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Department of Biological Sciences
College of Science and Engineering
921 South 8th Avenue, Stop 8007 • Pocatello, Idaho 83209-8007

RYAN BLACKADAR

Idaho State University
DeVlieg Taylor Graduate Assistantship 2011

October 17, 2011

Dear Janet and the DeVlieg Foundation,

It is amazing how fast time flies by when you are having fun, but it is still hard to believe that I am now in my second year of graduate school! My first year of school was demanding, as I had to balance full coursework with monthly research trips into Big Creek for data collection. Then in the Spring 2011 semester, I prepared a formal written proposal of my thesis project and presented a proposal talk to the Biology Department here at Idaho State University on April 28, 2011.

In my first year of school, I attended several scientific conferences to discuss my research with professionals from other institutions and to distribute preliminary results. In October 2010, I traveled to Boise, ID for the annual NSF Idaho EPSCoR conference to meet fellow researchers involved in climate change research in the Salmon River Basin. Then in March 2011, I attended two scientific conferences: the annual meeting for the Idaho Chapter of American Fisheries Society in Boise, ID, and also the Spring Runoff Conference at Utah State University in Logan, UT. I attended these conferences to learn about the latest research and techniques from a wide range of disciplines (fisheries, hydrology, geomorphology, etc.).

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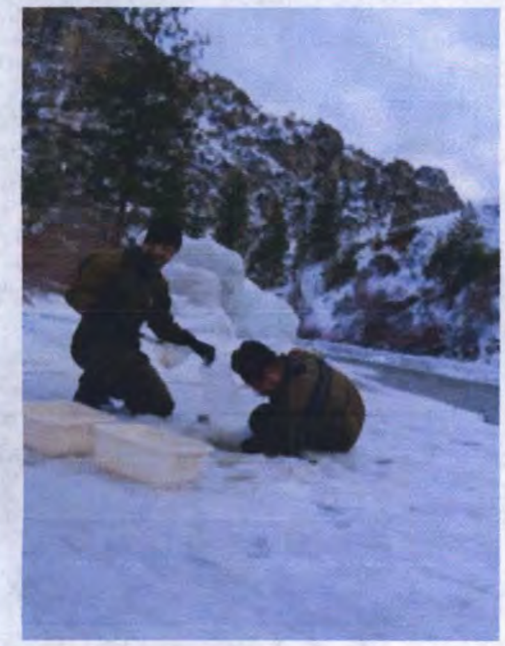
Next in May 2011, I traveled to Providence, RI for the North American Benthological Society annual meeting to present a research poster from data I collected in the winter of 2010-2011. Lastly, in August 2011, I helped organize and lead a collaborative EPSCoR research float trip down the Middle Fork Salmon River. This float trip allowed for quality time to discuss current research and brainstorm future directions with other EPSCoR scientists, including representatives from Idaho State University, Boise State University, and the University of Idaho. This inter-disciplinary trip was highlighted in the Summer 2011 EPSCoR newsletter and stimulated exciting ideas for the future of climate change research in Idaho. Even in just one year, I have been successful in distributing my research project to other scientists.

In addition to discussing my project with fellow scientists, I have been busy communicating my research concepts to the general public. My research was highlighted in the Spring/Summer 2011 edition of the *Idaho State University Magazine*, which is sent out to all ISU alumni and staff. This magazine article was successful in elevating the profile of my research by conveying my research in ordinary terms. This magazine article was recently followed up with an on-camera interview to be used in an ISU television show that will air around the state on Idaho Public Television in the Spring 2012. Also, the ISU Stream Ecology Lab is active in educating local youth about the importance of healthy watersheds. Recently in September and October 2011, I volunteered to help middle school students on field trips and lectured on aquatic macroinvertebrates and connections between land-use and water-quality. Relaying complex, scientific results to the general public is a hurdle for many scientists, but I have done my best to describe my research in terms that anyone can understand.



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Besides conducting my own research, I have also helped undergraduates prepare research projects conducted from TWFS and synthesize their results. During the winter of 2010-2011, I collected ~60 river otter scat samples near TWFS to be used in an undergraduate research project. Devin Baumer, ISU undergraduate, also helped collect the scat samples and then analyzed the proportion of prey items within the scat samples. Devin found that river otters primarily feed on fish in the winter; however, macroinvertebrates made up a significant proportion (~20%) of diet items as well. I am currently assisting Devin in preparing a poster presentation for her research project. In addition, I also helped Tess Gardner, 2011 DeVlieg Undergraduate Scholar, prepare for her summer research project focused on correlating periphyton standing crop biomass to metabolism. Prior to Tess flying into TWFS, I helped her design the research methods and practice the dissolved oxygen measurements. I am currently assisting Tess in the laboratory by teaching her sample-processing methods and will be involved with her research into the future. By mentoring undergraduate student researchers, I have helped develop new interest for science conducted from TWFS and a better understanding of the scientific process.

