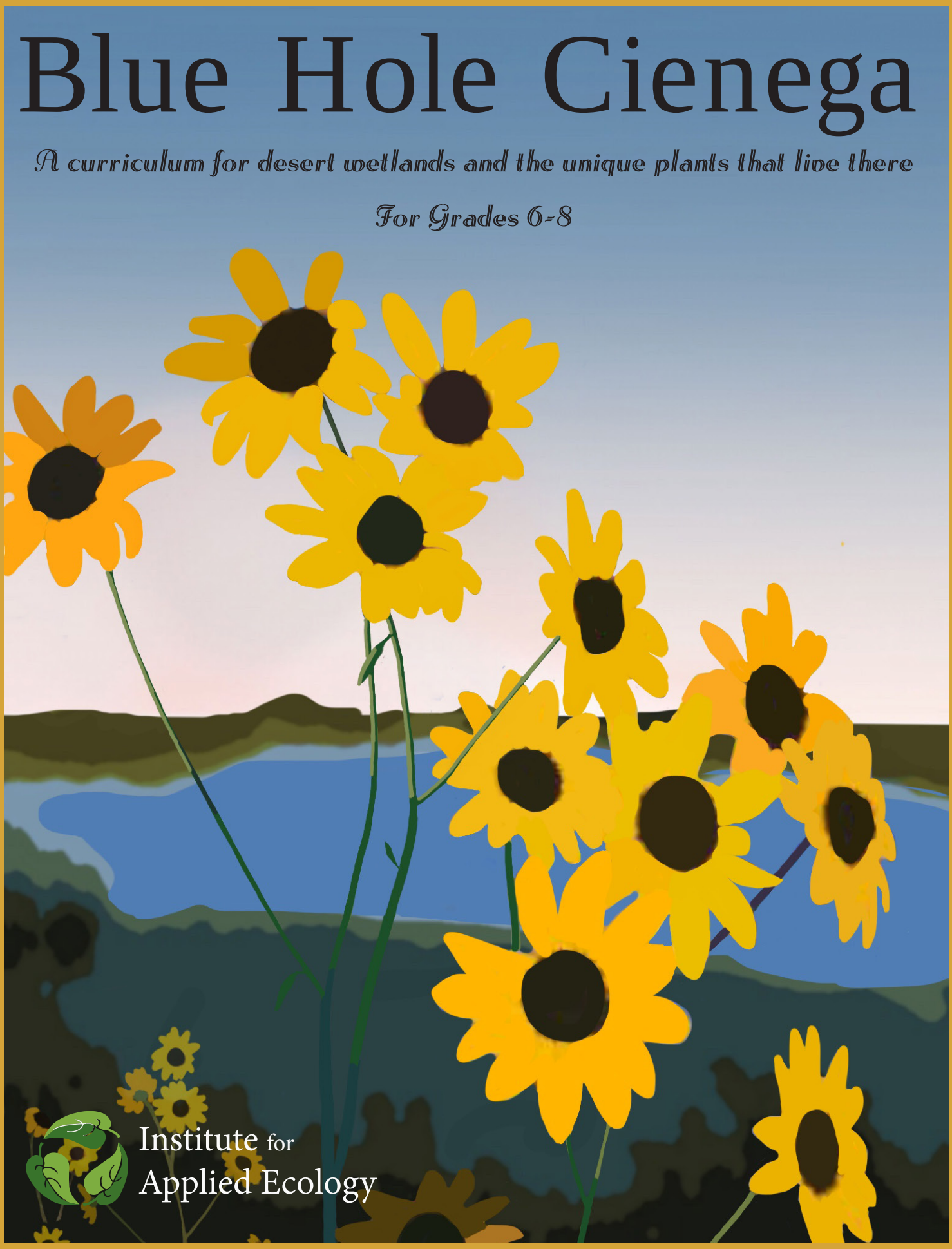
Blue Hole Cienega

A curriculum for desert wetlands and the unique plants that live there

For Grades 6-8



Institute for
Applied Ecology

Blue Hole Cienega

A curriculum for desert wetlands and the unique plants that live there

• For grades 6-8 •

Written by:
Ashlee Wolf, Melanie Gisler, and Yvonne Hickerson
Institute for Applied Ecology

Significant contributions by:
Estela Thompson
Santa Rosa High School
and
Morika Hensley and Mollie Walton
Quivira Coalition

Graphic Design and Layout:
Sara Digby, Institute for Applied Ecology

Cover Art:
Steven Gisler

Illustrations:
Sara Digby
Steven Gisler

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Grant to the Quivira Coalition from the New Mexico Environmental Department Wetland Program

Organization of the Curriculum

Lessons progress from setting the ecological stage into more advanced topics related to the ecology and conservation of native plants in Blue Hole Cienega; the curriculum is designed to be a complete unit of study. We also understand that many teachers are unable to commit to the entire unit of study, so lessons can also be used individually. All lessons start with a Teacher Page; check there for the Teachers Hints section to find any essential skills or background needed from earlier lessons. Study topics, background information, and associated sections are included with each of the lessons for study.

Student pages are written for self-guided studies. What better way for them to practice their literacy skills than to read, interpret, and follow written directions. As the teacher, you will need to be familiar with the background information and reflection activities found on the student pages. Of course as the teacher, you maintain the control to use this student directed learning feature as it works best in your classroom.

All lesson worksheets provided will follow the Student Pages. Lessons suggest ways to integrate student studies into service-learning and community projects.

Making the Most of this Curriculum

1. Create a student field journal at the beginning of the study. Encourage students to use them throughout the course of study. Allow time for students to observe, explore, and document their discoveries in field journals each time you take them outdoors. Over time their journal will become a handy reference for them to check back to when they are in the field. Journals, kept over time, can also serve to mark phenology - or changes in the timing of natural phenomena. In addition, the journal can be used throughout the curriculum as an assessment tool and portfolio.

2. Plan ahead to take advantage of outdoor, hands-on learning opportunities. Many of the activities lessons are outdoors-based. While many of these hands-on outdoor activities can be done in the schoolyard or an empty lot, we believe it is a hugely beneficial experience for students to discover and explore a natural area. When areas such as these are contrasted with human dominated environments, such as schoolyards, students can more easily understand human impacts. Some schools are lucky enough to be within walking distance of a wetland or other natural area, but many may need to take a field trip to incorporate this type of experience. If this is the case, plan ahead for lessons that would best be done at Blue Hole Cienega or other natural areas. Buses may need to be ordered, schedules arranged, permission slips signed, and permission may need to be requested from whomever owns or manages the natural area you plan to visit. We recommend always being in touch with the manager of the natural area before visiting, as they may be able to provide valuable information or even meet your class there to provide a tour and answer questions.

3. Make community connections. The best sources of knowledge about your specific area comes from those who live and work there. Reach out to local or regional groups including: conservation organizations; government land management agencies; watershed districts; soil and water conservation districts; the New Mexico Native Plant Society, land trusts; city, county, or national parks departments; colleges and university extension services. Contacts from these groups can provide a variety of assistance to your class, from recommending resources to helping to guide a native plant garden or restoration project. It is invaluable to have a go-to contact to answer questions and provide guidance as you teach about native plants.

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Content Reviewers

Karen Hall
Ecological Education Program Director
Institute for Applied Ecology

Christina Selby
Writer, Conservation Photographer, Naturalist

Bob Sivinski
Botanist

Clara Rabbani
Metcalf Intern, University of Chicago

About this curriculum

In 2016, the Institute for Applied Ecology published From Ponderosa to Prickly Pear- Exploring the Native Plants of New Mexico, the first comprehensive native plant curriculum for New Mexico. This Blue Hole Cienega curriculum follows the same principles and formatting. When Ponderosa to Prickly Pear is revised in the future, the Blue Hole Cienega will be featured as a new section, Section 8: Wetlands. The Quivira Coalition is working with stakeholders of the Santa Rosa Community and the New Mexico Environment Department Surface Water Quality Bureau Wetlands Program to guide wetland stewardship in Santa Rosa. As part of this effort, it became clear that educating Santa Rosa youth about the unique ecosystem surrounding them is one of the most important components for future stewardship of area wetlands. The curriculum developed by IAE in collaboration with Estela Thompson of the Santa Rosa school system will become part of the Wetland Action Plan funded by the NMED SWQB Wetlands Program.

About the Institute for Applied Ecology

Founded in 1999, the Institute for Applied Ecology (IAE) is a nonprofit organization with offices in Corvallis, Oregon and Santa Fe, New Mexico. Our mission is to conserve native species and habitats through restoration, research and education. Our vision is a world where all people and wildlands are healthy and interact positively, biological diversity flourishes, and environmental challenges are met with a social commitment to solving problems with scientific principles. Our ecological education programs provide place-based education and service learning opportunities for K-12 students, teachers, and students of all ages.

Institute for Applied Ecology
Southwest Office
1850 Old Pecos Trail, Suite I
Santa Fe, NM 87505

A very special thanks to funders of this curriculum:
Quivira Coalition & the New Mexico Environmental Department Wetland Program

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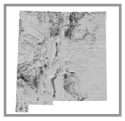


T Teacher Page

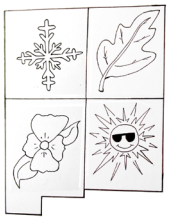
Just Add Water: The Wonderful World of Wetlands

"For many of us, water simply flows from a faucet, and we think little about it beyond the point of contact. We have lost a sense of respect for the wild river, the complex workings of a wetland, and for the intricate web of life that water supports." Sandra Postel

Time Estimate

40-60 minutes for classroom activity; 2-3 hours for Take it to the Cienega! field trip; 2-3 hours for a tour of the water treatment plant.

Best Season



Spring
Winter
Fall

Grade level
6-8

Overview

This unit sets the stage for future chapters in the curriculum by providing the ecological context and emphasizing the importance of wetlands and water for life. It highlights a rare type of wetland habitat that occurs in Santa Rosa, the cienega. It further illustrates water quality and cleanliness and all of the ways in which wetlands can be polluted or degraded. Students learn why wetlands are so critical and what functions they provide.

Preparation

- Acquire materials for model demonstration.
- Students can work in groups to build several models in the classroom, or you can assemble a single model for all students to view.

Learning Targets

1. Define/describe a wetland and a cienega
2. List 3 or more important functions of wetlands
3. Understand ways in which water quality can be affected

Teacher Hints

1 Up to 4 students in a group can play off of a game board printed on 8.5x11" paper. Alternatively, if one large game board is made (3x4 feet), 15 or more students can play off of just one game board. Consider laminating the board for reuse.

2 Select one student per group to be Rain Keeper. The Rain Keeper is responsible for the water bottle and mists the air (and other players that agree to this) every time somebody lands on the rain square on the game board. Ideally the students selected for this role would be more likely to respect the wishes of those declining a mist and would not be tempted to spray at times other than when playing the game.

3 Should you decide to do the field trip cienega activity, you will want to visit the site ahead of time to find a few places to sample water and order a water test kit in advance (many options available online for $25 or less).

4 The story map about Blue Hole Cienega can be browsed ahead of the lesson: https://storymaps.arcgis.com/stories/ab9b1d934dd94a3b8f4052a2f6059baa

S Student Project

Just Add Water: The Wonderful World of Wetlands

What will you learn?

- What is a wetland and a cienega
- Important wetland functions
- How water quality can be affected by humans and natural processes

"For many of us, water simply flows from a faucet, and we think little about it beyond the point of contact. We have lost a sense of respect for the wild river, the complex workings of a wetland, and for the intricate web of life that water supports." Sandra Postel

Overview

This unit kicks off the Blue Hole Cienega Curriculum by introducing you to the wonderful world of wetlands, the ecological stage on which all of the plants, people, and other players perform. You will meet the players in upcoming chapters. In this chapter you will learn about the importance and complexity of wetlands and will be introduced to a special type of wetland found in arid landscapes and in Santa Rosa, cienegas (pronounced: see-eh-nuh-guh). You will learn why wetlands are so critical and what functions they provide. Your activities will focus on water quality and cleanliness and all of the ways in which wetlands can be polluted or degraded.

Vocabulary

- *ecosystem*
- *biotic*
- *abiotic*
- *keystone*
- *ecosystem*
- *ecosystem*
- *services*
- *cienega*
- *habitat*
- *arid*
- *groundwater*
- *hydrology*

Materials Needed

- Wetland Board Game printed out (see board at the end of Unit 1)
- one die
- player pieces (one per student- they can be found objects)
- red, yellow, blue, and green food coloring (4 colors per group)
- clear plastic cups, large (one per student)
- water jug filled with water (enough for ~ 2 cups per student)
- large bin or sink for pouring out water
- spray bottle filled with water (one per group)
- ¼ cup measuring cups
- 1 tablespoon (one per group)
- soil (about one cup per group)

Background

Think about the surroundings in which you live. Is it lush with a lot of trees and shade? Is it more desert-like and dry with only a few plants, or is it dry but with some wet areas? If you live in or near Santa Rosa, New Mexico, you are probably familiar with the Blue Hole Cienega. Blue Hole, and its associated wetland, creates an island of lush habitat in the middle of a mostly dry region. As you will see in upcoming chapters, how much water is present and its quality affects not only the plant and animal life present but also how lands are managed.

A **wetland** is a distinct ecosystem defined by the presence of water in the soil or at the surface, either permanently (such as swamps), or seasonally (such as wet meadows that are saturated by winter or spring rains but dry up in the summer). The presence of water affects soil chemistry and texture. Both soil and water affect the types of plant and animal communities that can live there. The main factor that makes wetlands unique is that they have plants that are adapted to the **hydric** soils. Hydric soil is formed when water saturates, floods, or ponds the soil long enough that it becomes **anaerobic**, which means having low levels of oxygen.

Just Add Water: The Wonderful World of Wetlands

Background Continued

Wetlands are considered **keystone ecosystems** because, even when they are small, they are critical for the health and biodiversity of the larger landscape where they are located. Wetlands are especially important for ecosystem services, or benefits to humans provided by the natural environment. These ecosystem services include keeping water clean, preventing large-scale floods, and recharging groundwater resources. Wetlands clean water by removing pollutants through trapping sediment that then absorbs nutrients and chemicals (such as pesticides).. Wetlands also reduce the effects of flooding. As water from a stream or runoff enters a wetland, the water spreads out and flows through trees, root mats and other vegetation. The plants help to slow the water down which allows suspended material like soil particles carried by the water to settle on the surface of the wetland. Wetlands are like natural sponges, storing either flood waters that overflow riverbanks or surface water that collects in depressions. The combined benefits of storing and slowing down water reduces flooding and erosion.

