Share with Wildlife Endangered Species Curriculum

Educating Ecosystems Explorers

Key personnel and contact information:
Paul Mauermann, SMNHC Director; paul.mauermann@state.nm.us; (505)281-5259
Vanessa Barela, SMNHC Educator and Volunteer Coordinator; vanessa.barela2@state.nm.us; (505)281-5259

Table of Contents

Thank You

This curriculum was created and funded with the help of the New Mexico Department of Game and Fish Share with Wildlife program. Share with Wildlife is a New Mexico Department of Game and Fish program initiated in 1981 that depends on tax-deductible donations from the public. Its mission is to help those species that do not receive funding from any other source. The program funds four categories of wildlife
projects: research, education, habitat enhancement, and rehabilitation. It receives much of its funding through the state income tax check-off program. It is also supported through Share with Wildlife license plate sales and direct donations. Matching federal funds maximize the program's support of New Mexico's
wildlife. *(Hummingbird photo on cover page by Mark Watson.)*

How to Use: Implementation Ideas
This curriculum is designed with multiple implementation strategies in mind. Below are some suggestions for implementation.

Jigsaw with SMNHC Staff Help (Ideal)
The classroom teacher and SMNHC staff work to create 5 groups of students (one per animal) that will jigsaw the activities. Activities are marked with level of difficulty using DOK for grouping by the teacher. Students will read the information sheets as homework prior to SMNHC staff coming in for support. Students will work with SMNHC staff and their teacher to complete the activities, culminating in an extension presentation for the class about the Species of Greatest Concern (SGC).

Jigsaw
The classroom creates 5 groups of students (one per animal) that will jigsaw the activities. Students will read the information sheets as homework prior to completing the task with their group. Students will work with their teacher to complete the activities, culminating in an extension presentation for the class about the Species of Greatest Concern (SGC). Presentation optional

Unit of Learning
Using this curriculum as a unit for learning, the teacher can assign students to complete this as a packet, part of a unit, or parts of the curriculum. It is suggested that students start with Activity 1 to build scientific thinking and literacy to the culminating Activity 5 with the optional Activity 6 presentation.

Flipped Classroom
With the flipped classroom model, students will read the information sheets as homework prior to completing tasks in class for further support.

Online Learning
These activities are designed to allow students to complete these activities independently with teacher support in an online modality. They can be combined with best practices for online learning including, blended learning models.

Program Objectives

Students will be able to:

- Identify the causes for animals to become endangered.

- Identify historical ranges and present ranges of endangered species.

- Brainstorm solutions that can help these endangered species thrive.

- *Evaluate other groups' possible solutions to help endangered species.*

- Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

- Cite specific textual evidence to support analysis of science and technical texts.

- Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

- Create and present the causes for endangerment and possible recovery plans.

- Determine how humans influence species habitats and populations.

Title of Lesson: Introduction to Endangered Species	By: Juliette Conzuelo
Content Area: Science	
Materials Needed: None	
Handouts Attached Below: None	
Standard Addressed: N/A	
DOK: 1	
Skill to be Maintained: N/A	
Essential Question: Why are animals important?	
Academic Vocabulary/Word Wall words: extinction, ecosystem, habitat	
Brain Drain or Warm Up Activity: Have students close eyes and think of animals they saw on their way to school, or if students are doing blended learning, have students observe their yard for 5 minutes and write out what animals they observe (large and small).	
Basic Lesson Description and Procedure: 1. This basic reading is a primer for the rest of the activities. The teacher will hand out this page for students to read and allow students 5-10 minutes of observation time outside to create a list of animals, bugs, or other creatures they might see.	
Observation Activity: Students will observe animals in nature and make a list of them.	
Lesson Conclusion/Potential Practice at Home: Students can compare animals at their school location to home location.	
Accommodations-Modifications: For visually impaired students, this activity could be modified to include sounds of animals in nature using various apps with identification of sounds of any animals heard if students go outside or if using an application only, students can be told what animals they are listening to.	

Introduction to Endangered Species - Activity

Directions- Carefully read through to learn more about ecosystems and how animals are connected to each other and humans, and then answer the questions regarding your observations.

Definitions of bolded words can be found in the Share with Wildlife Program Glossary

Go look outside! Do you see animals? Do you see bees? Moths? Birds? Or even insects? How would it be to not see those animals anymore? How would life look without Earth's creatures?

Everyday animals are at risk of **extinction**. How would it feel to not see animals at all? No pigeons making their sounds, no snakes basking in the sun, no geese flying into open fields, or even Sandhill cranes. I know some of us are afraid of some animals and think it would be fine not seeing a snake, but understanding how these animals play into this thing we call an **ecosystem** is something we need to do. Our system is not linear; it is a circular one, where if one species is affected, it can bring down other species with too. This concept plays out all the time. For example, bees are creatures that pollinate plants, and plants depend on the bees to pollinate them so their species can reproduce and survive. Some of those plants that need pollination are the foods we put in our mouths and the mouths of animals that we eat as well. If bees were slowly to go away, then eventually those animals and plants that have connections with the bees will go away as well, and their activities, along with food sources for humans. Animals are at risk every day because of what human activities have contributed to changing their **habitat**. A changing habitat means living organisms must adapt quickly to survive. If they do not adapt, they may not be able to survive where they currently live.

In the space below, answer the following questions.

What animals did you see? If you do not know the animal, try to describe it.

What creatures did you hear, but weren't able to see?

7

Lesson Plan New Mexico Meadow Jumping Mouse

Title of Lesson: New Mexico Meadow Jumping Mouse	By: Juliette Conzuelo
Content Area: **Science**	
Materials Needed: Computer, phone, or tablet for map component	
Handouts Attached Below: None	
Standard Addressed: MS-LS2-1, MS-LS2-2, MS-LS2-4	
DOK: 3	
Skills to be Maintained: map reading and interpretation	
Essential Question: Why is the New Mexico Meadow Jumping Mouse the one of the most endangered species in New Mexico?	
Academic Vocabulary/Word Wall words: endangered, Endangered Species Act, diurnal, riparian, critical habitat, exacerbated, climate chance, extinction, conservation	
Brain Drain or Warm Up Activity: Introduction to endangered species activity done previously	
Basic Lesson Description and Procedure: 1. Students will read through the background information about the New Mexico Meadow Jumping Mouse (NMMJM). 2. Students will evaluate pictures of habitat and decide which to live in and answer relevant questions to justify their choice. 3. Students will use ArcGIS to answer questions while looking at a map of where the NMMJM lives. 4. Students are provided a list of FAQs and answers from the U.S. Fish and Wildlife Service. Teachers assist students in understanding the table. Students create ideas about conservation of the NMMJM based on the information presented in the table and present them in any way they wish.	
Observation Activity: If SMNHC Staff are able to present, artifacts or study skins may be brought for students to observe.	
Lesson Conclusion/Potential Practice at Home: Wrap up by having students share what they've learned in short 5 minute presentations per student, or have students group based on similarities of their ideas to create one larger presentation to share to the class of 10-15 minutes per group.	
Accommodations-Modifications: Students may need additional assistance using the map of NMMJM critical habitat.	

Activity- New Mexico Meadow Jumping Mouse

***Directions-* Carefully read through to learn more about the New Mexico meadow jumping mouse, then answer the questions regarding the endangered species.**

Definitions of **bolded words** can be found in the *Share with Wildlife Program Glossary*

Meadow Jumping Mouse
This *nocturnal* mouse differs from most other mice in having well-developed hind legs that allow it to jump as far as four feet. This little animal lives in the San Juan, Jemez, and Sacramento mountains and in the central Rio Grande Valley, where it occupies dense weedy and marshy areas. It maybe more common than previously thought. They may *hibernate* for as long as seven months of the year. State-listed as threatened.

Just like the bees, the New Mexico (NM) meadow jumping mouse's habitat is being threatened. If its habitat continues to be threatened, in 10 years this animal could become extinct. Then we will only have an animal displayed in museums that can never live again, similar to how we will never again see how a saber-toothed cat looks in real life; we can only see man-made interpretations of how it looks in drawings and movies. The U.S. Fish and Wildlife Service (USFWS) designated the NM meadow jumping mouse as **endangered** under the **Endangered Species Act** (ESA) on June 9, 2014. NM meadow jumping mice are small mammals that are generally **nocturnal** and occasionally **diurnal**. They hibernate for 8-9 months out of the year (imagine sleeping that long!) and are active in the summer for 3-4 months. They can be found in New Mexico, Arizona, and Colorado. These funny and amazing creatures have specific geographic areas that contain features essential to this animal's survival. The geographic areas where the mouse can live are shrinking, making the life of a NM meadow jumping mouse hard.
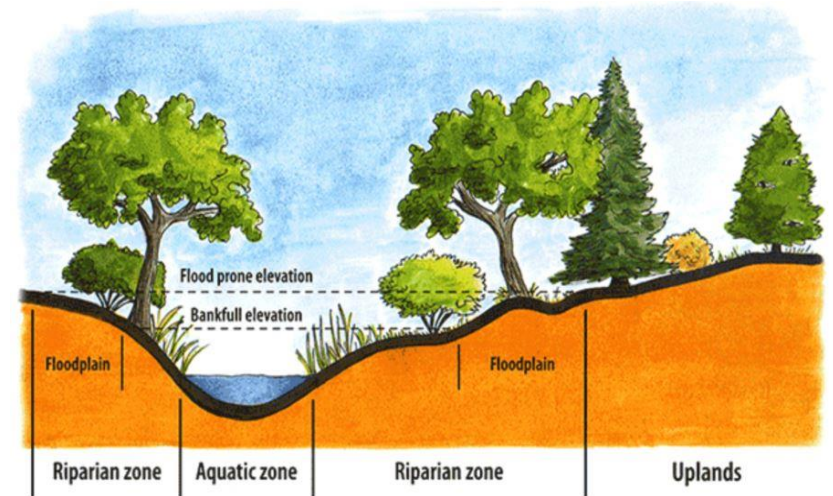
Critical Habitat! ⛰️

There are certain plant species that the NM meadow jumping mouse depends on to live, eat, breed, and raise their young. Places that have the right conditions for this species to live and thrive are identified by USFWS as critical habitat.

- Tall (**averaging 24 in,** *this paper is 11 in long*) **grassy riparian** vegetation along rivers, streams, wetlands, riverbanks, or canals and ditches.
- Forbs (Examples: sunflower, water hemlock, field mint, asters, they love the grass seeds!)
- Sedges (Examples: spike rush, beaked sedge, seeds)

Flood prone elevation
Bankfull elevation
Floodplain
Floodplain
Riparian zone | Aquatic zone | Riparian zone | Uplands

Water Hemlock (Forb)

Sunflowers (Forb)

Spike Rush (Sedge)

Squirrel tail (Grass)

Active Time! 🦋

These tiny little creatures do a lot during their time out of hibernation. They spend only 3-4 months being active during the summer. The NM meadow jumping mouse must breed, give birth, raise its young, and store enough fat reserves so it can survive next year's hibernation. (Wow that is a lot to do in 3-4 months!)

Directions: Answer the questions below and write your answers on a separate piece of paper.

If you were a NM meadow jumping mouse, what habitat would you choose to live in?
(1, 2, or 3)

Now, what habitat you would not choose and why?

Looking at these pictures, think about the activities that humans do that might affect habitats like these?

- What are those activities?
- How do they impact the land?
- What other animals might be impacted as well?
- What can humans do to stop wildlife from becoming endangered or extinct?
- What can we share with future stewards of the land?

11

New Mexico Meadow Jumping Mouse Critical Habitat Map

4/20/2020

1:5,940,051

| 0 | 40 | 80 | 160 mi |
| 0 | 65 | 130 | 260 km |

Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson,
NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA,
Geoland, FEMA, Intermap and the GIS user community, Sources: Esri,
HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and

On this map, you will see the **critical habitat in the brown** and the current habitat of the NM meadow jumping mouse.

Can you see their locations?

Key

- NM Meadow Jumping Mouse Critical Habitat

Get a closer look by clicking on the link or copy it to your web browser (computer or phone) so you see where they are.
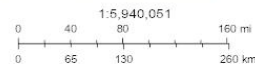
https://arcg.is/1arqmz 👆🌐

Follow the directions below and think about the following questions while looking at the map.

➔ What counties are the NM meadow jumping mouse in?
➔ How can the surrounding geographical or man-made features have an impact on the mouse?
➔ Do you think this map is helpful in seeing the locations of the NM meadow jumping mice? Why or why not?
➔ Now zoom in again, choose a location, and see what is nearby that might contribute to the loss of populations of the mice?
➔ Why might they choose to live in this location rather than another?

Below are some of the frequently asked questions for the final listing of the NM meadow jumping mouse, answered by the U.S. Fish and Wildlife Service on June 6th, 2014, and information from chapter 4 of the revised Species Status Assessment Report (Service 2020) that provides a detailed description of the threats and stressors that still affect the species.

Q- What are the threats to the jumping mouse?

A - Threats to the jumping mouse include grazing pressure (which removes the needed vegetation), water management and use (which causes vegetation loss from mowing and drying of soils), lack of water due to drought (**exacerbated** by **climate change**), wildfires (exacerbated by climate change), drought (also exacerbated by climate change), scouring floods, loss of beaver ponds, highway reconstruction, residential and commercial development, coalbed methane development, and unregulated recreation. We found the jumping mouse is at an elevated risk of **extinction** now and no data indicate that the situation will improve without significant **conservation** intervention. Conservation of the species requires the restoration of habitat within each of the eight conservation areas to provide additional areas for local populations to expand and become established. Consequently, current populations should be expanded as rapidly as possible by protecting and restoring (through grazing management and water management) at least 9 to 24 km (5.6 to 15 mi) of continuous suitable habitat along stream reaches, ditches, or canals.

Q- Are the threats substantial?

A- Yes. At the current rate of population extirpations, without substantial conservation efforts, the probability of persistence of the species is expected to be severely compromised in less than 10 years with decreasing viability beyond 10 years, presenting an elevated risk of extinction.

