Harnessing Prairie Survey and Restoration Through Applied Learning: Insights From Research Done in Missouri Western State University's John Rushin Teaching and Research Prairie

TYSON COOK, TILOTTAMA ROY
Missouri Western State University

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Author Note

Tilottama Roy https://orcid.org/0000-0001-8248-7710
We have no conflicts of interest to disclose. Correspondence concerning this article should be addressed to Tilottama Roy, Department of Biology, Missouri Western State University, 4525 Downs Dr, Saint Joseph, MO, USA
Email: troy1@missouriwestern.edu

Abstract

Prairie ecosystems, once expansive across North America, have faced significant degradation and fragmentation due to expanding agricultural development (World Wildlife Fund, 2023). Efforts to survey and restore prairies offer a unique opportunity for applied learning in environmental education. This paper explores the potential of prairie survey and restoration projects to enhance students' applied learning experiences and develop practical skills in ecological research, biodiversity conservation, and sustainable land management. Drawing upon interdisciplinary perspectives from ecology, education, and community engagement, and utilizing flora survey of the John Rushin Teaching and Research Prairie at Missouri Western State University as a model for applied learning, this paper examines the educational benefits of prairie survey and restoration and provides recommendations for integrating these activities into formal and informal educational settings. By engaging students in hands-on activities, we aim to enhance understanding, foster environmental stewardship, and contribute to effective prairie restoration.

Introduction

Amidst the growing number of stark ecological challenges (Seebens, 2017), the role of environmental education in shaping a future of sustainable resource usage has never been more critical. Institutions of higher education stand on the precipice of this fight, sporting both the responsibility and the potential to foster the knowledge, skills, and foundations for sustainable, ethical resource usage needed to address modern ecological challenges. When carefully integrated into existing curricula, environmental education surpasses traditional disciplinary boundaries and fosters a sense of connectedness and importance between conservation and everyday life. In doing so, it can help train and call all members of our society to support a common goal of sustainability and good stewardship of the land.

This study explores the vital role of environmental education in higher education, and through the use of a case study, emphasizes its importance in cultivating a generation that is aware of the environmental challenges at hand, but is also empowered to take action. By examining the state of current curricula, identifying gaps, and proposing strategies for improvement, we aim to contribute to the ongoing and necessary dialogue for expanding environmental education in academia, particularly in higher education.

Overview of Prairie Ecosystems and the Importance of Prairie Survey and Restoration for Biodiversity Conservation and Ecosystem Resilience

Ongoing studies so far have shown that regions of the North American prairie (including tallgrass, mixed, and short-grass prairies, an integral part of the Great Plains in North America) are among the continent's most endangered ecosystems, with tallgrass prairies being globally endangered (Rickletts et al., 1999). The decline of North American prairies has severely impacted native prairie plants and animals (Samson & Knopf, 1994; Knopf, 1996). Although considerable progress has been made towards the development of a conservation framework for the Great Plains (Risser, 1996), significant challenges persist in integrating social, economic, and biological factors into effective prairie conservation strategies.

In addition to the loss and fragmentation of native grasslands, the conservation of the Great Plains systems faces other significant challenges. A critical issue in contemporary conservation is understanding the role of ecological drivers (Knopf & Samson, 1997). Focusing solely on landscape patterns without considering the ecological drivers that shape species diversity overlooks a crucial aspect of conserving species, communities, and ecosystems. Ecological drivers in the Great Plains include broad scale drought, grazing and fire on landscape and local scales (Fuhlendorf & Engle, 2001). The Great Plains developed in the rain shadow of the Rocky Mountains, receive most of their seasonal precipitation in spring and summer. Precipitation increases and drought frequency decreases from the Rocky Mountains eastward to the Mississippi River. From central Texas to south-central Canada, the growing season shortens, average temperatures drop, and a larger portion of annual precipitation falls as snow. These broad-scale climate gradients play a significant role in determining the evolutionary composition and distribution of prairie communities (Steinauer & Collins, 1996). However, average conditions are only part of the story. The inherent unpredictability of year-to-year precipitation also has a major impact. Severe droughts can lead to widespread local extinctions of annual forbs (wildflowers and other broad-leaved, nonwoody plants) and grasses that have invaded perennial stands, and recolonization of these sites is a slow process. Prairies are ecosystems primarily composed of perennial grasses and forbs, interspersed with a few shrubs and very few trees.

