Stewards of the Llano Estacado

Science & Conservation Curriculum

Investigative lesson plans for high school students exploring the
Shortgrass Prairie/Sand Shinnery Oak Woodlands
of Eastern New Mexico and West Texas

The grasslands of eastern New Mexico are part of the Llano Estacado region of the Shortgrass Prairie ecosystem
Photo: John E Stout, USDA-ARS

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CEHMM
Conservation and Environmental Services

Project Narrative

Audubon New Mexico and the Center for Excellence in Hazardous Materials Management (CEHMM) have partnered to connect communities in the Llano Estacado region to the ecology, management, and cultural significance of the shortgrass prairie and shinnery oak woodlands. This curriculum incorporates hands-on activities, opportunities for field investigation, and a multi-generational teaching approach. Through these activities, we hope to inspire New Mexico's high school students to see natural resources management as both a viable and desirable career and to see firsthand that where birds thrive, people prosper.

Acknowledgements

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Stewarts of the Llano Estacado Curriculum Authors: Mark Madsen, Scot Pipkin, Katie Weeks, from Audubon New Mexico

This curriculum is also available electronically: https://nm.audubon.org/conservation/educational-resources

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How to Use This Curriculum

This curriculum will help high school students and community members understand the global significance of grasslands and the importance of their local grasslands for biodiversity, ecosystem services, and economic vibrancy. This program is designed to raise awareness of grassland ecology/conservation, encourage students to observe grassland management firsthand, and generate critical thinking skills about how to balance human needs and conservation. Group projects, in-class presentations, and field trips can put students in direct contact with biologists, ranchers, agency representatives, land managers, and Audubon staff, encouraging students to see the breadth of local STEM career opportunities.

There are five modules, or lesson plans, that may be used in any order or combination. The lessons utilize a diversity of approaches, including technology and research (World Grasslands), hands-on lab skills (Soil Investigation), to interpersonal discussion and group interaction (Wildlife Species of Concern Management)

The *Stewards of the Llano Estacado* curriculum has been aligned to the New Mexico STEM Ready! standards, which are based on the Next Generation Science Standards (NGSS). As is core to NGSS, the *Stewards* curriculum focuses heavily on students-centered learning, group reflection, and collective meaning making.
To learn more about NGSS, please contact your local district, NM PED, or visit the standards website (nextgenscience.org).

KEY:

Lesson Plan Title

Objectives: student learning goals

Location:

Time: Suggested

Materials:

- Suggested materials for activities

Procedures:

Introduction: Ways to warm up student interest, contextualize material
Direct Instruction: Potentially new learning that students need to complete the activity
Guided Practice: Intended as student-led with some facilitation from educator
Independent Practice: Intended as student-led with minimal facilitation from educator

Extensions:

Assessment: Suggested methods; educators should also consult their administration's requirements; may also utilize the additional assessment provided (p. 52)

Additional Materials:

Supplemental Background Information for educators or students

Student worksheets/materials to be printed and distributed

Standards Addressed

Introduction to World Grasslands:

HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Shortgrass Prairie/Sand Shinnery Oak Shrubland Species

HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Wildlife Species of Concern Management

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

LS2.A: Interdependent Relationships in Ecosystems.
LS2.C: Ecosystem Dynamics, Functioning, and Resilience.

LS4.C: Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individual's need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.

LS4.D: Biodiversity and Humans.

HS-ESS3-4. Evaluate or refine a technological solution that reduces the impacts of human activities on natural systems.

ESS3.A: Natural Resource.
ESS3.C: Human Impacts on Earth Systems.
ESS3.D: Global Climate Change.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

ETS1.A: Defining and Delimiting Engineering Problems.
ETS1.B: When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.
ETS1.C: Optimizing the Design Solution.

Soil Investigation Lab:

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

LS2.A: Interdependent Relationships in Ecosystems.

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LS4.D: Biodiversity and Humans.

STEM Careers:

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

ESS3.A: Natural Resources.
ESS3.C: Human Impacts on Earth Systems.
ESS3.D: Global Climate Change.

Introduction to World Grasslands

Objectives:

Students who complete this lesson will be able to:
- Define what a grassland ecosystem is
- Recall several species of grassland birds
- Recognize the two major types of grassland in the world (temperate/tropical)
- Recognize the two grassland ecosystems found in New Mexico (Chihuahuan and Short grass prairie)
- Describe different grassland ecosystems based on their geography, management, and other factors
-Summarize management tools (fire, grazing management, etc.) that are used for maintaining the health of grasslands throughout the world
- Classify specific kinds of temperate (prairies, steppes, Mediterranean) and tropical (savanna) grasslands
- Explain several factors that contribute to the decline of grassland bird species and ways those declines are being addressed.
- Explain the importance of the Ogallala Aquifer and summarize some of the threats to that water source

Location: Classroom or Computer lab

Time: 2hrs

Materials

- White board
- Computers with internet access
- Blank world maps with mountain ranges (1 per student)
- World Grassland Interactive Map student worksheets (1 per student)
- Writing utensil

Procedures

Prior to Instruction: Familiarize yourself with the Audubon New Mexico World Grasslands Interactive Map: http://arcg.is/1bjCva

Introduction: What is a grassland and where are they located?

1. Introduce the lesson by facilitating a group discussion around the question, "What is a grassland?"
   Give students a couple minutes to discuss their thoughts with a neighbor before sharing with the larger group.
2. Follow up/further prompting questions:
   a. Where are grasslands located in North America?
   b. Where are grasslands that exist outside of North America?
   c. Are there species that we associate with grasslands?
   d. How do humans rely on grassland ecosystems?

Direct Instruction

1. Distribute copies of the “What do you know about grasslands?” activity to each student, or project the file on the board and complete as a class

Guided Practice

1. Now that we know a little bit about grassland ecosystems, ask students to try their hand at identifying where the world's grasslands are located. Distribute blank world maps.
2. Give students 5-10 minutes to shade/indicate on the map where they think grassland ecosystems exist throughout the world.
   a. Keep in mind some of the important facts that shared above (grasslands represent ~40% of the earth's land mass that is not Greenland or Antarctica, grasslands typically exist on the leeward side of mountains and between deserts and forests, etc.)
3. Have students display their mapsy and perform a quick gallery walk to see where people predict grasslands are.

4. Next, ask students to work through an online interactive map that will provide more detailed information about the world's grasslands, the different types of grassland in the world, their location, and management issues.

Independent Practice

1. Depending on the number of computers available, divide students into small groups (3-4) and have each group take a computer workstation.

2. Distribute World Grassland Interactive Map student worksheet and ask the groups to complete the worksheet.

3. As groups complete their exploration of the online map and their worksheets, students should check their grassland prediction maps. Using another color or pattern, have students sketch the actual distribution of world grasslands. How accurate were their initial guesses?

Extension

Schedule a field trip to local grassland habitat with Audubon educators and experts

If students have grassland habitat close to their community, have them spend 20 minutes outside in a patch of habitat to do some field journaling and data collection. Suggested data to record:

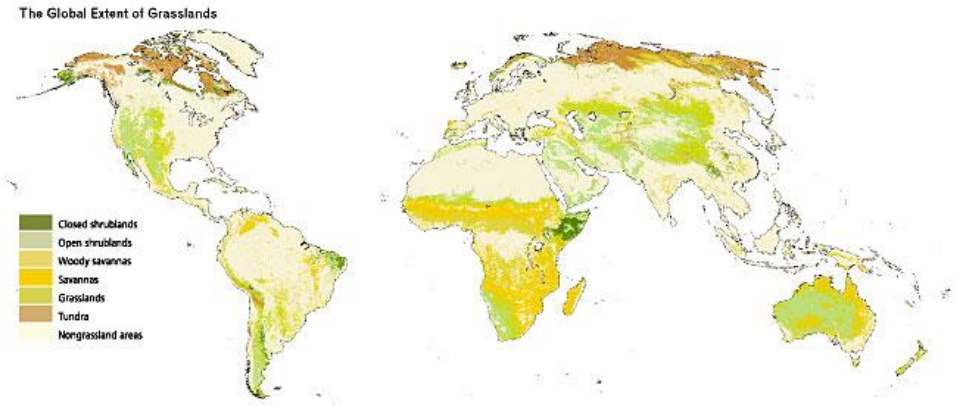
- Time of day
- Temperature
- Wind (calm, breezy, windy, etc.)
- Cloud cover
- A sketch/scientific illustration of their view of the landscape
- A close-up look at a small feature around them (grass seed head, insect, seed, pebble, etc.)

Assessment

1. Completed “What do you know about grasslands?” quiz
2. Hand-drawn maps of world grasslands both with predicted outline of grasslands and final completed sketch using the interactive map as a template.
3. Completed World Grassland Interactive Map worksheets

Supplemental Background: World Grasslands

Grassland is dominated by the presence of grasses as the major plant component. Herbaceous (non-woody) plants make up a portion of the total plant component. Grasslands are typically absent of trees or shrubs. Grasslands can also be described as natural or anthropogenic (man-made). Grasslands can be found on all continents with the exception of Antarctica.



Sources: White et al. [PAGE]2000. Map is based on the Global Land Cover Characteristics Database Version 1.2 (Loveland et al. 2000). The map shows all lands where grassland made up at least 60 percent of each 1 km^2 satellite mapping unit. Tundra areas are estimated using the Olson Global Ecosystem classification; all other areas are estimated from the International Geosphere-Biosphere Programme classification. Table is based on data from WWF and this map.

Grassland covers about 2/3 of the land masses of the world and makes up 1/4 of the earth's surface. Although grasslands contain mostly grass, they are actually areas of great variety since there are over 10,000 grass species, not to mention the 12,000 species of legumes that often grow with grasses. Most natural grasslands exist between deserts and forests, although man-made grasslands have been developed on land that would accommodate trees. Grasslands are usually divided into two categories: tropical (grasslands located near the equator such as those in Africa, southern Asia, Australia and northern South America) and temperate (grasslands located between the equator and the poles including those in North America, Europe, southern South America, Africa and Australia). Prairies, savannas, veldts, steppes, llanos, campos, downs, meadows, moors, pamir, pampas, pantanals, patanas, punas, pusztas, and sahel all describe grasslands of the world. Although different countries and languages have different names for grasslands, all countries are learning that grasslands are crucial to civilization as we know it. (*National Forage and Grassland Curriculum, Oregon State University*).

Tropical grasslands are characterized by having a yearlong growing season and are found within close proximity to the equator. Grasses in tropical grasslands tend to grow larger and taller than those of temperate grasslands. Rainfall in tropical grasslands tends to be greater than the rainfall amounts in temperate grasslands.

Tropical grasslands are commonly called savannas of which there are 3 types:

- Climatic- those grasslands that are the result of climatic and weather conditions.
- Edaphic-those grasslands resulting from thin, unfertile, rocky soil conditions. Normally found on hills, ridges, and valleys.
- Derived-those grasslands made by the actions of man. (Removal of forest, burning, and then re-established grasses.)

Temperate grasslands are found further north or south of the equator. Temperate grasslands have two seasons; a growing season and a dormant season. Grasses in temperate grasslands tend to be shorter and smaller than those found in tropical grasslands. Rainfall in temperate grasslands varies greatly depending upon the location of the grassland. There are many different types of temperate grasslands: desert, montane, flooded (Everglades), tundra, shortgrass, mid-grass, tall grass, and steppes.

Grasslands form in areas where there is not enough regular rainfall for forests but too much for deserts. In fact many of the world's grasslands are located between deserts and forests.

Student Worksheet: What Do You Know About Grasslands?

From the prairies of North America to the Savannas of Africa, South America, and Australia, grassland ecosystems provide millions of people their food, shelter, and fiber while also sustaining incredible biodiversity. Most people have a poor understanding of the importance of grasslands. In this activity, we will test your knowledge of the world's grasslands.

1. **Grassland Extent-** Estimates vary, but around what percent of the earth's terrestrial (non-water, non-ice) surface is covered by grasslands?
    a. 5-10%
    b. 15-20%
    c. 25-40%
    d. 0-5%

2. **Grassland Geography-** What factors cause grasslands to exist in their current locations?
    a. Grazing animals eat all of the trees that would otherwise grow
    b. They receive more rainfall than a desert, but not enough to support a forest
    c. The wind gets too cold in winter for other plants to grow
    d. Grasses exhibit a process called *allelopathy*, where they send chemicals into the soil to prevent other plants from growing

3. **Grassland Productivity-** True or false: grasslands represent 70% of the world's agricultural productivity.
    a. True
    b. False

4. **Grassland Conversion-** What percent of grasslands have been converted from native habitat to human landscapes (agriculture, cities, infrastructure, etc.).
    a. 35%
    b. 50%
    c. 75%
    d. 95%

5. **Grassland Threats-** Which ecological region was more impacted in 2014?
    a. The Amazon rainforest due to deforestation
    b. North American prairies due to conversion to agriculture

6. **Grassland Management**- Who owns/controls over 90% of US grasslands?
    a. Private Individuals
    b. State and local jurisdictions
    c. The Federal government
    d. Nonprofits and environmental groups

Teacher Key: What Do You Know About Grasslands?

