Forest Restoration on the Rowe Mesa Grassbank

A K-12 Curriculum Guide

By Tori Derr and The Quivira Coalition

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Introduction

This guide is designed as a resource for educators in the Pecos area interested in teaching about forest ecology and restoration. The guide provides background information and activities about forest restoration in Southwestern ponderosa pine forests, and whenever possible, provides information specific to a restoration project located on Rowe Mesa, just south of the town of Pecos within the Santa Fe National Forest. This project began in 2001 as part of the Collaborative Forest Restoration Program (CFRP) of the USDA Forest Service, Region 3. Activities are provided for grades K-12, and a number of these activities can be adapted to meet specific needs of teachers. In addition, each activity is correlated to New Mexico Education Standards.

More about the Guide

This curriculum provides opportunities for youth to learn many aspects of science, including some principles of forest restoration, observation and measurement skills, problem solving, and how people are currently influencing the forests where they live. These concepts are part of national and state standards for science literacy. Science literacy includes not just the understanding of scientific concepts, but also the role of science in society. By teaching about aspects of a specific restoration project, we hope to provide a broad opportunity for students to understand both aspects of scientific literacy.

This guide provides background information, classroom and field activities that educators may use with students. Many of the activities are designed for classroom use; however, others are for use outdoors or may be modified to fit other sites in the area. By exposing young people to resource management issues, this guide seeks to increase students' understanding of the following:

- Basic principles of forest restoration
- The diversity of plants and animals within an ecosystem
- Natural changes in ecosystems over time
- How people in the past have influenced the ecosystems where they live
- How people are currently trying to influence the ecosystems where they live
- Scientific principles of observation, measurement and evaluation

An introductory section provides background on the Rowe Mesa Grassbank restoration project and goals. A subsequent section provides activities for the classroom and field. Activities are provided for grades K-12, with the idea that some of the activities can be adjusted for the appropriate age group.

There are also seven appendices:

- Appendix 1 Gives a glossary of terms used throughout the text;
- Appendix 2 Provides a list of references and educational resources;
- Appendix 3 Provides links between activities and educational standards;
- Appendix 4 Provides photo examples for various terms on the bingo board;
- Appendix 5 Provides tree photos for the mystery tree activity;
- Appendix 6 Provides felt patterns for fire modeling in Activity 6; and
- Appendix 7 Provides an overview map of the general area, a Rowe Mesa Grassbank map and a restoration project area map.

More about the Project
The Rincon Ortiz Restoration Project on Rowe Mesa

Land Use History

Rowe Mesa is an approximately 100,000 acre plateau just south of Pecos in the Santa Fe National Forest. The mesa is a mix of open grasslands, pinyon-juniper woodlands, and mixed conifer forests, and has been used by local communities for many generations as a site for wood collection and grazing, among other uses.

During the 1800's and early 1900's, Rowe Mesa was the site of much goat and sheep grazing. Grazing was heavy in this area because there were many wool-growers that provided wool for local weavers. By the turn of the 20th Century, much of the area had been heavily grazed, with much of the soil and grassy areas showing declines both in diversity of species and productivity. The area was also popular for timber harvesting, fuelwood collecting, and selective cutting of trees for railroad ties.[1]

In 1907 the site became part of the Pecos National Forest. Local residents continued to use the area for fuelwood collection, hunting, and some grazing of cattle. At this time, the mesa was a mix of pinyon and juniper woodlands with some ponderosa pine and mixed conifer forests.

Under Forest Service policies, sheep and goats were no longer allowed to graze in the area. Once this practice stopped, many more seedlings of pinyon and juniper trees were able to grow to maturity. Because wildfires were also suppressed during this time, the pinyon and juniper trees grew to over-abundance. This resulted in a decline in the growth and health of other species, including some of the grasses and ponderosa pine trees.

Like many parts of the Southwest, this land use history led to a very different forest, with many of the following conditions:

- Decreased cover of grasses and wildflowers
- Shifts in wildlife diversity
- Increased densities of small trees
- Decreased numbers of large old-growth trees

[1] Stabler, H.O. 1906. "Proposed Addition to the Pecos National Forest, New Mexico." U.S. Forest Service Report.

- Increased death of old-growth trees, due to competition from thickets of smaller trees
- Change from low-intensity ground fires to increasingly large, high-intensity “crown” fires
- Increasing threats to property and human lives

These conditions are common in ponderosa pine forest across the Southwest today.

Current Restoration Efforts

In recent years, a number of rehabilitation activities have tried to address these conditions on Rowe Mesa. These include thinning of abundant pinyon and juniper trees from some areas, as well as prescribed burning of parts of the mesa.

The Rowe Mesa Grassbank project on Rowe Mesa is part of the Collaborative Forest Restoration Program (CFRP), a collaborative effort that relies on local residents, Forest Service managers, scientists, and youth crews to all work together. The Grassbank project set out to restore approximately 300 acres of forest on the mesa and provide local jobs and wood for area residents. This project area is called Rincon Ortiz.

More specifically, restoration goals of the Rowe Mesa Grassbank restoration project include:

- Changing fire regimes
- Preserving old and large trees
- Enhancing native plant populations and reducing any invasive, non-native plant populations;
- Conserving wildlife populations and habitats; and
- Conserving soil resources

Changing Fire Regimes

The primary goal of the project is to reduce excess fuels in ponderosa pine stands in order to create more natural structures and processes for a ponderosa pine forest. This reduction of fuels will reduce the threat of high-intensity fires and will reduce the unhealthy competition of plants for scarce resources such as soil nutrients, light, and water.

A second goal that relates to changing fire regimes is the establishment of conditions that can sustain a low-intensity fire on a regular, frequent basis. These fires would ideally be similar in effect and timing to those that probably existed before significant human activities in the forest. These surface fires are important because they help maintain a lower level of ground fuels and fewer excess small diameter trees. Without reintroduction of these surface fires, many of the positive ecological changes brought about by other treatments will be short-lived.

To achieve these two goals on Rowe Mesa, some small diameter trees were removed, and the slash that resulted was spread across the site or removed by fuelwood collectors. This will be followed by a prescribed burn, to be set by the Forest Service, which will remove many of the ground fuels, help to release nutrients to the soil, and allow greater grass growth in newly opened areas.

Preserving Old and Large Trees

Old and large trees have significant ecological value for many reasons. Due to logging, overgrazing, and fire suppression, large old trees are no longer common in Southwestern forests, so it is important to preserve those that do exist. Large trees, both living and dead, are important for wildlife. In addition, tree rings of old ponderosa pine trees are important for scientists to understand fire history, changes in climate, and other aspects of ecosystems. While there are not many old and large trees within the Rincon Ortiz project area, some of the ponderosa pine trees are nearly 30 inches (or 2.5 feet) in diameter. By thinning around these trees, the project hopes to reduce competition for resources and allow these trees to grow and thrive.

Enhancing native plant populations and reducing any invasive, non-native plant populations

Native grasses and forbs are an important part of Southwestern ecosystems. These plants make up the *understory* of a forest and contribute much of the biological diversity to these systems. Understory plants provide food and cover for fungi, insects, birds and butterflies, mammals and other organisms. They also help protect the soil from erosion and provide forage for grazing animals.

Understory plants also play an important role in carrying fires in ponderosa pine forests. When grasses are dry and abundant, they enable low-intensity fires to burn across the forest floor. Without enough understory, fires will not spread and will be unable to perform their natural functions.

Since the early 1900's, people have documented the decline in understory species, particularly of grasses, on Rowe Mesa. By removing an over-abundance of pinyon and juniper trees, opening up some areas to allow more sunlight, and reintroducing fire onto the site, the project hopes to enhance native understory species.

In addition, the project is monitoring the occurrence of any plants that are not native to the area. These non-native species are often invasive, meaning they can take over an area or have significant negative impacts on the native plants because they compete for space, light, water, and nutrients.

Conserving wildlife populations and habitats

The Rowe Mesa Grassbank project on Rowe Mesa was not specifically designed to restore wildlife habitat. However, one of the project goals was to create conditions that will support native wildlife and minimize negative effects to these animals. The project was designed to maintain wildlife habitat by preserving old and large trees, creating forest openings, and maintaining forest clumps. All of these structures in a forest provide important wildlife habitat.

A *habitat* refers to the place where an animal is usually found and includes food, water, shelter, and nesting conditions an animal needs to survive. Some animals rely on dense forest habitat, while others need open areas, and many need a variety of these conditions to survive.

Large trees are important to many different kinds of animals, including goshawks, songbirds, wild turkey, woodpeckers, and bats. When large trees die and remain standing, they are called *snags*. Snags are important to *cavity-nesting birds*, such as northern flickers, house wrens, and mountain bluebirds, which rely on these trees for nesting.

Some animals also need open areas for their habitat. For example, mountain and western bluebirds and spotted towhees are more common in open ponderosa pine forests than in dense forests where fires have been suppressed for many years. It is usually easy to see bluebirds in the open grassy areas of Rowe Mesa.

When trees are grouped in clumps, they can provide important habitat for squirrels, bear, turkey, deer and elk. Understory plants also provide food and cover. Woody trees and shrubs, such as oaks and junipers also provide large amounts of food for many animals.

Conserving soil resources

Soil actually refers to much more than "bare dirt." There are many components and functions of soil. For example, many organisms live in soil, including fungi and bacteria which help to free up nutrients so that they are in a more useable form for plants. Soil also stores seeds of many plants and provides homes for many invertebrates and small mammals.

Soils are the foundation of any ecosystem and are an essential part of ecosystem health. Soils can easily be damaged when they are exposed to high-intensity fires or when heavy equipment moves large amounts of soil or packs it down hard. Damaged soils can take a long time to recover. When soils are damaged, they are more likely to be invaded by non-native plants. The soil also becomes less favorable for tree seedlings to establish, and water is less likely to soak into the soil, which can lead to erosion.

The project on Rowe Mesa has tried to minimize negative impacts to soil resources by minimizing the use of any heavy equipment, covering tracks created by trucks, spreading slash across the site, and reintroducing low-intensity fire which will help restore nutrients to the soil.

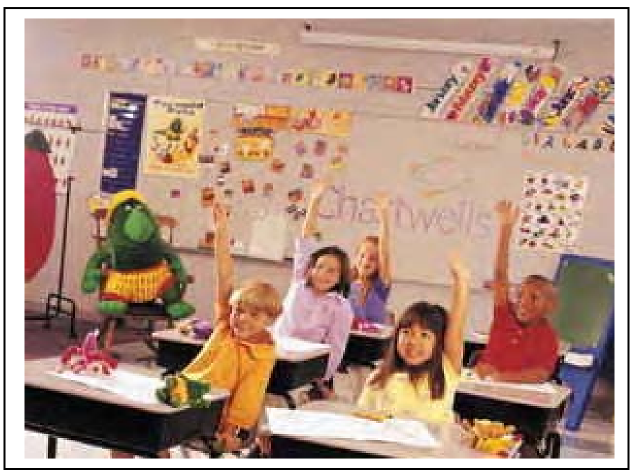
Restoration Project Partners

Funding for the Rincón Ortiz project was provided by the Collaborative Forest Restoration Program (CFRP) to the Four Corners Institute of Santa Fe, with the Rowe Mesa Grassbank, Quivira Coalition, Forest Trust, and USDA Forest Service participating as partners. The location of the project is on the Rowe Mesa Grassbank. This is a 36,000 acre federal grazing permit on Rowe Mesa in the Santa Fe National Forest. The permit is currently held by the Conservation Fund, a non-profit organization dedicated to protecting land and water resources. The Rowe Mesa Grassbank was established in 1997, offering the use of its grazing lands to federal permittees from northern New Mexico in exchange for a commitment to rest their home allotments from grazing and to implement restoration on these home lands. The hope of the Grassbank is that by fostering ecological restoration treatments on forested grazing allotments, it will increase herbaceous cover in many of the pinyon-juniper and ponderosa pine forests of northern New Mexico.

The steering committee of the Rowe Mesa Grassbank is comprised of representatives from four partner groups: the Conservation Fund, the Northern New Mexico Stockmen's Association, the New Mexico State Cooperative Extension Service, and the USDA Forest Service. Decisions and recommendations made by the steering committee are subject to the approval of the cooperating district and regional offices of the Forest Service.

Ponderosa Pine on the Rowe Mesa Grassbank
Photo Courtesy of Craig Conley

Classroom Activities



Classroom Activities

The following classroom activities are provided within this curriculum. Check marks indicate appropriate grades for each activity. However, many of the activities could be modified or adapted to fit an earlier or later grade.

	Grades K-4	**Grades 5-8**	**Grades 9-12**
Activity			
Restoration Bingo	X	X	X
Mystery trees	X	X	
Burned area scavenger hunt	X	X	X
Compaction action	X	X	X
Who Lives Here?	X	X	X
Understanding Forest Fires	X	X	X
Dendrochronology detectives		X	X
Fire & Diversity		X	X
Tree size structure		X	X
Determining Reference Conditions		X	X

Activity 1: Restoration Bingo

Studying forest restoration can introduce students to new vocabulary and concepts. This game can be played to introduce forest restoration terms and concepts to students, or it can be used after a field trip to Rowe Mesa or after completion of other activities in this guide, to reinforce concepts students will have learned.

Restoration bingo may be played in groups or as an entire class. At the end of each game, students should be able to explain the terms they used to each other or to the whole class.

Procedure:

Tell students they will be playing restoration bingo. Optional: break students into smaller groups to play the game. Introduce the following guidelines:

1. Students will be given a bingo board with restoration terms in each square.
2. Students cover up a term when they hear its definition given by the teacher or classmate.
3. When students have covered terms to form a straight line across or diagonal line on the board, they may say "Healthy Forests!" to indicate the game has ended.
4. Before everyone clears their bingo board, go through the terms the winning student has covered to make sure they are all correct.
5. If one of the terms was incorrect, uncover that term and continue playing until a student correctly covers all terms in a line.
6. Use photos to help students learn concepts that are part of the bingo board (Appendix IV).
7. Because there are only 5 bingo board templates, you many have 5 or more winners at one time, depending on the number of students in your class, and whether or not you work in groups.

Objectives:

Students learn vocabulary and concepts that are part of ponderosa pine forest restoration.

Duration:

30-45 minutes

Vocabulary:

See bingo board terms

Materials:

Bingo boards and chips, photos, photocopies of definitions

Preparation:

You will need to photocopy bingo boards and make or find bingo chips. You may also want to cut the bingo terms into sections to randomly draw from a hat.

Restoration Bingo Board Terms

Photocopy these terms and cut them out to randomly draw from a hat or bag. Make sure to read the meanings and have students mark the corresponding term. You may want to add to or simplify some of the definitions depending on the grade you are working with.

Term	Meaning
Cavity Nester	An animal that uses holes in trees for raising young. Common among these are northern flickers, house wrens, and mountain bluebirds
Competition	When two or more organisms seek an environmental resource that may be in short supply
Cover	The amount of the ground that is shaded by standing, living understory plants, usually expressed as a percentage.
Crown fire	A fire that burns in the canopy of trees. These fires can begin as surface fires and then move into the tops of trees. Then they move rapidly from one tree to another, especially if the wind is strong.
Density	The number of plants or animals in a given area
Diversity	Variety, for example, of organisms, species, genes, habitats, ecosystems, etc.
Fire Intensity	A reference to the amount of heat a fire generates in a particular location and time.

Term	Meaning
Fuel	The living and dead vegetation that can be burned in a forest fire. This term can include dead woody material from logs and branches, leaves of trees and shrubs, pine needles, grasses, and other plants.
Habitat	The place where an organism is usually found and includes food, water, shelter, and nesting conditions that the organism needs to survive
Litter	The top layer of soil comprised of a variety of organic material such as dead needles, twigs, branches, and dead grasses and forbs
Exotic Species	Plants that are non-native to a particular ecosystem or community, that often thrive on disturbed conditions and can become abundant after thinning or burning. These plants can displace and reduce populations of native species
Old & LargeTtrees	These are no longer common in Southwestern forests, so it is important to preserve those that do exist, especially because they are important for wildlife
Overgrazing	When wild and domesticated animals use an area to the extent that plants cannot easily grow and soil is degraded
Prescribed Fire	A wildland fire that is set by forest managers to meet particular goals
Process	Things that happen in a forest to help maintain it. For example, low-intensity fire

Term	Meaning
Regeneration	The processes plants use to maintain and expand their populations over time. This may happen through sexual reproduction or vegetative propagation.
Restoration	The process of returning more natural conditions to ecosystems that have been damaged by human activities
Slash	Debris, such as branches and needles, that remain on the ground after a thinning
Snag	A dead, standing tree. These provide important habitat for birds, small animals, insects, and fungi.
Stand	A group of trees that can be distinguished as a unit by arrangement of ages, species composition, site quality, or other factors. These groupings are often used to distinguish an area that will be managed in a certain way.
Structure	The spatial arrangement (both vertically and horizontally) or parts of an ecosystem
Thinning	The process of cutting some, but not all, trees in an area. The removal of trees (usually small diameter) from a forested area according to a set prescription
Treatment	The actions to achieve forest management objectives, usually according to a prescription
Understory	Plants that grow close to the ground in a forest. These include grasses, forbs, and woody shrubs

Bingo Board Template 1

Competition	Thinning	Density	Cover	Treatment
Snag	Old & Large Trees	Exotic Species	Ladder Fuel	Prescribed Fire
Understory	Restoration	Diversity	Process	Regeneration
Fire Intensity	Overgrazing	Cavity Nester	Crown Fire	Structure
Litter	Fuel	Habitat	Stand	Slash

Bingo Board Template 2

Treatment	Thinning	Process	Snag	Competition
Litter	Exotic species	Old & Large Trees	Ladder fuel	Prescribed fire
Overgrazing	Cavity nester	Diversity	Density	Understory
Regeneration	Restoration	Fire Intensity	Crown Fire	Structure
Cover	Fuel	Habitat	Slash	Stand

Bingo Board Template 3

Density	Process	Thinning	Regeneration	Competition
Cavity Nester	Overgrazing	Crown fire	Understory	Diversity
Ladder fuel	Old & Large Trees	Prescribed Fire	Treatment	Exotic Species
Fuel	Restoration	Fire Intensity	Habitat	Structure
Cover	Litter	Snag	Slash	Stand

Bingo Board Template 4

Old & Large Trees	Understory	Prescribed Fire	Exotic Species	Fire Intensity
Cavity Nester	Competition	Ladder Fuel	Overgrazing	Crown Fire
Slash	Snag	Habitat	Cover	Litter
Density	Structure	Treatment	Fuel	Diversity
Stand	Process	Regeneration	Thinning	Restoration

Bingo Board Template 5

Cavity Nester	Crown Fire	Understory	Overgrazing	Ladder Fuel
Stand	Cover	Fuel	Snag	Habitat
Thinning	Restoration	Prescribed Fire	Regeneration	Treatment
Structure	Fire Intensity	Competition	Exotic species	Old & large Trees
Process	Density	Diversity	Slash	Litter

Activity 2: Mystery Trees
This activity was adapted from the FireWorks Curriculum, Activity 4-3

Ecologists, botanists, and foresters all rely on the ability to identify plant species for aspects of their work. In this activity, students will examine specimens from three trees that are found on Rowe Mesa. Then the teacher or an older student will read a story about the life history of each tree and ask students to determine which tree they are describing. Students will verify facts in the story with the plant parts they have studied.

Objectives:

Given biological specimens, students will learn to distinguish three tree species and will use these specimens to illustrate points in a story.

Duration:

K-4: 2-3 20-minute segments
5-8: 1 50-minute session

Vocabulary:

- bark
- botanist
- cone
- dispersal
- ecologist
- forester
- needle
- seed

Materials:

- Tree bark, cones, needles and photographs of three tree species (ponderosa pine, pinyon pine, and Rocky Mountain juniper)
- Rulers
- Photographs of each tree

Procedure:

1. Set up three work stations, one for each species. At each station, place two rulers, a section of tree bark, tree photos (Appendix IV), cones, and needles from each species.

2. Divide the class into three "Tree Teams" and assign each group to a station.

3. Explain that the skills the students are learning are used every day by botanists, foresters, and ecologists.

4. Allow students 15 minutes to look at the specimens at their work station. Have students feel the plant parts, measure the length of cones and needles, and count the number of needles in a bunch.

5. Select one of the three species' stories to read in the class. The teacher, an older student, or teams may read the story aloud to the class.

6. Ask students to raise their hands when one of the facts from the story describes the tree species from their team. Let the students from that team pass around their specimens to other students in the class. When the story includes a measurement, such as how long the needles are, ask the Tree Team to measure their specimen to see if it matches the reported size.

7. Later in the day or on another day, repeat steps 5 and 6 with the other 2 specimens. Ask students to compare and contrast the three species.

8. Optional: have students draw a picture of their tree species that they have learned; labeling the parts of the plant and giving facts, such as numbers of needles in a bunch or length of cones.

Preparation:

You will need to collect and prepare tree specimens from ponderosa pine, piñon pine, and Rocky Mountain juniper trees. You can collect tree branches with needles, cones, and bark sections. You will also need to print out or copy photographs of each tree

Activity 2: Mystery Tree Stories: Ponderosa Pine

I am a tree. My scientific name is *Pinus ponderosa*. *Ponderosa* is a Spanish word meaning, "large, heavy, *ponderous.*" Some people call me yellow pine, "black jack" pine, or *pino real* (true pine) in Spanish.

Where do I live? I am native to the Rocky Mountain west and some of the midwestern states. I can grow in hot, places, from around 6,500-8,000 feet.

What do I look like? I am an evergreen tree. I grow to be 75 feet to 100 feet tall. My trunk can be more than 6 feet wide. I have long needles – about 8 inches long. My needles usually grow in clusters of three.

My bark gets very thick as I age. When I get old, my bark turns a yellowish orange and has deep, dark furrows. Then people call me a "yellow pine." This thick bark helps me to survive low-intensity forest fires. I can live a long time, sometimes as long as 300 to 400 years.

I grow many thick roots. Some of them grow 6 feet into the soil. Others may reach 90 feet out from my trunk under the soil.

Growing up. I grow from seed, especially in sunny places. I grow very fast in sunlight. I can be 3 feet tall when I'm 7 or 8 years old. By the time I'm 10 years old, I am able to make seeds and cones.