Attached are my written proposal and a statement of the current status of different components of my research project. My proposal explains in detail the overall hypotheses and goals of the project. The current status report describes where I currently am at with the components of the research described in the proposal. I hope these materials will be satisfactory as an annual report of my project. I have also prepared a short video of some of the fieldwork from winter 2010-2011 to help visually communicate my research project.

If you have any questions or comments, please feel free to let me know and I would be happy to discuss them with you. Also, if there is any other documentation that you need on the status of this project please let me know. I am excited for my second year in graduate school and look forward to talking with you soon. Once again, thank you so much for all of you support, this would not be possible without your assistance.

Sincerely,

Ryan J. Blackadar
Stream Ecology Center
Department of Biological Sciences, Box 8007
Pocatello, ID 83209-8007

THE PRICE OF ICE: ECOLOGICAL CONSEQUENCES OF CHANGING ICE REGIMES FOR LINKED AQUATIC-TERRESTRIAL FOOD WEBS

R. J. Blackadar, C. V. Baxter, J. M. Davis

Current Status of Research (17 October 2011)

Executive Summary:
My research project is focused on the ecology of rivers in winter and the role of ice in river ecosystems. The study design incorporates repeated sampling of aquatic organic material, which is known to serve as important food resources to aquatic consumers (macroinvertebrates, fish, etc.). I choose to sample two types of aquatic organic material, periphyton and transported organic material, because they represent two different types of food resources available to aquatic consumers. Periphyton is the complex assemblage of bacteria, fungi, and algae, that grows on rock surfaces and is an important food resource for aquatic macroinvertebrates specialized to scrape this material from the rock surfaces. Transported organic material is a combination of aquatic (algae, diatoms, macrophytes, etc.) and terrestrial (leaves, pine needles, wood, etc.) organic material that is suspended in the water column and is an important food resource for aquatic macroinvertebrates that filter food particles from the moving water. Thus, changes in the availability and use of periphyton and transported organic material by aquatic macroinvertebrates could help predict effects of altered river ice cover with future climate change. Also, organic material and macroinvertebrates form the base of food webs in river ecosystems. Therefore, if ungulate carcasses deposited into the river channel provide a nutrient subsidy to river ecosystems, I will detect this response by comparing organic material and macroinvertebrate gut contents at sites with an ungulate carcass to similar sites without an ungulate carcass.

Figure 1 – **Ryan Blackadar sampling organic material at night and locating ungulate carcasses.**

Hypothesis 1: The spatial extent and duration of ice cover on Big Creek has declined over time, likely due to associated increases in atmospheric and river temperatures. This has likely altered the timing and frequency of ice-out disturbance events.

The Taylor Wilderness Field Station (TWFS) research journals were hand-written by long-term station managers, Jim and Holly Akenson. In 2010, these hand-written research journals, which span the years March 1999 – May 2010, have been scanned onto a computer and are now accessible from the University of Idaho's Library Digital Collection: http://contentdm.lib.uidaho.edu/cdm4/browse.php?CISOROOT=%2Ftaylor. In the coming months, I will start scanning these research journals for anecdotes describing the spatial extent of river ice cover and the timing and frequency of ice-out disturbance events. By comparing these data to weather data, I will attempt to correlate past climate conditions with ice cover on Big Creek. Such a comparison will help assess what ice cover may look like in the future.

Hypothesis 2: Inputs of ungulate carcasses to Big Creek is positively related to the spatial extent and duration of ice cover for a given year.