The prairies in Missouri are known as tallgrass prairies due to their abundance of warm-season grass species that can grow from 2 to over 6 feet tall. Located just east of North America's Great Plains—one of the largest grassland regions in the world—Missouri benefits from more moisture and richer soils, which support taller grass species. Historically, the tallgrass prairie region extended from Manitoba southeast to eastern Indiana, and southwest to northeastern Oklahoma, including the eastern parts of Kansas, Nebraska, and the Dakotas. In contrast, the Great Plains to our west feature mixed-grass and, further west, shortgrass prairies, where drier conditions favor shorter grasses. Prairie plants can be incredibly variable and are dependent on different types of soil and access to water, and often show seasonal variability.

Experiential Applied Learning and its Application in Environmental Education Including Prairie Survey and Restoration

Integrating Experiential Learning Theory (ELT) (Kolb, 1984) and Place-Based Education (PBE) (Gruenewald, 2003) into prairie survey and restoration projects creates a dynamic and impactful educational framework that benefits both learners and the environment. By engaging in concrete experiences, such as conducting field surveys and participating in restoration activities, students and community members gain direct, hands-on knowledge of prairie ecosystems. These activities might include identifying and cataloging native plant species, monitoring wildlife, assessing soil health, and mapping invasive species. These practical experiences provide the foundational knowledge needed to understand the complexities of prairie ecosystems and the importance of their conservation.

Reflective observation plays a crucial role in this integrated approach. After participating in field activities, learners are encouraged to reflect on their observations and experiences. Discussions can be facilitated to explore what was observed, any unexpected findings, and the implications of these observations on the health and biodiversity of the prairie. This stage helps learners to develop critical thinking skills and a deeper understanding of ecological relationships and processes. Reflective sessions can be structured as group discussions, individual journals, or presentations, fostering a collaborative learning environment where insights and ideas are shared and expanded upon.

Abstract conceptualization involves synthesizing the reflections and observations into broader ecological concepts and theories. Learners develop an understanding of key principles such as ecosystem dynamics, biodiversity, and the impacts of human activity on natural habitats. This stage transforms practical experiences into theoretical knowledge, allowing learners to grasp the underlying science behind their hands-on activities. By connecting their direct experiences to broader environmental concepts, students and community members can see the relevance and importance of their work in a larger ecological context.

Active experimentation, the final stage of ELT, involves applying the newly acquired knowledge and theories to ongoing and future restoration projects. Learners are encouraged to develop and test new strategies for prairie conservation, such as experimenting with different methods of invasive species control, planting native species in different arrangements, or implementing innovative monitoring techniques. This stage not only reinforces learning but also contributes to the continuous improvement of restoration practices. By actively participating in the iterative process of experimentation and adaptation, learners become more proficient in problem-solving and more committed to environmental stewardship.

The integration of ELT and PBE in prairie survey and restoration projects fosters a deeper connection between learners and their local environment. This approach not only enhances educational outcomes but also promotes a sense of responsibility and empowerment among participants. By understanding and actively engaging in the restoration and preservation of prairie ecosystems, learners develop a lifelong commitment to environmental conservation and sustainability. This holistic educational model not only benefits the individuals involved but also contributes to the long-term health and resilience of prairie landscapes.

Principles and Practices of Prairie Restoration and its Significance in Providing Applied Learning Opportunities to Students: MWSU's John Rushin Teaching and Research Prairie is an Example

Missouri Western State University (MWSU), a primarily undergraduate institution, located in Saint Joseph, is situated in the North Western part of the state of Missouri. MWSU is a student-focused learning community dedicated to preparing individuals for lives of excellence through practical education. One of the assets of the biology department at Missouri Western State University is the John Rushin Teaching and Research Prairie (JRTRP), situated just outside the campus. Spanning across 34 acres of the southeast corner of the campus, this unique prairie habitat is a valuable resource for the campus community and attracts botanists and nature enthusiasts from beyond. It offers exceptional applied learning opportunities for students from a wide variety of disciplines. The prairie, championed by Dr. Mark Mills, biology faculty member and then department chair, was officially dedicated on October 31, 2020, to honor Professor Emeritus Dr. John Rushin and his career, and to support a tallgrass prairie restoration effort. This initiative provides an excellent platform for faculty and students to study, learn, and manage tallgrass prairie and oak savannah ecosystems.