Wetlands are also considered the most biologically diverse of all ecosystems, providing homes to a wide range of plant and animal life including amphibians, reptiles, birds and even mammals adapted to aquatic environments. In addition to serving as a food source, the dense vegetation found in most wetlands provides places for wildlife such as muskrat and beaver to build homes and to hide from predators. Upland wildlife like raccoons, coyotes, deer, elk and bears often visit wetlands to find food, water and shelter. Wetlands also provide important nesting habitat for migratory birds, such as sandhill cranes, ducks, herons, and cormorants. Migrating birds also rely on wetlands as rest stops on their long journeys.

A **cienega** is a unique wetland ecosystem characterized by a wet meadow with saturated soils in an otherwise **arid** land or desert environment. The water and soil are generally **alkaline** because of increased evaporation that takes place in shallow wetlands in dry environments. Alkalinity refers to its pH level being higher than seven on a scale of 0-14. When this happens, you can sometimes see a salty white crust on the soil.The plants that grow in these environments must be able to tolerate alkaline, salty soils.

Wetlands are rare in the Southwest, but cienegas are even more rare. Only a handful remain in Arizona, New Mexico, Texas, and Northern Mexico. Unfortunately, cienega habitats continue to become even more rare as a result of increasing development and extended droughts that stress plants, lower the water table, and prevent crucial recharging of surface springs. The Blue Hole Cienega Nature Preserve in Santa Rosa, New Mexico provides an opportunity to conserve a high quality wetland and the rare and unique plant and animal species that depend on this habitat, including Pecos sunflower, Wright's marsh thistle, and Great Plains lady's tresses orchids, roundnose minnow, and a recently discovered fairy shrimp. Not only is it one of the largest cienegas in the world, but as you will discover in future lessons, it receives a lot of positive attention from conservationists and the local community which further promotes its protection. While participating in the activitie s in this and future lessons, think about your role in conserving this special natural wonder and be proud that it exists in your own backyard!

S Student Project

Just Add Water: The Wonderful World of Wetlands

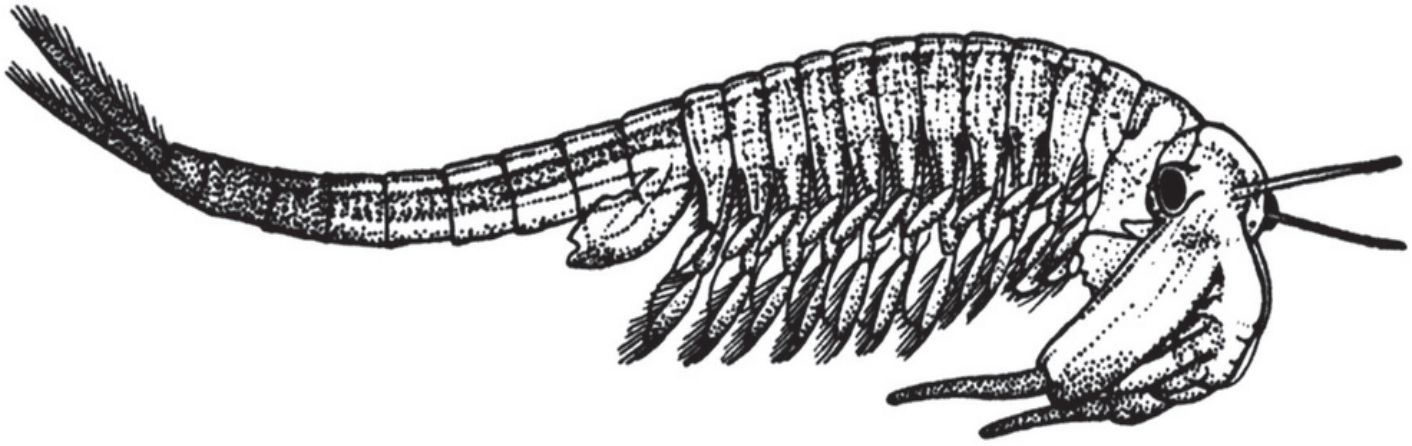
Student Directions

1. Get set up
   a. Lay out the Just Add Water game board
   b. Each student gets a clear plastic cup and fills it with ½ cup of water to start. This cup of water represents *your personal wetland*
   c. Gather dice, food coloring (brown, green, blue), water jug or bucket (filled), plastic bin, spray bottle (filled with water), dirt, measuring cups, tablespoon scoop
   d. Select your game piece

2. Your teacher or group will assign one person the job of Rain Keeper. The role of the Rain Keeper is to take care of the spray bottle and provide a mist (representing rain) each time anybody lands on the *rain square*. The rain keeper must first ask all players if anyone does not want to receive mist.

3. To play the game
   a. Players take turns rolling the dice and moving along the game board according to the number rolled
   b. When you land on a board square, read it for instructions about what will happen in your personal wetland (the plastic cup)
   Adding food coloring: Yellow or red drops usually occur if your water becomes polluted; blue drops usually occur if your water is purified; green drops signify an algal bloom or an imbalance in the wetland ecosystem.
   Adding water: Adding water is an opportunity to purify and refresh your wetland. Use the ¼ measuring cup to add water to your wetland.
   Removing water: Removing water signifies a drop in the water table. Use ¼ measuring cup to remove water into the disposal bin or on the ground if you are outside.
   Adding soil: Soil represents sedimentation resulting from erosion. Use the tablespoon to scoop dirt into your wetland if instructed to do so.
   Misting: Be prepared for a gentle misting representing rain when somebody lands on the rain square! It is OK to ask the rain keeper to mist your cup instead of you or to keep the mist away.
   c. At the end of the game, compare your wetland with others by holding the cup against a white piece of paper. Clean is clear or blue and dirty is brown or green. **The cleanest wetland with the most water wins!** If it is unclear, you can take a vote or agree to a tie.

Were most wetlands clean or contaminated? If your wetland got polluted at any time, did any purification squares remove the pollutant completely?



Student Project

Just Add Water: The Wonderful World of Wetlands

Take it to the Cienega!

Take a field trip to the cienega, and test water quality at several locations. For this activity, your teacher will bring a water quality test kit, and students will bring their field notebooks and take notes about their general impressions at each of the sites - observing water color, depth, disturbance, erosion etc. When you are out there, be sure to also observe any salty white crusting on the soil surface and discuss what this means. One test kit per class should be enough. The teacher will provide instruction and supervision while students take turns conducting the tests at each site. Class discusses any differences they observe from one location to the next and see if it makes sense based on the notes that they have taken. If your class is feeling really ambitious and wanting to explore water quality further, you could also tour the Santa Rosa Water Treatment Plant.

Reflection

How does it feel to live near such a unique and valuable natural feature - Blue Hole Cienega? Does this give you a sense of pride or awe? How do you think Santa Rosa would be different if the wetland was polluted or gone? How can you contribute to the protection of this resource?

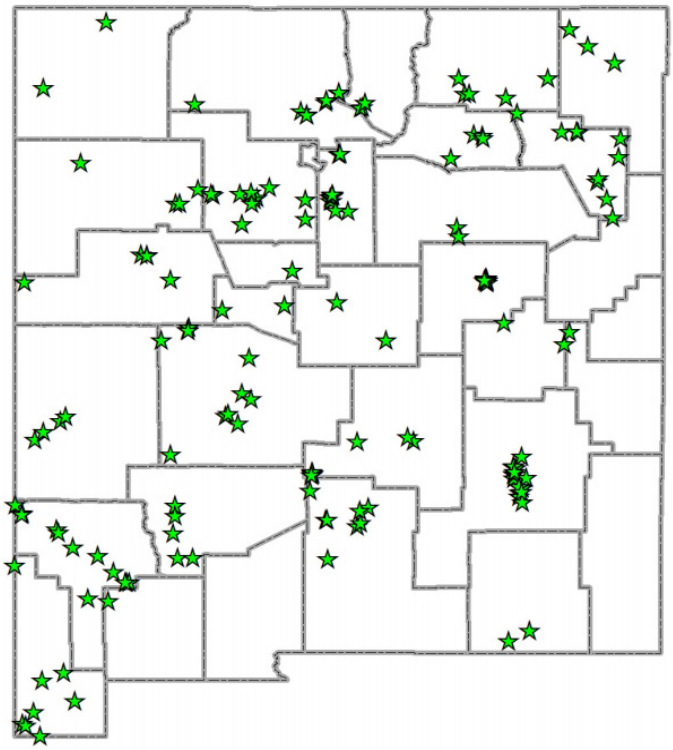


Figure 1. Distribution of arid-land spring ciénegas across New Mexico.

Resources

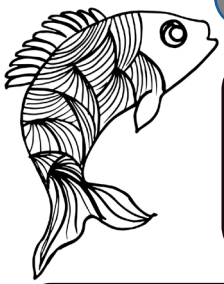
- Story map: https://storymaps.arcgis.com/stories/ab9b1d934dd94a3b8f4052a2f6059baa
- Blue Hole Cienega Nature Preserve, Santa Rosa, New Mexico; Groundwater Monitoring Project Final Report FY 2016-2017
- http://www.lockyphoto.com/wetlandskeystoneecosystem/

Student Project

Just Add Water: The Wonderful World of Wetlands

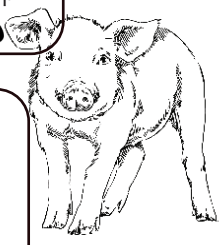
JUST ADD WATER BOARD GAME

START



Spring water is diverted from wetland to make a recreational fish pond. Remove ¼ cup water.

Santa Rosa initiates a water conservation measure and teenagers start taking shorter showers. Add ¼ cup water.



Overgrazing creates erosion and sedimentation. Add 1 TBS dirt.

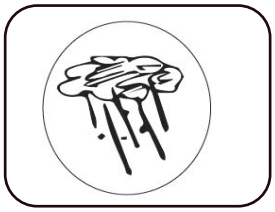
State Forestry removes water-hogging Russian Olive trees. Add ¼ cup water.

An invasive weevil eats all of the Pecos sunflower seeds and the loss of sunflowers hurts tourism and the economy. Lose 1 turn.

Oil drilling miles away contaminates groundwater feeding your wetland. Add 1 drop yellow + 1 drop red.

YCC crew builds one-rock dams improving hydrology and reducing erosion. Add your ¼ cup water.

Drift from aerial herbicide spray contaminates your wetland. Add 1 drop yellow.



A dam is removed upstream by River Stewards increasing water flow. Add ¼ cup water.

Factory uses the special alkaline water from your cienega for high tech cooling tanks. Remove ¼ cup water.

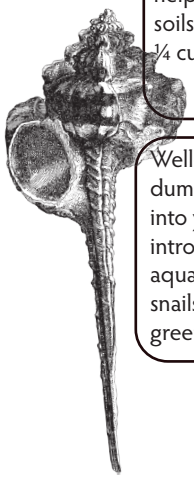
Monsoons deliver significant rain. Add ¼ cup water + 1 drop blue.

Neighbors drain standing water due to a mosquito outbreak. Remove ¼ cup water.

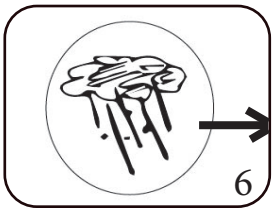
Wetland cleanup by city volunteers removes pet waste. Pet waste bags provided on site give an incentive for dog owners to clean up after their animals. Add ¼ cup fresh water.

Unseasonably hot weather and low precipitation result in algal bloom. Add 1 drop green.

Regenerative grazing helps improve health of soils and ecology. Add ¼ cup water.



Well-meaning fish owner dumps their aquarium into your wetland introducing invasive aquatic plants, fish, and snails. Add 1 drop green.

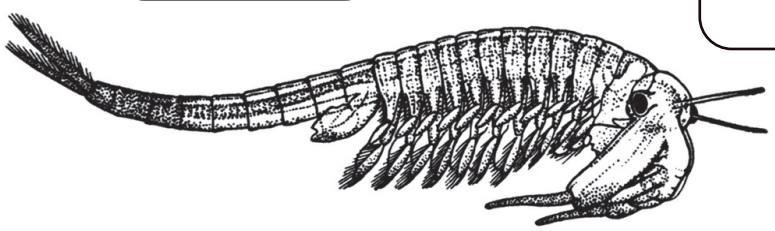


A new road is constructed changing the hydrology of your wetland. Remove ¼ cup water.

Your grandfather gives you his old tractor and you are able to remove fill dumped in your wetland by a previous landowner. Add ¼ cup water.

A parking lot is built on top of your wetland. Pour all water from your cup.

A local chef adds bullfrog legs to the menu, hunting this invasive species in your wetland. Add 1 drop blue.



A local school teacher puts on a Sunflower Festival raising awareness about the importance of the Santa Rosa cienega. Add ¼ cup water.

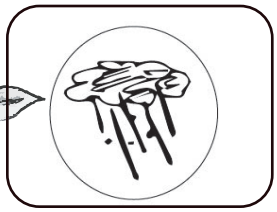
Mountain bikers hit the trails hard upstream causing erosion. Add 1 TBS dirt.

During a drought year, more water is used to keep gardens alive. Remove ¼ cup water.

A conservation organization does a large scale wetland restoration project in Santa Rosa. Add ¼ cup water.

Dog owners leave poop on wetland trails. Add 1 drop red.

A dike or dam restricting water flow is removed. Add ¼ cup water

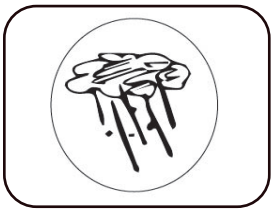


Local students monitor water quality and are able to detect early contamination. Add ¼ cup water.

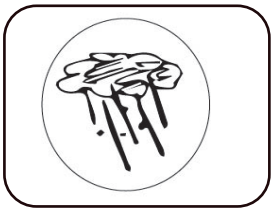
Heavy sudden rain causes erosion and fast moving water. Remove ¼ cup water.

A litter bug dumps garbage with constantly leaky oil cans, contaminating water in your wetland. Add 1 drop red.

Your cousin writes an award winning poem which inspires pride in Santa Rosa and wetland stewardship. Add ¼ cup water.



Biocontrol beetle lays waste to invasive salt cedar. Add ¼ cup water.



