From Salmonberry to Sagebrush

Exploring Oregon's Native Plants

An ecoregional curriculum for grades 9-12

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Institute for Applied Ecology

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About Institute for Applied Ecology

Founded in 1999, the Institute for Applied Ecology (IAE) is a non-profit organization established to provide a service to public and private agencies and individuals by developing and communicating information on ecosystems and effective management strategies. IAE offers habitat restoration services complete with habitat management plans, site preparation, maintenance and monitoring. Our Native Seed Network connects buyers and sellers of native seed while our Conservation and Research division conducts native ecosystem research and monitoring and provides surveys for rare plants. The Ecological Education Program provides opportunities for K-12 students, teachers and the adult community in place-based education and service learning projects. For additional copies of the curriculum contact:

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From Salmonberry to Sagebrush:
Exploring Oregon's Native Plants

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Introduction

Getting Started

The Institute for Applied Ecology is a non-profit organization with the mission to conserve native ecosystems through restoration, research and education. This high school curriculum, *From Salmonberry to Sagebrush; Exploring Oregon's Native Plants,* was developed working with students through our in-school programs to meet a need for science based lessons focused on native plants.

The goal of the curriculum is to introduce students to the wondrous biodiversity of flora, and the connections between plants and their ecosystems. It is designed specifically for Oregon's native plants and can be adapted to different ecoregions within the state. The lessons encourage students to study what is outside their door, or if adventuresome, learn about plants across the state. Along with the knowledge gained through these lessons, students will gain the skills to be informed and active citizens in local natural area issues and decisions in their future.

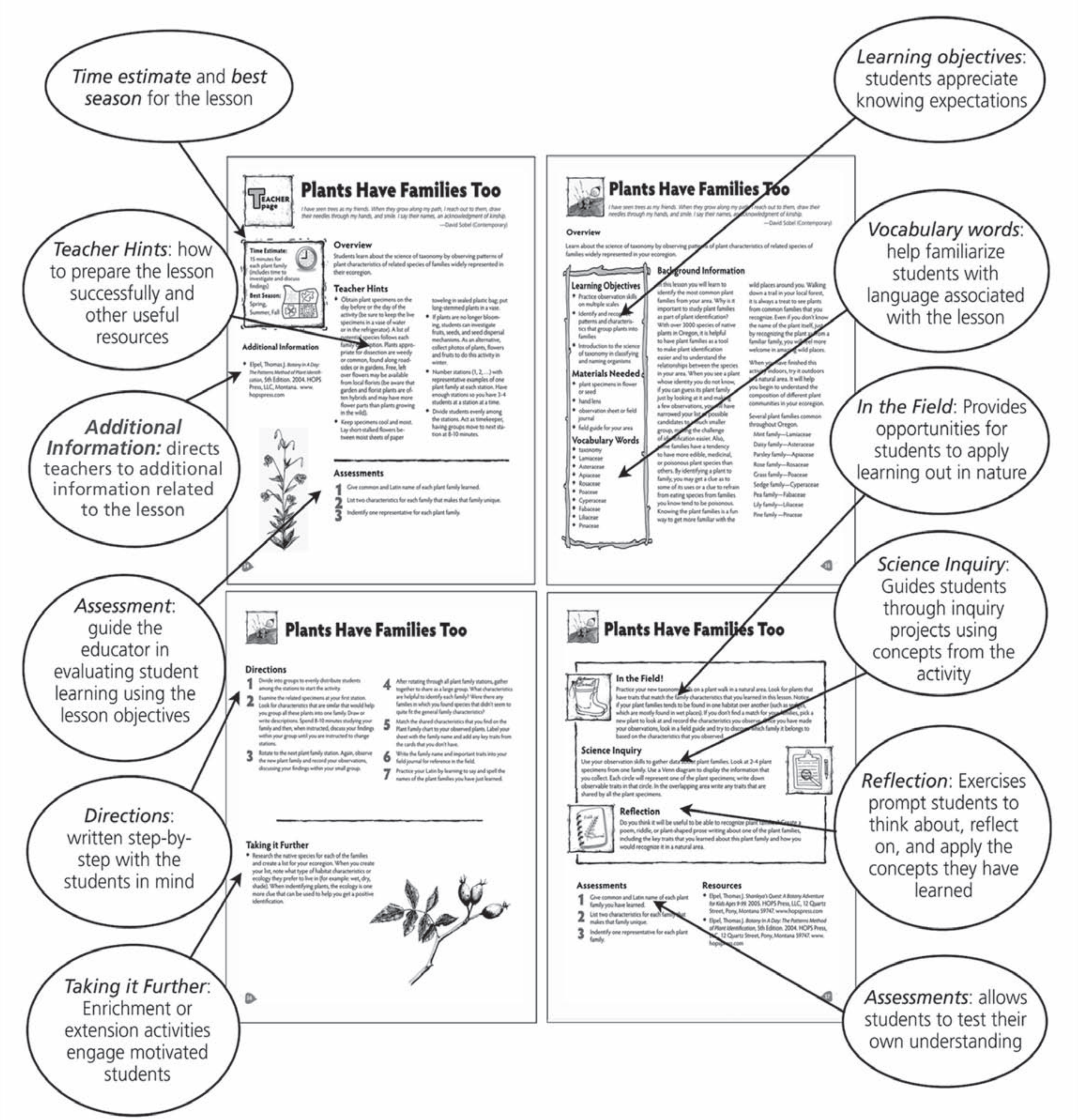
Development of the lessons followed the principles of North America Association of Environmental Educators (NAAEE) Guidelines for Excellence incorporating; fairness & accuracy, depth, emphasis on skills building, action orientation, instructional soundness, and usability. The overall curriculum goal is to lead students in the exploration and wonder of Oregon's plant life. It is not intended to teach general skills such as photosynthesis, plant growth, evolution, and natural selection that high school students receive in biology class.

Throughout the development, this project has had expert guidance and insight from a twenty-five member advisory council made up of teachers, students, science curriculum developers, natural resource agency educators, and field scientists. Much of the subject matter and organization of the curriculum comes from their collective suggestions.

Our guiding principles of lesson development:

1. **Place-based**: The local community is the starting point for teaching concepts in science and culture; students learn about where they live
2. **Hands-on**: Students actively use all of their senses to explore nature, stewardship, and science
3. **Inquiry-based**: Students learn science by asking and answering questions as a guide to discovering the world around them
4. **Experiential**: Students don't just learn, they DO
5. **Service-learning**: Learning activities directly benefit community, motivating students by giving extrinsic value to their work
6. **Education Standards:** Aligned with Oregon Department of Education high school standards and incorporates service learning methods
7. **Fosters community partnerships**: Students forge relationships with peers and professionals by taking part in their community
8. **Interdisciplinary**: Curriculum pieces integrate across disciplines teaching about native plants through science, math, social studies, art, and literacy
9. **Developed within the framework of the NAAEE Guidelines for Excellence**: Fairness and accuracy, depth, emphasis on skills building, action orientation, instructional soundness, and usability

Anatomy of a Lesson



Organization of Curriculum:

Lessons progress from basic plant identification into more advanced topics; the curriculum is designed to be a complete unit of study. We also understand that many teachers are unable to commit to the entire unit of study, so lessons can also be used individually. All lessons start with a *Teacher Page;* check there for the *Teachers Hints and Additional Information* sections to find any essential skills or background needed from earlier lessons. Addition background information, study topics and curricula are included with each of the lessons for further study.

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

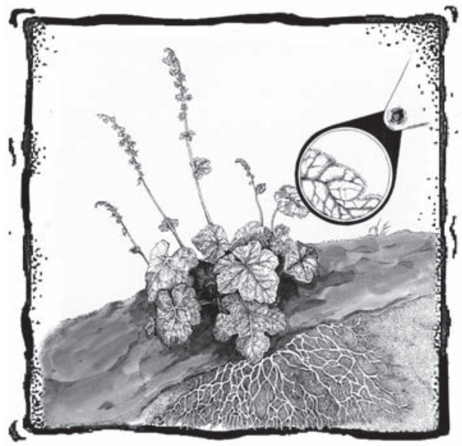
All lesson data or work sheets provided will follow the *Student Pages*. Occasionally lessons will ask students to create their own data collection sheet.

Lessons suggest ways to integrate student studies into service-learning and community projects. Appendix VII will guide you to possible partners in your ecoregion for such projects.

Making the Most of This Curriculum:

1. **Create a student field journal at the beginning of the study**. Encourage students to use them throughout the course of study. Allow time for students to observe, explore, and document their discoveries in their field journals each time you take them outdoors. Over time their journal will become a handy reference for them to check back to when they are in the field. You will find the *"In the Field"* sections often reference journals. In addition, the journal can be used throughout the curriculum as an assessment tool and portfolio. See the activity *Field Journaling; Observations from a Special Spot* to get you started.

2. **Purchase field guides specifically written for your ecoregion.** Check Appendix I for our recommended list of guides for your ecoregion. Field guides are an essential part of becoming familiar with local plant identification. Several of the lessons reference students using these field guides. Ideally your classroom will have one available for each pair of students. Grants are available to purchase field study equipment, including field guides. Oregon teachers and students can apply for the Diack Ecology Education Program, a division of Oregon Science Teachers Association, among others. Challenge a group of your students to write a grant; this is good experience for the students and gives them buy-in on future projects.



Section 1:
Plant Identification

Botany Bouquet

All of us are watchers—of television, of time clocks, of traffic on the freeway—but few are observers. Everyone is looking, not many are seeing.

—Peter M.Leschak (1951-present)

Time Estimate:

30-45 minutes

Best Season:

Spring/
Summer/Fall

Teacher Hints

- This activity is a good starting point to a plant studies unit because it highlights for students that specialized terminology might be useful in attempting to describe plants and that a system for identifying plants would be handy.
- This activity also works as an "ice-breaker" among a group of students who do not know each other.

Overview

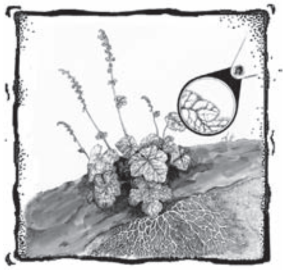
This activity awakens basic plant observational skills as students examine and describe plants collected by the teacher. Students have fun making up descriptive common names for their species and getting up close and personal with their species to make a great description. Students present their species to their class. The activity is followed by a discussion on the usefulness of a language of plant terminology to help with plant description.