During the growing season between late May and early September, this prairie is usually dominated by big and little bluestem grasses with a high concentration of asters, legumes, and milkweeds. The JRTRP, which encompasses the MWSU cross country track, is used for a variety of applied learning experiences including undergraduate research, class field trips, and Course-based Undergraduate Research Experience (CURE) projects, and is also utilized by local citizens as a walking trail and conserved nature area. The prairie has been subjected to prescribed burns periodically, the first one being done in the spring of 2023. It has also been subjected to weeding and removal of invasive species, notably Johnson grass (*Sorghum halepense* L. (Pers.)) and invasive bull thistle (*Cirsium vulgare* (Savi) Ten.). Most of these initiatives were undertaken by students majoring in Wildlife Conservation and Management that were also active members of MWSU's Student Chapter of The Wildlife Society, and formed an active part of MWSU's mission to provide students with unique and exciting experiential applied learning experiences. Students were helped in their efforts by biology faculty members from MWSU, as well as community members and nature lovers. Although the initial seeding of the prairie was performed in 2021 from seeds provided by the Missouri Department of Conservation (MDC) and the Dunn Ranch Prairie in Missouri, about one thousand milkweed (*Asclepias* sp.) seedlings (comprising butterfly milkweed, swamp milkweed, whorled milkweed and the common milkweed) were also planted across the prairie during June, 2023.

Premise of Current Study, Summary of Key Findings, and Significance

Our case study aims to better understand the composition and populations of prairie forbs on an institutionally managed tall grass prairie. Through this study, students investigated whether or not the ‘Occupancy Modeling’ method was able to accurately reflect the composition of the campus prairie, and create plans for future management with a baseline model to evaluate the effectiveness of future management strategies. ‘Occupancy Modeling’ is a statistical approach to estimate the true population of a given species. The ‘Occupancy’ relies on the assumption that human-conducted surveys are not perfect and help us determine the percentage of missed detections. We chose to utilize this approach because it is easily adaptable for use on a variety of species and allowed us to utilize data collected from previous surveys for a larger, more complete data set.

This study focused on conducting flora surveys of the JRTRP, concentrating on dicotyledonous flowering plant species, during the period between the first burn and the first frost event occurring in early November, 2023, to identify the effects of plant growth in a post-burn restored prairie habitat. The prairie was split into four sections following boundaries created by the cross-country track (Fig. 1). Each section was sampled independently every two weeks. Sampling was conducted using a 1-meter square plot made of PVC pipe, all plants within the plot were recorded. Each plot was at least 1 meter away from the previous plot to ensure plants were not counted multiple times. Special considerations were made for plants over 4 feet in height, as they could not be reasonably contained within the square plot. These plants were counted if they were touching the outside boundary of the plot. Surveys were conducted from the beginning of May to the first part of November at the start of the first frost event. Occupancy Modeling was performed in R using the “unmarked” package (R Core Team, 2021). All models were run at a 95% CI.

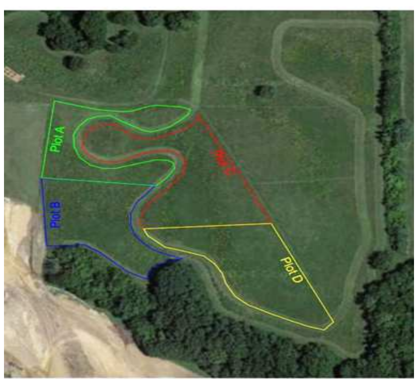

Figure 1. Plot Boundaries for the Current Study

For our survey results (Table 1; Fig. 2), we found *Asclepias*, *Cichorium*, *Rudbeckia*, and *Daucus* to have an occupancy rate of 99%. The numbers for *Asclepias* are likely inflated due to the planting efforts of native milkweeds for monarch butterfly populations. It is important to recognize that the effects of heavy-handed management are at play and can influence the results of occupancy. Detection probability represents the probability that species will be detected within the given parameter. For us, this equals a 1-meter squared plot. It is also important to note that non-detection does not mean that a species/genus is not present. Detection probabilities are relatively stable across our genera, which generally shows that there is not a large selection bias towards one genus. *Cirsium* and *Rumex* had the two highest detection probabilities within our study (38 and 36%, respectively). *Cirsium*, however, was found to be statistically significant and fit within the expected parameters of the Mackenzie-Bailey test for goodness of fit (Mackenzie & Bailey, 2004). This distinction is important because *Cirsium* is mainly composed of the species *Cirsium vulgare* (Savi) Ten (Common Bull Thistle), which is an extremely invasive plant in our prairie system. The model for *Cirsium* gives us important baseline information on the population structure of the genus and can give us a comparison tool to evaluate the effectiveness of future management techniques. 'C-Hat' is a value that represents the overinflation of data. Our survey bases parameters for C-Hat on a study published by Mackenzie and Bailey (2004), which puts normal ranges between 1 and 2. C-Hat values under 1 are generally underinflated and can indicate underrepresented species or sampling bias. The C-Hat values over 2 can indicate overrepresented species or sampling bias. Our study found an overinflation of *Rudbeckia* and an underinflation of *Rumex*, *Silphium*, and *Daucus*. All other genera fit within the expected value. The P-value measures the probability that a result is as extreme or more extreme than the observed data, assuming the null hypothesis is true. In essence, it is the likelihood that our data occurred by random chance. For this study, we utilized a 95% confidence interval (P = 0.05 for significance). The null hypothesis for this study argues that there is no difference in populations between genera of plants. Any estimates of genera found to have a p-value less than or equal to 0.05 and a C-Hat value between 1-2 are considered to be well-fit; this distinction is present in the genera *Asclepias*, *Cichorium*, *Erigeron*, *Rudbeckia*, and *Cirsium*. These genera are marked in the table and graph with an asterisk to represent well-fit models (Table 1; Fig. 2). These genera can be used to reject the null hypothesis and indicate that there are population differences between some species of prairie plants.

Genera	Occupancy *P.*	SE	Detection *P.*	SE	C-Hat	*P*-value
*Asclepias**	0.99	0.011	0.22	0.042	1.79	0.05
*Cichorium**	0.99	0.011	0.22	0.042	1.79	0.04
*Erigeron**	0.88	0.178	0.29	0.074	1.48	0.09
*Rudbeckia**	0.99	0.022	0.23	0.043	2.11	0.01
Rumex	0.55	0.137	0.36	0.089	0.66	0.83
Silphium	0.97	0.190	0.28	0.071	0.94	0.50
*Cirsium**	0.72	0.129	0.38	0.076	1.84	0.03
Calystegia	0.62	0.170	0.29	0.089	1.02	0.41
Daucas	0.99	0.008	0.18	0.040	0.44	0.93
Solidago	0.88	0.316	0.19	0.079	1.74	0.06

Table 1. Probabilities of Occupancy and Detections

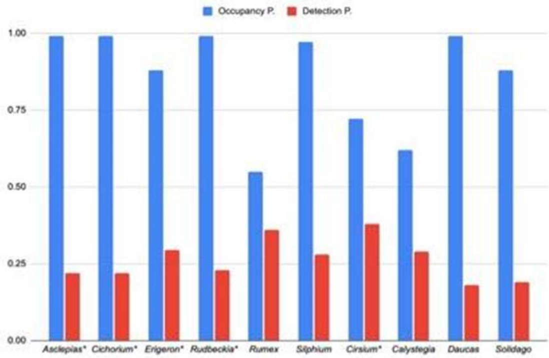

Figure 2. Probabilities of Occupancy and Detection

Integrating Prairie Survey and Restoration in Curricula: Challenges and Opportunities; Future Directions and Recommendations

Students pursuing a career in natural resource management can be afforded the opportunity to practice management principles by engaging in survey and restoration efforts similar to the ones that are being pursued in the John Rushin Teaching and Research Prairie discussed above, especially our study discussed in this paper. An essential piece to any management plan is site selection and monitoring. Prairie surveys allow students the ability to study the impacts of micro-habitat differences and its importance for site selection. Variances in soil composition, nutrient density, sun exposure, topography, and a host of other factors all present unique variables to be monitored and studied intensely. This study focused on the presence and absence of key native and invasive species, which allowed us to more narrowly select survey sites based on ecological factors such as the presence or absence of targeted species, proximity to natural corridors, access to resources, and human disturbance. Site selection must be done methodically and precisely to accomplish the goals of any project. Including students in the process allows for them to gain a better understanding of the factors at play and begin to build a system for evaluating confounding variables and selecting a site that maximizes the probability of favorable outcomes. Involvement in the initial steps of project development helps to empower students and foster the growth of their professional and skill set development.

In order to be best served, it is essential that students be involved in all stages of restoration. From initial planning, to surveying, to maintenance; students provided both eager hands and hungry minds. Introducing students to common restoration techniques such as prescribed burning and invasive species control is critical to a well-rounded education in natural resource management. Including students serves to simultaneously accomplish two goals, students learn valuable hands-on skills and necessary maintenance is completed. Applied learning experiences on the John Rushin Teaching and Research Prairie have taken a variety of forms, but all serve the same purpose: get students involved in good stewardship of the land.

Long term management strategies can be further leveraged to give students the largest benefit in the smallest area. Structured patch burning can create a variety of habitats that can be used for comparative studies and allow students to get the most opportunities to participate in applied learning experiences. Utilizing a routine system of burning (i.e. 1,3,5 year patch burn plots) allows the land to be managed long term for targeted species while still providing students the opportunity to learn necessary career skills like prescribed burning. Furthermore, students should be involved in the planning and execution of management plans, this should range from being present at meetings for the creation of burn plans, site surveys, weather monitoring, and date selection. While it is critical for students to be involved in the execution of the plan, students are often left out of the administrative duties that are essential for the successful execution. Students are then expected to perform many of the administrative and planning duties with little to no experience in these skills. Expanding prairie management initiatives in higher education settings offers numerous opportunities to further student learning and environmental stewardship. Applied learning experiences, as a whole, allow students the opportunity to practice a variety of skills and techniques to reinforce prior learning (Hensel, 2018) By incorporating applied learning experiences in prairie restoration, students can further develop their professional and practical skills and gain a more in depth understanding of the ecosystem. Universities may further this goal by building partnerships with local conservation agencies, non-government organizations (NGO's), and naturalist groups to encourage community support. Integrating prairie restoration projects into existing biology, environmental science, and natural resource curricula can provide students with unique research opportunities and allow students to build a deeper sense of connection to their environment.

To further the goals of environmental education and applied learning, research should focus on several key areas including the effectiveness of applied learning initiatives, long term ecological impacts, interdisciplinary approaches, and stakeholder involvement. Investigations of applied learning projects centering on prairie restoration may help to grow student engagement, knowledge retention (Concilio, 2024), and attitudes towards conservation and may be particularly effective in general biology or non-major biology courses to further foster a sense of good stewardship of the land in a larger population of students. Building a framework of applied learning experiences focused on prairie restoration can serve to answer several unique questions such as how do hands-on restoration activities influence students' understanding of ecological principles? What are the long-term effects of applied learning projects on students' attitudes towards conservation and their likelihood of engaging in future management activities? Can applied learning experiences boost students' critical thinking and problem-solving skills compared to traditional classroom-based education?

Our research priorities can also serve to help prepare students for field-based biology work. By tackling questions relating to student outcomes and career pathways, we may be able to see trends in participation in applied learning activities centered on prairie restoration and students' career and education trajectories. Studies involving new technology can give students insights into the cutting edge of their chosen career field and may include questions such as the effectiveness of digital tools to enhance students understanding and engagement of prairie restoration projects (which may include the use of GPS/GIS technologies, drone applications, species identification using Artificial Intelligence, etc.), or assessing the role of online collaboration for facilitating networking experience and communication between students, partners, and stakeholders.

By addressing these research priorities, we can hope to further advance the field of environmental education, leading to more effective pedagogy, better student learning outcomes, and greater community involvement in conservation efforts. Supporting prairie conservation and education efforts requires robust policy frameworks at the local, state, and national levels. Ideally, policies will aim to ensure consistent funding for university-based environmental projects through grants and programs, incentivize the inclusion of environmental education with a focus on local ecosystems in curricula, provide training and resources to educators to effectively teach environmental management and restoration projects, and promote the allocation of land for conservation programs and to integrate these spaces into curricula. Supporting prairie conservation and education efforts requires robust policy frameworks at the local, state, and national levels. Ideally, policies will aim to ensure consistent funding for university-based environmental projects through grants and programs, incentivize the inclusion of environmental education with a focus on local ecosystems in curricula, provide training and resources to educators to effectively teach environmental management and restoration projects, and promote the allocation of land for conservation programs and to integrate these spaces into curricula.

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