Monthly fixed-wing aircraft flights (December 2010-March 2011) into TWFS allowed me to video-document the spatial extent of river ice cover for a 24 km segment of Big Creek surrounding TWFS (MF Salmon confluence upstream to Cabin Creek). As these videos were collected during the flights in and out of TWFS, I have two sample dates for each month. These videos are currently being catalogued and analyzed. For each flight along the entire 24-km research segment, I am classifying river ice coverage into one of four categories: (0-25, 25-50, 50-75, 75-100%). Because the flight surveys were only conducted bimonthly, I also used digital interval cameras (primarily used for hunting) programmed to take hourly photos of river ice cover in Big Creek. These cameras took more detailed photos of a ~2 km segment of Big Creek near TWFS. From December 11, 2010 through February 9, 2011, I documented ice cover on an hourly basis along this approximate 2km segment of Big Creek. This method allowed me to quantify ice cover and ice-out events at a finer timescale. In fact, I precisely documented a significant ice-out event on December 27, 2011, even without being onsite at Taylor (Fig. 2). The combination of the flight and camera ice data will allow me to assess ice conditions at both a large spatial scale and a fine timescale. Data generated by these two methods will be combined with my ungulate carcass data to help assess Hypothesis 4 (*see* below).

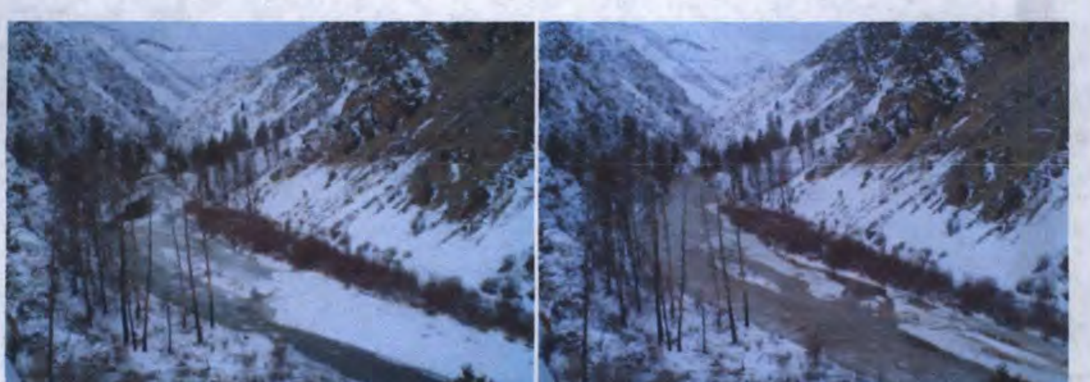

Figure 2 – December 2010 Big Creek ice-out event. Photo on left taken one hour prior to photo on right.

Hypothesis 3: Periods of surface ice cover are associated with reduced periphyton standing crop biomass and a decrease in transported organic material when compared to pre-ice cover conditions. Similarly, ice-out events scour the riverbed and reduce periphyton standing crop biomass, but increase transported organic material. A reduction in periphyton biomass from river ice cover and ice scour will result in a decrease in the proportion of periphyton within the gut contents of aquatic invertebrates.

I collected monthly (December 2010 – March 2011) periphyton samples from 36 sites encompassing ~3 km segment of Big Creek surrounding TWFS. Although Big Creek did not experience 100% ice cover during this past winter, we were still able to assess impacts of ice cover on edge habitat. In edge habitats sampled in December, ice cover increased periphyton standing crop biomass by 44 % compared to sites without ice cover, by perhaps creating a buffer from disturbance. Furthermore, we observed two significant ice-out events during our field season, allowing us to assess their effects on periphyton biomass. In December 2010 and January 2011, we observed two separate ice-out events that reduced periphyton standing crop biomass by 37% and 53%, respectively (Fig. 3). However, preliminary observations suggest that these scouring events may have actually increased the quality of periphyton because we observed significantly greater chl-*a* to AFDM ratios post-scour. This suggests that ice-out scour may have reduced the amount of dead organic matter in the periphyton, increasing the relative amount of higher quality cells post-scour. I am currently preparing periphyton samples for nutrient analysis to more fully quantify shifts in periphyton quality.