How do I reproduce? I am a *conifer*, which means I put my seeds in cones. My cones are big, brown, and woody, with large, sharp prickles. My seeds have a paper-like "wing" that helps them float a little way in the wind when they fall out of the cone. They may travel 150 feet before they land.

Botanical Trivia:
Ponderosa pines can live for many centuries. The oldest known ponderosa pine was found in Colorado and was 1,047 years old when it died.

Source: Peterson Field Guides to Western Trees, George A. Petrides/Olivia Petrides

Activity 2: Mystery Tree Stories: Pinyon Pine

I am a tree. My scientific name is *Pinus edulis*. I am the state tree of New Mexico. Some people call me "nut pine" because occasionally I have a really good year and produce a bumper crop of nuts.

Where do I live? I am native to the Rocky Mountain west. I tend to grow in dry, rocky places from about 4,000 to 8,000 feet in elevation.

What do I look like? I am an evergreen tree. I can grow to be about 35 feet tall. My trunk can be 6-10 inches wide. My trunk often grows slightly crooked. Sometimes if I am cut for fuelwood, I look more like a shrub than a tree. I have short needles – about 1-2 inches long. My needles usually grow in clusters of two.

My bark is a reddish-grey color and slightly furrowed. My wood is prized for the fragrance it gives off for firewood.

How do I reproduce? I am a *conifer*, which means I put my seeds in cones. My cones are small, only about 1-2 inches long, with thick thornless scales and 2 nuts per scale. My seeds are spread around by many of the small animals and birds that love to eat me.

Botanical Trivia:
Resin from the trunk of pinyon pines is said to have been used by Native Americans to waterproof woven bottles and to cement turquoise jewelry.

Source: Peterson Field Guides to Western Trees, George A. Petrides/Olivia Petrides

Activity 2: Mystery Tree Stories: Rocky Mountain Juniper

I am a tree. My scientific name is *Juniperus scopulorum*. I am sometimes called red cedar, or *cedro rojo* in Spanish. My wood is highly prized and can be used for fenceposts, fragrant fuel, cedar chests, and pencils.

Where do I live? I grow on rocky, mountain slopes and dry mesas, from around 5,000 to 9,000 feet in elevation. I can be found in the Rocky Mountains up to Canada.

What do I look like? I am an evergreen tree. There are other trees I am related to that look a lot like me. But I have smaller needles, grow upright, and have stringy bark. My relatives tend to be shrubbier than me. I can grow to be 30 or 40 feet tall. My trunk can be 2 feet wide. I have short, scaly needles that are bluish in color. My needles and twigs tend to droop from my branches.

My bark is stringy and the inside is often a reddish color. I can live a long time, usually for 200-300 years. I tend to only have one trunk, but sometimes I have 2 or more.

How do I reproduce? I produce fruits that are only about ¼ inch across and are a bright blue color. Animals help me spread my seeds around. There are hundreds of birds and animals that eat my fruits and *disperse* my seeds. In fact, sometimes even bighorn sheep have eaten my seeds.

Botanical Trivia:
A Rocky Mountain Juniper tree was found in Logan Canyon, Utah that was about 1,500 years old.

Source: Peterson Field Guides to Western Trees, George A. Petrides/Olivia Petrides

Activity 3: Burned Area Scavenger Hunt

Low-intensity surface fires have been suppressed from ponderosa pine forests for many years. The primary goal of the Rowe Mesa restoration project is to reduce excess fuels in ponderosa pine stands in order to create more natural structures and processes for a ponderosa pine forest. This reduction of fuels will reduce the threat of high-intensity fires and will reduce the unhealthy competition of plants for scarce resources such as soil nutrients, light, and water.

A second goal is to establish conditions that can sustain a low-intensity fire on a regular, frequent basis. These fires would ideally be similar in effect and timing to those that probably existed before significant human activities in the forest. These surface fires are important because they help maintain a lower level of ground fuels and fewer excess small diameter trees.

To achieve these two goals on Rowe Mesa, some small diameter trees were removed, and the slash that resulted was spread across the site or removed by fuelwood collectors. This will be followed by a prescribed burn, to be set by the Forest Service, which will remove many of the ground fuels, help to release nutrients to the soil, and allow greater grass growth in newly opened areas.

This activity is specifically designed for use after the Rincon Ortiz site on Rowe Mesa has been burned through prescribed fire.

Procedure:

1. Introduce the lesson by telling students they will be going into the field to observe effects of a recent prescribed fire. Give a bit of history on the fire. If possible, have someone from the project present for this trip to share information and background on the project site and how it was burned.

2. Review safety guidelines, such as working in pairs, always being within eyesight of an adult, etc. Also review guidelines for

Objectives:

In a recently burned area, students can find plants, animals, and animal sign, and use them to infer characteristics of the fire and fire ecosystem.

Duration: 30 minutes plus travel time

Vocabulary:

- cavity-nesting birds
- field site
- habitat
- old-growth forest
- prescribed fire
- scat
- snag
- understory

Materials:

- Pencils and paper
- Photocopies of worksheet
- Clipboards or hard writing surface
- Optional: field guides for trees, shrubs, birds, mammals, scat

working in the forest, such as using quiet voices, leaving all objects where they are found, returning rocks and logs to their original location, treating all objects in the forest with respect, observing but not disturbing wildlife, etc.

3. Depending on time limitations and group dynamics, this activity can work well with two variations:
   - **Variation 1:** Break students into 2-person teams. Assign 2 items from the scavenger hunt to each team. Give them approximately 10 minutes to find their items. Then have each team present their items to the class as a whole and explain what they've learned. This works particularly well with groups that are independent and interested in exploration.
   - **Variation 2:** Break students into 2-person teams. Give each team the entire scavenger hunt and have the team identify each item. Then have each team present 2 items that they think are unique or interesting to the entire class.

4. Discussion Points:
   - Ask the students to evaluate the burned area: did many trees die? Was there much regrowth of understory plants? Are there many trees re-sprouting? Did they find much sign of wildlife? Ask students to categorize positive and negative effects on the forest. Review the importance of snags for cavity-nesting birds (see the introduction on restoration goals for more information).

In the classroom, have students sketch, draw, paint, or write about what they learned and their perspectives on fire.

Activity 3: Burned Area Scavenger Hunt Worksheet

Name ____

Burned areas can be exciting places to explore. They can also be dangerous. Don't ever go into an area burned by crown fire on a windy day. Listen and watch for falling trees and ash-filled stump or root holes.

See how many of these things you can find in the burned forest. Check them off as you go:

1. ☐ Find a place where the fire burned in the tree crowns

2. ☐ Find a place where the fire only burned on the ground in grass, shrubs, or needles

3. ☐ Find a tree cone. Can you tell what species it is?

4. ☐ Find a shrub or small plant that sprouted after the fire. How can you tell it was burned?

5. ☐ Find a tree that burned but did not die. What kind of tree is it? How can you tell it burned?

6. ☐ Find a tree killed by fire. What does the tree look like now? How old do you think the tree was? Draw the tree on the back.

7. ☐ Find a "snag." Do you see signs of insects or birds at this tree? Describe what you see.

8. ☐ Find a place where an animal was feeding. What was it feeding on – an animal, grass, shrub, or tree? How can you tell?

9. ☐ Find animal tracks. Draw them on the back. What kind of animal made them?

10. ☐ Find animal scat. Draw it on the back. What kind of animal left it there?

11. ☐ Find a place where an animal made a hole in a tree. How big is the hole?

12. ☐ Find signs that insects fed on a burned tree. Draw what you see on the back.

Activity 4: Compaction Action

Soil is an often overlooked, yet essential, part of the forest. Healthy soil provides a good home for large burrowing animals, earthworms, and microbes and fungi that help decompose dead wood and needles and help plants absorb nutrients and water. Healthy soil is also soft and porous enough to allow rainwater to easily reach tree roots. Restoration projects should be careful not to harm the soil and its ability to absorb rainfall or provide habitat for animals and microbes.

In this activity, students will look at the effects of equipment or roads on soil. This is ideally a field activity, but can also be done in a schoolyard where there is soil of different conditions.

Background:

Prior to the restoration treatment, the soil stability within the Rincon Ortiz area was fairly high, especially as compared to the neighboring grassland sites. This is probably due to the depth and extent of litter cover under the ponderosa pine and pinyon-juniper trees. However, there were also many areas within the treatment area that had bare soil. In these spaces, usually much farther away from trees, there was little growth of grasses and forbs. After treatment, you may find that some areas were damaged from trucks driving across the site. You may also see changes to the soil after the area has been burned by fire.

Preparation:

You may want to prepare small cards or pieces of paper with a description of each of the six sites. You may also want to prepare data sheets that students can use to record information in the field.

Procedure:

1. Introduce the lesson by telling students they will be looking at the soils on the Rincon Oritz site, and the effects of heavy equipment, roads (and possibly fire) on soil, plants, and microorganisms.

Objectives:

Students will learn how roads and equipment impact soil. They will understand the importance of soil for plants and microorganisms.

Duration: 40 minutes

Vocabulary:

- soil compaction
- understory

Materials:

- 6-30 tin (soup) cans with tops and bottoms removed (all tin cans should be the same size)
- Water
- 6 or more watches with a second hand or timers
- Calculators
- Clipboards or hard writing surface
- Copies of data sheet
- Optional: hand lenses, plan identification guides, invertebrate identification guides

2. Explain that six teams of students will be looking at soil compaction by measuring the rate that water percolates into the soil at different sites. The sites are as follows:

   - An area beneath trees where there are needles and leaves where no vehicles have driven
   - An open area with bare soil where no vehicles have driven
   - An area beneath trees where there are needles and leaves and where equipment or vehicles have driven
   - An open area with bare soil where equipment or vehicles have driven
   - An area at the side of a road
   - An area in the middle of a road

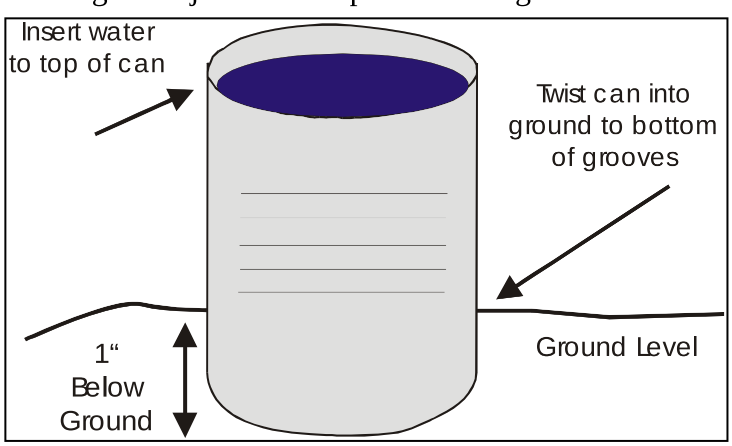
Note: If this activity is done after the prescribed fire has burned, you may want to add two additional sites: in two areas burned by fire beneath trees and in an open area.

Preparation:

You may want to prepare small cards or pieces of paper with a description of each of the six sites. You may also want to prepare data sheets that students can use to record information in the field.

3. Have students create hypotheses for which areas will have the greatest soil compaction and have them explain why.

4. Divide the students into six teams. Assign each team to one of the six sites and have students complete the following exercise:
   a. Go to the site and record what the ground looks like. Make a sketch of the vegetation that may be growing in the area and use terms such as: grasses, forbs, litter, and bare soil to describe the site. Optional: use field guides to identify plants growing on this site.
   b. Take the tin can and twist it into the ground so that it is about 1 inch below ground (enough so that water will not leak out the bottom). For cans with grooves in the middle of the can (many soup or vegetable cans have these), the students can put the can into the ground just to the top of the first groove.



c. Fill the tin can with water.
d. Record how long it takes for the water to penetrate the soil in the table at the end of this activity. (For compact soils or soils with heavy clays, it may take 5-15 minutes or more for water to completely filter.)
e. Repeat this 2 more times at the same site. Spread the measurements out by about 5-10 feet. (Students can do all trials at the same time if there are enough cans and timers.)
f. Add up each of these times and divide the total time by 3 to get the average.
g. While still at the area, use a hand lens to look for any microorganisms that may be living in the soil. Turn over leaves, needles, and logs to see if there are any invertebrates at the site. Record this as part of the site description. Make sure to return logs to their original position, and cover soil with litter again. Optional: use field guides to identify any organisms found.

5. Have each group present their findings to the class as a whole.

6. Rank each area from fastest to slowest to percolate the soil. Were the students' hypotheses correct?

7. Discuss how restoration work at the Rincon Ortiz site might have positively and/or negatively impacted soil based on these findings. Some discussion points might include:

   - Were there different kinds of plants growing at the site? Were any of these plant species exotic (non-native)?
   - Think of three things that might lead to soil compaction at a site.
   - Did anyone observe gullies from rain or other types of erosion?
   - What effect might compacted soil have on the forest? How would it affect plants and animals? How might it affect trees?
   - You might also discuss how performing repeated measurements affects the accuracy of data.

8. Discuss the soil conditions given in the background information for this activity, and how soil might be affected differently when there is bare soil, pine needle litter, and grass cover.

Activity 4: Compaction Action

Soil Compaction Data Sheet

Site Description:	
Trial #	**Time to percolate (in minutes and seconds)**
Trial #1	
Trial #2	
Trial# 3	
Total Time for all 3 Trials (Add times for Trials 1-3)	
Average Time (Divide Total by 3)	

Activity 5: Who Lives Here?

In recent years, populations of many native animals in the Southwest have declined in part due to changes in forest conditions, such as fire suppression or removal of old, large trees from the forest. Restoration projects that protect old and large trees, preserve large snags, promote meadows, and support grass and wildflowers, will also help to bring back native wildlife that depends on these conditions for their survival.

The Rowe Mesa Grassbank project on Rowe Mesa was not specifically designed to restore wildlife habitat. However, one of the project goals was to create conditions that will support native wildlife and minimize negative effects to these animals. The project was designed to maintain wildlife habitat by preserving old and large trees, creating forest openings, and maintaining forest clumps. All of these structures in a forest provide important wildlife habitat.

In this activity, students identify ways plants and animals depend on trees for survival. This is ideally a field activity, but can also be done in a schoolyard where there are a few trees. It is also an activity that can be assigned for students to do at home, or in an area where they can make repeated observations of the same tree.

Objectives:

Using observation skills, students will learn that forests provide many different habitats for diverse animals.

Duration:

50 minutes

Vocabulary:

- cavity-nesting bird
- habitat
- old-growth forest
- snag
- understory

Materials:

- Paper and pencil
- Clipboards or hard writing surface
- Optional: field guides for trees, shrubs, birds, mammals
- Optional: binoculars, hand lenses

Background:

A *habitat* refers to the place where an animal is usually found and includes food, water, shelter, and nesting conditions an animal needs to survive. Some animals rely on dense forest habitat, while others need open areas, and many need a variety of these conditions to survive.

Large trees are important to many different kinds of animals, including goshawks, songbirds, wild turkey, woodpeckers, and bats. When large trees die and remain standing, they are called *snags*. Snags are important to *cavity-nesting birds*, such as northern flickers, house wrens, and mountain bluebirds, which rely on these trees for nesting.

Some animals also need open areas for their habitat. For example, mountain and western bluebirds and spotted towhees are more common in open ponderosa pine forests than in dense forests where fires have been suppressed for many years. It is usually easy to see bluebirds in the open grassy areas of Rowe Mesa.

When trees are grouped in clumps of trees, they can provide important habitat for squirrels, bear, turkey, deer and elk. Understory plants also provide food and cover. Woody trees and shrubs, such as oaks and junipers also provide large amounts of food for many animals.

Procedure:

Introduce the lesson by telling students they will be observing a tree to see which animals may rely on it for food, shelter, nesting, or in some other way.

1. Have students bring a pencil, paper, and clipboard or notebook into the field. You may also want to bring field guides and/or binoculars or hand lenses for students to share.

2. Prior to going into the field, discuss with students the importance of being quiet and still so that they can observe as many different kinds of animals as possible.

3. Students can work in pairs or small teams to observe a tree. They should look for holes in the bark of trees, chewed plants or bark, animal scat, animal tracks, nests, seed caches, invertebrates beneath leaves and needles, and so on.

4. Have students record what they see and hear. Have them identify plants, animals, scat, and other signs of wildlife that they find. Hand lenses can be used for looking at smaller invertebrates. Binoculars can be used for observing birds or mammals higher up. Have students draw what they see.

5. Many animals require trees and plants of different "height classes," such as grasses, shrubs, and trees. Have students record if these types are present in the following table:

A. 3 or more height classes (grass, shrubs, and trees present)	**B.** 2 height classes present (mostly trees)	**C.** 1 height class present (grasses and herbs only)	**D.** 1 height class, mostly sparse vegetation
Excellent	Good	Fair	Poor

Is this an excellent, good, fair, or poor site for wildlife habitat based on the height classes present? ___________________________

6. Wildlife also require many different kinds of plants for food. Look at the different species of plants (grasses, forbs, shrubs, trees), and record how many you can find according to the following table:

A. >20 plant species	**B.** 15-19 plant species	**C.** 5-14 plant species	**D.** 0-5 plant species
Excellent	Good	Fair	Poor

Is this an excellent, good, fair, or poor site for wildlife habitat based on the number of plant species present? ____________________

8. The Rincon Ortiz set aside areas for wildlife. What are 3 reasons why it is important to set aside areas for wildlife in a forest restoration project?

9. Have students organize their observations and present them to the other groups. This can be done in the field so that other students can observe what each group found, or back in the classroom.

10. Discuss how the restoration project may affect wildlife habitat: Has it provided new habitats? Did it preserve existing habitats?

Activity 6: Understanding Forest Fires

A similar activity is found in Project Learning Tree, 311-315.

The way forests burn depends on many things: the structure of the forest, local weather conditions (whether it is dry or relatively wet), wind speed, and other factors. Because people have suppressed surface fires in ponderosa pine forests for many years, these forests are now more vulnerable to crown fires. One of the primary goals of Rowe Mesa restoration project is to reduce excess fuels in ponderosa pine stands in order to reduce the threat of high-intensity fires and create conditions for low-intensity fires to burn on a more regular basis.

In this activity, students learn the three elements of a fire triangle and the terms used to describe a forest fire. They apply this knowledge in the construction of felt board models of surface and crown fires. They interpret what they have learned in relation to restoration efforts on Rowe Mesa.

Procedure:

1. Introduce the lesson by asking what students think about forest fires. Ask students to say if they think fires are "good," "bad," or "sometimes good and sometimes bad." Have them explain their thinking for each of these categories.

2. Ask students for feedback about how fires start (Look for natural fires – through lightning; human-caused – campfires, cigarette butts, burning debris, sparks from ATVs or other vehicles, etc.). Explain that these are sources of *ignition* and are needed to provide heat to start a fire.

3. Ask students what three things a fire needs to burn: have them generate a list of as many things they can think of and categorize them according to the three elements of the fire triangle: oxygen, heat, and fuel.

Objectives:

Students will be able to identify the three components fire needs to burn, understand conditions that cause fire risk and spread, and describe the characteristics of crown and surface fires.

Duration: 50 minutes

Vocabulary:

- crown fire
- drought
- fire manager
- fire spread
- ignition
- slash
- slope
- spot fire
- surface fire

Materials:

- String or thick yarn approximately 10 feet in length
- Construction paper or notecards
- Felt board
- Copies of Fire Worksheet

Preparation:

1. Copy and cut fire risk scenarios
2. Copy fire worksheets
3. Prepare felt board patterns (Appendix VI) and background using patterns from activity.

4. Have students think about conditions that make a forest fire more or less dangerous. These include:
    - Windy days
    - Hilly slopes
    - Heat (fire season is in the hot part of spring; fires usually burn most in the daytime, etc.)
    - Dry fuels (versus wet)
    - Lots of downed wood or thick needles

5. To apply this knowledge, have student play the Fire Scenario game. Each student will take a piece of paper from a bag and decide if the scenario on their paper is a low, moderate, or high fire risk. To play the game:
    - Place a yellow card marked LOW and a red card marked HIGH at either end of a 10-foot long string.
    - Have each student pick one paper with a scenario from a bag.
    - Have each student decide the fire risk (standing by the low end or high end or in the middle) for their scenario.
    - Have students read their scenarios to the class and explain why they chose the level of fire risk. (You can make scenarios increasingly complicated depending on the age of the students.)

6. Next introduce how fires are described:
    - Fire intensity (how hot it burns)
    - Fire severity (how much it kills)
    - Rate of spread

    Discuss what factors might affect fire intensity, fire severity, and rate of spread, using the fire triangle to discuss each of these factors.

7. Bring out the felt board and explain to students that they are going to use the felt board to model different kinds of fires. Discuss how the felt pieces represent different aspects of the forest, and have students identify what each color and shape of felt represents (for example, ponderosa pine trees, pinyon pine trees, oak shrubs, grasses, and fire).

8. Ask the class who has heard of a surface fire. If someone has heard of it, ask them to explain what they think it means. Next ask who has heard of a crown fire, and ask them to explain what it means. Clarify student definitions and make sure everyone understands the difference.

9. Have 2 students volunteer to use the felt pieces to create conditions that would support a surface fire.

10. Have 1 student volunteer to place the lightning bolt on the felt board to start the fire.

11. Have another student volunteer to show how the fire might spread. Have the class evaluate the fire spread as the student places fire pieces onto the felt board. Have the class decide whether the felt board model would indeed remain a surface fire, or if they think it might become a crown fire. Look for presence of ladder fuels, many connecting tree canopies, or dense fuels on slopes. Also look for enough ground fuels (such as grasses and shrubs) to carry a fire across the surface. Have students use the words fire intensity, fire severity, and rate of spread to describe the fire modeled. If appropriate, have 2 more students adjust the felt board so that it would support a surface fire.

12. Discuss how a surface fire might be beneficial to the forest. Some possibilities include:

    - Surface fires recycle nutrients into the soil, which can then be used by plants
    - Killing small trees helps keep the forest naturally “thinned”
    - Surface fires help reduce ground and ladder fuels
    - Surface fires can help reduce the risk of catastrophic crown fires to nearby homes
    - Old and large ponderosa pine trees are able to survive these fires. These trees benefit from low-intensity surface fires because the fires reduce competition of smaller trees and provide more readily available nutrients in the soil.
    - Frequent surface fires can spread more quickly and thus are less likely to damage soils
    - Surface fires promote greater plant diversity (see activity 9)

13. Next, have 2 students volunteer to use the felt pieces to create conditions that would support a crown fire.

14. Have 1 student volunteer to place the lightning bolt on the felt board to start the fire.

15. Have another student volunteer to show how the fire might spread. Have the class evaluate the fire spread as the student places fire pieces onto the felt board.