Teacher Preparation

- Prepare bouquets of wild plant species (native or non-native) from your area. You will need one bouquet for each group of students. Each bouquet needs to be made up of the same plants and contain one plant for each person in the group.
- Divide the class into groups (adapt to fit your classroom, making groups of 3-5 students) and give each group one of the bouquets.
- Hand the students a hand lens or magnifying glass and instruct them to use it to get intimate with their plant.
- If you can, be prepared with the common and scientific name of the plants used in the bouquet for sharing at the end of this activity. Be able to supply the real name and description of each plant that the students can't identify. Add an additional ecological or human use for each plant to make it memorable.

Assessments

1. Look for detail in group description of the plant, and for names that are creative.
2. Did students make observations about every visible part of the plant?
3. Did students make any creative interpretations about parts of the plants they cannot see or habitat, pollinations, or uses?



Botany Bouquet

All of us are watchers—of television, of time clocks, of traffic on the freeway—but few are observers. Everyone is looking, not many are seeing.

—Peter M.Leschak (1951-present)

Overview

Explore the usefulness of a common plant language. Use your observational skills to examine and describe plants by getting up close and personal. Give your plant a made up name using theri plant characteristics to guide you. Then share your *new* plant with your classmates.

Learning Objectives

- Develop and use botanical observational skills
- Examine different plants and compare how they differ structurally from one another
- Increase understanding of plant diversity

Materials Needed

- sample plant cuttings that are representative of the native plants in or around your school grounds
- hand lenses or magnifying glasses
- several plant identification/ field guides (see Appendix I for suggestions for your region)

Vocabulary Words

- botany

1

Background Information

How can you tell one type of plant from another? If you were a trained botanist (person who studies plants) you would already have the skills needed to identify the plant through descriptions, keys, botanical drawings or photographs, and habitat knowledge. The first step for you to obtain these skills is develop your observation skills.

Observation is the act of noticing. Observational skills are very important in all fields of science and in all aspects of life. In this activity we are going to stretch our plant observational skills, using them to differentiate among examples of local plants. Carefully examine the plant you have been given. Use your hand lens or magnifying glass to observe fine details. Notice not only the flower color, but the size, the numbers of different parts. Are their other colors inside the flowers aside from the color of the petals? Do you see hairs on your plants? If so, where? When observing the leaf, compare the top and bottom. Look at the shape, number, edges of your leaves. In addition to using your eyes for your observations, use touch and smell. Feel the texture of your leaves and stems. Crush the leaf tip and smell it. However, please do not taste your plant! You do not know its identification and natural history, and it may be poisonous. Once you are an adept botanist, the world of edible wild plants will be more accessible to you.

Use your observations to write a description of your plant. Draw your plants. Describe your plant with enough detail that someone could pick it out of a field of hundreds of other plants. Lastly, choose a name for your plant that will help describe something about its appearance or natural history.

When you observe plants closely you will begin to notice how different they are. Scientists estimate that there are 300,000 species of plants in the world. Oregon has 3,161 known native plant species(1). This doesn't include landscape plants from other parts of the world, agriculture plants developed for food use, or invasive plants that were accidentally or purposely introduced to the state. The term native plant is usually used

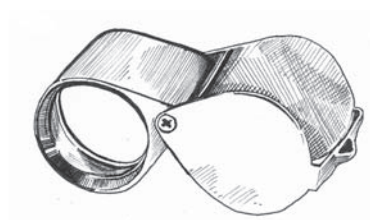
Botany Bouquet

to describe a plant that naturally grew in its current habitat prior to European settlement.

As you work through this activity you will get a better understanding of the need for a system of sorting and naming plants. It is not necessary for you to know the name of your plant. If you do know the name, keep it to yourself until the very end of the activity, when you can share it with your classmates. For now, examine your plant as if you are a pioneering botanist who has never seen it before.

Directions

1. If you know names of the plants being passed out please do not share that information until the end of the activity.
2. Have each member of your group take one plant from the bouquet.
3. Take 3 minutes to look at your plant closely and give your plant a descriptive name (for example: wooly, tough-stemmed daisy).
4. Move around the room finding others that have the same plant as you and form a new group. Introduce yourself to the new members of your group if you do not already know them.
5. Use your hand lens or magnifying glass as well as all your senses (except taste) to get to know your plant. Take turns pointing out your observations to others in your small group.
6. As a group, come up with a creative name for your plant based on your close observations. In addition, designate one member of the group to write a description you come up with as a group. Make your description detailed so a stranger could pick out your plant from a field of many plants. Be sure to describe all the parts of the plant if they are present, including: roots, leaves, stem, flowers, fruits, seeds.
7. If you have time, flip through a field guide and try to find the real name of your plant. Look at the description and see if you can learn something about the uses of your plants or something you did not notice in your observations. What kind of habitat does your plant live in?
8. Designate a representative(s) from your group to present the name and description of your plant to the rest of the class. The other members of your group should stand and hold up the plant and pass it around to other students so they can examine your plant.
9. If your group knows the real common and scientific name of your plant, you can share it now with the class (you do not need to know this piece of information).
10. If your small group does not know the name, ask the class if anyone knows it. Your teacher can help with this if needed.



Critical Thinking

Explore the need for botanical terminology:

a. Did anyone have trouble describing any part of their plants for lack of a word to describe what they were observing? What parts of the plants were hard to describe?

b. Did the class understand the small group presentations? Is there anything else they would have liked to know about the plants they met?

c. Discuss the need for a common plant vocabulary that all can understand. Would it be helpful to have another way to identify plants other than flipping through the pages of a field guide?

Botany Bouquet

Critical Thinking

d Do you have any ideas of another way to identify plants that would work for them?

e Do you think any of the plants from the bouquet are closely related to one another? What makes you think that? (Point out similarities on the plants.)

f Based on your observations, do you think any of the plants perform similar functions? What makes you say this? (For example, perhaps there were two sticky plants.)

Taking it Further

- Collect other plant samples and complete this activity with additional plants from a different ecosystem or area.
- Research a plant species; describe its characteristics, habitat where the species is most likely to be found, and common human uses. Make an oral report to the class and conduct peer reviews of these reports.
- Develop a web page on the plant species from this activity using photos, drawings, and life history information.

In the Field!

Try this activity when working in a new outdoor area. It will help you to improve your observational skills and improve your identification skills, all which will help you know the plants in your local area.

Reflection

Write a short story or poem that describes your plant, its characteristics, human and/or wildlife uses, adaptations related to habitat, and the root words of the plant's scientific name.

Self Assessments

1. Look for details in group descriptions of the plant, and for names that are creative.
2. Did you make observations about every visible part of the plant?
3. Did you make any creative interpretations about parts of the plants you cannot see or habitat, pollination, or uses?

TEACHER page

Botanical Terms Challenge

Learn a new language and get a new soul. —Czech Proverb

Time Estimate:
20 – 30 minutes

Best Season:
Any

Teacher Hints

- Include this activity in students' field journals for a vocabulary reference on field trips and during outdoor activities.

Assessments

1. Give students a stem with leaves, flowers, or fruits attached and ask them write a description using at least 4 new vocabulary words.
2. Read students the description of a particular plant species from a field guide. Have students sketch the whole plant or plant part with only the description to guide them.

Overview

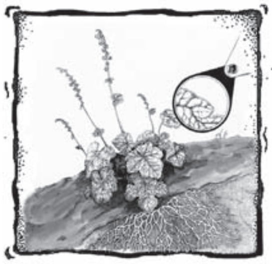
Students gain an understanding of plant structure and descriptive botanical terminology required for advanced botanical studies.

Preparation

- The crossword included in this lesson is designed to be a review of botanical terminology. Some students may have learned these terms in grades K-8 while others may be learning them for the first time. The words learned in this section are used throughout the curriculum. If students do not have any experience with plant terminology or need more than a quick review, use the included Botanical Terms Self-Study sheet to review or introduce basic botanical terminology.
- Assemble sufficient references for student teams to work on definitions independently. Field guides, internet resources, and biology/botany textbooks listed in the "Resources" section below are good options. Discuss how to determine if a source of information is reliable, especially if students are using the internet.
- For the "In the Field!" section, collect twigs with more than one leaf to show twig attachment patterns. Each team should use a different species.

Additional Information

- Harris, James G. and Melinda Woolf. 1994. *Plant Identification Terminology: An Illustrated Glossary*. Sixth Edition. Spring Lake Publishing, Spring Lake, Utah.
- A discussion of leaf form and function; includes possible journaling topics: http://www.learner.org/jnorth/tm/tulips/FormFunction.html
- A long list of botanical terminology and definitions : http://www.calflora.net/botanicalnames/botanicalterms.html
- Most field guides contain glossaries of plant terminology. Check out *Plants of the Pacific Northwest Coast* by Pojar and MacKinnon.
- A teacher resource with techniques for teaching new vocabulary to students : http://www.nifl.gov/partnershipforreading/publications/reading_first1vocab.html



Botanical Terms Challenge

Learn a new language and get a new soul. —Czech Proverb

Overview

This lesson will teach basic and advanced botanical vocabulary so that users can identify and describe plant anatomy and function. This will ease identification and lead to a better understanding of plant biology. The vocabulary list below contains essential plant terminology for activities in this curriculum.

Learning Objectives

- Understand basic botanical terminology required for high school level activities
- Increase botanical vocabulary to assist with describing and identifying plants
- Relate plant structure to function

Materials Needed

- colored pencils for drawings (optional)

Vocabulary Words

Basic plant anatomy:

root	fibrous root
taproot	stem
vein	petiole
axil	leaf margin
bud	flower
fruit	seed
node	internode

Leaf shapes & patterns:

simple	compound
opposite	alternate
whorled	basal
palmate	pinnate
lobed	

Basic flower and fruit parts

sepal	petal
tepal	bract
pistil	ovary
carpel	style
stigma	peduncle
stamen	filament
anther	receptacle

Background Information

One of the most formidable tasks of the aspiring botanist is gaining a working knowledge of the vast terminology required to use a typical plant identification guide. Botanists love to make up new words that are rarely used outside of the world of botany! The experience of trying to properly identify a plant without a working botanical vocabulary can be challenging and frustrating for the beginning plant lover. The purpose of this lesson is to teach you basic botanical terms and introduce some more complicated terminology.