From the prairies of North America to the Savannas of Africa, South America, and Australia, grassland ecosystems provide millions of people their food, shelter, and fiber while also sustaining incredible biodiversity. Most people have a poor understanding of the importance of grasslands. In this activity, we will test your knowledge of the world's grasslands.

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For more info: Suttie, JM, Reynolds, SG and Batello, C. (2005). *Grasslands of the World, Chapter 1*. Food and Agriculture Organization Of The United Nations. http://www.fao.org/3/y8344e/y8344e05.htm

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For more info: Nunez, C. (2019). *Grasslands, Explained*. National Geographic. https://www.nationalgeographic.com/environment/habitats/grasslands/

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For more info: *Grasslands, Rangelands, and Forage Crops.* Food and Agriculture Organization of the United Nations. http://www.fao.org/agriculture/crops/thematic-sitemap/theme/spi/grasslands-rangelands-and-forage-crops/en/

4. **Grassland Conversion-** What percent of grasslands have been converted from native habitat to human landscapes (agriculture, cities, infrastructure, etc.).
    a. 35%
    b. 50%
    c. 75%
    d. 95%

For more info: Wolters. (2019). *Grassland Threats, Explained*. National Geographic. https://www.nationalgeographic.com/environment/habitats/grassland-threats/

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    a. The Amazon rainforest due to deforestation
    b. North American prairies due to conversion to agriculture

For More Info: Harvey, C. (2016, November 29). North America's grasslands are slowly disappearing — and no one's paying attention. *Washington Post*. Retrieved from https://www.washingtonpost.com/news/energy-environment/wp/2016/11/29/north-americas-grasslands-are-slowly-disappearing-and-no-ones-paying-attention/

6. **Grassland Management**- Who owns/controls over 90% of US grasslands?
    a. Private Individuals
    b. State and local jurisdictions
    c. The Federal government
    d. Nonprofits and environmental groups

For More Info: Cornell Lab of Ornithology. (2013) State of the Birds 2013: Report On Private Lands USA. https://archive.stateofthebirds.org/state-of-the-birds-2013-report/

Student Worksheet: World Grasslands Interactive Map

Grasslands cover almost 40% of the Earth's terrestrial ecosystems (excluding Greenland and Antarctica). They occur extensively on all continents except Antarctica and are among the most important natural systems for human habitation and food production. As a result, many grassland ecosystems have been highly altered due to extensive agriculture, livestock grazing, oil/gas/mineral extraction, and water use. This means that very few intact grassland systems exist at a large scale on the planet. In this exercise, you will be learning more about the diversity of grasslands on Earth, as well as some of the resources, threats, and actions people are taking to ensure the sustainability of these systems as homes, food sources, and ecosystems.

Directions: Follow the directions to navigate the ArcGIS Grasslands map. Answer the questions using the information found in the map and text. You must go step-by-step. Do not skip ahead.

Part 1. World Grasslands at a Glance

Navigate to the Interactive Map URL (http://arcg.is/1bjCva) and familiarize yourself with the map interface. Before scrolling through the text in the sidebar to the left, navigate the main map on the right.

1. Locate the Legend tab on the upper right of the map. **What are the names of the layers contained in the main map of the first frame?**

2. Zoom into a continent and click on one of the polygons (colored shapes). **What information comes up when you single click? Record the data for the grassland you selected.**

3. Find the grassland in Australia whose ECO_NAME is "Cape York Peninsula Tropical Savanna" (hint: it is in the very north of the country, near Papua New Guinea). **Look at and record the Area category of this polygon.** In this data set, Area is calculated in Hectares (100mX100m). There are about 2.47 acres in a hectare. **Approximately how many acres is the Cape York Peninsula Tropical Savanna?**

4. When you click on the text "LIKE THIS" at the bottom of the first section of the map (scroll down within the Home frame of the side panel), **where does the map take you?**

Part 2. Temperate Grasslands

1. Prairies-Scroll down, or click on the third circle on the scrollbar. Looking at the legend, or the map, **how many types of plains grasslands are in North America? By area, which are the largest and the smallest Prairie ecosystems?**

2. Steppes- **Which continent (besides Antarctica) does not have any true Steppe grasslands?** Why? (Hint: this continent has fewer than a dozen peaks that are above 4,000 feet tall)

3. Steppes- **Is fire an important disturbance factor in the Central Asian Steppe (6:30)? What are some of the causes of fire in this ecosystem?**

4. Mediterranean Grasslands- **What are the main geographic factors that give rise to these ecosystems?**

Part 3. Tropical Grasslands

1. **What is the nearest Savanna to our own Western Shortgrass Prairie?**

Part 4. Bringing it Home: Southern Shortgrass Prairie

1. Which states does the Western Shortgrass Prairie go through?

2. According to the Scientific American article linked to in the map, how far have groundwater levels dropped in Kansas (in feet)?

Part 5. Grassland Management

1. List 3 reasons to use fire as a tool to manage grasslands (Watch *EcoFire: Managing Fire in the Kimberley;*):

2. How have international researchers incorporated traditional knowledge in Mongolia?

3. What are the three benefits of bunching cattle in Northern Kenya?

6. A North American Solution: Conservation Ranching

1. Watch the first 8 minutes of the video Grassland Conservation: Protecting our Legacy. **What are CCA/CCAAs and how were they developed?**

2. Starting at 3:15, watch the video, Dr. Becker interviews Alison Holloran (Executive Director of Audubon Rockies in Colorado and Wyoming) and stop at 7:43. **Which native animal does conservation ranching try to mimic? How does conservation ranching add value to a rancher's product?**

3. In the video "A Fence and An Owner", Nancy Ranney and Melvin Johnson introduce some of the techniques they employ and how those practices have affected their habitat starting at 1:30. Describe the primary technique employed and 3 positive effects it has had on their operation.

Teacher Key: World Grasslands Interactive Map

Background: Grasslands cover almost 40% of the Earth's terrestrial ecosystems (excluding Greenland and Antarctica). They occur extensively on all continents except Antarctica and are among the most important natural systems for human habitation and food production. As a result, many grassland ecosystems have been highly altered due to extensive agriculture, livestock grazing, oil/gas/mineral extraction, and water use. This means that very few intact grassland systems exist at a large scale on the planet. In this exercise, you will be learning more about the diversity of grasslands on Earth, as well as some of the resources, threats, and actions people are taking to ensure the sustainability of these systems as homes, food sources, and ecosystems.

Materials:
- Computer with internet access
- Audubon World Grasslands Interactive Map: http://arcg.is/1bjCva
- Student Worksheet

Procedure:

1. World Grasslands at a Glance
   Navigate to the Interactive Map URL (http://arcg.is/1bjCva) and familiarize yourself with the map interface. Before scrolling through the content on the sidebar to the left, navigate the main map on the right.

   a. Locate the Legend tab on the upper right of the map environment. What are the layers contained in the main map of the first frame?

   Global Tropical Grasslands; Global Temperate Grasslands; Equator and Tropics

   b. Zoom into a continent and click on one of the polygons. What information comes up? Record the data for the grassland you selected.

   ECO_NAME; Formation; ECO_CODE; Division; Area

   c. Find the grassland in Australia whose ECO_NAME is "Cape York Peninsula Tropical Savanna" (hint: it is in the very north of the country, near Papua New Guinea). Look at and record the Area category of this polygon. In this data set, Area is calculated in Hectares (100mX100m). There are about 2.47 acres in a hectare. About how many acres is the Cape York Peninsula Tropical Savanna?

   Area= 11,602,844.03ha which converts to 28,659,024.75 ac

   d. When you click on the text "LIKE THIS" at the bottom of the first section of the map (scroll down within the Home frame of the side panel), where does the map take you?

   To New Mexico!

2. Temperate Grasslands

   a. Priority Grassland Birds- Follow the link to the U.S. Fish and Wildlife Service report on grassland birds. How has the removal of fire from grassland ecosystems affected grassland birds? List two ways different stakeholders can work together to promote grassland bird habitat.

   The removal of fire has converted extensive grasslands to shrublands, displacing grassland birds.

Conservationists and hunters can work together to promote upland game bird habitat, which will benefit other grassland birds species; Joint ventures are cooperative partnerships between public and private stakeholders to promote conservation efforts; Developing multi-generational partnerships

b. Prairies- How many major prairie types are in North America? By area, what is the most extensive Prairie ecosystem? Which is the smallest?

15 Prairie Ecosystems

Largest is the Northern Short Grasslands

Smallest is the Flint Hills Tall grasslands

c. Prairies- Identify the two Prairie ecosystems that do not border any other Prairies.

Western Gulf Coastal Grasslands; Palouse Grasslands

d. Prairies- How does managed grazing in Missouri help Greater Prairie-Chickens survive?

By simulating the grazing patterns of bison, cattle can knock back tallgrass stands and open up habitat for Prairie-Chickens.

e. Steppes- Which continent (besides Antarctica) does not have any true Steppe grasslands? Why you think that continent lacks true Steppe grassland (Hint: this continent has fewer than a dozen peaks that are above 4,000')?

Australia; Lack of mountains/high elevation landscape

f. Steppes- Is fire an important disturbance factor in the Central Asian Steppe? What are some of the causes of fire in this ecosystem.

Not historically. Many fires are caused by human activity, including old ammunition and military equipment that has been left in the Steppe region.

f. Mediterranean Grasslands- What the three main geographic factors that give rise to these ecosystems?

Close to a cold water current; Between 33-40 degrees latitude; long, dry summers with wet winters

3. Tropical Grasslands

a. What is the nearest Savanna to our own Western Shortgrass Prairie? What major river influences these grasslands? *Llanos of Venezuela and Colombia; the Orinoco River*

4. Bringing it Home: Southern Shortgrass Prairie

a. List the 5 other North American grasslands that border the Western Shortgrass Prairie
Chihuahuan, Edwards Plateau Savanna, Northern Short Grasslands, Nebraska Sandhill Grasslands, Central Mixed Grasslands

b. According to the Scientific American article linked to in the map, how far have groundwater levels dropped in Kansas? *150 feet*

5. Grassland Management

a. List 3 reasons to use fire as a tool to manage grasslands.

1. *To reduce woodland/forest encroachment*
2. *To increase weight gain for some species of cattle*
3. *To improve habitat for wildlife- such as the Gouldean Finch*
4. *To increase resources for humans such as game*
5. *To reduce the severity of late-season human and lightning-caused wildlife and protect old-growth vegetation*

b. How have international researchers incorporated traditional knowledge in Mongolia?

They took a herder's suggestion to fence off pastures; researchers listened to herders about cooperation among families

c. What are the three benefits of bunching cattle in Northern Kenya?

1. *It requires fewer herders*
2. *Cattle hooves break up the soil, which leads to improved rangeland health*
3. *Different parts of the rangeland are allowed to rest and recover*

6. A North American Solution: Conservation Ranching

a. Watch the first 8 minutes of the video Grassland Conservation: Protecting our Legacy. What are CCA/CCAAs and by what process were they developed?

CCA is a conservation candidate agreement. CCAA is a conservation candidate agreement with assurances. These tools were developed over a three-year collaboration between industry representatives, agency partners, researchers, and nonprofits. During this process, the various stakeholders worked to find techniques that would benefit both habitat conservation and economic activity. The key is collaboration between stakeholders, not competition.

b. Starting at 3:15, watch the video, Dr. Becker Interviews Alison Holloran (Executive Director of Audubon Rockies in Colorado and Wyoming) and stop at 7:43. What native animal does conservation ranching try to emulate the patterns of? How does conservation ranching add value to a rancher's product?

Emulate the pattern of bison. Value is added because unlike "organic" and "hormone-free" products, conservation ranching directly benefits the habitat and biodiversity of the ranch where those techniques are employed. Other certifications merely relate to the health of the livestock, not necessarily the rangeland.

c. In the video A Fence and An Owner, Nancy Ranney and Melvin Johnson introduce some of the techniques they employ and how those practices have affected their habitat starting at 1:30. Describe the primary technique employed and 3 positive effects it has had on their operation.

They employ rest-rotational grazing, where cattle are moved regularly from pasture to pasture, allowing grasslands to recover and a seed bank to develop. Positive effects on the Ranney Ranch include:

- *Lower medical bills*
- *Fewer flies*
- *Lower feed bills*
- *Better forage conditions*
- *The presence of cool season grasses*
- *10 times as many grass species*
- *Better soil conditions*

Shortgrass Prairie/Sand Shinnery Oak Shrublands Species

Objectives

Students will:

1. Develop a species profile for animal and plant species found in shortgrass prairie/sand shinnery oak shrublands.
2. Understand and explain the hierarchical classification scheme of their chosen species.
3. Identify any special adaptations that their species have for life in the shortgrass prairie/sand shinnery oak habitats.