16. Have the class evaluate whether the felt board model would likely lead to a crown fire. Look for presence of ladder fuels, tightly grouped tree crowns, or dense fuels on slopes. Have students use the words fire intensity, fire severity, and rate of spread to describe the fire modeled. If appropriate, have 2 more students adjust the felt board so that it would support a crown fire.

17. Discuss the effects a crown fire might have on the forest. Some possibilities might include:

- Crown fires can kill old and large trees (as well as the smaller ones)
- Crown fires tend to burn hotter and can damage the soils. Soils take a long time to recover once burned.

- Crown fires tend to be a high severity fire, which means that they can kill everything and take a long time to recover.
- Crown fires can create openings, or meadows, which are important for wildlife, such as elk. But this, too, can take a long time.

18. Discuss the thinning and burning prescribed for the Rincon Ortiz site on Rowe Mesa. Ask students to "treat" the crown fire felt board according to the prescription. Have students discuss what the benefits might be for Rowe Mesa.

19. Ask students again what they think about forest fires. Compare answers to beginning of class.

20. Evaluation: Have students complete the accompanying worksheet, and/or have them re-create drawings that model surface and crown fires and write accompanying explanations.

Activity 6: Understanding Forest Fires Forest Fire

Worksheet

Name____

1. Fires need three different things to burn. Draw a triangle below and label each of the three sides with a word and picture for each part of a fire.

2. Fires need fuel to burn. Name three types of fuel you might find in a forest:

    1. ________________________
    2. ________________________
    3. ________________________

3. Name two possible effects of a surface fire on the forest:

    1. ________________________
    2. ________________________

4. Name two possible effects of a crown fire on the forest:

    1. ________________________
    2. ________________________

5. List two ways Rowe Mesa will be treated:

    1. ________________________
    2. ________________________

6. What kind of fire is this restoration effort trying to promote?

Activity 6: Understanding Forest Fire
Scenarios for Understanding Fire Risk

It hasn’t rained for 3 months.	It is a hot summer day, and there has been no rain for 2 months.
It hasn’t rained for 3 months, and it is a very windy day.	It is a cool spring morning after a light rain.
It is a cloudy winter day, and snow is expected for the next 3 days.	It rained for 4 days, setting a record for the most rainfall in one week
It is a hot, dry summer, and a lightning storm comes at night.	A lightning storm hits in a wet, alpine meadow.
It is a dry winter and a dry spring. Someone forgets to put their campfire all the way out.	It is a dry winter and a dry spring. Someone throws a cigarette butt in the forest.

There is no rain for many months. Many trees die. The dry needles are still on the trees.	There is a drought, and many trees die. The dry needles fall from the trees onto the ground.
Someone cuts many small trees and leaves them on the ground in large piles in the forest.	Someone cuts many small trees. They remove the trees and spread the slash over the ground.

Activity 7: Dendrochronology Detectives

Adapted from FireWorks Activity 5-1, 5-2, and 5-3, pages 91-107

Tree rings provide important background information for forest restoration. Tree rings can help determine the age of a tree or a group of trees. When scientists know the age of groups of trees in the forest, they can determine what forests looked like in the past. When scientists can determine what a forest looked like 100 or 200 years ago in a particular location, they can set goals for restoring this same area today.

Fire scars on tree rings can show whether a tree has survived a fire, or many fires, when and how often these fires occurred. From this information, scientists can set goals for restoring fire to forests.

In this activity, students learn about growth rings and how fire scars form on trees. They use *dendrochronology* to describe the history of ponderosa pine forests over the past several hundred years. They learn that restoration requires understanding what historical forests were like, and they learn how tree rings and fire scars can help to determine these historic conditions.

Objectives:

Students learn to describe how tree growth rings are formed, how to estimate tree age, and how to determine fire intervals.

Duration: 2 50-minute sessions

Vocabulary:

- cambium
- crown fire
- dendrochronology
- fire scar
- growth ring
- reference conditions
- restoration
- surface fire
- tree cookies

Materials:

- Tree cookies from ponderosa pine (about 1 per 2-3 students)
- Tree cookie photos (if no real tree cookies are available) (about 1 per 2-3 students)
  - Hand lens (1 per 2-3 students)
  - Straight pins
  - Ancient tree cookie photo
  - Calculators
  - Copies of *Dendrochronology detectives* worksheet

Background:

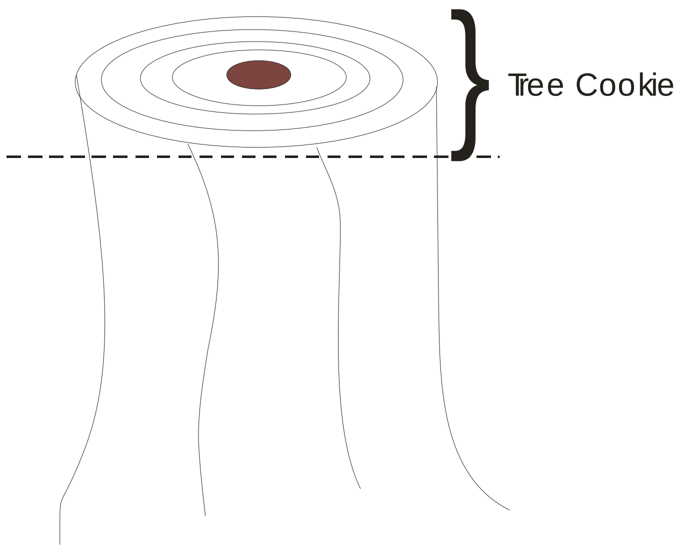
Dendrochronology is the study of tree rings to determine approximate dates of past climatic and other environmental events. The study of tree rings can help scientists understand historic conditions of a forest. Scientists sometimes study tree rings by examining tree cookies, or the cross-section of trees, which are usually cut from dead trees and stumps. The tree rings on these cookies can give information about climate, such as periods of drought (represented by more narrow tree rings) or periods of higher rainfall (represented by wider tree rings). Fire scars can give clues as to the frequency and types of fires that may have been present in different types of forests in the past.

Preparation:

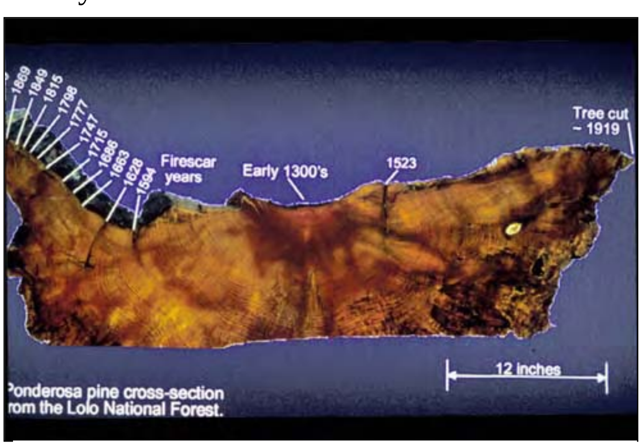
Try to obtain tree cookies and cookies with fire scars from the Pecos area.

If no tree cookies are available with fire scars, you can use color copies of photographed cross-sections (see appendix).

Fire scars are made on trees by <u>surface fires</u> that are not severe enough to kill the tree. A fire scar is formed when part of a tree's <u>cambium</u> is killed by the heat of a fire. If the cambium is damaged only part-way around the tree; the tree often survives. In the years after a fire, new wood forms at the edge of the damaged area. Year after year, new rings are formed that gradually curl over the edges of the damaged area. This new growth begins to cover up the fire scar. Fire scar samples usually show fire scars on one side of the sample, where the fire scorched through the bark and burned the cambium.



Historians recognize two important sources of fire prior to European American settlement of North America. Most fires were started by natural lightning, but some also were started by Native Americans. It is clear that crown fires were rare in ponderosa pine forests. The *Ancient Tree* picture for this activity shows a ponderosa pine tree that survived many fires and lived for nearly 600 years. It is unlikely that there was a crown fire in the location of this tree for these six centuries.



Ancient Tree poster. Various trunks may contain different versions.

Preparation:

These activities are most easily done with real cross-sections of trees (also called tree cookies). These may be available from the Forest Service or from the Laboratory of Tree Ring Research at the University of Arizona. It may also be possible to borrow tree cookies from the Forest Guild in Santa Fe. You will need trees or portions of trees that contain fire scars to complete this activity. If no tree cookies are available with fire scars, you can use color copies of photographed cross-section, such as the Ancient Tree photo. This activity works well if students work in pairs or groups of 3 people (at most), so you will need the appropriate number of cookies or photographs for your class size.

Procedure:

1. Introduce the topic to students by explaining to them that they will be *dendrochronologists* for the day. Ask students to break down the word *dendrochronology* to see if they can figure out its meaning. (*Dendro* = tree; *chrono* = events in a time series; *logy* = the study of). Explain to students that the study of tree rings can help scientists understand historic conditions in the forest. Tree rings can give information about climate, such as periods of drought or periods of higher rainfall. Tree cookies with fire scars can give clues as to the frequency and types of fires that may have been present in different types of forests in the past.

2. Have students examine the growth rings on the *Ancient Tree* picture. The tree in the *Ancient Tree* photo was nearly 600 years old when it died. Look at the scars that form little notches along the blackened edge of the *Ancient Tree.* The scars on this tree were made by surface fires. Because this tree lived for nearly 600 years, and was only burned by surface fires in that time, we can determine that no crown fires occurred where the tree was located for nearly 6 centuries, between the early 1300s and 1919.

3. Explain fire scars to the students: Fire scars are made on trees by <u>surface fires</u> that are not severe enough to kill the tree. A fire scar is formed when part of a tree's <u>cambium</u> is killed by the heat of a fire. If the cambium is damaged only part-way around the tree, the tree often survives. In the years after a fire, new wood forms at the edge of the damaged area. Year after year, new rings are formed that gradually curl over the edges of the damaged area. This new growth begins to cover up the fire scar.

4. Explain that students are going to describe the fire history of a tree. Break students into pairs or groups of 3. If available, pass a fire-scarred ponderosa pine cookie to each group of students. (Use photos if no cookies are available.) Pass out hand lenses to students. **Warning: If students are working with hand lenses in direct sunlight or near sunny windows, be alert for students trying to light fires with the hand lenses.** Also distribute straight pins, *Dendrochronology Detectives,* and calculators.

5. Explain that students are going to be counting the rings of trees to determine the age of the tree (if the pith in the middle of the tree is present), and the number of years between each fire. Tell students they may keep track of tree ring counts by sticking pins into the wood (or photo) or by using a light pencil. **They may not use ink in any form**. Note: When students are counting tree rings, sometimes they will be unable to see a section clearly or to tell if there are one or two rings in a particular area. Explain to the students that when they can't count clearly, that they just estimate one ring. Then when they record the number, they should use the greater-than (>) sign, to denote that there are probably more rings on the cookie. Explain to students that this is a conservative estimate of the age or intervals between years.

6. Have students complete the *Dendrochronology Detectives* worksheet using their tree cookie or photo. Give students 15-30 minutes to study their tree cookies and complete their worksheets. If needed, remind students how to calculate averages. To calculate the average interval between fires, students will add up the numbers of years between each fire scar and divide by the total number of fires.

7. When students have completed their worksheets, have each student share their data. Ask them to determine an average interval of fire for ponderosa pine forests based on the entire class's data.

8. Discussion questions:

   - What does the tree ring data tell us about fire intervals in ponderosa pine forests?
   - Can we learn anything from fire scars about crown fire? Were there any crown fires in the area of each student's tree? How do they know? [The answer should be that a crown fire was very unlikely because a crown fire would have killed the tree. They know this because the tree survived its fires.]
   - Did the students find a particular time period (if they were able to age the tree) when fires become less frequent? Why might fires have been less frequent? [Fire suppression was extensive in the 1920s and 1930s. This was from actively putting out fires, and also from an increase in grazing, which led to a decrease in fine vegetation (fuels) to carry a fire.

- Why might some students have found poor growth after a fire, while other students found good growth? [Poor growth is likely to occur after a fire if the fire killed many of the tree's needles, or if the fire scorched much of the cambium. Rapid growth after fire may be caused by decreased competition from other vegetation for moisture and nutrients, or by an increase in soil nutrients from burned vegetation.]
- How might tree ring data be used for restoration of a particular forest? [Restoration requires the understanding of reference conditions that give information about what a forest used to look like and how it used to function. Historic fire intervals give information about how the forest used to function. Fire intervals from tree cookies can help to estimate how often a surface fire burned in the area where the tree grew. This information can be used to re-establish conditions in forests today so that surface fires may safely burn at similar intervals.]
- Since tree rings are windows into the past, have students compare the following dates in history with the growth rings on their tree cookies. (This extension works only if students can age the trees and the trees are sufficiently old.)

    1) railroads built, 1875
    2) mining boom, 1880s
    3) increase in grazing, 1880s to 1890s
    4) increase in fire suppression, 1920s and 1930s

Have students mark each of these dates with a straight pin and paper. Also have them note if the tree growth changed before or after these dates in any noticeable way. Ask students to explain the relationship between these events and the effects in the forest in terms of a) fire history; b) timber usage; and c) ability of ponderosa pine seedlings to regenerate.

Activity 7: Dendrochronology Detectives

Worksheet

Name ____

A. Does your tree cookie have pith (a ring in the middle) or is it missing? ________

(If the pith is missing, then skip to step D.)

B. If the pith is present, estimate the age of the tree by counting the lines starting from the pith and going to the bark.

C. How old is the tree? ________ years

D. If the pith is present, how old was your tree before it was first scarred by fire? _______

E. How many fires have burned your tree? _______

F. How many years were there between each fire? _______ _______ _______

_______ _______ _______ _______ _______ _______ _______ _______

G. What is the average interval between fires? _______

H. How long has it been since your tree's last fire scar? _______

I. Is this interval very different from the average in question F? _______

If it is different, try to explain why this might be.

J. At what age did your tree grow best? (Where are the rings the widest)? _______

(Wide tree rings show good years for tree growth, when moisture, sunlight, and nutrients were plentiful.)

K. At what age did your tree grow most slowly? (Where are the rings the narrowest?) _______

Rings that are very close together show years of drought, disease, injury, shading, or crowding by other trees.

L. Were the years right after fire usually good or poor for growth? _______

M. How do you explain your tree's response to fire (your answer in part K)?

Activity 8: Fire & Plant Diversity

This activity was adapted from the Fire Ecology Curriculum of the USDA Forest Service, Region 3

As you may have learned, low-intensity fires were a natural part of Southwestern ponderosa pine forests. Records show that these fires burned every 2-10 years. These fires help to recycle nutrients back into the soil by burning excess pine needles, pine cones, and many of the small diameter trees. Larger ponderosa pine trees have adapted thick bark, which allows them to survive, and sometimes thrive, after these fires. Grasses and wildflowers also benefit from the nutrients released by these fires, and these plants often grow quickly in areas burned by low-intensity fire.

In this activity, students will learn about the relationship between low-intensity fires and plant diversity by analyzing data gathered before and after a treatment of thinning and prescribed burning in a ponderosa pine forest near Flagstaff, Arizona. In general, this is a similar treatment to that on the Rincon Ortiz site on Rowe Mesa, so although the species may vary, the effects on diversity should be somewhat similar to what is anticipated for Rowe Mesa.

Objectives:

Students will learn about the relationship between low-intensity fires and plant diversity in ponderosa pine forests of the Southwest.

Duration: 40-50 minutes

Vocabulary:

- Species composition
- Frequency
- Diversity

Materials:

- Photocopies of data sheets
- Overhead with data (optional)
- Graph paper

Procedure:

1. Introduce the lesson by asking students what some of the effects of low-intensity fire might be in the forest. Ask students to define diversity and discuss its importance to ecosystem health.

2. Ask students whether low-intensity fire will increase or decrease plant diversity. Ask students to explain their hypotheses.

3. Explain that students will receive data collected from research plots near Flagstaff, Arizona. Tell students that this site was also treated by thinning and prescribed burning, similar to the site on Rowe Mesa.

4. Also tell students that data was collected before the treatments and then 3 years after the treatments. Ask students why it might be important to have both *before* and *after* data.

5. Tell students that data was collected in two plots – represented as Plot A and Plot B. Ask students to explain why it might be important to gather data in more than one plot.

6. Explain that there will be two kinds of data: a species list and a frequency list. Pass these lists out to the group, or place them on an overhead projector. Ask students to explain the difference and meanings of the two lists.

- A species composition list shows the species that were present at the site.
- A frequency list shows the percentage of total sample plots that contain an individual plant species. So, for example, if big sagebrush is present in 3 out of 4 plots, then its frequency is 75%. Frequency also allows us to compare species. So, for example, if the frequency of big sagebrush is 1.81% and the frequency of common dandelion is 0.30%, then we know that big sagebrush was more common (or occurred more frequently) than the dandelion.

Preparation:

You will need to make photocopies of data sheets and supply graph paper for this activity. You may also copy data sheets onto an overhead projector so that all students may review the data together at the beginning of the exercise.

5. Refer back to students' earlier hypotheses about the relationship between plant diversity and low-intensity fire. Ask them to refine this hypothesis to include both species composition and frequencies before and after the treatment.

6. Break students into 5 groups. Pass out graph paper and data sheets. Give each group their assignments as follows. Also have each group decide whether they should use line or bar graphs to represent their data.

- Group 1: Graph the <u>number</u> of species for both PRE and POST treatments for plots A and B. (Use data sheets 1 and 2.)
- Group 2: Graph the <u>frequency</u> of each species that is present BOTH PRE and POST treatments for Plot A. (Use data sheet 3.)
- Group 3: Graph the <u>frequency</u> of each species that is present BOTH PRE and POST treatments for Plot B. (Use data sheet 4.)
- Group 4: Graph the total <u>number</u> of species both PRE and POST treatment for Plot A. Then calculate the percent change in number of species before and after treatments. (If species are only present in the pre- or post-treatment, then the number is 0 when the species is not listed.) (Use data sheet 1.)
- Group 5: Graph the total <u>number</u> of species both PRE and POST treatment for Plot B. Then calculate the percent change in number of species before and after treatments. (If species are only present in the pre- or post-treatment, then the number is 0 when the species is not listed.) (Use data sheet 2.)

7. Have students present their graphs to the class, explaining how they constructed their graphs and what the data mean.

8. Have students revisit their hypotheses. Were they correct? Have students explain why or why not.

9. Discussion points:

    - Were there a greater <u>number</u> of species present in each plot before or after? (after)
    - Were there higher or lower numbers of each plant species after thinning and burning? (higher)
    - Was there much difference in the data from plot A versus plot B? What might explain these differences?
    - What does this data tell you about plant species diversity in ponderosa pine forests?
    - What were the most effective ways to graph this information?