Botanists commonly use several different words to describe similar things. For example, if a plant has hair on its leaves, there are several possible words that you may use to describe the type of hair you see. A leaf that is tomentose would have lots of short, wooly hairs; a leaf that is pubescent would have short, soft hairs; a scabrous leaf would be rough to the touch, resulting from the presence of stiff short hairs. And the list goes on… One might question why we need to differentiate between types of hair. The easy answer to this is that different hairs serve different functions. For example, tomentose leaves are nearly white in appearance, making them able to reflect solar radiation in high light environments so they do not burn. Scabrous leaves may serve to deter insect predators and herbivores. When you are learning these new terms, try to think a bit about how the form you are learning about may serve a useful function to the survival of a plant.

Often, botanical terms can be best described with a simple illustration rather than words. Utilize the websites and books listed in the “Resources” section to find pictures of the words in your vocabulary list.

It is important that everyone in your group develop a similar basic foundation in plant anatomy and terminology. This activity is self guided—you can proceed at your own speed, or you may choose to work with a partner. Your goal should be to become familiar with all the terms listed in this activity.

Botanical Terms Challenge

Directions

Option 1: Vocabulary Building Sheet

1 Work individually or in pairs.

2 Complete vocabulary sheets by writing one new word in each box. In the appropriate columns, write a definition and the knowledge connection. The knowledge connection should be a reference to the function of the plant part or something else about the word that will help you to remember it. Fold your paper to cover all but the word column; this will line up a drawing box on the back of the sheet with each word. In this box, draw a simple illustration of the vocabulary word. Use field guide glossaries, textbooks, or internet sources to complete the definition and knowledge connection boxes.

3 Use your completed sheet to test yourself. Fold the paper so that the vocabulary word and drawing are visible. Can you give a definition and function for this plant part? If you need a clue, uncover the knowledge connection column. Check your answer by uncovering the written definition.

Option 2: Crossword (use for terminology review)

1 Work individually or in pairs to complete the Botanical Terminology crossword. The words in this puzzle are basic terms that you will need in future lessons. Use the glossary, field guides, textbooks, or internet sources to complete your crossword.

Taking It Further

- Build your botanical vocabulary by using the vocabulary sheets to learn the lingo in "The Secret Life of Flowers" and "Drupes, Pomes, and Loculicidal Capsules: a Botanist's Lingo for Describing Native Fruits" lessons. If you are a real plant nerd (an excellent thing!), make your own vocabulary lists! Look through the glossary section of your favorite local field guides and add words that you feel are important in your plant study.

Botanical Terms Challenge

In the Field!

[Note to Instructor: Each team should collect a plant with leaves attached (be sure your students are aware of poison oak!) and attach a number label to it. Each team should work with a different species.]

- Use unlined paper and fold in half widthwise to make two 5.5" x 8.5" sections. Record team member names and twig number on the back of your paper.
- On one half of the front of your paper, sketch your twig and leaves showing important details. Be sure to show the leaf attachment, shape, margin, and anything that would help others to identify your plant.
- On the other half of the front of your paper, write a detailed description of your plant. Make sure the description matches your drawing and is as complete as possible. Use terminology from the vocabulary list.
- Make a classroom identification game. Display the twigs with the numbers visible so that teams can rotate around to view them. Fold the description papers in half. Shuffle and hand out the description papers to the teams with the description side visible and the drawing hidden. Try to match the written descriptions to the numbered twigs.
- Critique your description. Did it make matching the twigs easy or difficult? If some of the twigs were similar, how much detail was needed to make a correct match? What else could have been included that could have made matching easier? Would measurements help?

Science Inquiry

For each of the following growing conditions, make a list in your field journal of the leaf characteristics that you think would help a plant thrive: windy, very dry, very wet, low light (shade), and high light (full sun). Keep your list for testing in future lessons.

As you explore different habitats, take note of the leaf characteristics. Do leaves in a sunny meadow tend to look different than the leaves that you find near the heavily shaded forest floor? How might those leaf characteristics help the plant thrive in that particular habitat?

Reflection

Make a journal entry about leaf shapes or margins. Make a sketch or leaf rubbing of two leaves that have different shapes. Why do you think leaves come in so many different shapes and with so many different types of margins? Put on your analytical hat and brainstorm. How might those differences benefit the plant?

Botanical Terms Challenge

Self Assessments

1. Examine a plant specimen. Write a thorough description using the vocabulary words in this lesson. Your description should include the shape and arrangement of the leaves, flowers, and fruits as well as any other key characteristics that would help someone identify the plant you are describing.
2. Use your Vocabulary Building Sheet and quiz yourself. Keep your sheet and refer to it throughout your study.
3. Work with a partner. One partner will read a plant description from a field guide aloud. The other partner will sketch the plant from the written description only. The reader will need to give detailed and complete descriptions.

Resources

- Harris, James G. and Melinda Woolf. 1994. *Plant Identification Terminology: An Illustrated Glossary.* Sixth Edition. Spring Lake Publishing, Spring Lake, Utah.
- A long list of botanical terminology and definitions: http://www.calflora.net/botanicalnames/botanical-terms.html
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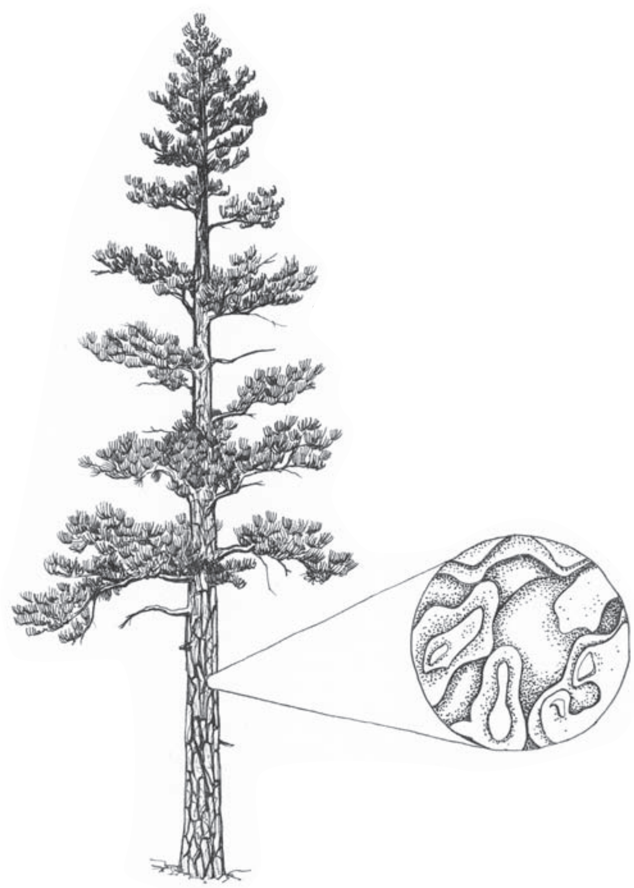
- Hough, John. 1953. *Scientific Terminology*. New York: Rhinehart & Company, Inc.



Botanical Terms Challenge

Vocabulary Building Sheet

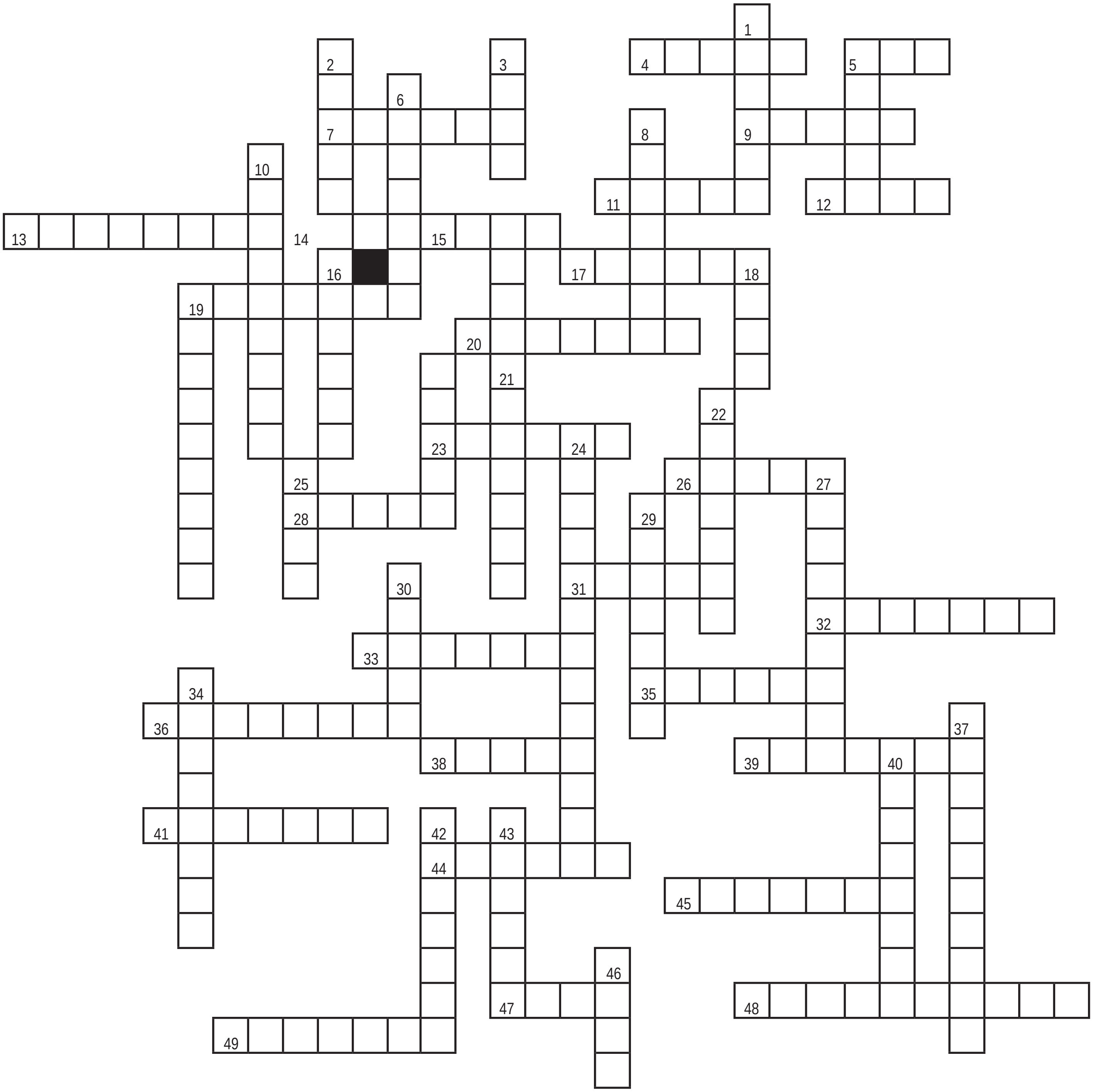
Name ____________________________________