Materials

- Wildlife ID keys/guides
- Plant ID keys/guides
- Computers with internet access
- Shortgrass Prairie/Sand Shinnery Oak Woodlands Species List
- Copies of Wildlife Profile Template (1 per student)
- Copies of Plant Profile Template (1 per student)

Preparation and Procedures:

Direct Instruction/Warmup (5-10 minutes)

1. Introduce the importance of shortgrass prairie/sand shinnery oak shrublands habitat for wildlife and plants:
   a. As a group, have students try to list as many local grassland plant and animal species that they can.
   b. According to New Mexico Department of Game and Fish's BISON-M database, there are over 617 species of animals alone that depend on shortgrass prairie in New Mexico.
   Have students calculate the percentage of animals based on the list they created.
   c. Did you know that prior to European settlement; the Llano Estacado ecosystem hosted an even greater diversity of plants and animals? Following is an example:

      Early Spanish visitors like Vazquez de Coronado and Castaneda de Najera as well as later Hispanic and Anglo-American explorers were astounded by the wildlife, especially the endless herds of buffalo (Bison bison). Vazquez de Coronado wrote to the king of Spain: "On [the plains] I found such a multitude of [bison] that to count them is impossible. [That is] because I did not travel a single day through the plains, until I returned to where I [first] found them, on which I lost sight of them." The land was also home to antelope, deer, coyotes, rabbits, bobcats, turkeys, and prairie dogs. (New Mexico History.org, Llano Estacado by Richard Flint and Shirley Cushing Flint)

   d. Read the following statement:

      Things have changed on the Llano Estacado; the buffalo are gone. Other wildlife species have disappeared changing the biodiversity of the grasslands. Native grasslands are among the most altered ecosystems in North America. This is reflected by the steep population declines documented in roughly 2/3 of grassland bird species over the last 50 years. The shortgrass prairie stretches from New Mexico to Alberta, in the rain shadow of the Rocky Mountains, and is the most intact native grassland ecosystem in North America today. Historically, this region was shaped by fire, grazing and the arid climate. This variety of conditions has allowed different grassland bird species to flourish and adapt to specialized habitat niches within the shortgrass prairie ecosystem (Bird Conservancy of the Rockies Best Management Practices for Grassland Birds. Prepared September, 2016)

      We talked a lot about wildlife, but what about plants? The shortgrass prairie and sand shinnery oak woodlands is also home to hundreds of species of grasses and thousands of species of forbs and other plants.

      Through this exercise, you will become more knowledgeable about animals and plants that inhabit the shortgrass prairie and sand shinnery oak shrublands of eastern New Mexico and west Texas, some of which are found nowhere else.

Guided Practice (15-60 minutes)

1. Have students choose one species from the list we were able to generate and create a simple species summary of that plant or animal based on what you know right now. This should include:

   a. Where would you find that plant or animal such as open fields, fence lines, or along the road?
   b. Your best attempt at a sketch of this species
   c. Description of what you know this species needs to survive including diet, breeding habits and habitat.
2. Have students put their simple species profiles on the wall for everyone to view

Independent Practice (40 minutes)

1. Give examples of a basic hierarchical classification scheme.
2. Distribute copies of shortgrass prairie/sand shinnery oak species lists as well as wildlife and plant profile templates to each student.
3. Have each student select one animal and one plant species from the provided lists.
4. Give students 30-40 minutes to research their chosen species and add that information to the profile templates.
5. Have students insert/add a photo, drawing, or other image of their chosen species.
6. Have students give a short presentation on their chosen species including any special adaptations that that species has for living in the shortgrass prairie/sand shinnery oak habitats.

Extension:

Obligate and Facultative Species

Hundreds of species of wildlife call the shortgrass prairie and sand shinnery oak habitats home. Many are permanent residents and others are visitors. Some spend the entire year in shortgrass prairie and sand shinnery oak shrublands while others are only found at certain times of the year.

Some species are found only in one habitat type such as shortgrass prairie or sand shinnery oak shrublands; they are found nowhere else. Animals that are restricted to a specific or limited habitat are known as ***obligates***. Their very existence is dependent upon a certain habitat defined by geographic or physical features or specific plant communities. An example of an obligate species would be the Lesser Prairie Chicken found only in sand shinnery oak habitats in New Mexico.

Other wildlife species can be found in a variety of habitats and are not limited or restricted to a certain area. These animals are ***generalists or facultative***. The Black-tailed Jackrabbit is a generalist or facultative species. They can be found anywhere from upper Chihuahuan grasslands, shortgrass prairie, sand shinnery oak, to the pinyon-juniper highlands.

Based upon the species selected by students, are the wildlife or plant species found only in the shortgrass prairie? Are there species found only in the sand shinnery oak shrublands? Are there species of wildlife or plants found in both habitat types? Using the definitions above, have students determine whether their species is an obligate or facultative/generalist species.

Additional Resources

Audubon Bird Pro application.
Audubon online bird guide: http://www.audubon.org/bird-guide
Cornell Lab of Ornithology All About Birds: https://www.allaboutbirds.org/
Cornell Lab of Ornithology- Birds of North America (access to full species accounts requires a fee): https://birdsna.org/Species-Account/bna/home
BISON-M – Biotic Information System of New Mexico.
Plant Classification link:http://www.nrcs.usda.gov/wps/portal/detail/plantmaterials/technical/tools
A Field Guide to Grasses of New Mexico (3rd edition by Kelly W. Allred)
Flora Neomexicana III: An Illustrated Identification Manual
(1st edition by Kelly W. Allred and Robert DeWitt Ivey)

Pronghorn (*Antilocapra americana*), Tabosa Grass (*Pleuraphis mutica*) by Mark Madsen

Supplemental Background: New Mexico Grasslands

Over 25% of New Mexico is covered by grasslands or sand shinnery oak shrublands. This includes many different types of grasslands ranging from the upper Chihuahuan desert to the sub-alpine areas of the northern mountains. Portions of eastern New Mexico are included in the southern end of the largest grassland in North America; the Great Plains. The Great Plains extend from New Mexico north to Alberta. This extensive complex of grasslands is the result of being in the rain shadow of the Rocky Mountains and was historically shaped by fire, grazing, and the overall lack of precipitation.

One of the largest intact grasslands in New Mexico is the Llano Estacado. The Llano Estacado (Palisaded Plains) includes the majority of the shortgrass prairie/sand shinnery oak ecosystems of eastern New Mexico and west Texas. The Llano Estacado covers approximately 30,000 square miles and ranges from 3,000 to 4,000 feet above sea level. The Llano Estacado covers an area from the Canadian River Valley in the north, south to the Edwards Plateau of Texas. East to west it covers an area from "breaks of the plains" east of Lubbock to the Mescalero Ridge or Caprock west of Tatum.

Sand shinnery oak shrublands are found in the deep sand country of eastern New Mexico, west Texas, Oklahoma, Kansas, and southeast Colorado. In New Mexico sand shinnery oak woodlands encompass around 8,650 square miles with 59 percent being privately owned. (*Long-Range Plan for the Management of the LPC. 2002-2006, NMDGF*). While not part of the Llano Estacado, the Mescalero Sands sand shinnery oak woodlands complex starts at base of the 'Caprock' or Mescalero Ridge and extend to the Pecos River Valley east of Roswell.

Shinnery oak (*Quecus havardii*) is the main plant component in the sand shinnery oak shrubland ecosystem. Grasses and forbs make the secondary component of the ecosystem. Shinnery oak trees maybe hundreds or possibly thousands of years old. While only being a couple of feet high the majority of the shinnery oak tree is found underground in an extensive root system. Research has shown that as much as 90 percent of a shinnery oak tree is found underground. Numerous grass species can be found in shinnery oak woodlands including: big bluestem, little bluestem, and sand dropseed. Other shrub species can also be found including: sand sage, yucca, and mesquite. Topography consists of deep sandy soils with large sand dunes being present in some locales.

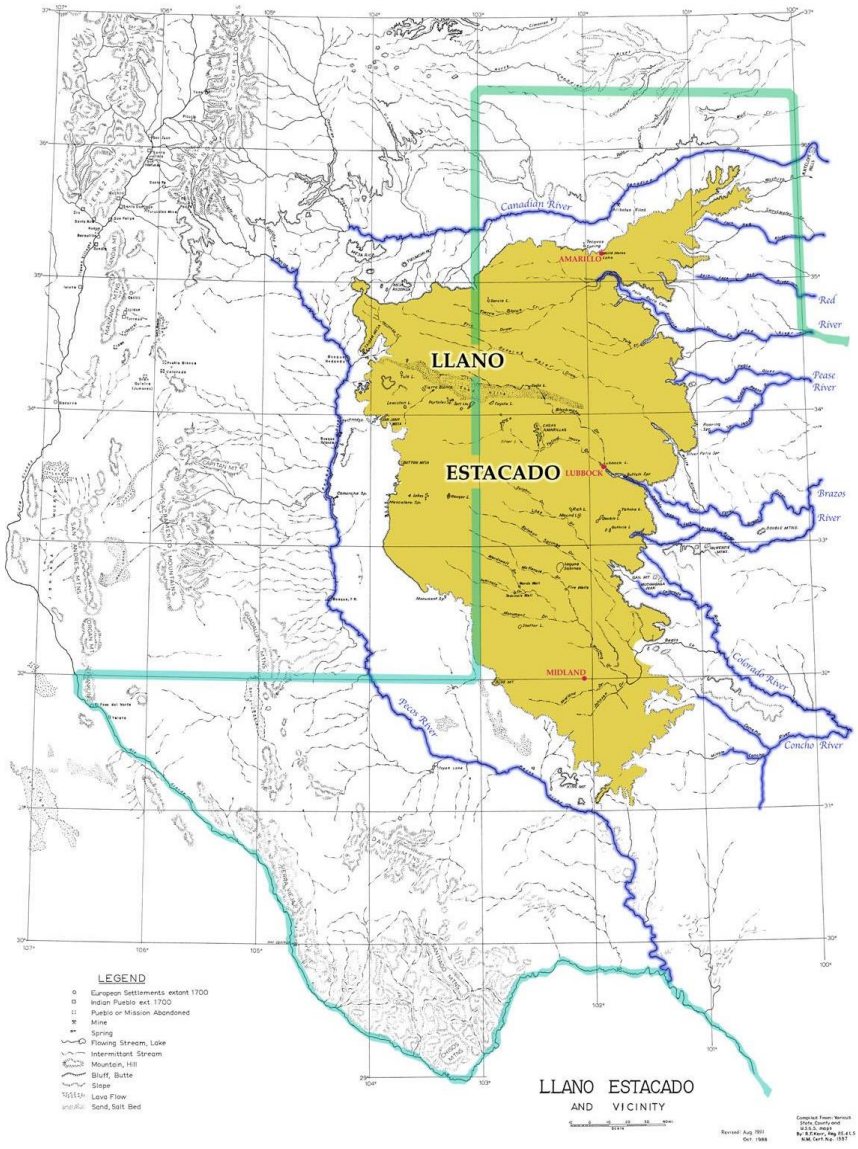
Texas Shortgrass Prairie by Mark Madsen

Upper Chihuahuan Desert Grassland by Mark Madsen

Northern Shortgrass Prairie by Mark Madsen

Northern New Mexico Montane Grassland by Mark Madsen

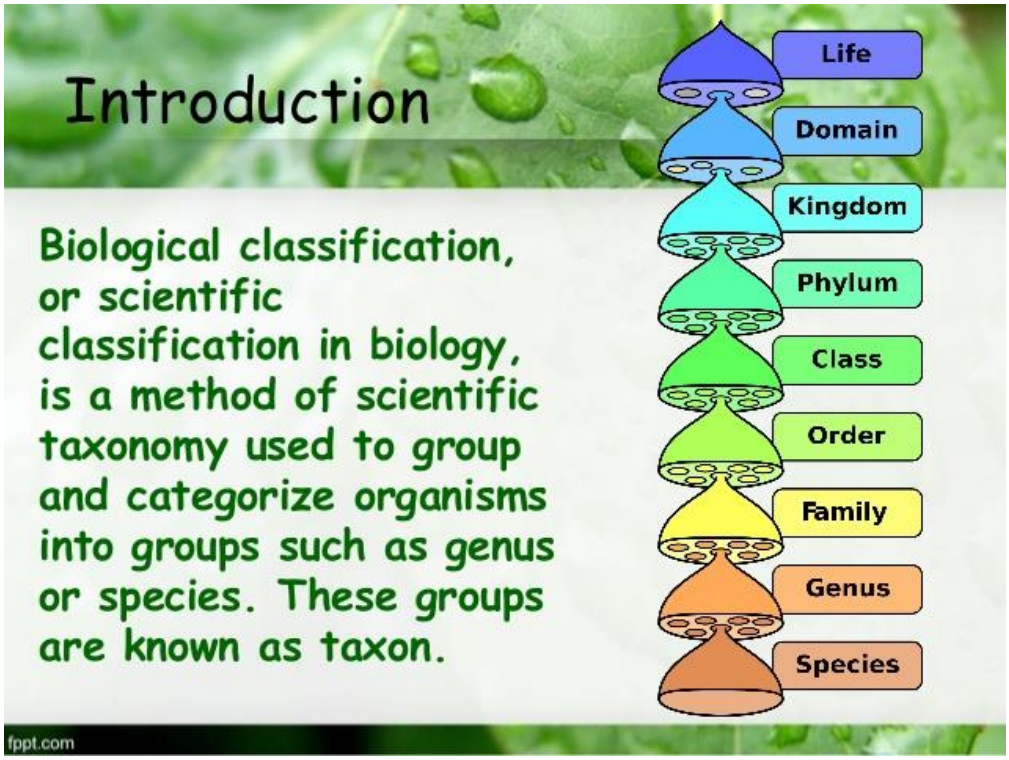
New Mexico's shortgrass prairie and shinnery oak shrublands are home to a diverse flora and fauna that require vast, unaltered tracts of native landscape to ensure their continued survival. In particular, species such as the Lesser Prairie-chicken (*Tympanuchus pallidicinctus*) and Dunes Sagebrush Lizard (*Sceloporus arenicolus*) are prime examples of the unique fauna that has evolved to survive in the western shortgrass/shinnery oak vegetation communities. Thoughtful land use practices in the ranching, oil and gas, and wind energy development industries can have profound positive effects on these and other associated species, while simultaneously allowing economic activity to continue.



