No such thing as a free lunch: Trade-offs of trees in grassy ecosystems

Student Handout 1

1. Background

Nebraska has been called a fly over state for decades. There aren't any visitors coming through Wheeler County to hike mountains or dip their toes in the ocean. But for residents, you couldn't find a better view than the rolling sea of green and gold grasses stretching across an endless horizon. For generations, ranchers like Henry Miller have enjoyed the secret beauty of the quite wide-open. Like the hardy trees planted along the pasture's edge so long ago, the family memories are entrenched in the lines and breaks of the landscape.

"When I was younger, I used to ride my ATV out there," Henry says, tracing a dark patch to the left of the porch with his index finger. The sun is setting. Its beams are difficult to distinguish from the waves of grass that crash against the darkened trees in the wind. The tree patch's edge bleeds into the landscape, like sea breaks into a golden ocean. "One time I was riding up to the east pasture and flipped over a cedar tree hidden in the grass. Took me ages to get back to the house, and I broke my arm."

He brushes his arm absentmindedly as he says "I told my dad that we needed to cut down some of the trees popping up in the pastures- 'They're a hazard!' Well, you should have seen his face!" He laughs, and then says in a crackly imitation, "Henry, you don't ever cut a tree down in the Sandhills, do you hear me? Do you know how hard it was to get those things to survive out here?"

His smile fades and he sighs, looking back across the darkening landscape. "Funny, ain't it? Seeing as now, no matter how hard I try, I can't cut these damn things down fast enough!"

In many regions of the Great Plains, Eastern redcedar has transitioned from a rare species used to improve the quality of life of homesteaders, to an invasive pest. In this case study we follow cedar's changing role from rare to invasive in Nerbaska's grassland systems in order to explore the social-ecological dimensions of environmental decision making.

1.1 A rare species in a hostile environment

Food, water, shelter, and fuel are essential resources, and accessing most or all of them at the same time is a common human challenge. Early European American settlers on the North American Great Plains found weather and resource availability extreme and unpredictable. One of the most noticeable differences between Great Plains landscapes and those of eastern North America and Europe was the plains' lack of trees. Trees provided fuel, lumber, food,

windbreaks, and shade. Settlers liked trees, but they were rare, and those that did grow huddled along streams and in areas with rough terrain—areas that did not burn. Prairie fires set by Native Americans and lightning strikes were common up until the turn of the twentieth century. These frequent fires generally encouraged grass growth and discouraged tree growth, to the point of making most of the plains virtually treeless. People thought planting trees could make life better. Orchards of fruit trees yielded both fruit and shade, and shelterbelts of eastern redcedar shielded people, buildings, and livestock from strong Great Plains winds. For these reasons, government programs incentivized settlers to improve their properties through tree-planting. In addition, putting out prairie fires helped ensure that planted trees would survive to maturity and continue to provide benefits, so a culture of fire-suppression developed. In this scenario, is tree-planting a worthwhile activity?

Group tasks:

1. Use the above scenario to create a list of key components related to **how you will decide whether or not to plant trees in the Great Plains**

2. From your list identify which components are related to grassland ecology and which components are related to social benefits/consequences.

3. Create a concept map using these concepts to understand **how you will decide whether or not to plant trees.** In your maps, label the arrows (+/-) to show the nature of relationships.

4. Using your concept map, does planting trees appear to be a win-win solution to improving quality of life or do trade-offs exist? Explain your reasoning in groups.

Student Handout 2

The cedar-apple rust problem

Some of the European-American settlers who moved into the Great Plains planted orchards in the hope that fresh fruit could become a viable commercial industry for the region. Settlers who planted apple orchards followed their neighbors' common practice of planting Eastern redcedar for windbreaks. In the orchardists case, these windbreaks were planted specifically around the orchards to protect them from the cold, wind, and snow of the Great Plains. As the orchards and the windbreaks that protected them grew, however, the orchardists experienced the first serious drawback to tree planting, which their neighbors had not: a type of fungus called cedar-apple rust.