Word	Knowledge Connection	Definition

Botanical Terms Challenge

Picture

Botanical Terms Challenge



Botanical Terms Challenge

Across

4. Ripened flower part that contains the seeds
5. Undeveloped stem or flower; covered with scales
7. Portion of pistil receptive to pollen
9. Whorl of modified flower leaves, between sepal and stamens
11. Unbranched inflorescence with single, unstalked flowers
12. Above-ground part that supports leaves and flowers
13. Thread-like stalk that supports the anther
14. Edge of a leaf
17. Often colorful and showy; reproductive unit
19. Heart-shaped
20. Margin with teeth like a saw
23. Female reproductive structure of the flower
26. Possessing rounded segments on the margin
28. Umbrella-like inflorescence with multiple small flowers
31. Oval or egg-shaped
32. Without stalk, stem, or petiole
33. Leaf pattern that is divided from a central point into lobes
35. Margin that is not toothed, notched or divided
36. Single flower and not in cluster
38. Part that connects the stigma to the ovary
39. Stalk that attaches a leaf to a stem
41. All the petals of a flower
44. Enlarged, pollen-bearing part of the stamen
45. Branching root system
47. Small swelling or knob where new growth originates
48. Lance-shaped, much longer than wide
49. Underground stem

Down

1. Undivided leaf
2. Positioned at the base
3. Blade; primary site of photosynthesis
5. Small, leaf-like part at the base of a flower
6. Leaves or veins emerging from a central stalk or vein
8. A primary thick root
10. One leaf growing from alternating sides of stem
15. Fruit not opening on maturity
16. Unbranched inforescence with single, stalked flowers
18. Anchors the plant and takes up nutrients and water
19. Numerous small flowers on a single base
21. Green, leaf-like part of a flower, whorl below petals
22. Three or more leaves arising from the same spot on stem
24. Cluster of flowers
25. Short, vertical, thickened underground stem, not a root
27. Fruit opening on maturity
29. Division of a compound leaf
30. Enlarged base of the pistil; contains developing seed
34. Leaf divided into two or more leaflets
37. Structure sitting atop the stem where flower parts attach
40. Two leaves growing directly across from each other on a stem
42. Branched inflorescence; central stalk with side stalks containing multiple flowers
43. Male reproductive structure of the flower
46. Transports water, sugars, and minerals within the leaf

Vocabulary Words

root
stem
leaf
flower
fruit
bud
vein
petiole
leaflet
margin
entire
serrate
ovate

lobed
cordate
lanceolate
simple (leaf)
palmate
compound
pinnate
alternate
opposite
whorled
basal
taproot
fibrous

sepal
petal
pistil
ovary
style
stigma
stamen
filament
anther
receptacle
bract
corolla
composite

inflorescence
spike
raceme
panicle
solitary
umbel
indehiscent
dehiscent
node
bulb
rhizome
sessile

TEACHER page

The Secret Life of Flowers

Nobody sees a flower really; it is so small. We haven't time, and to see takes time—like to have a friend takes time.

—Georgia O'Keefe (1887-1986)

Time Estimate:

1 class session, additional time for art project

Best Season:

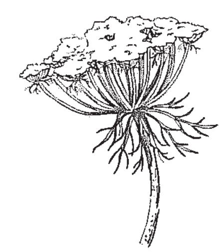
Spring

Overview

Students will dive into the inner workings of a flower and put their own creative spin on their findings, combining science observation with artistic appreciation and expression. In the process, they will learn flower anatomy, function, and inflorescence type.

Teacher Preparation

- Set up a classroom display of inflorescence types for students to view. Use live flowers, if available, labeled and in water. If live flowers are not available, use photographs.
- Visit your local farmers market or ask a florist to donate slightly wilted flowers to use in this activity.
- Choose large solitary flowers for students to dissect. Flowers in the lily family are especially useful for this activity because their floral anatomy is generally well developed and easily viewed.



Teacher Hints

- Divide students into teams and give each team a flower in water.
- Give students time to explore their flowers. Hand out a flower anatomy diagram sheet or project on an overhead for classroom viewing. Take a minute to point out the parts of the flower. Explain that it can be called a perfect flower with both male and female parts, or an imperfect flower with only male or female parts.

Additional Information

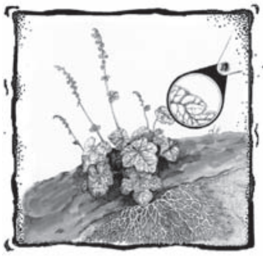
- An overview of co-evolution with many examples: http://biology.clc.uc.edu/Courses/Bio303/coevolution.htm
- Advanced flower dissection lesson: http://www.fairchildgarden.org/uploads/docs/Education/teacher%20training/flower%20power/Flower%20Dissection%20LabII.pdf
- Nature's Partners: Pollinators, Plants, and You; a pollinator curriculum, with excellent background information: http://www.nappc.org/curriculum/

Assessments

1 Label the parts of a flower and name the function of each.

2 Define perfect and imperfect flower.

3 Describe inflorescence types.



The Secret Life of Flowers

Nobody sees a flower really; it is so small. We haven't time, and to see takes time—like to have a friend takes time.

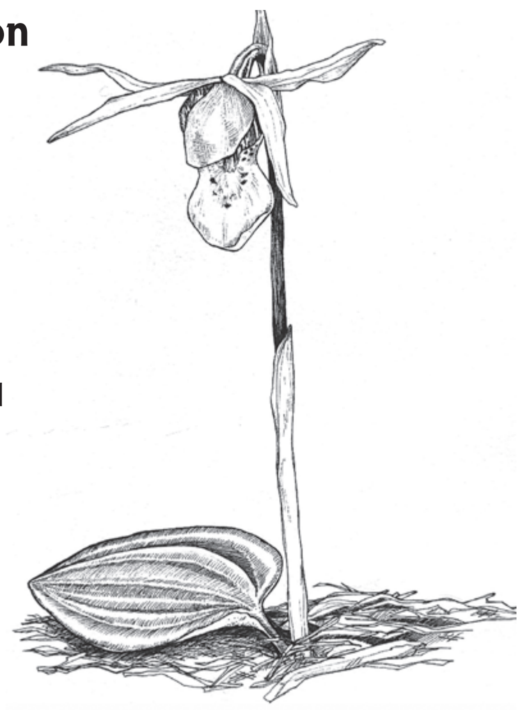
—Georgia O'Keefe (1887-1986)

What skills do scientists and artists share? Although artists are thought to be more intuitive and subjective, and scientists are often associated with being rational and objective, both utilize a keen sense of observation in their work. In this lesson, you will immerse yourself in the inner workings of a flower, using your creative skills to record your findings. In the process, you will learn flower anatomy, function, and inflorescence types.

Background Information

Some flowers announce their presence with bold and vibrant hues, while others remain modest and drab. Some are simple and open in form, but others feature tricky entries or convoluted mazes.

Flowers have long inspired humans with their beauty and fragrances, and we've bestowed them with symbolic meanings. Myths and symbolism aside, the real job of flowers is to ensure that plants produce offspring.



Animals can roam about and seek mates with whom to reproduce, but imagine the challenge for a plant, rooted firmly to the ground, to achieve the same end. Over millions of years, flowers have evolved a remarkable range of strategies to guarantee that male **pollen** is transferred to female flower parts so fertilization and seed production can occur. Together, these processes of pollination and fertilization that occur within the flower to produce seeds are a type of sexual reproduction, ensuring that genes from parent plants are recombined in novel ways. This diversifies the genetic composition of the resulting offspring (seeds). To ensure the continuation of the species, plants and animals use two methods of reproduction—sexual and asexual. Sexual reproduction is the more common form of reproduction. It involves the fusing of genes from two partners. Asexual reproduction doesn't require a second partner.

Vegetative reproduction is a form of asexual reproduction in plants, where parts of the plant fall off and develop into new plants. Potato tubers are one example of a plant that uses this form of reproduction. Since asexual reproduction doesn't require another partner, or pollen transfer, it doesn't require flowers

Learning Objectives

- Name and locate the parts of a flower
- Discuss flower anatomy and function
- Define the difference between a perfect and an imperfect flower
- Describe a flower using inflorescence type
- Understand the role of pollinators in shaping flower anatomy
- Understand plant reproduction and the role of pollination
- Connect left brain and right brain processes of science and art

Materials Needed

- large flower for dissecting (one per student pair)
- Exacto knife
- labeled flower diagram
- 11x17 white paper
- hand lens

The Secret Life of Flowers

Vocabulary Words

- sepal
- perfect flower
- spike
- bract
- imperfect flower
- raceme
- receptacle
- anther
- panicle
- petal
- filament
- solitary flower
- pistil
- stamen
- umbel
- ovary
- stigma
- composite flower
- style
- inflorescence
- nectary
- corolla
- ovule
- peduncle
- calyx
- pedicel

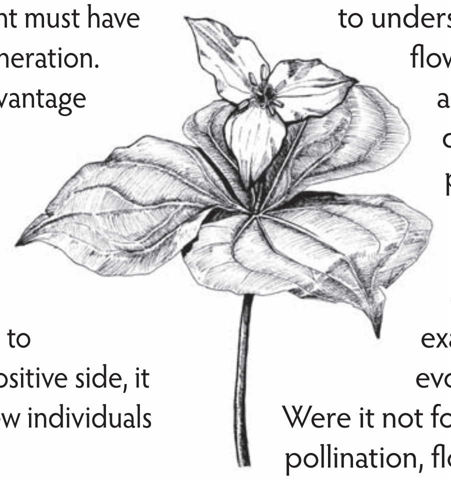
Background Information, continued

and it is very quick and is guaranteed. The main disadvantages of this form of reproduction is that the new plants will all grow very close to each other and to the parent, and no new genes enter the gene pool. This will cause a struggle for soil, nutrients and light, and will consequently cause the plants to be less healthy.