Threats Analysis

Listing Factor	Threat Description
Factor A: The present or threatened destruction, modification, or **curtailment** of its habitat or range	These factors continue to be the primary threats to the species throughout its range. Habitat destruction and isolation significantly compromised at least 11 of the 29 known populations from 2011 to 2014, as described in the listing rule. Livestock grazing continues to be the major source of habitat destruction. Grazing has been modified or eliminated in some critical habitat. However, these conservation efforts have not occurred at a level sufficient to reduce the threat to a point that justifies any change to its current endangered status.
Factor B: **Overutilization** for commercial, recreational, scientific, or educational purposes	We have no information that indicates overutilization for commercial, recreational, scientific, or educational purposes pose a substantial risk to the New Mexico meadow jumping mouse. Ongoing research has resulted in very few mortalities from live trapping or telemetry efforts; therefore, these activities do not pose a threat to the viability of the species.
Factor C: Disease or **predation**	We have no information that indicates disease or predation pose a substantial risk to the New Mexico meadow jumping mouse. There is no available information that indicates disease or predation are

	currently or likely to become a substantial concern to the jumping mouse in the future.
Factor D: Inadequacy of existing regulatory mechanisms	Most State and Federal laws are currently inadequate in removing or reducing threats to the subspecies. The jumping mouse has been on the U.S. Forest Service Sensitive Species List since 1990. This designation does not provide protection from Forest actions but only requires it to be considered in Forest planning. The species was classified as endangered by the New Mexico Department of Game and Fish in 2006, and as a Species of Greatest Conservation Need by Arizona Game and Fish Department (2012) and Colorado Parks and Wildlife (2015). New Mexico and Colorado designations provide some protections against take, but do not protect the species' habitat. Arizona regulations currently have few provisions for the species.
Factor E: Other natural or manmade factors	Unregulated recreation (e.g., camping, fishing, boating, ATV use) can modify habitat conditions for New Mexico meadow jumping mice detrimentally. This can reduce forage and vegetation cover, increasing metabolic stress and predation risk. Catastrophic events such as prolonged drought and increased risks of severe wildfire and floods can all have detrimental effects on local populations.

Now THINK and EXPLORE some conservation methods to help stop the New Mexico meadow jumping mice from being endangered or, even worse, extinct. Think about what plans the U.S. Fish and Wildlife Service can produce. What plans can you think of producing as a steward of this land to help stop this issue? What can we do at home or what can we tell friends or neighbors help inform them and make them aware of this species and the threats it faces.

Once you have gathered up your ideas, you can present these ideas in any way you wish! You can make an online graphic post with words and pictures, a video, drawing, song, or even a poem. Share it your unique way! Share it online on your Instagram or your Facebook account with the hashtag #StopExtinction.

Also, do not forget to share who you are and why you care about our ecosystems.

May your creations come to life and help our home (ecosystem, Mother Earth, the world)!!

Lesson Plan- A Place for Pikas

Title of Lesson: A Place for Pikas	By: Fiana Shapiro
Content Area: Science	
Materials Needed optional- Computer for viewing full geographic range of pikas.	
Handouts Attached Below: A Place for Pikas worksheet	
Standard Addressed: MS-LS2-1, MS-LS2-2, MS-LS2-4	
DOK: 2	
Skill to be Maintained: Reading graphs, mapping, interpreting data, analyzing impacts	
Essential Question: How does climate change impact the pika's ecosystem?	
Academic Vocabulary/Word Wall words: habitat, range, talus, humidity, permafrost, climate change, greenhouse gases, global warming, adaptation, precipitation, extirpated	
Brain Drain or Warm Up Activity: The teacher has students think of how the climate might be different at the top of a mountain versus in a desert. This can be a simple discussion or list students create.	

Basic Lesson Description and Procedure:
  1. Students will read through the activity "A Place for Pikas". Questions are embedded throughout the activity to answer.
  2. Students will look at graphs to interpret data and answer questions about pikas and their habitat.	

Observation Activity: If SMNHC staff is able to present, a collection of study skins for pikas can be shown to students collected from all over the US.	
Lesson Conclusion/Potential Practice at Home Have students watch the videos below. *Pika YouTube Videos* How the Pika Adapts to Climate Change https://youtu.be/IF8ym4g2SCU Why Pika Populations are Declining (Colorado) https://youtu.be/2YG8TlnupBU Pika Stories in Rocky Mountain National Park https://youtu.be/QxBaqSAX_Tg Possible extension activities *Other Pika Activities* Activity: The Effect of Snowpack and Connectivity on Pika https://www.lessonsinlifescience.org/snowpack-and-connectivity Activity: Pikas and Their Environment: Predicting Where They Live https://www.lessonsinlifescience.org/pikas-and-environment	
Accommodations-Modifications: None	

Activity- A Place for Pikas

Begin by reading through this fact sheet about pikas and their habitat. Definitions of bolded words can be found in the *Share with Wildlife Program Glossary*.

Pikas are small mammals related to rabbits. They have been living in their modern **range** in North America for about 11,000 years. Pikas are found mostly in the mountains on rocky slopes. They live in groups and communicate with one another using squeaks and whistles.

Talus slope near Telluride, Colorado, gjhikes.com

Pikas need certain conditions in their habitat to survive, including:

- **Talus** slopes: take cover under rocks to protect themselves from heat, cold, and predators.

- Cool temperatures: they can overheat within *hours* when out in temperatures of 78°F and above!

- Snow: when temperatures drop low in winter, they can freeze without enough snow to insulate them.

- Vegetation: small plants, grasses, flowers. They are constantly eating and collecting food, which they cache (store) in a "haypile", letting it dry out to save through the winter. One pika can store up to 30 pounds of food!

- Moisture & **Humidity**: not too dry.

- **Permafrost:** only live in places with a layer of ground that remains frozen all year.

*Pika collecting food, Photo by Jon LeVasseur*

Pika Importance

Not only do pikas need plants to survive, the plants also need them. Pikas engineer where different species of plants are found in the ecosystems they live in as they move plants, and their seeds, around. Their haypiles put nitrogen back into the ground as they decompose. Pika predators, including hawks, weasels, and coyotes, need them for food; especially in the harsh, high elevation environments where the pikas live where food can sometimes be scarce. Pikas' bodies are hosts to several intestinal parasites and fleas, which, believe it or not, are needed also!

Pikas even help other organisms when they pee and poop! Their urine is concentrated into crystals as a way to conserve water, and they deposit it on rocks to mark their territory. Reddish-orange lichens (a relationship between fungi and algae) grow on these crystals! Their scat also provides fertilizer for plants. Importantly, pikas are considered an indicator species for climate change, meaning that we humans should consider their decline as a warning of how quickly the climate is changing and how climate change may be impacting other wildlife and the mountain ecosystem where pikas live.

Your job is to consider pika habitat conditions and the ways the conditions have and are predicted to continue changing it in the coming years, in order to determine how pikas may be affected. Also, consider how human activities have affected and will continue to affect these habitats.

**Investigate the following data, graphs, and information carefully. Use your interpretations, scientific knowledge, and your own ideas to answer the questions.**

In New Mexico, pikas live in the Sangre de Cristo, Jemez, and San Juan mountains at elevations between about 8,000 and 13,000 ft.
The range map to the right shows where they live in the state.
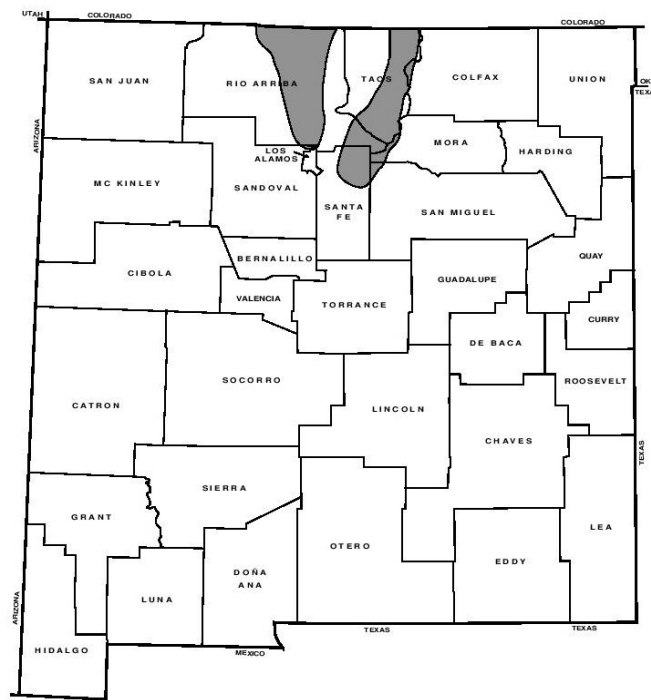
Range of pikas in New Mexico, Wildlife Notes, NM Game & Fish, 1996

The map below is zoomed in on the areas they are found.
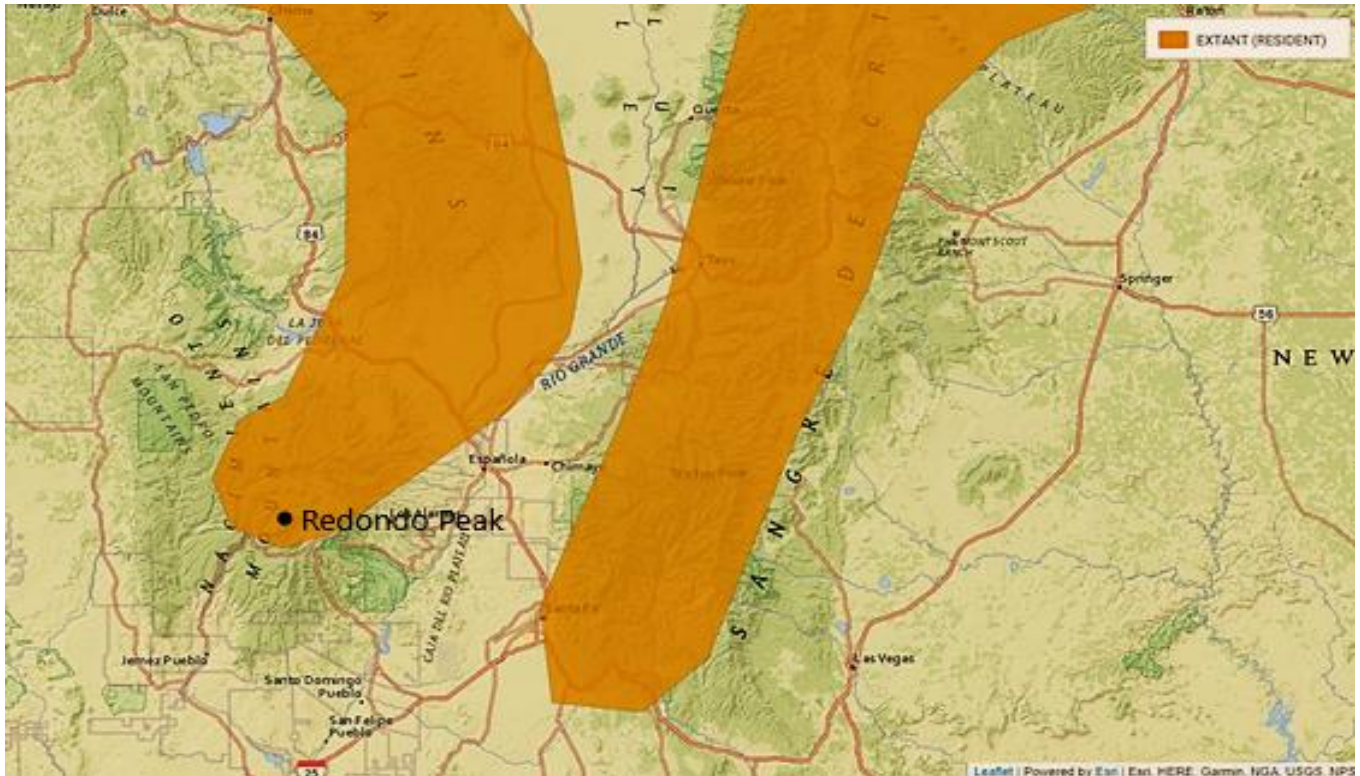
Esri, HERE, Garmin, FAO, USGS, EPA, NPS; IUCN (International Union for Conservation of Nature) 2016. Ochotona princeps. The IUCN Red List of Threatened Species. Version 2020-1

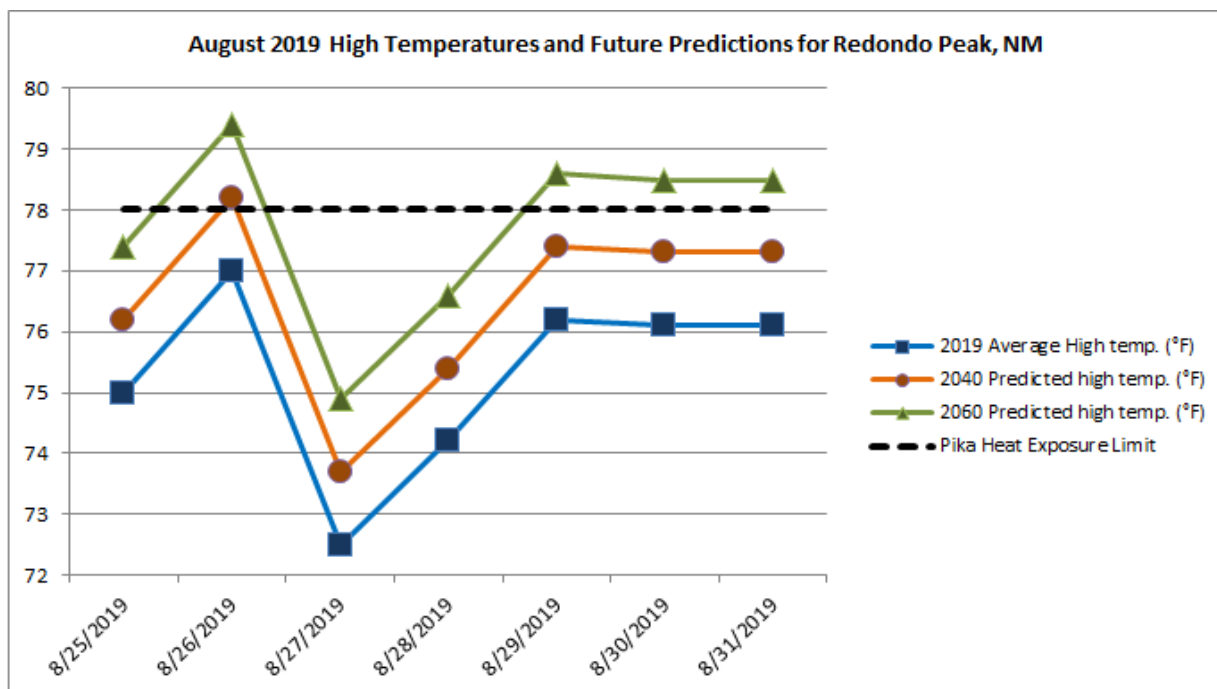You can also view the full range of pikas in North America at this link: https://www.iucnredlist.org/species/41267/45184315

1) Why do you think pikas are living in these particular areas of the state, and not others?

Directions: Study the following information, graphs, and map related to weather and climate change on Redondo Peak, New Mexico.