Activity 8, Data Sheet 1: Species Composition, Plot A

Plot #	Pre- or Post-Treatment	Common Name	Date
A	PRE	Beardslip penstemon	4/10/96
A	PRE	Big sagebrush	4/10/96
A	PRE	Carruth's sagewort	4/10/96
A	PRE	Common dandelion	4/10/96
A	PRE	New Mexico locust	4/10/96
A	PRE	Silver lupine	4/10/96
A	PRE	Thick-leaf beardtongue	4/10/96
A	PRE	Western bottle-brush grass	4/10/96
A	POST	American dragonhead	5/31/99
A	POST	Beardlip penstemon	5/31/99
A	POST	Big sagebrush	5/31/99
A	POST	Birdsfoot trefoil	5/31/99
A	POST	Blue grama	5/31/99
A	POST	Canadian horseweed	5/31/99
A	POST	Cheatgrass	5/31/99
A	POST	Common mullein	5/31/99
A	POST	Coyote tobacco	5/31/99
A	POST	Desert ragwort	5/31/99
A	POST	Douglas' knotweed	5/31/99
A	POST	Fendler's rockcress	5/31/99
A	POST	Gambel oak	5/31/99
A	POST	Hoary aster	5/31/99
A	POST	Horned spurge	5/31/99
A	POST	Lambs'quarters	5/31/99
A	POST	Lobeleaf groundsel	5/31/99
A	POST	Longleaf phlox	5/31/99
A	POST	New Mexico bird's foot trefoil	5/31/99
A	POST	New Mexico locust	5/31/99
A	POST	Nodding buckwheat	5/31/99
A	POST	Pale agoseris	5/31/99
A	POST	Ponderosa pine	5/31/99
A	POST	Red monkeyflower	5/31/99
A	POST	Silver lupine	5/31/99
A	POST	Slender phlox	5/31/99
A	POST	Smallflower blue eyed Mary	5/31/99
A	POST	Spreading groundsmoke	5/31/99
A	POST	Stickywilly	5/31/99
A	POST	Tall annual willow herb	5/31/99
A	POST	Thick-leaf beardtongue	5/31/99
A	POST	Wax currant	5/31/99
A	POST	Western bottle-brush grass	5/31/99
A	POST	wheatgrass	5/31/99

Activity 8, Data Sheet 2: Species Composition, Plot B

Plot #	Pre- or Post-Treatment	Common Name	Date
B	PRE	Big sagebrush	4/10/96
B	PRE	Cheatgrass	4/10/96
B	PRE	Common mullein	4/10/96
B	PRE	Desert ragwort	4/10/96
B	PRE	Hoary aster	4/10/96
B	PRE	Horned spurge	4/10/96
B	PRE	Lobeleaf groundsel	4/10/96
B	PRE	Pale agoseris	4/10/96
B	PRE	Silver lupine	4/10/96
B	PRE	Wax currant	4/10/96
B	PRE	Western bottle-brush grass	4/10/96
B	POST	Beardlip penstemon	5/31/99
B	POST	Big sagebrush	5/31/99
B	POST	Canadian horseweed	5/31/99
B	POST	Carruth’s sagewort	5/31/99
B	POST	Cheatgrass	5/31/99
B	POST	Common mullein	5/31/99
B	POST	Common pepperweed	5/31/99
B	POST	Cryptantha	5/31/99
B	POST	Desert ragwort	5/31/99
B	POST	Douglas’ knotweed	5/31/99
B	POST	Fendler’s rockcress	5/31/99
B	POST	Gambel oak	5/31/99
B	POST	Hoary aster	5/31/99
B	POST	Horned spurge	5/31/99
B	POST	Lambs’quarters	5/31/99
B	POST	Lobeleaf groundsel	5/31/99
B	POST	New Mexico locust	5/31/99
B	POST	Nodding buckwheat	5/31/99
B	POST	Prickly lettuce	5/31/99
B	POST	Red monkeyflower	5/31/99
B	POST	Showy goldeneye	5/31/99
B	POST	Silver lupine	5/31/99
B	POST	Slender phlox	5/31/99
B	POST	Smallflower blue eyed Mary	5/31/99
B	POST	Spotted missionbells	5/31/99
B	POST	Spreading fleabane	5/31/99
B	POST	Spreading groundsmoke	5/31/99
B	POST	Spreading sandwort	5/31/99
B	POST	Tall annual willow herb	5/31/99
B	POST	Toadflax penstemon	5/31/99
B	POST	Western bottle-brush grass	5/31/99
B	POST	Wright’s deervetch	5/31/99
B	POST	Yellow salsify	5/31/99

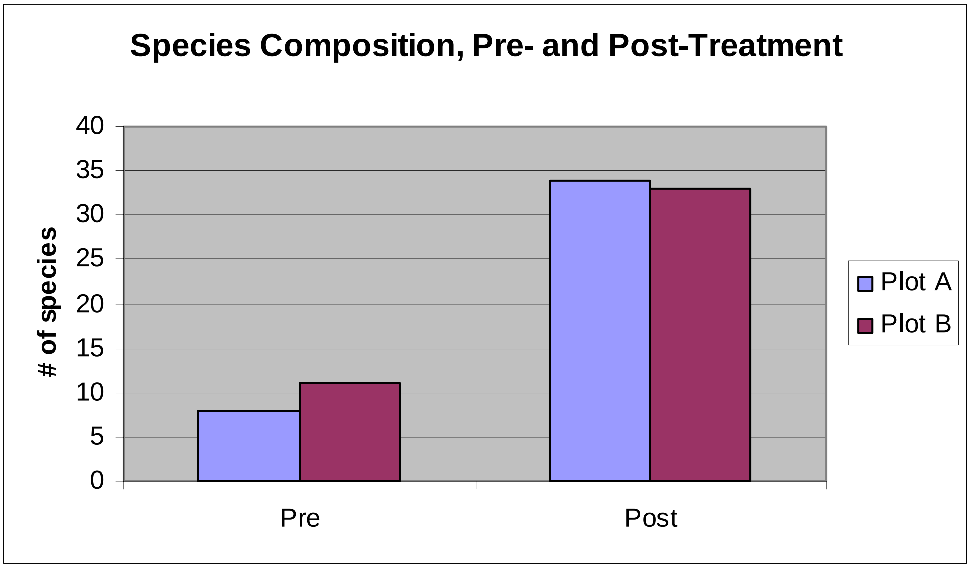
Activity 8, Data Sheet 3: Plant Species' Frequencies, Plot A

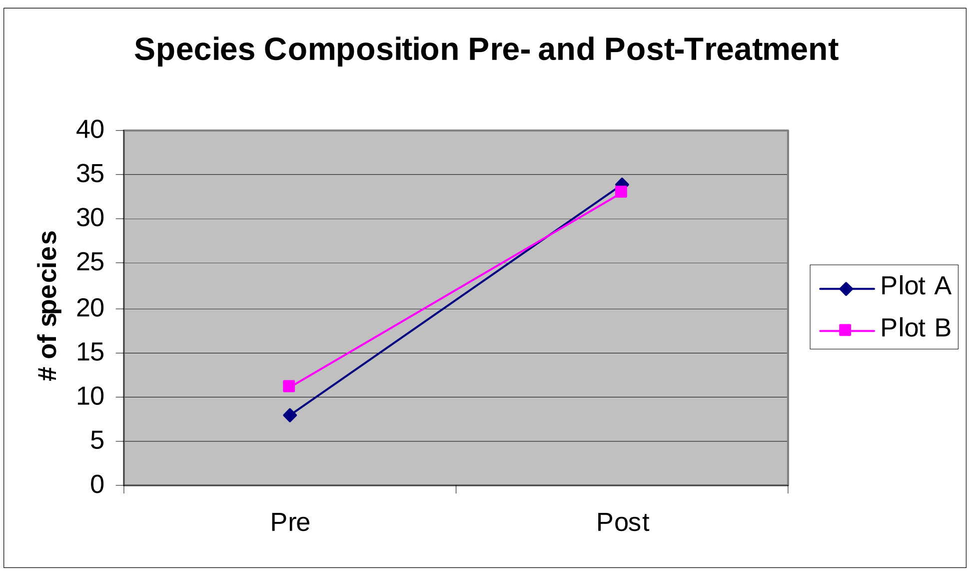
Plot	Pre- or Post-Treatment	Common name	Frequency (%)	Date
A	PRE	Big sagebrush	1.81	4/10/96
A	PRE	Western bottle-brush grass	1.51	4/10/96
A	PRE	Silvery lupine	1.20	4/10/96
A	PRE	Thick-leafed beardtongue	0.60	4/10/96
A	PRE	New Mexico locust	0.30	4/10/96
A	PRE	Common dandelion	0.30	4/10/96
A	POST	Silvery lupine	9.94	5/31/99
A	POST	New Mexico locust	3.31	5/31/99
A	POST	Cheatgrass	3.01	5/31/99
A	POST	Smallflower blue eyed Mary	2.71	5/31/99
A	POST	Western bottle-brush grass	2.71	5/31/99
A	POST	Big sagebrush	2.11	5/31/99
A	POST	Lobeleaf grounsel	1.20	5/31/99
A	POST	Thick-leaf beardtongue	1.20	5/31/99
A	POST	Gambel oak	0.90	5/31/99
A	POST	Slender phlox	0.60	5/31/99
A	POST	Common mullein	0.60	5/31/99
A	POST	Spreading groundsmoke	0.30	5/31/99
A	POST	New Mexico bird's-foot trefoil	0.30	5/31/99
A	POST	Wheatgrass	0.30	5/31/99
A	POST	Blue grama	0.30	5/31/99

Activity 8, Data Sheet 4 Plant Species' Frequencies, Plot B

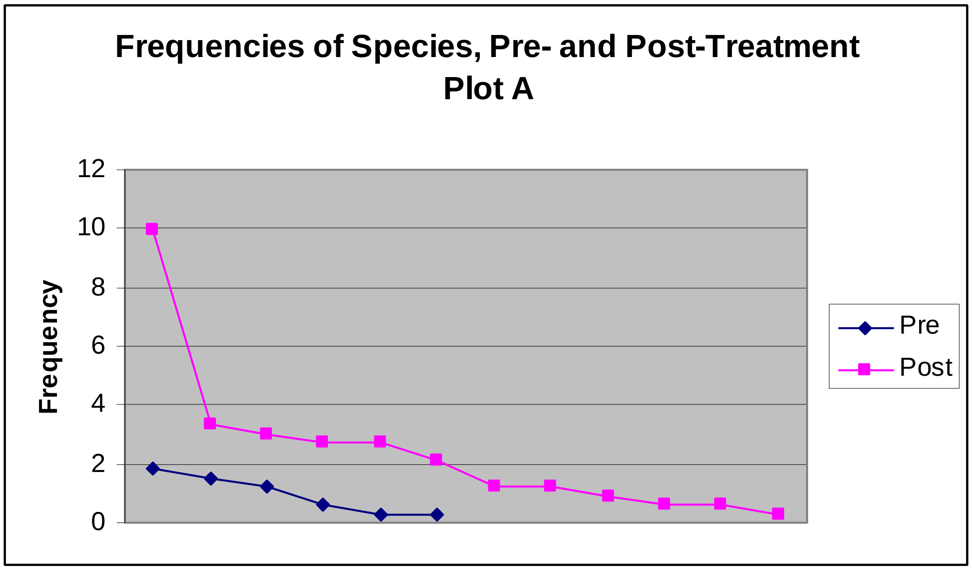
Plot	Pre- or Post-Treatment	Common name	Fre-quency (%)	Date
B	PRE	Big sagebrush	2.41	4/10/96
B	PRE	Western bottle-brush grass	1.81	4/10/96
B	PRE	Cheatgrass	1.20	4/10/96
B	PRE	Common mullein	0.30	4/10/96
B	POST	Big sagebrush	4.22	5/31/99
B	POST	Smallflower blue eyed Mary	4.22	5/31/99
B	POST	Silvery lupine	3.61	5/31/99
B	POST	Western bottle-brush grass	3.01	5/31/99
B	POST	cheatgrassttle-brush grass	2.71	5/31/99
B	POST	New Mexico locust	2.41	5/31/99
B	POST	Lobeleaf grounsel	2.11	5/31/99
B	POST	Canadian horseweed	1.81	5/31/99
B	POST	Common mullein	1.81	5/31/99
B	POST	Tall annual willow herb	0.90	5/31/99
B	POST	Desert ragwort	0.60	5/31/99
B	POST	Slender phlox	0.30	5/31/99
B	POST	Gambel oak	0.30	5/31/99
B	POST	Red monkeyflower	0.30	5/31/99
B	POST	Lambs' quarters	0.30	5/31/99
B	POST	Prickly lettuce	0.30	5/31/99

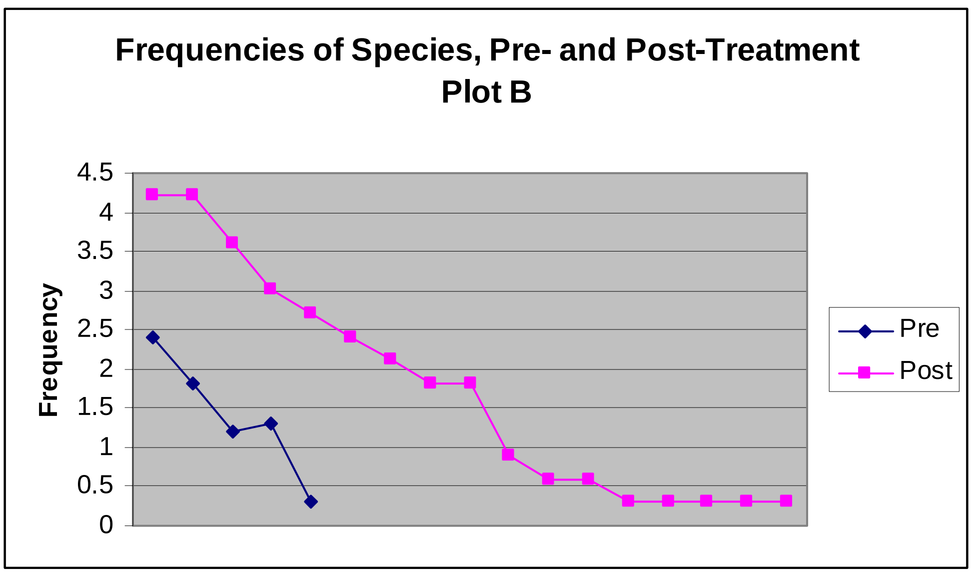
Activity 8, Sample Graphs for Group 1:



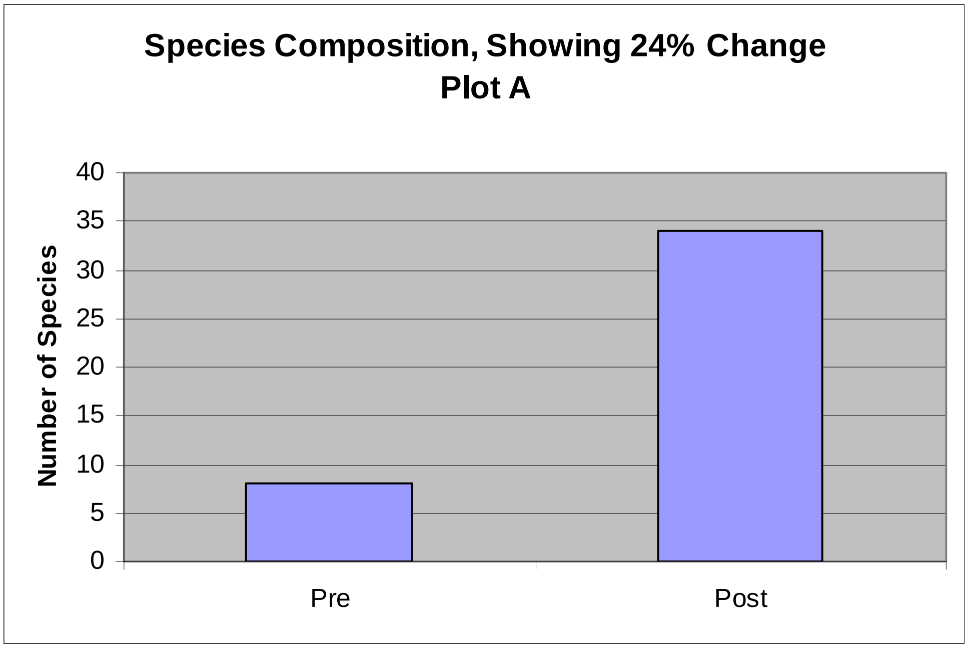


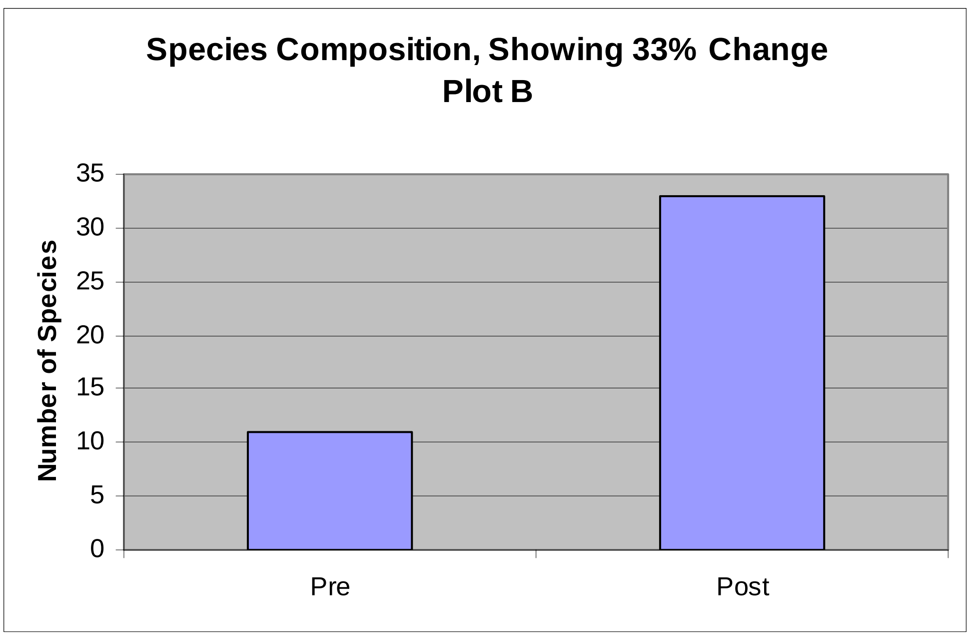
Activity 8, Sample Graphs for Groups 2 & 3





Activity 8, Sample Graphs, Groups 4 & 5:





Activity 9: Forest Composition & Tree Size

Ponderosa pine forests used to have trees of all ages. Tree size structure tells us how many trees there are of different sizes. Every forest type has a characteristic tree size structure that was typical of natural conditions. The structure would change somewhat with changing conditions, such as climate or disturbances like fire, but would tend toward that typical structure with time.

Ponderosa pine forests, for example, typically had trees in all age classes. In other words, there were young, middle-aged, and mature trees. Sometimes a group of trees established in past centuries in favorable climate conditions and a group of trees on the ground are around the same age. In general, trees can grow at different rates, and tree size isn't always a reflection of tree age. But for ponderosa pines in the Southwest before human activities changed forest structure so dramatically, there was a good relationship between age and size.

The restoration project on Rowe Mesa used the knowledge of these natural structures for ponderosa pine forests in the Southwest to set goals and targets. For thinning, this meant taking away many of the smaller diameter trees and leaving larger ones. It also meant removing much of the piñon and juniper, and leaving some of the remaining trees in clumps.

In this activity, students will analyze data gathered before and after thinning on the Rincon Ortiz site. They will assess whether the project made progress toward its goals.

Objectives:

Students will learn about the structure of ponderosa pine trees by analyzing data.

Duration: 40 minutes

Vocabulary:

- diameter at breast height
- forest composition
- mean
- species composition
- tree size

Materials:

- Pencil
- Photocopies of data tables
- Photocopies of worksheets

Preparation:

Photocopy the data tables and worksheets for each student.

Procedure:

1. Introduce the lesson by telling students they will be analyzing data to assess whether the restoration project on Rowe Mesa has met some of its objectives.

2. Remind students that the primary focus of the restoration project was to change the forest structure and to re-create conditions to allow low-intensity surface fires on Rowe Mesa. Ask students specifically what this might entail. Answers should include:
   - Removing many of the pinyon pine and juniper trees
   - Removing the small diameter ponderosa pine trees

3. Explain that students will be analyzing data on forest composition and tree size to see if the project was successful in achieving these goals.

4. Ask students to define forest composition and tree size:

    - Forest composition is a list of the tree species present at the site. (It is the same as species composition but focused on trees rather than all species.)
    - Tree size tells us the diameter of the tree. The diameter of the tree is measured at a standard height of 4.5 feet from the ground. This measurement is called "diameter at breast height" and is abbreviated DBH.

5. Ask students to predict what should happen if the project was successful in terms of:

    - Forest composition (there should be fewer pinyon and juniper trees after treatment than before; there should be fewer or relatively same number of ponderosa pine trees than before).
    - Tree size (there should be larger diameters of all tree species because the smaller trees were cut).

6. Pass out copies of data tables.

7. Review the data tables. Make sure students understand the mean (the average). As an introduction to the tables, ask students to find the following information:

    - The mean count (number) of pinyon pine trees before treatment at site 1 (37)
    - The mean DBH of all ponderosa pine trees before treatment (23.4 cm)
    - The mean count (number) of Rocky Mountain juniper trees at site 4 after treatment (5)

8. Have students complete the worksheet questions.

9. Next have students revisit their predictions. Were they correct? Have students explain why or why not.

10. Discussion points:

    - Did the forest composition change? How so? (Yes, the composition changed: The numbers of pinyon pine trees were reduced so that even though there are still more pinyon pine trees than ponderosa pine trees at the site, it is less dominant on the site. The project also successfully reduced the numbers of Rocky Mountain junipers.)

    - Did the tree size change? How so? (Yes, the tree sizes changed: the mean DBH for pinyon pine was increased from 12.1 cm to 14.1 cm. The mean DBH of Rocky Mountain juniper also increased, from 10.0 cm before treatment to 13.3 cm after treatment. This means that the smaller trees were cut and the larger trees were kept. The mean DBH for ponderosa pine decreased slightly, going from 23.4 cm to 22.1 cm. This could be due to one larger tree being cut. However, the overall tree size of ponderosa pines remained about the same.)

    - Did the project succeed in moving in a direction toward its goals? Explain. (Yes, because it reduced the fuel, as evidenced by reducing the numbers of smaller trees.)

Activity 9: Forest Composition and Size

Table 1: Forest Composition and Size in 2002 (Pre-Treatment)

This data was collected in the Rincon Ortiz site before it was treated, in 2002. PIED stands for pinyon pine (*Pinus edulis*); PIPO stands for ponderosa pine (*Pinus ponderosa*); and JUSC stands for Rocky Mountain Juniper (*Juniperus scopulorum*). The count is the total number of individuals found in each site. The mean DBH is given in centimeters. At the bottom of the table is the mean value for all sites.

Site	PIED count	PIED mean DBH (cm)	PIPO count	PIPO mean DBH (cm)	JUSC count	JUSC mean DBH (cm)
1	37	11.8	8	25.6	5	8.0
2	34	10.4	21	21.0	3	9.7
3	37	12.3	10	29.0	4	13.7
4	45	13.1	4	17.8	10	11.7
5	51	12.8	0	--	6	11.4
Mean	**40.8**	**12.1**	**8.6**	**23.4**	**5.6**	**10.9**

Table 2: Forest Composition and Size in 2004 (Post-Treatment)

This data was collected in the Rincon Ortiz site after it was treated, in 2004. PIED stands for pinyon pine (*Pinus edulis*); PIPO stands for ponderosa pine (*Pinus ponderosa*); and JUSC stands for Rocky Mountain Juniper (*Juniperus scopulorum*). The count is the total number of individuals found in each site. The mean DBH is given in centimeters. At the bottom of the table is the mean value for all sites.

Site	PIED count	PIED mean DBH (cm)	PIPO count	PIPO mean DBH (cm)	JUSC count	JUSC mean DBH (cm)
1	12	16.7	23	26.2	1	19.3
2	31	9.1	20	25.8	2	12.9
3	23	15.6	25	30.3	2	9.8
4	26	17.0	12	16.4	5	14.3
5	40	12.2	1	12.0	7	10.5
Mean	**26.4**	**14.1**	**16.2**	**22.1**	**3.4**	**13.3**

Activity 9: Forest Composition and Tree Size Worksheet

Name ____

1. Look at table 1 for pre-treatment data. Record the mean count (in the bottom row of the table) for each species. Rank each tree species from 1 to 3, with 1 being the most abundant and 3 being the least abundant:

Species	**Count**	**Rank**
Pinyon pine		
Ponderosa pine		
Rocky Mountain Juniper		

2. Now look at table 2 for post-treatment data. Record the mean count (in the bottom row of the table) for each species. Rank each tree species from 1 to 3, with 1 being the most abundant and 3 being the least abundant:

Species	**Count**	**Rank**
Pinyon pine		
Ponderosa pine		
Rocky Mountain Juniper		

3. Did the counts increase or decrease for piñon pine? _____ for ponderosa pine? _____ for Rocky Mountain juniper? ____

4. Did the ranks change after treatment as compared to before?

5. Now look at the mean DBH given in table 1 for pre-treatment data. Which species had the largest mean DBH? __ Which species had the smallest mean DBH ________?