Fragmentation is another form of asexual reproduction in plants, and is very similar to vegetative reproduction. This is when an organism is broken into 2 or more pieces, and each one grows into a new individual. For this type of reproduction the plant must have good powers of regeneration. This could be a disadvantage if the plant is in poor conditions, as it wouldn't have strong powers of regeneration, and so it wouldn't be able to reproduce. On the positive side, it can produce many new individuals very quickly.

Each method of reproduction has advantages and disadvantages. Overall, asexual is faster and easier than sexual reproduction because another partner is not needed and doesn't have to be found. Another advantage of asexual reproduction is that pollinators and pollen don't have to travel in order to propagate the species. This means the plants can conserve energy and be more discreet. Because genetic information is shared by the two gametes in sexual reproduction, variety is produced in the species. In the long run, this will create a species better at survival in a changing environment. Of course, sexual reproduction has won out in this day and age of flowering plants, which is why we have such beautiful and amazing floral diversity throughout the world.

Since so many plants produce flowers, a basic understanding of floral anatomy will aid you tremendously in the proper identification of plants. In learning to identify plants, it is important to understand that flower anatomy and structure is directly linked to pollination. This plant-pollinator relationship is one of the best examples of co-evolution in nature. Were it not for the process of pollination, flowers as we know them might look dramatically different, perhaps more different than we can imagine!



Relying on wind to move pollen, as grasses, some wildflowers, and many trees do, is the oldest method of ensuring pollination. In these cases, plants produce massive quantities of pollen, with only a small amount reaching its destination on another flower of the same species. These species often have small or no petals

The Secret Life of Flowers

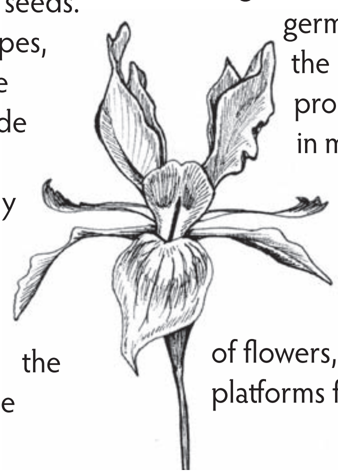
Background Information, continued

so as not to block the wind and are rarely showy in any way since they do not need to draw in any animals. They also commonly have feathery stigmas that aid in combing pollen from the air. But a more efficient— and fantastic— means of pollination, observed widely among flowering plants, is by luring unsuspecting animal partners to inadvertently transfer pollen from one flower to another as they search for food.

Insects — especially beetles, ants, flies, bees, wasps, butterflies, and moths — are the predominant animal pollinators. They have physical characteristics that make them extremely efficient in locating flowers and transferring pollen from one flower to another. Flowers and their pollinators have evolved together throughout time, frequently engaging in relationships in which the two depend on each other for survival.

Of course, animals don't do the work of pollination for nothing (or even realize they are doing the work in the first place), so plants offer rewards to attract pollinators. Animals use flowers as sources of food for themselves and their offspring. First of all, animal-pollinated flowers produce **nectar**, a sugary substance that also contains vitamins, amino acids, and other nutrients. The amount of nectar a flower typically produces relates to the needs of its pollinators. Second, **pollen** itself is a good source of protein for many animals. Finally, a few plants reward their pollinators with fatty oils, resins, or wax.

A typical flower contains the necessary anatomy to support transferring pollen and producing seeds. Flowers come in a broad range of sizes, shapes, and colors, from beautiful and showy to the modest and plain, but most flowers are made up of basically the same parts arranged in the same order. Flowers parts are commonly described as occurring in whorls, or rings, with different anatomical parts usually occurring in the same order, regardless of species. The part of the flower where the reproductive parts are attached is called the **receptacle**; the receptacle in turn attaches the remainder of the flower to the rest of the plant by a stalk called a **peduncle.** The center of a flower usually contains the female, pollen-receiving **pistil**. The **stigma** at the pistil's tip is often sticky, feathery, folded, or otherwise designed to trap pollen. When they're ready to accept pollen, stigmas prepare themselves for the transfer. They may be pushed upward by the long **style** that supports them, lean toward the male parts, or become stickier. At the base of the pistil, the frequently hidden **ovary** protects **ovules** (eggs), which become seeds when fertilized.



The male parts, or **stamens**, typically surround the pistil, forming the next whorl out from the center of the flower. They can be quite long to maximize exposure to wind and pollinators, hidden inside the flower to force pollinators to touch the stigma on their way in or out, or able to lengthen and shorten over time, as needed. The stamen is made up of the **filament** that is a thread-like stalk that supports the **anther,** which produces and releases pollen. Animal-pollinated plants have large, irregular pollen grains with lots of tiny hooks, spines, and craters on the surface. A rough texture and sticky surface ensure that the pollen will stick to a visiting animal's hair, scales, feathers, or appendages and then stay there until the animal visits another flower. At the next flower, the pollen will be rubbed off onto the strategically placed stigma. If the conditions are right, the pollen grain germinates and sends a tube down the style of the stigma and fertilizes an ovule, leading to seed production. Once fertilized, the ovary wall takes in moisture and swells, becoming the fruit, which surrounds and protects the developing seeds.

The next whorl out from the stamens is usually made up of the **petals**. The petals are typically the most noticeable parts of flowers, and are designed to attract and provide platforms for insects, bats, birds, and other roving

The Secret Life of Flowers

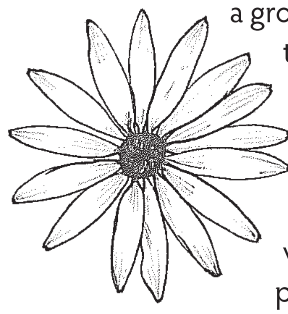
Background Information, continued

pollinators. All of the petals of a flower are collectively referred to as the **corolla**. At the base of many flowers are **nectaries**, which produce the nectar. Since this food treasure is typically tucked deeply in the flowers, pollinators are coaxed into touching the flower's reproductive organs, thus transferring pollen in their search for nourishment.

The **sepals** commonly make up the final whorl in the flower's anatomy. Collectively, they are referred to as the **calyx**. They form a protective, petal-like layer that covers an unopened bud, and are usually small and inconspicuous when a flower is open. The sepals are usually green and peel back as the flower opens; sometimes they will even fall off as the bud opens. In some flowers, there is an additional whorled ring outside of the sepals. This ring is made up of **bracts**, or modified leaf-like structures. A common example of bracts in a flower is in the Pacific dogwood (*Cornus nuttallii).* What may appear as large, white petals are actually bracts. The petals on this species are actually tiny.

As is always the case in nature, there are exceptions to the rule. Many plants produce flowers containing both male and female parts. These are referred to as **perfect flowers**. But some plant species have flowers that contain only male parts and some that contain only female parts, both referred to as **imperfect flowers**. In these cases, one of the whorls described above will be absent from the flower's anatomy. In some species, these flowers are located on the same plant; in others they are found on separate plants.

There is a long list of vocabulary that is used to describe the way in which flowers are attached together to form a group of flowers. Sometimes plants have flowers that are found singly on the plant. These are called **solitary flowers**. More commonly, flowers are found in clusters, called an **inflorescence**. Like the anatomy of a flower itself, the arrangement of flowers in a cluster varies widely, a testament to the diversity of pollinators and plant adaptations that ensure healthy reproduction. A cluster of small flowers in a flat to rounded shape, such as Queen Anne's Lace, is called an **umbel**. A cluster comprised of a long central stalk with flowers attached directly to the stalk is called a **spike**. A spike with flowers attached by short stalks (**pedicels**) is called a **raceme**. A raceme that is further branched is called a **panicle** (many grasses, but not nearly all!). Flowers in the Sunflower family (Asteraceae) may look like single flowers; however, if you look closely, each flower head is actually composed of numerous individual flowers, sometimes hundreds. These are called **composite flowers**.



One explanation for the vast and varied differences of flower shapes, sizes, colors, and smells is that flowers have co-evolved with their pollinators. When you are observing your flower, ponder how the design might best be suited to a specific pollinator. The stigma is often sticky. Can you guess why? The ovary is often hidden. Why? The stigma generally appears sturdy compared to other parts. Why? The stamens are often frail and in great numbers. Why? Why are petals colorful? Some plants have scented flowers. Why is this? Why are some flowers showy and some very plain?

In this indispensable partnership, flowers and pollinators are utterly dependent on one another for survival. In turn, we depend on this process for much of the food we enjoy. In the process of exploring flower anatomy, you gain the skills to understand not only how to identify plants, but also to observe nature's diversity in greater detail (1).