The rust is *heteroecious*, which means it requires two different species in order to complete its lifecycle. You will not be surprised to learn that this particular rust requires cedar trees and apple trees in order to complete its lifecycle. Without both species in proximity to each other, the rust will not affect the trees. For the first stage of the lifecycle, the fungus creates "cedar galls" - hard, nut-like spheres - on the branches of the cedar trees. The galls are mostly harmless to cedars, although in cases of extreme infestation they can become weighed down by large numbers of galls. The galls then bloom into "cedar flowers," which extend long tendrils that allow the wind to blow the fungus to the apple trees for the second stage of the lifecycle. Unlike with cedars, the fungus has a much more adverse impact on apple trees. Leaves form lesions, and apple production is stunted. The apples that are produced have orange or brown lesions themselves, and are commercially unsalable. Extreme infestation can dramatically stunt tree growth or even kill them off.

While the cedar-apple rust affected apple orchards from the east coast to the Great Plains, Nebraska orchardists in particular suffered heavy infestations because they had intentionally planted both types of trees next to each other. Faced with the collapse of their industry, orchardists removed the windbreaks from around their apple trees. Unfortunately, it was not enough. Even with the windbreaks removed, the rust was able to use cedars from neighboring properties to maintain its lifecycle. For the neighbors, these cedar trees held value as windbreaks for their own properties, or were a source of cultural pride, and they were reluctant to take them down.

Group tasks:

1. Incorporate key components from the cedar-apple rust problem into your concept map.

2. How does incorporating cedar-apple rust into your concept map change how you will decide whether or not to plant trees, do win-win or trade-off scenarios emerge?

3. What actions or policies could be implemented to address the cedar-apple rust problem?

Student Handout 3

From rare to invasive: a rancher's perspective

As a sixth-generation rancher, Herb Husker knows his property and everything contained within it as well as he knows his own kids. Herb loves the prairie, and always makes sure to take some time out of his busy day to just take it all in: the wide stretches of grass and sky, the patterns the grass makes as it moves with the wind, the beautiful grassland birds. Herb also loves what he does, working outside and managing cattle. Aside from four years at college, Herb has spent his entire life working on the Big Red Ranch, and he hopes at least some of his children and grandchildren will continue working the ranch long after he is gone. However, for the past decade or so Herb has become increasingly worried his vision of the future is in jeopardy. When Herb worked on the ranch as a child, the landscape was almost treeless; only a few trees near the creek and the cedars planted as windbreaks for the cattle broke up the endless sea of grass.

As time has passed, though, more and more cedar trees have popped up on the landscape. At first, cedar invasion was so slow Herb barely registered the change as spreading cedars simply became part of the landscape over the course of the years. Recently, however, cedar trees have popped up faster and occupied ever more of the good quality rangeland Herb and his family rely on to feed their cattle. Herb is also concerned with how much water all of these trees are pulling up from the creek and the aquifer. Herb fears the trees are now spreading too far and too fast to manage, especially since bringing in heavy tree removal equipment would be too expensive for a land-rich but cash-poor ranching operation. Prescribed burning would be a good option, but Herb is unfamiliar with this approach and does not want to excite his neighbors. Herb recently heard from another rancher about a community meeting being organized to discuss cedar invasion and what could be done about it. Herb has decided to attend the meeting to learn about the other interested parties, and to provide his comments and concerns about what needs to be done to address the tree invasion problem and keep productive rangeland as productive rangeland.

Group task:

1. Use the rancher's perspective to modify your concept map. Note that cedar's context has changed socially in the system. Your concept map will now be used to **understand how to navigate cedar invasion.**

Student Handout 4

From rare to invasive: Federal Grassland Management Service's perspective

The Federal Grassland Management Service's mission is to manage federally owned grasslands, conduct research, and provide funding, and expert advice for owners of privately-held grasslands in a way that promotes a good quality of life on the Plains. The purpose of this mission is to conserve healthy grasslands for multiple uses, such as cattle production, recreation, and hunting opportunities, both for people today and for future generations. To ensure a good quality of life, FGMS must consider a range of factors, both ecological and social. Furthermore, as a federal agency FGMS is obligated to consider a range of environmental effects, such as the environmental impacts of its projects and risks to threatened and endangered species. The agency also does its part to help address climate change. FGMS has watched with increasing concern as cedar tree invasion has occurred across the Great Plains, with invasion occurring faster in the southern states.