6. Look at the mean DBH given in table 2, after treatment. Which species had the largest mean DBH? __________________ Which species had the smallest mean DBH? ______________________

7. Did the mean DBH get bigger or smaller for pinyon pine? ________ For ponderosa pine? __________ For Rocky Mountain juniper? ____________

Activity 10: Determining Reference Conditions

A fundamental part of ecological restoration is to understand the natural or historical conditions of the system that is being restored. Scientists need to uncover what a forest looked like or behaved like in the past, before the system was damaged or changed. Scientists often use these past conditions, called "reference conditions," as targets for restoration activities in the present.

In this activity, students will learn about different tools to determine reference conditions, and will apply these tools to specific case studies. They will gather information about past conditions on Rowe Mesa and will work in teams to describe reference conditions. They will apply this knowledge to restoration goals on the mesa and discuss the actions that were taken to restore the forested areas of the site.

Objectives:

Students will use data gathering and analysis skills to determine reference conditions for a restoration site. Students will learn about different kinds of information that scientists can use and apply to understanding a system.

Duration: 50 minutes

Vocabulary:

- ethnobotany
- pack rat middens
- reference conditions
- tree rings

Materials:

- Photocopies of student investigator cards
- Completed packets for student investigations, including worksheets
- Accompanying CD with photographs for Dendrochronologist and Environmental Historian

Background

Researchers use a variety of tools to investigate past ecological conditions. Some are biological and some are cultural. Examples of biological evidence include tree rings and pack rat middens. Examples of cultural data include old photographs and documents such as diaries and logs of early explorers.

Sometimes people have been influencing an ecosystem for so long that physical evidence – whether biological or cultural – does not exist to show its natural state. In these cases, scientists have to apply what they know from research to estimate historical conditions for a system or site. At other times, changes in an ecosystem are recent enough that scientists can reconstruct what the system was like with a much greater degree of accuracy. Some methods that help to estimate past ecological conditions include:

- Physical evidence from the ecosystem being studied, such as tree ring data, fire scars, and pack rat middens
- Old maps and photographs
- Old aerial photographs

- Ethnobotanical evidence, such as oral histories; anthropological literature about peoples' uses of plants for food or medicine; and analysis of materials used to make baskets, clothing, food bags, etc.
- Written records, including the logs and diaries from explorers, military expeditions, trappers, missionaries, and merchants
- Census data, including population and land surveys
- Reports from early scientific expeditions

While scientists use a combination of all these forms of information to try to determine past ecological conditions for a system, they try to rely most heavily on physical evidence because of possible inaccuracies in reports, exaggeration in diaries, or natural variations in a landscape that a single photograph or document cannot capture. Physical evidence provides the best insight into a forest's history when that forest has not been heavily influenced by people for a long time. In the case of Rowe Mesa, which has been used by people for centuries, it is not possible to reconstruct exactly what conditions were like on the site. In these instances, scientists rely more heavily on reference conditions from other ponderosa pine forests in the area that were used much less by humans.

In addition, all ecosystems naturally change with time so there is no single set of conditions that existed in the past. More likely, any ecosystem had a natural range of variation in conditions, so that, for example, some ponderosa pine forests were more densely populated with trees, while others were open areas scattered with old, large pines.

Preparation:

You will need to prepare materials for student investigations in advance. To do this, cut out enough "student investigator cards" so that each group of students can receive one of the four cards. These can be photocopied and cut out from the worksheet that follows this activity. You will also need to prepare student investigation packets. You will need one of each of these. If you have a large class, you may want to make two of each so that all students will be able to interpret materials. For student investigations as the Dendrochronologist and the Environmental Historian, it is best to make colored photocopies or print-outs from the CD that accompanies this curriculum and to use the student investigation text only as a reference.

Procedure:

1. Introduce the topic of restoration by asking students to describe in sketches and words the forests in the Pecos area. Have them use as much detail as they can, including names of plants and animals, existence of meadows or different forest types, and so on.

2. Next ask students to list all the ways they can think of that their families use the forest and its products. Examples of uses might include for picnics and hiking, for gathering fuelwood, hunting wild turkeys, collecting pinyon nuts, cutting small trees for latillas, or gathering medicinal plants for grandparents.

3. Explain that student drawings or lists of family uses are similar to what scientists sometimes draw upon to determine the conditions of ecosystems 100 or more years ago. Ask students to give the pros and cons for using this information as a reference for restoring the forest. (Pros include documentation of many of the plants and animals that existed in the forest; Cons include limited spatial references, possible mis-identification of plant species, or exaggerated perceptions of explorers as they moved from flat and open plains to a forested, mountainous region.)

4. Ask students to think about other kinds of evidence scientists might use to determine past conditions of an ecosystem. Introduce the term <u>reference condition</u>, and explain the importance of this in restoration efforts.

5. Next explain to students that they will break into groups of "investigators." Students will examine evidence from an ethnobotanist, military expedition, environmental historian, or restoration ecologist.

6. Pass out student investigator packets that they will use to determine reference conditions.

7. Tell students that they have 10 minutes to analyze the material they are given and to list what kinds of data they kind find from their sources. They should record data on their investigator's worksheet.

8. After 10 minutes, ask each team to present their findings to the class as a whole. On a classroom board, flip chart, or overhead projector, record these findings as students present them.

9. When each group is finished presenting their findings, ask students to look at the findings as a whole and to identify commonalities from the different sources of data.

10. Ask students to create a list of reference conditions that they feel fairly certain might have represented the site 100-150 years ago.

11. Ask students how they would apply these conditions to the forest they described earlier. What changes would need to be made to the site in order for it to look like it did 100-150 years ago?

12. Points of discussion:

    - What are some of the pros and cons in using different types of data to determine reference conditions?
    - Did you have enough data? From the right years? To adequately determine reference conditions? If not, what would you need in addition?
    - If you are trying to restore a forest today, how would you use these types of data in deciding how to manage the forest?

Activity 10: Determining Reference Conditions

Student Investigator Cards

You are an ethnobotanist and document cultural uses of plants among Native Americans and Hispanic families.	You are part of a military expedition, and are taken by the landscape of the Southwest and write about it in your diary and reports. The year is 1858.
You are a restoration ecologist and are studying tree rings to learn about forests of the past.	You are an environmental historian and analyze aerial photographs, maps, and old Forest Service documents to determine what the West was like at the beginning of the 20^{th} Century.

Activity 10: Determining Reference Conditions
Student Investigations

Ethnobotanist[2]

You are an ethnobotanist, studying the Native American and Hispano uses of the Pecos area. This is some of the information you have found documenting land uses in 1906:

The grazing of sheep and goats is the most important industry in the area. B few cattle are also owned but the number is not large. It is impossible to say how many sheep and goats use this range or the proportion that there is of each. The sheep are largely owned by well to do Mexicans who live in Santa Fe and Galisteo. The goats are owned in small bands as nearly every Mexican family owns some goats; however, several of the large sheep owners also have angora goats to run with their sheep. Owing to great prosperity among wool-growers, all the ranges of New Mexico have been greatly overstocked during the past ten years. Much of the range has been so badly eaten out that it will not carry half as much stock as it would at one time.

Every “live” stream has its full quota of Pueblos along it and all available agricultural land is farmed, corn and frijoles being the main crops. Much alfalfa is also raised. Throughout the mesa country there are numerous ranches of temporary nature as they are used only as sheep and goat camps during part of the year. (p. 11)

In the immediate vicinity of Santa Fe, the juniper and piñon have been cutover continuously for the past 300 years until now the stand is in very poor shape. Conditions are similar near all the Pueblos. The Mexicans have long been in the habit of packing wood into Santa Fe (from further away).

[2] All information comes from “Propsed Addition to the Pecos National Forest, New Mexico.” By H.O. Stabler, Forest Assistant, Forest Service, 1906. Approved August 2, 1907 by D.D. Bronson, Chief Inspector.

Military Expedition[3]:

You are part of a military expedition, and have recorded the following in your journal:

September 8, 1858: "We come to a glorious forest of lofty pines, through which we traveled 10 miles. The country was beautifully undulating, and although we usually associate the idea of barrenness with the pine regions, it is not so in this instance; every foot being covered with the finest grass, and beautiful broad grassy vales extending in every direction. The forest was perfectly open and unencumbered with brush wood, so that traveling was excellent."

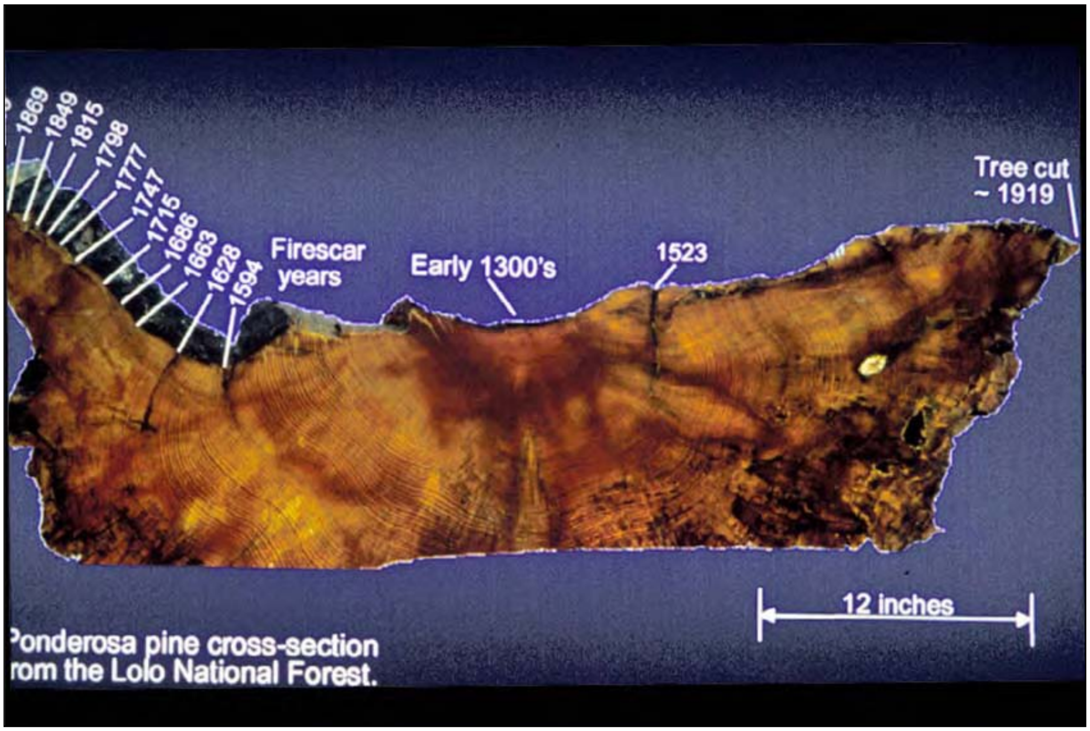
September 21, 1858: "B vast forest of gigantic pine, intersected frequently by extensive aspen glades, sprinkled all over the mountain meadows and wide savannahs, filled with the richest grasses, were traversed by our party for many days."

May 5, 1882: "The trees are large and noble of aspect and stand widely apart, except o the highest part of the plateau where spruces predominate. Instead of dense thickets where we are shut in by impenetrable foliage, we can look far beyond and see the tree trunks vanishing away like an infinite colonnade. The ground is unobstructed and inviting. There is a constant succession of parks and glades—dreamy avenues of grass and flowers winding between sylvan walls, or spreading out in broad open meadows…The way here is as pleasing as before, for it is beneath the pines standing at intervals varying from 50 to 100 feet, and upon a soil that is smooth, firm, and free from undergrowth."

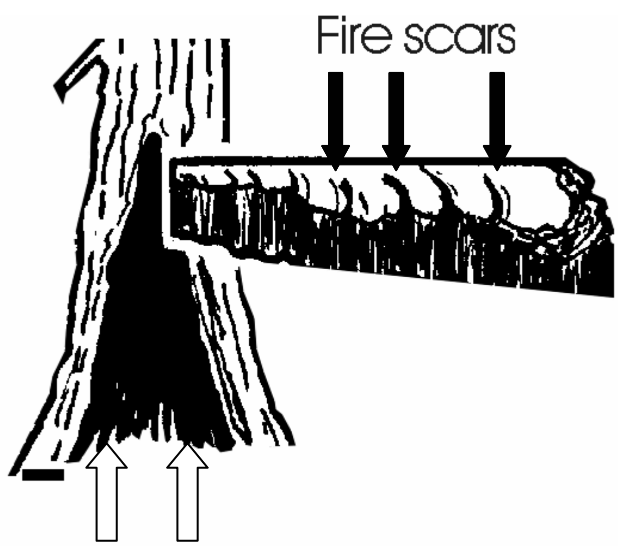
[3] Quotes 1 & 2 come from Beale, E.F. 1858. "Wagon road from Fort Defiance to California." 35 Congressional Session, Senate Executive Document 43. The 3rd paragraph comes from Dutton, W.L. 1882. "Physical geology of the Grand Canyon District." United States Geologic Service 2nd Annual Report: 49-166.

Dendrochronologist:

You are a dendrochronologist and study tree ring scars. Analyze the following photos as part of your research.



Ancient Tree poster. Various trunks may contain different versions.



Fire Scars

Environmental Historian:

You are an environmental historian and are studying the Pecos National Forest. You have photos and text from a 1906 report written by the Forest Service[4].

Commercial Forest & Timberland

Immediately south of the Pecos National Forest there is some very good pine and red fir but, unfortunately, much of the best of this timber has been taken up by the Santa Fe Railroad. On the northern part of Glorieta Mesa are several small areas containing the commercial type. These stands are usually open but some of the draws and canyons have a small amount of good saw-timber.

In places, the pine occurs as scattered individual trees through the piñon and juniper, or the pine may be found as solid clumps surrounded by the piñon and juniper. On the northern part of Glorieta Mesa some of the piñon is large enough for ties and in a few years it will certainly pay to cut it. In many places it seems probable that a thinning of the juniper and piñon would lead to reproduction of the pine. Throughout the type, there is evidence that the pine is increasing rather than decreasing.

Woodland

Juniper and piñon compose the stands of the woodland type almost entirely though along the streams there is some cottonwood and oak. The density of the stands varies greatly though the typical stand is rather open, the trees limby, and rarely over 30 or 35 feet in height. In such a stand as this there is good grazing, provided it has not been overgrazed. On better soil, where piñon predominates, the stand is often too dense for the best grazing conditions. Some of the piñon on Glorieta Mesa will make [rail road] ties.

Open Grassland

The area of this type is relatively small. There is, or has been, good grama grass on all of the open land, however, overgrazing is common. The open area on Glorieta Mesa west of San Jose is nearly level and is very good grazing land but of recent years it has been severely overgrazed by sheep and goats.

Fires

There have been no fires of any consequence, at least there have been none for a great many years. Evidence of light ground firest is occasionally seen but these covered only small areas. It is strange that there have been no fires in the timber in the timber immediately south of the present Pecos

[4] All materials directly quoted from "Proposed Addition to the Pecos National Forest, New Mexico" by H.O. Stabler, Forest Assistant, Forest Service, 1906. Approved August 2, 1907 by D.D. Bronson, Chief Inspector.

Forest. Lumbering has been going on there on railroad and private holdings and there has, of course, been a great deal of slash in which fires could have started.

Old foundation on the Rowe Mesa Grassbank
Photo: Deborah Myrin

Activity 10. Determining Reference Conditions

Student Investigations Worksheet

Name ____________________________ Date __________________________

What is your job? ____

What is the year(s) you have information from? ____

What kinds of documents did you have to analyze? _______________________________________

____

What types of plants were described at the site? ____

____

What kind of habitat types did you find evidence of? (For example, did you find meadows, forests, wetlands, open plains, or others?)

____

____

Was there any evidence of fire? If so, what was the evidence? Do you know the intervals of fire from your data?

____

____

What does this tell you about historic site conditions? (Do you know if the site was densely forested, relatively open, meadows, wetlands, had frequent fires, etc.)

____

____

Are there any other conditions at the site that you know of?

____

Appendix 1

Glossary

Adaptation: Something about an organism that helps it survive and reproduce; an aspect of its form, function, or behavior that helps it out-compete other organisms.

Bark: The tissue that covers stems, branches, and roots of a tree or shrub.

Biodiversity. Variety of living organisms. See diversity.

Botanist: A person who studies plants.

Cambium: A thin layer of tissue, located between the bark and the central wood of a tree, where all plant growth occurs.

Canopy cover: The area in a forest covered by tree crowns, measured as the percentage of horizontal cover of the ground that the canopy covers.

Cavity: A hole or hollow place, usually used to refer to a hole in a tree that is used by animals for nesting.

Cavity nester: An animal that uses holes in trees for raising young. Common cavity-nesting birds include northern flickers, house wrens, and mountain bluebirds.

Competition: When two or more organisms seek an environmental resource that may be in short supply.

Composition: A list of all the species that live in an area.

Cone: The physical structure that stores seeds of coniferous plants.

Cover: The amount of the ground that is shaded by standing, living understory plants, usually expressed as a percentage. Also, the cover of the ground by dead plants and plant parts, usually called litter.

Crown: The uppermost leafy portion of a tree.

Crown fire: A fire that burns in the canopy of trees. Crown fires can begin as surface fires and then move into the tops, or "crowns," of trees. Then they move rapidly from one crown to another, especially if the wind is strong. During a crown fire, the wind sometimes carries burning branches far ahead of the fire. These "firebrands" can start new fires. A spotting fire "leapfrogs" through the forest, so it can move very fast, especially when it is windy.

Data: A set of observations collected through measurements. The word "data" is plural. The singular form of data is "datum."

Degraded: Reduced quality or condition.

Dendrochronology: The science of learning about trees and climate from tree growth rings.

Density: The number of plants or animals in a given area. For example, tree density is often measured in trees per acre.

Diameter at breast height: The diameter of a tree at breast height (approximately 4.5 feet above the ground on the uphill side of the tree).

Dispersal: The process or result of spreading something from one place to another. Plants often produce seeds and fruits so that animals will eat them and carry them away from the original plant. This action is called dispersal.

Diversity: Variety, for example, of organisms, species, genes, habitats, ecosystems, etc.

Drought: A prolonged period with much lower rainfall than is typical of a region.

Ecologist: A person who studies the relationships between organisms and their environments.

Ecosystem: An interacting system of living plants and animals and the nonliving parts of their environment.

Erosion: The movement or wearing of soil or rocks by wind or water.

Ethnobotany: The study of plants and the ways they are used and managed by people.

Exotic plants: Plants that are non-native to a particular ecosystem or community, that often thrive on disturbed conditions and can become abundant after thinning or burning. Exotic plants can displace and reduce populations of native species.

Extinct: When a species no longer exists, either locally or entirely.

Factors: Specific events, situations, conditions, policies, attitudes, beliefs, or behaviors that may affect the desired future condition.

Field site: The location of a study or project.

Fire intensity: A reference to the amount of heat a fire generates in a particular location and time.

Fire manager: A person who takes actions to prescribe, suppress, or manage wildfires for particular purposes.

Fire regime: The pattern of fire occurrence, size, and severity typical of an ecosystem.

Fire spread: The rate a fire moves per unit of time.

Fire scar: A wound at the base of a tree caused by heat damage to the cambium.

Fire triangle: The three things necessary for fire: fuel, oxygen, and a source of heat.

Forb: A broad-leafed green plant whose stems are not woody, but not including grasses, sedges, or rushes.

Forest composition: The species present within a forest.

Forester: A person who studies forests and is involved in forest management and use.

Frequency: The number of times a certain value or response occurs in a set of data points. Usually represented as a percentage.

Fuel: The living and dead vegetation that can be burned in a forest fire. Fuel can include dead woody material from logs and branches, leaves of trees and shrubs, pine needles, grasses, and other plants.

Goal: A general summary of the desired state that a project is working to achieve. A good goal meets the criteria of being visionary, relatively general, brief, and measurable. A goal is typically less specific than an objective.

Ground cover: The cover that grasses, forbs, and other plants cast on the forest floor. Ground cover also includes other materials on the ground, such as needles, leaf litter, and rocks. Ground cover is usually expressed as a percentage.

Ground fire: After a surface fire burns through an area, patches of deep fuel may continue smoldering. This is called a ground fire. Ground fires burn the fallen leaves and small branches that have started to decay and become part of the soil. Ground fires don't move very fast and hardly make any flames. They can take days or even weeks to burn themselves out.

Growth ring: The annual layer of growth in a tree. Also referred to as a tree ring.

Habitat: The place where an organism is usually found and includes food, water, shelter, and nesting conditions that the organism needs to survive.

Heat: A form of energy that raises the temperature of matter.

Hypothesis: An informed prediction of the outcome of an experiment. An explanation that can be tested.

Ignition: The act of starting a fire.

Ladder fuels: Live shrubs and small trees, dead and leaning logs, and branches of live trees that fill the space between the forest floor and tree crowns with flammable material. Ladder fuels provide a "ladder" from the forest floor to the tops of trees.

Litter. The top layer of soil comprised of a variety of organic material such as dead needles, twigs, branches, and dead grasses and forbs.

Mean: The value obtained by dividing the sum set of numbers by the total amount of numbers within the set. The average.

Model: An object made to represent something that exists, or a mathematical model that helps explain hypothetical relationships.

Mortality: The number of deaths in a given time and place.

Native species: A species of plant or animal that naturally occurs in a place.

Needle: A long, narrow specialized leaf, such as a pine needle.

Old-growth forest: Patches of forest where old and large trees are found along with trees of other sizes and ages. A forest that has been undisturbed for a long time.

Overgrazing: Grazing, usually by cattle or other domesticated animals, to the extent that plants cannot easily grow and soil is degraded.

Pack rat middens: Areas where pack rats store quantities of plant material, seeds, and other items. Remains from these middens can provide clues to forest history when they are carbon-dated.

Pitch: Resin that comes from coniferous trees; often used synonymously with *sap*.

Prescribed fire: A wildland fire that is set by forest managers to meet particular goals.

Prescription: A description of actions to be taken in order to achieve forest management objectives.

Reference conditions: The natural or historical conditions of ecosystems that are being restored.

Regeneration: The processes plants use to maintain and expand their populations over time. Regeneration may be through sexual reproduction or vegetative propagation.

Restoration: The process of returning more natural conditions to ecosystems that have been damaged by human activities.