The Secret Life of Flowers

Directions

1. Work with a partner on this activity. You will be sharing a flower, but each of you will turn in your own 3-panel sheet. Help each other to locate the flower parts.
2. Observe your flower closely without touching it. Can you see all of the reproductive parts or does the plant hide the flower parts? Take note of the size, showiness, color, aroma, and anything else interesting that you observe. Use a hand lens to observe closer. Can you see nectar or pollen? Take a couple minutes to brainstorm with your partner why your flower is designed the way it is. Think of where it might grow and how it might be pollinated. Write down your ideas.
3. Fold and crease a 11x17 inch paper into three equal parts (like a brochure). Open the paper and in the first panel, draw your flower. Include the pedicel (flower stem) and how it is attached to the flower. Draw the flower as accurately as you can, showing all the different parts that are visible without touching your flower.
4. Compare your flower to the diagram of "parts of the flower". Look for the reproductive parts of your flower. Most flowers have both; some have one or the other. The parts are easy to find on some flowers, such as a lily. On some flowers, such as a sunflower, the parts are very difficult to see. If the male and female parts are not visible, gently move or remove a petal or two. In the second panel of your data sheet draw the inner whorls of your flower (pistil(s) and stamen(s)). Is your flower perfect or imperfect?
5. Carefully use your knife to cut a cross section through the center of your flower. Try to slice through the ovary to show the inside. This will take a steady hand as the ovary is often quite small. Use your hand lens to view the inner parts of your flower closely. What does the inside of the ovary look like?
6. In the third panel of your data sheet, draw an extreme close-up of the inner flower parts. Be as accurate as possible, use your hand lens and fill your drawing panel with what you see.
7. Using the flower diagram as a guide, label the parts of your flower. Use the panel(s) that best shows the parts you are referencing.
8. Label your flower with the inflorescence type. Compare to the flower diagram or classroom display and to your vocabulary words.

Taking It Further

Turn your drawings into an art project:

- Color your 3-panel sheet and use shading techniques to show depth. Cut out the panels and mount them on a complementary color background.
- View your flower like a pollinator might see it and draw a part of your flower that you find most interesting. Draw the piece in great detail, large like Georgia O'Keefe would have. Fill the page or even larger, letting parts of the flower trail off the page. Use your hand lens to look for subtle vein patterns, hairs, color variations, nectar droplets, etc. and include these observations in your drawing. The great American artist Georgia O'Keefe painted flowers like this. View some of her works online for inspiration.
- Portray your flower in an alternate artistic medium of your choice from the perspective of a pollinator. Paint, sculpt, design a video game, film, poetry/creative writing, music, dance; the options are limitless.
- Design a flower for a specific new pollinator (you could use a black bear!). What kind of characteristics will this flower need to attract the pollinator? What shape, size, and smell will the flower have? Include a drawing and description of your new flower.

Reflection

Georgia O'Keefe had a unique way of viewing flowers and was drawn to their beautiful flowing lines. Pick your favorite flower and write as if you are looking at

The Secret Life of Flowers

Reflection, continued

a section of your flower through a microscope. Make the lines of your writing flow like the lines of the flower in one of O'Keefe's paintings. Think outside of the box; what are ways you could make your writing "flow"? Use your creativity. You might also write a poem to accompany your illustration.

In the Field!

- Go outside to draw flowers in the field. Discover the nuances of different flowers. Many of our native wildflowers are small and take close observation to note their beauty. View flowers with a hand lens to look for the fine details you learned about.
- Visit a field of wildflowers. Look for different types of inflorescences. Is one type more common than others? See if you notice flowers on more cryptic species such as grasses and sedges, or willows. Visit the same site over time. Does the type of dominant inflorescence change? Could inflorescence type be linked to pollination? Is one type of inflorescence more common at specific times (March compared to May)? Why? Remember that flowers must be open at the same time that their pollinators are active in order to reproduce. How might climate change affect the plant-pollinator relationship?

Science Inquiry

- Study a native flower. Draw the flower in your field journal and identify the parts, making notes about the color, scent, nectar, pollen, and anything else you observe. Be sure to date your journal entry. Use your observations and the background information to hypothesize how or who pollinates this flower. Keep your prediction and re-visit your journal entry after studying pollinators in the Native Plant Ecology section. Re-evaluate your original hypothesis. Do you want to make changes? How would you test it?
- In the spring and summer, do a comparative study between two habitat types, analyzing aspects of floral structure that you learned in this lesson. Choose two habitat types that are readily accessible near your school (i.e. edge, prairie, woodland, wetland). In each habitat, choose ten plant species and make notes about important aspects of their floral structure. Record the plant form (herb/forb, shrub, or tree), inflorescence type, whether it has perfect or imperfect flowers, and whether it is wind or animal pollinated. It is not necessary that you know the name of the plant for this exercise, though it should be recorded if you know. Do you notice any trends? Is one inflorescence type more common in one habitat type than another? Is there a difference in the abundance of perfect or imperfect flowers between habitats? Are wind or animal pollinated plants more common in one habitat type? Make these comparisons across different plant forms (tree, shrub, herb, grass, etc.) and see if you notice any trends. Speculate as to why you observed these trends.

Self Assessments

1. Label the parts of a flower and name the function of each.
2. Define perfect and imperfect flower
3. Describe inflorescence types.

Resources

Overview of co-evolution with many examples: http://biology.clc.uc.edu/Courses/Bio303/coevolution.htm

Harris, James G. and Melinda Woolf. 1994. *Plant Identification Terminology: An Illustrated Glossary.* Sixth Edition. Spring Lake Publishing, Spring Lake Utah.

The Secret Life of Flowers

Resources, continued

This source lets you view many of Georgia O'Keefe's flower paintings: http://www.artst.org/okeefe/ ; and here is a brief biography of the artist: http://www.pbs.org/wnet/americanmasters/episodes/georgia-okeeffe/about-the-painter/55/

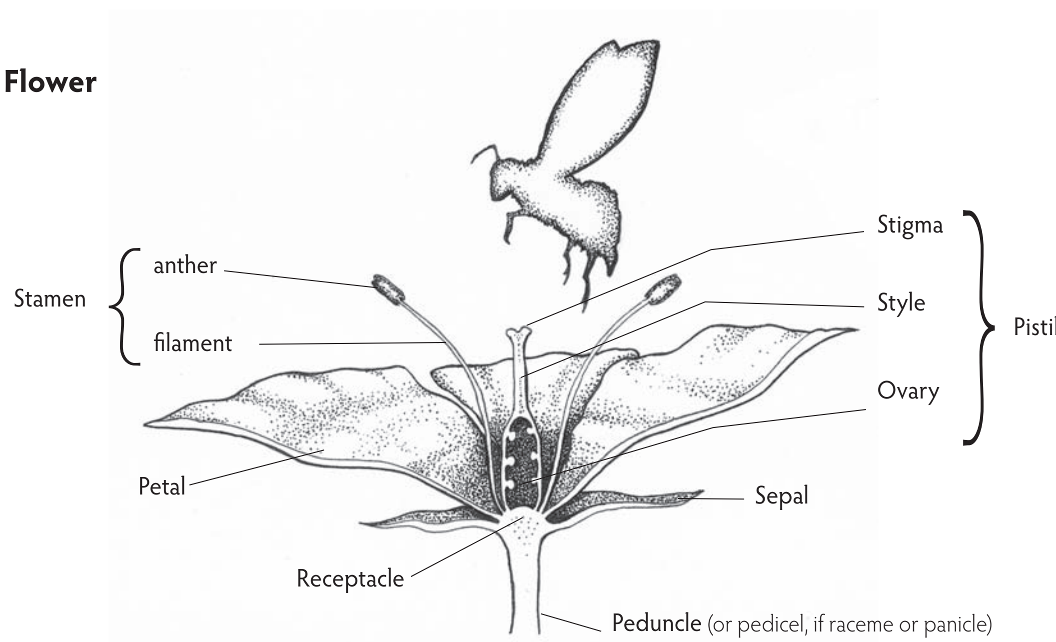
Exploratorium Website—cool interactive website, esp. "secret life of flowers" : http://www.myexploratorium.org/gardening/index.html

Kew Gardens definitions and diagrams of flower structure fact sheet: http://www.kew.org/ksheets/pdfs/b4flower.pdf

Flower Structure from Merriam Webster online visual dictionary: http://visual.merriam-webster.com/plants-gardening/plants/flower/structure-flower.php

Inflorescene Type

A Perfect Flower



TEACHER page

Drupes, Pomes, and Loculicidal Capsules:
a botanist's lingo for describing native fruits

Time flies like an arrow, fruit flies like a banana. —Groucho Marx (1890-1977)

Time Estimate:

45-60 minutes in the classroom

Best Season:

Fall , Winter

Overview

In this hands-on lab, students learn about the basic parts and development of fruits. By classifying familiar fruits using observable characteristics and fruit type vocabulary words, students familiarize themselves with the botanical origins of fruits and the adaptations of different fruit types. Following the lab experience, students can extend their new knowledge of fruits to native plants by collecting fruits of native species in the field and comparing them to familiar fruits to understand their botanical relationships. This is a great winter activity, as many native fruits can be foraged easily in the wintertime and many tropical examples are available in the grocery store.

Teacher Hints

- Let students sample store-bought fruits by having bite-sized samples at each station.
- Encourage students to use hand lenses to examine fruit carefully.

Assessments

1. Students use a key to classify common grocery fruits and apply to native fruits.
2. Through observation, students make inferences to seed dispersal methods by analyzing fruit types.
3. Identify and name the three parts of a fruit as applied to common fruit types.

Additional Information

- Plant Genome Research, Boyce Thompson Institute for Plant Research. Lesson—Tomato DNA Extraction and Dissection. Students learn the parts of a fruit by dissecting a tomato: http://bti.cornell.edu/pgrp/pgrp.php?id=302

Preparation

- Collect fruit from a local market and set up about ten stations chosen from the list below. Number the stations, and include at least two or more of each suggested fruit (when possible) at the station. Include one that is whole and one cross section for each different fruit used.
  - pome: apple, pear
  - berry: tomato, grape, avocado, pomegranate, banana, date
  - drupe: peach, plum, nectarine, apricot, cherry, olive, walnut (including hull and shell), almond (including hull and shell)
  - nut: hazelnut, acorn, chestnut
  - caryopsis: corn, wheat, barley, oat, rice
  - legume: bean (in pod), peanut (in shell), snow pea (in pod)
  - achene: sunflower seed in shell
  - multiple fruit: blackberry, raspberry
  - pepo: cucumber, pumpkin, squash
  - aggregate fruit: pineapple, mulberry

Include for "expert" level vocabulary

- hesperidium: orange, lemon, lime, grapefruit

Supplies needed for set-up: plates, cutting boards, and knives for slicing and displaying fruits. Towels for clean-up. Hand-clippers for collecting native plant materials.