END

Nutria fur is suddenly valued and farmed in Santa Rosa, but invasive nutria escape into your wetland. Add 1 drop green.

Big rain event floods homes and the city installs dikes to protect homes. Remove ¼ cup water.

A Land Trust purchases several neighboring wetland properties to protect for many years to come. Add ¼ cup water.

Several local wetlands are included in a large vegetation management study, improving knowledge of best practices. Add ¼ cup water.

A local farmer attends an organic workshop and reduces pesticide use on his crops. Add ¼ cup fresh water.

A construction worker misreads a map and accidentally dumps fill in your wetland. Remove ¼ cup water.

T Teacher Page

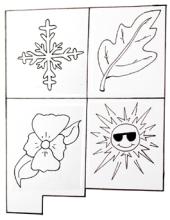
A Sinking Feeling:
Karst Limestone and the formation of Blue Hole

"The earth is a book in which we read not only its history, but the history of the living things it has borne." Isaac Asimov

Time Estimate

60 minutes; additional time is required for Take it to the Cienega!

Best Season



Spring
Winter
Fall

Grade level
6-8

Overview

This lesson uses a model demonstration to explore how geologic features on and below the earth's surface form the topography and resulting ecosystems we see today. Students will build a model of karst limestone terrain using sugar cubes and modeling clay to learn how the sinkholes and springs around Santa Rosa, NM were formed.

Preparation

- Acquire materials for model demonstration.
- Students can work in groups to build several models in the classroom, or you can assemble a single model for all students to view.

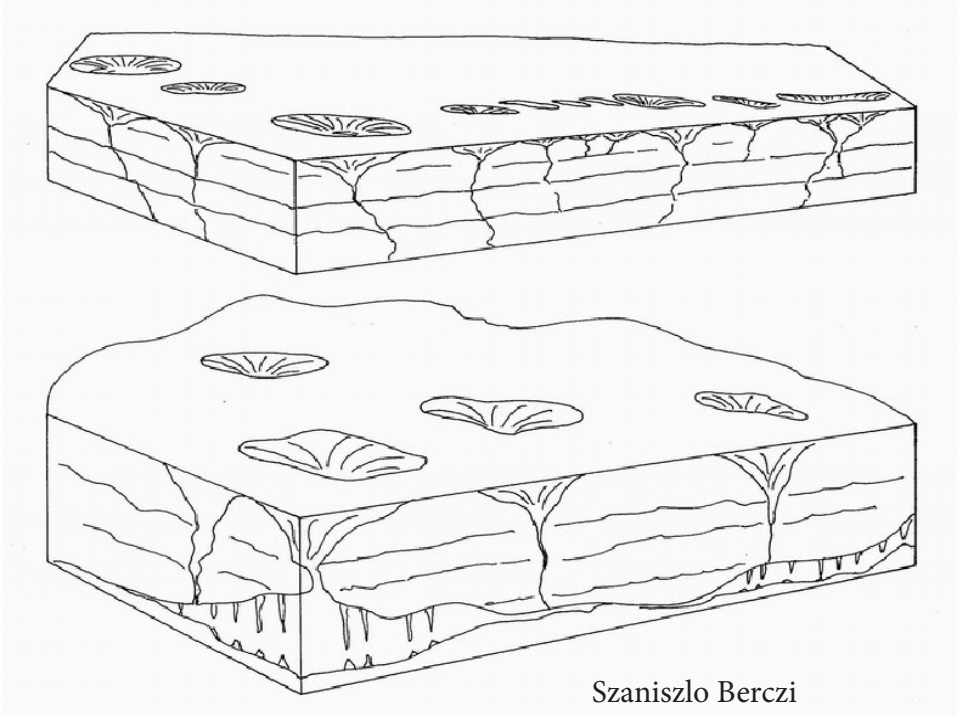
Learning Targets

1. List the properties of karst limestone and how they lead to the formation of sinkholes and caves.
2. Describe the process that formed the Blue Hole

Teacher Hints

1 Students can work in groups to build several models in the classroom, or you can assemble a single model for all students to view.

2 Discuss examples of sinkholes and lakes in the Santa Rosa area.



Szaniszlo Berczi
Eötvös Loránd University

S Student Project

A Sinking Feeling:
Karst Limestone and the formation of Blue Hole

"The earth is a book in which we read not only its history, but the history of the living things it has borne." Isaac Asimov

What will you learn?

- Increase understanding of geology and how it shapes the physical and biological world
- Visualize how the Blue Hole Cienega and other Santa Rosa wetlands were formed
- Understand the properties of karst limestone

Overview

You will explore how geologic features on and below the earth's surface form the topography and resulting ecosystems we see today. You will build a model of karst limestone terrain using sugar cubes and modeling clay to learn how the sinkholes and springs around Santa Rosa, NM were formed.

Vocabulary

- *geology*
- *topography*
- *limestone*
- *karst*
- *karst limestone*
- *sinkholes*

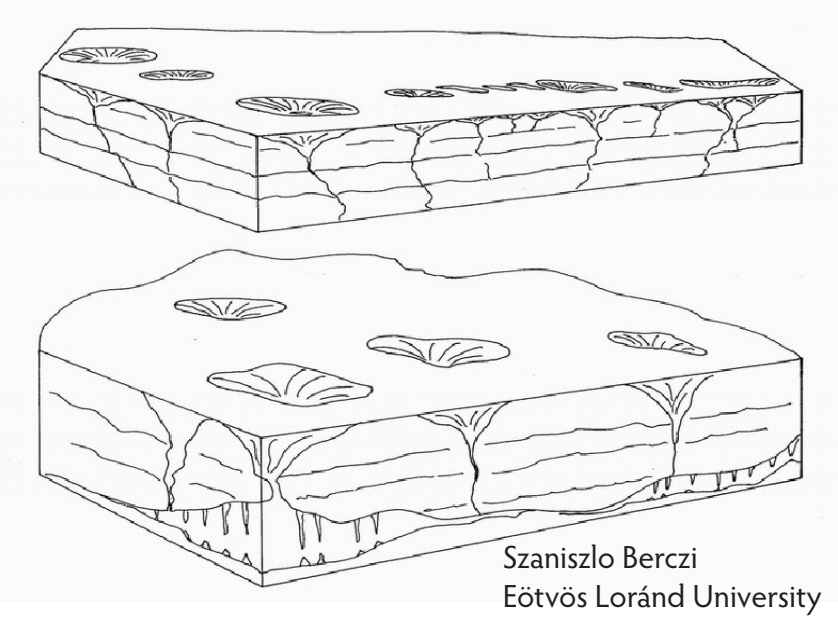
Materials Needed

- Box of sugar cubes
- Modeling clay (green or brown)
- Clear glass container with high sides
- Water
- Toothpick or pencil
- Rolling pin

Background

The landscape of Santa Rosa is defined by its **karst limestone** terrain. All of the lakes, wetlands, and underground features not visible to us are a result of this unique geology. Understanding geology and how the **topography** (physical shapes and features of the area) was formed gives us a better understanding of biology and why plants grow where they do.

Limestone is composed mainly of calcium carbonate left behind by organic matter from seashells and plants that once lived in ancient oceans that covered the region. **Karst** is a type of geologic feature made up of limestone that dissolves in water and forms sinkholes and caves. Blue Hole and the other lakes in Santa Rosa are sinkholes that filled with water after the karst dissolved and collapsed. Water continuously flows out of Blue Hole from deep underground caves and rises to the surface to feed the wetlands known as the Blue Hole Ciénega.



Szaniszlo Berczi
Eötvös Loránd University

S Student Project

A Sinking Feeling:
Karst Limestone and the formation of Blue Hole

Student Directions

Make a sinkhole!
In this activity, sugar cubes are used to represent karst limestone, covered with clay, representing the earth's surface. Holes are poked through the clay and water pours over the clay to show how water seeps into the ground.

1. Arrange the sugar cubes in the bottom of the glass container, loosely stacked 3-4 cubes high and 3-4 cubes deep to make a "hill".
2. Cover the outside of the cubes with modeling clay. The cubes should be completely covered except for one part at the bottom, which will be the cave mouth or spring. Decorate the outside with additional clay or other materials to represent grass, rocks, flowers, etc.
3. Use the toothpick or sharp pencil to poke 2-3 holes (the size of a pencil eraser) in the top of your clay hill –These will be the holes that allow water to seep into the hill.
4. Slowly pour water over the top of your formation. It should filter down through the holes and start to dissolve the sugar before flowing out of the opening at the bottom, creating a sinkhole and spring!

Take it to the Cienega!

Take a field trip to Blue Hole Ciénega after discussing karst limestone and see the sinkhole for yourselves!

Reflection

How do you think the formation of Blue Hole impacted the surroundings and the kinds of plants that grow in the area today?

Resources

- This lesson was adapted from Education Possible: https://educationpossible.com/geography-activities-make-sugar-karst-cave-sinkhole/#_a5y_p=4771528
- Caves and Karst in New Mexico: https://geoinfo.nmt.edu/publications/periodicals/earthmatters/3/n1/em_v3_n1.pdf
- National Geographic: Karst: https://www.nationalgeographic.org/encyclopedia/karst/

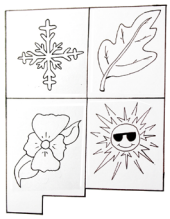
Teacher Page — Plants in their Places: Plant Adaptations in Deserts and Wetlands

"Look closely at nature. Every species is a masterpiece, exquisitely adapted to the particular environment in which it has survived." - E. O. Wilson

Time Estimate

60 minutes; additional time is required for Take it to the Cienega!

Best Season



Spring
Winter
Fall

Grade Level
6-8

Overview

This lesson explores how environmental conditions shape the physical traits of plants. Students will read, research, discuss, observe, and speculate about the traits of plants and how these traits may help a plant survive in different environments. They will look at live plants or specimens that have been previously collected from the field or schoolyard to make observations and relate plant traits to potential environmental adaptations.

Preparation

1. Locate suitable outdoor sites for plant observations or collect plant specimens by digging them up (root and all) and bringing them into the classroom.
2. Conduct the plant observations during class or assign them for outside of class time. Without giving students any additional background information, have them complete the plant adaptation observation worksheet. Copy only the activity directions for students to guide their observation session.

Learning Targets

1. Explain how plant traits relate to environmental adaptations
2. Make detailed observations and use them to make inferences

Assessments

- Explain how plant traits relate to environmental adaptations
- Make detailed observations and use them to make inferences

Teacher Hints

1. Introduce the plant observations with a class discussion: Ask students to brainstorm: What environmental conditions do plants face in deserts? What do they face in wetlands? What kind of traits might a plant need to survive in a desert? What about in a wetland?

2. Try to find a location with a variety of plants that have different adaptations or collect a variety of plant specimens for classroom observations. Print pictures of cacti or plants with unique adaptations that you may not be able to find.

S Student Project

Plants in their Places: Plant Adaptations in Deserts and Wetlands

"Look closely at nature. Every species is a masterpiece, exquisitely adapted to the particular environment in which it has survived." - E. O. Wilson

Materials Needed

- Copy of observation directions

What will you learn?

- Hone observation skills; record data and discuss findings
- Understand different types of plant traits and environmental adaptations
- Increase understanding of interactions between plants and their abiotic environments

Vocabulary

- *adaptation*
- *abiotic factors*
- *biotic factors*
- *taproot*
- *competition*
- *seed dispersal*
- *herbivory*
- *endangered species*

Overview

In this lesson, you will explore how plants are adapted to their environment. You will read, research, discuss, observe, and speculate about the physical traits of plants and how they help plants survive in different environments.

Background

Plants have evolved to thrive in a variety of environments across the globe. From snowy mountaintops to hot and dry deserts, plants can be found proliferating under extreme conditions. A plant's ability to survive and reproduce in any environment is related to its **adaptations**. **Adaptations** are special features that allow a plant to live in a particular place or environment. Because they can't get up and move around, plants must have **adaptations** to both the **abiotic** and **biotic factors** in their environment. **Abiotic factors** are the nonliving parts of the environment that can influence plant adaptations-- these include things like soil, temperature, and precipitation. **Biotic factors** are the living elements within a habitat or environment that influence plant adaptations, such as pollinators, herbivores, and surrounding plants that are competing for resources.

Plants in deserts have adaptations that allow them to acquire and conserve water. For example, some desert plants have **taproots**, long, straight roots that can access water stored in deep underground soil layers. Additionally, because plants lose water out of their leaves, many desert plants have small leaves with minimal surface area to prevent water loss. Some desert plants even have waxy layers or hairs on the outside of their leaves to help hold in water and/or shade the leaf surface from the hot sun. Many plant adaptations in deserts are driven by abiotic factors of heat and aridity (low rainfall or precipitation and high evaporation).

Plants in wetlands like the Blue Hole Cienega have very different adaptations from desert plants. Because they don't have to worry about water, they often have larger leaves that allow them to take in more sunlight to produce sugars and grow tall. However, when water is abundant, biotic factors such as **competition** from other plants for space and sunlight can shape adaptations in wetland plants. Karst environments may also drive plant adaptation because of the higher pH of the surrounding soil.

Student Project

Plants in their Places: Plant Adaptations in Deserts and Wetlands

Background Continued

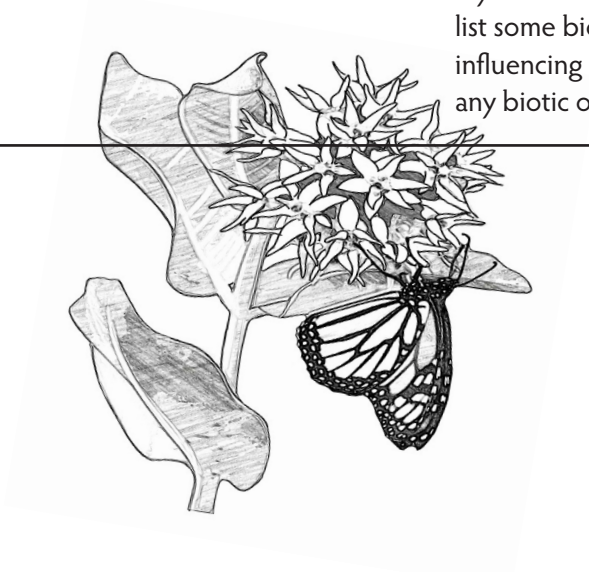
Plants also have general adaptations across environments that help them survive and reproduce. Flower colors and shapes are often adapted to attract specific pollinators. For example, flowers that are red and tubular typically attract hummingbirds. Large white flowers are often pollinated by moths that can easily see the white flower in the night. Plants can also have specific adaptations for **seed dispersal**, or methods that allow their seeds to be transported to new locations. Seed dispersal adaptations can include fluffy attachments that help a seed be carried in the wind, or spiky seed parts that help the seed stick to animal fur or even your socks! Other general adaptations include physical and chemical defenses like thorns or poisonous compounds that protect plants from **herbivory** (getting eaten by animals like mammals or insects). For example, the Wright's marsh thistle *(Cirsium wrightii)* that lives in Blue Hole Cienega has spiny attachments to it's flower head and leaves that help prevent things from eating it!