Scat: Feces from animals, such as a bear or coyote.

Seed: A plant's reproductive structure after fertilization. Seeds are composed of the embryo, its nutritive tissue, and the seed coat.

Slash: Debris, such as branches and needles, that remains on the ground after a thinning.

Slope: The steepness of hillside.

Snag: A dead, standing tree. Snags provide important habitat for birds, small animals, insects, and fungi. Living snags, where only part of the tree is dead, also provided habitat and may have been the dominant source of snag habitat in a frequent-fire forest.

Soil compaction: Soil that is compressed. When soil is compacted it generally loses its porosity, making it difficult for gases to move, water to spread, and plants to grow.

Soil moisture: The amount of water held in soil pores.

Soil resources: All the components and functions of soil, including the minerals and nutrients of soil, the organisms that live in soil, and seed stores.

Species: A particular kind of living thing. Individuals within a species can breed with each other and produce fertile offspring under natural conditions.

Species composition: A list of the species present within a given area.

Spot fire: A fire that starts when burning material is carried from an existing fire to a new location.

Stand: A group of trees that can be distinguished as a unit by arrangement of ages, species composition, site quality, or other factors. Forest stands are often used to distinguish an area that will be managed under a set prescription.

Structure: The spatial arrangement (both vertically and horizontally) or parts of an ecosystem.

Surface fire: Fires that burn along the forest floor. Surface fires burn fallen leaves and branches, and wildflowers and grasses on the forest floor. Surface fires also burn bushes and small trees, but they do not burn the tops of grown trees. Surface fires kill a tree only when they are hot enough to damage the roots or kill the growing cells under the tree's bark.

Thinning: The process of cutting some, but not all, trees in an area. The removal, according to a set prescription, of trees (usually small diameter) from a forested area.

Treatment: The actions to achieve forest management objectives, usually according to a prescription.

Tree cookie: A cross-section cutting of a tree, showing all growth rings and the inner pith.

Tree ring: The annual layer of growth in a tree; also referred to as a growth ring.

Tree size: Typically refers to the diameter of a tree at breast height (DBH).

Understory: Plants that grow close to the ground in a forest. These include grasses, forbs, and woody shrubs.

Wildlife: Animals which are not tamed or domesticated.

Appendix 2

Educational References and Resources

General Education Resources

The Society for Ecological Restoration is a useful resource and provides a helpful primer in terms and concepts. See http://www.ser.org/content/ecological_restoration_primer.asp for an overview of restoration & restoration terminology.

The Ecological Restoration Institute of Northern Arizona University also provides information on forest restoration at their website: www.eri.nau.edu.

Project Learning Tree, Environmental Education Activity Guide, Pre K-8, produced by the American Forest Foundation, provides nearly 100 activities related to diversity, interrelationships, systems, structure and scale, and patterns of change in forested ecosystems. American Forest Foundation, 1111 19th Street, NW, Washington DC 20036. www.plt.org, 202-463-2462.

Rocky Mountain and Southwest Forests: A field guide to birds, mammals, trees, flowers, and more by John Kricher/Gordon Morrison, from the Peterson Field Guide series, provides a helpful overview of the characteristics, plants, and animals of different forest ecosystems in the Southwest.

Acorn Naturalists, Resources for the Trail and Classroom is an excellent source of reference books, educational resources, field guides and equipment. To obtain a catalog call 1-800-422-8886, or visit their website at www.acornnaturalists.com

C. Finlayson, C. E. Lev, D. O'Connor, and S. Chandler. 1997. *Tools, Trees, and Transformation: A Collection of Restoration Stories from Schools and Community Groups in and around Portland*. Tualatin, OR: The Wetlands Conservancy. This resource provides an overview of a variety of restoration projects that tie together schools and community groups in the Portland, Oregon area. They also give ideas for involving schools in monitoring restoration efforts.

The Environmental Protection Agency provides many resources, activities, and links for teachers on several topics, including endangered species and watersheds on its website at: http://www.epa.gov/teachers/curriculum_resources.htm.

The ForestERA project (located at http://jan.ucc.nau.edu/~fera-p/, is a project to use comprehensive spatial data sets and modeling tools in order to make landscape scale decisions about restoration. It's an excellent website for students to explore and learn about different principles, aspects, and choices for restoration in the Southwest, especially for teachers and students interested in applications of technology in science.

Wildlife

"The Great Escape," an activity in the FireWorks Curriculum produced by the U.S. Forest Service, helps elementary students understand ways that animals are adapted to and can escape from wildfires. Visit http://www.fs.fed.us/rm/pubs/rmrs_gtr65.pdf to access the activity.

Restoring North America's Birds, Lessons from Landscape Ecology, by Robert A. Askins, 2002, Yale University Press, provides an excellent scientific overview of the effects of different types of logging, fire, and other disturbance on birds of western forest in Chapter 7: Birds of the Western Mountain Slopes.

Produced by Cornell Lab of Ornithology and Thayer Birding Software, the *Guide to Birds of North America v.3* is an extremely comprehensive CD that contains photographs, habitats, range maps, songs, and identification tips for most birds found in North America. A bird identification window allows you to select color, size, habitat, and other variables that can help you identify unknown birds. There are more than 700 quizzes, from easy to difficult, that can be formatted into multiple choice, fill-in-the-blank, or flash cards quizzes. Thayer also produces a *Birds of New Mexico* CD, which contains 320 birds, or *Birds of the Southwest*, which contains 362 species. CDs are available on-line at www.thayerbirding.com, by calling 800-865-2473, or writing 809 Walkerbilt Rd, Suite 4, Naples FL 34110-1511.

Tyler, Hamilton A. 1991. *Pueblo Birds & Myths*. Northland Publishing Co., Inc, P.O. Box N, Flagstaff, AZ 86002. This is an excellent resource for any Pueblo tribe who wants to incorporate traditional knowledge and stories about culturally important birds into youth education or monitoring projects. It contains a brief overview of Pueblo classification of birds and then provides mythology about various birds such "Birds of the Sun," (macaws, parrots and parakeets), "Birds of the Sky" (eagles, ospreys, and large hawks), "Rain Birds" (swallows, swifts, hummingbirds, and doves) "Water Birds" (ducks, snipes, killdeer, and sandhill cranes) and others.

Partners in Flight has an informative website (www.partnersinflight.org) with lists of organizations involved in bird conservation. They also list many helpful birding resources for educators at www.partnersinflight.org/birdbib/. Or order *A Guide to Bird Education Resources, Migratory Birds of the Americas: An Annotated Bibliography*, which contains 128 pages with sections on curricula, lessons, activities, workshops, books, videos, and more. The guide can be ordered by calling 800-850-2473 or writing the American Birding Association Sales, P.O. Box 6599, Colorado Springs, CO 80934, or abasales@abasales.com.

Fire Ecology Resources

Fireworks Curriculum, Featuring Ponderosa, Lodgepole, and Whitebark Pine Forests, by Jane Kapler Smith and Nancy E. McMurray, is produced by the USDA Forest Service, Rocky Mountain Research Station. The curriculum provides many activities in western fire ecology and is on-line at http://www.fs.fed.us/rm/pubs/rmrs_gtr65.html. In addition, there is an internet site (www.firelab.org) which lists locations of *Fireworks* workshops and trunks on loan. To obtain a CD with posters, booklets, and handouts, contact one of the authors at jsmith09@fs.fed.us or nmcmurray@fs.fed.us.

Fire Ecology Curriculum, USDA Forest Service Southwestern Region, created by Jackie Denk and Sharon Waltrip at the Kaibab National Forest provides regional lessons and activities for K-12. It is designed for use by land use managers but can be easily adapted for use by teachers as well. To obtain a copy, visit www.fs.fed.us/r3.

The Changing Forest: Forest Ecology is a video from the Temperate Forest Foundation that explores the role of fire in a forest ecosystem. Videos are available for $15 for 1-4 orders from the Temperate Forest Foundation, 503-579-6762.

The National Park Service Fire Management Program Center offers educational resources in fire ecology including lesson plans and fire facts. For more information, visit their website at: www.nps.gov/fire/educational/edu_tea_interagencyfire.html.

The U.S. Geological Service's Land Use History of North America (LUHNA) provides good background information on land use and land changes for much of North America. The website provides historical photos and data for the Southwestern United States, which may be particularly helpful for Activity 1: Determining Reference Conditions. Visit the website at http://biology.usgs.gov/luhna/. The link http://biology.usgs.gov/luhna/chap9.html gives information specific to the Southwest.

Appendix 3

Links to Education Standards

The activities in this curriculum can be linked to many national and state standards for science learning. Applicable National Science Education Standards are listed in the table below. In addition, applicable state standards are listed for each activity in subsequent tables. You may want to review these standards in advance so that appropriate concepts are addressed during your lesson.

National Science Education Standards	**Grades 5-8**	**Grades 9-12**
Science as Inquiry	Abilities necessary to do scientific inquiry	Abilities necessary to do scientific inquiry
	Understanding about scientific inquiry	Understanding about scientific inquiry
Physical science	Properties and changes of properties in matter	Structure and properties of matter
	Transfer of energy	Interactions of energy and matter
Life Science	Structure and function in living systems	Interdependence of organisms
	Regulation and behavior	Behavior of organisms
	Population and ecosystems	Matter, energy, and organization of living systems
	Diversity and adaptations of organisms	
Science and Technology	Understanding about science and technology	Understanding about science and technology
Science in Personal and Social Perspectives	Populations, resources, and environments	Natural resources
	Natural hazards	Environmental quality
	Risks and benefits	Natural and human-induced hazards
	Science and technology in society	Science and technology in local, national, and global challenges
History and Nature of Science Standards	Science as a human endeavor	Science as a human endeavor
		Nature of scientific knowledge

New Mexico Science Content Standards, Benchmarks, and Performance Standards Grades K-4

Strand I: Scientific Thinking & Practice

Standard I: Understand the processes of scientific investigations and use inquiry and scientific ways of observing, experimenting, predicting, and validating to think critically

K-4 Benchmark I: Use scientific methods to observe, collect, record, analyze, predict, interpret, and determine reasonableness of data

Performance Standard	Activities
Grade K.1. Use observation and questioning skills in science inquiry	2, 3, 4, 5, 6
Grade K.2. Ask and answer questions about surroundings and share findings with classmates	2, 3, 4, 5
Grade K.3. Record observations and data with pictures, numbers, and/or symbols	3, 4, 5, 6
Grade 1.2 Describe relationships between objects and predict the results of changing the relationships	3, 4, 5, 6
Grade 2.2 Use tools to provide information not directly available through the senses (e.g., magnifiers, rulers, etc.)	2, 4
Grade 2.3 Make predictions based on observed patterns rather than random guessing	4, 5, 6
Grade 3.3 Use numerical data in describing and comparing objects, events and measurements	4, 5
Grade 3.4 Collect data in an investigation and analyze those data	4
Grade 4.1 Use instruments to perform investigations and communicate findings	2, 4
Grade 4.3 Conduct multiple trials to test a prediction, draw logical conclusions, and constructs and interpret graphs from measurements	4

New Mexico Science Content Standards, Benchmarks, and Performance Standards Grades K-4 (continued)

Strand II: Content of Science

Standard II (Life Science): Understand the properties, structures, and processes of living things and the interdependence of living things and their environments

K-4 Benchmark I: Know that living things have diverse forms, structures, functions, and habitats

Performance Standard	**Activities**
Grade K.1. Identify major structures of common living organisms (e.g., needles, cones, seeds, bark of plants)	2
Grade 1.1 Know that living organisms have needs	2, 3, 4, 5, 6
Grade 2.1 Observe that diversity exists among individuals within a population	1, 2, 3, 5
Grade 3.2. Observe that plants and animals have different structures that serve different functions	2, 3, 5
Grade 3.4 Classify plants according to their characteristics	2, 6
Grade 4.4 Describe the components of and relationships among organisms in a food chain	3, 5

New Mexico Science Content Standards, Benchmarks, and Performance Standards Grades K-4 (continued)

Strand II: Content of Science

Standard II (Life Science): Understand the properties, structures, and processes of living things and the interdependence of living things and their environments

K-4 Benchmark II: Know that living things have similarities and differences and that living things change over time.

Performance Standards	Activities
Grade K.1 Observe and describe similarities and differences in the appearance and behavior of living organisms	1, 2
Grade 2.3 Observe how the environment influences some characteristics of living things	2, 3, 4, 5
Grade 3.1 Identify how living things cause changes to the environments in which they live, and that some of these changes are detrimental to the organism and some are beneficial	2, 3, 5, 6
Grade 4.1 Know that in any particular environment some kinds of plants and animals survive well, some survive less well, and others cannot survive at all	1, 2, 3, 5, 6
Grade 4.2 Describe how some living organisms have developed characteristics from generation to generation to improve changes of survival (e.g., ponderosa pine bark)	2, 3, 6

New Mexico Science Content Standards, Benchmarks, and Performance Standards
Grades K-4 (continued)

Strand III: Science and Society

Standard I: Understand how scientific discoveries, inventions, practices, and knowledge influence and are influenced by, individuals and societies

K-4 Benchmark I: Describe how science influences decisions made by individuals and societies

Performance Standards	Activities
Grade 1.3 Describe how tools and machines can be helpful, harmful, and both	3, 4, 6

New Mexico Science Content Standards, Benchmarks, and Performance Standards Grades 5-8

Strand I: Scientific Thinking & Practice

Standard I: Understand the processes of scientific investigations and use inquiry and scientific ways of observing, experimenting, predicting, and validating to think critically

Benchmark	Activities
5-8 Benchmark I: Use scientific methods to develop questions, design and conduct experiments using appropriate technologies, analyze and evaluate results, make predictions, and communicate findings	4, 5, 6, 7, 8, 9, 10
5-8 Benchmark II: Understand the processes of scientific investigation and how scientific inquiry results in scientific knowledge	3, 4, 5, 7, 8, 9, 10
5-8 Benchmark III: Use mathematical tools and techniques to understand scientific knowledge	7, 8, 9, 10

Strand II: Content of Science

Standard II (Life Science): Understand the properties, structures, and processes of living things and the interdependence of living things and their environments

5-8 Benchmark 1. Explain the diverse structures and functions of living things and the complex relationships between living things and their environments

Performance Standard	Activities
Grade 5.3. Know that changes in the environment can have different effects on different organisms	3, 4, 5, 6, 8, 10
Grade 5.4. Describe how human activity impacts the environment	3, 4, 6, 7, 8, 9, 10
Grade 6.2. Describe how weather and geologic events affect the function of living systems	6, 7
Grade 6.3 Describe how organisms have adapted to various environmental conditions	6, 7, 8
Grade 7.3. Explain how individuals of species that exist together interact with their environment to create an ecosystem	6, 8, 9, 10
Grade 7.4. Explain the conditions and resources needed to sustain life in specific ecosystems	4, 5, 6, 7, 8, 9
Grade 7.5 Describe how the availability of resources and physical factors limit growth	3, 4, 5, 6, 7, 8
Grade 7.6 Understand how diverse species fill all niches of an ecosystem	1, 3, 5, 6, 8, 9
Grade 8.3. Explain how a change in the flow of energy can impact an ecosystem	1, 3, 5, 6, 7, 8

New Mexico Science Content Standards, Benchmarks, and Performance Standards Grades 5-8 (continued)

Strand II: Content of Science

Standard II (Life Science): Understand the properties, structures, and processes of living things and the interdependence of living things and their environments

5-8 Benchmark II: Understand how traits are passed from one generation to the next and how species evolve

Performance Standards	Activities
Grade 6.2. Describe how species have responded to changing environmental conditions over time	1, 6, 7, 8, 10
Grade 7.10. Identify adaptations that favor the survival of organisms in their environments	6, 7, 8

Strand II: Content of Science

Standard II (Life Science): Understand the properties, structures, and processes of living things and the interdependence of living things and their environments

5-8 Benchmark III Understand the structure of organisms and the function of cells in living systems

Performance Standards	Activities
Grade 7.3. Understand that many basic functions of organisms are carried out in cells, including specialized functions of cells	7

Strand II: Content of Science

Standard III (Earth and Space Science): Understand the structure of Earth, the solar system, and the universe, the interconnections among them, and the processes and interactions of Earth's systems

5-8 Benchmark II: Describe the structure of Earth and its atmosphere and explain how energy, matter, and forces shape Earth's systems

Performance Standards	Activities
Grade 7.1. Understand how the remains of living things give us information about the history of Earth	7, 10
Grade 7.2. Understand how living organisms have played many roles in changes of Earth's systems through time	1, 3, 6, 7, 8, 10
Grade 7.3. Know that changes to ecosystems sometimes decrease the capacity of the environment to support some life forms and are difficult and/or costly to remediate	1, 4, 5, 6, 7, 8, 9, 10

New Mexico Science Content Standards, Benchmarks, and Performance Standards Grades 5-8 (continued)

Strand III: Science and Society

Standard I: Understand how scientific discoveries, inventions, practices, and knowledge influence and are influenced by, individuals and societies

5-8 Benchmark I: Explain how scientific discoveries and inventions have changed individuals and societies

Performance Standards	Activities
Grade 5.1. Describe the contributions of science to understanding local or current issues	1, 3, 6, 7, 8, 9, 10
Grade 6.1. Examine the role of scientific knowledge in decisions	3, 6, 7, 8, 9, 10
Grade 8.2. Describe how scientific information can help to explain environmental phenomena	4, 5, 7, 10
Grade 8.3. Describe how technological revolutions have significantly influenced societies	6, 7, 10

New Mexico Science Content Standards, Benchmarks, and Performance Standards
Grades 9-12

Strand I: Scientific Thinking & Practice

Standard I: Understand the processes of scientific investigations and use inquiry and scientific ways of observing, experimenting, predicting, and validating to think critically

9-12 Benchmark II: Understand that scientific processes produce scientific knowledge that is continually evaluated, validated, revised, or rejected.

Performance Standards	**Activities**
1. Understand how scientific processes produce valid, reliable results	4, 7, 8, 9, 10
2. Use scientific reasoning and valid logic to recognize faulty logic, cause and effect, difference between observation and unsubstantiated inferences, potential bias	7, 8, 9, 10
3. Understand how new data and observations can result in new scientific knowledge	7, 8, 9, 10
5. Examine investigations of current interest in science	1, 3, 4, 5, 6, 7, 8, 9, 10
6. Examine the scientific processes and logic used in investigations of past events	10

Strand I: Scientific Thinking & Practice

Standard I: Understand the processes of scientific investigations and use inquiry and scientific ways of observing, experimenting, predicting, and validating to think critically

9-12 Benchmark III: Use mathematical concepts, principles, and expressions to analyze data, develop models, understand patterns and relationships, evaluate findings, and draw conclusions

Performance Standards	**Activities**
3. Use technologies to quantify relationships in scientific hypotheses (e.g., calculators, spreadsheets)	8, 9
5. Use mathematics to express and establish scientific relationships	8, 9

Strand II: The Content of Science

Standard I (Physical Science): Understand the structure and properties of matter, the characteristics of energy, and the interactions between matter and energy

9-12 Benchmark I: Understand the properties, underlying structure, and reactions of matter

Performance Standards	**Activities**
15. Describe how the rate of chemical reactions depends on many factors that include temperature, concentration, and the presence of catalysts	6

New Mexico Science Content Standards, Benchmarks, and Performance Standards Grades 9-12 (continued)	
Strand II: The Content of Science	
Standard II (Life Science): Understand the properties, structures, and processes of living things and the interdependence of living things and their environments	
9-12 Benchmark I: Understand how the survival of species depends on biodiversity and on complex interactions, including the handling of matter and the flow of energy	
Performance Standards: Ecosystems	**Activities**
1. Know that an ecosystem is complex and may exhibit fluctuations around a steady state or may evolve over time.	6, 10
2. Describe how organisms cooperate and compete in ecosystems	1, 5, 6, 7, 8, 9, 10
3. Understand and describe how available resource limit the amount of life an ecosystem can support (e.g., energy, water, oxygen, nutrients)	1, 3, 4, 5, 6, 7, 8, 9
4. Critically analyze how humans modify and change ecosystems	3, 4, 6, 7, 8, 9, 10
Performance Standards: Biodiversity	**Activities**
8. Understand and explain the hierarchical classification scheme including: classification of an organism into a category, similarities of organisms reflecting evolutionary relationships	6
9. Understand variation within and among species, including factors that affect the survival of an organism	6, 8, 9
Strand III: Science and Society	
Standard I: Understand how scientific discoveries, inventions, practices, and knowledge are influenced by individuals and societies	
9-12 Benchmark I: Examine and analyze how scientific discoveries and their applications affect the world, and explain how societies influence scientific investigations and applications	
Performance Standards	**Activities**
3. Evaluate the influences of technology on society	1, 3, 4, 6, 7, 8, 9, 10
9. Describe how scientific knowledge helps decision makers with local, national, and global challenges	10
12. Explain how societies can change ecosystems and how these changes can be reversible or irreversible	1, 3, 4, 6, 7, 8, 9, 10
13. Describe how environmental, economic, and political interests impact resource management and use in New Mexico	1, 10

Appendix IV

Restoration Bingo Photos

1. Cavity Nesters
2. Crown Fire
3. Fuel
4. Habitat
5. Litter
6. Prescribed Fire
7. Restoration
8. Slash
9. Snag
10. Thinning
11. Treatment

