

Food Web Structure and Connectance Between Protected and Impaired Prairie Rivers.

Project Description:

North American prairie streams are critically understudied despite their importance as model systems for disturbance ecology, their necessity in agriculture, their significant cultural value in the form of recreation, and their role as drivers of downstream water quality¹. Another hallmark of prairie streams is they harbor significant biodiversity, including threatened and endangered fishes, mollusks, and invertebrate species. Yet, the lack of emphasis on these systems and their proximity to intensively managed landscapes has resulted in a shortage of protections often provided to larger or forested streams, ultimately making them and the biodiversity they support among the most endangered ecosystems on the planet^{2,3}. Further neglecting prairie streams puts them in danger of permanent functional loss or change, so learning more about these systems and their functions is imperative to providing them with increased protection and ensuring their continued existence.

Biodiversity is often a predictor of ecosystem functions, such as productivity, nutrient cycling rates, and decomposition⁴. Furthermore, greater biodiversity provides a system with stability and resilience from physical, chemical, and biological disturbance, suggesting biodiversity is essential to an ecosystem's long-term persistence⁵. However, before one can begin to make assumptions about ecosystem function based on biodiversity, it is necessary to forge a connection between the two. A popular method to achieve this is through the use of community food webs. Food webs are a useful way to describe the myriad connections among species and the energy pathways nutrients take through these connections, simultaneously informing us about community composition and trophic interactions⁶. Both community composition and trophic interactions can strongly and reciprocally affect ecosystem functionality like productivity and respiration via indirect interactions such as top-down control⁷. Food webs are thus an integrative measure of how biodiversity affects ecosystem function that remains understudied in mid-sized rivers of the Great Plains.

Key Terms	Definition
<i>Macroinvertebrate</i>	An animal lacking a backbone in addition to being visible to the naked eye
<i>Biodiversity</i>	The variety and variability of life found within a given area
<i>Stable Isotope</i>	Non-radioactive form of atoms which can be used as tracers in biological systems
<i>Trophic structure</i>	The way organisms are organized in relation to the flow of energy/biomass
<i>Connectance</i>	The fraction of possible links that are realized in a system
<i>Food web</i>	All of the possible pathways energy and nutrients take between organisms
<i>Top-Down Control</i>	predators consuming herbivores that control autotrophic production

Table 1: Key terms of the proposal and their definitions

My project aims to compare the two systems in order to study the effects of protection status designation on ecosystem-wide processes like productivity, macroinvertebrate diversity, and nutrient composition through integrative measures such as food web composition.

For the purposes of this project, I propose to construct a macroinvertebrate food web, including all of their potential food sources within and adjacent to the streams, with the use of stable isotope analysis for both the Niobrara and Elkhorn rivers. Specifically, I will use the stable isotopes of nitrogen ($d^{15}N$) and carbon ($d^{13}C$). The concentrations of these isotopes in biotic tissues give us insights into trophic position (i.e., food chain length) and the breadth of resource use, respectively, allowing us to position consumers and producers in relation to one another as well as estimate trophic structure and diversity¹⁰. Macroinvertebrates are a diverse group encompassing intermediate and upper trophic levels while also being important indicators of aquatic ecosystem health in addition to being cost-effective and requiring minimal permitting for collection, which

A substantial section of the Niobrara River flowing through Nebraska is classified as a national scenic river under the Wild and Scenic Rivers Act of 1968, meaning it has 76 miles of relatively undeveloped shorelines, clean water, and semi-pristine habitat⁸; making it an excellent model system for studying the effects of contemporary agricultural and urban pollution and the importance of federal protections to conserve prairie streams. Conversely, the Elkhorn River is an unprotected tributary of the Platte River, running through northeast Nebraska and draining predominately agricultural and suburban landscapes, making it subject to excessive anthropogenic inputs resulting in increased water toxicity and nutrient loading⁹.

makes them an ideal study group ¹¹. We also intend to use ecosystem-wide data from our lab to associate productivity and respiration rates via diel changes in dissolved oxygen to food web connectance and structure, bridging the gap between biodiversity and function. In short, the primary objectives of this project are to construct and compare food webs between the protected Niobrara and the impaired Elkhorn and to test their efficacy as predictors of ecosystem function and health.

Methodology:

Study sites:

Niobrara River- four sites along a ~32-km stretch of the Niobrara, specifically Smith Falls State Park, Brewer Bridge, Sunny Brook campgrounds, and the Niobrara Valley preserve.

Elkhorn River- four sites along a ~23-km stretch of the Elkhorn, specifically the Elkhorn Crossing NRD recreation area, Elkhorn Shores boat launch, Graske Crossing boat launch, and the UNO Elkhorn River Research Station.