Humans release extra carbon dioxide and other **greenhouse gases** into the atmosphere by burning fossil fuels. These gasses trap more heat near our planet's surface, which causes **global warming**. New Mexico is the 6th fastest warming state in the country, and the average annual temperature in New Mexico has been increasing about 0.6°F per decade since 1970. Average annual temperatures are projected to rise 3.5 to 8.5°F this century (by 2100).
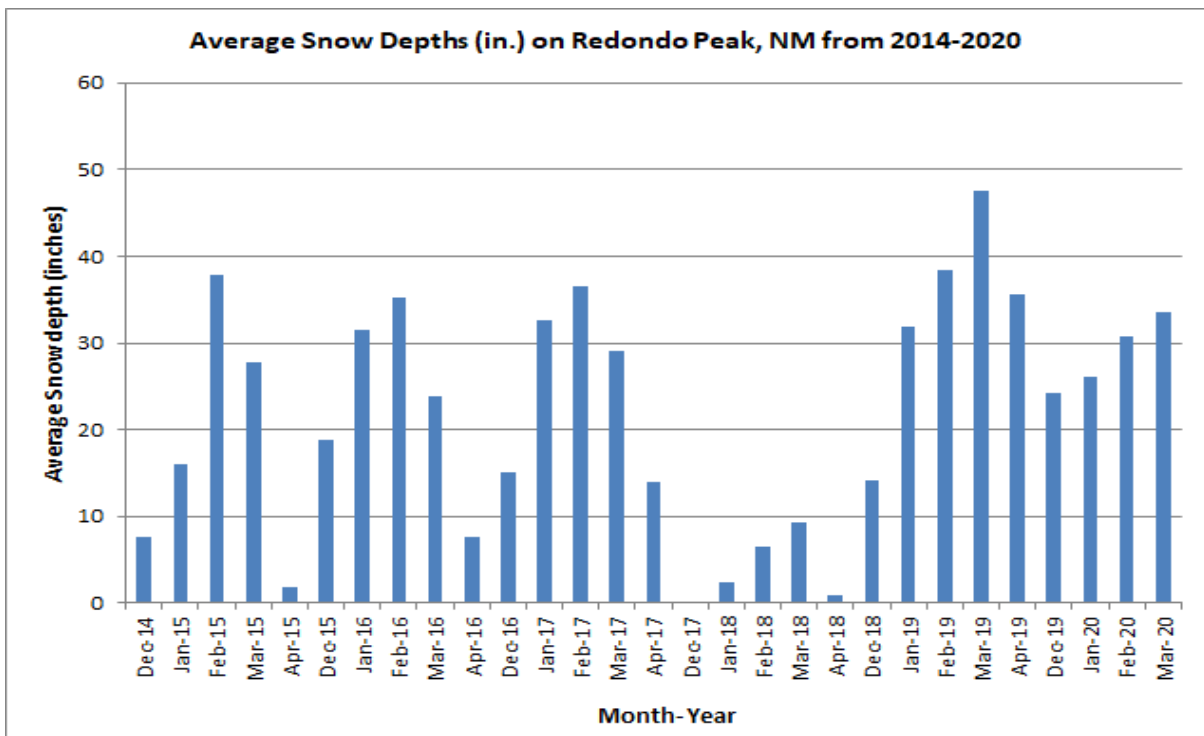
This graph shows high temperatures during the last week of August 2019, the hottest week of that year, on Redondo Peak in the Jemez Mountains (in Valles Caldera National Preserve) at 10,601 feet elevation.

August 2019 High Temperatures and Future Predictions for Redondo Peak, NM

Legend:
- 2019 Average High temp. (°F)
- 2040 Predicted high temp. (°F)
- 2060 Predicted high temp. (°F)
- Pika Heat Exposure Limit

2) How many high temperatures in 2040 are predicted to be at or above the 78°F line? How many are in 2060? How many do you predict will be over the line in 2080? Add a line for 2080 on the graph.

3) What could such temperature changes in future years do to pikas? Do they have any **adaptations** that could help them survive?

4) Look back at the full list of what pikas need in their habitat to survive. Could increasing temperatures affect any of their other habitat needs? If yes, describe what this could do to pikas. Are there any factors that probably would not change?
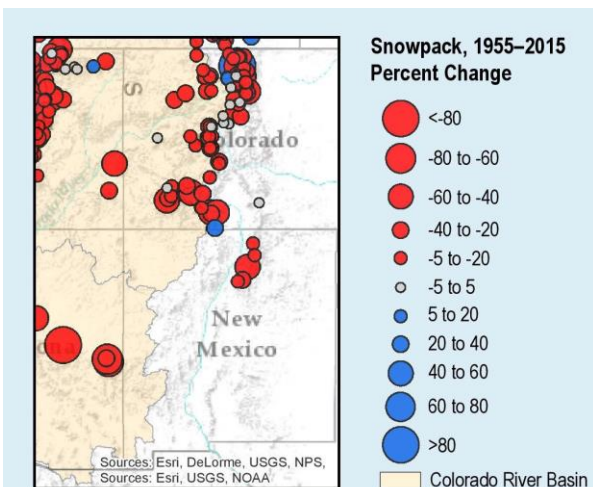
19

Not only is climate change causing temperatures to rise, but it can also change **precipitation** amounts and patterns. Since 1950, conditions have been drier in the Southwestern U.S. compared with any time period in the last 600 years! (Based on scientists' investigations into what the **climate** was probably like in the past). Climate scientists are observing the following trends and expect these trends to continue in the coming years:

- Less predictable winters (ups and downs of snow and temperatures that don't always follow past patterns)
- Fewer cold snaps, but not necessarily less extreme low temperatures.
- Less precipitation overall
- More of the precipitation falling as rain, rather than snow
- More extreme snowfalls (more at one time, rather than spread out through the winter)
- Less snowpack (layers of snow that stay on the ground through the winter)
- Earlier snowmelt in the spring

Average Snow Depths (in.) on Redondo Peak, NM from 2014-2020

Snowpack, 1955–2015 Percent Change

- <-80
- -80 to -60
- -60 to -40
- -40 to -20
- -5 to -20
- -5 to 5
- 5 to 20
- 20 to 40
- 40 to 60
- 60 to 80
- >80
- Colorado River Basin

Sources: Esri, DeLorme, USGS, NPS, Sources: Esri, USGS, NOAA

Trends in April snowpack in New Mexico and Colorado, 1955–2013. The snowpack has declined at most monitoring sites in both states. Source: EPA.

5)   In what ways might you expect this snow depth graph to change by 2040? How do you think any changes would affect pikas?

6)   How could the other changes in winter conditions impact New Mexico pikas? Explain your answer, referring to the above list and looking back at their habitat needs list. You can talk about changes that have already happened, or what may be seen in the future.

Use all that you have learned to answer this last section of critical thinking questions.

7) If their habitat was no longer suitable, could a population of pikas migrate from Redondo Peak in the Jemez Mountains to a mountaintop in the Sangre de Cristo Mountains? How about to another nearby peak in the Jemez Mountains? Explain your answers.

8) What do you think would happen if wild pikas were collected and introduced to the Sandia Mountains (or another mountain range close to where *you* live)?

9) Do you think the pika populations in New Mexico will survive climate change? Why or why not? What do you think will be the biggest factor in determining whether or not they survive?

10) If all pikas were to be **extirpated** from a particular area, how would this affect other parts of the ecosystem where they used to be found?

11) What can humans do to help pikas?

Lesson Plan- A Refuge for Rattlesnakes

Title of Lesson: A Refuge for Rattlesnakes	By: Fiana Shapiro and Juliette Conzuelo

Content Area: Science,

Materials Needed: Computer

Handouts Attached Below: A Refuge for Rattlesnakes

Standard Addressed: MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ETS1-1

DOK: 3

Skill to be Maintained: Interpreting maps, analyzing impacts

Essential Question: What are the greatest threats to the New Mexico ridge-nosed rattlesnake in the past, present, and future? What can humans do to protect their survival? Where is critical habitat for this sub-species in New Mexico?

Academic Vocabulary/Word Wall words: subspecies, habitat, conifer, canopy, precipitation, range, climate change, critical habitat, adaptation, endangered, conservation, threatened, venomous, Endangered Species Act

Brain Drain or Warm Up Activity: Discuss if students have ever seen an animal they are afraid of. How did it make them feel? What was the animal? Why are they afraid of it?

Basic Lesson Description and Procedure: 1. Students will read about, and obtain an in-depth understanding of, the past and present threats to New Mexico ridge-nosed rattlesnakes, as well as protections in place for them.   2. Students will identify and analyze which threats have had the greatest impacts in the past and which may be more impactful in the future.   3. Students will write a management plan for the rattlesnakes and design new solutions for their protection.   4. Students will view and analyze a map of the critical habitat of the New Mexico ridge-nosed rattlesnake.

Observation Activity: If SMNHC staff are able to present, skeletons of rattlesnakes can be brought in

Lesson Conclusion/Potential Practice at Home: Design a poster providing information to the public about why people should care about rattlesnakes and not fear them and ways they can help protect them.   Utilize ArcGIS tutorials to work on digital mapping skills. Learn to manipulate maps, including adding and removing layers, etc. Tutorials can be found at: https://www.esri.com/en-us/arcgis/products/arcgis-online/resources

Accommodations-Modifications: Students may need additional support using ArcGIS

Activity- A Refuge for Rattlesnakes

Begin by reading through this fact sheet about New Mexico ridge-nosed rattlesnakes and threats to them and their habitats Definitions of bolded words can be found in the Share with Wildlife Program Glossary.

NM ridge-nosed rattlesnake in Hidalgo Co., NM

The New Mexico (NM) ridge-nosed rattlesnake *(Crotalus willardi obscurus)* is 1 of 5 known **subspecies** of the ridge-nosed rattlesnake. It grows to be 1-2 feet long, which is fairly small for a rattlesnake, and is grey or brown-grey in color, with distinctive light lines bordered by darker lines across its back.

In New Mexico, these snakes are found only in Hidalgo County in the southwestern part of the state, in small areas of the Animas and Peloncillo Mountains.

Their **habitat** is in canyons, often near drainages. They need wooded areas with oaks and/or **conifer** trees (i.e., junipers or piñons) and enough tree **canopy** cover, along with open areas and steep slopes covered in vegetation, including bunchgrass and beargrass.

The diet of this rattlesnake primarily consists of lizards, centipedes, small mammals, and passerine birds such as perching birds or songbirds.

Ridge-nosed rattlesnake in its habitat (can you spot it?)

These are species living in Hidalgo County that the New Mexico ridge-nosed rattlesnake might consume.

| Greater short-horned lizard | Common desert centipede | Pygmy mouse | Yellow-eyed junco |
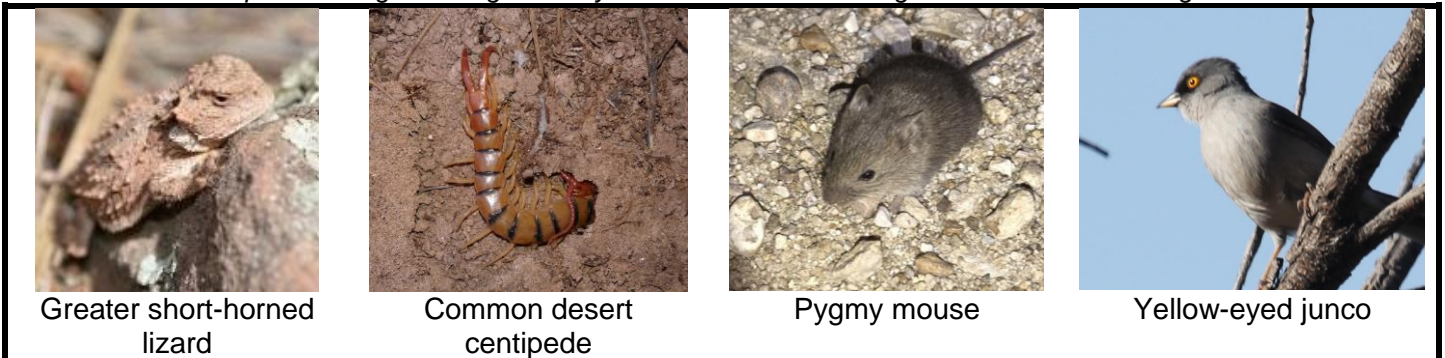
Why protect rattlesnakes?

Rattlesnakes are not the vicious, scary predators they're often made out to be. Humans are far more likely to harm them than rattlesnakes are to bite a human. In fact, snakes rattle when we get too close so that we'll go away. They do not want to bite us, as it takes a lot out of them to attack and inject their venom. The prey of the ridge-nosed rattlesnake is much smaller than a human. Snakes help control the sizes of rodent and insect populations and keep them from getting too big, which is helpful for humans. By controlling populations of "pest" animals, they lower the risk of diseases being spread to humans by rodents and tick-borne bacteria.

23

Predators, including birds of prey and some mammals, rely on rattlesnakes for food. Without snakes, food chains would lose a very important link.

Part 1: Management Plan for the Rattlesnake

Imagine that you are in charge of the protection of the NM ridge-nosed rattlesnake. Gain knowledge of the various threats to this species and their habitat and the protections in place. You will then design a protection plan for this species' survival and health into the future. *See the guidelines for what to include in your plan at the bottom of this activity.*

The following sections cover the biggest threats to the snakes in the last 60 years

Cattle grazing

Cows eat grasses and other vegetation in large quantities and are often free to roam across the land, including through mountainous areas. They disturb leaf litter in canyon bottoms as they trample through.

The rattlesnakes need leaf litter, loose rocks, or grasses and other vegetation on the ground to hide under. Think about what plants their prey animals may need as well.

Cattle grazing, BLM,
https://www.flickr.com/photos/blmoregon/35598758355/in/photostream/https://www.flickr.com/photos/blmoregon/35598758355/in/photostream/

Climate change

New Mexico is the 6th fastest warming state in the country, and average annual temperatures are expected to rise 3.5-8.5°F over this century. Scientists predict seasonal changes including earlier springs, hotter summers, warmer falls, and unpredictable temperatures in winter.

Overall, there will likely be less **precipitation** due to the changing climate, including less snow, and more drought. At the same time, there may be more extreme monsoons and snowfall events (with lots of rain or snow falling in a short period of time instead of spread out during the entire season). This would cause more flash floods in rivers and through canyons, with so much water coming down in a short time that it cannot be absorbed by the dry soil.

A climate model looking at predictions through 2080 found that the climate conditions these snakes live in now will shift roughly470 miles north (like as far north as Flagstaff, AZ). There will be no areas with suitable climate conditions for the rattlesnake within their current range by 2080.

Ridge-nosed rattlesnakes live in areas called "sky islands." They are called "sky islands" because they are mountains with very different habitats than what is found in the surrounding, low elevation areas. In these "sky islands", snake populations on one mountain are separated from other populations found high on other mountains. Will they be able to migrate if the temperatures keep increasing and weather patterns continue to change? Think of how **climate change** may affect their prey and the plants that both the snakes and their prey need.

Collection

In 1957, a ridge-nosed rattlesnake was found in the Animas Mountains, and this sighting was published. People liked the look of the snake's markings, and they started coming from around the country to find a rattler of their own through the 1960's and 70's. The snakes became valuable in the pet trade and could also have been killed by some collectors to make into decorative objects or as hunting trophies.