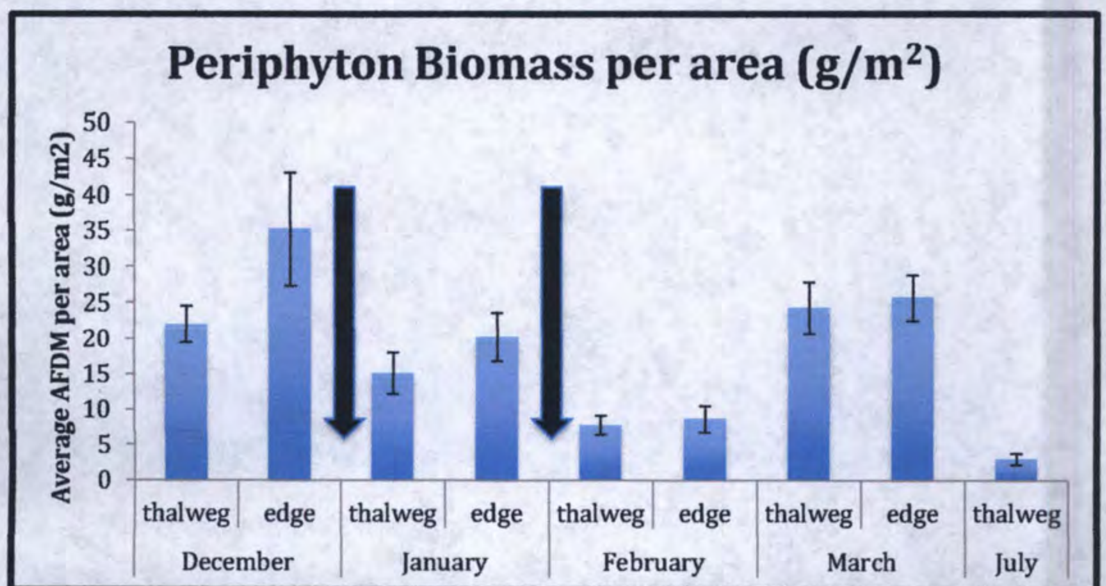

Figure 3- Average periphyton biomass (g/m²) collected from thalweg (middle) and edge habitats from December 2010 – March 2011 (July sample was collected in 2010 to represent pre-ice conditions). Two vertical, black arrows represent significant ice-out events. Periphyton biomass (g/m²) substantially decreased in both thalweg and edge habitats following December and January ice-out events.

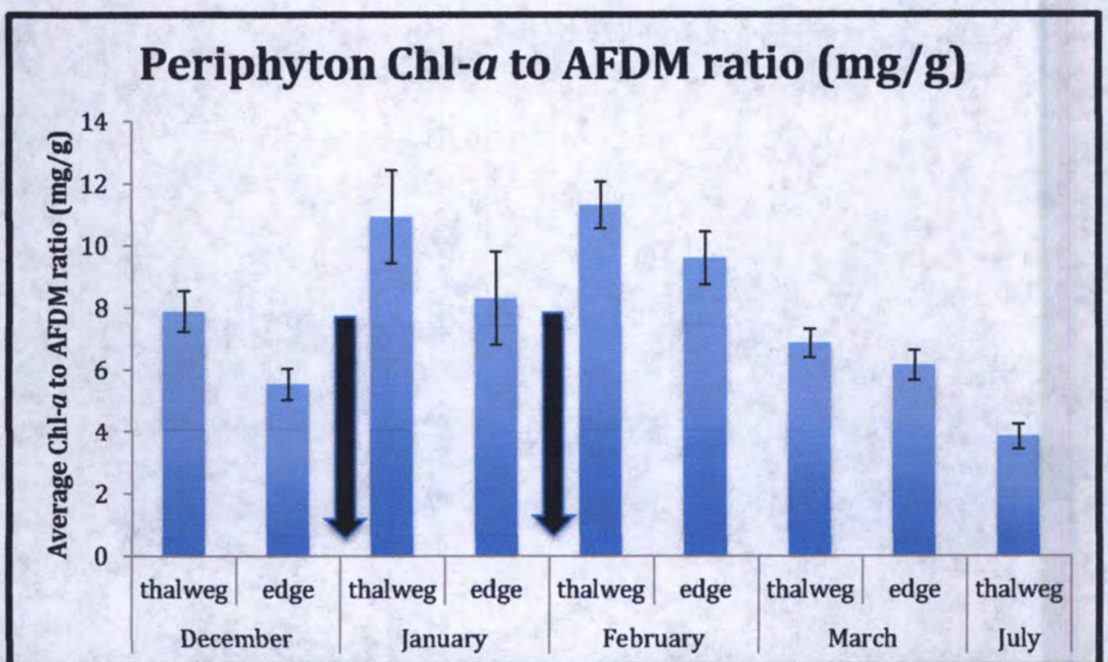

Figure 4 – Average periphyton chl-*a* to AFDM ratios (mg/g) from thalweg (middle) and edge habitats from December 2010 – March 2011 (July sample was collected in 2010 to represent pre-ice conditions). Two vertical, black arrows represent significant ice-out events. Periphyton chl-a to AFDM ratios increased in both thalweg and edge habitats following December and January ice-out events.