Some plants have adaptations that are restricted to very specific environments. For example, the Pecos sunflower *(Helianthus paradoxus)* found at the Blue Hole Cienega in Santa Rosa, New Mexico only grows in arid land cienegas with alkaline soils that are wet year-round. These special requirements, and the fact that cienegas are rare, mean that the Pecos sunflower is a rare and endangered species. **Endangered species** are species that are at risk of extinction because of a sudden rapid decrease in its population or a loss of its critical habitat. Endangered species, including the Pecos sunflower, are protected by federal laws to ensure they are able to survive and recover. You will learn more about endangered species conservation in Unit 4 of this curriculum.

Directions

Observering plant adaptations

1. Choose a plant or group of plants to observe for plant adaptations.
2. Make notes about the physical characteristics of the plant or plants you are looking at. Include details about their roots, height, leaf size, leaf texture, flower color, number of flowers, seeds, and anything else you notice about the plant. You can even draw pictures of what you see and label them.
3. For each characteristic you observe, write down how you think it could help the plant survive in its environment. If it is a desert plant, how does it acquire and conserve water? If it is a wetland plant, how does it compete for sunlight and space? What kind of pollinators does the flower attract? How do the seeds get dispersed into new locations?
4. If you are observing the plant in its natural habitat, list some biotic and abiotic factors that may be influencing the plant's adaptations. Did you observe any biotic or abiotic factors influencing the plant?

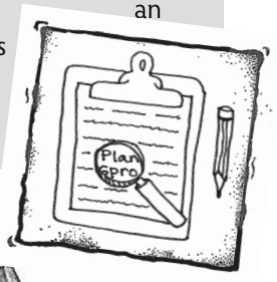


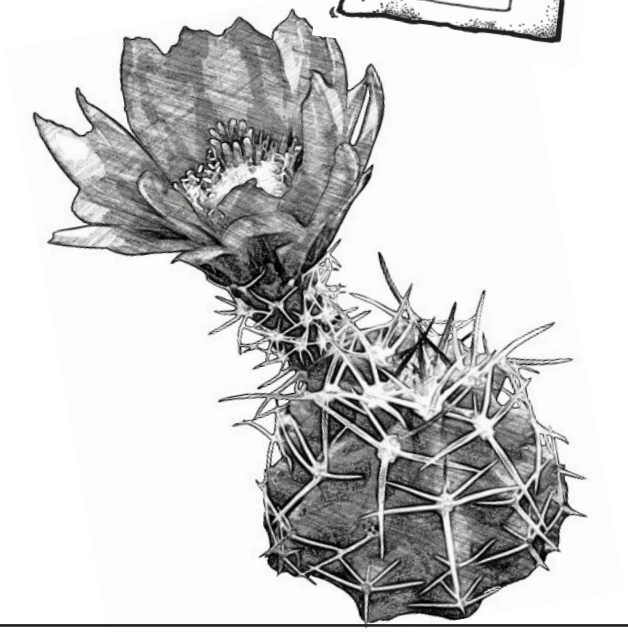
Student Project

Plants in their Places: Plant Adaptations in Deserts and Wetlands

Take it to the Cienega!

This lesson and activity can take place in the Blue Hole Cienega or outside at the schoolyard. If you go to the Cienega, do not dig up any plants since they could be an endangered species like the Pecos sunflower or Wright's marsh thistle.





Reflection

Humans can change both biotic and abiotic factors that plants are adapted to, causing plants to have to re-adapt or die off. What are some ways that plants react to human-caused changes in the environment? How can understanding plant adaptations help humans avoid negative impacts to plants and their environment?

Resources

- Appendix I - table of plant adaptations
- New Mexico Rare Plants: Helianthus paradoxus (Pecos sunflower): https://nmrareplants.unm.edu/node/95
- New Mexico Rare Plants: Cirsium wrightii (Wright's marsh thistle): https://nmrareplants.unm.edu/node/52
- Pollinator Syndromes: US Forest Service: https://www.fs.fed.us/wildflowers/pollinators/What_is_Pollination/syndromes.shtml
- How do desert plants adapt to their environment? https://sciencing.com/climate-landlocked-gets-little-precipitation-21799.html
- Wetland Adaptations: New York Botanical Garden: https://www.nybg.org/garden/wetland-trail/wetland-adaptations/

Observation Worksheet:

1. Describe and/or draw the following parts of your plant and how they might be an adaptation to the environment:

Roots (length, structure)-

Stem (height, structure, texture)-

Leaves (size, texture, hairs, number of leaves, etc.)-

Flowers (color, number, size)-

Seeds (number, size, structure)-

2. What are some abiotic factors this plant might be adapted to?

3. What are some biotic factors this plant might be adapted to?

4. How might this plant defend itself from being eaten?

5. Where do you think this plant grows? Why?

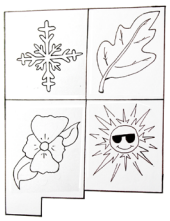
T Teacher Page

The Rare Ones: Conservation of Biodiversity

Time Estimate

60 minutes; additional time is required for Take it to the Cienega!

Best Season



Fall

Grade level 6-8

"We all have a responsibility to protect endangered species, both for their sake and for the sake of our own future generations." Loretta Lynch

Overview

This lesson explores the biology and characteristics of two endangered plant species. Students will create educational materials to share what they learn in order to support conservation of these species.

Learning Targets

1. Explain what endangered species are and why we should care about them
2. Name two endangered plant species that live at the Blue Hole Cienega
3. Share information about local endangered plant species with their peers and community

Preparation

- Watching the film Saving Beauty (link) will help provide context for the endangered species that grow in Santa Rosa
- Gather materials for students to make brochures and flyers (paper, pencils, markers, crayons, etc.) and, if you decide to do Activity 2, poster board(s) and a table for the booth.
- Print copies of the informational handouts for each species.
- Coordinate with Sunflower Festival event planners for your class and school to have a booth at the event.
- Coordinate with elementary school teachers to potentially create and carry out an educational activity with younger students.

Teacher Hints

1. Depending on classroom facilities, students can make their brochures or flyers using paper and colored pencils, crayons, and markers or using computer software.
2. Activity 1 could be assigned as homework or completed in class. This activity could be adapted to include designing a billboard, comic strip, or other materials related to the endangered species in Santa Rosa.
3. If students have access to computers and the internet in class, they can use both the handouts that accompany the lesson and independent internet research.
4. Students can host a booth at the annual Sunflower Festival (Activity 2) on behalf of their class and school. They can display their materials, such as brochures/flyers and educational products created from other lessons (such as the Karst limestone model from Unit 6).
5. In Activity 3, students will create an activity for younger students (K-2nd grade) to teach them about the endangered plants in Santa Rosa. For example, they could make paper plate sunflowers and/or thistles with a kindergarten class. This activity could also be included at the Sunflower Festival booth.

S Student Project

The Rare Ones: Conservation of Biodiversity

What will you learn?

- Increased awareness of the endangered species that live among us
- Ability to share information to educate others on the biology and importance of endangered species

"We all have a responsibility to protect endangered species, both for their sake and for the sake of our own future generations." Loretta Lynch

Overview

Did you know that there are endangered species in your community? The Pecos sunflower and Wright's marsh thistle only grow in a few places in the Southwest, including the Blue Hole Cienega. In this lesson, you will learn about these plants and how to protect them through educating your peers and community members.

Vocabulary

- *Threatened and endangered Species*
- *Threats*
- *Conservation*

Materials Needed

Activity 1

- Paper
- Writing/coloring utensils (colored pencils, markers, crayons)
- And/or access to computer software like Microsoft Powerpoint

Activity 2 (optional)

- Poster board
- Writing/coloring utensils (colored pencils, markers, crayons)
- And/or access to computer software like Microsoft Powerpoint

Activity 3 (optional)

- Paper plate sunflower and thistle materials listed in links under Resources

Background

Federal and state laws protect species that are designated as endangered or threatened. **Threatened and endangered species** are species that are at risk of extinction because of sudden rapid decreases in their population and/or a loss of their critical habitat. If the federal government calls a species **endangered**, it means that species is on the brink of extinction. If a species is listed as **threatened**, it is likely to be at the brink of extinction, but doing better than if it were called endangered. The main federal law that protects these species is the Endangered Species Act (ESA). The ESA provides strict rules for protecting species and guidelines to actively help them recover so they are no longer at risk of going extinct. Additionally, the State of New Mexico has a list of species that are designated as threatened or endangered. Two plants that live in the Blue Hole Cienega are listed as endangered by the State of New Mexico, and are either currently or proposed to be listed as threatened under the ESA.

Wright's marsh thistle (Cirsium wrightii) is found in only 8 places in New Mexico, including the Blue Hole Cienega, where it grows in wet soil near springs or streams. Its flower color ranges from white to pink. It is covered in spikey attachments on the leaves and flower heads. It is listed as endangered by the state, and proposed to be listed as threatened under the federal ESA.

Student Project

The Rare Ones: Conservation of Biodiversity

Background Continued

Pecos sunflower (Helianthus paradoxus) may look like other common sunflowers that you may notice growing along roadsides throughout New Mexico, but it has narrower leaves, fewer hairs, and smaller flower heads. It lives in arid land wetlands, also called cienegas, where the soil is always wet and has a high pH (alkaline). It can be found in both New Mexico and Texas. It is listed as endangered by the state and threatened under the federal ESA.

You can learn more about both of these species from the handouts your teacher gave you.

Threats to endangered species are stressful conditions or disturbing events that can reduce the health of individual plants or populations. Threats can include natural factors like insect predation or fires, as well as human-caused disturbances like building roads or using too much water. Both of the endangered plant species in Santa Rosa are threatened by climate change which, on average, is causing warmer temperatures and drier weather (less snow and rain). A warmer and drier climate means there is less water available to support not only human needs, but also the wetland habitats where these plants grow. Humans directly impact water availability in wetlands by using water for agriculture and supplying growing cities and towns.

Invasive species can also negatively impact these endangered plants. For example, in the Blue Hole Cienega, Russian olive (Elaeagnus angustifolia) and tamarisk (Tamarix spp.) are growing in the cienega and competing with the Pecos sunflower and Wright's marsh thistle for water, nutrients, and space.

Conservation is the protection of things found in nature. Endangered species conservation includes researching the species to understand what they need to survive, protecting their habitats, and monitoring populations to make sure they are healthy and not decreasing.

Botanists, land managers, and the people of Santa Rosa are working to conserve the Pecos sunflower and Wright's marsh thistle by removing invasive species, protecting the Cienega from threats, and educating the community. One of the most important parts of endangered species conservation is educating people about the species and what threatens them. In 2021, the community of Santa Rosa hosted the first annual Santa Rosa Sunflower Festival to celebrate the wetlands and the endangered Pecos sunflower. As you learn about endangered species, especially the ones that live in your surroundings, you can share what you learn with your family, friends, and community. When people learn about the beautiful living things that share their community, they can feel empowered to protect these species and their habitats!

S Student Project

The Rare Ones: Conservation of Biodiversity

Student Directions

Activity 1: Make an educational brochure or flyer about Pecos sunflower or Wright's marsh thistle

1. Using information from the handouts for each species, make an informational item like a poster, brochure, or flyer to teach people about one of the endangered plant species in Santa Rosa.
2. Be sure to include pictures of what the plant looks like and where it grows.
3. Include the following information in your own words and using visuals:
   a. Describe the plant (height, flower color, leaf shape, etc.)
   b. Where does it grow?
   c. What are its threats?
   d. How can people help protect it?

Activity 2: Design a booth for the sunflower festival while representing your school.

1. Using information from the handouts for each species, create a poster for your booth

Activity 3: Design a lesson to teach kindergartners through second graders about the sunflower and thistle. Since one of the most important parts of learning is sharing what you learn with others, this is a special opportunity to do so.

Take it to the Cienega!

Go to the wetlands when both species are in bloom and learn to identify them in their natural habitat!

Reflection

Should we protect endangered species? What do you think you can do to help protect the endangered species that live in your area?

Resources

- Movie- Saving Beauty: https://www.savingbeautyfilm.com/
- Daniela Roth Introducing Blue Hole Cienega: https://vimeo.com/user104669649
- New Mexico Rare Plants: Helianthus paradoxus (Pecos sunflower): https://nmrareplants.unm.edu/node/95
- New Mexico Rare Plants: Cirsium wrightii (Wright's marsh thistle): https://nmrareplants.unm.edu/node/52
- Paper plate sunflower craft: https://www.theresourcefulmama.com/paper-plate-sunflower-craft/
- Paper plate thistle craft: https://www.activityvillage.co.uk/paper-plate-thistle

Pecos Sunflower *(Helianthus paradoxus)*

Description:

Height: 1-2m tall (3-6 feet)

Flowers: August-October; a composite head of brown tubular disk flowers in the center and yellow petal-like ray flowers

Leaves: Wider at the base and narrowing at the tip (lanceolate) with rough, sandpaper-like texture and 3 prominent veins.

Habitat

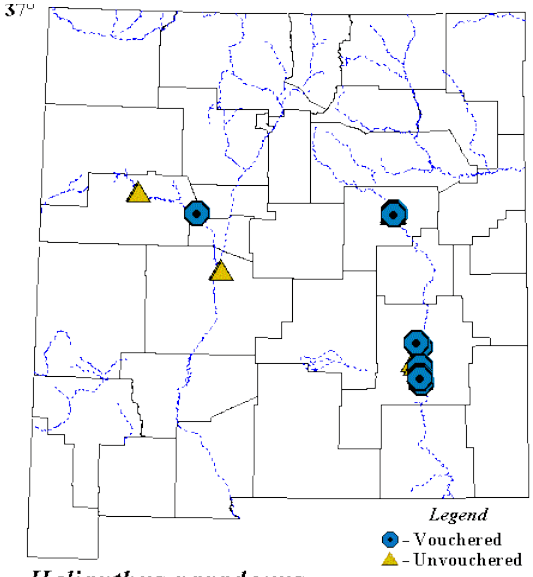
Pecos sunflower grows in wet soils of desert wetlands and is found only in a few locations in New Mexico and Texas (see .