Collectors overturned rocks and logs using crowbars, even used gasoline in attempts to find the snake, and

trampled plants as they searched, thereby destroying habitat. While no historic population counts or data on snakes collected exist, the New Mexico Department of Game and Fish included estimates in their "New Mexico Ridgenose Rattlesnake Recovery Plan". In 1985 that there may have been no more than 500 individuals alive at a time in the 1960's, and perhaps 130 snakes were collected from 1961-74 if 10 were taken per year.

There are no recent, known records of collection, as this would be very hard to catch in the remote areas where this species lives, but the snakes would probably get a high price on the black market due to their beautiful, unique appearance.

Disease

These snakes can be infected by bacteria, viruses, and other microorganisms and come down with a variety of diseases that can kill them. They are known to die from disease, but no research has been done into how many or if it is a large problem for them. In captivity, they are especially prone to disease. If many in a population *were* to ever be infected and die, they are not close to any other populations that could move into the area.

Snake fungal disease on broad-headed snake, Adelaide Zoo.

Fires

With climate change leading to more drought and rising temperatures, the risk of fires goes up. Larger, more intense fires break out, because of weather conditions and since humans suppressed fires for many years, so trees and dead wood have built up and provide large amounts of fuel for wildfires. The fire season has increased from 5 to 7 months over the past 40 years.

A trend of more and worse fires is expected to continue. Intense fires kill all trees and other plants in their path. They can move very quickly and suddenly through canyons, making it hard for animals to escape in time.

Fire is expected to have the most impact in the highest elevations of the NM ridge-nosed rattlesnake's range.

Limited range

In New Mexico, the main known range of this rattlesnake subspecies is in the Animas Mountains. (To visit a 3D aerial view of this range, complete Part 2 of this activity.) The only other places they are found is in small portions of the Peloncillo Mountains in New Mexico and Arizona, and the Sierra San Luis mountains in Chihuahua, Mexico.
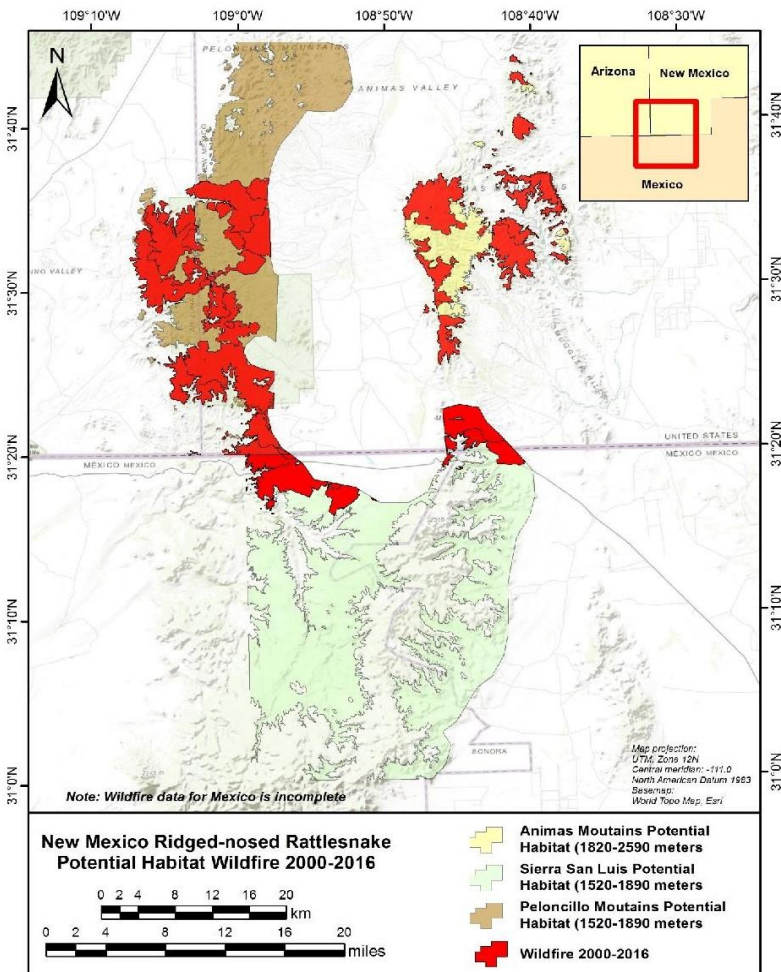
Map taken from NM ridge-nosed rattlesnake 5-yr review (2019), U.S. Fish & Wildlife Service

Because of these small, separated populations at high elevations in each mountain range, the snakes don't have a lot of genetic diversity and

have become inbred, so they can more often have deformed rattles and other health issues.

Mining
In 1880, the arrival of the railroad started up a large mining industry in the region. Small mines were dug in the Animas and Peloncillo mountains. As of 1965, Hidalgo County (the county these mountains are in) had the second highest number of mines for non-radioactive minerals of all counties in New Mexico. Most of the mines in Hidalgo County are copper mines, with some for gold and silver. However, only 1 mine is listed as having been in the **critical habitat** of the snake in the Animas Mountains.

Nowadays, no active mines are shown to be within the critical habitat of the rattlesnake. You can view a mines map of the area at https://thediggings.com/mining-districts/nm2255/map

Predation and Killing

Photo © Jim Rorabaugh

Predators of adult rattlesnakes can include owls, eagles, and hawks that swoop down from above to grab them in their talons. Land predators, like coyotes and foxes, will eat them if they have the chance. Newborn snakes can be hunted by a lot more animals, including raccoons, roadrunners, crows, and skunks,

Deer and horses have been known to stomp on a rattlesnake with their hooves to kill it if they are feeling threatened, though they will not eat it.

As explained above, humans were a large threat to these snakes as well due to collection activities. It's hard to know if collection by people is still a major cause of snake death.

Looking at this snake, how do you feel about it? Do you know what your family or friends might say or do if they encountered it? Consider the physical and behavioral adaptations that may help this snake survive and any features that actually might lead to it being harmed.

Low Reproductive Rate
NM ridge-nosed rattlesnakes breed in June through October. The females are then pregnant for up to a year or a little more! They appear to need a cool winter season before giving birth the following summer to an average of 4-8 live babies.

You can watch this video of another local species of rattlesnake, the western diamondback, giving birth to live baby snakes at a zoo: https://youtu.be/gvol8ORlwc4

If many snakes die due to any one of the other threats listed above, population numbers will be slow to increase again, because of how long it takes to birth young.

The following protections exist for NM ridge-nosed rattlesnakes:

- In 1974, Mr. Peter Wray, owner of the Pruett-Wray Cattle Company that owned the Animas Mountains, signed an agreement with the U.S. Fish and Wildlife Service to stop allowing people onto the land and to protect the snakes' habitat by reducing cattle grazing.

- Since 1975, the NM ridge-nosed Rattlesnake has been listed as an **endangered** species by the State of New Mexico, protected under the New Mexico Wildlife **Conservation** Act. This act makes it illegal to "harass, hunt, capture, or kill any wildlife" that is protected under it. A scientific collection permit is required to capture, harass, or possess a rattlesnake (alive or dead). It is also listed as a "Species of Greatest Conservation Need". State laws do not protect their habitat or address the causes of their endangerment.

- Since 1978, the U.S. Fish and Wildlife Service has listed the NM ridge-nosed rattlesnake as **threatened** under the **Endangered Species Act**. It is against Federal law to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" them. They also designated the western part of the Animas Mountains, in Bear, spring, and Indian canyons from 6,200 to 8,532 ft. elevation, as critical habitat for the snake, thereby protecting it. It is one of few **venomous** snakes to be listed as threatened. Due to this federal listing, a federal permit is required to do hands-on research on this species.

- In 1982, American Breco Corporation bought the Animas Mountains and did not renew the agreement that Mr. Wray had signed, so it was not as protected anymore.

- In 1990, most of the Animas range was bought by The Nature Conservancy and sold to the Animas Foundation in the mid-90's. The Diamond A Ranch, as it is called, is thought to be tightly controlled, with little to no access allowed by outsiders.

Now it is time to take what you have learned from the above information, utilize your own prior knowledge, critical thinking skills, and creativity, and write a plan for the protection of the NM ridge-nosed rattlesnake for the next 30 years.

Include in your plan:
- Which threats seem to have had the biggest impacts on these snakes in the past, and why you think so? *(You do not need to discuss all threats.)*
- Which threats you predict will have the biggest impacts on them in the future and why.
- What protections or laws are already in place that you will continue to support?
- New regulations or laws that you would support or work to have passed.
- Actions you will take and/or encourage others to take to help the rattlesnakes survive.

Part 2: Rattlesnake Range Mapping Activity

Pop yourself into this interactive map to explore the critical habitat of the NM ridge-nosed rattlesnake in the Animas Mountains!


Click on the link to go to a digital map of NM ridge-nosed rattlesnake habitat:

https://arcg.is/054O9T

Use these screenshots to help you navigate through the map. Play around with it until you feel comfortable navigating (like how you might in a video game). You can use the

plus/minus signs to zoom in or out on the screen.

Once you have a good aerial view of the rattlesnake's critical habitat, use the "Analyze" tool to outline the shape as best you can to calculate the area of the snake's critical habitat in square miles.
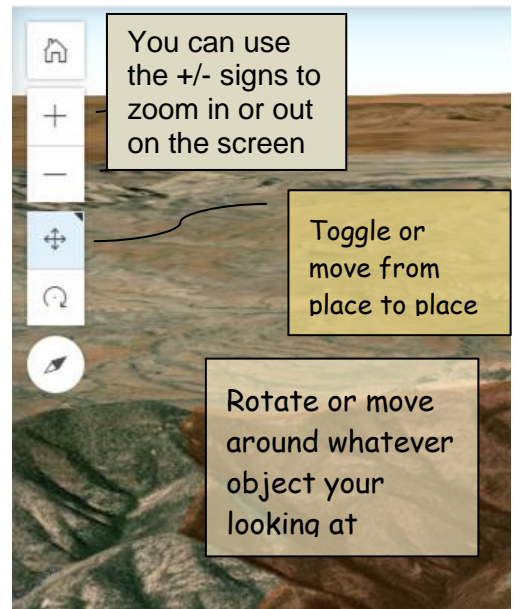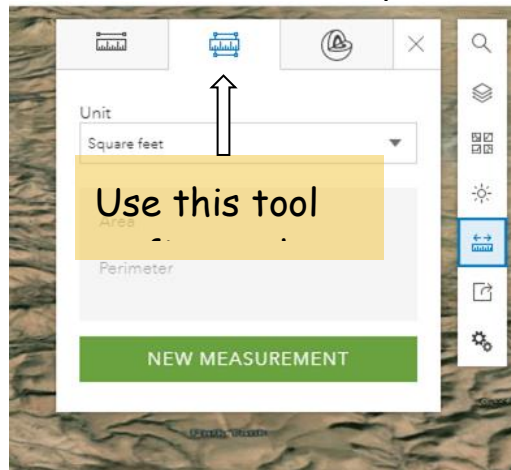
1. What area (in square miles) did you calculate on the map for this snake's range?

2. Explain why mapping critical habitat and knowing its area is significant if you are studying or managing the survival of these snakes.

3. Are there any other features you notice about the mountain range or the surrounding landscape that could affect the snakes? (For example, human impacts, possible locations of running water, etc.) Are there things you wish were visible on this map to help you have a more informed answer?

4. Why don't you think these snakes have been found in a larger area of the Animas Mountains or in other nearby mountain ranges?

Lesson Plan- Mexican Spotted Owls

Title of Lesson: Mexican Spotted Owl's Predicament	By: Vanessa Barela
Content Area: Science	
Materials Needed: Optional - rulers, calculator	
Handouts Attached Below: Mexican Spotted Owls Predicament	
Standard Addressed: MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5 (If extended with lesson conclusion), MS-ETS1-1	
DOK: 4	
Skill to be Maintained: Interpreting primary resources	
Essential Question: How does human activity impact the Mexican spotted owl's habitat and recovery?	
Academic Vocabulary/Word Wall words: mortality, threatened, habitat, conifer, humidity, canopy	
Brain Drain or Warm Up Activity: Have students recall their 5th grade field experience at the Sandia Mountain Natural History Center or another trip they may have taken to an area like the Bosque or Rio Grande Nature Center. What importance does water play in the lives of the animals that live there? What about the trails humans use? How do we respectfully observe wild animals in nature?	
Basic Lesson Description and Procedure: 1. Students will read about Mexican spotted owls and determine the ideal habitat for an owl based on images of forest types. 2. After determining ideal habitat, students will use a double bubble map to compare and contrast two of the habitat images of their choosing. 3. Students will use information from primary resources to determine if they believe that the proposed trail is too close to the owl's nest.	
Observation Activity: If SMNHC staff are able to present, staff can present on data they have about owls in the area, show owl pelts, and demonstrate owl calls.	
Lesson Conclusion/Potential Practice at Home Students could send in their letters to the Forest Service representative or create a presentation summarizing their findings. Students can design a management plan.	
Accommodations-Modifications: Primary resources may be difficult to read in their entirety. Chunking them or dividing them among a group can make them easier to understand.	

Activity-Mexican Spotted Owls (*Strix occidentalis lucida*) Predicament

Directions Part 1: Read this information page about Mexican spotted owls (MSO). After you have learned about MSOs, you will determine the ideal habitat for an owl based on images of forest types, and then you will use your knowledge to complete part 2. Definitions of bolded words can be found in the *Share with Wildlife Program Glossary.*

Figure 1: Mexican spotted owl

Where they live

The MSO occurs in disjointed areas corresponding to isolated mountain systems and canyons. The estimated number of occupied owl sites is 1000 in the U.S. and 100 in Mexico. Lincoln National Forest in New Mexico has approximately 136 sites of owls with the most in Cloudcroft, New Mexico with 109 sites. The Sandia Mountains can be home to MSO, however, there have been no positive sightings of MSO in these mountains since 2009 using the U.S. Fish and Wildlife procedures for finding MSO. A MSO was seen in the spring of 2018 near the Sandia Mountain Natural History Center (SMNHC)) by two employees and a volunteer. SMNHC staff has been unable to find the owl's nest.

Mortality Factors- Reasons for Endangerment

Predators

Mexican Spotted Owls have a few reasons that they are listed under the Endangered Species Act as **threatened**. The first is predators. Great horned owls are the most competitive species with the MSO. They live in similar **habitat** and will eat a MSO given the opportunity. Other types of birds that might be a predator are northern goshawks, red-tailed hawks, and golden eagles. There are also ground predators (ringtails, raccoons, long-tailed weasels) that sometimes raid nests housing eggs and young. House cats are an increasing problem in urban interface areas.

Figure 2: Great horned owl

Starvation

The young are most susceptible to starvation; the most aggressive young get food first from their parents. After they have left the nest, young MSOs have poor hunting skills after fledging. (Even adults look clumsy when hunting!). Where there is overlap with barred owls, the barred owl has more common habitat and prey than the MSO, so it becomes a competitor for resources.

