“Go-Back” Land:
Restoring Abandoned Farmland & Sustaining Farm Towns

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Summary

Rural-to-urban flight and farmland abandonment are often associated with the Dust Bowl era. Yet rural depopulation has continued for decades in parts of the U.S. due to global economic forces, disparate opportunity between rural and urban counties, and the lack of affordable access to water. Where agricultural productivity is high or predictable, rural emigrants have been able to sell their farms before leaving. In more marginal areas, farms may be abandoned. This trend is likely to intensify in coming years due to climate change, aquifer drawdown, social disruption caused by energy booms, and increasing competition for scarce water from burgeoning metropolitan areas.

This case asks students to consider how remaining residents and government officials can address issues associated with “go-back land” – abandoned farmland left to “go back” to a more unmanaged state. It is designed in three tiers so that instructors can use some or all of the case depending on time constraints. Students act as members of a local community task force to recommend policy mechanisms that might restore and conserve ecosystem integrity and protect rural community cohesion in an area undergoing agricultural land abandonment. While set in Utah, it can be adapted to other affected regions such as the Great Plains, elsewhere in the Intermountain West, or the Appalachians.

Farmlands provide ecosystem services that benefit local communities and the broader society. After abandonment, some services decline while others may become available. Students use an ecosystem service framework to weigh alternative outcomes for the land. Simultaneously they consider social and economic consequences of those outcomes, attempting to balance social system and ecosystem goals. To do so, they must consider successional dynamics of rangelands and of rural communities, the role of environmental and socioeconomic forces beyond local control, and issues of temporal and spatial scale.

Which course(s) and academic level is the case designed for?

If used in its entirety, the case is appropriate for an upper-division undergraduate or Master’s-level course where students have some prior exposure to grass/shrubland successional processes and/or rural community dynamics. It could be expanded to serve as the basis for a capstone course in natural resource management or environmental studies. Alternatively, if Part I alone is used, it could become an exercise within an introductory environmental studies, range management, or agriculture and society course.

<u>SES learning goals addressed</u>

Part I: Understanding and Describing the Problem

1. Understand the structure and behavior of socio-environmental systems.
    - Identify the environmental and social components of the system and their interactions.
    - Identify feedbacks and explain the dynamics of an S-E system.
    - Use tools and modeling approaches to understand dynamics of an S-E system.
2. Consider the importance of scale and context in addressing socio-environmental problems.
    - Understand that ecological and social processes interact across different scales.

    <u>Related activity</u>: Students work in groups to develop and diagram a conceptual model of the system. Next they consider issues of spatial scale, discussing how "top-down" forces influence options and decisions at the local scale.

Part II: Predicting Consequences of the Problem

2. Consider the importance of scale and context in addressing socio-environmental problems.
    - Understand that ecological and social processes often vary across differing contexts, including space, time, and conditions (e.g. economic or political).
3. Co-develop research questions and conceptual models in inter- or trans-disciplinary teams.
    - Communicate across disciplinary boundaries.
4. Find, analyze, and synthesize existing data, ideas (e.g. frameworks or models), or methods.
    - Identify data sources and appropriate tools, evaluate quality of data, and manage data.
    - Understand the different kinds of data and research methods used by relevant disciplines in the natural and social sciences.

    <u>Related activities</u>: Students identify ecosystem services that may be affected by farmland abandonment and/or restoration, as well as processes that may positively or negatively affect flows of those services. After dividing into expertise groups to review concepts of ecosystem and community transition and succession, they predict current and potential alternative trajectories for their system, and identify data they would need to test those predictions. Each set of experts teaches the other what they learned from those concept reviews.

Part III: Potential Routes to Restoration and Sustainability

1. Understand the structure and behavior of socio-environmental systems.
2. Consider the importance of scale and context in addressing socio-environmental problems.
3. Co-develop research questions and conceptual models in inter- or trans-disciplinary teams.

- Identify disciplines and approaches relevant to the problem.
- Communicate across disciplinary boundaries.
- Identify potential users of and applications for research findings.

4. Find, analyze, and synthesize existing data, ideas (e.g. frameworks or models), or methods.
   - Identify data sources and appropriate tools, evaluate quality of data, and manage data.
   - Understand the different kinds of data and research methods used by relevant disciplines in the natural and social sciences.
   - Integrate different types of data (interdisciplinary integration).

   Related activities: Students consider and propose mechanisms for capturing the value of ecosystem services, considering issues of equity as well as political and economic feasibility. After reviewing case studies of rural community and land preservation strategies, they propose policy mechanisms to create incentives for preservation and restoration. They use U.S. and agricultural census data, as well as soils data, as well as considerations of top-down forces and temporal discontinuities, to evaluate tradeoffs associated with their policy choices.

Learning objectives

I. Understanding the problem – what's happening and why is it happening?

   A. What contemporary coarse-scale forces (economy, demographic change, climate change, etc.) influence the viability of agriculture in water-scarce regions?
   Learning objectives: Students will be able to (a) *identify* coarse-scale (top-down) forces that are beyond local actors' control, but can influence the viability of rural agricultural economies in dryland regions of the U.S.; and (b) *explain* how those forces are likely to constrain or enhance the opportunities rural communities have to respond to changing conditions.

   B. What historical legacies tend to direct abandoned agricultural lands, and the social systems that are linked to them, toward particular trajectories?
   Learning objectives: Students will be able to (a) *describe* historical legacies that influence the capacity of abandoned farmlands and/or depopulating rural communities to respond to system-level stressors; and (b) *predict* how those legacies can influence the successional pathways those lands and/or communities are most likely to follow.

   C. How do these coarse-scale and historic factors interconnect with factors at the property/household scale (e.g., income, family structure, property characteristics) to influence decisions to abandon agricultural properties?
   Learning objectives: Students will be able to *describe* the social-ecological system in a landscape experiencing agricultural land abandonment using a visualization technique such as Mental Modeler.

II. Consequences of the problem - what will happen if the problem isn't addressed, and what are possible alternative outcomes?

A. What ecosystem services are associated with farmlands in farmed vs. abandoned vs. restored states? If the goal of policy and management is to sustain ecosystem services, does the "restored" landscape need to consist entirely of native species?
Learning objectives: Students will be able to *identify* and *classify* ecosystem services, and *evaluate* tradeoffs among (a) ecosystem service provision options and (b) using native vs. non-native species in restoration strategies.

B. What alternative stable states could an abandoned agricultural property move toward?
Learning objectives: Students will be able to (a) *describe* successional processes in the context of dryland ecosystems altered by agriculture; and (b) *explain* why one or more pathways are more likely than others.

C. What alternative stable states could a population-depleted agricultural community move toward?
Learning objectives: Students will be able to (a) *describe* a range of community transition processes that may occur in the face of a disruption in the local agricultural economy; and (b) *explain* why one or more pathways are more likely than others.

D. Which livelihoods are most at risk under different SES trajectories?
Learning objectives: Students will be able to *compare* risk factors for different livelihoods within a depopulating agricultural community.

III. Potential opportunities to address the problem – how can we conserve, restore and sustain social-ecological systems?

A. How can we capture the value of ecosystem services produced on abandoned agricultural land? Who should be responsible for paying for those? (Note: provisioning services accrue benefits to the individual or household unit; supporting services accrue benefits to the landscape or watershed unit. This is a way to show scale effects on S-E synthesis.)
Learning objectives: Students will be able to (a) *propose* at least two alternative mechanisms for capturing the value of specific ecosystem services within at least two different categories (e.g., supporting and provisioning); and (b) *compare* advantages and disadvantages between the two alternative mechanisms.

B. What policy mechanisms exist that can encourage uses of abandoned agricultural lands that facilitate restoration of native rangeland?

Learning objectives: Students will be able to (a) *evaluate* sources of information about restoration policy options; (b) *describe* two or more alternative policy mechanisms that they perceive are appropriate to the case; and (c) *compare* tradeoffs among those alternative policy mechanisms.

B. What are the discontinuities between time scales of different social and ecological processes involved in this case?
Learning objectives: Students will be able to (a) *recognize* and *describe* time scales associated with social and ecological processes; and (b) *explain* how differences between time scales might influence the ability to evaluate the success of proposed policy mechanisms.

Introduction

Scene-setting narrative for students:

Vacationers bound for Great Basin National Park generally drive westward from I-15 down Highway 50. Two miles past the farm town of Hinkley, Lake Sevier comes into view. Most years the lakebed is dry, but the reflection of white sand shimmering in the desert sun creates a mirage – the illusion of water. Across the highway, a dirt road meanders north. Beside the road, a 1950s-era farmhouse stands empty, its windows boarded up. A broken child's bicycle lies in the driveway. The flag on the mailbox is still up. Weeds choke the field behind the house.

"We left three years ago," said Judd Christensen. "Used to be we could get four cuttings of alfalfa off those fields. Then it was three, then two. We just couldn't get enough water anymore."

In 2008, Christensen and his family put the land up for sale. But this far from the thriving urban communities on the Wasatch Front, there were no buyers. Finally, reluctantly, they packed up the pickup and moved into town. But neither Judd, his wife, Claire, nor their eldest son Jason could find work in a depressed economy. Last year they relocated to Las Vegas. They still own the farm, but with no buyers on the horizon, they wonder if it's worth it to keep paying the taxes. Their farm life, like Lake Sevier on the horizon, is nothing more than a mirage – an illusion buried in dust.

Imagine you live in Hinkley, Delta, or another town on the edge of the West Desert. You've watched as more and more families like the Christensens have left for greener pastures. It pains you to see good neighbors leave town because they can't afford to stay. Your own roots run deep and you can't imagine leaving, but you fear for the future of your hometown. So you and a few like-minded neighbors ask to speak with your county leaders, urging them to take action to stop the flow of emigrants. But the local officials, feeling at a loss for solutions, turn the tables on you: They ask you to form a citizens' task force that will recommend a strategy that can protect the land and the community. You agree … but now what will you do? What options are open to your county and your community?

Explanatory introduction:

Ever since the Dust Bowl era, rural depopulation has been an issue in some U.S. agricultural counties as a consequence of global economic forces, growing disparity of opportunity between rural and urban counties, and the lack of affordable access to water. This trend is likely to intensify in coming years due to climate change, aquifer drawdown, energy booms, and increasing competition for scarce water from burgeoning metropolitan areas.

When a farm goes bust due to marginal conditions, several things can happen to it. Banks might hold foreclosed properties for years before a buyer is found. Land speculators might purchase it hoping to develop housing or shopping or industry centers. Parts of a property might be used for energy development while the rest remains vacant and unmanaged. Perhaps more wealthy neighbors will acquire the land for livestock grazing. Meanwhile, it typically does not revert to a native condition, but instead becomes a mottled weed-scape, susceptible to wildfires, with patches of bare ground that may generate new dust storms. As more farms are abandoned and their owners leave the area, towns can no longer support businesses, schools, congregations, and other institutions. Eventually the town, like the land, may be largely abandoned.

This case asks students to consider how remaining residents and government officials can address these issues associated with "go-back land" – abandoned farmland that is left to "go back" to a more unmanaged state. It is designed in three parts, so that instructors can use some or all of the case depending on time constraints. If the entire case is used, students will act as members of a local community task force to recommend policy mechanisms that might restore and conserve ecosystem integrity and protect rural community cohesion in an area undergoing agricultural land abandonment.

In **Part 1** students describe and depict the social-ecological system, discovering how environment considerations such as soil fertility and water availability interconnect with rural community livelihoods and institutions, and how larger-scale forces such as climate change and economic globalization define the course of rural change and constrain the options of local leaders.

In **Part 2** students begin to uncover the consequences of local- and coarse-scale forces as they act upon the socio-environmental system. They use ecosystem services and livelihoods frameworks to explore how local communities and the larger society are affected by environmental change associated with farmland abandonment. Using concepts drawn from ecological succession, community transition, and resilience theory, they predict alternative trajectories for lands and communities affected by these forces.

In **Part 3** students look for solutions. Given examples drawn from other contexts, they learn about a range of possible policy mechanisms that might be used to incentivize rangeland restoration, promote land-based livelihoods, and build rural community capacity. They then propose and analyze alternative mechanisms for their community, considering winners and losers, risks and constraints, and probabilities of success.

Classroom Management

This case study is designed with three sequential modules, each of which is designed to take about 2.5 hours over two 75-minute periods. Reconfiguration for classes offered once or three times weekly should be possible. (*NOTE: Because this case has not yet been tested, times are estimates and may require adjustment.*) Part I can be used by itself or as a building block for Parts II and III. The latter two parts are best spread over two or more class periods with homework assignments between them. Part II can be administered without continuing to Part III, but the exercise may not lead to a satisfying conclusion for students.

Part I: Understanding the problem – what's happening and why is it happening?

In the class period prior to beginning the case study, ask students to do three things as **homework** before coming to the next class:

- Read the student handout outlining the abandoned farmland situation (Student Handout- Go Back Land.docx)
- Scan the Mental Modeler website (http://www.mentalmodeler.org/) making sure to view the 4-minute tutorial video.
- Read the Wikipedia entry for "rural flight," skipping the international examples if they prefer.

At the start of the class, the instructor should ask one or more students to summarize what they learned from Wikipedia entry and discuss briefly, to ensure that students understand the study problem (15 mins.)

Next the instructor should do a brief Mental Modeler demonstration, choosing a simple system familiar to the students. The example system need not be socio-environmental (I often use a coffeemaker), and should probably only have 4-5 elements. (15 mins.)

Students then break into groups of 4-6 students. It helps if these groups are pre-selected to include some students whose backgrounds are primarily in the natural sciences and some who are primarily in the social sciences. Provide small packs of Post-It notes, and suggest that students spend 15 minutes working individually to begin to map out a conceptual diagram of the social-environmental system described in the introduction. Then, for the next 30 minutes, they will use the Mental Modeler software to negotiate and draw a concept map for their group that describes their collective vision of the system. (45 mins.)

Between class periods for Part I, as **homework** assign students to read Morris et al. (2011), which describes how historical legacies of plowing rangeland can last for many decades.

At the start of Day 2, the instructor briefly asks students to summarize the main point of Morris's paper, then adds yet another source of complexity: the influence of scale as exhibited by top-down forces outside the influence of the local social-ecological system such as climate change, globalization, or national politics. The instructor demonstrates cross-scale for students by walking them through a systems diagram that incorporates influences at multiple scales. Any such diagram could work, but two relevant examples can be found in Collins et al. (2011), Fig. 1, or Brunson (2014), Fig. 2. These can also be used in Part II when the discussion turns to ecosystem services. (25-30 mins.)

Students then return to their groups, deciding how to incorporate these top-down forces into their systems diagrams. (25-30 mins.)

Finally, students reconvene as a class. They are not asked to share their groups' maps – these are not finished products, but guides for further work if the entire case is used – but instead they should engage in a group discussion of the difficulties of incorporating scale into their systems models, and how it forced them to change their maps. (15-20 mins.)

<u>*Assessment*</u>:
Assessments are partly formative, partly summative. Each group should turn in its concept map at the end of the second day. This can be evaluated using an assessment rubric (one is provided with this case). The rubric and maps should be returned to students in time for Part II, as it will be used throughout the remainder of the case study. At the end of each part of the case study, students will be asked to submit a brief (maximum 2 pages) reflections paper. Here are questions for Part I:

1. What was the most unexpected thing you learned from engaging in the concept mapping exercise?
2. What top-down and historic forces may make regions such as western Utah vulnerable to farmland abandonment?

<u>Part II: Consequences of the problem - what will happen if the problem isn't addressed, and what are possible alternative outcomes?</u>

The initial **homework** assignment is Brunson (2014), which describes the ecosystem services framework and places it in the context of shrubland degradation, while reinforcing issues of top-down forces interplaying with local-scale legacies.

When class convenes, the instructor will display the ecosystem services framework (Fig. 1 in Brunson 2014), give a brief overview of the categories (supporting, provisioning, regulating, cultural), and ask students to write down one service within each category that is specific to the abandoned farmland case. (5 mins.)

Then the instructor will ask for 2 or 3 volunteers to suggest services within each category. This will formatively assess whether students understand the ecosystem service concept. [*NOTE: Experience suggests that the concept of regulating services may require further explication than others.*] (15 mins.)

Next students rejoin their original groups to brainstorm as many ecosystem services as they can that may be provided by three categories of farmland: (a) actively farmed; (b) abandoned; (c) restored to a native or partially native condition. (20 mins.)

For most of the rest of the class period, they return to their groups' conceptual models to predict processes or system linkages that can positively or negatively affect flows of those services. (30 mins.) At the close of the period, students volunteer to be either "land experts" or "community experts" based on their levels of training in natural resource science (land) or social science (community). Ideally about half of each group should fall into the land expert or community expert category.

As a **homework** assignment for the next class, <u>land experts</u> will read Monaco et al. (2012), which discusses the use of state-and-transition models in restoring degraded rangelands. <u>Community experts</u> will read McManus et al. (2012), which discusses methods to protect communities undergoing depopulation.

For the next class students immediately convene in their new "expert" groups for facilitated discussion. Two instructors are needed for this part of the exercise, one who feels comfortable leading a discussion of rangeland successional processes and one who feels comfortable leading a discussion of rural community transition and resilience. The basic questions in each group are the same:

1. What trajectory would you expect the land (or community) to follow if nothing is done, and why?
2. What alternate trajectories do you believe are possible for the land (or community), and why?

This exercise can last as long as the instructors believe they're getting useful information, but will fit most easily into a 75-minute class period if it lasts about 30 minutes.

At the conclusion of this discussion, students reconvene in their original groups. Land experts then take the next 15 minutes to teach the fundamental concepts of rangeland succession and state-and-transition models to community experts. At the end of this period, roles are reversed and the community experts teach fundamental concepts of rural community transition and resilience to the land experts. (total 30 mins.) (*NOTE: It is important that students are informed <u>when the homework reading is assigned</u> that they will be asked to explain their expertise to their colleagues.*)

During the final 15 minutes of the period, experts within each group share what they believe are the most likely trajectories with and without local policy interventions.

<u>Assessment</u>:
Each group should turn in their categorized ecosystem service list at the end of the first class period. This should be reviewed to ensure categorizations are correct (i.e., that it's likely the category of land could provide that service, and that the service is classified as the appropriate type of service), and returned corrected by the start of the 2nd class period in Part II. After the second class period, each student will be asked to complete another brief paper (1-2 pages). Questions for this assignment are:

1. Which of your predicted trajectories (from the expert group discussion) do you feel *most* confident about, and which of your predictions do you feel *least* confident about. Explain, with reference to successional and/or community transition processes. (*NOTE: This should lead to reflections about data quality.*)

2. What did you learn from the *other* expert group that you hadn't known previously? (Ask for some level of explanation to formatively assess whether understanding is reasonably correct.)

Part III: Potential opportunities to address the problem – how can we conserve and restore social-ecological systems?

The **homework reading** for this session is MacLeod and Brown (2014), which describes how landowners might be rewarded for providing ecosystem services from rangelands.

To begin, the class convenes as a whole for a facilitated discussion. The instructor asks for examples of ecosystem services, drawn from the students' work in Part II, that might be provided by previously farmed and restored rangelands. Quickly obtain four or five examples. (5 mins.)

Students are then asked to propose approaches to "capture" the value of the example services by rewarding management actions that promote those services. (For example, if reduced wind erosion/cleaner air is one of the services, a student might propose a USDA program to cost-share no-till drilling of native seed). Refer students to the homework assignment for examples of practices that can add value to ecosystem services. Ask for one approach per service, but each service should have a different proposal (10 mins.)

Next lead a discussion of the pros and cons of each proposed capture mechanism. Students should be prompted to consider political feasibility, economic feasibility, and equity implications (who pays? who has access?) of each proposed method. (30 mins.)

For the remainder of the period, students break into their original groups. Their first assignment is to choose *two* of the services they identified in their group (these must be from different groups, e.g., supporting and provisioning), and propose *two* alternative mechanisms for capturing the value of those services, basing their decisions on the discussion of pros and cons they have just concluded (30 mins.)

The **homework** for the final class period in the case study is a student handout "Land Protection Strategies for Struggling Rural Areas (provided with this case description), which offers descriptions of rural community and land preservation strategies that have been implemented elsewhere in the U.S. or world.

The final class period takes place primarily in the original groups. Students are shown maps (see the Background section for details on how to access the maps) that describe soil conditions, taken from representative USDA "ecological site descriptions" for the region, U.S. Census data, and USDA Census of Agriculture data. Students then are asked to review their alternative ecosystem service capture strategies based on those data and the examples they read about in the homework assignment. Fortified with this additional background, they should collectively choose a "best" strategy (most likely a combination of two or more policy mechanisms) to achieve community and land goals. (60 mins.)

The last 15 minutes of this class period is reserved for debriefing. (If there's room in the course, instructors may want to hold this session for the following class period when there's more time available.)

Assessment:
The instructor should collect the final strategies for each group. This is mainly for analytical and formative purposes – to see whether there are common themes or misunderstandings and to look for novel ideas that could be discussed in class at a future date if time allows. Also assign students a third 2-page reflection paper, which asks:

1. In this exercise you were asked to consider questions of feasibility (political as well as economic) and equity. Do you feel that the most feasible solutions were also the fairest? If so, why? If not, how did your group resolve conflicts between feasibility and equity?
2. In your analyses you have seen that information about some ecosystem services is easier to obtain than information about other ecosystem services. What do you believe is the best way to address this discrepancy in real-world decision-making?

Background

The inspiration for this case study comes from a June 2014 workshop on "usable science" where ranchers, researchers, and government land managers were asked to collaboratively craft a research agenda guided by the concerns of stakeholders rather than scientists. Non-scientist participants from the southern Great Plains introduced the "go-back land" topic, expressing concern that farms are beginning to be abandoned in the western parts of the region because, as the Ogallala Aquifer is drawn down, owners of more marginal land are no longer able to afford the cost of pumping water or drilling deeper after wells run dry. The participants worried not only about the ecological impacts of abandonment (because plowed prairie does not automatically revert to native prairie when plowing ceases) but also the effects on small towns as people move away in search of opportunity. The Great Plains has been slowly depopulating anyway since the Dust Bowl era, and water shortage is expected to hasten this trend. A valuable web-based summary of the Ogallala Aquifer problem is provided by the Human Resources Development Working Group of Asia Pacific Economic Cooperation (APEC). Many sources including Wikipedia describe the Great Plains population loss issue; one brief but information-filled source is from Anonymous (2008).

In the energy boom lands of western North Dakota and northeastern Montana a different scenarios plays out: Here, the difficulties of farming have led many to leave the farm and seek jobs in the oil fields. Housing is in very short supply in the region, and often farms are carved into smaller parcels and put up for sale at prices that far outstrip the agricultural value of the land. Purchasers may buy parcels of 10, 20, or 40 acres and simply move a mobile home onto the property, leaving most of their land to lie unmanaged. When the boom inevitably busts, many if not most owners will not be able to afford to keep the overpriced properties. Meanwhile, some farmers who wish to remain in business are unable to do so because of local labor shortages or because of damage due to brine spills from oil and gas wells. A good brief description of the situation can be found in a June 2014 *National Geographic* article (Eaton 2014).

While the term “go-back land” is used colloquially in the Great Plains, it is not commonly found in academic literature. The exception is a 1965 paper by Owensby and Anderson, who demonstrated that one could grow 11 native grasses and one native legume on abandoned farmland under a mulch of sorghum stubble. However, the Flint Hills is a relatively well-watered, forgiving environment. Most abandoned farmland in the Great Plains and further west is found in areas where native prairies or sagebrush rangelands are difficult to restore under ideal conditions. For example, the Morris et al. (2011) article assigned as homework describes lands in northwestern Utah where the effects of plowing can still be observed nearly 100 years after they were abandoned.

Instructors wishing to learn more about conceptual modeling can find many resources in the Mental Modeler website (http://www.mentalmodeler.org/). Its developers describe Mental Modeler as “modeling software that helps individuals and communities capture their knowledge in a standardized format that can be used for scenario analysis.” It is a Microsoft application, so cannot be downloaded onto Apple computers but the online version can be used on any machine. The site offers a downloadable manual and other teaching resources, as well as research articles based on use of the application.

The concept of ecosystem services has been well explored in scientific literature over the past decade, and there now is even an academic journal by that name. For those who are unfamiliar with the framework, in addition to the homework articles by Brunson (2014) and MacLeod and Brown (2014), one of the best overview descriptions is found in United Nationals fact sheet (http://www.unep.org/maweb/documents/document.300.aspx.pdf).

State-and-transition modeling for rangelands can easily become complex. The Monaco et al. (2012) article was chosen because it simplifies the process as well as any, but this part of the exercise will work best if there is an instructor who is familiar with state-and-transition concepts and if some of the students have been introduced to them. The key goal is that students will think through challenges associated with restoring native plant communities.

Soil mapping likewise can be daunting for instructors unfamiliar with the concepts of soil type and ecological site. For this exercise, maps can be downloaded (or displayed from a computer) using the USDA Natural Resource Conservation Service’s Web Soil Survey online application (http://websoilsurvey.nrcs.usda.gov/app/). Instructors should spend some time using the application and learning what it can do. For the landscape described in this case study, instructors need only proceed to the third step in the four-step process. Choose an Area of Interest, making certain to zoom in on a small enough rectangle that the soil map is readable and there aren’t too many types for students to consider. The next step yields the soil map. Step 3, the Soil Data Explorer, provides a set of five tabs. For this exercise, the most useful tab is Ecological Site Assessment. The display will show the map, overlaid on a satellite image, a list of Ecological Sites (which describe natural vegetation supported by that soil) in the Area of Interest, and a table describing which Ecological Sites correspond to each soil type. Instructors should identify the Ecological Sites that are most common in the area, and download copies of an Ecological Site Description (ESD) report for those sites, found at https://esis.sc.egov.usda.gov/Welcome/pgReportLocation.aspx?type=ESD, and provide them to students. (Once a site is chosen, lick on the link for "Complete Report.") Information can be obtained for physical features, climate, soils, plant communities, and most importantly, site interpretations. These describe what the site is suited for and how native rangelands are typically used.

For this case study, the Area of Interest was Utah, Millard County, and Delta area (area symbol UT 632). To simplify the analysis the map was zoomed in on a rectangle around the town of Hinckley, bounded on the east by State Route 257 and the junction of 2500 South and U.S. Route 6/50. In this case, the only important ecological site is Alkali Flat (Black Greasewood), found in MLRA 28A. Typically a state-and-transition model is included with the ESD. For this particular site, however, the model is under final review and will be approved for public use by early 2015. Meanwhile the agency has given permission for it to be used in conjunction with this case study, and it is included in supplemental materials.

What the model shows is that when this type of ecological site is disturbed and begins to degrade, it first becomes invaded in the understory by non-native annuals such as cheatgrass and various weedy mustard species. Gradually this can lead to a situation where the native shrub layer is mostly gone, replaced by invasive grasses and forbs. No one has documented a shift from this degraded state back to a native community, which would be dominated by the shrubs black greasewood and shadscale saltbush and grasses such as bottlebrush squirreltail, Indian ricegrass, and saltgrass. Therefore, the recommended treatment for a degraded site is to plow, disk, or burn and seed to non-native forage species that are better adapted to highly disturbed conditions such as crested wheatgrass, tall wheatgrass, or Russian wildrye. Since an abandoned farm has already been plowed, the choices are likely to be between reseeding with non-native forage species or allowing it to revert to a highly degraded weed-dominated condition. Students may advocate for using a process called "assisted succession" (Cox & Anderson 2004), in which a non-native grassland is first established and native grasses and shrubs are then seeded into the site in hopes they will eventually come to dominate. No one has documented this process working on an Alkali Flat (Black Greasewood) site, but that doesn't mean it can't be done. In working through the problem – including a consideration of labor and financial resources needed to make assisted succession work – students will be able to assess which ecosystem services may be provided by each type of non-native rangeland, try to identify sources of labor and funding to support costs of high-input management, and evaluate social, ecological, and economic tradeoffs between high-input and laissez-faire approaches to management in response to farmland abandonment.

Suggested Modifications

As noted previously, this case study is designed in three tiers so that instructors can choose either Part I, Parts I and II, or the entire exercise. With some advance preparation, it can be adapted to any location that students are likely to be familiar with, and does not have to be focused on western Utah. However, it works best with a rangeland setting, and Ecological Site Descriptions have not been created in every state.

The case study is designed so that it *could* constitute a three-week unit of its own during a course, but it may be more useful to schedule each part as a week-long unit at different stages of a quarter- or semester-long course on social-ecological systems, natural resource management, planning, or a similar topic.

Homework References

Brunson, Mark. 2014. Unwanted no more: land use, ecosystem services, and opportunities for resilience in human-influenced shrublands. *Rangelands* 36(2):5-11.

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Answer Key

One of the hallmark characteristics of wicked problems is that there are no "correct" answers, only more or less useful solutions. In fact, that is one of the key learning outcomes of this case study: Students should recognize that when trying to direct the course of socio-environmental systems any "answer" will be subject to uncertainty and tradeoffs.

Assessment

This case study offers six opportunities for assessment, one for each part at the group level and one for each part at the individual level. Group-level assessments are intended to be formative – helping the instructor(s) determine whether students are understanding and can apply key concepts, and potentially identifying topics for which further clarification may be needed. These are:

- *Part I*: Collect the concept maps for each group. Look for students' ability to identify components of the systems – are there elements you hoped they'd find that most groups did not? Do they correctly recognize the existence and direction of connections between system components? Are feedbacks included, and if so, how? If you want to do a summative assessment, an excellent rubric for assessing systems modeling was created by the Ecoplexity group, a National Science Foundation-funded project that was designed to train high school teachers to use qualitative modeling to broaden students' understanding of complexity, diversity, and ecology as a science. The rubric can be found at http://ecoplexity.org/files//1WeekTeacher_StudentRubric.pdf
- *Part II*: Collect the ecosystem service lists. Students should be able to identify at least one, and hopefully several ecosystem services from each of the four categories (supporting, provisioning, regulating, cultural), and be able to do so for a farmed system, an abandoned system, and a restored system.
- *Part III*: Collect the final strategies for each group. Are there common themes that students focused upon? Are there themes that might have been addressed, but for the most part were not? Are there novel ideas that you hadn't considered, and might be the foundation for further discussions later in the course?

The individual-level assessments come from students' homework essays, assigned at the end of each part of the case study. As described here, each of the essays consists of two questions (roughly one page of response each). The first question calls for reflection on the part of the student. It is included partly to encourage students to re-process information and experiences gained through participation in the case, and partly to assist instructors in identifying areas for potential further reinforcement of material. The second question in each essay requires the student to demonstrate competency:

- *Part I*: *What top-down and historic forces may make regions such as western Utah vulnerable to farmland abandonment?* Students should be able to identify economic, large-scale social/political, historical, geologic and climatic top-down forces. In the eastern Great Basin where this case is situated, those could include changes in prices of commodities or water, Farm Bill program components, rapid urbanization in Utah that affects demand for water as well as availability of economic options elsewhere, the development pattern of Mormon settlements and farming practices, the geologic origin of local soils from ancient lakebed deposits, and a semi-arid climate where most precipitation falls in winter months.

- Part II: *What did you learn from the* other *expert group that you hadn't known previously? Explain.* Students should be able to provide at least one concept, and be able to explain it well enough that the instructor can evaluate whether it is understood.
- Part III: *In your analyses you have seen that information about some ecosystem services is easier to obtain than information about other ecosystem services. What do you believe is the best way to address this discrepancy in real-world decision-making?* Students should be able to identify these discrepancies and think logically about the tradeoffs involved in obtaining information. Data about provisioning services (especially those sold in markets) is almost always more easily obtained than data about other types of services. Data for ecological stocks and flows is measurable, but rarely available for a specific location without installation of new monitoring equipment and/or protocols. For some cultural ecosystem services, we don't even know *how* to measure these services. The essay should show some ability to reflect on these issues, but evaluation most be highly qualitative.

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