The Llano Estacado spans Eastern New Mexico and West Texas. Image from "El Llano Estacado: Exploration and Imagination on the High Plains of Texas and New Mexico" by John Miller Morris

Hierarchical Classification Examples

Plants	**Animal**
Kingdom	Kingdom
Division (Phylum)	Phylum
Class	Class
Subclass	Order
Order	Family
Family	Genus
Genus	Species
Species	
Variety	



List of Suggested Species

Wildlife

Badger *(Taxidea taxus)*
Black-tailed Prairie Dog *(Cynomys ludoviciamus)*
Burrowing Owl *(Athene cunicularia)*
Cassin's Sparrow *(Aimophila cassinii)*
Coachwhip *(Masticophus flagellum)*
Couch's Spadefoot *(Scaphiopus couchi)*
Coyote *(Canis latrans)*
Desert Massasauga *(Sistrurus catenatus)*
Grasshopper Sparrow *(Ammodrummus savanarum)*
Gray Fox *(Urocyon cinereoagrenteus)*
Great Plains Skink *(Eumeces obsoletus)*
Least Shrew *(Cryptosis parva)*
Loggerhead Shrike *(Lanius ludovocicianus)*
Long-billed Curlew *(Numerius americanus)*
Mule Deer *(Odocoileus hemionus)*
Northern Pintail *(Anas acuta)*
Ornate Box Turtle *(Terrapene ornate)*
Plains White-tailed Deer *(Odocoileus virginianus texanus)*
Pronghorn Antelope *(Antilocapra americana)*
Scaled Quail *(Callipepla squamata)*
Striped Skunk *(Mephitis mephitis)*
Swainson's Hawk *(Buteo swainsoni)*
Texas Horned Lizard *(Phrynosoma cornutum)*
Tiger Salamander *(Ambysoma tigrinum)*
Vesper Sparrow *(Pooecetes garmineus)*
Western Meadow Lark *(Sturnella neglecta)*

Plants

Grasses
Big Bluestem (*Andropogon gerandii*)
Blue grama (*Bouteloua gracilis*)
Buffalo grass (*Bouteloua dactyloides*)
Giant Dropseed (*Sporopolus giganteus*)
Indiangrass (Sorghastrum nutans)
Lehmann's Lovegrass (*Eragrostis lehmanniana*)
Little Bluestem (*Schizachyrium scoparium*)
Purple Three Awn (*Aristida purpurea*)
Sand Bluestem (*Andropogon hallii*)
Sand Dropseed (*Sporobolus cryptandrus*)
Sideoats grama (*Bouteloua curtipendula*)

Forbs
African Rue (*Peganum harmala*)
Bractless Blazing Star (*Mentzelia nuda*)
Broadleaf Milkweed (*Asclepias latifolia*)
Broom Snakeweed (*Gutierrazia sarothrae*)
Chinese Lantern (*Quincula lobata*)
Plains Fleabane (*Erigenron modesta*)
Scarlet globemallow (*Sphaeralcea coccinea*)
Silverleaf Nightshade (*Solanum elaeagnifloium*)
Upright Prairie Cone Flower (*Ratibida columnifera*)
Western Tansy Mustard (*Descurainia pinnata*)
Western Wallflower (*Erysimum capitatum*)
Wooly Locoweed (*Astragalus mollissimus*)
Yard Aster (*Symphyotrichum divaricatum*)

Shrubs/Other
Honey Mesquite (*Prosopis glandulosa*)
Sand Sage (*Artemisia filifolia*)
Shinnery Oak (*Quercus havardii)*
Soapweed Yucca (*Yucca glauca*)
Twisted Spine Prickly Pear (*Opuntia macrorhiza*)

Student Worksheet: Wildlife Species Profile Template

SPECIES COMMON NAME:

SPECIES SCIENTIFIC NAME:

PICTURE/ILLUSTRATION:

Hierarchical Classification (Taxonomy):

Physical Characteristics (unique features):

Distribution/Range:

Habitat Requirements:

Breeding Behavior: (*Example: Bird's breeding/nesting/foraging behavior*)

Student Worksheet: Wildlife Species Profile Template (Pg 2)

Status:	Common	Rare	Native/Introduced
	Threatened	Endangered	Umbrella Species
	Obligate Species	Migratory	Resident

(Circle all that apply)

Diet:

Similar Species:

Competition/Predator/Prey:

Special Adaptations:

Conservation Threats/Management Issues:

State-listed as Threatened or Endangered:	YES	NO
Federally listed as Threatened or Endangered:	YES	NO

IUCN (International Union for Conservation of Nature) Status:
(http://www.iucn.org)

Student Worksheet: Plant Species Profile Template

SPECIES COMMON NAME:

_____

SPECIES SCIENTIFIC NAME:

_____

PICTURE/ILLUSTRATION:

Hierarchical Classification (Taxonomy):

Physical Characteristics: (circle one)

Forb Grass Shrub Tree

Perennial or Annual? _____

Habitat/Soil Type:

Status: (circle all that apply)

Common Rare Native Introduced Exotic

Threatened Endangered Invasive/Noxious

Benefits to Wildlife/Livestock: (circle all that apply)

Food Cover Thermal Regulation

Special Adaptations:

Management Issues/Threats:

Wildlife Species of Concern Management

Objectives

Students will:

1. Understand that the management of wildlife is a complex issue involving numerous groups, agencies, industry leaders, and landowners.
2. Identify different points of view for groups, agencies, or individuals concerning the management issues for lesser prairie chickens and dunes sagebrush lizards
3. Describe the effects of those management issues on various groups, agencies, or individuals.
4. Discuss potential solutions to those differing points of view concerning the management lesser prairie chickens and dunes sagebrush lizards.
5. Synthesize an array of information to make an informed decision about resource use.
6. Be able to defend a position about the conservation or utilization of natural resources and understand how those decisions may affect biodiversity, human communities, or both.

Method

In-class role-playing discussion and debate based upon the differing opinions on the management of lesser prairie chickens and dunes sagebrush lizards and the impacts of those management issues on different groups, agencies, and individuals.

Materials:

- Species background/fact sheets for lesser prairie chicken and dunes sagebrush lizard.
- "Philosophical Differences" fact sheets
- Board or paper to record input

Preparation and Procedures

Direct Instruction/Introduction (10 minutes)

1. Introduce the lesson introduction/background to the class. Have student discuss their ideas regarding how wildlife management and land management decisions are made. Who is involved in those decisions? What do they each prioritize or care about?

2. "There are many wildlife species of concern that inhabit the shortgrass prairie/sand shinnery oak shrublands of eastern New Mexico and west Texas. Those species include mammals, reptiles, amphibians, fish, and numerous birds. In fact, research has shown that 2/3 of all grassland bird populations are in decline."

3. "Today we're going to focus on a couple of ***species of concern*** inhabiting the shinnery oak woodlands of the Llano Estacado: the lesser prairie chicken and dunes sagebrush lizard. Both species are at the forefront of management issues and conflicts in eastern New Mexico and west Texas. Management of the lesser prairie chicken and dunes sagebrush lizard and the habitat they need is a complex and important issue. Many factors come into play when dealing with the management of these two species. There are environmental factors that deal primarily with the biology, physical and habitat needs for each species. Of equal importance, and often more difficult, are the philosophical or "difference points of view" factors on how to best manage these two species."

4. Define the following terms/ideas:
   - **Species of concern-** An 'at risk' species that has some concerns regarding status and threats but not enough to warrant listing under the Endangered Species Act.
   - What are some of the factors that could lead an animal to be a species of concern? Serious population declines, extirpated/eliminated from state or area, significant loss of habitat.
   - Are all species of concern considered endangered or threatened? No: even some common or game species can be species of concern. Examples: burrowing owl, scaled quail.

Guided Practice (30-45 minutes)

1. Groups of students will assume or role-play as an individual who would be involved in the decision-making process of managing lesser prairie chickens and dunes sagebrush lizards. For example, whether or not these species should be listed as threatened or endangered under the Endangered Species Act.
2. Distribute the "Philosophical Differences" fact sheet to each group. Groups will also receive copies of the background/fact sheets for lesser prairie chickens and dunes sagebrush lizards.
3. Each group will identify and write down their management concerns which will be presented to the class. (Students can also include any additional management issues they come up with.)
4. Based upon the information and identity received, each group will present their opinions on the management of lesser prairie chickens and dunes sagebrush lizards and how the potential management actions could affect their livelihoods.
5. Each group's management issues will be recorded. Have students discuss if are there any similarities or differences?
6. Now that we've recorded all of the management issues for lesser prairie chicken and dunes sagebrush lizard the class will work on a simple management plan that addresses those issues. Give students 15-30 minutes to work as a class and try to formulate a management plan. Students should stay "in character" and advocate for their assigned identities' priorities.
   Emphasize that real life conservation management is complicated as different parties try to balance their individual priorities.
7. When the class has completed their management plan, or at the end of the allotted time, give students the opportunity to reflect on the experience.
   - Would they do anything different if repeating the exercise in the future?
   - What other challenges might occur when creating a management plan for these species?
   - What could make this process easier?

Extension

Work with Audubon education staff to schedule in-class presentations from biologists, ranchers, agency personnel, energy company representatives, CEHMM or Audubon staff to discuss real world efforts to work cooperatively on the management plans for lesser prairie chickens and dune sagebrush lizards.

Students can research management plans used in other grassland habitats, or for other habitats around the country.

Additional Resources

Grassland Conservation: Protecting Our Legacy video http://www.youtube.com/watch?v=zqtimagzzX8
Lesser Prairie Chicken Management Plan, 2002-2006:
http://www.wildlife.state.nm.us/download/conservation/species/birds/management-recovery-plans/Lesser-Prairie-Chicken-Management-Plan-2002_2006.pdf.
Candidate Conservation Agreements for Lesser Prairie Chicken and Dunes Sagebrush Lizards:
http://www.cehmm.org/docs/2016AnnualReport.pdf.
Southern Great Plains Crucial Habitat Assessment Tool: http://kars.ku.edu/geodata/maps/sgpchat/

Lesser Prairie Chicken Fact Sheet

Source: Wikicommons

HABITAT NEEDS: Large intact tracts of sandy soils with dominant plant species being shinnery oak (*Quercus havardii*), bluestem grasses (*Andropogon sp*.) and sand sage (*Artemesia filifolia*). Lek (areas used for group breeding rituals) sites tend to be small slightly elevated bare or sparsely vegetated areas of finer soils. Nesting areas are normally found in areas of taller grasses with shrubs in low lying sand hills. Shinnery oak and sand sage normally present with many nests being found in sand bluestem clumps. Brooding (raising young) habitat will be near nesting sites but more open areas with a higher coverage of shrubs and forbs. Summer habitat will be similar to brooding habitat and may include agriculture fields or fallow fields. Autumn and winter habitat includes area with a higher percentage of grasses.

MANGEMENT ISSUES:

- Significant decline in the overall population of up to 80 percent over the entire range.
- Loss of habitat due to conversion of shinnery oak shrublands to agriculture/crops and other factors. Up to a 40% reduction in shinnery oak shrublands over the last couple of decades.
- Removal of shinnery oak by the use of herbicides.
- Habitat fragmentation due to oil and gas infrastructure: roads, pipelines, oil pads, and storage tank locations.
- Noise generated from oil and gas infrastructure and general disturbance from oil field traffic and seismic activity (thumper trucks).
- Improper grazing practices-over grazing - removal of mid/tall grasses necessary for nesting and brooding habitat.
- Wind farm development-general avoidance due to high structures, bird strikes, and habitat fragmentation.
- Long-term fire suppression has led to the conversion of shinnery oak habitat by invasive plant encroachment such as mesquite.

What can be done to help the Lesser Prairie Chicken?

- Avoid disturbance of Lesser Prairie Chickens during breeding season.
- Manage livestock in a fashion that creates suitable nesting and brood rearing habitat for lesser prairie chickens.
- Provide escape ramps in watering units.
- Avoid removal of native grassland/sand shinnery oak shrublands.
- Prevent fragmentation by installing infrastructure outside of occupied habitat.
- Reclaim unnecessary roads and oil pads. Remove fences, and vertical structures.

Dunes Sagebrush Lizard Data Sheet

Photo Source: Wikicommons

Habitat: Dunes sagebrush lizards are habitat specialists. They are only found in sand shinnery oak shrublands habitats with deep sand and only those areas that have bowl-shaped blowouts interspersed with sand dunes covered by shinnery oak. The blowouts must have vegetated edges providing escape cover, thermoregulation and habitat for insect prey. Dunes sagebrush lizards prefer blowouts containing coarse sand.

Management Issues:

- Loss of specialized habitat in shinnery oak shrublands.
- Removal of shinnery oak with herbicides.
- Infrastructure associated with oil and gas extraction; roads, oil pads, storage tanks, pipelines in suitable habitat.
- Noise generated from oil and gas infrastructure and general disturbance from oil field traffic and seismic activity (thumper trucks).
- Localized off highway vehicle (OHV) use.
- Wind and solar energy development leading to habitat loss.
- Encroaching human development.
- Populations of DSL are not always connected by suitable habitat, which limits breeding and repopulation.

What can be done to help the Dunes Sagebrush Lizard?

- Minimize disturbance of sand shinnery oak dune habitat.
- Do not remove shinnery oak.
- Provide escape ramps in all water sources.
- Proper management of livestock in shinnery oak habitat.
- Remove mesquite to prevent encroachment into shinnery oak habitat.
- Remove unnecessary roads, fences, and structures.
- Do not use OHV’s in shinnery oak sand dunes.

Philosophical Differences Information Sheet

NEW MEXICO GAME AND FISH WILDLIFE BIOLOGIST

As a field scientist, you have spent the last 15 years of your career studying the grassland species of eastern New Mexico. You are concerned about some of the more recent changes and are afraid that further changes could harm two major species, the lesser prairie chicken and dunes sagebrush lizard.

Lesser Prairie Chicken Management Issues/Concerns

- Overall population decline up to 80% over entire range.
- Loss of shinnery oak/grassland habitat – 40% reduction over last 20 years.
- Potential listing under Endangered Species Act could limit New Mexico's ability to manage the lesser prairie chicken with authority being given to the US Fish and Wildlife Service.
- Improper grazing practices affect lesser prairie chicken habitat.
- Oil and gas exploration/development leading to further habitat destruction and loss.
- Wind energy development (wind farms, roads, transmission line, etc.) fragments and degrades essential habitat. I also have concerns about bird strikes from the turbine blades.
- What can be done to increase Lesser Prairie Chicken population numbers? What is being done to increase Lesser Prairie Chicken numbers?

Dunes Sagebrush Lizard Management Issues/Concerns

- Highly fragmented specialized shinnery oak/blowouts habitat that is scattered throughout the sand shinnery oak shrublands. This specialized habitat is already fragmented and not continuous throughout dunes sagebrush lizard habitat.
- Oil and gas exploration/development can destroy this specialized habitat by the construction of pad sites, roads, pipelines, and storage facilities.
- Illegal ATV/ off road vehicle use in shinnery oak dunes can alter or destroy critical habitat.
- The dunes sagebrush lizard is found in localized populations depending upon their very specialized habitat. Most of these populations are isolated and separated by unsuitable habitat.
- What can be done to increase Dune Sagebrush Lizard population numbers? What is being done to increase Dune Sagebrush Lizard numbers?
- How do you increase Dune Sagebrush Lizard suitable habitat?

Philosophical Differences Information Sheet

RANCHER

You and your family have been ranching in Eastern New Mexico for many generations. You make your livelihood and feed your family by raising and selling cattle. This requires large swaths of grassland and access to water. You've heard about other places around the country where a rancher found an endangered species on their land and was prevented from making necessary changes due to federal regulations.

Lesser Prairie Chicken Management Issues/Concerns

- Potential listing under Endangered Species Act – designation of critical habitat under the Endangered Species Act would restrict what I could do on my private property.
- I need to treat/remove shinnery oak to promote grass growth for livestock grazing which could affect lesser prairie chicken habitat.
- I need to install a couple of windmills to increase water availability for livestock. However, I've been told that lesser prairie chickens tend to avoid areas with tall structures due to those structures providing perch sites for predators like hawks, eagles, and owls.
- We've had good precipitation this year resulting in good grass production. I need to increase livestock stocking rates to take advantage of excellent range conditions.

Dunes Sagebrush Lizard Management Issues/Concerns

- Potential listing under Endangered Species Act – designation of critical habitat under the Endangered Species Act could restrict what I can do on my private property.
- I need to treat/remove shinnery oak to promote grass growth for livestock grazing. Some of the areas I need to treat have sand dunes with blowouts that might be dunes sagebrush lizard habitat.
- With the good precipitation we've had this year I need to increase livestock stocking rates to take advantage of the increased forage production.

Philosophical Differences Information Sheet

OIL AND GAS COMPANY REPRESENTATIVE

Oil and gas production is big business in eastern New Mexico and important to the economy of New Mexico. Oil and gas exploration and production provides numerous jobs in eastern New Mexico. Many eastern New Mexico communities rely heavily on oil and gas economically.

Lesser Prairie Chicken Management Issues/Concerns

- Potential listing under the Endangered Species Act and the designation of critical habitat could limit the ability to explore and/or produce oil or natural gas.
- Timing/noise restrictions limit the ability to get oil/natural gas out of the ground.
- Further Lesser Prairie Chicken restrictions limit the ability to open more property to oil and gas development.
- Much of southeastern New Mexico's economy is based upon the oil and gas industry.
- Lesser Prairie Chicken restrictions hurt jobs.
- In many cases, oil and gas development benefits the landowners financially.

Dunes Sagebrush Lizard Management Issues/Concerns

- Potential listing under the Endangered Species Act – designation of critical habitat could limit the ability to explore and/or produce oil or natural gas.
- Rerouting pipelines and roads to avoid dunes sagebrush lizard habitat adds to the cost of producing petroleum.
- Limiting infrastructure locations outside of dune sagebrush lizard habitat and associated buffers could be costly.
- Some research has shown that oil and gas infrastructure (pipeline development) might actually increase dune sagebrush lizard habitat by creating blow-outs.

Philosophical Differences Information Sheet

WIND ENERGY DEVELOPMENT ENGINEER

Renewable energy is the wave of the future. New Mexico is one of the leading states when it comes to 'green' energy. Eastern New Mexico has some of the most favorable locations in the state for wind farm development due to continuous southwest winds. Most of the property in eastern New Mexico is privately owned reducing the 'red tape' required for development.

Lesser Prairie Chicken Management Issues/Concerns

- Listing the lesser prairie chicken under the Endangered Species Act would limit the locations where we could establish wind farms. The designation of critical habitat could directly affect the location of wind farms, on public and private property.
- The siting of wind turbines, roads, and transmission lines outside of lesser prairie chicken habitat could be cost prohibitive.
- The installation of wind farms benefits the landowners financially.
- Renewable energy is big business in New Mexico.
- Moving wind turbines sites out of Lesser Prairie Chicken habitat and associated buffer zones may not be cost effective.
- Lesser prairie chicken numbers were declining before the installation of wind turbines.
- Wind turbines are not the only factor in the decline of lesser prairie chickens.

Dunes Sagebrush Lizard Management Issues/Concerns

- Listing the Dune Sagebrush Lizard under the Endangered Species Act would limit the locations where we could establish wind farms. The designation of critical habitat could directly affect the location of wind farms, on public and private property.
- The siting of wind turbines, roads, and transmission lines outside of dune sagebrush lizard habitat could be cost prohibitive.
- The installation of wind farms benefits the landowners financially.
- Renewable energy is big business in New Mexico.
- Moving wind turbines sites out of dune sagebrush lizard habitat and associated buffer zones may not be cost effective.
- Dune sagebrush lizard numbers were declining before the installation of wind turbines.
- Wind turbines are not the only factor in the decline of dune sagebrush lizard.

Soil Investigation Lesson Plan

Objectives

Students who complete this lesson will be able to:

- Distinguish between the major components of soil (sand, silt, clay, organic matter)
- Classify a soil sample based on its composition of sand, silt, clay, and organic matter
- Calculate an estimate of soil organic matter and air
- Compare data collected from a soil sample in class to NRCS data about the soils found in the same sample location

Location: Science lab or classroom

Time: 90 minutes

Materials

- 1 Apple (1 per group)
- Knives for cutting apples (1 per group)
- Paper plates for cutting apples on (1 per group)
- Soil horizons graphic (http://soils4teachers.org/soil-horizons)
- Soil Investigation Kit (one per group):
    - 1000g Soil samples from throughout New Mexico, labeled with lat/long of sample location
    - Soil sample data sheet (1 per group)
    - 1 jar per soil sample
    - Hardware cloth screens (1 per soil sample)
    - 1 spray bottle
    - Laminated NRCS Soil Organic Matter and Particle Size sheets (1 set per group)
    - Laminated soil textural triangle sheet (1 per group)
    - 500ml distilled water
    - 250ml cups Baking soda
    - 500ml vinegar
    - pH litmus paper (1-2 per group)
    - 50ml, 250ml measuring cups (1 set per group)
    - Map of soil sample locations
- Guardian article on soil loss (https://www.theguardian.com/environment/2015/dec/02/arable- land-soil-food-security-shortage)

-Optional: National Geographic article about Dutch food production (https://www.nationalgeographic.com/magazine/2017/09/holland-agriculture- sustainable-farming/)

Procedures

Warm Up: Apple Demonstration

Modeled after the Soil Society of America activity.

1. Introduce the activity of investigating soils and their properties. However, before we do that, we want to emphasize how important and overlooked soils are with a demonstration. We are going to use an apple as a model of our earth. We will cut away parts of the earth to reveal how much of our planet represents arable soil.
    a. What is arable soil? Arable soil is that which can support the production food, fiber, and timber.
2. Have students make educated guesses as to what percentage of our planet is arable soil?
3. Begin dissection with the following narration:
    a. First, about what proportion of our planet is water? Approximately 75%.
    Cut away 3/4 of the apple and hold up the remaining quarter.
    b. Next, how much of our planet is "rock and ice?" That is to say, mountains and ice caps, where there is no real soil to speak of? The answer is about half of the remaining apple quarter, or 12.5% of the earth's surface.
    c. Now, with the final 1/8 apple remaining, let's think about how much of it represents land that is too hot, cold, wet, dry, or shallow-soiled to sustainably grow food, fiber, and timber.
    The answer is about 3/4 of the remaining apple. Cut and discard.
    d. Now, we have 1/32 of the apple remaining. Cut the skin off of that piece and discard the flesh.
    e. This skin, off of 1/32 of the apple represents all of the arable soil on our planet. Not much. This scarceness is why healthy soil is important and essential to conserve.

Guided Practice

1. We will now spend some time familiarizing ourselves with soil, learning about some of its constituent components, and testing the qualities of various soil samples.
2. Give students a few minutes to discuss and come up with their own definition for “soil”.
    a. According to the textbook, Soil Taxonomy, 2nd ed, soil is: *A natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment.*
3. Let's unpack that definition a little bit. When it mentions the "result of additions, losses, transfers, and transformations," what might that be referring to?
    a. Depending on the resulting discussion, consider asking some guiding questions such as:
    What happens when a big flood rushes down a mountainside?
    As organic material gets broken down by chemical and biological processes, what is created?
    As rocks are broken down by weathering and chemical reactions, what happens to the smaller bits of rock?
4. What about the first part of the definition, which mentions horizons or layers? Has anyone observed this phenomenon of layers in soils? If so, what did they notice?
    a. Display soil horizons graphic and discuss the various horizons.
5. As students will see in the next part of the lesson, the A horizon is primarily comprised of three particle sizes, which all have different characteristics. These are sand, silt, and clay. Sands are the largest particles, followed by silt, then clay. The proportion of each of these particles in a given soil is what gives the soil a lot of its properties. For instance, very sandy soils drain water rapidly, whereas clays drain extremely slowly. Additionally, clays increase the Cation Exchange Capacity (CEC), which improves soil nutrient retention.
6. Here is a resource to learn more about CEC: https://youtu.be/HmEyymGXOfI
7. If not already divided, split class into groups of 3-5 students each. Explain that each group will get a datasheet and soil sample from a different location in New Mexico. They will be asked to perform a number of simple tests on their soil sample to determine some of the soil qualities in that particular part of our state.

Independent Practice

1. Distribute soil test kits to each group

2. Optional: If a scale is available, have each group record what a 100ml cup of their soil sample weighs (in grams). If multiple scales are available, students can weigh out 150g samples for each test.

3. First, groups will separate a handful of soil and investigate the texture of that sample using the feel test, ball test, and ribbon test. Students will record their observations after each test.

Video Demonstration of the above tests (Optional): Soil Texture- https://www.youtube.com/watch?v=0FSTZXkJT5

4. Set the first subsample aside

5. Using the NRCS Organic Matter and Particle Size sheets, perform each test on its own 100ml sample. Perform particle size first as samples should be observed at 5min, 1hr, and 24hrs. Record observations as prompted by worksheet.

6. Display map of soil sample locations. Based on the characteristics of their soil, each group should guess where in the state their soil sample came from. Why do they have that hypothesis?

7. After particle size samples have sat overnight, have students record observations about their soil sample.

Extensions

Using the Web Soil Survey to learn more about soil samples:

1. Have students navigate to Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm) and press the green "Start WSS" button

2. Using the "Latitude and Longitude or Current Location" option under "Quick Navigation," have students input the latitude and longitude of their sample location.

3. Using the "Scale" button next to the Area of Interest tools, calibrate your scale on screen.

4. Generate an AOI around the group's sample location at a scale of 1:24,000

5. Navigate to the "Soil Map" tab and record the mapped soil unit of their sample. The name should be something like, "Enmedio-Atalaya-Rock outcrop complex, 5 to 60 percent slopes"

6. Click on the hyperlink of the "Map Unit Name" for their sample and look at the various characteristics of the soil profile in that location.

7. Based on the data they recorded, does their sample fit any of the soil types in their mapped unit? Record answer.

8. Click on the "Soil Data Explorer" tab and navigate to the "Suitabilites and Limitations for Use" sub-tab

9. Expand the Vegetative Productivity menu and check the suitability of your map unit for Range Productivity in a Favorable Year, Normal Year, and Unfavorable Year. Record your answers.

Technology and Our Food Supply

1. Either in class or as homework distribute the National Geographic article about Dutch food production and scientific advances in greenhouses.

2. In class or as homework, also assign students to watch this short video on cost-benefit analysis: https://www.youtube.com/watch?v=7tdKkeNClPE

3. Pair students and ask them to discuss the article and video with the guiding questions: “If technology can help us increase agricultural productivity without the use of native soil, should we care about soil loss on the landscape?” ; “What do you see as the biggest cost associated with soil degradation?”; “The Dutch agricultural model in the article seems to focus only on the production of plant foods. How might livestock production and ranching be affected by these new advancements, if at all?”

4. Ask the student pairs to think about how more extensive greenhouse production and technology-driven agriculture might

benefit a country like the United States. With less land needed for growing crops, would it be beneficial to restore prairie grassland ecosystems for recreation and biological diversity?

5. Ask students to develop a hypothetical model for how food production, soil conservation, and other human uses could be better balanced with techology. This model should have some graphical representation, whether it be maps, graphs, or diagrams.

Visit a local grassland to perform some soil/vegetation field surveys:

1. Contact an Audubon educator to coordinate a field trip to a local grassland for soil/vegetation sampling.

Assessment

1. Evaluation of soil lab data sheet
2. Data retrieved from Web Soil Survey
3. Graphical representation of future food production/conservation scenario

Accommodations & Modifications

1. Instead of a visual demonstration, provide enough apples and knives for students to break into groups and perform the cuts on their own.

2. Compost discarded apple pieces and build some soil of your own!

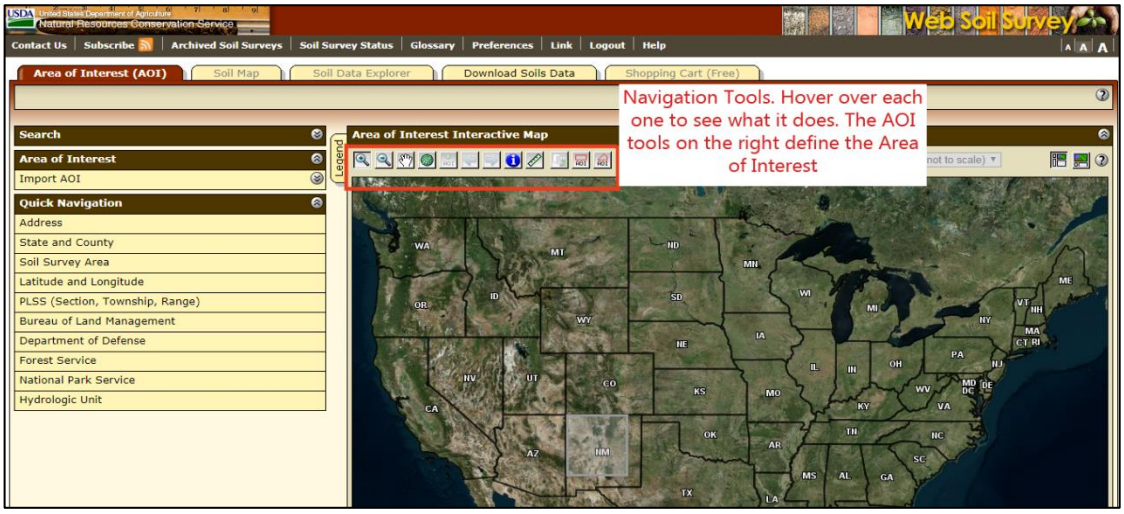
Navigating the Web Soil Survey

Introduction: The US Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) provides technical assistance, tools, and support for landowners and land managers looking to implement conservation practices across the country. Although we may not think about it often, conservation begins with the soil, both understanding and protecting the complex ecosystems that support the life we encounter above ground. Every year, NRCS agents work to map soils across the United States to help land managers and decision-makers better understand these important and fragile resources. All of these data are uploaded to an online database called the Web Soil Survey, which allows anyone with an internet connection to access soil maps and data about the suitability of their soils for construction, agriculture, ranching, and other activities. Learning to navigate the Web Soil Survey is a useful skill for anyone who does work on the land.

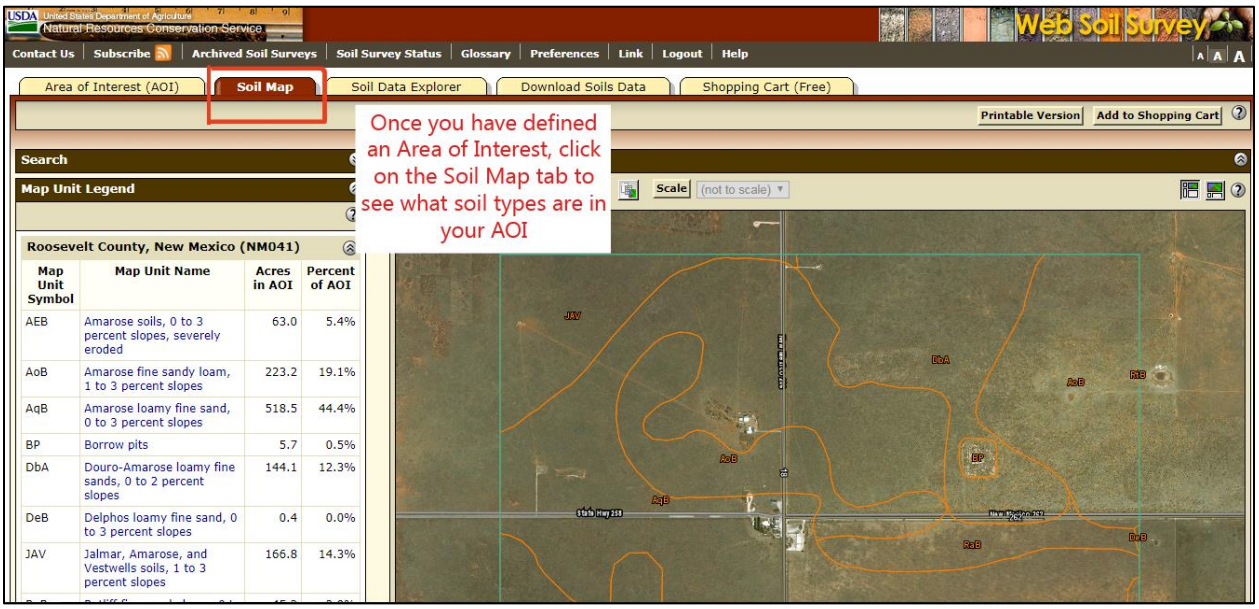
STEP 1: Navigate to the Web Soil Survey www.websoilsurvey.nrcs.usda.gov

STEP 2: Click the large, green "Start WSS" button at the top of the screen

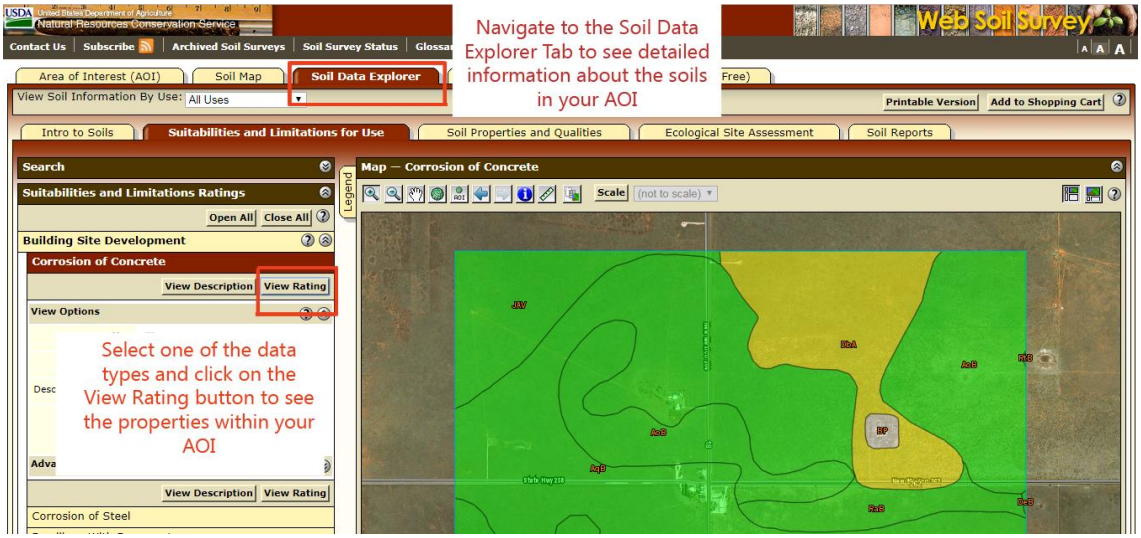
STEP 3: Navigate using the tools at the top of the map and define an Area of Interest (AOI). You can hover over each of the icons to find out exactly what it do



STEP 4: After defining an Area of Interest, click on the Soil Map tab to see what soil types are in your area.



STEP 5: Click on the Soil Data Explorer tab to learn more about the suitability of human different human activities in your Area of Interest. Using the drop-down menus on the left, click on a topic and View Rating to view a description of how suitable the soils in your Area of Interest are for that human use.



Additional NRCS Soil Resources:

Soil Education Page- https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/edu/

Soil Health for Educators- https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/health/assessment/?cid=nrcs142p2_053870

Soils 101- https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/7thru12/?cid=nrcseprd885606

Helping People Understand Soils: Ten Key Messages slide deck- https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052550.pdf

Living Kingdoms Beneath Our Feet. video (YouTube)- https://youtu.be/HQMlAX6yTd8

Water Movement In Soil video (YouTube)- https://youtu.be/vmo0FRAVgkM

Supplemental Soil Testing Information

Determining soil types in a local grassland

4 Easy Do-It-Yourself Soil Tests (By Colleen Vanderlinden)

Soil Test #1: The Squeeze Test

One of the most basic characteristics of soil is its composition. In general, soils are classified as clay soils, sandy soils, or loamy soils. Clay is nutrient rich, but slow draining. Sand is quick draining, but has trouble retaining nutrients and moisture. Loam is generally considered to be ideal soil because it retains moisture and nutrients but doesn't stay soggy.

To determine your soil type, take a handful of moist (but not wet) soil from your garden, and give it a firm squeeze. Then, open your hand. One of three things will happen:

1. It will hold its shape, and when you give it a light poke, it crumbles. Lucky you—this means you have luxurious loam!
2. It will hold its shape, and, when poked, sits stubbornly in your hand. This means you have clay soil.
3. It will fall apart as soon as you open your hand. This means you have sandy soil.

Soil Test #2: The Percolation Test

It is also important to determine whether you have drainage problems or not. Some plants will eventually die if their roots stay too wet. To test your soil's drainage:

1. Dig a hole about six inches wide and one foot deep.
2. Fill the hole with water and let it drain completely.
3. Fill it with water again.
4. Keep track of how long it takes for the water to drain.

If the water takes more than four hours to drain, you have poor drainage.

Soil Test #3: The Worm Test

Worms are great indicators of the overall health of your soil, especially in terms of biological activity. If you have earthworms, chances are that you also have all of the beneficial microbes and bacteria that make for healthy soil and strong plants. To do the worm test:

Be sure the soil has warmed to at least 55 degrees, and that it is at least somewhat moist, but not soaking wet.

1. Dig a hole one foot across and one foot deep. Place the soil on a tarp or piece of cardboard.
2. Sift through the soil with your hands as you place it back into the hole, counting the earthworms as you go.

If you find at least ten worms, the soil is in pretty good shape. Less than that indicates that there may not be enough organic matter in the soil to support a healthy worm population, or that the soil is too acidic or alkaline.

Soil Test #4: Ph Test

The Ph (acidity level) of soil has a large part to do with how well plants grow. Ph is tested on a scale of zero to fourteen, with zero being very acidic and fourteen being very alkaline. Most plants grow best in soil with a fairly neutral Ph, between six and seven.

When the Ph level is lower than five or higher than eight, plants just won't grow as well as they should.

Every home and garden center carries Ph test kits. These kits are fairly accurate, but you must make sure you follow the testing instructions precisely.

Particle Size Using a Mason Jar Soil Test (By Shelle, preparednessmama.com/jar-soil-test/)
There are three soil components – Clay, Sand, and Silt

Clay is the smallest mineral component. These tiny flat particles fit closely together to create the greatest surface area of all soil types. Clay soil contains needed nutrients and also stores water well. So well in fact, that drainage is slow in clay soil. It is also the slowest to warm in the spring.

Sand makes up the largest particles in soil structure. These are rounded, rather than flat and allows for larger space between the particles. Water drains quickly from the soil that has a lot of sand and the nutrients drain faster too. If your soil is mostly sand the plants will need more water and fertilizer.

Silt represents the middle size pieces. It is made up of rock and mineral particles that are larger than clay but smaller than sand. Individual silt particles are so small that they are difficult to see. To be classified as silt, a particle must be less than .005 centimeters (.002 inches) across.

The Mason Jar Soil Test

1. Use a clear, clean, empty jar with a tight lid. A pint or quart Mason jar works fabulously.
2. Fill the jar about half full of soil.
3. Fill the jar nearly to the top with water. Leave room for shaking.
4. Tighten the lid and shake the jar for several minutes so that all the particles are in suspension.
5. Set your mason jar soil test aside for several hours, so the particles have a chance to settle. They will separate into clay, silt, and sand layers.

Read the Results of your Mason Jar Soil Test

- The bottom layer will be the heavier particles, sand, and rocks.
- The next layer will be the silt particles.
- Above that are the clay particles.
- Organic matter may be floating on the surface of the water.
- The color of the soil gives a clue to its character – light colors usually have less organic content than dark soil and dark soil warms faster in the spring.

If your jar test is: 20% clay, 40% Silt, 40% sand = Loam
30% clay, 60% silt, 10% sand = Silty Clay Loam
15% clay, 20% silt, 65% sand = Sandy Loam
15% clay, 65% silt, 20% sand = Silty Loam

Lesson #2: Determining soil types in a local grassland.

How to Test Soil Acidity/Alkalinity without a Kit (By Erin Huffstetler)
What You Need:

- A soil sample
- White vinegar
- Baking soda
- Water
- 2 sample containers (a disposable cup, etc.)

Here's How:

1. Scoop some soil into a container. Then, add half a cup of vinegar. If the soil bubbles or fizzes, it's alkaline. That chemical reaction that you're seeing is what happens when an acid (the vinegar) comes into contact with something alkaline (the soil).
2. If no reaction occurs, scoop a fresh soil sample into a second container. Add half a cup of water and mix. Then, add half a cup of baking soda. If the soil bubbles or fizzes the soil is highly acidic. That reaction you're seeing is the result of acidic soil coming into contact with an alkaline substance (the baking soda).
3. If your soil doesn't react to either test, it has a neutral pH.

Soil Investigation Lab: Student Worksheet

INTRODUCTION: Soils support almost all terrestrial life on earth, making them an extremely critical resource to understand and conserve. Humans rely on soils for the production of food, fiber, timber, but soils are also the foundation for most terrestrial ecosystems. Where soils change, the trained eye can observe subtle changes in vegetation, which can have monumental impacts on a given habitat. Despite their importance, soils are poorly understood by most people. In this investigation, you will be asked to look more closely at the components of soil, the properties of soil, and how to classify soils. By the end of the activity, you should be able to see the differences between various soil types in the state of New Mexico and have a better sense of how soils create the basis for the habitats around us.

MATERIALS:

Soil Investigation Kit (one per group):

- 1000g Soil sample
- Soil sample data sheet
- Soil test jar
- Particle Size test jar
- Ruler
- Hardware cloth screen
- 1 spray bottle
- Can of spray polyurethane
- Laminated NRCS Soil Organic Matter and Particle Size sheets (1 set per group)
- Laminated soil textural triangle sheet (1 per group)
- 1000ml distilled water
- 250ml Baking soda
- 500ml vinegar
- pH litmus paper
- 50ml, 250ml measuring cups
- pH test dishes
- Map of soil sample locations

A NOTE ABOUT YOUR SOIL SAMPLES:

Your soil sample was collected in New Mexico. The coordinates on your sample bag indicate where your sample was taken from. Each sample is comprised of soil dug from multiple pits in a 30m area because soils express subtle variation across the landscape and sampling from multiple locations can help capture a more refined picture of the soils in your sample location.

PROCEDURE:

PART I: Determining soil texture

1. Open your soil sample bag and grab a handful of soil. Rub the soil between your thumb and forefinger. Describe the texture of your sample (smooth, coarse, rough, etc):

   _____

2. Using your spray bottle wet the sample in your hand and knead the soil around until it has the consistency of cookie dough. Compress the sample into the palm of your hand as if you were turning it into a ball.
   Does the ball maintain its shape, or does it crumble up? Record your observation: _____

3. Lightly toss your soil ball 2-4 inches into the air and catch it in the palm of your hand.
   Does the ball maintain its shape, or does it fall apart? _____

4. Ribbon test: Begin pushing your soil sample between your thumb and forefinger to create a ribbon that advances beyond your hand. (See photo)

5. Does your sample hold together or fall apart quickly? _____

6. Record how long of a ribbon you can make with your sample:_____
   Consider this: If your sample was very coarse and had trouble holding its shape as a ball, or created a brittle ribbon that broke immediately, it probably has a high sand component.

7. If your sample held its shape somewhat, but made a short ribbon, it is likely very silty.

8. If your sample was very sticky, held its shape well as a ball, and created a long ribbon, it probably has a high clay component. Record a guess as to which of the three particle sizes is dominant in your sample:

   _____

PART II: Determining Particle Size

We can now test the results of your texture tests by performing what is known as a particle size test. This involves submerging part of your soil sample in water and letting it sit for a number of hours. Due to the qualities of sand, silt, and clay, each of the three primary soil particle sizes will create layers in your vessel. Clays can take up to 24hrs to settle, so you will be able to record your most accurate results after letting your particle size sample sit for at least 24hrs.

1. Look at your packet of soil test instructions and find the Particle Size instruction set. Instead of separating your sand and silt/clay components, simply place your entire 100ml subsample into your bottle with 500ml of water. Shake your bottle and let your sample sit.
2. Observations during the first 2 minutes of settling: _____
    a. Observations after 10 minutes: _____
    b. At the end of your class period, record the height of each layer of particles with your ruler: _____
    c. After 24 hours, record final measurements of each layer: _____
    d. Calculate what percentage sand, silt, and clay you have in your sample by dividing the height of each layer by the overall height of your sample.

Sand Height/Total Height=	Silt Height/Total Height=	Clay Height/Total Height=
_____ % Sand	_____ % Silt	_____ % Clay

3. Use the Soil Texture Triangle sheet in your lab kit to determine your sample's soil type: _____

PART III: Calculating Soil Organic Matter

Follow instructions on the Soil Organic Matter sheet in your lab kit and record how long it took your soil to dissolve: _____

PART IV: Calculating Soil pH- The pH of your soil is a measure of how acidic or alkaline your sample is. Knowing soil pH is extremely helpful for food production as certain crops require specific conditions to thrive and produce high yields. Similarly, soil pH helps influence vegetation patterns on a landscape scale.

1. **Vinegar test-** Pour two 50ml scoops of soil into one of your pH test dishes. Add 500ml of vinegar.
   Record results: _____

   If your sample reacted, it is likely somewhat alkaline.
2. **Baking Soda test-** Pour two 50ml scoops of soil into one of your pH test dishes. Add distilled water until you get a thick slurry. Sprinkle baking soda onto the mixture.
   Record results: _____

   If your sample reacted, it is likely somewhat acidic soil.
3. **pH Paper Test-** In a pH test dish, mix two 50ml scoops with distilled water until the solution is the consistency of a milkshake. Dip a strip of pH paper in the soil solution and remove the paper. Wait 10 seconds, match the color of your paper to the pH measurement. Record results: _____
4. Did the results of your vinegar and baking soda tests match with the results of the pH test? Explain: _____

Science, Technology, Engineering, Mathematics (STEM) Careers Lesson Plan

Objectives

1. Students will identify science, technology, engineering, and mathematics (STEM) careers dealing with management in the shortgrass prairie/sand shinnery oak shrublands ecosystems.
2. Students will understand how STEM careers benefit traditional land management practices while conserving or enhancing habitat for birds and other wildlife.
3. Through this exercise students will understand that science plays an important role in many different kinds of careers and activities.

Materials

- Computers with internet access
- Board or poster paper
- Optional: STEM Jobs sheet
- Optional: Career Pathways sheet

Preparation and Procedures

Direct Instruction (5 minutes)

1. In a class discussion, ask students: "What kinds of jobs are available in or around our local community?" Record those jobs on a board or paper.
2. Have students review the list and determine if any of those jobs deal with science, technology, engineering, or mathematics (STEM).
3. Circle or highlight those jobs that your students have identified as STEM careers. If students are having difficulty with identifying STEM careers use the attached examples to guide their efforts.

Independent Practice (30 minutes)

1. Break the class in small groups (group size depends upon class size).
2. Distribute one career worksheet (worksheet in development) to each group.
3. Allow 25 - 30 minutes for each group to complete their worksheet and determine what it takes to prepare for that career. (College, special equipment, techniques, special skills, etc.)
4. Allow 10 minutes for each group to determine whether those careers benefit traditional land management practices (i.e.: farming and ranching).

Extension

Work with Audubon education staff to schedule in-class presentations from STEM professionals: biologists, range techs, ranchers, Audubon staff, or agency representatives and have them discuss their career choices. Have STEM college students, Audubon staff, ranchers, and others mentor high school students interested in STEM careers.

Depending on your class' interest in a particular career or field, coordinate with Audubon education staff to target visitors who represent those careers.

Additional resources

Wildwork, Project WILD, 2002.
http://www.stemcareer.com
http://www.ed.gov/Stem

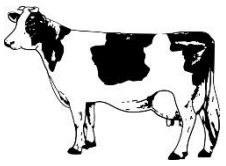
STEM Careers Examples

Below are some possible jobs you could have in the science, technology, engineering, and math fields.

Agricultural Engineer
- Prepare sketches, working drawings, specifications, proposals, reports and budgets for sites or systems.
- Discuss plans with clients, contractors, consultants, and other engineers so that they can be evaluated and necessary changes made.
- Meet with clients, such as district or regional councils, farmers, and developers, to discuss their needs.
- Provide advice on water quality and issues related to pollution management, river control, and ground and surface water resources. Outdoor and field visits part of the job.
- Plan and direct construction of rural electric-power distribution systems, and irrigation, drainage, and flood control systems for soil and water conservation.

Agriculture Science Teacher
- Prepare and deliver lectures to students on topics such as crop production, plant genetics, and soil chemistry.
- Evaluate and grade students' class work, laboratory work, assignments, and papers.
- Prepare course materials, such as syllabi, homework assignments, and handouts.
- Work with students in both indoor and outdoor settings.

Agriculture Technician
- Record data pertaining to experimentation, research, or animal care.
- Measure or weigh ingredients used in laboratory testing.
- Prepare data summaries, reports, or analyses that include results, charts, or graphs to document research findings and results.
- Set up laboratory or field equipment as required for site testing.
- Prepare laboratory samples for analysis, following proper protocols to ensure that they will be stored, prepared, and disposed of efficiently and effectively.



Animal Scientist
- Study nutritional requirements of animals and nutritive values of animal feed materials.
- Advise producers about improved products and techniques that could enhance their animal production efforts.
- Develop improved practices in feeding, housing, sanitation, or parasite and disease control of animals. Communicate research findings to the scientific community, producers, and the public through written and verbal methods.
- Study effects of management practices, processing methods, feed, or environmental conditions on quality and quantity of animal products, such as eggs and milk.

Biology Science Teacher
- Prepare and deliver lessons to students on topics such as molecular biology, ecology, and botany.
- Prepare course and laboratory materials such as syllabi, homework assignments, and handouts.
- Evaluate and grade students' class work, laboratory work, assignments, and papers.
- Maintain student attendance records, grades, and other required records. Supervise students' laboratory work.

Biology Technician
- Conduct research or assist in the conduct of research, including the collection of information and samples, such as blood, water, soil, plants and animals.
- Use computers, computer-interfaced equipment, robotics or high-technology industrial applications to perform work duties.
- Monitor and observe experiments, recording production and test data for evaluation by research personnel.
- Analyze experimental data and interpret results to write reports and summaries of findings.

- Provide technical support and services for scientists and engineers working in fields such as agriculture, environmental science, resource management, biology, and health sciences.

Civil Engineer
- Inspect project sites to monitor progress and ensure conformance to design specifications and safety or sanitation standards.
- Compute load and grade requirements, water flow rates, or material stress factors to determine design specifications.
- Provide technical advice to industrial or managerial personnel regarding design, construction, or program modifications or structural repairs.
- Test soils or materials to determine the adequacy and strength of foundations, concrete, asphalt, or steel.
- Manage and direct the construction, operations, or maintenance activities at project site.

Soil and Water Conservationist
- Implement soil or water management techniques, such as nutrient management, erosion control, buffers, or filter strips, in accordance with conservation plans.
- Monitor projects during or after construction to ensure projects conform to design specifications.
- Visit areas affected by erosion problems to identify causes or determine solutions.
- Advise land users, such as farmers or ranchers, on plans, problems, or alternative conservation solutions.
- Develop or maintain working relationships with local government staff or board members.

Range Manager
- Regulate grazing and help ranchers develop grazing systems in order to manage, improve and protect rangelands, while and maximizing profitablility.
- Measure and assess vegetation resources for biological assessment companies, environmental impact statements, and rangeland monitoring programs.
- Maintain soil stability and vegetation for non-grazing uses, such as wildlife habitats and outdoor recreation.
- Mediate agreements among rangeland users and preservationists as to appropriate land use and management.
- Manage forage resources through fire, herbicide use, grazing, or revegetation to maintain a sustainable yield from the land.

Remote Sensing/Geographic Information Systems Technician
- Analyze geographic data collected from drones, planes, satellites, and on-the-ground methods.
- Produce maps and reports to help researchers, land managers, equipment operators and others perform accurate work.
- Collaborate in a team environment to solve problems.
- Calibrate equipment and plan data gathering missions on the ground and in the air.
- Write software and develop digital databases to store and analyze information

Hydrologist
- Design and conduct scientific hydrogeological investigations to ensure that accurate and appropriate information is available for use in water resource management decisions.
- Prepare written and oral reports describing research results, using illustrations, maps, appendices, and other information.
- Study and document quantities, distribution, disposition, and development of underground and surface waters.
- Install, maintain, and calibrate instruments such as those that monitor water levels, rainfall, and sediments.
- Prepare hydrogeological evaluations of known or suspected hazardous waste sites and land treatment and feedlot facilities.

Pathologist
- Examine microscopic samples to identify diseases or other abnormalities.
- Diagnose diseases or study medical conditions using techniques such as gross pathology, histology, cytology, cytopathology, clinical chemistry, immunology, flow cytometry, or molecular biology.
- Write pathology reports summarizing analyses, results, and conclusions.
- Identify the etiology, pathogenesis, morphological change, and clinical significance of diseases.
- Analyze and interpret results from tests such as microbial or parasite tests, urine analyses, hormonal assays, fine needle aspirations (FNAs), and polymerase chain reactions (PCRs).

Surveyor
- Verify the accuracy of survey data, including measurements and calculations conducted at survey sites.
- Direct or conduct surveys to establish legal boundaries for properties, based on legal deeds and titles.
- Prepare or supervise preparation of all data, charts, plots, maps, records, and documents related to surveys.
- Prepare and maintain sketches, maps, reports, and legal descriptions of surveys to describe, certify, and assume liability for work performed.
- Write descriptions of property boundary surveys for use in deeds, leases, or other legal documents.

Veterinarian
- Examine animals to detect and determine the nature of diseases or injuries.
- Treat sick or injured animals by prescribing medication, setting bones, dressing wounds, or performing surgery.
- Collect body tissue, feces, blood, urine, or other body fluids for examination and analysis.
- Inoculate animals against various diseases, such as rabies or distemper.
- Counsel clients about the deaths of their pets or about euthanasia decisions for their pets.

Zoologist/Wildlife Biologist
- Study animals in their natural habitats, assessing effects of environment and industry on animals, interpreting findings and recommending alternative operating conditions for industry.
- Inventory or estimate plant and wildlife populations.
- Organize and conduct experimental studies with live animals in controlled or natural surroundings.
- Make recommendations on management systems and planning for wildlife populations and habitat, consulting with stakeholders and the public at large to explore options.
- Disseminate information by writing reports and scientific papers or journal articles, and by making presentations and giving talks for schools, clubs, interest groups and park interpretive programs.

Wind Energy Engineer
- Create or maintain wind farm layouts, schematics, or other visual documentation for wind farms.
- Recommend process or infrastructure changes to improve wind turbine performance, reduce operational costs, or comply with regulations.
- Create models to optimize the layout of wind farm access roads, crane pads, crane paths, collection systems, substations, switchyards, or transmission lines.
- Provide engineering technical support to designers of prototype wind turbines.
- Investigate experimental wind turbines or wind turbine technologies for properties such as aerodynamics, production, noise, and load.

Student Worksheet: STEM Career Pathways

My interests or skills (things I'm good at or enjoy):

Which of my interests or skills would translate well into a job?

STEM Job I am interested in:

Why are you interested in this career?

What does this job do?

What is this job/field's average annual salary?

What steps would you need to take to achieve this job? What sort of skills, education level, or certifications do you need?

Which people or organizations can you talk to in order to learn more about this job or its field?

Getting Involved

Audubon New Mexico and the National Audubon Society are staunch proponents of community science. Community Science is a great way for students to connect with the natural world through fun activities that generate vital information for bird conservation. This partnership benefits us all: students will learn about birds by taking part in these science-based activities, and Audubon's science staff gains valuable information. Most importantly, the birds benefit because it helps Audubon focus on the birds that need our help most.

Ways students can get involved with community science:

The Great Backyard Bird Count

Scheduled annually for mid-February during Presidents Day weekend. Students can identify and report birds that they find during the 4-day event. Surveys can be as little as 15 minutes or longer. Surveys can be completed for one or more days during the event. Sightings are reported at http://www.birdcount.org
Additional information can be found at http://gbbc.birdcount.org

Christmas Bird Count

As the oldest community science program, the Christmas Bird Count has been monitoring wintering birds since 1900. The Christmas Bird Count is annually scheduled for December 14 through January 5. Students can choose to become part of a team that surveys birds in a specific area during this time frame. Teams normally include one experienced birder. Two Christmas Bird count areas are found in southeastern New Mexico; both are coordinated by Grant Beauprez, Lesser Prairie Chicken Biologist, New Mexico Department of Game and Fish. Additional information can be found at: http://audubon.org/conservation/science/christmas-bird-count

iNaturalist

Students can contribute to a global community science documenting the biodiversity of their local environment. All they need is the free iNaturalist app and a camera and they can begin uploading their observations of various local flora and fauna. Using their predictive technology, students can make an educated guess as to the classification of their observations. Later, other community members can either verify or make a different suggestion about the observation's data. When an observation has been verified by three independent sources, it is considered "research grade" and usable in local data sets.
Learn more: inaturalist.org

Lesser Prairie Chicken Surveys

Working in conjunction with the New Mexico Department of Game and Fish students can assist with roadside and management area lesser prairie chicken surveys. Students will receive experience with data sheets and survey protocols.

Additional Assessment Tool

The included assessment tool is for use to evaluate students' feelings towards science, nature, and the outdoors. They are based on best practice within the environmental education field (Nisbet, Zelenski, & Murphy, 2008). It has been pared down for simplicity and efficiency, and made available in both English and Spanish.

The primary purpose of the assessment is to measure student growth, and thus should not be administered like a test, but rather a simple evaluation. This assessment should be administered ahead of any programming or lessons, and immediately following the completion of the final lesson. Student responses can be scored using the rubric below. Additional content knowledge questions can be added to the end if educators are interested in tracking specific lesson points. Comparative scores may lend insight to the effectiveness of lessons and/or programming.

Question #	***5 Points***	***4 Points***	***3 Points***	***2 Points***	***1 Points***	***0 Points***
1	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Answer
2	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Answer
3	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Answer
4	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Answer
5	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Answer
6	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Answer
7	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Answer
8	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Answer
9	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Answer
10	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	No Answer
11	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Answer

Question	***4 Points***	***3 Points***	***2 Points***	***1 Points***	***0 Points***
Grassland Impacts	Provides two detailed answers that are correct	Provides one detailed correct answer and one incomplete answer	Provides one detailed answer that is correct or two short incomplete answers	Provides one, incomplete answer	No Answer or incorrect answers
– Not graded – What job do you want when you grow up? Note if student says scientist to count if an increase from pre-test results					

Student Name:_____ **Date:**_____ **Pre or Post**

Multiple Choice. Check the answer that best matches what you think or feel.

		Strongly agree	Agree	Don't agree or disagree	Disagree	Strongly Disagree
						
1	Humans are a part of the natural world					
2	I like to be outside when learning science					
3	I like to be inside when learning science					
4	I enjoy being outdoors					
5	I am in nature when I am out in the schoolyard					
6	I am in nature when I am in an arroyo					
7	I am in nature when I am in the forest					
8	Being outside in nature makes me feel peaceful					
9	My actions will make the natural world different					
10	Science is hard					
11	Science is helpful in understanding nature					

What are two things that impact grasslands/the Llano Estacado?

1._____

2._____

What job do you want when you grow up?_____

Nombre:_____ Fecha:_____ Pre o Post

Selección múltiple. Selecciona la respuesta que mejor representa tus pensamientos.

		Muy de acuerdo	De acuerdo	Neutral	En desacuerdo	Muy en desacuerdo
						
1	Los humanos son parte de la naturaleza.					
2	Me gusta estar afuera cuando estudio las ciencias.					
3	Me gusta estar adentro cuando estudio la ciencia.					
4	Me gusta estar afuera.					
5	Cuando estoy en el patio de recreo, estoy en la naturaleza.					
6	Cuando estoy en un arroyo, estoy en la naturaleza.					
7	Cuando estoy en el bosque, estoy en la naturaleza.					
8	Estar afuera en la naturaleza me da un sentido de paz.					
9	Mis acciones pueden hacer una diferencia para la naturaleza.					
10	La ciencia es difícil.					
11	La ciencia me ayuda a entender la naturaleza.					

¿Qué son dos cosas que afectan al Llano estacado?

1._____

2._____

¿En qué quieres trabajar cuando seas grande? _____

Glossary

Adaptation: adjustments or changes in behavior, physiology and structure of an organism to become more suited to an environment.

Annual: plant living one year

Anthropogenic: originating from human activity; caused or produced by humans.

Climatic grassland: grassland as the result of climate rather than to soil or topography

Conservation: the wise use of natural resources.

Derived grassland: grassland as the result of the actions of man.

Edaphic grassland: grassland related to or caused by particular soil conditions, as of texture or drainage, rather than by physiographic or climatic factors.

Endangered species: a species threatened with extinction.

Facultative species: plant or animal that can occur in numerous habitat types.

Herbaceous plant: non woody plant

Hierarchy: any system of things ranked one above another.

Homogeneous: of the same kind or nature; essentially alike.

Obligate species: plant or animal that has a narrow range of defined habitat.

Perennial: plant living more than one year.

STEM: science, technology, engineering, mathematics; normally associated with careers.

Temperate: moderate in respect to temperature; not subject to prolonged extremes of hot or cold weather.

Threatened: any species which is vulnerable to endangerment in the near future. A species likely to become endangered in the foreseeable future.

Tradition: a long-established or inherited way of thinking or acting.

Tropical: pertaining to characteristics of, occurring in, or inhabiting, the tropics; very hot and humid.