In contrast to the periphyton data, transported organic material did not increase in response to ice-out events as predicted. Surprisingly, the chl-*a* to AFDM ratios decreased following the December and January ice-out events (Fig. 5), indicating perhaps a slower positive response in transported organic material to ice-out events then found in periphyton. I am currently processing the gut contents of aquatic macroinvertebrates collect in the winter of 2010-2011, but do not yet have any results.

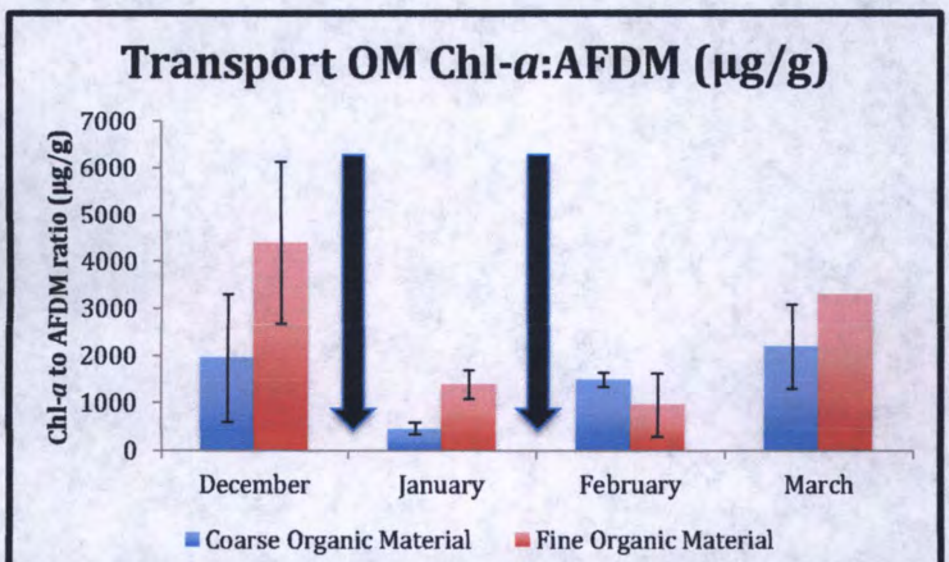

Figure 5 – Average transported organic material (µg/g) collected water column near TWFS from December 2010 – March 2011. Two vertical, black arrows represent significant ice-out events.

Hypothesis 4: Ungulate carcasses represent an important localized subsidy that increases river productivity at the 'patch-scale.' Specifically, dissolved nutrient concentrations and periphyton biomass will be higher at those sites receiving ungulate carcasses than at random sites without such carcasses. This increased benthic production will increase the relative contribution of carcass-derived nutrients in the gut contents of aquatic macroinvertebrates in those patches receiving ungulate carcasses.

Over the winter of 2010-2011, I located three fresh ungulate carcasses deposited into Big Creek while backpacking the same 24 km segment of Big Creek studied for ice cover mapping (MF Salmon confluence to Cabin Creek). My first ungulate carcass (#1), discovered February 11, 2011, was a cow elk located in a steep, narrow section of river between Cougar Creek and Goat Creek. Due to the dangerous location of the kill site, I was not able to sample this carcass until my next sampling March 25, 2011 and I did not find any remains of the carcass due to a turbulent eddy. The second fresh ungulate carcass (#2), discovered March 22, 2011, was an adult cow elk located ~1/4 mile downstream of the 'Sheepeater Flats Salt Lick.' The third ungulate carcass (#3), discovered April 29, 2011, was an adult cow elk located ~1/2 downstream of Cabin Creek.

Figure 6 – Ungulate carcass #2 located ~1/4 mile from TWFS near 'Sheepeater Salt Lick.' Carcass #2 was located on a backpacking survey along Big Creek, March 22, 2011.

