Summer Research Fellows Grant at DePauw University - $1000

Literature Cited

Boyero, L., Pearson, R. G., and Bastian, M. 2007. How biological diversity influences ecosystem function: a test with a tropical stream detritivore. Ecological Research 22:551-558.

Carpenter, J. H. 1965. The Chesapeake Bay Institute technique for the Winkler dissolved oxygen method. Limnology and Oceanography 10:141-143.

den Heyer, C. and Kalff, J. 1998. Organic matter mineralization rates in lakes: a within- and among-lake study. Limnology and Oceanography. 43:695-705.

Downing, J. A., Prairie, Y. T., Cole, J. J., Duarte, C. M., Tranvik, L. J., Striegl, R. G., McDowell, W. H., Kortelainen, P., Caraco, N. F., Melack, J. M., and Middleburg, J. J. 2006. The global abundance and size distribution of lakes, ponds, and impoundments. Limnology and Oceanography 51:2388-2397.

Fortino, K. 2010. Organic matter processing in arctic lake sediments. Dissertation. University of North Carolina at Chapel Hill.

Hargrave, B. T. 1969. Similarity of oxygen uptake by benthic communities. Limnology and Oceanography 14:801-805.

Harrault, L., Allard, B., Danger, M., Maunoury-Danger, F., Guipart, A., and Lacroix, G. 2012. Influence of food-web structure on the biodegradability of lake sediment. Freshwater Biology 57:2390-2400.

Hillebrand, H. and Matthiessen, B. 2009. Biodiversity in a complex world: consolidation and progress in functional biodiversity research. Ecology Letters 12:1450-1419.

Hooper, D. U., Adair, E. C., Cardinale, B. J., Byrnes, J. E. K., Hungate, B. A., Matulich, K. L., Gonzalez, A., Duffy, J. E., Gamfeld, L., and OConner, M. I. 2012. A global synthesis reveals biodiversity loss as a major driver of ecosystem change. Nature 486:105-108.

Hunting, E. R., Whatley, M. H., van der Geest, H. G., Mulder, C. Kraak, M. H. S., Breure, A. M., and Admiraal, W. 2012. Invertebrate footprints on detritus processing, bacterial community structure, and spatiotemporal redox profiles. 2012. Freshwater Science 31:724-732.

Tranvik, L. J., Downing, J. A., Cotner, J. B., Loiselle, S. A., Striegle, R. G. , Ballatore, T. J., Dillon, P., Finlay, K., Fortino K., Knoll, L. B., Kortelainen, P. L., Kutser, T., Larsen, S., Laurion, I., Leech, D. M., McCallister, S.L., McKnight, D.M., Melack, J. M., Overholt, E., Porter, J. A., Prairie, Y., Renwick, W. H., Roland, F., Sherman, B. S., Schindler, D. W., Sobek, S., Tremblay, A., Vanni, M., Verschoor, A. M., von Wachenfeldt, E., Weyhenmeyer, G. S. 2009. Lakes and reservoirs as regulators of carbon cycling and climate. Limnology and Oceanography, 54:2298-2314.