Accidents, Disease, and Parasites

Accidents are usually human-caused; they can result from a car hitting them or their running into power lines or telephone lines. Accidental destruction of habitat can be a big problem if a bird was nesting there, especially if it was a mother with young. Not much is known about disease and parasites. They do exist, but the MSO seems to be highly resistant.
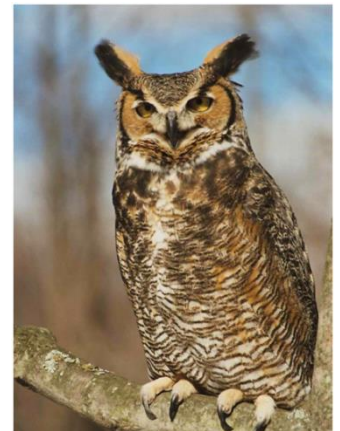
MSO have a variety of habitats they can live in: mixed-**conifer** and pine-oak forests, riparian habitats, and rock-walled canyons. In forested areas, MSO ideally like to use areas with a multi-layered **canopy** with large overstory trees and a moderate to high canopy closure, meaning not too much sunlight comes through. The trees should be different sizes and ages, with some large snags (standing dead trees) and downed woody debris.

In rock outcrops or other rocky areas, they like to live on steeper slopes with an elevation generally between 5,000 and 9,000 ft. The canyons they live in frequently contain riparian or conifer pockets, but may also have little forest structure.

Regardless of specific habitat type, the areas where the MSO lives are typically cool have high **humidity**, and several vegetation layers present like grasses, forbs, shrubs, and shrubby trees. Mexican spotted owls nest in witches brooms, rock outcrops, tree cavities, ledges, old raptor, or stick nests, caves, and squirrel nests.

Forest Cover Types

Mixed-conifer	Rock-walled Canyons
Pine-oak	Riparian

Directions: Using your knowledge, look at the images below. For each photo, answer the following questions. Is this habitat good for the MSO; is it poor for the MSO? Which habitat looks the best to raise young? Explain your reasoning in complete sentences. If you need more space, please write on a separate piece of paper.

Directions: Using the double bubble map, pick two of the ecosystems shown in the four photos from the Forest Cover Types and compare and contrast them. You can add more circles if you need.

Ecosystem

Ecosystem
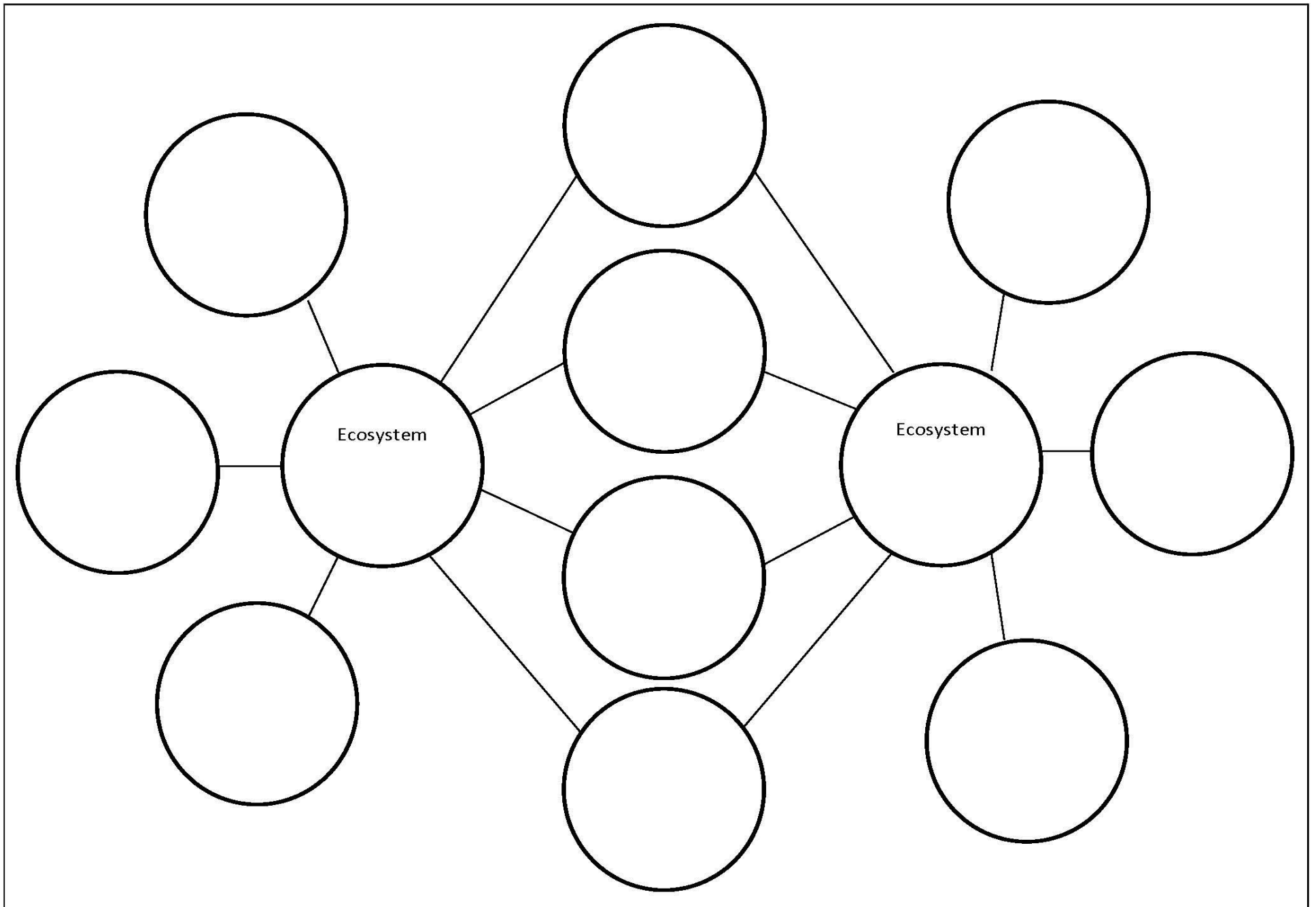
Activity Part 2

Directions: Using the information contained in the letter below, the map of Mud Spring near Sandia Mountain Natural History Center, graphs of animal sightings near Mud Spring, and images of Mud Spring, construct an argument for or against the two proposed trails. One is a 3-mile mountain bike trail and the other is a proposed trail for foot traffic. A box is drawn on the maps to help you focus on the proposed trails. SMNHC's trail map is also included. Consider the habitat that the MSO needs. By law, a MSO requires a Protective Activity Center (PAC), which consists of 600 acres of the best possible habitat, surrounding the nest or activity center of the owl. Is the proposed trail too close to the owl's nest? These are actual letters, maps, and images of the area. The MSO's home is marked with a star and SMNHC is marked with a bear paw. Your teacher will let you know if you are going to complete the practice at home section.

Figure 3: Proposed Trail Letter

USDA	United States Department of Agriculture	Forest Service	Cibola National Forest and National Grasslands	Sandia Ranger District 11776 Highway 337 Tijeras, NM 87059 505-281-3304 Fax: 505-281-1176

File Code: 2310; 1900
Date: June 28, 2019

Dear Interested Party:

The Sandia District of the Cibola National Forest and National Grasslands proposes the Sandia Trails Improvements project to expand and improve recreational opportunities and access points for the Sandia Ranger District designated trails system. Trails on the Sandia Ranger District are highly sought after for recreational opportunities of various types due to their close proximity to the Albuquerque metropolitan area. The current designated system of trails on the Sandia Ranger District provides an inadequate number and type of opportunities for the current and anticipated levels of use. Ever-increasing demand for trail-based recreation opportunities has contributed to the proliferation of user-created trails and parking areas resulting in varying levels of damage to natural, cultural and wilderness resources as well as contributed to recreational user conflict.

The project is needed to expand existing trail systems on the Sandia Ranger District, reduce the proliferation of user-created trails and associated parking areas and ensure the designated trail system(s) are designed and managed to reduce the overall maintenance burden, and establish a sustainable trail system. There is also a need to balance the provision of recreation opportunities with protection of natural, cultural and wilderness resources and addressing recreation conflicts.

The project area lies within "Management Area II" according to the 1985 Cibola National Forest Land and Resource Management Plan with an emphasis on "providing opportunities for a variety of year round recreation experiences consistent with the guidelines established for maintaining viable wildlife populations and ecosystem health." The project encompasses the following actions to address this emphasis.

Three areas of the Sandia Ranger District (Placitas, Sandia Mountains, and Casa Loma (see enclosed map (overview) 1 of 5)) are being proposed for improvements as follows:

- Designate as National Forest System Trail (NFST) approximately 11 miles of user-created trails. Implement trail maintenance projects including small scale relocations to improve sustainability.
- Construct approximately 27 miles of new multi-use, non-motorized NFST.
- Construct (and designate as NFST) approximately 3 miles of purpose-built cross-country skiing trails. Prohibit all other uses on designated trails.
- Designate (as NFST) and rebuild approximately 3 miles of user-created purpose-built mountain bike trails. Prohibit all other uses on designated trails.
- Decommission/rehabilitate approximately 7 miles of user-created trails and prohibit further use.

36

- Install barriers at a select number of informal parking areas/trailheads along FS Rd 445 to prevent further resource damage and expansion. Close/rehabilitate a number of informal parking areas and cross-country motorized routes along 445.
- Designate (as NFST) 1.5 miles of user-created trails west of Sandia Museum of Natural History. Trails will be designated as open to foot traffic only.

Providing Input

I value your interest in the management of the Sandia Ranger District, Cibola National Forest and Grasslands. I will begin preparation of a categorical exclusion in order to determine the potential effects of this proposed action under 36 CFR 220.6(e)(1). Your input on the Sandia Trails Improvements Project will be essential to assisting the District in their environmental analysis efforts. Scoping for this project will begin on Monday, July 1, 2019. Comments received by July 30, 2019 will be most helpful. Please send your comments to the project manager, Kerry Wood, at Kerry.wood@usda.gov with Sandia Trails Improvements in the subject line or to the following address:

Cibola National Forest
Attn: Kerry Wood
2113 Osuna Road NE
Albuquerque NM 87113

I will respond to any significant issues identified from public comments within the Decision Memo.

Sincerely,

CRYSTAL POWELL
District Ranger

Figure 4: Proposed trail map. Star marks location of a MSO. Box represents the area to focus on. Focal trails for this exercise have single (3-mile trail) and double (1.5-mile trail) crosshatches.

PROPOSED TRAIL DECOMMISSION/REHABILITATE
PROPOSED DESIGNATION OF USER TRAIL*
PROPOSED DESIGNATION OF USER TRAIL (OPEN TO FOOT TRAFFIC ONLY)
PROPOSED NON-MOTORIZED, MULTI-USE TRAIL CONSTRUCTION
PROPOSED PARKING BARRIER ACTION
NATIONAL FOREST SYSTEM TRAIL
BERNALILLO COUNTY OPEN SPACE

*The Forest Park Trail and Casa Loma Trail are both formerly designated National Forest System Trails that were put in decommissioned status due to limited/no legal public access. Both trails continue to be used by a limited number of users. With construction of the north/south trail east of the Wilderness boundary, legal access will be restored thereby creating a need to re-designate both trails.

FOREST PARK TRAIL

PERIMETER BARRIER INSTALLATION

OJITO de SAN ANTONIO OPEN SPACE

0   0.075 0.15   0.3   0.45   0.6
                                              Miles
Copyright © 2013 National Geographic Society, I-cubed

38

SANDIA TRAILS IMPROVEMENTS PROJECT

MAP 5 OF 5 NAD 83 1:12,000   The Cibola National Forest uses the most current database available. Updates occur as new information becomes available. No warranties are made regarding the accuracy of these data.

USDA

Figure 5: SMNHC trail map. Star marks the location of a MSO. Mud spring is found near the star as well. The box is your focus area same as above.
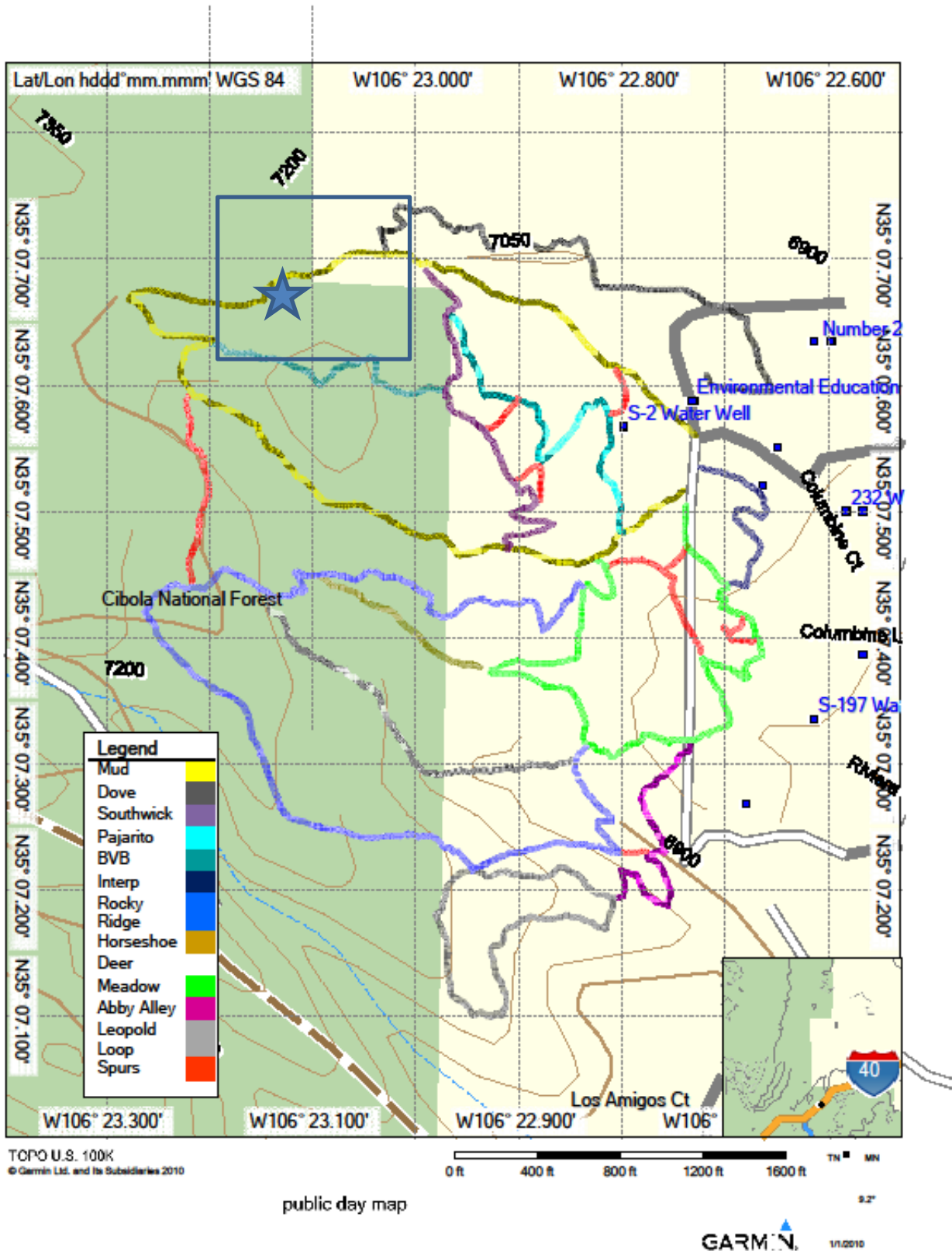
Figure 6: Animals at Mud Spring
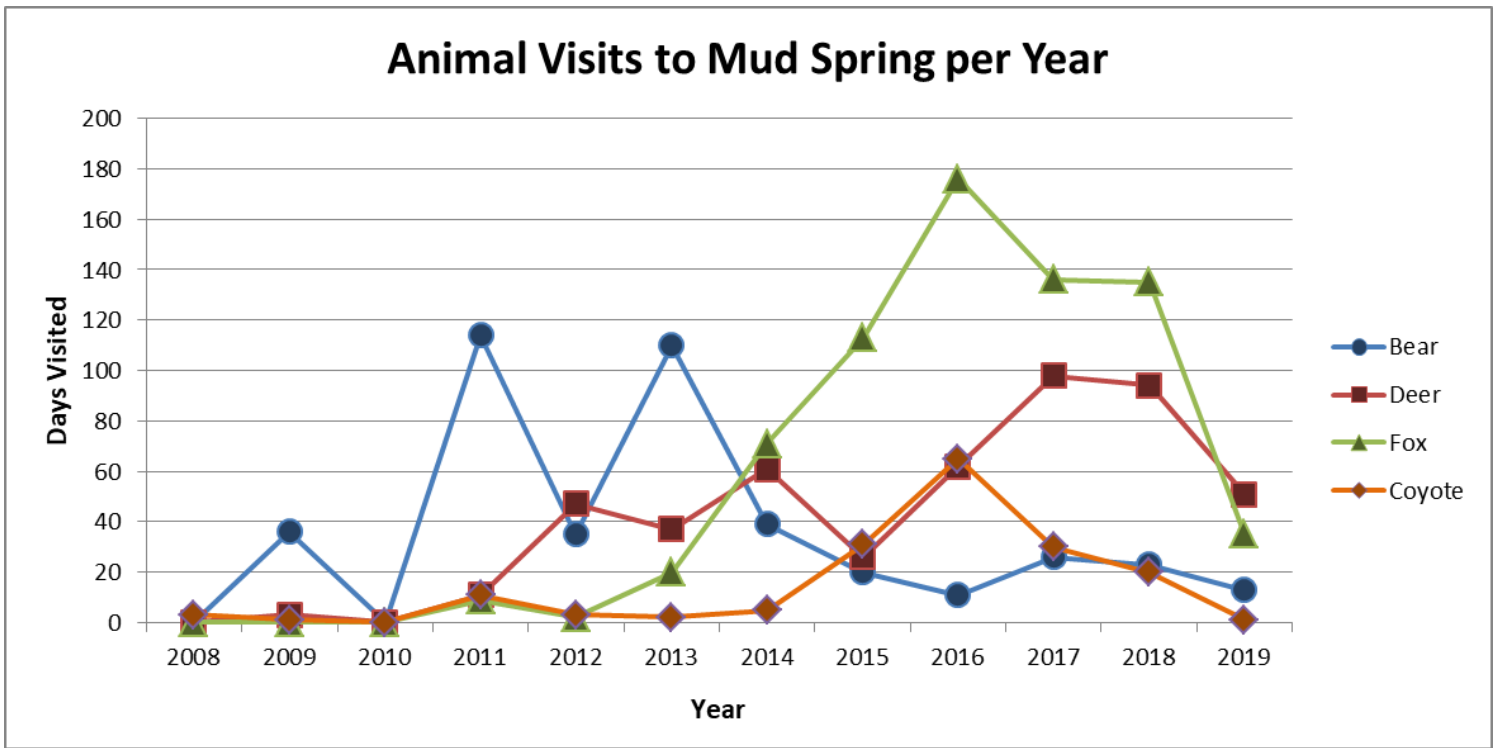
Spotted Owl (*Strix occidentalis*)
Subspecies Distribution

California Spotted Owl
Strix occidentalis occidentalis

Mexican Spotted Owl
Strix occidentalis lucida

Northern Spotted Owl
Strix occidentalis caurina

States

1:18,000,000

0 70 140   280   420   560
Mi

0 137.5275   550   825   1,100
Km
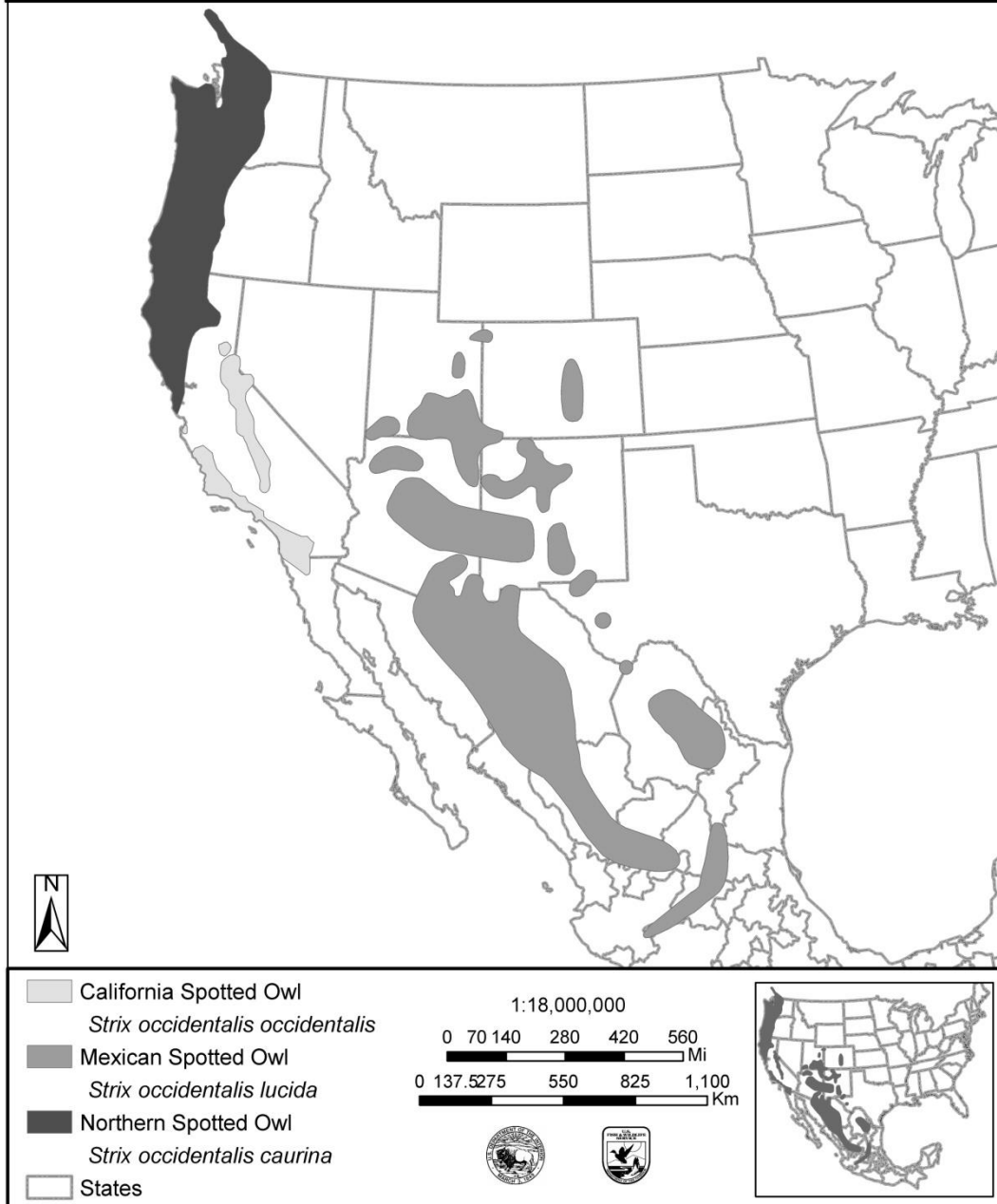
Mexican Spotted Owl
Ecological Management Units
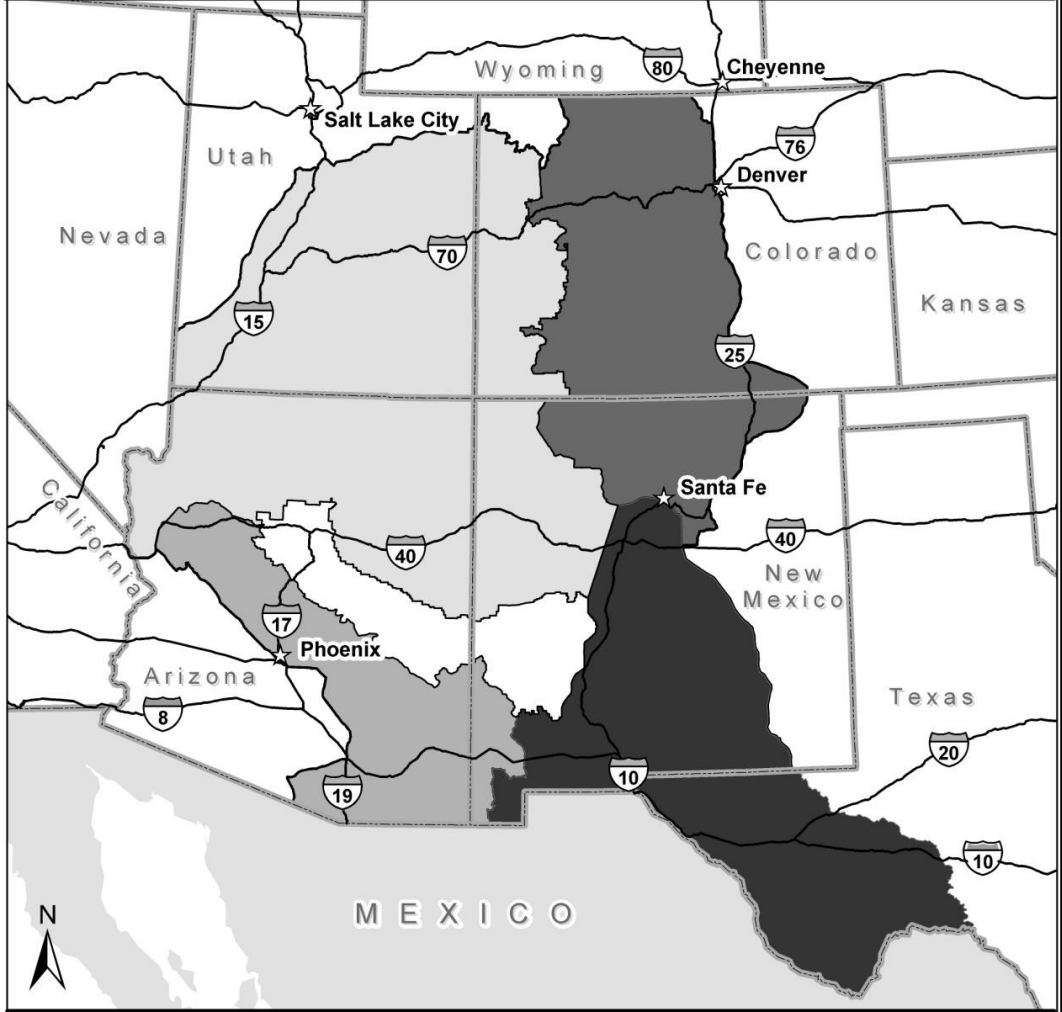
Major Cities: ☆
States
Colorado Plateau EMU
Upper Gila Mountains EMU
Basin and Range East EMU
Basin and Range West EMU
Southern Rocky Mountains EMU

1:7,250,000

| 0 | 30 | 60 | 120 | 180 | 240 |
Mi

| 0 | 62.5 | 125 | 250 | 375 | 500 |
Km
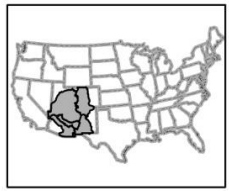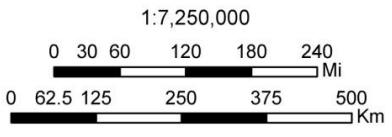
Lesson Plan- Rio Grande Silvery Minnow Controversy (*Hybognathus amarus*)

Title of Lesson: Rio Grande Silvery Minnow Controversy	By: Vanessa Barela
Content Area: Science	
Materials Needed: none Possible:	
Handouts Attached Below: Rio Grande Silvery Minnow Controversy	
Standard Addressed: MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ETS1-1	
DOK: 4	
Skill to be Maintained: Interpreting primary resources	
Essential Question: Why is the Rio Grande silvery minnow controversial? How does the Rio Grande silvery minnow keep the river flowing?	
Academic Vocabulary/Word Wall words: reservoir, range, endangered, critical habitat, habitat, irrigation, conservation, Endangered Species Act, sedimentation, water rights	
Brain Drain or Warm Up Activity: Discuss with students water in New Mexico. What do they know about the Rio Grande? What outdoor recreation activities do they enjoy that are in the water? (Fishing, boating, kayaking, etc.)	
Basic Lesson Description and Procedure: 1. Students will read about the Rio Grande silvery minnow. 2. Students will complete the River Changes activity using images from Bosque Ecosystem Monitoring Program (BEMP) and the Bosque Education Guide, selecting which area they think the Rio Grande silvery minnow would live, and answering comprehension questions. 3. Students will interpret primary resources (i.e., articles) and create a water management plan for the Rio Grande that considers the needs of the silvery minnow.	
Observation Activity: Student could optionally have a debate for or against the conservation of the Rio Grande silvery minnow.	
Lesson Conclusion/Potential Practice at Home Students can learn more about river flow and changes along the Rio Grande and complete activities from BEMP or the Bosque Education Guide about the Rio Grande.	
Accommodations-Modifications: Primary resources may be difficult to read in their entirety. Chunking them or dividing them among a group can make them easier to understand.	

Activity- Rio Grande Silvery Minnow
Controversy *(Hybognathus amarus)*

Read this information page about the Rio Grande silvery minnow. After you have learned about the Rio Grande silvery minnow, you will determine where the Rio Grande silvery minnow would like to live based on diagrams of the Rio Grande and then you will construct a plan for balancing competing water use needs for part 2. Definitions of bolded words can be found in the Share with Wildlife Program Glossary.