For native fruit, set up the lab with wild fruit and have students repeat the activity. Field guides can help you classify wild fruit types. Some suggestions:

- pome: crab apple, rose hip, hawthorn, mountain ash
- berry: Oregon grape, huckleberry, manzanita, honeysuckle, many Lily family plants
- drupe: bitter cherry, elderberry, Indian-plum
- nut: hazelnut, acorn, chinquapin
- legume: lupine, vetch
- samara: maple, ash
- caryopsis: the fruit of any grass species
- achene: wild sunflowers, dandelion, thistles, burdock (Arctium)
- capsule: bedstraw, iris, willow, violet
- aggregate fruit: blackberry, salmonberry, thimbleberry, brambles, and their relatives

Drupes, Pomes, & Loculicidal Capsules:
A Botanist's Lingo for Describing Native Fruits

Time flies like an arrow, fruit flies like a banana. —Groucho Marx (1890-1977)

In this lab, you will learn how to classify fruits and understand their development. You will have a chance to familiarize yourself with the botanical origins of fruits and the adaptations of different fruits types. Compare what you learn in the lab to the fruits of native plants to understand their botanical relationships.

Learning Objectives

- Develop and use observational skills on multiple scales
- Understand how fruits are categorized botanically
- Increase understanding of plant diversity
- Increase botanical vocabulary
- Apply knowledge of familiar fruits to local native plants

Materials Needed

- magnifying or hand lens
- key for common fruit types handout

Vocabulary Words

Amateur Botanist	legume	pericarp
drupe	berry	seed
pome	indehiscent	nut
achene	dehiscent	ovule
locule	simple fruit	ovary
hip	multiple fruit	carpel
capsule	aggregate fruit	
Expert Botanist		
exocarp	hesperidium	nutlet
mesocarp	follicle	samara
endocarp	silique	caryopsis
pepo	schizocarp	accessory fruit
Professional Botanist		
parthenocarpy	circumscissile capsule	poricidal capsule
funiculus	loculicidal capsule	septicidal capsule

Background Information

If a friend asks you for a piece of fruit, they might give you a strange look if you hand them a cucumber. Or perhaps you have heard people argue as to whether a tomato is a fruit or a vegetable. In the grocery store, things that are sweet and potentially used in desserts are generally labeled as fruits. In the world of botany, the term "fruit" means something else, and encompasses many things that are commonly referred to as vegetables, nuts, and even grains.

From a botanist's perspective, a fruit is the ripened (mature) ovary of the flower, containing one or more seeds. Sometimes a fruit contains other parts of the flower as well. Fruits develop after a flower is pollinated and the ovules inside the flower's ovaries are fertilized. Every fruit contains at least one or more seeds inside (with the exception of some commercial fruits that are intentionally bred to be seedless). Fruits come in many shapes and sizes and are divided into different fruit types with fancy botanical names to describe their form and function. As the seed develops or matures, the ovary tissue undergoes changes that result in fruit. This ovary-turned-fruit is made up of three layers, together called the pericarp. These three layers are easy to see in some fruit, such as the apple, which has skin, flesh, and a core. In other plants, the pericarp layers are very hard to see, such as in the grasses. Fruits with similar forms are often evolutionarily related, such as cucumber and zucchini. However, other fruits that may appear to look nothing alike, such as strawberry, raspberry, apple, and cherry, may be lumped into one plant family, in this case the Rosaceae or Rose family.

Why is it important to be familiar with the different types of fruit? Field guides often use fruits as an important feature for identifying plants. Being able to distinguish

Drupes, Pomes, & Loculicidal Capsules:
A Botanist's Lingo for Describing Native Fruits

Background Information, continued

fruit type will get you one step closer to proper identification. Also, plants from the same family will frequently have the same type of fruit, another hint to their identification. Fruit type can also give you a hint as to how the seeds are dispersed, an important window into the ecology of the plant and the animals that may depend on it.

The method by which a fruit is dispersed can generally be determined by examining the structure of the fruit itself. Fleshy, sweet fruit is likely to be eaten, with the seeds transported inside of an animal, to be deposited somewhere else with a ready-made packet of fertilizer to get it started. Hard nuts are cached (buried) by squirrels and jays to eat later in the winter, but many are never found and from them sprout new trees. Light seeds may be dispersed by wind or water, and often have special appendages on them such as wings, parachutes, or corky floats to aid in the process. Some fruits also have hooked barbs on them that adhere to animal fur for dispersal. During this exploration, you will have an opportunity to think critically about the mechanisms of dispersal of native fruits.

What do the fruits you find in the grocery store have in common with our native plants? Many of our native plants have domesticated relatives that have delicious edible fruit. For example, the delectable cherry you find in the produce section is related to our Oregon native bitter cherry (*Prunus emarginata)*, which has a fruit so bitter that it is inedible for humans. If you look at native plants, you will find that many of them have fruits that are similar to ones you are familiar with from the grocery store. However, many fruits that are popular to eat are shipped from subtropical and tropical areas, such as bananas, pineapples, and citrus, and have no local relatives.

In this lab you will be looking at fruit from the grocery store as well as fruits from local native ecosystems. Use your observation skills to examine the structure and characteristics that are used to classify fruit into categories or types.

Directions

1. You and your classmates should divide yourselves evenly across the stations. You will begin by visiting only the stations with commercial, grocery store fruits. Native, wild fruits will be examined later.
2. Spend 3-5 minutes at each station. Note the number of the station on your paper (use a half sheet of paper for each station). Sketch a cross section of the fruit and write a description in words. Observe closely all the small details you find in each group of fruits. Is the fruit soft, fleshy, dry, hard? How many seeds are there? What is the arrangement and texture of the pericarp? Are there any chambers within the fruit? Note anything else that may be an important identifying feature. Use the magnifying lens to look closely.
3. Rotate to the next fruit station; write the station number and continue to sketch and gather observations. Be sure to visit all the stations (or the number specified by your teacher).
4. Once you have observed the fruit at all the stations, use the Dicchotomous Key for Common Fruit Types to determine what type of fruit is at each station you visited. Fill in the fruit type in the top right corner of your data sheet.
5. After you have visited all of the stations with commercial, grocery store fruits, visit the native, wild fruits stations. Follow the same directions for the native fruits stations as you did for the grocery fruit. Use a hand lens to examine the fruits carefully, as wild fruits are often much smaller than their grocery store cousins.
6. Apply what you have learned. Can you match the wild version with fruit types you eat? In all likelihood you will discover some new fruits that do not fall into the categories that you have worked with so far, as they do not have a domestic equivalent that we eat (e.g. samara).

Drupes, Pomes, & Loculicidal Capsules:
A Botanist's Lingo for Describing Native Fruits

In the Field!

Take an outing in the fall to see how many different wild fruit types you can collect. When collecting, if you know the name of the plant, write it down. Take your collection back to the classroom. Dissect your wild fruits and use your observation skills to classify them by fruit type. How many different types of fruit did you find? If you were able to identify any of the plants when collecting, look in the field guide to see what type of fruit it has. Does your plant name and fruit type match what is found in the field guide? *When you are finished with this activity, dispose of the seeds in the trash can. Invasive plants are common and it is likely that you have them in your collection. Don't take a chance of spreading them—act responsibly and dispose of the seeds properly.*

Science Inquiry

Are certain types of fruits more common in a specific ecosystem? Do comparative studies in the late summer or early fall to find out. Choose two ecosystem types that are easy for you to access. Riparian, woodland, forest, shrubland, wetland, and prairie are all reasonable choices. Determine some simple parameters to follow. An example would be to collect fruits from 10 species in a riparian area and 10 in a prairie. Determine the fruit types found in each ecosystem and compare. Does one fruit type predominate? Are the types of fruits found between the two ecosystems different? Do the types of fruits found in the ecosystems reflect some advantage related to habitat (e.g. corky, buoyant fruits in the riparian area that float well on water, or light and airy seeds in prairies that can be dispersed by the wind)?

Reflection

Use your imagination. Invent a fruit and draw it inside and out. Describe it in detail. Write a story or poem about you and your fruit, or from a fruit's perspective. Describe its habitat and how the seeds are dispersed. Hypothesize about why this fruit looks, tastes, smells, and lives as it does.

Taking It Further

Some fruits are designed to literally hurl the ripe seeds at you when you touch them, while others hold their seeds deep within fleshy layers. Take this lab one step further by making observations and inferences as to what method of seed dispersal (water, animal carried). Examine the structures of the fruit and make your best guess as to how the fruit may be dispersed to new sites. Refer to the paragraph in the background information for clues. What structures on the fruit lead you to think that it is dispersed in that way?

Self Assessments

- Use observational skills to identify fruit types using a dichotomous key. Apply the knowledge to native plant fruits.
- Through observation, make inferences to seed dispersal methods by analyzing fruit types.
- Identify and name the three parts of a fruit as applied to common fruit types.

Resources

Harris, James G. and Melinda, Woolf Harris. 2001. *Plant Identification Terminology: An Illustrated Glossary* (2nd ed.). Spring Lake Publishing, Spring Lake, UT.