At each of these sites where an ungulate carcass was located, I collected river water samples above and below carcasses to be analyzed for dissolved nutrient concentrations. I am currently in the process of sending them to Utah State University for analysis. Although I collected periphyton samples above and below carcasses #2 and #3, we did not find increased periphyton biomass at sites with carcasses. As this lack of response may have been due to carcasses moving prior to sampling, we will increase sampling frequency this coming winter to better correlate sampling location and carcass positioning. In addition, I collected aquatic macroinvertebrates directly from carcasses #2 and #3 in order to perform gut contents analyses. I am currently processing the gut contents of aquatic macroinvertebrates collected in the winter of 2010-2011 from elk carcasses #2 and #3. Furthermore, I plan to process a subset of the aquatic macroinvertebrates collected from ungulate carcasses to be analyzed for elemental composition using stable isotopes, with help from ISU professor Dr. Bruce Finney. The combination of the gut content and isotopic data will assess how much invertebrates are eating these carcasses.

Hypothesis 5: These potentially negative direct (Hypothesis #3) and positive indirect (Hypothesis #4) effects of ice cover interact to alter dissolved water nutrients, periphyton standing crop biomass, transported organic matter, and the gut contents of aquatic invertebrates. However, the net effects of changing ice regimes for river ecosystems are difficult to predict because they largely depend on the relative magnitude of these direct and indirect effects.

Hypothesis #5 will be assessed by combining data collected to answer H#3 and H#4; therefore, this component of my research is still ongoing. Upon completion of ice cover mapping and plotting ungulate carcass distributions, I will scale up the results of river ice regimes generated at the small spatial scale, to the larger river segment-scale. By extrapolating measurements collected at the small-scale to the river segment-scale, I will be able to calculate the response of aquatic organisms (algae and macroinvertebrates) to current ice regimes. Furthermore, once I have produced the response of aquatic organism to present ice regimes, I can then begin to predict the response of aquatic organisms to changing ice dynamics related to global climate change (i.e. the—price of ice).

R. J. BLACKADAR
M.S. Candidate – Stream Ecology Center
Idaho State University Department of Biological Sciences
Advisor: Dr. Colden Baxter

DeVlieg Taylor Graduate Research Assistantship 2010-2011

Research: "The Price of Ice: Ecological Consequences of changing Ice Regimes for linked Aquatic-Terrestrial food Webs"

RESEARCH UPDATE REPORT October 2012

To the DeVlieg Foundation,
Currently, I am focused on analyzing and synthesizing my results to be published in a peer-reviewed scientific journal. I am enrolled in a scientific writing class at Idaho State University to assist me preparing a manuscript for submission to *Freshwater Science*. My goal is to finish up laboratory work with one month and begin preparation for my thesis defense. I would like to thank everyone at the DeVlieg Foundation for their support over the years and I hope to send a new publication your way soon!

Please see the next 3 pages for an update summary of my research.

"A DeVlieg Reunion at Taylor"

In July 2012 during Janet Pope's visit we had a reunion of several DeVlieg Taylor students:

Janet Pope and **Colden Baxter**, professor Stream Ecology Idaho State University, and his daughter

Mark Schenk, 2010 DeVlieg Taylor Undergraduate Research Scholar ISU

Matt Lyon, 2012 DeVlieg Taylor Undergraduate Research Scholar ISU

Tess Gardner, 2011 DeVlieg Taylor Undergraduate Research Scholar ISU

Ryan Blackadar, 2009 Bleak Intern U of Idaho, 2010-11 DeVlieg Taylor Graduate Assistantship, and **Hannah Harris**, research assistant ISU for the Field Trip.

THE PRICE OF ICE: ECOLOGICAL CONSEQUENCES OF CHANGING ICE REGIMES FOR LINKED AQUATIC-TERRESTRIAL FOOD WEBS

R. J. Blackadar, C. V. Baxter, J. M. Davis

Current Status of Research (15 October 2012)

Executive Summary:
My research project is focused on the ecology of rivers in winter and the role of ice in river ecosystems. This study repeatedly sampled aquatic organic material, which is known to serve as important food resources to aquatic consumers (macroinvertebrates, fish, etc.). I collected two types of organic material, periphyton and transported organic material, because they represent two different types of food resources available to aquatic consumers. Periphyton is a complex assemblage of bacteria, fungi, and algae, that grows on rock surfaces and is an important food resource for aquatic macroinvertebrates specialized to scrape this material from the rock surfaces. Transported organic material is a combination of aquatic (algae, diatoms, macrophytes, etc.) and terrestrial (leaves, pine needles, wood, etc.) organic material that is suspended in the water column and is an important food resource for aquatic macroinvertebrates that filter food particles from the moving water. After two years of winter research, we discovered ice break-up events are critical disturbances affecting aquatic ecosystems during winter. Our results indicate that ice break-up events scour the river channel and reduce periphyton and transported organic material biomass. Additionally, recent gut-content analysis suggests that diets of aquatic invertebrates shift in response to ice disturbance. Changes in the availability and use of periphyton and transported organic material by aquatic macroinvertebrates may help predict effects of altered river ice regimes with future climate change.