Where they live

The Rio Grande silvery minnow historically occupied approximately 2,400 miles of river in New Mexico and Texas. It lived in the Rio Grande from Española, New Mexico to the Gulf of Mexico. It was also found in the Pecos River, a major tributary of the Rio Grande, from Santa Rosa, New Mexico, downstream to its confluence with the Rio Grande in Texas.

Currently, the Rio Grande silvery minnow is known to occur only in a small part of the Rio Grande in New Mexico, a 280 km stretch of river that runs from Cochiti Dam to Elephant Butte **Reservoir.** This means that, today, it lives in only 7% of its former **range**. The Rio Grande silvery minnow was listed as federally **endangered** in 1994 and **critical habitat** was designated in 2003.

Mortality Factors- Reasons for Endangerment

There are a few reasons that the Rio Grande silvery minnow is endangered. A few threats are loss of and changes to its **habitat**. Other reasons include water pollution, competition, and predation.

Loss of Habitat

The Rio Grande used to be a river that flooded and expanded with the seasons. The river was wide, with a sandy bottom, floodplain lakes and marshes, and woody debris. In the past 150 years, the river has changed due to human impacts. Dams, **irrigation** diversions, levees, and other human-built diversions changed the flow of the river and made it flow straighter, causing a loss of habitat suitable for the silvery minnow.

Water Pollution

The water in the Rio Grande can be contaminated from many sources, including oil, pesticides, and other pollutants, that collect in or on the soil or on paved surfaces, such as roads and parking lots, that wash into the river when it rains.

Disease and Predation

As the habitat of the Rio Grande silvery minnow changed and the river became straighter and narrower, the fish was confined to smaller areas. Stress associated with these habitat changes and the above-mentioned pollution and weakens the minnow's immune system, which can make it easier for the minnow to catch a disease. Having smaller areas of the river where the minnow can live also means that there are fewer places for the minnow to hide from predators, including other fish, birds, and mammals. It also means that more species are competing for resources in a smaller area.

Characteristics of Good Habitat

The Rio Grande silvery minnow uses only a small portion of the available aquatic habitat. The minnow requires that the flow is low or moderate in velocity (speed and direction) and prefers to use silty areas. The silty areas are usually formed by eddies, debris piles, pools, or backwaters. They also can be found in habitats with mud or sand at the bottom. The Rio Grande silvery minnow is rarely found in high velocity water. It prefers a shallow depth of less than 20 cm in the summer and 31-40 cm in winter. It can rarely be found in water deeper than 50 cm. The Rio Grande silvery minnow feeds on

diatoms, algae, sediment, and plant material it finds on the bottom of the river. In the wild, this species usually lives 1-2 years. It spawns in the spring and summer and releases from 1,000 to 4,000 semi-buoyant eggs.

River Changes Activity

For this activity, you are going to use the three images below from the Bosque Education Guide. You will identify the areas you think the Rio Grande silvery minnow would prefer to live and the ideal habitat for the minnow. After you have drawn where you think the fish would live on the below three images of the Rio Bravo, Manso, and Nuevo, you will use the box provided to write where you think it would like to live and justify your answer. For historical context, you are also provided the River of Change Model from BEMP.

86

River Model Activities
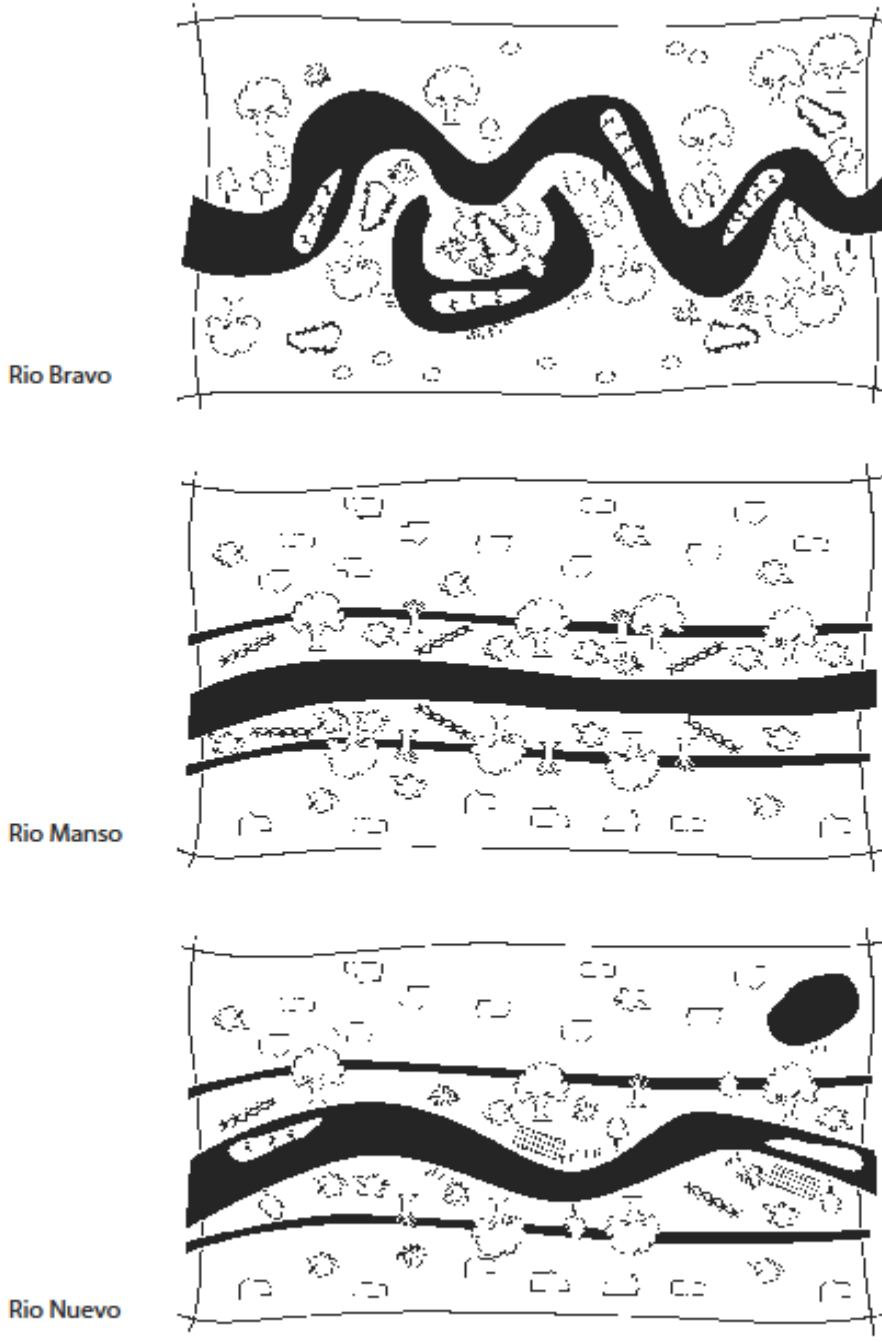
Rio Bravo

Rio Manso

Rio Nuevo

Lower Rio Grande Edition

47

2000 years ago – Rio Bravo

1. **1600 years ago** First permanent Puebloan settlements along the Rio Grande. Add a few pueblos and agriculture fields

2. **750 years ago** Major drought in the SW, the Rio Grande becomes a focus for Puebloan settlement. Add more pueblos and agriculture

3. **400 years ago** Spanish begin settling in New Mexico. Violent conflicts with Puebloan people led to the **Pueblo Revolt** in 1680. Remove some pueblos and replace with European settlements

4. **300 years ago** City of **Albuquerque** founded in 1706. Add more European settlements

5. **1870s-1940s** Large floods occur, population increases, over grazing leads to erosion & more sediments in the river.

6. **1900s** Saltcedar and Russian olive are introduced as garden plants but they SPREAD into the wild. Add exotic trees

7. **1920s** Levees and ditches were constructed to limit flooding. Add levees and ditches

8. **1941** Rio Grande floods over levees for the last time. One of the last times cottonwood seedlings sprout naturally. Add snags to river and over levees. Add some CW seedlings to banks

9. **1957** Jetty Jacks are placed along riverbanks.

10. **1965 - 1975** Cochiti Dam built. Place dam on model

11. **1996** First BEMP site! Place three BEMP sites along the river

Today!

BEMP Bosque Ecosystem Monitoring Program

River of Change

Rio Manso

Using the space below write where you think the Rio Grande silvery minnow would prefer to live in the above images of the Rio Bravo (how the Rio Grande looked 2,000 years ago), Manso (how it the Rio Grande looks today), and Nuevo (how it could look in future with habitat improvements) and justify your answer.

Answer the questions below to help prepare you for Part 2 of this activity.

1. What year was the Rio Grande silvery minnow placed on the Endangered Species List?

2. What percentage of the river does the minnow currently use as its habitat?

3. List the top reasons the minnow is endangered:

4. What is the ideal habitat for the minnow? Identify depth and velocity of the water based on your reading.

The Rio Grande silvery minnow is surrounded by controversy when it comes to its conservation**. These quotes come from three sources over a period of years. Now, respond to the following situation. You are appointed as the new manager for the flow of the Rio Grande and you have to ensure that New Mexico provides the required water to Texas, cities, and farms in New Mexico, but also keeps the Rio Grande silvery minnow alive. How would you respond to both sides of the issue of conserving the minnow? What issues can you identify related to conserving the minnow? How could you keep all sides of the issue happy? You may use a separate piece of paper to draft your response.**

Quote 1

"For more than a decade, activists have used **Endangered Species Act** protections for species like the silvery minnow as a way to protect the Rio Grande itself.

Last year, the Middle Rio Grande dried between the town of San Antonio and the southern boundary of Bosque del Apache National Wildlife Refuge

"The river can't do it all," said Pelz. "It's feeling the brunt of everyone's use—and it's the last being considered." Unlike in some states, New Mexico's rivers don't have rights to their own waters. In states like Colorado and Oregon, rivers have what are called "instream **water rights**." That is, water doesn't only belong to farmers or cities. Rivers also have an intrinsic right to some of their own waters to support ecosystems, fish and wildlife.

On the Middle Rio Grande, however, the 2003 plan's flow requirements were the only thing that kept longer stretches of the river from drying each summer." (Paskus, 2017)

Quote 2

"Water managers need to consider how much water cities and farmers need and also comply with the 1938 Rio Grande Compact and ensure water deliveries to Texas. Federal laws even control how much water can be stored in which reservoirs, when and under what circumstances. For example, if levels at Elephant Butte Reservoir—which stores water for Texas as well as farmers in southern New Mexico—are below a certain level, water can't be stored at upstream reservoirs that were built after 1929.

Making any changes to the Rio Grande Compact would require not only an act of Congress. They would also need to be ratified by the state legislatures in Colorado, New Mexico and Texas." (Paskus, 2017)

Quote 3

"Efforts to stabilize or restore aquatic ecosystems create substantial pressures to leave water in place, often quite far down the river reaches. The allocation of water for ecosystem maintenance and recovery is likely to increase in the future and could contain the traditional ability of cities to dewater watersheds. The Endangered Species Act (ESA) is the major possible environmental constraint on urban water use. To date, many of the conflicts have pitted farms against fish, but the on-going efforts to save the silvery minnow in the Middle Rio Grande basin pits the fish against water-stressed Albuquerque and other New Mexico cities. For several years, temporary releases have kept the minnow alive, but in 2002 a federal district judge ordered the Bureau of Reclamation to release municipal drought reserve water directed from the Colorado basin by the San Juan-Chama project from an upstream reservoir. The court ruled that the U.S. Fish and Wildlife Service's jeopardy opinion, which recommended upstream storage rather than release, was arbitrary and capricious." (Environmental Law Institute Washington, D.C, 2005)

Quote 4

*"One of the things that we're working on right now is what can be done to reduce the potential for island formation downstream of the dam. Another major issue is **sedimentation** of the irrigation works. The problem seems to be getting worse and worse because we're getting sediment buildup upstream of the dam, we're having problems with sediment transport below the dam and the sediment up above the dam when we do get good flows gets pushed into the irrigation infrastructure. So it's causing a variety of problems. And then, after June 30 when a lot of the water gets diverted into the ditches and the channel gets dry below, there are implications not only for Isleta's religious and cultural practices, but also for endangered species like the silvery minnow. In 2005, there were over a hundred thousand silvery minnow that were rescued out of the floodplain when the flood flows subsided, so this is a really important area for a lot of reasons, for endangered species, and of course for culture for the Pueblo, and also as probably the biggest diversion for irrigated agriculture in the Middle Rio Grande valley." (Benevidez, 2008)*

Remember to respond to both sides of the issue as the water manager. How do you keep all sides of the issue happy?

Lesson Plan- Culmination Activity

Title of Lesson: Culmination Activity	By: Vanessa Barela
Content Area: Science	
Materials Needed: Dependent on presentation selected	
Handouts Attached Below: None	
Standard Addressed: MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ETS1-1	
DOK: 4	
Skill to be Maintained: Dependent on presentation selected	
Essential Question: Why are threatened and endangered species important?	
Academic Vocabulary/Word Wall words: none	
Brain Drain or Warm Up Activity: Review the five species that students have learned about	

Basic Lesson Description and Procedure:
  1.   Students will now complete a final presentation on one of the animals of their choosing.
  2.   Their final project can be one of any number of artistic presentations. Some ideas include: song, play, memes, comic, slide deck, video, poster, poem, or interpretive dance.
  3. Within their presentation, students should cover the following: species, why it is important, why it is threatened or endangered, how humans impact the species, and how we can help with the species' recovery.	

Lesson Conclusion/Potential Practice at Home Students can learn about other species that are threatened or endangered.	
Accommodations-Modifications: None	

Share with Wildlife Program Glossary

Adaptation- something an organism has that helps it survive in its environment; it could be a physical part of their body or a behavior. Adaptations evolve over time from mutations that happen in a species' genetic material.

Canopy- all of the crowns, or tops, of trees and plants; often referred to when talking about amount of cover (shade) that they provide to the ground or spaces beneath them.

Conifer- a tree that has cones and has needles or scales for leaves; usually is an evergreen (keeps green foliage year-round).

Conservation- protecting a species, ecosystem, or other part of the natural world from destruction, overuse, endangerment, loss/extinction, or anything that harms its health or balance.

Climate- average weather conditions and trends over a long period of time, often defined as a 30-year average.

Climate change- change over a long period of time to the temperature, precipitation levels, and weather patterns in an area (or across the planet); global warming is a major climatic change that is occurring.

Critical habitat- area(s) that contain all required needs of a threatened or endangered species; this habitat often needs special management and protection to help that species survive. Could include areas the threatened or endangered species doesn't currently occupy but that are important for the conservation of the species; this term is from the Endangered Species Act.

Diurnal- a species that is active mostly during the daytime.

Ecosystem- a biological community of interacting organisms and their physical environment.

Endangered- a species at serious risk of going extinct.

Endangered Species Act- passed by U.S. Congress in 1973; created to protect and help recover species that are threatened or endangered and the ecosystems these species rely on for survival. Species can be added or removed from protection under the act through a multi-step process.

Exacerbated- make (a problem, bad situation, or negative feeling) worse.

Extinction- the state or process of a species, family, or larger group having no living members.

Extirpation- removal or loss of a species from a particular area; also called "local extinction" (i.e., the species is present in other locations).

Global warming- a gradual increase in the overall temperature of the earth's atmosphere generally attributed to the greenhouse effect caused by increased levels of carbon dioxide, chlorofluorocarbons, and other pollutants.

Greenhouse gas- a gas that, when released to or found in the atmosphere, traps heat from the sun near Earth's surface; these gases include water vapor, carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons (CFCs), and hydrofluorocarbons (HFCs).

Greenhouse effect- the greenhouse effect leads to global warming/global warming is an outcome of the greenhouse effect and the ever-increasing amounts of greenhouse gases in our atmosphere

Habitat- the natural environment where a species lives; contains the food, water, shelter, space, and other needs for its survival.

Humidity- the concentration of water vapor that is suspended in the air at any given time. The more water vapor in the air, the higher the humidity.

Irrigation- using natural water resources to provide water for agriculture or other land; can include complex systems of water movement including arroyos, acequias, channels, ditches, hoses, sprinklers, etc.

Mortality- death rate of a species, population, etc.

Nocturnal- a consumer that is active primarily at night, when it is dark out.

Permafrost- a thick subsurface layer of soil that remains frozen throughout the year, occurring chiefly in polar regions.

Precipitation- any form of water that falls from the sky; rain, snow, hail, and sleet are all types of precipitation.

Talus- large rocks that pile up on a mountain slope; the rocks have broken off and fallen down a slope or cliff

Threatened- a species that is considered vulnerable to endangerment, but not yet endangered.

Range- the geographic area(s) that a species is found in, including any areas, they migrate to at certain times of the year; ranges can change over time due to habitat changes, climate change, and other impacts to the species.

Reservoir- a collection of water, in a lake or pond, that is stored for usage (for irrigation, drinking water, human recreation, power generation, etc.); reservoirs are often human-created by constructing dams on rivers, but they can sometimes be natural.

Riparian- the area right along the sides of a river/stream/creek (a.k.a. its "banks"); a zone that is often partially wet or gets flooded at certain times and provides important habitat to many species during at least a part of their life.

Sedimentation- when particles of sediment (sand/silt/soil, etc.) settle to the bottom of a body of water; often collects in certain locations, including behind dams.

Subspecies- a population of a species that usually lives in a particular geographic area, separate from other populations of that species. H as unique genetic characteristics and could breed with other subspecies of its

species if they were to interact.

Venomous- an organism that makes venom (poison) and is able to release or inject it with a bite, sting, etc.; a poisonous organism is one that releases toxins only when eaten.

Water rights- laws that define who- an individual landowner, state, country, etc. - may remove and use water from a river, lake, groundwater, or other freshwater source. Water rights can be very complicated and are granted in different ways (sometimes by having been there and claimed access first). They are very important to consider in an arid place like the southwestern U.S.

STEM READY Standards

SWW Standards

Standard	What it says	SEP	DCI	CC	CCSS
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. [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]	• Analyze and interpret data to provide evidence for phenomena.	LS2.A: Interdependent Relationships in Ecosystems • Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. • In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. • Growth of organisms and population increases are limited by access to resources.	Cause and Effect • Cause and effect relationships may be used to predict phenomena in natural or designed systems.	*ELA/Literacy -* RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-1) RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS2-1)
MS-LS2-	Construct an	Construct an	Similarly,	Patterns	*ELA/Literacy -*

2	explanation that predicts patterns of interactions among organisms across multiple ecosystems. [Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.]	explanation that includes qualitative or quantitative relationships between variables that predict phenomena.	predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.	Patterns can be used to identify cause and effect relationships	RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-2) WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS2-2) WHST.6-8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-2) SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. *(MS-LS2-2)* SL.8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. *(MS-LS2-2)* *Mathematics -* 6.SP.B.5 Summarize numerical data sets in relation to their context. *(MS-LS2-2)*
MS-LS2-4	Construct an argument supported by empirical evidence that changes to physical or biological components of an	Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience Ecosystems are dynamic in nature; their characteristics can vary over**	Stability and Change Small changes in one part of a system might cause large changes in another part.	*ELA/Literacy -* *RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-4)* *RI.8.8 Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the*

	ecosystem affect populations. [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]	explanation or a model for a phenomenon or a solution to a problem. Connections to Nature of Science Scientific Knowledge is Based on Empirical Evidence Science disciplines share common rules of obtaining and evaluating empirical evidence.	**time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.**		*evidence is relevant and sufficient to support the claims. (MS-LS2-4) WHST.6-8.1 Write arguments to support claims with clear reasons and relevant evidence. (MS-LS2-4) WHST.6-8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-4)*

Possible for extension of presentation

Students create a solution for the issue or recovery plan

Standard	What it says	SEP	DCI	CC	CCSS
MS-LS2-5	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.* Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]	Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	LS2.C: Ecosystem Dynamics, Functioning, and Resilience Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. LS4.D: Biodiversity and Humans Changes in biodiversity can influence humans' resources, such as food,	Stability and Change Small changes in one part of a system might cause large changes in another part. Connections to Engineering, Technology, and Applications of Science Influence of Science, Engineering, and Technology on Society and the Natural World The use of technologies and any limitations on their use are driven by	ELA/Literacy - RST.6-8.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. (MS-LS2-5) RI.8.8 Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS2-5) Mathematics - MP.4 Model with mathematics. (MS-LS2-5) 6.RP.A.3

			energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary) ETS1.B: Developing Possible Solutions There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (secondary)	individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. Connections to Nature of Science Science Addresses Questions About the Natural and Material World Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.	Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-LS2-5)
MS-ETS1-1	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.	Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible	ETS1.A: Defining and Delimiting Engineering Problems The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints	influence of Science, Engineering, and Technology on Society and the Natural World All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the	ELA/Literacy - RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ETS1-1) WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms

		solutions.	includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.	natural environment. The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.	effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ETS1-1) Mathematics - MP.2 Reason abstractly and quantitatively. (MS-ETS1-1) 7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-1)

References

Meadow Jumping Mouse

U.S. Fish and Wildlife Service. (2016). New Mexico meadow jumping mouse (*Zapus hudsonius luteus*). Southwest Region 2, New Mexico Ecological Services Field Office.
https://www.fws.gov/southwest/es/NewMexico/NMMJM.cfm

U.S. Fish and Wildlife Service. New Mexico meadow jumping mouse (*Zapus hudsonius luteus*). Environmental Conservation Online System.
https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=A0BX#crithab

U.S. Fish and Wildlife Service. (2016). Final critical habitat for New Mexico meadow jumping mouse (*Zapus hudsonius luteus*). New Mexico Ecological Services Field Office.
https://data.doi.gov/dataset/final-critical-habitat-for-new-mexico-meadow-jumping-mouse-zapus-hudsonius-luteus

U.S. Fish and Wildlife Service. Some background on the mouse.
https://www.fws.gov/southwest/es/NewMexico/documents/NMMJM%20background%20page.pdf

U.S. Fish and Wildlife Service. (2014). Species status assessment report: New Mexico meadow jumping mouse (*Zapus hudsonius luteus*). Listing review team Albuquerque, New Mexico.
https://www.fws.gov/southwest/es/NewMexico/documents/New%20Mexico%20meadow%20jumping%20mouse%20final%20SSA.pdf

U.S. Fish and Wildlife Service. (2014). Recovery outline: New Mexico meadow jumping mouse (*Zapus hudsonius luteus*). New Mexico Ecological Services Field Office, Albuquerque, New Mexico.
https://www.fws.gov/southwest/es/NewMexico/documents/Recovery%20Outline%20New%20Mexico%20meadow%20jumping%20mouse.pdf

U.S. Fish and Wildlife Service. (2014). Frequently asked questions for the final listing of the New Mexico meadow jumping mouse.
https://www.fws.gov/southwest/es/NewMexico/documents/New%20Mexico%20jumping%20mouse%20FAQs%20final%20listing%206-6-14.pdf

Pika

Funk, J., C. Barnett-Loro, M. Rising, M., and J. Deyette. (2016). Confronting climate change in New Mexico: action needed today to prepare the state for a hotter, drier future. Union of Concerned Scientists. https://www.ucsusa.org/NewMexicoClimateChange

Galbreath, K. E., D. J. Hafner, and K. R. Zamudio. (2009). When cold is better: climate-driven elevation shifts yield complex patterns of diversification and demography in an alpine specialist (American pika, *Ochotona princeps*). *Evolution*, 63(11). https://onlinelibrary.wiley.com/doi/10.1111/j.1558-5646.2009.00803.x

Hafner, D. J. (2018). Pikas and permafrost: post-Wisconsin historical zoogeography of *Ochotona* in the southern Rocky Mountains, U.S.A. *Arctic and Alpine Research*, 26(4), 375-382.

https://www.tandfonline.com/doi/abs/10.1080/00040851.1994.12003082

MacCarter, J. S. (1996). Wildlife notes: pika. New Mexico Department of Game & Fish, Conservation Section: Santa Fe, New Mexico. http://www.wildlife.state.nm.us/download/education/conservation/wildlife-notes/mammals/pika.pdf

National Park Service. (2018). Pika Monitoring. Upper Columbia Basin Inventory & Monitoring Network. National Park Service. https://www.nps.gov/im/ucbn/pika.htm

Western Regional Climate Center. Station summary: Redondo (VC) New Mexico. https://wrcc.dri.edu/cgi-bin/rawMAIN3.pl?nmvrdd

Valles Caldera Trust. Valles Caldera National Preserve: wildlife existing condition report. State of New Mexico, Jemez Springs, New Mexico. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5383845.pdf

U.S. Environmental Protection Agency. (2016). What climate change means for New Mexico

https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-nm.pdf

Wilkening, J. L., C. Ray, N. Ramsay, and K. Klinger. (2015). Alpine biodiversity and assisted migration: the case of the American pika (*Ochotona princes*). *Biodiversity*, 16(4), 224-236.

https://www.tandfonline.com/doi/full/10.1080/14888386.2015.1112304

Rattlesnake

Baltosser, W. H., and J. P. Hubbard (1985). New Mexico ridge-nosed rattlesnake recovery plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico and New Mexico Department of Game and Fish, Endangered Species Division, Santa Fe, New Mexico.

https://www.fws.gov/southwest/es/arizona/Documents/RecoveryPlans/RidgenoseRattlesnake.pdf

Brennan, T. C. (2008). Ridge-nosed rattlesnake: *Crotalus willardi*. http://www.reptilesofaz.org/Snakes-Subpages/h-c-willardi.html

Union of Concerned Scientists. (2016). Confronting climate change in New Mexico: action needed today to prepare for a hotter, drier future.

https://www.ucsusa.org/NewMexicoClimateChange

Crotalus willardi obscurus. (2020). Wikipedia.

https://en.wikipedia.org/wiki/Crotalus_willardi_obscurus

Crotalus willardi obscurus: New Mexico ridge-nosed rattlesnake. (2020). NatureServe Explorer.

https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.100194/Crotalus_willardi_obscurus

The Diggings. Leaflet. Open Map Tiles.
https://thediggings.com/mining-districts/nm2255/map

Elston, W. (1965). Mining districts of Hidalgo County, New Mexico. Southwestern New Mexico II. *New Mexico Geological Society 16th Annual Fall Field Conference Guidebook.* The University of New Mexico, Albuquerque, New Mexico. https://nmgs.nmt.edu/publications/guidebooks/downloads/16/16_p0210_p0214.pdf

Holycross, A., C. Painter, D. Barker, and M. Douglas. (2002). Foraging ecology of the threatened New Mexico ridge-nosed rattlesnake (*Crotalus willardi obscurus*). *Biology of the Vipers*. Eagle Mountain Publishing, Eagle Mountain, UT.

https://www.researchgate.net/publication/303684844_Foraging_ecology_of_the_threatened_New_Mexico_Ridge-nosed_Rattlesnake_Crotalus_willardi_obscurus

Biota Information System of New Mexico. (2019). New Mexico ridge-nosed rattlesnake. Natural Heritage New Mexico, Albuquerque, New Mexico and New Mexico Department of Game and Fish, Santa Fe, New Mexico.

https://www.bison-m.org/booklet.aspx?SpeciesID=030170#

U.S. Fish and Wildlife Service. New Mexico ridge-nosed rattlesnake (*Crotalus willardi obscurus*).

https://www.fws.gov/southwest/es/arizona/Documents/Redbook/New%20Mexico%20Ridgenose%20Rattlesnake%20RB.pdf

U.S. Fish and Wildlife Service. (2019). New Mexico ridge-nosed rattlesnake (*Crotalus willardi obscurus*) 5-year review: summary and evaluation. New Mexico Ecological Field Office, Albuquerque, New Mexico. https://ecos.fws.gov/docs/five_year_review/doc6184.pdf

New Mexico Department of Game and Fish. New Mexico ridge-nosed rattlesnake: threats and conservation actions. New Mexico State Wildlife Action Plan. https://nmswap.org/species/411/*

New Mexico ridgenose rattlesnake. (2019). Encyclopedia.com.

https://www.encyclopedia.com/environment/science-magazines/new-mexican-ridgenose-rattlesnake

Rattlesnake. (2020). Wikipedia.
https://en.wikipedia.org/wiki/Rattlesnake

Tucson Herpetological Society. (2019). Ridge-nosed rattlesnake (*Crotalus willardi*). Tucson, Arizona.
https://tucsonherpsociety.org/amphibians-reptiles/snakes/ridge-nosed-rattlesnake/

Ryan, T. (2020). What are a rattlesnake's predators? Pets on Mom.com. Wild Sky Media.
https://animals.mom.me/rattlesnakes-predators-7915.html

Mexican Spotted Owls

Nelson, E. (2017). Mexican Spotted Owl Protocol Training. *Mexican Spotted Owl Protocol Training*. NM, US: USDA Forest Service.

Rio Grande Silvery Minnow

Benevidez, R. (2008). Pueblo of Isleta Viewpoint Rio Grande Changes and Management Approach. The 12th Annual Water Assembly. Isleta Pueblo.

Environmental Law Institute Washington, D.C. (2005). Wet Growth: Should Water Law Control Land Use? Washington, D.C.

Paskus, L. (2017, March 28). Rio Grande water managers freed up from some ESA constraints. The NM Political Report. https://nmpoliticalreport.com/2017/03/28/no-jeopardy-for-the-minnow/