In response to rising concerns, the FGMS met with scientists from the University of Nebraska to discuss the impacts of cedar invasion in the Great Plains. Scientists explained that cedar invasion has been shown to convert a grassland into a dense cedar woodland in 40 years if left unchecked. Moreover, there are many consequences that emerge when grassland transition to cedar woodland and include: a loss of forage for cattle and wildlife, reduced diversity of grassland plants and animals, reduced resources for insect pollinators, a loss of funding for public education generated from grazing leases on school-owned properties, reduced water yield, increased wildfire risk, spring allergies are worsened as cedar pollen becomes more abundant, and species that are sensitive to cedar are at an increased risk for becoming threatened, endangered, or extinct. The scientists also noted that belowground carbon storage changes, but that both increases and decreases in belowground carbon have been observed depending on the study.

Now, Nebraska is on the frontlines of cedar invasion. Cedar spread into grasslands brings a host of uncertainties to grassland management. FGMS is worried about the impacts to its multiple-use mission as well as both grassland ecological health and human health and safety. However, within the agency officials are divided on what should be done to address the problem. Some believe FGMS should focus on tree removal and grassland restoration projects, especially in the southern states where the impact of tree invasion has been felt the hardest. Other officials argue the agency needs to sacrifice already invaded areas in order to move aggressively to protect uninvaded grasslands. Still others question the concern over the spread of cedar which store more carbon aboveground compared to grasslands and generate wood products. As an initial compromise, FGMS has decided to send representatives to a community meeting in Nebraska on cedar invasion in order to (1) assess the positions of landowners and other stakeholders affected

by the problem, and (2) promote the different paths forward FGMS is considering to gage stakeholders' response.

Group task:

1. Use the Federal Grassland Management Service's perspective to modify your concept map. Note that cedar's context has changed socially in the system. Your concept map will now be used to **understand how to navigate cedar invasion.**

Student Handout 5

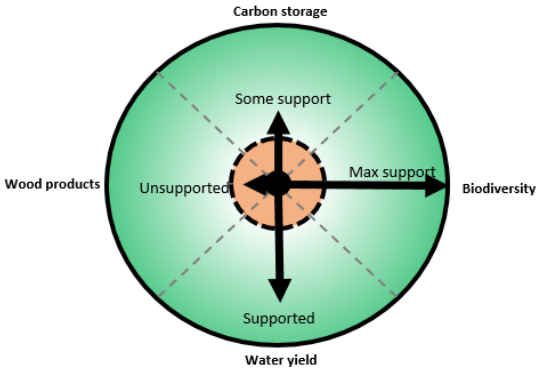
Group tasks:

1. In your new groups merge the rancher's and FSGM's perspectives to understand how to navigate the cedar issue.

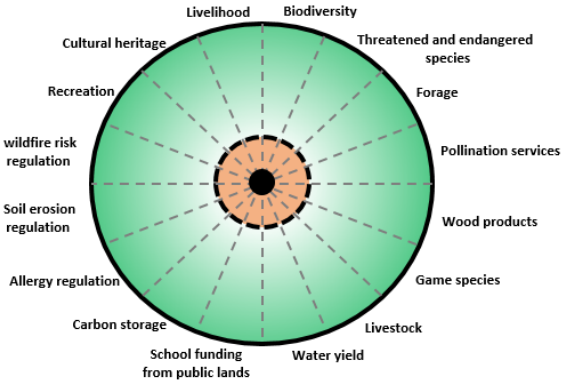
2. Using your concept map identify:
    - What system components support a grassland?
    - What system components support a cedar woodland?

3. Using your concept map, determine whether the following policies/actions support a grassland, woodland, or both.
    - Incentivized cedar planting
    - Incentivized cedar removal
    - Removal of seed producing cedar trees
    - Fire suppression
    - Prescribed burning
    - Restricting the number of days prescribed fires can be conducted
    - Doing nothing

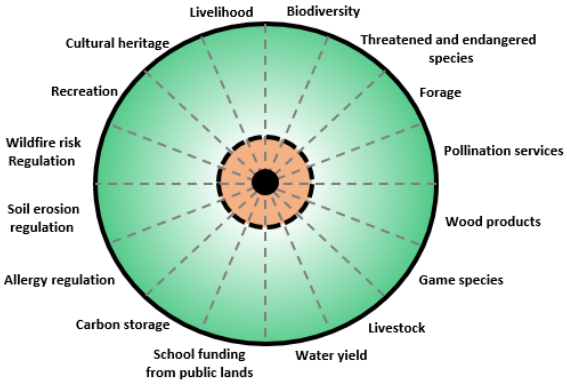
4. Use your concept map to create ecosystem service assessments for a grassland and cedar woodland. Populate the **grassland** and **cedar woodland** ecosystem service diagram with arrows to show the relative support (unsupported to maximum support) for each ecosystem service (see example). Arrows in the red zone show no support, arrows in green show varying levels of support.



Example system



Native Grassland



Eastern redcedar woodland

5. Conduct a stakeholder analysis using arrows to connect stakeholder groups to their most valued ecosystem service(s). Many stakeholders will value multiple ecosystem services.

Stakeholder groups
Ranchers association
Natural Resource Conservation Service (NRCS)
U.S Forest Service
U.S. Fish and Wildlife Service
Board of Education
Environmental Protection Agency
National Parks Service

Ecosystem services
• Biodiversity
• Threatened and endangered species
• School funding from public lands
• Pollination services
• Wood products
• Game species
• Livestock
• Water yield
• Forage
• Carbon storage
• Allergy regulation
• Soil erosion regulation
• Wildfire risk regulation
• Recreation
• Cultural heritage
• Livelihood

6. Different stakeholder groups use different approaches for managing ecosystem services in grassland systems. Use arrows to connect stakeholders to policies/actions you expect them to implement.

Stakeholder groups	Policies/Actions
Ranchers association	• Do nothing
Natural Resource Conservation Service (NRCS)	• Incentivized cedar planting
U.S Forest Service	• Incentivized cedar removal
U.S. Fish and Wildlife Service	• Removal of seed producing trees
Board of Education	• Fire suppression
Environmental Protection Agency	• Prescribed burning
National Parks Service	• Restricting the number of days prescribed fire can be conducted

7. Using what you have learned in the case study, describe potential points of conflict and agreement in determining how to navigate the cedar problem. Think about ecosystem service tradeoffs versus win-wins and how these relate to socio-environmental feedbacks (i.e., questions 2-6).

8. What assumptions did Great Plains citizens make in part 1 of the case study that led to a biome-wide afforestation program? Did these assumptions prove to be true in part 2? Explain your reasoning.

9. What assumptions are made in part 2 of the case study to help us understand how to navigate the cedar issue? Explain.

10. What information would you want to know in order to make policy and management decisions regarding the cedar issue on a property, county, and state?

Take home essay question:

A recent study published in *Science* (Bastin et al. 2019) predicts that the world can support more than 2 billion acres of trees in addition to the current 8.6 billion acres. Adding this many trees to the planet is predicted to lower atmospheric carbon pool by about 25%, but would require converting many grasslands into woodlands and forests. Many countries are in the early stages of afforestation, planting millions of trees in grass dominated ecosystems. Using what you have learned from this case study, write an elevator pitch (no more than 200 words) that you would use to help a manager understand how to decide whether or not to plant trees in a grassland dominated ecosystem.