Figure 1 - Ryan Blackadar sampling organic material at night and locating ungulate carcasses.

Hypothesis: River ice-out events scour the riverbed and reduce periphyton standing crop biomass, but increase transported organic material. A reduction in periphyton biomass from river ice cover and ice scour will result in a decrease in the proportion of periphyton within the gut contents of aquatic invertebrates.

We collected monthly (December 2010 – March 2011) periphyton samples from 36 sites encompassing ~3 km segment of Big Creek surrounding TWFS. Although Big Creek did not experience 100% ice cover during the past two winters, we were still able to assess impacts of river ice on organic material and aquatic insects. We observed two significant ice-out events during our first field season, allowing us to assess their effects on periphyton biomass. In December 2010 and January 2011, we observed two separate ice-out events that reduced periphyton standing crop biomass by 37% and 53%, respectively (Figure 2). In contrast, ice-out disturbance events increased the quality of periphyton because we observed significantly greater chlorophyll-*a* to AFDM ratios post-scour. This suggests that ice-out scour may have reduced the amount of dead organic matter in the periphyton, increasing the relative amount of higher quality cells post-scour.

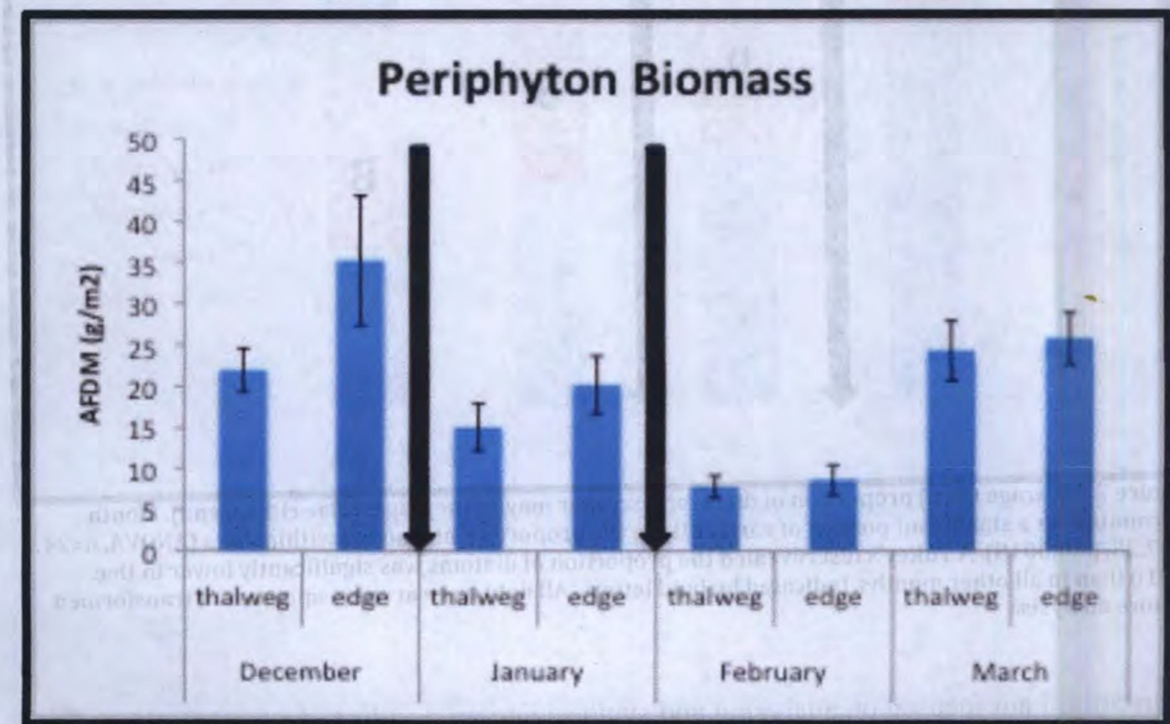

Figure 2 – Monthly periphyton average biomass (g/m²) ±1 SE collected from Big Creek mainstem. Black arrows represent ice-out events. Average periphyton biomass decreased 53% from Dec. 2010 – Jan. 2011 and 37% from Jan. 2011 – Feb. 2011 suggesting that ice-out events are critical disturbance events during winter.