Sampling and data analysis: The project will occur over three phases (1) sampling for macroinvertebrates and basal food resources (periphyton, detritus, biofilm, etc.), (2) subsampling, sorting, enumeration, and isotope analysis prep for macroinvertebrate samples, and (3) analyzing and modeling isotope data for food web construction. Macroinvertebrate sampling will be done in a quantitative to semi-quantitative fashion using standardized collection protocols such as D-Net timed kick samples, Surber drift net collection, benthic core samples, diaphragm pumping out of the water column, zooplankton horizontal tows and a catch per unit effort approach to estimate species abundance as outlined in Hauer & Lamberti¹² as well as Thorp & Mantovani¹³. The second and third phases will occur in the lab; samples will be identified and sorted prior to being freeze-dried and shipped to the UNL Water Sciences laboratory for isotope analysis. Sorting will be done to a family or order level depending on overall species richness and will be kept consistent between both study sites; small microfaunal food sources will be sorted according to size. I will analyze the data using appropriate statistical tools, such as ordination analysis (for macroinvertebrate community structure comparisons), and mixed models to make inferences about macroinvertebrate diets, trophic position, and other food web metrics (e.g., connectance, linkage density).

Timeline: All sampling, sorting, and a large portion of analysis events, accounting for over half of all tasks, will occur exclusively during the summer months (>50%).

	2023/2024	2024					2025
<u>Task</u>	October-April	May	June	July	August	Sep	March
Methodology refinement, Field Planning							
Data collection							
Data Analysis, Construction of Food Webs							
Creation of poster/presentation for RCAF*							
Present at UNO RCAF* 2025							

*Research and Creative Activity Fair

Student/Faculty Mentor Roles

Student Role: To collect samples, decide on best practices for data collection, select sites within the bounds of the overarching lab project, sort samples, analyze data, and construct food webs.

Faculty Mentor Role: To offer guidance and support for all facets of the project when necessary, including modeling and statistical analysis, to review any products to come out of the project (thesis, presentations, etc.), and to oversee the budget of the project not funded by the GRACA.

Products:

The project will ultimately serve as the basis for a master’s graduate thesis in addition to a presentation/poster for the Research and Creative Activity Fair and has the potential for publication in the scientific literature.

Previous Internal Funding: None

Budget justification:

<i>Item</i>	<i>Estimated Price</i>
Student stipend	\$5,000
Lodging	Niobrara Valley Preserve (no-cost lodging for university researchers) \$0
Cost for undergraduate assistant	\$1200
Cost to analyze samples	\$3120
Travel	\$250
Total Cost of Project:	~\$9570

The total amount of \$5,000 is requested to be used as a stipend to be paid over the summer months (May-August) in order to fund student activities related to the project. Activities include but are not limited to data collection, data analysis, sorting and identification of samples, and the creation of any final products related to the GRACA. Lodging, sample analysis, and all other costs listed in the budget table are to be supplemented by the faculty advisor and associates of the project through a USGS grant as part of the overarching lab project.

Citations

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11 October 2023

Dear GRACA Review Committee members:

I am writing to offer my full support for **Rodrigo Meza Gonzalez's** GRACA proposal titled "*Food web structure and connectance between protected and impaired prairie rivers.*" I am the chair of Rodrigo's Master's thesis committee and have worked with him as a student in the BIOL 4180 Freshwater Ecology course this semester. Rodrigo has already shown impressive motivation and work-ethic, as he has identified an appropriate project and is collecting supporting data within weeks of arriving on campus. Specifically, for this proposal, he seeks to understand how biodiversity and ecosystem functions are related, via food web analysis, and how they differ in two rivers influenced by watershed management. This research project is complementary to a funded research program centered on understanding ecosystem function in the protected Niobrara River and impaired Elkhorn River in Nebraska. Rodrigo has already shown he is capable of developing his project independently, including methods development for sampling overlooked consumer groups, such as zooplankton, in river systems.

Rodrigo has already developed a solid background in the ecology of aquatic insects, which I expect will serve him well as he develops his research project about their role in food webs of Great Plains rivers. Further, Rodrigo's undergraduate coursework in Biology (including Principles of Ecology, Entomology, and Biogeography) has given him experiences with the conceptual underpinnings and tools needed to complete the research project. I am ready to provide oversight and guidance for Rodrigo's research project, including facilitating biweekly meetings, monthly progress reports, and networking with other experts in the region. Further, I am competent in the field and statistical modeling approaches needed to complete the work he has proposed; thus, I will be available to provide guidance to Rodrigo in terms of requisite experimental design, interpretation, and presentation of the findings of the project.

Overall, I expect Rodrigo's proposed project has a high probability for success and I am confident it will produce findings that will directly inform management of Nebraska's rivers and their ecosystem health. Specifically, the timeline of the project is reasonable, and the budget reflects the substantial time commitment that will be required to perform the field work, enumerate macroinvertebrates, prepare them for stable isotope analysis, and analyze the results of this work. Rodrigo will have access to the field equipment and lab resources necessary to complete these tasks, including sampling equipment, a supplementary budget for consumables and analysis costs, and computational resources.

I am impressed by Rodrigo's commitment to research related to aquatic macroinvertebrates and their role in the function and health of aquatic ecosystems with differing management strategies, at this early stage in his scientific career. I strongly support his proposal and I am committed to ensuring its successful implementation.

Sincerely,



David Manning
Associate Professor, Department of Biology