Threats

Decreased water availability, invasive species, disturbance of fragile wetland habitats, and climate change all threaten this species.

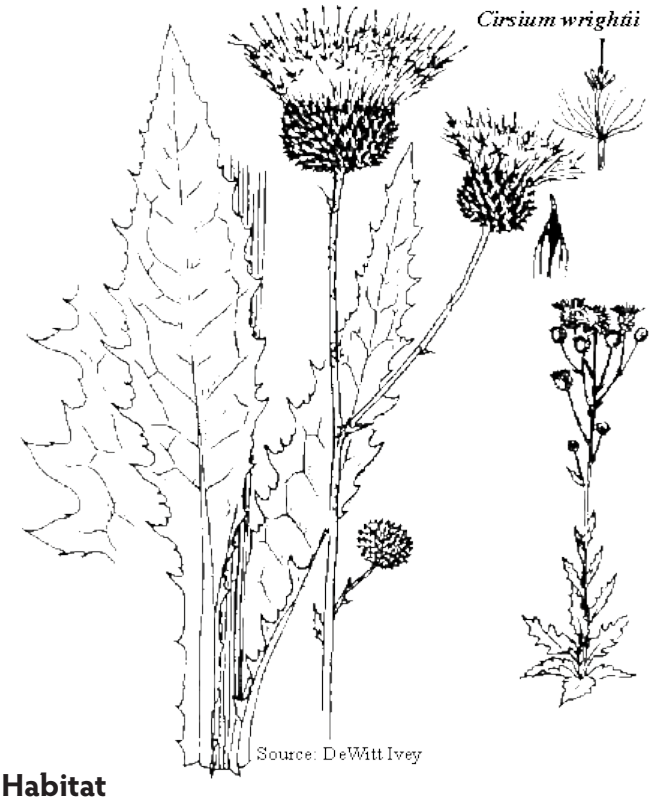
Conservation

Avoid damaging wetlands, reduce water usage, work with researchers to study its biology and population health. Collect, store, and grow seeds for long term conservation.



Left: a photo of Pecos sunflower growing in a desert wetland habitat. Right: a map showing the distribution of Pecos sunflower in New Mexico from https://nmrareplants.unm.edu/node/95

Wright's Marsh Thistle *(Cirsium wrightii)*



Description:

Height: 1-2.5 m tall (3-8 feet)

Flowers: August-October; a composite head of white to pink disk flowers held in a receptacle with spiny attachments.

Leaves: basal rosette of thick leaves with short black spines and stem leaves similar and get smaller in size towards the top of the stem.

Habitat

Wright's marsh thistle grows in wet soils near springs, seeps and streams. It is known from only in a few locations in New Mexico, Texas, and Mexico (see map of New Mexico distribution below).

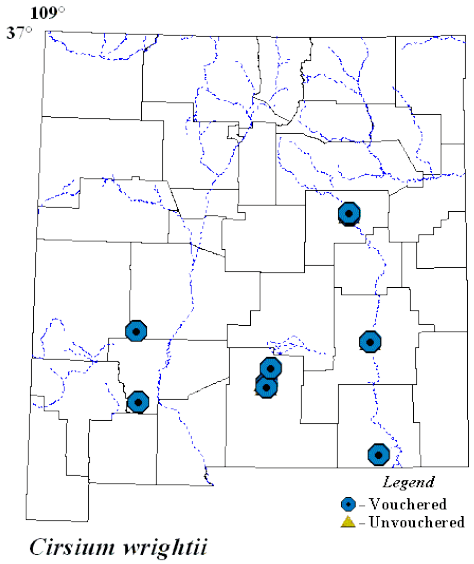
Threats

Decreased water availability, invasive species, disturbance of fragile wetland habitats, and climate change all threaten this species. Insects called weevils also eat the flowers and seeds and can negatively impact the Wright's marsh thistle.

Conservation

Avoid damaging wetlands, reduce water usage, work with researchers to study its biology and population health. Collect, store, and grow seeds for long term conservation.

Photo: Robert Szynski 2011



Left: a photo of Wright's marsh thistle growing in a desert wetland habitat. Right: a map showing the distribution of Wright's marsh thistle in New Mexico from https://nmrareplants.unm.edu/node/52

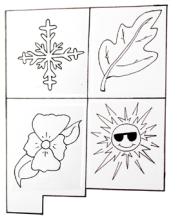
T Teacher Page

Data Talks: Measuring Plant Populations

Time Estimate

30-45 minute introduction, 60-90 minute field session; an additional session or two would be needed for Take it to the Cienega!

Best Season



Spring
Summer

Grade level
6-8

"An experiment is a question which science poses to Nature, and a measurement is the recording of Nature's answer." - Max Planck

Overview

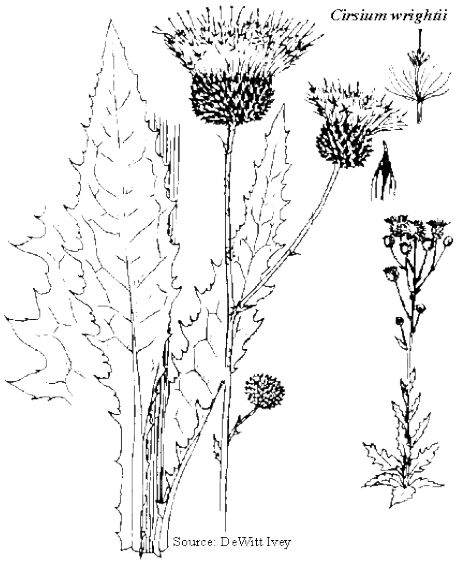
It is important for scientists and land managers to measure various characteristics of plant communities. These measurements allow us to evaluate ecosystem health and document changes occurring over time or in response to management actions. It is not practical or possible to count each plant out there, so we use different methods of sampling portions of a larger population or plant community to collect information

Learning Targets

1. Students will understand why monitoring is important and be able to describe two methods of sampling plant populations
2. Students will be able to discuss the pros and cons of taking a census versus a sampling method

Preparation

- Identify a study area; it could be the school yard, adjacent to the school property or if you have time, at the Blue Hole Cienega.
- Locate an ideal place to run the transect and get familiar with a number of plants in your study area.
- Pick one focus plant species for each group. Focal plant species should be common enough to be encountered in most of the plots.
- Prepare 10 hula hoops for estimating percent cover by using string to divide the hula hoops into 4 sections (25% cover)
- Label the hula hoops with tape or flagging for each plot 1-10, indicating where it is located along the transect (ie. Plot 1 @ 3 meters, Plot 2 @ 6 meters)



Teacher Hints

1. If you can not purchase a 30 meter tape, the 10 hula hoop plots could be placed randomly in your study area or you can measure a 30m rope and mark every 3m with flagging tape.

2. This lesson can be adjusted to make it more challenging or less challenging. For instance, each group could study a common plant species as well as a less common plant. To simplify, students could have fun throwing hula hoops to random plot locations.

S Student Project

Data Talks: Measuring Plant Populations

"An experiment is a question which science poses to Nature, and a measurement is the recording of Nature's answer." - Max Planck

What will you learn?

- Why and how plant populations are monitored
- Strengths and weaknesses of using different methods of sampling vegetation
- Data analysis skills

Overview

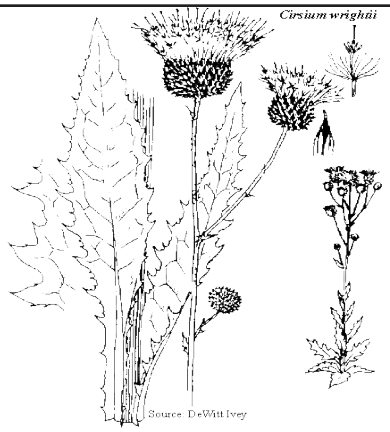
It is important for scientists and land managers to measure what is happening in a plant community to evaluate ecosystem health and document changes occurring over time, or in response to management actions. It is not practical or possible to count each plant out there, so they use different methods of sampling portions of a larger population or plant community to collect information that is representative of the whole. This lesson will introduce you to several methods of sampling populations and the different types of data that can be collected.

Vocabulary

- *monitoring*
- *census*
- *cover*
- *transect*
- *plot*

Materials Needed

- 30 meter measuring tape
- hula hoops
- tape or flagging
- sturdy string
- clipboards/data sheets/pencils
- 2 oversized nails
- field guides
- graph paper



Background

Ecosystem managers and scientists sample plant populations for many reasons, including **monitoring** or "keeping tabs" on a population of rare plants, comparing the results of habitat treatments in an experiment, or determining the impact of an activity or event (e.g., building a new road, wildfire, or grazing) on a plant population. There are many aspects of the plant populations to consider, such as plant height or number of leaves or how many individuals are present.

Some common types of data collection to meet different objectives are listed below.

Presence/absence: Is the species of interest present or not? This is the fastest and easiest type of data to collect. However, it only lets the researcher know if the species is present or absent.

Population estimates: This method estimates the size of the population without actually counting every plant. During sampling, a representative portion of the population is counted and then this data is extrapolated to estimate the size of the entire population. For this method to be legitimate, the part of the population that is counted (the sample) must be selected carefully, in an unbiased manner and must also be representative of the rest of the population as a whole.

Student Project

Data Talks: Measuring Plant Populations

Background Continued

Percent cover: This is a measure of the amount of the ground covered by the plant from a bird's eye view. This is a very useful measure for comparing the abundance of different species. One drawback of measuring cover is that it can vary drastically for an individual plant over the course of the growing season and can be difficult to measure accurately because it is based on visual estimation. This measure is commonly used to study plant communities, showing which species is most abundant and indicating which plants are using resources.

Census (complete population counts): To complete a census, first decide on the area within which all plants will be counted. No statistical analysis is required and therefore any changes in counts from year to year are real. However, this method can be extremely time consuming, costly and, and often impossible. This is the preferred method when possible.

Sampling Layouts: There are different sampling methods and layouts that researchers use to collect data. Here are some examples of common layouts for sampling:

- **Transects** can be long, narrow strips or wide belts that traverse the landscape. The area within the boundary of the transect is sampled and transects are placed randomly or in intervals across the area to be sampled. Target species within the transect can be counted or percent cover of any or all species present can be assessed.

- **Plots** are square, round, or rectangular areas within the sampled area in which data is collected. The size of plots can vary with sampling method, though one meter square plots are common.

- **Photo points:** A picture is worth a thousand words! With this method, the photographer takes photos in the four directions (north, east, south and west) from a set of permanently marked points within the area of study. The photo points should give a good visual assessment of the entire area. Photo points can then be revisited over time, the photos re-taken, and compared to the initial (baseline) photos to evaluate change over time.

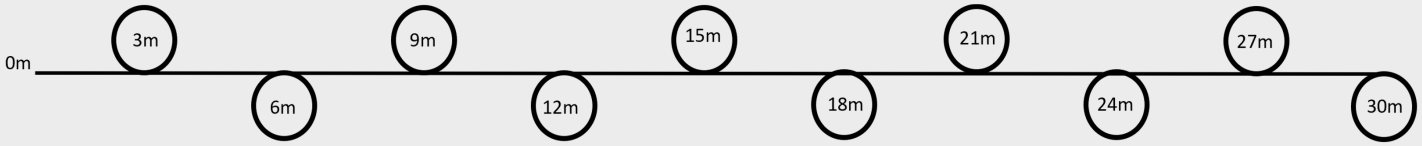
Once you have collected your data, the next step is data analysis. Until you do this you just have a bunch of numbers on a piece of paper. Data analysis involves quantitatively summarizing your data to paint a picture of what is happening with the plant community you measured. For example, you may want to know the average cover or average number of individuals across the area you measured. If you repeat these measurements year after year, you can monitor how a population is growing or shrinking over time.

S Student Project

Data Talks: Measuring Plant Populations

Student Directions

1. Divide students into groups of 3-4.
2. Your teacher will tell you what plant you will be measuring. This is your group's "focal plant species". Make sure you can recognize younger and older or flowering and non-flowering individuals. This monitoring exercise will answer the question of how common your chosen plant species is within your survey site.
3. Set up a 30 meter long transect in your study area. Typically plant ecologists randomly locate transects or plots, but for this activity, your teacher will help you set up the transect to make sure you intersect plants you are studying.
4. Once your transect is established, place the hula hoops every 3 meters, alternating sides, starting at the 5 meter mark along the transect line.
5. At each sample point (3 m, 6 m, etc.) place the apex of the hula hoop ring.
6. Record three types of data for the focal plant species on the handout. :
   a. Presence/absence- Is the species present in the plot (yes or no)?
   b. Percent cover- visually estimate how much of the plot the species is taking up (% out of 100% cover).
   c. Count the number of individuals
7. Data analysis- Calculate the frequency (% of plots in which your species is found) at which each species was present in your sample of ten plots. Calculate the average percent cover for each species. Average your count data for each species. Do the same techniques yield similar or different results?
8. Discuss your results as a class. Which type of data most accurately represents the population of plants you are studying? Compare the efficiency of data collection (how long it took) against the usefulness of the information you collected. Which methods were best for the plants you studied? How could you change your methods to collect more accurate data? How might you change the data you collect if you had a different research question?



Take it to the Cienega!

Activity could be done at the Blue Hole Cienega. Students should be mindful of trampling vegetation.