Drupes, Pomes, & Loculicidal Capsules:
A Botanist's Lingo for Describing Native Fruits

Dichotomous Key for Common Fruit Types

1a. Fruit from one ovary of one flower (simple fruit).....2

1b. Fruit from more than one ovary but from a single flower…..**Aggregate fruit**

2a. Fruit fleshy at maturity…..3

3a. Single large, hard seed, (a "stone" fruit)…..**Drupe**

3b. More than one seed; seed not enlarged and hardened….4

4a. Seeds in a single linear order, separating from ovary wall; forming a pod…..**Legume**

4b. Seeds not in a single linear order…..5

5a. Inner layer of ovary (endocarp) papery, forming a core…..**Pome**

5b. Endocarp fleshy and not papery…..6

6a. Outer layer (exocarp) thin, easily peeled off, not leathery…..**Berry**

6b. Exocarp thickened and leathery (modified berries)…..7

7a. Fruit interior divided into sections w/ cross-walls; citrus…..**Hesperidium**

7b. Fruit interior not divided; exocarp a rind….. **Pepo**

2b. Fruit dry at maturity…..8

8a. Dehiscent (splits open at maturity); usually many seeds…..9

9a. Fruit contains only one distinct chamber (locule)…..**Legume**

9b. Fruit contains more than one locule, or with a lid-like top…..**Capsule**

8b. Indehiscent (does not split open); usually one-seeded…..10

10a. Ovary wall extends to form a wing…..**Samara**

10b. Fruit not winged…..11

11a. With many seeds in single linear order forming a pod…..**Legume**

11b. Fruit with one seed, or not in single linear order…..12

12a. Outer wall not especially thick or hard; fruit small…..13

13a. Seed not tightly attached to ovary wall…..**Achene**

13b. Seed fused to ovary; grains; seeds of grasses…..**Caryopsis**

12b. Outer wall hardened; fruit relatively large…..14

14a. Ovary hard throughout…..**Nut**

14b. Middle of ovary fibrous; seed hardened…..**Drupe**

Adapted with permission, the University of the Ozarks

TEACHER page

What's in a Name?

What's in a name? That which we call a rose by any other name would smell as sweet.

—William Shakespeare (1564-1616), Romeo and Juliet

Time Estimate:

15-20 minutes inside; additional time needed for field journal and outside components.

Best Season:

Spring, Winter, Fall

Preparation

- Student pairs will need access to a computer with internet capability.

Additional Information

- Botanical Latin hints: http://www.calflora.net/botanicalnames/pronunciation.html
- USDA/NRCS PLANTS Database home page: http://plants.usda.gov/
- *The Jepson Manual: Higher Plants of California.* Hickman, James C (ed.). University of California Press, Berkley, 1996.
- Concise information on scientific names: http://oregonstate.edu/dept/ldplants/sci-names.htm
- International Association for Plant Taxonomy website with the official regulations on botanical nomenclature: http://ibot.sav.sk/icbn/main.htm

Overview

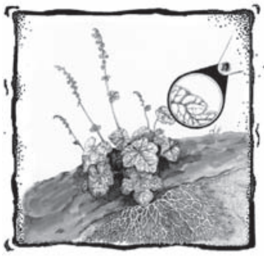
This lesson uses a technology-based practical application to explore scientific names. Students will access the United States Department of Agriculture (USDA) website to explore some of the challenges with using common names. They will learn a brief history of scientific names, general rules on how to write scientific names, and hints for pronouncing botanical Latin.

Teacher Hints

- Plants commonly referred to as "thistles" provide an excellent opportunity to explore the utility of scientific names and the challenges with common names. For example, the plants in the genus **Cirsium** are referred to as thistles, while the genus **Centaurea** represents star thistles, and plants in the genus **Sonchus** are sowthistles. Each of these genera, however, are distinctly different. Make a set of thistle identification cards for Oregon or specifically for your ecoregion. Find photos and species lists on the USDA PLANTS database site. Use these cards when you go out in the field to help students identify the "thistles" found in your area. When using photos from this site, set a good example for your students and include the credits on your cards. This may also be set up as a student project.
- If your students need extra practice to remember the proper techniques for writing scientific names, make up a worksheet writing scientific names incorrectly and have students rewrite them in the correct form.

Assessments

1. Students can recognize and use proper formatting for written scientific names. (capitalization—Genus, species; *italics* if typed, underlined if handwritten).
2. Students can describe at least one situation where it is important to use scientific names and why.
3. Students can name at least one situation where using a common name is preferable.



What's in a Name?

What's in a name? That which we call a rose by any other name would smell as sweet.

—William Shakespeare (1564-1616), Romeo and Juliet

Overview

This lesson uses a computer-based application to explore the importance of scientific names. Using the USDA PLANTS database website, you will explore the importance of using scientific names to describe plants and the challenges that arise from the use of common names. You will do this by researching a group of familiar and common plants, the thistles. Learn the history of scientific and common names, formatting guidelines for writing names, and hints for pronouncing botanical Latin that will make you sound like a pro.

Learning Objectives

- Become familiar with a technical website resource to gather scientific information
- Understand the history and function of scientific names
- Understand the importance of using scientific names
- Understand the uses for common names of plants
- Write scientific names in the proper format

Materials Needed

- computer with internet access
- digital camera for use outdoors (optional)

Vocabulary Words

- genus/genera
- species
- binomial nomenclature
- scientific name
- common name
- taxonomy

Background Information

Chances are you are familiar with a plant called a thistle. The name "thistle" is a common name used to describe many different plants that are spiny or prickly. However, some plants that are called thistles have no spines. If someone says they saw a thistle, how do we know which one they are describing?

Common names can function appropriately when everyone uses the same name for the same plant. However, this is a rare occurrence. Most plants are known by more than one common name. Sometimes these names differ from one region to another. Common names also do not cross over language barriers. Imagine a plant found in both Arizona and northern Mexico, where the common name for a plant found in both of these neighboring places would be different in Spanish and English. This variation can make plant names very confusing! In spite of this variation and the challenges that arise from it, common names are used frequently. They are easy to pronounce, can be easier to remember than scientific names, and are often descriptive of the plant (e.g. blackberry). All of these factors contribute to the utility of common names in communicating with your friends and acquaintances in your community. However, there is often a need for a greater level of accuracy than common names allow. For this use, we have a standardized system of scientific names that do not change by language, region, or local usage. As you learn some of the Latin roots used to make scientific names, they become easier to understand and remember, and can help you learn more about the cool plants where you live.

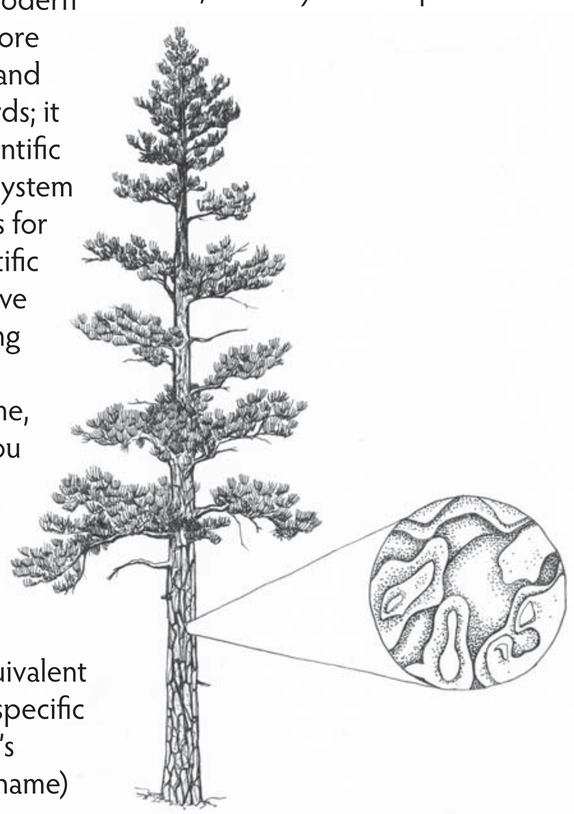
Scientists have experimented with many systems for classifying living things. Prior to the invention of our current system, scientific names were long descriptive phrases that were hard to remember. An example of a plant name under one such system was *Physalis annua ramosissima, ramis angulosis glabris, foliis dentato-serratis*. Now that is hard to remember! The system in use today was created by Carolus Linnaeus (1707-1778), a Swedish botanist and physician. Linnaeus's system, referred to as binomial nomenclature (*bi* = two, *nomen* = name, *calo* = call), involves a standardized two-part name. In

What's in a Name?

Background Information

binomial nomenclature, the name for the species above was shortened to *Physalis annua*. Although other earlier scientists had worked on such a system, Linnaeus formalized the system and in 1753 published names for all known plant species in his book *Species Plantarum*. Linnaeus is credited with implementing the hierarchal classification system and is often referred to as the father of taxonomy (the science of classification).

This hierarchical classification system uses the genus name and a species name to make up the scientific name of an organism. Scientific names use Latin and sometimes ancient Greek as the root sources. Latin was chosen for several reasons. It is not used as a modern spoken language and therefore does not change with slang and the introduction of new words; it was historically used for scientific names prior to our current system of classification; and it allows for the standardization of scientific names regardless of the native spoken language. This naming system gives each species a surname and a personal name, much like many people. If you are named Pat Jones, then Jones is your surname, and Pat is your personal name. Scientists call the equivalent of a person's last name the genus and the equivalent of a person's first name the specific epithet. Unlike most people's names, the genus name (surname) comes first and the specific epithet (personal name) is second in the binomial system. For example, the Latin name for the tree commonly known as the bigleaf maple is *Acer macrophyllum*. *Acer* is the genus name; there are two other species in this genus that are native to Oregon. This is similar to how you and your two siblings would have the same last name. The species name, *macrophyllum*, is only used in naming this species in the genus *Acer*, similar to how your first name and your siblings' first names are unique in your family. However, just like you may know other students who have the same first name as you, sometimes the species name for two different plants are the same, but only if those plants are in different genera.



Scientific names often reference a physical characteristic of the plant, a famous person or scientist, or the geography of a plant's range. They can come from a person (*Lewisia* for Capt. Meriwether Lewis), ancient Greek (*Daphne* from Greek mythology), a local language (*Camassia* for a Native American word Camas), a false resemblance (*Pseudotsuga* = a false *Tsuga*), a place (*columbiana* = Columbia River), a color (*alba* = white) or a description (*contorta* = twisted). In fact, "*macrophyllum*" means "large leaf" in Latin and describes the species (*Acer macrophyllum*= bigleaf maple) with the largest leaf size of all the maples—up to 15 inches wide!

To maintain this standardized naming system, there are some basic rules.

- The genus is listed first and is always capitalized.
- The specific epithet is listed second, is never capitalized, and is unique among members of the same genus.
- The entire two-part name should be underlined if hand written or in italics if typed.
- When writing a name multiple times, use the entire name the first time. In successive uses of the scientific name in the same work, abbreviate the genus by using only its first letter, e.g. *Acer macrophyllum* becomes *A. macrophyllum*.

What's in a Name?

Directions

1. Each person or pair needs to work at a computer with internet access. