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Lesson

# An Interrupted Case Study on Urban Prairie Restoration

**Amy L. Concilio[1*], Maria Lazo Macik[2], and X. Ben Wu[2]**

[1]School of Behavioral and Social Sciences, St. Edward's University

[2]Department of Ecology and Conservation Biology, Texas A&M University

## Abstract

Engaging students in meaningful discussions can be a challenging task for science instructors, especially in introductory courses. The story-telling approach used in case studies can increase student participation by demonstrating the relevance of scientific inquiry to society. We developed an interrupted case study focused on a real-world example of a 40-acre native prairie restoration in an urban park in Austin, TX, for use in introductory undergraduate Ecology, Biology, or Environmental Science classes. The case study consists of five modules that challenge students to generate hypotheses, calculate summary statistics and generate graphs in Microsoft Excel, and discuss the challenges, costs, and benefits of ecological restoration in urban settings and the role of prescribed fire in land management. This lesson was tested in an introductory Environmental Science class at a liberal arts college, but it can be adapted for use in a variety of Biology courses over one to multiple class periods.

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***Correspondence to:** St. Edward's University, 3001 South Congress Ave., Austin, TX 78704, aconcili@stedwards.edu

## Learning Goals

Students will:

◊ describe the impacts of land use on ecosystem function and biodiversity.

◊ explain the role of science in society.

◊ From the Ecology Learning Framework:

» What impacts do humans have on ecosystems?

» What can or do humans do to mitigate negative impacts they have on ecosystems?

» How do humans depend on ecosystems for their health and well-being?

◊ From the Science Process Skills Framework:

» pose testable questions and hypotheses to address gaps in knowledge.

» interpret, evaluate, and draw conclusions from data.

» recognize the important roles that scientific models, of many different types (conceptual, mathematical, physical, etc.), play in predicting and communicating biological phenomena.

» apply the tools of graphing, statistics, and data science to analyze biological data.

## Learning Objectives

At the completion of this activity, students will be able to:

◊ formulate a hypothesis regarding the impacts of land use on ecosystem function and biodiversity.

◊ graphically represent data and interpret scientific results.

◊ discuss the role of prescribed fire in grassland ecosystems.

◊ describe ecosystem services provided by grasslands.

◊ evaluate the costs and benefits of restoration in urban ecosystems.

## INTRODUCTION

There have been increasing calls for the use of case studies and other active learning pedagogy in undergraduate science classrooms due to their well-documented benefits (1, 2). In active learning, students directly engage with the material they are studying, for example through discussion, reflection, brainstorming, and problem-solving. Benefits include increased student engagement, attendance, and development of critical thinking skills (2–4). This contrasts with the passive method of delivering lectures, which has long been the dominant approach to undergraduate teaching (5). Much evidence points to the limited ability of lectures to foster engagement, critical thinking skills, or student learning of key concepts (3, 6). Indeed, paired studies where the same information was delivered via passive and active learning approaches have shown dramatic gains in achievement with active learning (2). With active learning, students can construct their own interpretation of information and thus, better retain it in their memory (3). Importantly, students from disadvantaged backgrounds can benefit most from active learning—helping to close the achievement gap in STEM classrooms (7, 8).

The case study method of college science teaching is also particularly well-suited for helping students see the connections between course content and societal issues (9). Case studies are stories that are often based on real-world challenges without clear right or wrong solutions. Students may be asked to analyze scientific data and then interpret the significance of their results to society—for example, how they might be used to inform management or policy decisions—allowing for the development of critical thinking skills. These challenges inspire creativity and engagement, encourage full participation by students from all backgrounds, and provide benefits for both majors and non-majors (1). This is particularly important in today's world, considering that trust in scientists to provide fair and accurate information for informing societal issues is low in many countries, including the United States (10). One of the key critiques of science education is that students find it "uninteresting" and "irrelevant" for themselves and society (11, 12). Providing more context in science classrooms for students to connect course concepts with societal decisions may have the dual benefit of increasing student engagement **and** facilitating the development of a more informed electorate who can contribute substantively and intelligently to socio-scientific discussions. Indeed, a scientifically literate society is needed now more than ever as science and technology continue to rapidly advance, and we need to make decisions collectively about how they can best serve society (13).

Here, we present an interrupted case study on a complex real-world issue implemented in an introductory science classroom with science majors and non-majors. This case study is about the costs and benefits of ecological restoration in an urban environment, and it also introduces students to changing perspectives and scientific understanding of the role of fire in grassland ecosystems. Both topics provide for provocative discussion. The students are introduced to prescribed fire as a management tool for degraded grasslands, which scientists have found is often critical for maintaining and restoring diversity and ecosystem function in these systems (14). The American public, however, has low knowledge and mixed opinions about prescribed fire (15, 16), some of which is fueled by misinformation (17). Because fire affects the public in a multitude of ways and there are both increased opportunities and formidable barriers to its use in Great Plains ecosystems, this topic stimulates rich discussion. Students are also introduced to the concept of ecosystem services and then challenged to consider the costs and benefits of restoring green spaces in fragmented urban and suburban environments—another provocative topic (18) that can spark creative and meaningful discussion. This activity allows students to participate in the scientific process, make connections between science and society, and engage in stimulating discussion, thus promoting inclusivity in the classroom and enhancing student learning.

### Intended Audience

This lesson is designed for use in undergraduate introductory Ecology, Biology, or Environmental Science classes. This lesson has been implemented in a lower-division Environmental Science course at a small liberal arts college in Austin, Texas over four semesters from Fall 2021 to Spring 2023 using both hybrid and in-person course delivery. The course is lecture-only, meets two times a week for a 75-minute class period, and has a mix of science and non-science majors. This activity is well suited for classes with students from a broad range of backgrounds, and although tested on a small class size (15–20 students per section), would likely work equally well in larger classes.

### Required Learning Time

As written, this case study requires a total of about 2–3 hours of time in class. We taught this lesson during two back-to-back 75-minute class periods. It can be revised to be used in a single class, or over 3–5 class periods. We did not require students to work on the case study outside of class (aside from a final essay assignment, see Supporting File S1), although other instructors may choose to assign readings to be completed before class to help students prepare for the discussions.

### Prerequisite Student Knowledge

In this case study, students are introduced to key concepts and topics in ecology, such as ecosystem services, invasive species, and ecological restoration, and challenged to consider how biodiversity affects ecosystem services, and what challenges and opportunities might arise in conducting ecological restoration treatments in urban settings. To complete the activity in the recommended time (2.5–3 hours), students should have already been introduced to basic ecological concepts, such as ecosystem function and biodiversity, and the causes and consequences of biodiversity decline, urbanization, and habitat fragmentation. Students in our course had also already read and discussed an article about the impacts of spending time in nature on human health (19), which helped prepare them for the discussion of cultural ecosystem services. Suggested background reading is listed in the Case Study Instructor Guide (Supporting File S4); instructors may choose to assign one or more of these articles to students before beginning this activity. Lastly, it is helpful if students have used Microsoft Excel to calculate summary statistics and generate graphs, but not necessary.

### Prerequisite Teacher Knowledge

Instructors should have some background knowledge of the history and impacts of fire suppression on rangeland ecosystems in North America, the benefits of prescribed fire

for rangeland ecosystem function and biodiversity, and the challenges and benefits of ecological restoration in urban ecosystems. We have provided a list of suggested readings on these topics at the end of the Case Study Instructor Guide (Supporting File S4). Instructors must be able to explain how to calculate averages, standard deviations, and plot bar graphs using Microsoft Excel.

## SCIENTIFIC TEACHING THEMES

### Active Learning

This lesson involves an interrupted case study, where students work in small groups to generate hypotheses, make predictions, analyze and interpret real data, and discuss benefits, costs, and challenges of ecological restoration in urban environments. They are challenged to apply concepts learned through readings and lectures to an actual land management scenario involving prescribed fire and control of invasive species on public land. This makes for ripe discussion, high levels of engagement, and valuable practice analyzing data and interpreting scientific results.

### Assessment

Student learning was assessed via a graded assignment, which included in-class participation in discussions, graphing exercises, and a short essay summarizing some of the main take-home points they were expected to learn (Supporting File S1). We also used a pre-post survey to measure student knowledge and perspective of key concepts of rangeland ecosystem processes and services and rangeland management practices (Supporting File S7). The survey was anonymous and conducted using Google Forms.

### Inclusive Teaching

Case studies naturally lend themselves to more complete engagement and participation by students from different backgrounds, perspectives and levels of preparation (1). Indeed, we found that students with different skillsets were easily able to find ways to contribute to this activity, perhaps due to the interdisciplinary content covered and the diversity of tasks that each group was expected to complete, thus leading to a more inclusive classroom experience. This case study also touched on themes that were of broad interest to students from diverse backgrounds—including benefits of urban green spaces, access to high quality green spaces, the challenges of using fire as a management tool, and the value of engaging everyday citizens in ecological restoration. Our students had read and discussed an article earlier in the semester (19) about the health benefits of spending time in nature, which brought up equity issues about access to green space in cities. Previous exposure to these topics prepared students for a deeper and more complex understanding and evaluation of the challenges and benefits of ecological restoration in urban green spaces. Some instructors might consider assigning this reading as preparation for the case study, along with a more recent article (20) that directly speaks to issues of inclusivity in urban parks.

## LESSON PLAN

This activity was designed to be conducted over two 75-minute class periods (Table 1) but can be altered for different class meeting times. In preparation for the activity, review the Supporting Materials provided and make any changes necessary for your class (Supporting Files S1–S8). We used a pre- and post- survey (Supporting File S7) to assess how well the students met the course learning goals. If you plan to do the same, we advise giving students time to take the pre-survey in class before the activity. We did not ask students to do any additional readings to prepare for the activity, but they had already been introduced to many concepts earlier in the semester that were helpful in contextualizing this case study, for example: trophic interactions and energy flow through ecosystems, the relationship between biodiversity and ecosystem function, biology and impacts of invasive species, the importance of biodiversity for human health and well-being, and impacts of habitat degradation and fragmentation on small populations.

On Day 1, introduce the case study and guide students through Parts 1, 2, and 3, using short lectures (Supporting File S2) interspersed with group brainstorming and discussion activities (Supporting File S3). Use the Instructor Guide for tips about how to lead the discussions and activities (Supporting File S4). At the start of class, assign groups of 3–6 students and instruct them to download the materials for the day (Parts 1–3 of Supporting File S3). Part 1 provides some background information about the scenario and challenges students to come up with hypotheses about why bird diversity is low. Give the students about 10–15 minutes to read Part 1 and brainstorm ideas in their small groups. Then, call on each group to share their hypotheses with the class, and discuss how they might test them. Next, use slides 4–9 (Supporting File S2) to give some definitions (rangelands, grasslands, woody encroachment, invasive species), and provide more information about what the threats to grassland ecosystems are in the Great Plains and how they have led to low bird diversity at this site. You might consider asking students what they think should be done to increase bird diversity at the site before going on to Part 2 (which discusses how restoration treatments were conducted).

Next, students should be directed to go back into their small groups and read and discuss Part 2, which deals with the challenges of restoration in an urban setting. Once they have time to brainstorm with their groups, ask them to report back for a class discussion. We advise using a white board and making two lists as a class: the first should include all the barriers that might limit or prevent restoration in urban settings (*e.g.,* risk of fire escaping into nearby neighborhoods, smoke from fire affecting air quality, cost of seeds and other materials, technical skill needed), and the second should include a list of opportunities (*e.g.,* lots of people may be available and interested in volunteering, companies might donate supplies or act as a financial sponsor for a project that will be visible to a large number of people). Slides 10–15 (Supporting File S2) detail the methods that were used to restore this grassland site and can be shared before, during or after the discussion, depending on your preference. See the presenter notes in the lecture slides for more information about the prairie restoration.

Before students return to their small groups to read and discuss Part 3, you might consider introducing them to the methods used to collect data for the study. Start by asking the

students to brainstorm how scientists might measure success of the restoration, recalling that bird diversity in Great Plains grasslands was historically high because the native grasses and forbs provided habitat for a wide range of species. The question for the students could be: how, exactly, would you measure bird diversity? And how would you measure habitat quality for birds? In our class, students had participated in a lab earlier in the semester where they conducted point counts for birds and fixed-area surveys for trees, so those were methods with which they were already familiar. You can explain other common methods for surveying birds and plants, and/or use slides 16–17 (Supporting File S2) to explain the methods used in this study to survey breeding birds and plant species composition. See presenter notes for details in the lecture slides about sampling methods used in this study, and for more information about common sampling techniques for grassland birds and plants.

Next, students should work in small groups on Part 3 of the activity, which challenges them to create predicted outcomes graphs for four variables: bird abundance, bird species richness, plant species richness, and invasive plant species dominance. After about 10 minutes, the instructor can call the groups back for a full class discussion. We recommend asking one student from each group to come up to the white board and draw and explain one of their predicted graphs. As a class, discuss whether their graph looks reasonable and why or why not. In our experience, most students drew linear relationships between each variable and time (either steadily increasing or decreasing after the restoration). We used this as an opportunity to discuss how and why we might expect non-linear responses. For example, in 2013, after the restoration treatments were first fully deployed, invasive species cover was likely to drop dramatically and might increase again in certain years if, for example, on-going maintenance was neglected. You can also point out how the restoration treatments are not likely to be the only factor affecting birds and plants at this site. For example, we also might see inter-annual variability in bird abundance or diversity depending on whether it was a wet year or a dry year. At the end of class, give students a brief idea about what they will be working on during the next class period.

On Day 2, students will spend most of the class analyzing data and creating graphs, so make sure there are computers for them to use with Microsoft Excel installed. When they arrive, ask them to get back into their groups and download the dataset (Supporting File S5) and Parts 4–5 of the case study (Supporting File S3). The case study description includes detailed instructions about how to calculate summary statistics and draw bar graphs in Excel, but you might choose to give a brief tutorial about how to use Excel depending on their level of experience with the program. Students will likely need about 25–30 minutes to complete the required calculations and graphs and discuss their findings. See instructor guide (Supporting File S6) for an answer key to Part 4. Once all groups have completed Part 4, lead a full class discussion about how the actual results compare to their predicted results, and what factors could have influenced the patterns observed in addition to the restoration treatments.

Finally, students should return to their small groups and read and discuss Part 5. In the reading, they will be introduced to the concept of ecosystems services and then be asked to discuss how it applies to grassland systems and restoration. Each group must list five ecosystem services that prairies provide and then use plus, minus, and equal signs (+, -, =) to indicate whether that service would likely improve or not with restoration and by how much. Once students have had a chance to brainstorm as a small group, bring them back for a full class discussion, asking each group to report back and justify their reasoning for their responses. Come up with a collective list of ecosystem services on the white board, organized into categories according to how much they are likely to change, and encourage students to think of at least a few for each category. Slide 24 includes some additional examples of ecosystem services that students might not mention. If time allows, you might pose additional questions to the students about how they would quantify these services if they were to conduct a scientific study measuring impacts of restoration treatments. During Part 5, students are also asked to consider some of the social benefits of ecological restoration, and how we might maximize inclusivity with projects like this one. We recommend discussing this topic as a large group.

End the class by explaining what is expected of the students for their take-home assignment. If you plan to include a pre-post survey (Supporting File S7), we advise giving students time to complete the survey at the end of the class or the beginning of the following class. Lastly, if students will be graded individually based on participation in the group work, you might consider asking them to rate one another on contributions and engagement using confidential surveys (Supporting File S8).

## TEACHING DISCUSSION

Past research has found that case studies can help students to meet course learning goals by increasing engagement, developing critical thinking skills, and helping students see the value and relevance of science in its application to societal issues (1, 9). We found evidence to support these previous findings. In the classes where we tested this case study, student learning was assessed using a pre-post survey, in-class assigned group work, and a take-home essay assignment, and engagement was informally assessed by observing participation in group discussions and activities during class.

Notably, this case study was successful in sparking lively discussion and full engagement by students from diverse backgrounds, levels of preparation, and majors. Students who participated were from 20 different majors (78% were non-science majors), all levels of academic standing—from freshmen through seniors—and with varying levels of experience with Microsoft Excel and preparation in the biological sciences (11% biological science majors). As is a common struggle for classes composed of mixed majors/non-majors, this class generally suffers from relatively low levels of voluntary participation during discussions by most students. During the case study activity, however, even the quietest students spoke up and contributed, and no signs of egregious "free-loading" were observed. Because this was tested on small classes, the instructor was able to walk around the room, check to see that everyone was participating, and if not, encourage students who were less interactive to speak up, but we did not formally quantify participation. We recommend

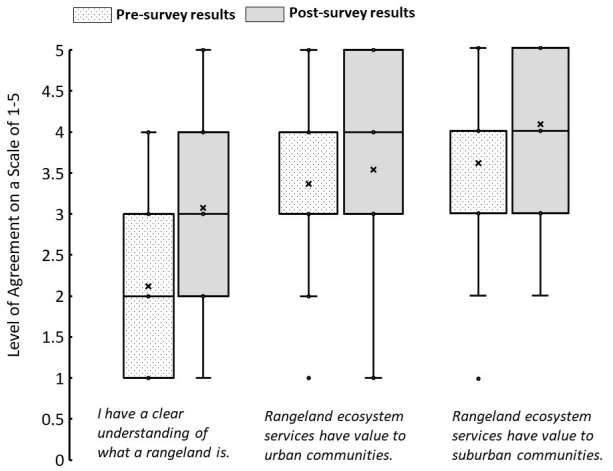


**Figure 1.** Responses from pre-post surveys demonstrated an increased understanding of rangelands and their benefits. Students were asked to rate their level of agreement or disagreement on a scale of 1–5 (strongly disagree to strongly agree) with the statements that appear at the bottom of each pair of box plots. Box plots represent the pre- and post-survey responses, including minimum and maximum responses, 25%, 50%, and 75% quartiles. Outliers are shown as dots and mean values are shown as cross marks.

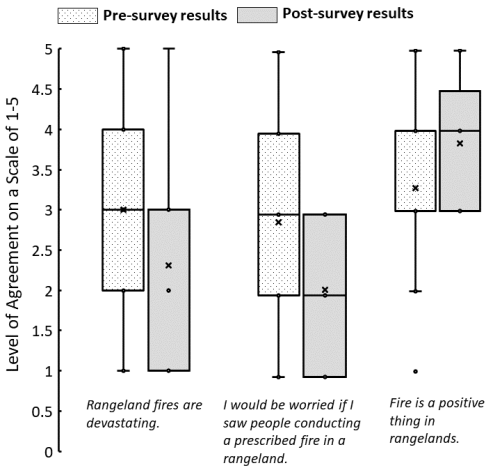


**Figure 2.** Responses from pre-post surveys demonstrated an increased understanding of the impacts of prescribed fire on rangeland ecosystems. Students were asked to rate their level of agreement or disagreement on a scale of 1–5 (strongly disagree to strongly agree) with the statements that appear at the bottom of each pair of box plots. Box plots represent the pre- and post-survey responses, including minimum and maximum responses, 25%, 50%, and 75% quartiles. Outliers are shown as dots and mean values are shown as cross marks.

assessing participation through peer feedback from students in larger classes, where it would be more difficult to gauge by the instructor.

Preliminary results from the pre-post survey suggested that students did learn key concepts about rangeland health, threats to rangelands, and ecosystem services that rangelands provide through participation in this case study. This project is part of a larger educational research program spearheaded by Texas A&M University, called "The Prairie Project," and the survey we used was developed and validated for use by all educators who participated in the program. The survey instrument was approved by the Texas A&M University Institutional Review Board (IRB2019-0429, Reference Number 109744) and through a reciprocity agreement, by the St. Edward's University IRB. The survey included questions about perspectives and understanding of the role of fire in rangelands, the threat of fire suppression and woody encroachment, and the benefits of rangelands (Supporting File S7). Our students self-reportedly gained a better understanding of what a rangeland is and showed a greater appreciation of the benefits that rangelands provide to both rural and urban populations in their post-survey responses (Figure 1). Students' perspectives and knowledge of the impacts of prescribed fire in rangeland ecosystems also changed after participating in the activity so that it was better aligned with scientific understanding (Figure 2). For example, they were less likely to agree with the statement that "rangeland fires are devastating." Through trial and error, we found that response rate to the survey was much higher when we gave students time to complete it during class rather than sending it as a link via email (62% versus 14%). Students demonstrated an understanding of some of these same concepts in their assigned essays (Table 2). For example, many students described the benefits of healthy functioning rangeland ecosystems in detail and highlighted the ecosystem services provided by restored urban green spaces. This included both ecological services, such as water purification, and social and cultural services, such as access to nature and subsequent impacts on mental health. Students also recognized the challenges inherent in restoring ecosystems in urban areas. Many commented on how fire might be looked at unkindly by the surrounding community, and how urban restoration depends on public support. Lastly, students also brought up a legitimate concern that conservation biologists struggle with: does it make sense to spend valuable resources in urban environments, where there are numerous other threats, or would that time and money be spent better elsewhere? Many of these same points were brought up by students in small group discussions during class, which made for stimulating and lively conversation.

## Adaptation of This Case Study for Hybrid, Online, or Larger Classrooms

This case study is adaptable to hybrid, online, or larger classrooms. Although we have observed that group discussions are generally most dynamic and engaging when students are together in person, we tested the case study on a hybrid class during the fall and spring semester of 2021–2022, and it worked well. In these classes, most students were present in person, but 1–3 students joined remotely and worked with their group with the help of Zoom breakout rooms and Google docs. With hybrid and remote classes, the use of online breakout rooms and shared Google docs is an effective way for students to engage in group work remotely and for the professor to observe their progress. Parts 1–3 and 5 of the Case Study involve readings and discussion, and students may participate whether they are online or in person. Part 4 involves calculating summary statistics and generating graphs in Excel. For in-person classes, some instructors might decide to allow a group to work on these graphs together. If some or all students are joining remotely, however, we advise asking each student to work alone in generating the graphics. Since there are four graphs, students can be placed in groups of four and each student can be expected to generate one of the four graphs themselves. They would then still interpret the graphs together.

For online classes and larger classes, gauging and/or grading student understanding of key concepts and participation in

the activity will be more difficult. In these cases, clicker-style questions can be used during class to determine whether there are concepts that students are having a hard time understanding so that they can be discussed and explained further. We advise using team evaluations for larger classes so students can rate their teammates on participation and contributions. In this case, a notetaker can be assigned for each group and asked to record who contributed comments to their discussion, and participation can then by graded based on number or quality of comments. In larger classrooms, because instructors will not have time to individually help each group with their summary statistics and graphs, instructors might consider posting a video about how to calculate summary statistics and generate graphs in Excel. This could be assigned as required asynchronous work before class so that students are better prepared to complete Part 4 of the activity.

Lastly, this case study can easily be reduced or expanded for use during fewer or more class periods, and altered based on course learning goals, location, and how much prerequisite knowledge students have on the various topics presented. To reduce the time spent on this assignment in class, Parts 1–3 and 5 could work easily as a stand-alone activity, as could Parts 3 and 4. In the instructor guide, we suggested that the discussion about access to restored green spaces can be deleted if time won't allow for it (see Part 5, Question 2 in Supporting File S4). Particularly if this topic has not been discussed previously, students could easily take up a whole class period answering that one question. This case study is set in an urban environment in the Great Plains, and may be most valuable for instructors in similar settings. For courses in other regions, instructors may decide to spend more time providing background or less time by removing parts of the assignment and focusing on those that are most relevant. Lastly, instructors may choose to assign some of the case study as asynchronous work (*e.g.,* lectures or graphics activities) and spend more time in class on discussion, data analysis, and graphing.

To extend the case study, readings and/or videos could be assigned that provide more background information on key concepts such as the role of fire and grazing in rangeland ecosystems, the threat of woody encroachment, and the effectiveness of restoration treatments for returning ecological function and biodiversity to degraded ecosystems. There are tools to evaluate woody encroachment over time, such as the Rangeland Analysis Platform, that could easily be integrated into this lesson. Finally, an additional assignment could be a peer review of several other students' essays.

## Conclusions

In sum, this case study is a versatile mechanism for teaching key concepts about rangeland ecology, urban ecology, and ecosystem services, and for helping students to see connections between science and society. It would be appropriate for introductory Biology classes with a mix of majors and non-majors, and it can be applied to in-person, hybrid, or remote classes of any size.

## SUPPORTING MATERIALS

- S1. Urban prairie restoration – Assignment description and rubric
- S2. Urban prairie restoration – Lecture slides
- S3. Urban prairie restoration – Case study, Student handout
- S4. Urban prairie restoration – Case study, Instructor guide
- S5. Urban prairie restoration – Plant and bird diversity and abundance data
- S6. Urban prairie restoration – Answer key to graphics activity
- S7. Urban prairie restoration – Survey questions
- S8. Urban prairie restoration – Sample team evaluation

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**Table 1.** Lesson plan and timeline for case study activity and assignment.

| Activity | Description | Estimated Time |
|---|---|---|
| **Pre-Project Preparation and Assessment** | | |
| Preparations by instructor | • Review the case study instructions, lecture slides, and data files provided (Supporting Files S1–S6), and revise according to class goals, timeline, and level<br>• Prepare assignment description and rubric (Supporting File S1)<br>• If you plan to do this over two class periods (as suggested here), break the case study (Supporting File S3) into two parts: Parts 1–3 for Day 1 and Parts 4–5 for Day 2<br>• Upload case study files, assignment description, and rubric to the Learning Management System (*e.g.,* Canvas)<br>• Prepare a brief pre-survey to test student learning outcomes (Supporting File S7) | 2–4 hours |
| Student pre-survey | • Share a link to the pre-survey with students and ask them to fill it out either on their own or during a class period prior to beginning the activity | 10–15 minutes |
| **Case Study Activity: First Class Period** | | |
| Part 1: Where are all the birds? | • Start by introducing the activity to students (5 minutes; Supporting File S2, slides 1–2)<br>• Ask students to form groups and download the case study file for Day 1 (Supporting File S3). Note: the instructor might also decide to hand out hard copies of Parts 1–3 of the case study<br>• Ask students to review Part 1 of the case study and answer the questions with their group (10 minutes; Supporting File S2, slide 3)<br>• Ask each team to report back about their responses (5 minutes)<br>• Give a brief interactive lecture about the issues facing grasslands in the Great Plains and more background on this site specifically (5–10 minutes; Supporting File S2, slides 4–9) | ~30 minutes |
| Part 2: Returning fire to the prairie | • Ask students to read and discuss Part 2 of the case study with their teams (10 minutes; Supporting File S2, slide 10)<br>• Ask each team to report back about their responses (5 minutes)<br>• Give a brief interactive lecture about how the restoration was conducted and discuss some of the challenges and opportunities for restoration in urban environments as a class (10 minutes; Supporting File S2, slides 11–15) | ~25 minutes |
| Part 3: Predicting restoration outcomes | • Briefly explain how birds and plants were surveyed for abundance and diversity in this study (2–3 minutes, Supporting File S2, slides 16–17)<br>• Ask students to read and discuss Part 3 of the case study with their teams and then draw predicted graphs about how they think plants and birds responded to the treatments (8–10 minutes; Supporting File S2, slides 18–19)<br>• Instruct each team to report their responses to the whole class, drawing their graphs on the white board and explaining their rationale. As a class, discuss some of the factors that will influence response to the restoration (8–10 minutes)<br>• Wrap up the discussion, and give a preview of what students will be working on during the next class period (1–3 minutes) | ~20 minutes |
| **Case Study Activity: Second Class Period** | | |
| Part 4: Data analysis | • Give a brief introduction to the data analysis assignment (5 minutes; Supporting File S2, slide 20)<br>• Ask students to download Parts 4–5 of the case study (Supporting File S3, Parts 4–5) and the spreadsheet (Supporting File S5). Note: the instructor might also decide to hand out hard copies of Parts 4–5 of the case study<br>• Students will work in small groups to calculate summary statistics (means and standard deviations) of bird diversity, plant diversity, bird abundance, and invasive species dominance and then draw bar graphs (25 minutes)<br>• In their groups, students will discuss their graphs and how the actual results compare to their predicted results (5 minutes)<br>• Facilitate a whole class discussion on factors that could have influenced the patterns observed in addition to the restoration treatments (10 minutes; Supporting File S2, slide 21) | 40 minutes |

| Activity | Description | Estimated Time |
|---|---|---|
| Part 5: Ecosystem services of a restored prairie | • Introduce the final part of the activity and ask students to read and discuss Part 5 (2 minutes; Supporting File S2, slide 22)<br>• Students work in groups to generate a list of ecosystem services provided by grasslands and predict how the restoration treatment would impact them (15 minutes)<br>• As a whole class, discuss ecosystem services of native and restored prairies. Talk about the definition of ecosystem services first (Supporting File S2, slide 23). Using the white board, write a list of all the services students generated in their groups. Explain some additional ecosystem services they might not have mentioned (10 minutes; Supporting File S2, slide 24)<br>• Ask students to submit their group work at the end of class. Describe what they need to do for their take-home assignment (3 minutes; Supporting File S2, slide 25) | 30 minutes |
| **Post-Activity Assessment** | | |
| Student individual assignment | • Students will write a 1.5–2-page essay about the costs, benefits, and opportunities for urban restoration, and come up with some best practices for how and when they would recommend focusing efforts (Supporting File S1) | variable |
| Student post-survey | • Share a link to the post-survey with students, and ask them to fill it out either on their own or during a class period after having completed the activity (Supporting File S7)<br>• Ask students to fill out a team evaluation (Supporting File S8). | 10–15 minutes |
| Instructor grading and assessment | • Grade group work according to rubric (~5–10 minutes per group; Supporting File S1)<br>• Grade essay according to rubric (~5–10 minutes per essay; Supporting File S1)<br>• Analyze the differences in response between pre-and post-surveys to determine what students gained from the activity and what are some areas that need improvement or further explanation (~2 hours) | variable |

**Table 2.** Excerpts from student essays demonstrating their understanding of the benefits and challenges of restoring grasslands in urban and suburban areas.

| **Benefits of Ecological Restoration in Urban Areas** |
|---|
| "Another massive plus of prairie restoration in urban areas is the benefits that prairies provide the soil by securing the topsoil, reducing soil erosion, and storing water while reducing the risk of flooding to the surrounding areas. Additionally, prairies are excellent for sequestering carbon from the atmosphere and converting it into plant tissue. Prairies also can contribute to improved water quality, a benefit that should be especially incentivizing for residents in urban areas." |
| "Urban restoration of any kind is important because it gives people access to nature, which can help to increase their mental health." |
| **Challenges of Ecological Restoration in Urban Areas** |
| "Some challenges of urban prairie restoration include things like cost, getting nearby residents onboard, the time it takes to perform treatments, and keeping controlled burns under control." |
| "Something else to consider is that even if the treatments are successful, wildlife still has urbanization playing against it." |
| "Taking into consideration the benefits and the difficulties associated with restoring an urban prairie, I do believe urban prairie restoration could be beneficial to do. However, I have two main concerns… The second concern is more connected to the idea of habitat fragmentation. Is it more beneficial to try and save areas that are connected to a larger whole, to try and keep the whole habitat from fragmenting? Or is it better to try and save the already-fragmented areas? If a restored prairie is completely separated from any other non-urban land, how much good will it do compared to restoration efforts elsewhere?" |

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