Resources

- Measuring and Monitoring Plant Populations- http://msuinvasiveplants.org/documents/archives_cism/BLM_Measuring_and_monitoring.pdf

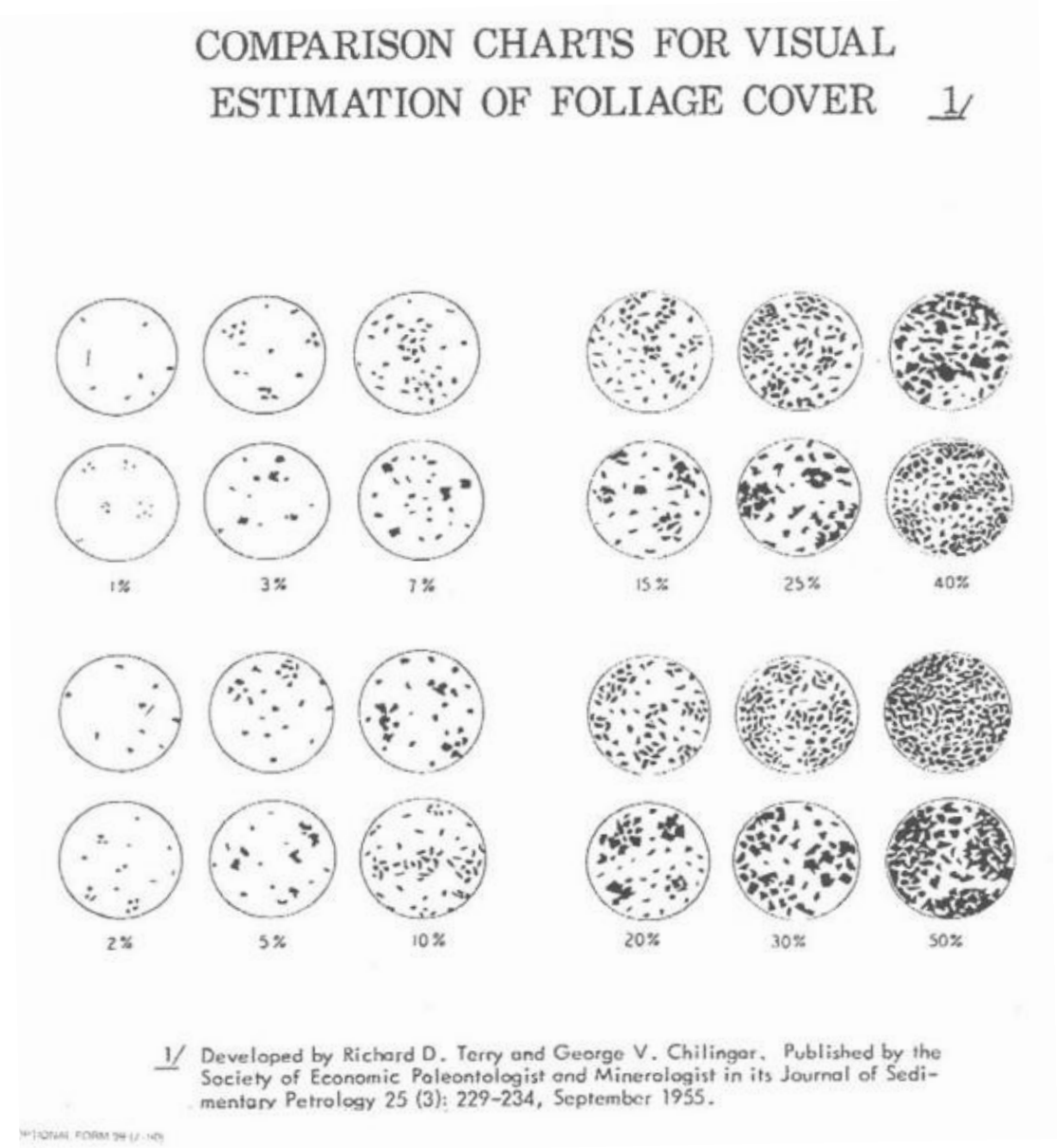
Reflection

What did you learn about measuring plant populations? Why do you think there are so many different methods used? Does the sampling method influence your interpretation of the data? Will you have greater confidence in some methods of data collection than others?

Tips for Estimating Percent Cover

Estimating percent cover takes practice. Here are a few tips to get you started:

- Work with your team to calibrate your estimations. Have everybody come up with an estimate in their minds. Then share your estimates and compare how different they are across the team. If needed, explain why each of you estimated what you did and reach a consensus on what makes the most sense.
- Narrow down your range. Start by asking yourself, "Is it more than half or less than half? If it's less than half, is it more than a quarter or less than a quarter?"
- Visualize moving everything to one side so that it is all clumped together to help estimate how much space it is taking up.
- The back of a closed fist is about 1% of a 1x1 meter plot.
- Use the chart below to help estimate:



Datasheet

Record data from each hula hoop plot in the table below.

Focal plant species description and/or name *(ex. small hairy plant with yellow daisy flowers):*

Plot #	Plot Info	Present (Y/N)	Cover %	Count
1	3m			
2	6m			
3	9m			
4	12m			
5	15m			
6	18m			
7	21m			
8	24m			
9	27m			
10	30m			

Data Analysis

1. Calculate the frequency your focal plant species was detected:

   a. Number of plots the focal plant was present in _____

   b. Multiply the number of plots the focal plant was present in by 10 = ____%

2. Calculate average cover:

   a. Sum of 'Cover %' column = _____

   b. Sum of Cover % column divided by 10 =_____

3. Calculate average count:

   a. Sum of 'Count' column =_____

   b. Sum of 'Count' column divided by 10 = _____

T Teacher Page

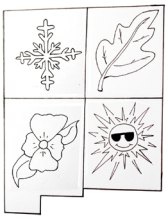
Let's Restore! Ecological Restoration

"You cannot get through a single day without having an impact on the world around you. What you do makes a difference, and you have to decide what kind of difference you want to make."– Jane Goodall

Time Estimate

60 minutes; additional time is required for Take it to the Cienega!

Best Season



Spring
Fall

Grade level
6-8

Overview

In this lesson, students will learn about concepts of restoration and ecology and apply what they learn to assess the schoolyard, create a plan for a restoration project, and potentially carry out a mini-restoration demonstration project. Students will make observations, identify problems, and visualize solutions to restore the schoolyard or Blue Hole Cienega. They may also conduct a real restoration project in a small area of the schoolyard where they can put their ideas into action by sowing native seeds or planting potted plants.

Learning Targets

1. Explain restoration and why it is necessary.
2. Observe damaged areas that are in need of restoration.
3. Create a restoration vision with clear goals (e.g. more wildflowers, less bare ground).

Preparation

- Print copies of handouts and schoolyard maps.
- Obtain permission to plant seeds or container plants for a mini-restoration project in the schoolyard.
- Acquire seeds and/or container plants. See resources for vendor ideas.

Teacher Hints

1 Have students share their before and after map drawings in small groups or with the whole class to prompt discussion

2 Make a list with photos of what plant species they may run into in the schoolyard that they can use in their restoration assessment; you can use various free plant identification apps to help create the list.

S Student Project

Let's Restore! Ecological Restoration

What will you learn?

- Learn about ecological restoration
- Assess areas at your school or at the Cienega that are in need of restoration and plan what you would like to improve

"You cannot get through a single day without having an impact on the world around you. What you do makes a difference, and you have to decide what kind of difference you want to make."– Jane Goodall

Overview

We, as humans, are capable of causing significant damage to the ecosystems we rely on for our health, enjoyment, and economic resources. The practice of ecological restoration is an opportunity to restore or fix some of the damage we cause and improve our environment for both ourselves and the plants and animals in our communities. In this lesson, you will learn about restoration, identify areas that could be restored, and make a restoration plan.

Vocabulary

- *ecological*
- *restoration*
- *biodiversity*
- *invasive*
- *species*
- *prescribed fire*
- *erosion*

Materials Needed

- markers (Activity 1)
- print out of school map (Activity 1)
- seeds (Activity 2)
- plants (Activity 2)
- shovel (Activity 2)
- rakes (Activity 2)

Background

Humans rely on healthy and functioning ecosystems for clean water, clean air, pollination of food crops, and for recreational and spiritual enjoyment. When an ecosystem becomes damaged, by natural events like fire or human activities like building roads, people can take action and help recover what was lost or changed. **Ecological restoration** is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. For example, after a wildfire burns in the forest, land managers may practice ecological restoration by planting trees and seeds of native wildflowers and grasses. By planting seeds, land managers are working to restore **biodiversity** (the variety of different species living in a particular habitat or ecosystem) and stabilize the ground after plants that were there before have been destroyed by fire.

Restoration can have many different goals including:

- increase biodiversity
- improve flower resources for pollinators
- reduce invasive species
- recover rare or endangered species
- prevent loss of soil from wind and water erosion
- improve water quality

Student Project

Let's Restore! Ecological Restoration

Background Continued

In Blue Hole Cienega, invasive species such as Russian olive *(Elaeagnus angustifolia)* and tamarisk *(Tamarisk sp.)* are growing in the wetlands and competing with **native species**. **Invasive species** are species that are introduced from other parts of the world and are causing ecological or economic harm in their new environment. Invasive species are one of the biggest threats to biodiversity and conservation of native species.

In Santa Rosa, **prescribed fire** is used in the Cienega to help control invasive species. Prescribed fire is planned and controlled use of fire for ecosystem management. Land managers in Santa Rosa use prescribed fire in the Cienega in order to reduce the amount of Russian olive and tamarisk. The fire does not hurt native plants, which are able to resprout or reseed during the next growing season. Other methods for controlling invasive species include digging them up, targeted use of chemicals called herbicides, and introducing the species' natural predators.

Areas with large amounts of bare ground where plants are unable to grow on their own are often a focus of restoration efforts. Bare ground can be caused from wildfires that kill vegetation, livestock eating or trampling plants, off-road vehicles driving over plants and compacting the soil, and abandoned agricultural fields where soil health has been reduced and plants can no longer grow. When there are large areas of bare ground, there are no plants to act as a sponge to keep water from quickly running off and causing **erosion**. Erosion happens when particles of soil are carried off by water or wind, eventually, leading to deep channels or loss of plant-supporting soil. All of these different disturbances may require different methods to re-establish plants and prevent erosion. Sometimes, large machinery is required to make depressions in the soil where water can sink in. Other times, simple structures made of rocks can help capture water that would otherwise run off. Planting native plants can also help, since their roots and above ground growth can help retain water on the land.

Student Project

Let's Restore! Ecological Restoration

Student Directions: School Yard Restoration

Activity 1: Restoration Plan - What would a restored schoolyard look like?

1. Use the Restoration Planning handout to assess what could be done to restore the schoolyard into a healthy ecosystem.
2. Use the first map to draw where there are areas that are in need of restoration. These can be areas with weedy plants, bare ground, or erosion issues.
3. Use the second map to draw what you would want the area to look like after restoration (i.e. would there be more wildflowers, water features, wildlife, butterflies?). You can be creative and aim for the stars with your ideas!

Activity 2: Planting

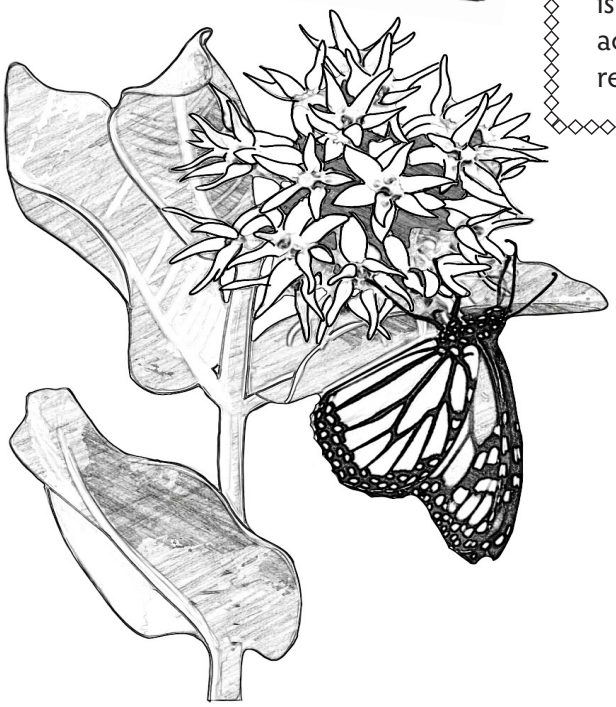
1. Pick a planting location. Reflecting on your restoration design, is there a place on the school grounds where you can plant seeds or container plants from a native plant nursery? Things to consider:
   a. Does the planting location you selected have access to water?
   b. Start small so that you are able to take care of this area.
   c. Avoid areas that might disturb existing native plants.
2. Pick your plant species for restoring a section of the school yard. Using your restoration plan, decide which species you want to plant in this location. You can gather the seeds from plants at the school yard or even at the wetland if you get permission.
3. Decide when is the best time to plant. During the school year, spring temperatures may be more mild and give plants more time to establish than fall plantings. You can sow seeds in the fall that can wait to germinate until spring, but potted plants may not survive the winter.
4. Prepare the ground. If the area you picked for planting has some weeds, pull them out before you plant. If the ground is hard, roughing up the ground with hoes and rakes will make it easier for the roots to grow and seeds to germinate.
5. Plant! If sowing seeds, sprinkle them over the surface of the soil and cover them very lightly with soil. If planting, dig holes a little deeper than the pot and at least an inch wider than the pot. Be careful not to squish the roots.
6. Water. If you are planting container plants from a native plant nursery, water them right after they are planted. Check on the plants every week for 6 weeks, and water them as needed. After 4 weeks, students can take turns checking plants once per month and watering as needed until they are established.
7. Protect. Put up a sign or pin flags around your planting area so nobody accidentally tramples your plants.

Student Project

Let's Restore! Ecological Restoration

Take it to the Cienega!

Activity 1 can be completed in the Cienega using a similar aerial image of the area where the class will be visiting.



Reflection

Why do you think restoration is important for wildlife? Why do you think restoration is important for the economy? Why do you think restoration is important for human health? What actions can we take to prevent the need for restoration up front?

Resources

- Society for Ecological Restoration: https://www.ser.org/
- Native Seed Source: https://plantsofthesouthwest.com/
- Erosion control field guide: http://www.watershedartisans.com/wp-content/uploads/2016/03/Erosion-Control-Field-Guide.pdf

Activity 1: Restoration Planting

Answer the following questions to help assess the schoolyard and plan a restoration project.

What kinds of plants do you see? Make a list, or describe the different types of plants present in the area.

Is there high biodiversity (i.e. a variety of different kinds of plants)? Could there be more?

Are there any invasive species or weeds? Make a list or describe plants that may be invasive.