1

Mountain Bluebird

House Wren

Northern Flicker

Cavity Nester Home in Ponderosa Tree
Rowe Mesa Grassbank
Photo: Deborah Myrin

2

Crown Fire

Crown Fire in Yellowstone National Park

3

Fuel from slash. Rowe Mesa Grassbank
Photo: Craig Conley

4

Forest Habitat

Wetland Habitat

5

Litter after Fire
Photo: Deborah Myrin

6

CFRP Burn on the Rowe Mesa Grassbank

Photos: Craig Conley

7

PJ Control Project on Rowe Mesa
Photo: Deborah Myrin

CFRP Project on Rowe Mesa Grassbank
Photo: Craig Conley

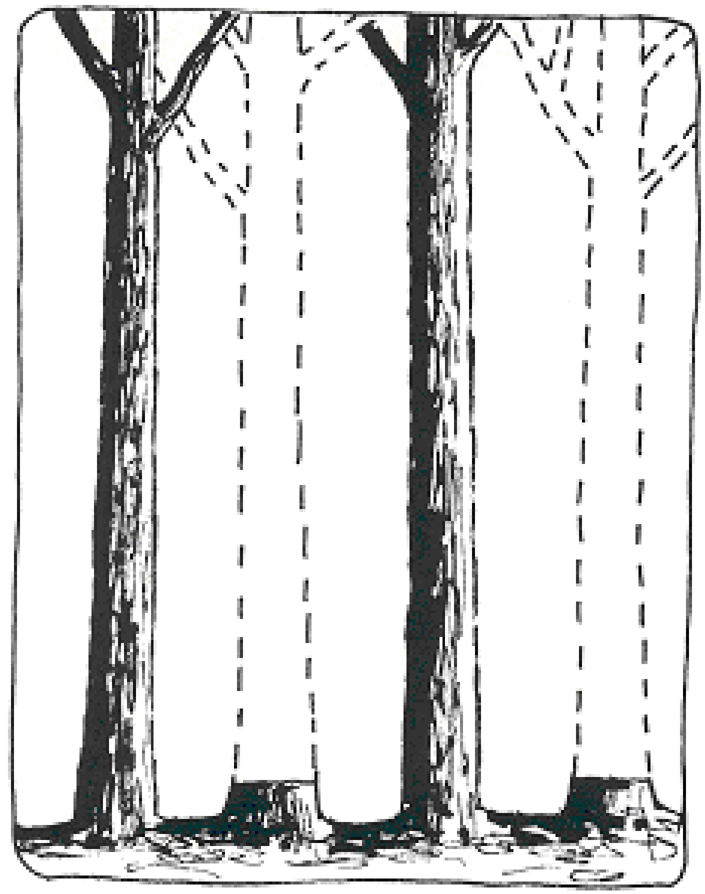
8

Slash on Rowe Mesa
Photos: Deborah Myrin

9

Snags on Rowe Mesa
Photos: Deborah Myrin

10



11

CFRP Treatment on Rowe Mesa Grassbank
Photo: Craig Conley

Appendix V

Mystery Tree Photos

Photo #

1 – Juniper Bark

2 – Juniper Tree

3 – Juniper Leaves with Fruits

4 – Juniper Leaves

5 – Pinyon Pine Tree

6 – Pinyon with Immature Cone

7 – Pinyon Bark (Immature)

8 – Pinyon Bark (Mature)

9 – Pinyon Cone

10 – Ponderosa Pine Tree

11 – Ponderosa Bark

12 – Ponderosa Needles

13 – Ponderosa Cone

Photos 1-4, 6-9 & 11-13 Courtesy of the Quivira Coalition

1

2

3

4

5

6

7

8

9

11

12

13

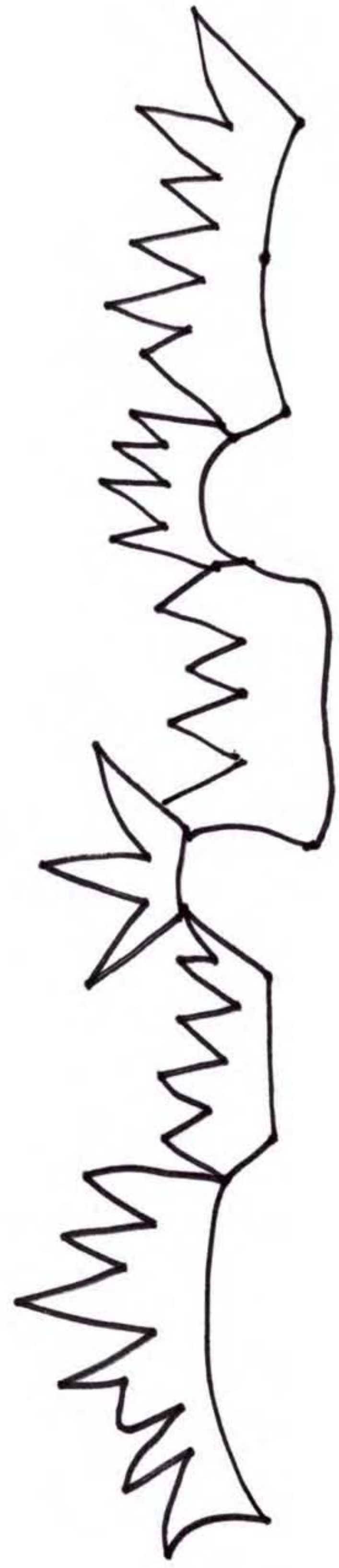
Appendix VI

Felt Board Patterns

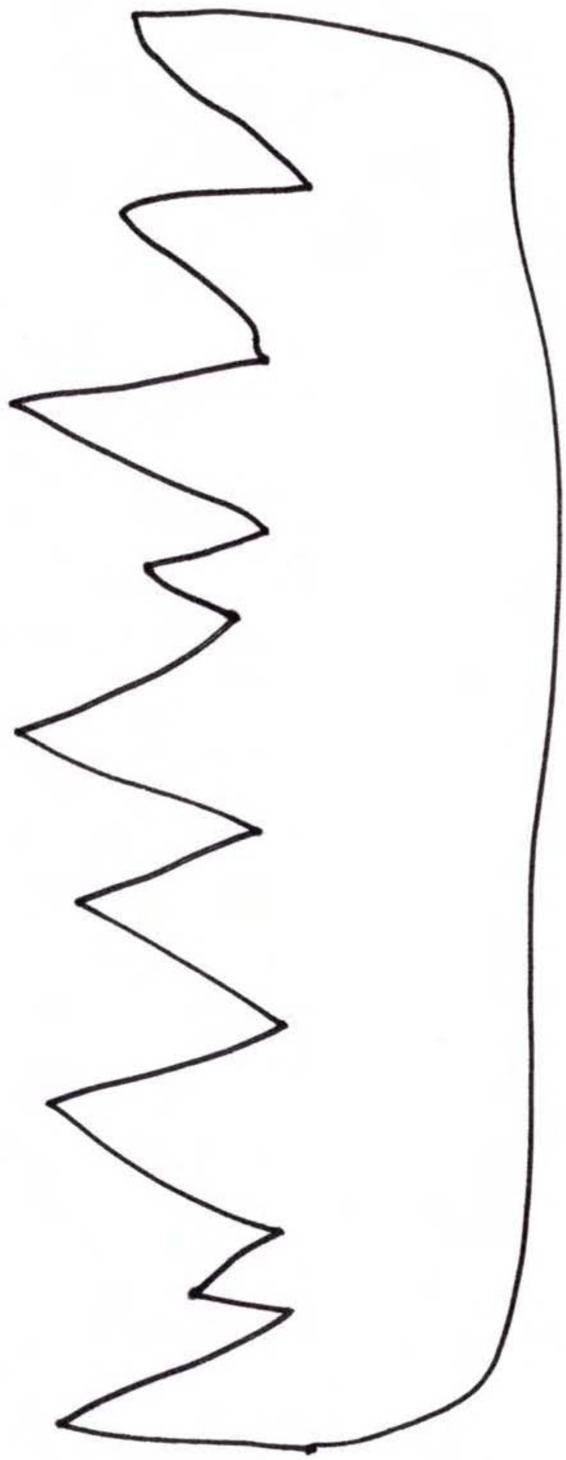
1. Grass Forb
2. Ground/Surface Fire
3. Ground/Surface Fire Small
4. Juniper/Pinyon
5. Lightening Bolt
6. Log or Branch
7. Packed Ponderosa Pine
8. Ponderosa Pine
9. Oak Scrub Thicket
10. Single Grass Forb
11. Single Scrub Oak
12. Spot or Crown Fire
13. Spot or Crown Fire

Activity 6: Understanding Forest Fires
Felt Board Patterns

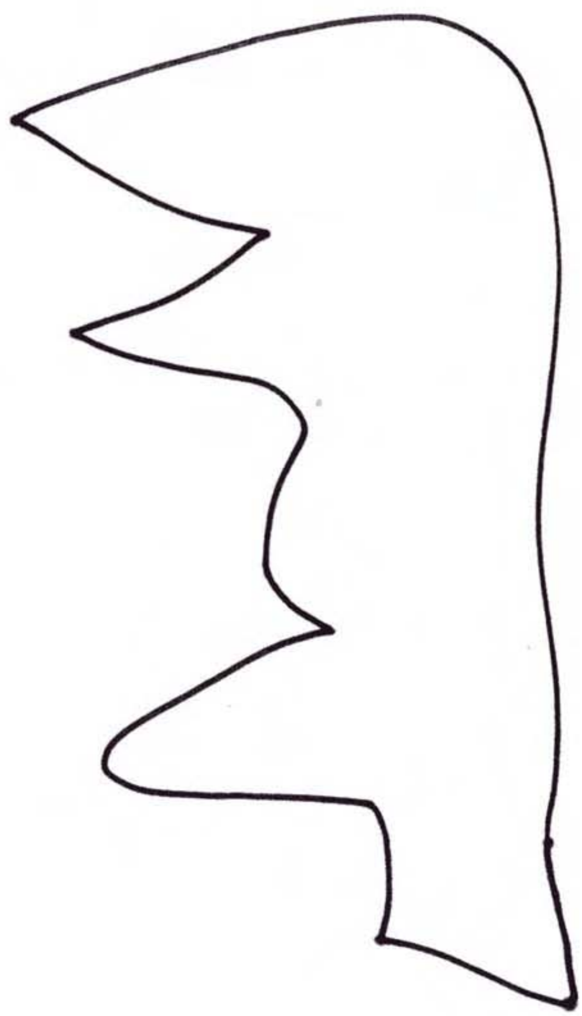
Grass Forb: Green



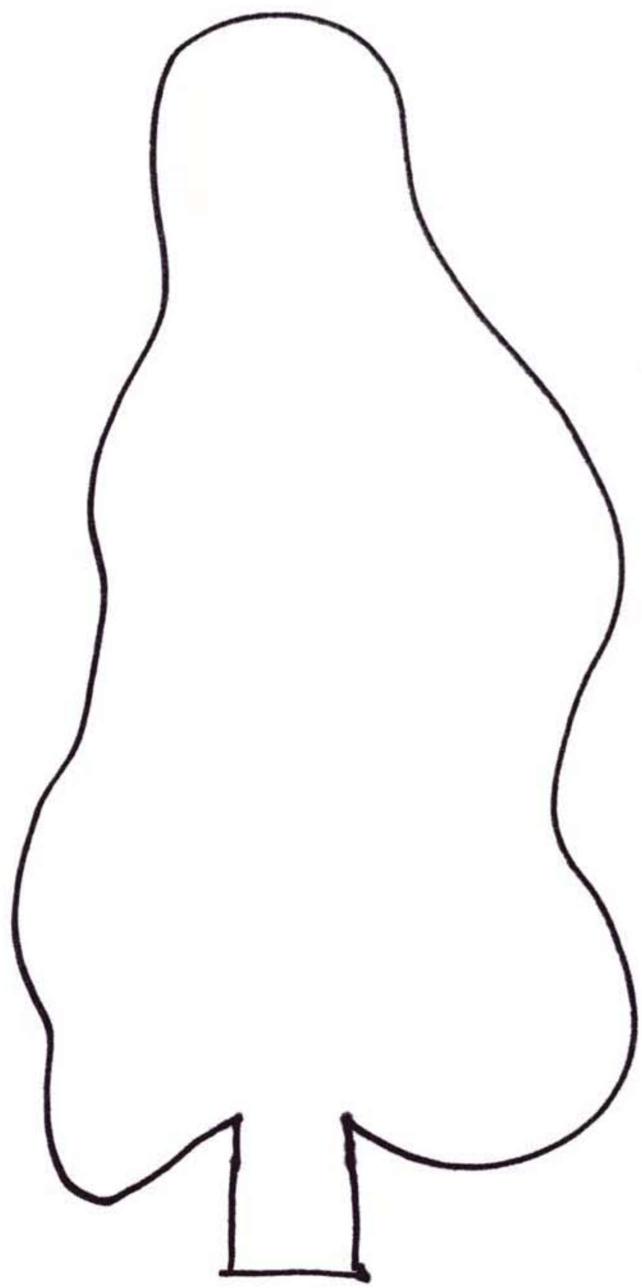
Ground or Surface Fire: Red



Ground or Surface Fire; Small: Red

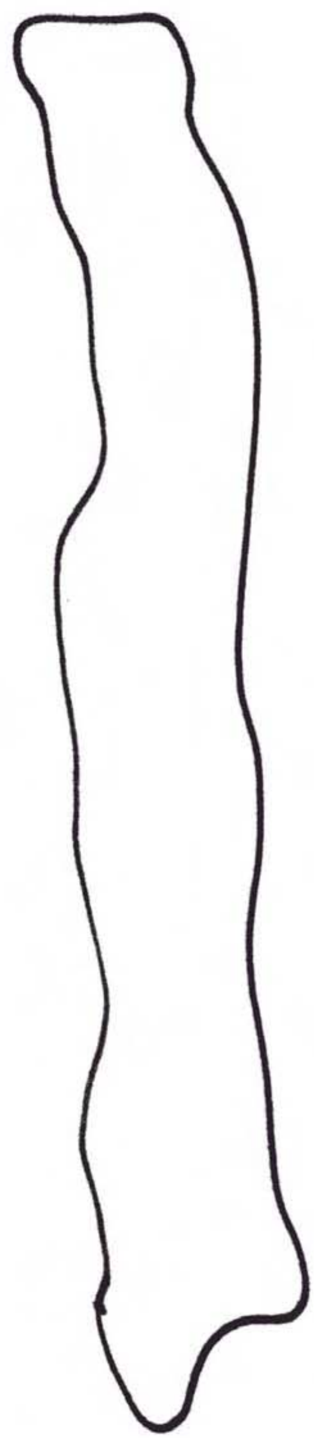


Juniper/ Pine: Green

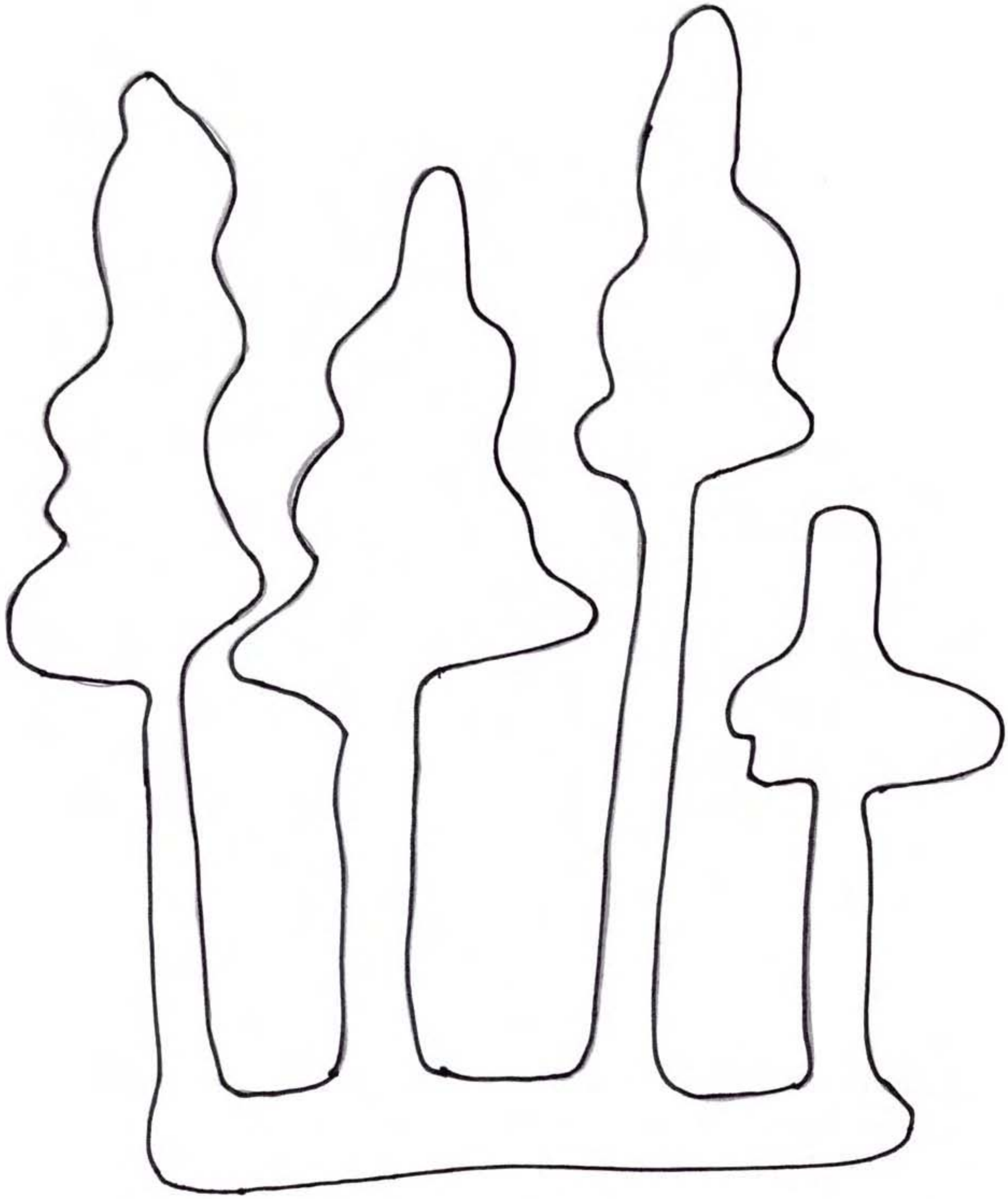


Lightning Bolt: Yellow

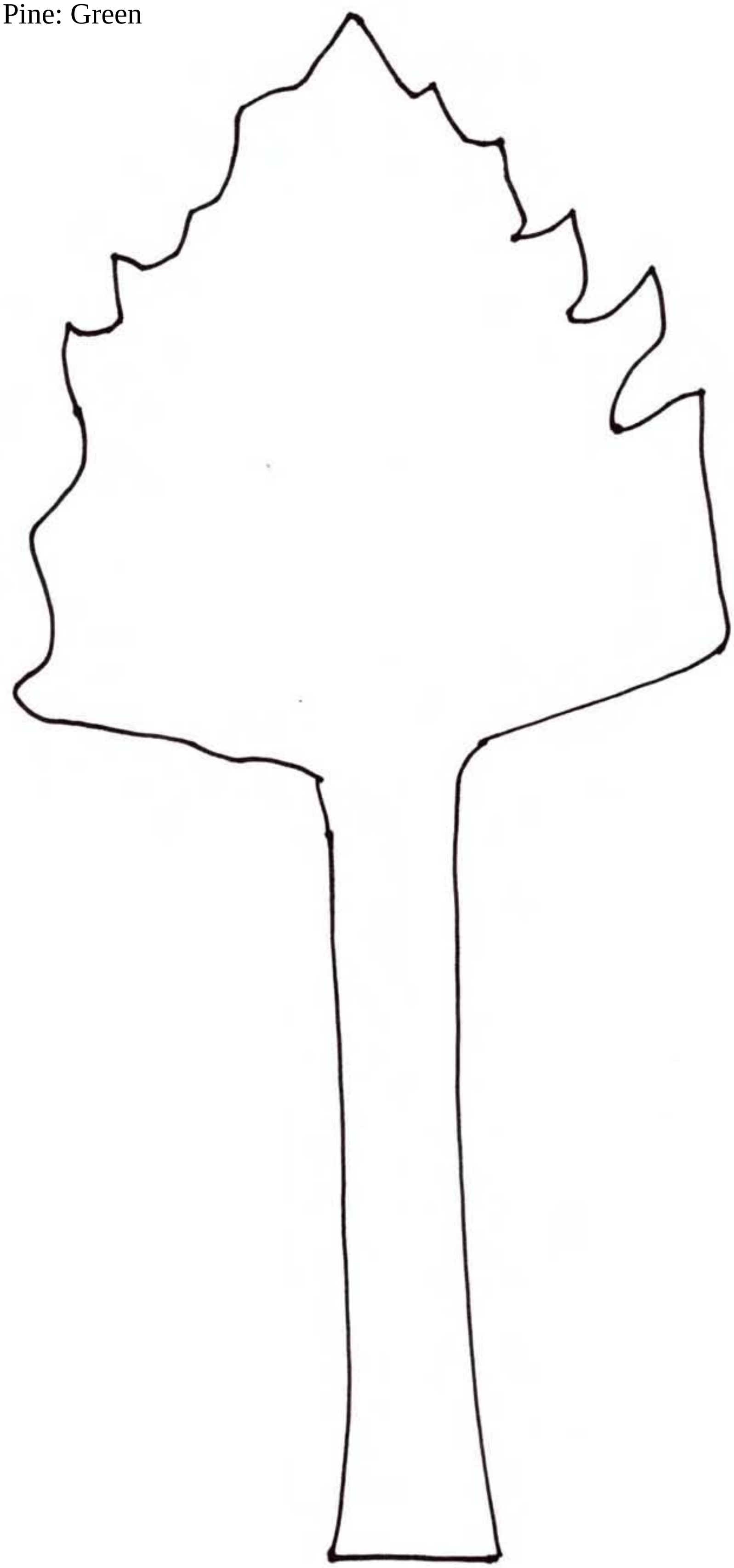
Log or Branch: Brown

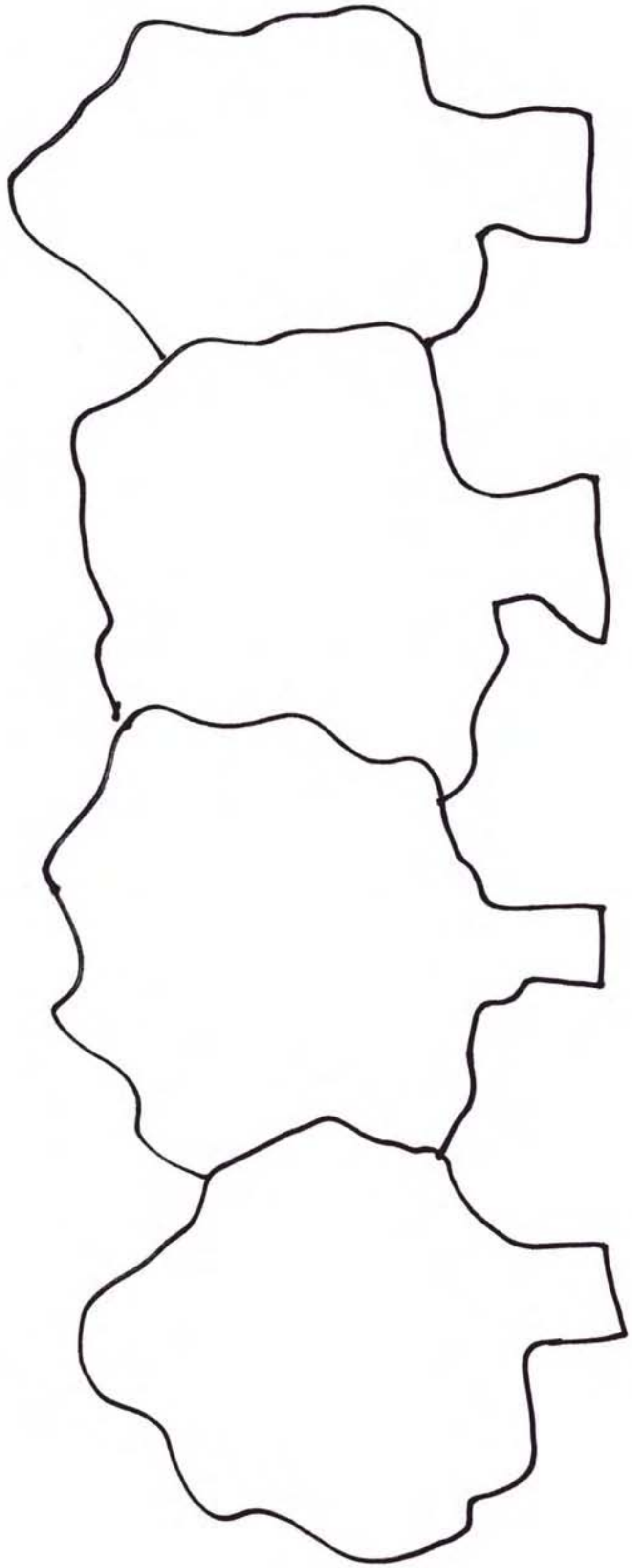


Packed Ponderosa Pine: Green



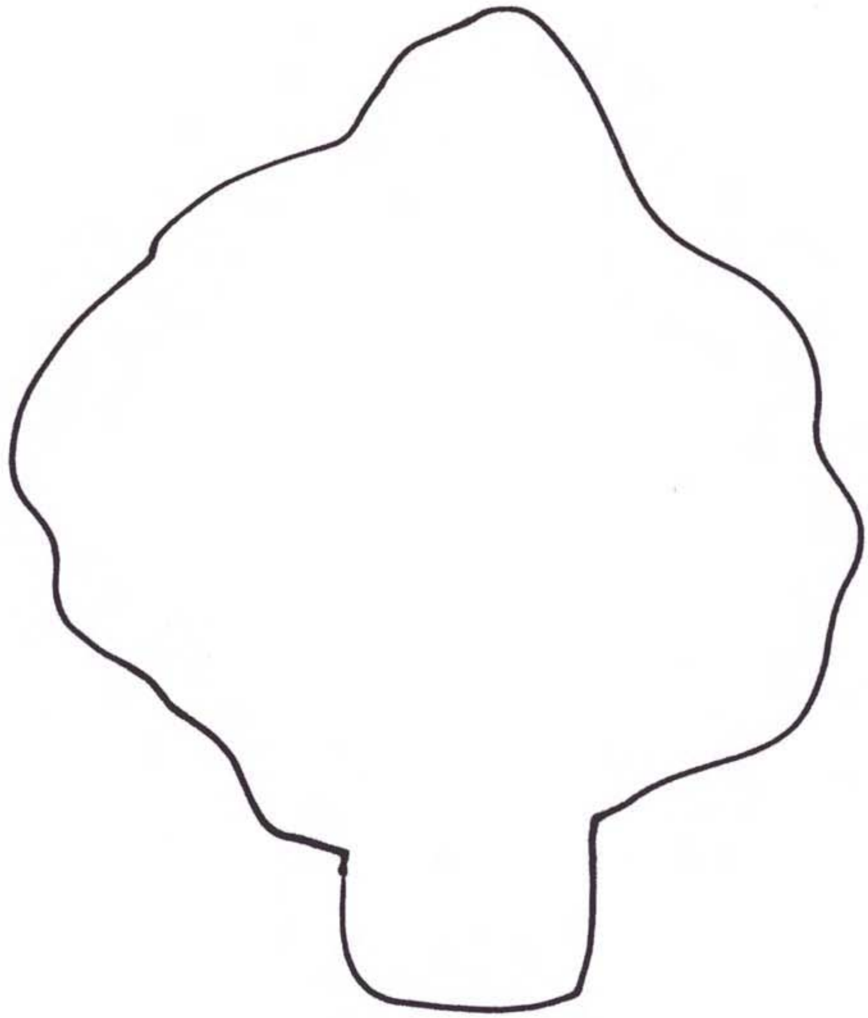
Ponderosa Pine: Green



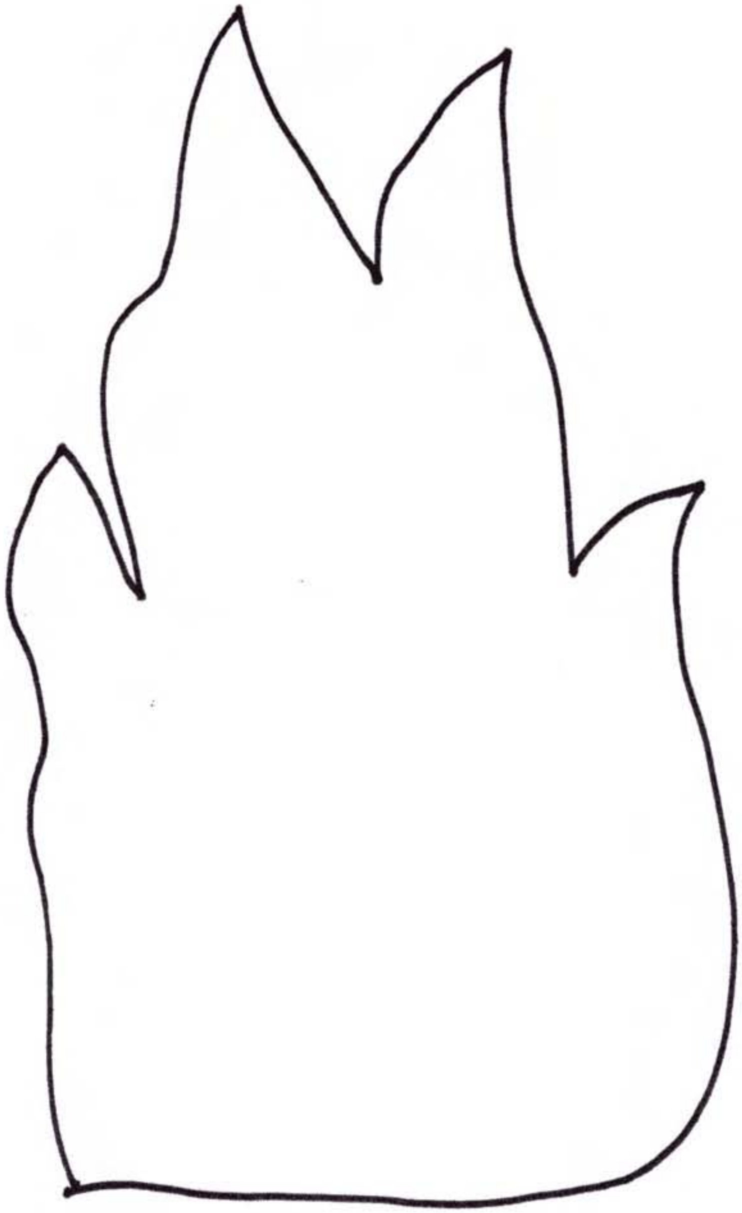


Single Grass Forb: Green

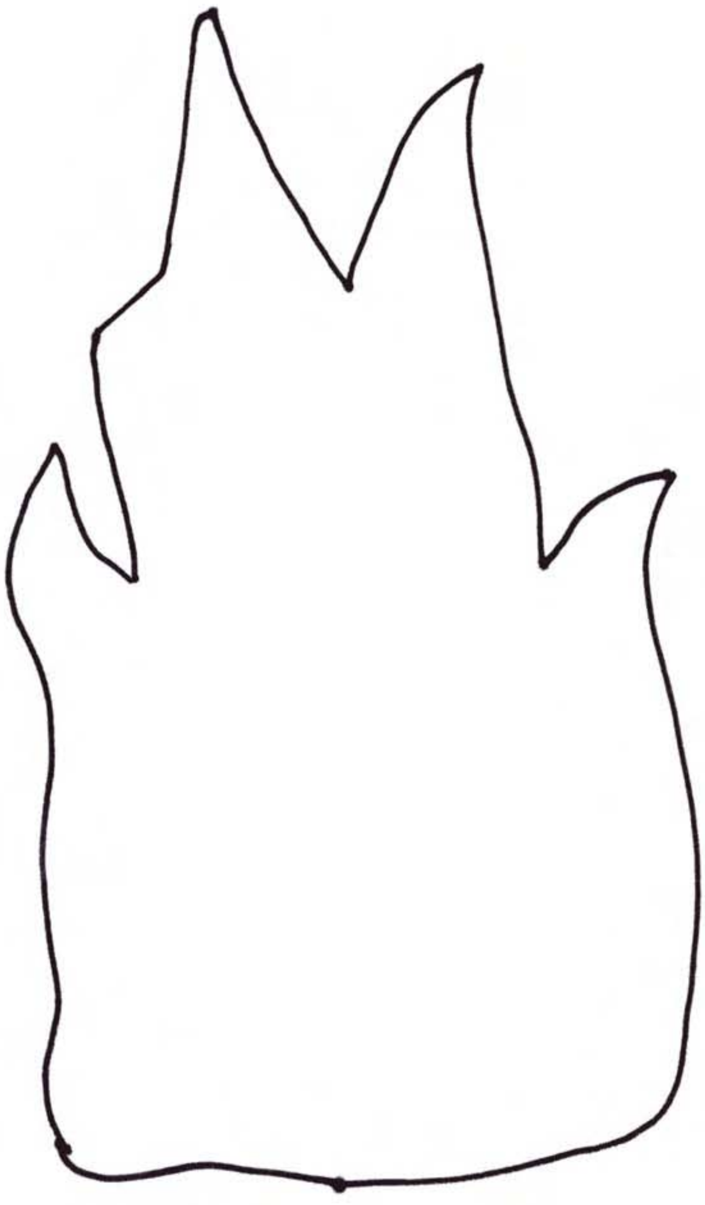
Single Scrub Oak: Gold



Spot or Crown Fire: Orange



Spot or Crown Fire: Red



Appendix VII

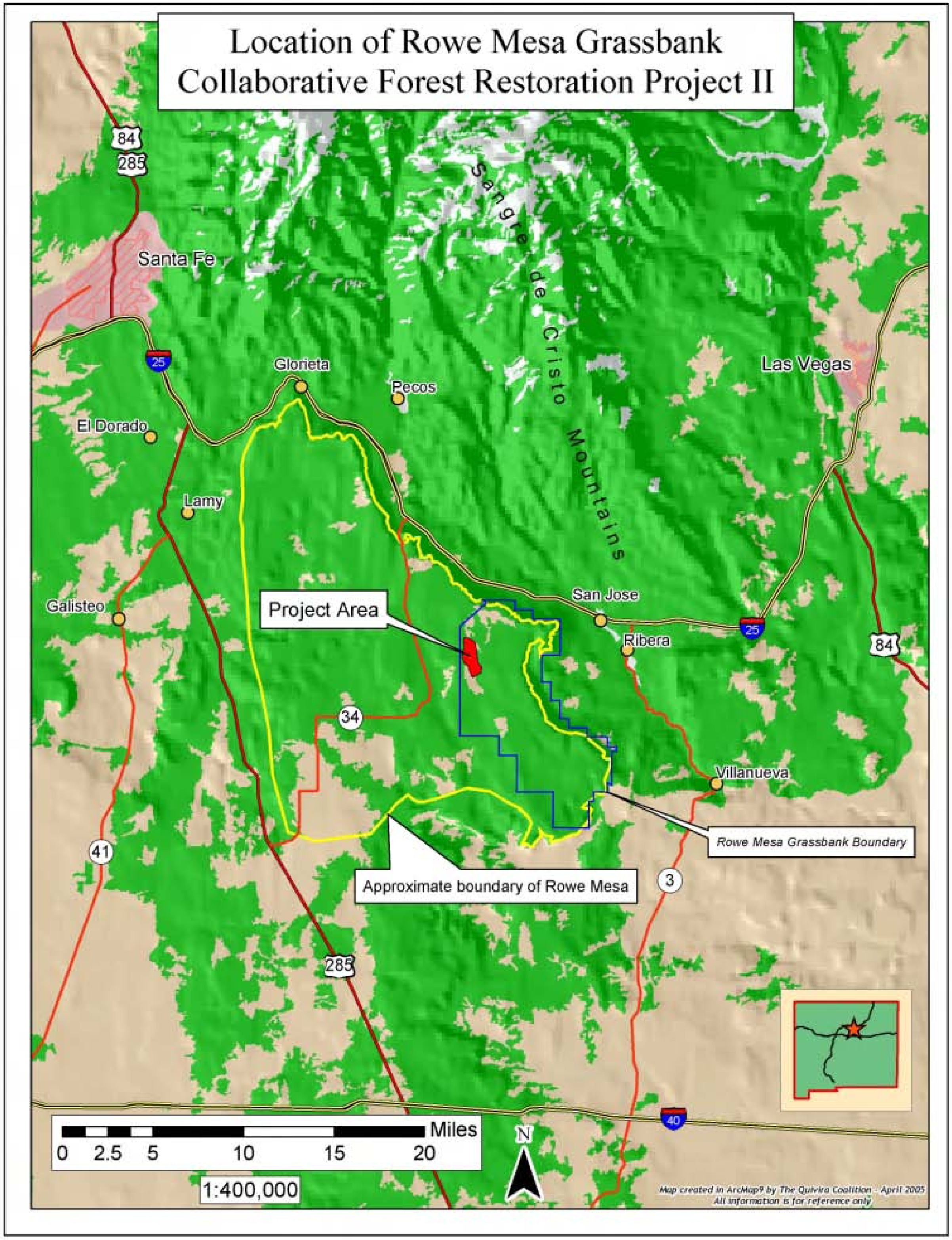
Maps

Map 1 – General Location: CFRP II

Map 2 – Rowe Mesa Grassbank Map with CFRP Location

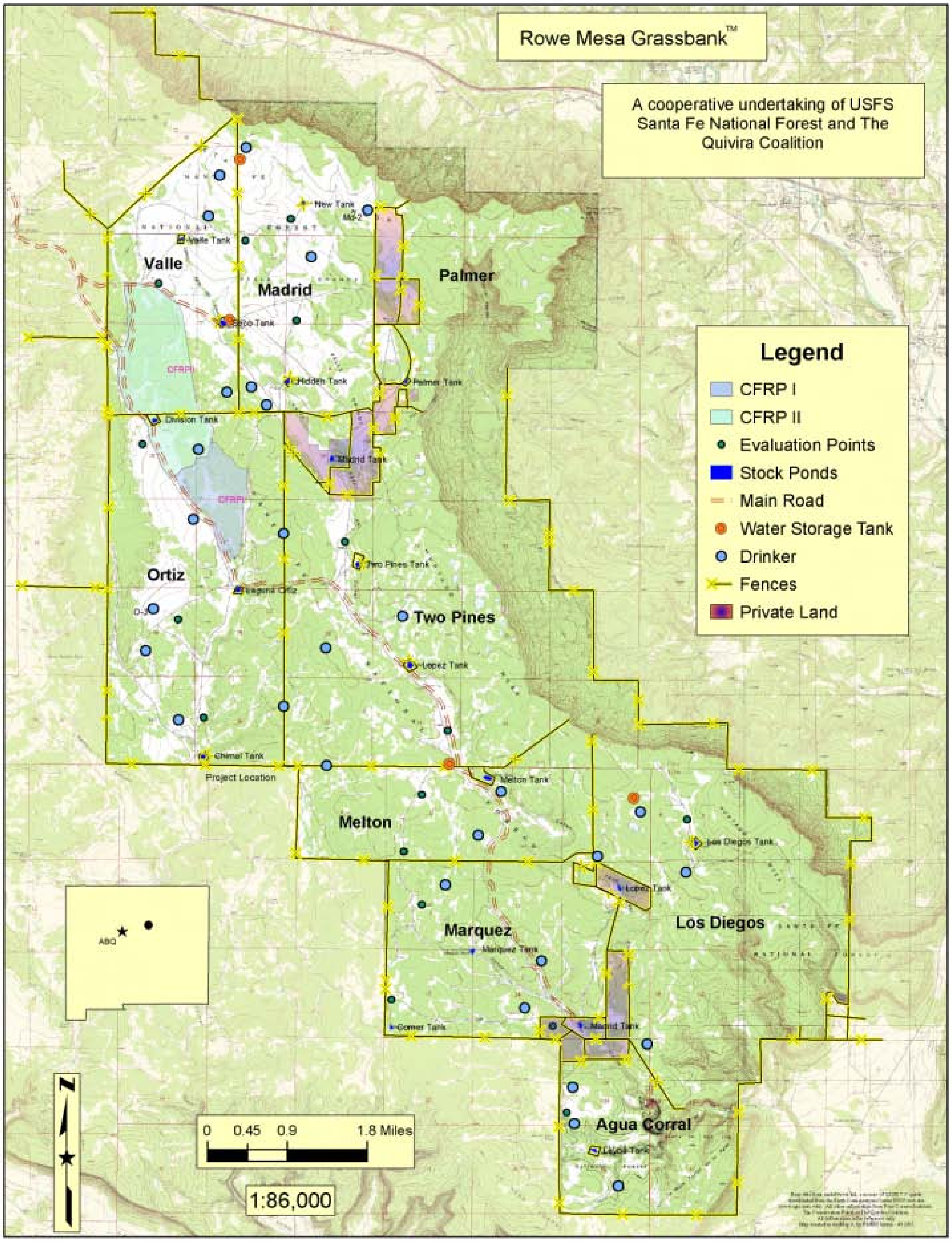
Map 3 – CFRP I and II Project Areas

Map 1



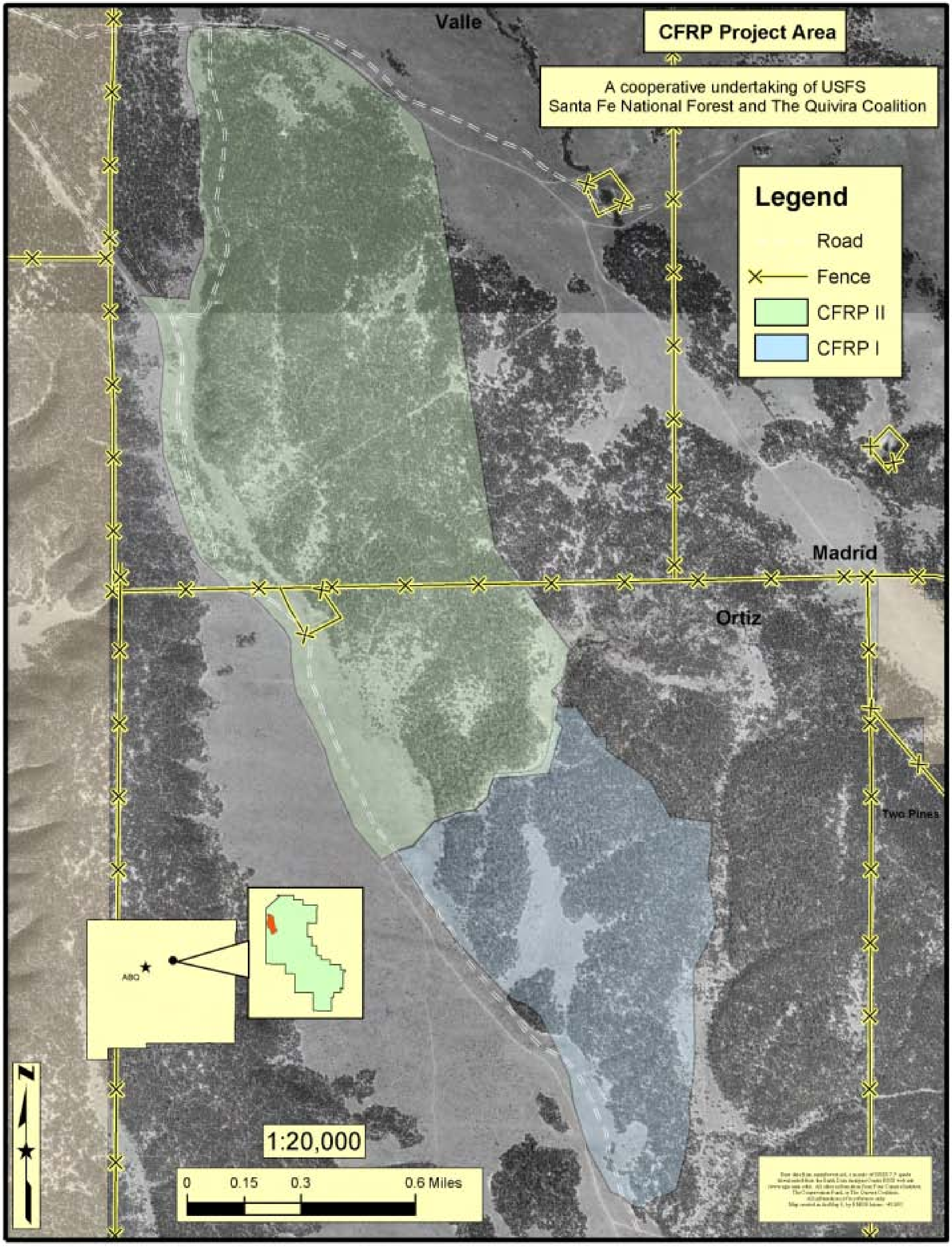
Map Created by Gen Head

Map 2



Map Created by Deborah Myrin

Map 3



Map Created by The Quivira Coalition