In contrast to the periphyton data, transported organic material did not increase in response to ice-out events as predicted. Surprisingly, the chlorophyll-*a* to AFDM ratios decreased following the December and January ice-out events, indicating perhaps a slower positive response in transported organic material to ice-out events then found in periphyton.

Using the patterns of organic material, we conducted gut-content analyses on aquatic macroinvertebrates collected before and after the ice-out disturbances. The results of these gut-content analyses indicate a shift in the diets of aquatic insects before and after ice-out disturbance (Figure 3). We believe that the shift in diets is associated with the effects of ice-out disturbance events. These results have been very exciting to us because, to our knowledge, this is the first ecological study to document a diet shift to a river ice disturbance. Our results will add to general disturbance theory, the role of river ice on aquatic ecosystems, lead to future winter research.

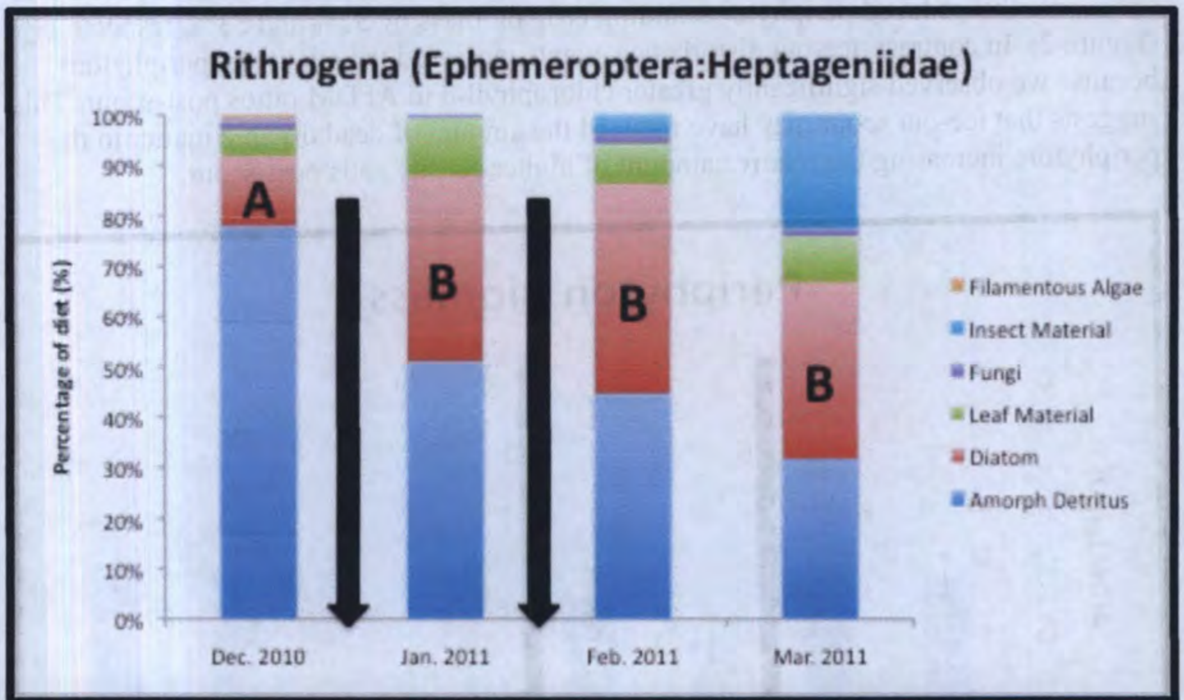

Figure 3 - Average (n=6) proportion of diets for a scraper mayfly (heptageniidae rithrogena). Month accounted for a significant portion of variability in the proportion of diatoms within diets (ANOVA, n=24, F=7.25, p<0.0018). A Tukey's test revealed the proportion of diatoms was significantly lower in Dec. 2010 than in all other months, indicated by bold letters. All data were arcsine-square-root transformed before analysis.

Currently, I am focused on analyzing and synthesizing my results to be published in a peer-reviewed scientific journal. I am enrolled in a scientific writing class at Idaho State University to assist me preparing a manuscript for submission to *Freshwater Science.* My goal is to finish up laboratory work within one month and begin preparation for my thesis defense. I would like to thank everyone at the DeVlieg Foundation for their support over the years and I hope to send a new publication your way soon!