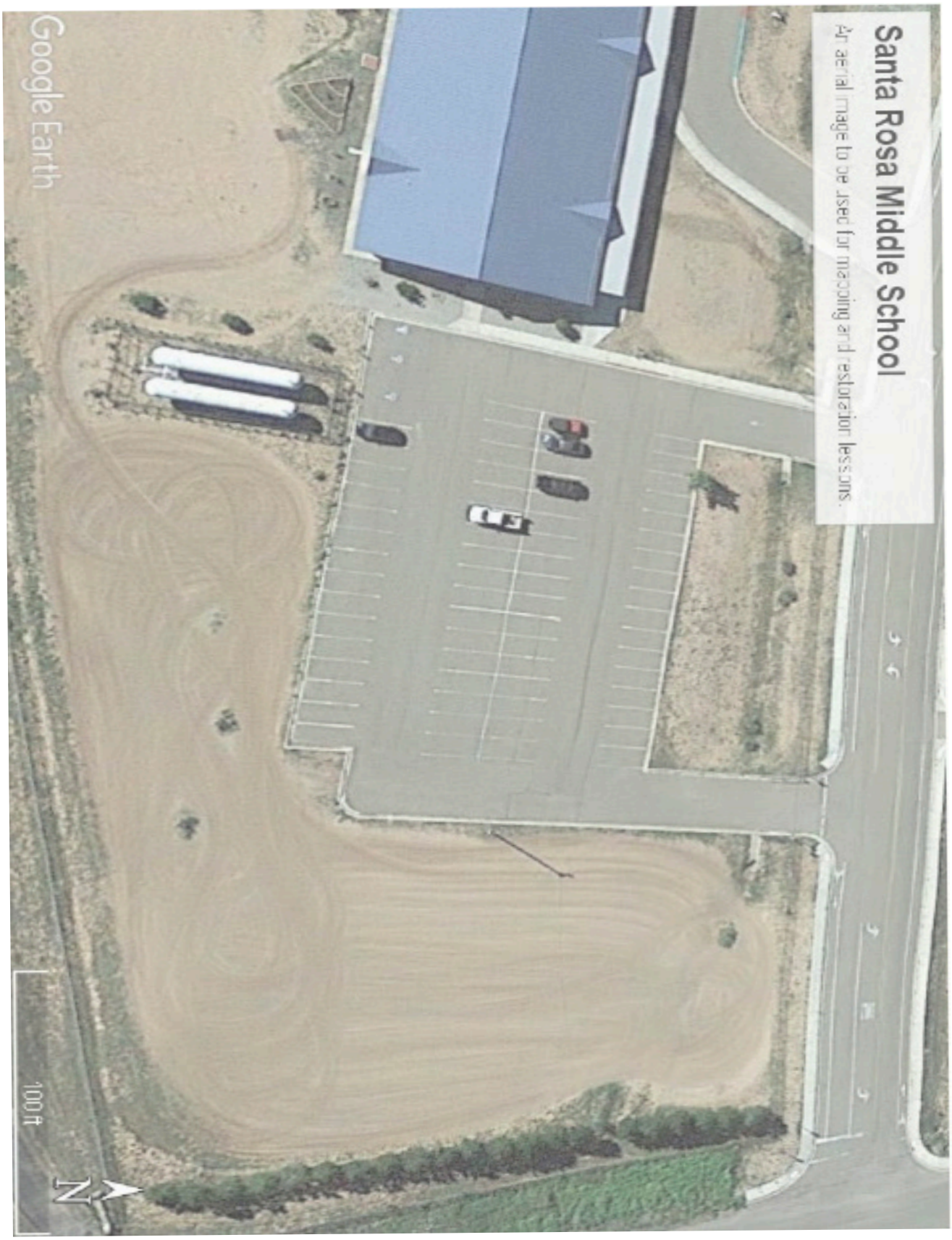
Are there places where water is causing damage or erosion? What about places where water could be slowed and captured with rocks or plants? This would look like bare ground or places where channels are forming.

Are there places with a lot of bare ground?

What would you do to improve this area?

Use the maps on the next 2 pages to draw 1) areas that are in need of restoration on the first map and 2)what you want the schoolyard to look like on the second map.

Use this map to show areas that are in need of restoration.



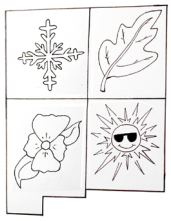
Use this map to draw what the area will look like after restoration

T Teacher Page

Saving Beauty or Bottom Line?
Finding Common Ground for Plants and People

Time Estimate
1-2 hours

Best Season



Spring
Winter
Fall
Winter

Grade level
6-8

"Begin challenging your own assumptions. Your assumptions are your windows on the world. Scrub them off every once in a while, or the light won't come in." Alan Alda

Overview

In this lesson, students will play a role-playing game based on issues relevant to the Blue Hole Cienega management and protection. Students will develop roles, form opinions that reflect their position, and defend their position during the game. The goal is for students to gain knowledge of the issues, cultivate empathy for stakeholders with differing perspectives on a controversial issue, and prepare them for stewardship decisions.

Learning Targets

1. Students participate in role-playing discussion in a positive and productive way.
2. Students state their opinion on a controversial environmental subject and give one or more reasons based in fact to back up their opinion.
3. Students demonstrate empathy by listening to differing viewpoints and demonstrate respectful disagreement.

Preparation

- Determine a specific decision that needs to be made. This gives the conversation a clear goal.
- Identify specific roles for each student or group of students. Give them time to think about and research the viewpoints and concerns of the demographic that they are representing.
- Provide background information or time for research so that students can back up their ideas and arguments.

Teacher Hints

1 This role playing exercise is a discussion with an emphasis on listening (not a debate with a winner). Students will get the most out of this exercise if they have clear objectives and support in staying focused in discussions.

2 Students are instructed to listen to other viewpoints, weigh all sides of the issue, form an opinion, and work creatively to find common ground.

3 Establish clear guidelines of acceptable behavior in role-playing games. Controversial issues can and often do lead to strong feelings and arguments; it is important that no one feels intimidated. Learning is enhanced by constructive feedback from the teacher and peers and freedom to explore alternate roles.

4 For larger groups, assign multiple copies of roles or create additional roles of your own. For smaller groups leave out some roles, but be sure to balance both sides of the issue. Students reluctant to participate in oral projects could pair up as teams.

S Student Project

Saving Beauty or Bottom Line?
Finding Common Ground for Plants and People

What will you learn?

- Examine values and beliefs in controversial environmental issues
- Explore diverse opinions in a safe environment through role-playing
- Gain insight into problem solving skills, using defined steps to analyze the process
- Exercise the process of being an informed citizen and making personal stewardship decisions
- Learn ways to become involved in local issues

Vocabulary

- *stakeholder*
- *stewardship*

Materials Needed

- scenario description

"Begin challenging your own assumptions. Your assumptions are your windows on the world. Scrub them off every once in a while, or the light won't come in." Alan Alda

Overview

In this lesson you will consider how important natural resources in Santa Rosa will potentially be managed in the future to improve the economy. Can your class find a compromise that brings more jobs and makes Santa Rosa a destination for tourists but also prioritizes resource protection? Tourism is healthy, but too many people enjoying the area can damage natural resources like clean water, biodiversity, and scenery. Finding a healthy balance is the goal.

Background

Have you noticed a tension in your community over environmental problems such as limited water resources, decreasing air quality, or climate change? Maybe you know someone that is concerned that the Endangered Species Act will give the government control of how he or she manages his or her property. Are you aware that Santa Rosa has a rare cienega that is threatened by a growing number of impacts? There may be conflict over the management of this native ecosystem because each **stakeholder** (person or group with different interests and concerns) has different ideas on how the resource should be managed. How do these issues become conflicts? Conflicts can arise when the livelihood, or ability to make a living, of people feels threatened by the conservation of natural resources and vice versa.

There are no right or wrong answers to the issues in this activity. The main purpose of this role-playing game is to provide an opportunity to explore viewpoints on controversial environmental issues in a non-judgmental atmosphere. Begin by considering what environmental **stewardship** means. Stewardship is generally defined as responsible caretaking, or management of the environment for future generations. Under this definition of stewardship we are all responsible for natural resource management. With each decision we make, we can consider all kinds of future impacts, including economic, social, cultural, and environmental. It is said that native peoples took into consideration the impact of all decisions on the next seven generations. How do we form our opinions when making stewardship decisions?

Student Project

Saving Beauty or Bottom Line?
Finding Common Ground for Plants and People

Background Continued

Often we fall back on our **values**- an individual's standard of right and wrong. Factors such as economics, education, politics, spiritual beliefs, and culture all go into forming our values. As you can imagine, this complex stew of values can make reaching an agreement on environmental issues difficult, and often requires diplomacy and compromise between all the parties involved. Even though people have different opinions, most people generally want to do what they feel is the "right" thing. Role playing is a chance to practice listening to the viewpoints of others on controversial subjects.

Student Directions

1. Context: This activity is designed to help you evaluate your own feelings and form your own viewpoint while listening to and weighing the differing viewpoints of others. Be sure to weigh all the information before forming your own opinion.
   a. You will gain the most by participating fully, but relax and view the role-playing as a learning experience.
   b. Ask questions as needed to clarify your understanding, but respect the opinions of others.
   c. Notice the friction that can arise over environmental concerns in different segments of society. How will you resolve these issues?
2. Student roles:
   a. Work in groups of 6.
   b. Each person is assigned a character from the list in the scenario. First, complete the "Role Development" sheet individually. Take time to develop your character's background and values, using both your imagination and research. The viewpoints and concerns you will discuss should reflect your character and not your personal viewpoint.
   c. Staying in character, have a discussion with your group about the future of the Blue Hole Cienega and what you want to see happen there. Play your role as accurately as possible; realize that it may not mirror your own viewpoint, but do your best to empathize (walk in your character's shoes).
3. Sharing with the class:
   a. Each group will share what decision they made and what compromises they made to reach a decision.

Class Discussion

Is there any part of this conflict that both sides of the issue can agree on?
What values do both sides share?
How might people's values influence their viewpoint?
How do you recognize bias?
How would you weigh information to determine bias?
Do you recognize how your values have influenced your decisions?
What have you learned through participating in this meeting?
Do you think it has improved your listening skills, why or why not?
Values and prior knowledge will shape your first impressions; did any of the presentations cause you to change your first impression?
How successful do you think a solution will be if it requires people to change or compromise their values?
Look at the issue; what do you think would happen if no decision is made?
Do you see any parallels between this local issue and larger global issues?

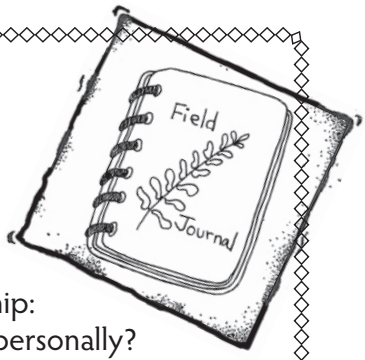
Student Project

Saving Beauty or Bottom Line?
Finding Common Ground for Plants and People

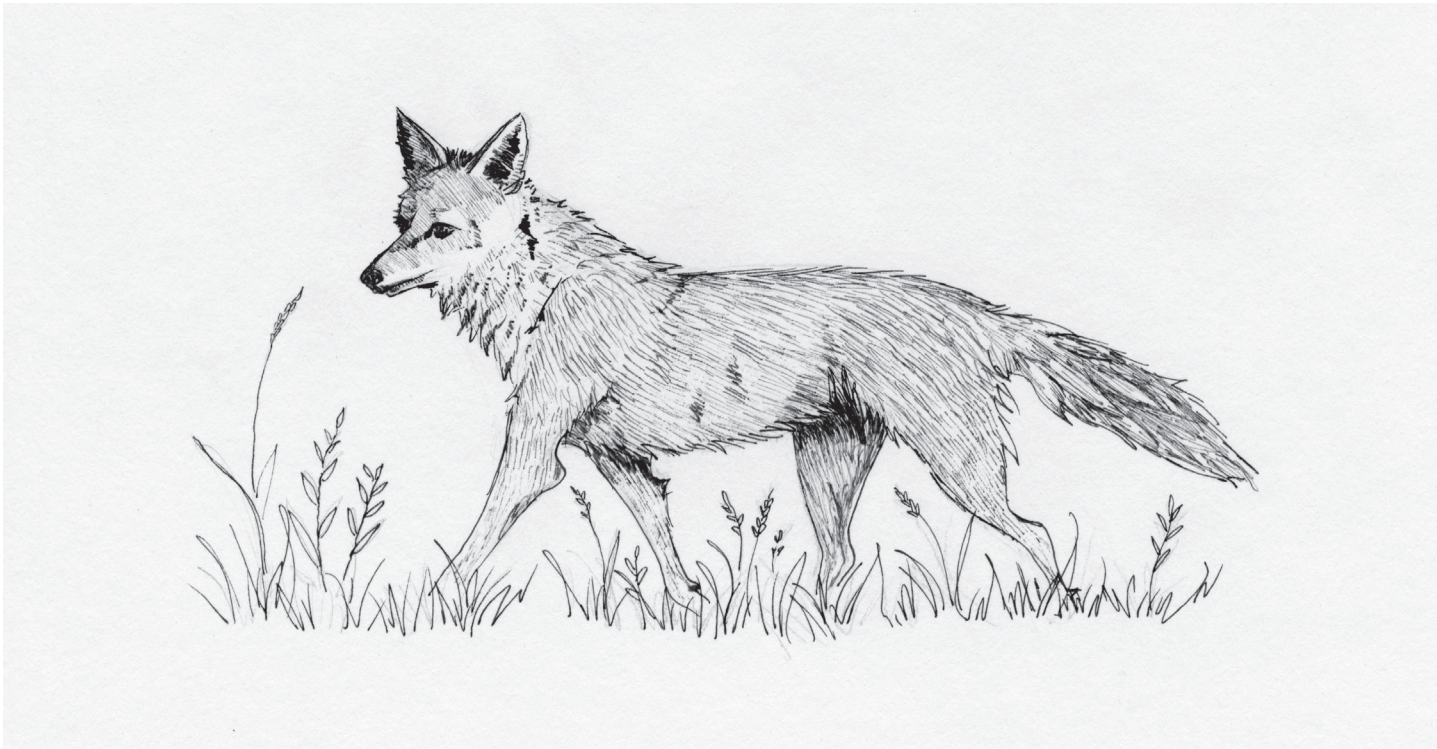
Take it to the Cienega!

Take a tour of the different places the Cienega touches from Blue Hole dive site and recreation area to the wet meadows with rare plants and stream outlets and sinkholes. Note impacts to these places and also discuss how these places seem to support humans.

Reflection



How do you feel when you see a rare field of sunflowers in your hometown? Reflect on the definition of stewardship: what does it mean to you personally? Do you feel that you have a responsibility as a citizen to help make decisions on land management issues? How can an individual's actions make a difference to their community, to the world? Do you think the role-playing activity will change the way that you make decisions in the future? Explain your reasoning.



Resources

- Materials from the previous units

Saving Beauty vs. Saving Bottom line - Role Play Scenario

Scenario: Thirty years in the future a taskforce is formed to create a plan for the Blue Hole Complex. Does the plan support development, conservation, or compromise and how?

Conservation History:
In the 1990's, the discovery of the endangered Pecos sunflower living in the Blue Hole Cienaga brought attention to this special ecosystem. Ten years later, the state botanist helped establish the116-acre Blue Hole Nature Preserve to protect the sunflower. The state prioritized habitat enhancement and monitoring for this species, and the town of Santa Rosa planned improvements that increased the protection of natural resources. The Mayor of Santa Rosa saw Pecos sunflower as an opportunity to draw tourists into town, and he agreed to build a boardwalk (to help people visit the wetland without harming the plants) and install interpretive signs (so people could learn more about the wetland resources). A local educator started the tradition of hosting a festival to celebrate the sunflower bloom every September.

Fictitious Future:
Fast forward thirty years from now!

Mayor Coffers is concerned about many jobless citizens- even some of his closest friends have lost their jobs. He does not understand the environmental value of protecting Blue Hole Cienega and thinks the Pecos sunflowers are weeds. He is attracting new developers with a vision of filling the cienega and turning the Blue Hole water park into a premier amusement park. Tourists and local youth would be excited to visit an expanded and improved premier amusement park.

The New Mexico education board is stressing lab science over natural resources. Teacher Sally Science has a degree in microbiology and does not have any training in ecology. Sally does not have time to add any ecology lessons or put any energy into festivals for rare plants or go on field trips.

The future state botanist is trying to maintain the Blue Hole Nature Preserve and is opposed to any development that will adversely impact the cienega and sunflower.

Local ranchers and the Quivira Coalition understand the fragility and importance to the wetland resources and will stand up for rangeland health.

The local community enjoys walking the boardwalk with family and friends, especially in September when sunflowers are blooming.

The Community:
Everyone in this community is connected in one way or another to this issue and decisions will have a ripple effect throughout the town of Santa Rosa. Decisions regarding the management of the Blue Hole Cienega and the surrounding wetlands will have an effect on the economy. Increased tourism and development can boost the economy. Local businesses will benefit and more jobs will be created.

The Decision:
Are there scenarios for both improving the economy and preserving the natural resources of the Blue Hole Cienega thirty years from now? What sort of compromises can be made among your group?

Characters:

- Mayor of Santa Rosa, Kevin/Kasey Coffers
- Teacher, Sam Science
- Amusement Park Developer, Morgan Moore
- New Mexico State Botanist, Daisy/Danny Diaz
- Rancher, Cindy/Caesar Sanchez
- Restaurant Owner, Paula/Paul Padilla

Taking it Further

Now that you are aware of how important and limited water resources are, what might you be able to do to conserve water?

Role Development Sheet

Your Name _____

Name of your character:	Occupation:

Briefly describe your fictional self (work, hobbies, home, family, values).	How does the issue affect your fictional life (economics, politics, ethics, etc.)? Does it conflict with any of your values?
Do you support or oppose the issue (in character)?	Give reasons to support your position (in character).

Role Development Sheet

Your Name _____

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NEW MEXICO STEM READY SCIENCE STANDARDS

		UNITS						
		1	2	3	4	5	6	7
STANDARDS	**Description**							
MS-LS1-4	Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively			x				
MS-LS1-5	Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms			x	x			
MS-LS2-1	Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem	x		x	x	x		x
MS-LS2-2	Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems			x	x	x		
MS-LS2-3	Develop a model to describe the cycling of matter and flow of energy among living and non-living parts of an ecosystem	x						
MS-LS2-4	Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations	x	x	x	x	x	x	x
MS-LS2-5	Evaluate competing design solutions for maintaining biodiversity and ecosystems services						x	x
MS-ESS2-4	Develop a model to describe the cycling of water through the Earth's systems driven by energy from the sun and the force of gravity	x	x					
MS-ESS3-1	Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes		x					
MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment						x	x

MS-ESS3-4	Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems		x	x			x	x
MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century							x
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions						x	x
MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved					x	x	x
1-SS-1 NM	Obtain information about how men and women of all ethnic and social backgrounds in New Mexico have worked together to advance science and technology				x	x	x	x
5-SS-1 NM	Communicate information gathered from books, reliable media, or outside sources, that describes how a variety of scientists and engineers across New Mexico have improved existing technologies, developed new ones, or improved society through applications of science						x	
MS-ESS3-3 NM	Describe the advantages and disadvantages associated with technologies related to local industries and energy production		x		x		x	x
HS-LS2-7 NM	Using a local issue in your solution design, describe and analyze the advantages and disadvantages of human activities that support the local population such as reclamation projects, building dams, and habitat restoration	x	x	x	x	x	x	x
HS-SS-2 NM	Construct an argument using claims, scientific evidence, and reasoning that helps decision makers with a New Mexico challenge or opportunity as it relates to science				x		x	x

GLOSSARY

abiotic: the nonliving elements of an ecosystem. Example: rocks, water

abiotic factors: see 'abiotic'

adaptation: a process over multiple generations in which an organism changes to better fit the habitat

Example: Natural selection would favor the deeper-rooted plants during climate shifts that cause drought conditions

arid: land or climate that receives limited precipitation (rain or snow)

biodiversity: every living organism within a single ecosystem or habitat, including numbers and diversity of species

biotic: living elements of an ecosystem. Example: soil bacteria, plants, predators

biotic factors: see 'biotic'

census: a complete population count

cienega: alkaline, freshwater, spongy, wet meadows with shallow-gradient, permanently saturated soils in otherwise arid landscapes that often occupied nearly the entire widths of valley bottoms. They are usually associated with seeps or springs, found in canyon headwaters or along margins of streams.
competition: Occurs due to limited resources, which prevents equal access and supply, as organisms compete for survival. Competition can occur between organisms of the same species or between members of different species.

conservation: the preservation and protection of natural resources through sustainable practices to prevent loss of habitats and biodiversity

cover: the area that plants take up when viewed from a bird's-eye perspective

ecological restoration (restoration): the process of repairing sites in nature whose biological communities and ecosystems have been degraded or destroyed

ecosystem services: the benefits humans obtain from ecosystems. Examples: food and water, flood and disease control, nutrient cycling

ecosystem: an interacting system of biotic and abiotic elements linked together through nutrient cycles and energy flows

endangered Species: organisms whose number have reduced drastically and if not conserved could become extinct

erosion: the process by which the surface of the earth is worn away by the action of water, glaciers, winds, waves, etc.

geology: the study of the earth's physical structure and substance, history, and the processes that act on it groundwater: water held underground in the soil or in pores and crevices in rock.

habitat: The area or natural environment in which an organism or population normally lives

herbivory: the consumption of plant material by animals

hydrology: the study of water, and especially its movement in relation to land

invasive species: an introduced organism that becomes overpopulated and negatively alters its new environment. Although there may be beneficial aspects, invasive species adversely affect the invaded habitats, causing ecological, environmental, and/or economic damage.

GLOSSARY cont...

karst: A landscape produced by the natural processes of solution and leaching of soluble rocks, generally carbonate rocks, in which the ensuing topography is mainly characterized by sinkholes, sinking streams,

underground drainage networks, and caves.

karst limestone: a soft rock that dissolves in water

keystone ecosystem: an ecosystem that has a greater influence on the surrounding landscape than other ecosystems relative to their size (i.e. they can be small but have a large influence on biodiversity and function)

limestone: a hard sedimentary rock, composed mainly of calcium carbonate or dolomite

monitoring: the act of observing and assessing the state and ongoing changes in ecosystems

plot: a sample area

prescribed fire: a form of land management in which fire is intentionally applied to vegetation

seed dispersal: the spread of seeds away from the parent plant. Facilitated by abiotic vectors such as wind and biotic vectors such as birds.

sinkholes: a depression in the ground that has no natural external surface drainage. Most common in karst terrain, where the types of rock below the land surface can naturally be dissolved by groundwater circulating through them

stakeholder: beneficiaries, persons of interest

stewardship: the responsible use and management of the natural world and its resources

taproot: main root of a primary root system, growing vertically downward

threats: an infectious disease with the potential to spread and cause an outbreak.

topography: the arrangement of physical features on the earth's surface (i.e. mountains, hills, canyons, etc.)

transect: a line across a habitat or part of a habitat. It can be as simple as a string or rope placed in a line on the ground. The number of organisms of each species along a transect can be observed and recorded at regular intervals.

APENDIX I: Plant Adaptations

Challenge	Adaptation	How It Works	Example
Limited			
	Hairs	Hairs slow down the movement of air over the surface of leaves and stems to minimize water loss by evaporation. Light-colored hairs can also reflect solar radiation.	Sagebrush, desert ironwood
	Water Storage	Some plants store large amounts of water within their stems and leaves for use during dry periods. Waxy coatings and thorns help protect these water stores.	Cacti, aloe
	Reduced Leaves	Decreasing or eliminating leaf surface area minimizes water loss by evaporation.	Conifers, cacti
	Specialized Root Systems	Deep root systems allow plants to reach low water tables. Alternatively, extensive, shallow root systems maximize absorption of light precipitation by capturing water that doesn't infiltrate deeply into soil layers.	Mesquite, saguaro cacti
High Moisture or Aquatic Conditions			
	Hollow or spongy stems	Air spaces in stems transport oxygen to waterlogged plant roots.	Cattail
	Flexible stems	Plants growing in the water column can bend in currents without breaking.	Water lily
	Prolonged seed viability	Seeds can wait to germinate for many years until they come in contact with soil and air.	Bulrush, cattail
	Floating leaves	Buoyant leaves allow plants rooted in standing water to reach sunlight and air. Stomata are located on the upper surface of the leaf for gas exchange.	Water lily
	Lenticels	Specialized pores allow plants to absorb nutrients, water, and necessary gasses from the water.	Willows
	Modified root systems	Modified and adventitious roots can extend above the waterlogged soil or water line to allow contact with oxygen. This also provides support in soft soil.	Mangroves
	Rot Prevention	Anti-fungal or anti-bacterial chemicals can help prevent rotting.	Cedar, larch
Hot Conditions			
	Hairs	Hairs can insulate a plant against heat. Light-colored hairs can also reflect solar radiation.	Brittlebush
	Leaves used as shade	The arrangement of leaves, spines and persistent dead leaves on the plant can provide umbrella-like shade.	Joshua tree
	Altered daily rhythms	Flowers may open only at night to attract nocturnal pollinators that avoid daytime heat.	Evening primroses
Cold Conditions			
	Evergreen needles	Small, low-growing plants, sometimes called "dwarf," are more protected from cold air, and require less water and nutrients.	Arctic willow
	Deciduous leaves	Thick, woolly hairs help insulate plants against cold air and wind.	Lousewort

Limited Nutrients			
	Symbiotic relationships	Soil bacteria including Rhizobia and Frankia form nodules on the roots of certain plants and fix nitrogen into a usable form. Some fungi can help plants increase their absorption of water and nutrients. Under some soil conditions, certain nutrients can only be taken up by plants with the help of these fungi.	Legumes, alders
	Carnivory	In nutrient-poor soils, some plants obtain nutrients by trapping and digesting insects and other arthropods.	Pitcher plant
Limited Light			
	Vines	Vining plants use larger plants as ladders to reach light without putting energy into producing large supporting trunks and branches.	Muscadine
	Broad leaves	Increased leaf area maximizes the photosynthetic capacity in light-limited conditions, but result in increased water loss as well.	Oaks, maples
	Specialized life cycle	Some understory plants in deciduous forests develop and mature early in spring in order to utilize light before they are shaded out by the growth of leaves on larger trees.	Spring beauty, trillium
	Height	Trees can grow very slowly under low-light conditions, eventually reaching incredible heights in order to reach sunlight at the canopy of a forest. A very strong trunk and root system are required to support such height, which can only be obtained through plentiful water and nutrients.	Oaks, cedars, maples, hemlocks
Herbivory			
	Armaments	Different types of armaments work against different types of herbivores. Large thorns and spines deter larger animals like deer, while hairs can be effective at deterring insects.	Cacti, roses
	Toxins	A wide variety of toxins, both mild and potent, keep herbivores from eating certain plants. Effects can range from bitter tastes to skin irritation to fatal poisonings.	Poison ivy, water hemlock
	Protected crown	Buds and stored carbohydrates located in the crown at the base of a plant are protected and allow for quick and low-cost recovery if the top of the plant is grazed.	Grasses
	Mast-fruiting	This is a phenomenon where individuals of a certain species will produce very few seeds for several years, followed by a year of high seed production. It is thought that this helps keep the population of seed predators low so they don't devastate the seed bank each year.	White oak

APENDIX II:
Supplemental Lessons from the "From Ponderosa to Prickly Pear" New Mexico Native Plant Curriculum

Each Unit in this curriculum can be supplemented with additional lessons from the "From Ponderosa to Prickly Pear:Exploring the Native Plants of New Mexico". These lessons can be used as a reference for teachers, or as supplementary lessons for the Units in the Blue Hole Cienega Curriculum.

Unit 1 Just Add Water: The Wonderful World of Wetlands

- The Place I Call Home (page 80)
- Biodiversity and Ecosystem Services: Can't Live Without 'Em (page 230)

Unit 2: A Sinking Feeling: Karst Geology and the Formation of Blue Hole

- No applicable lessons.

Unit 3: Plants in their Places: Plant Adaptations in Deserts and Wetlands

- Plant Adaptations:Create-A-Plant (page 60)
- Plant Wars: A Tale of Offense and Defense (page 118)
- What's Going Down Underground? (page 102)

Unit 4: The Rare Ones: Conservation of Biodiversity

- Saving Botanical Treasures (page 237)

Unit 5: Data Talks: Measuring Plant Populations

- Ecosystem Comparisons (page 87)
- Phenology: Tracking the Seasons in Your World (page 211)
- Measuring and Monitoring Plant Populations (page 173)

Unit 6: Let's Restore! Ecological Restoration- Planning and Planting

- Nurture a Native Garden (page 142)
- Designing a Habitat Restoration Plan (page 257)

Unit 7: Saving Beauty or the Bottom Line? Finding Common Ground for Plants and People

- Nobody Right, Nobody Wrong (page 245)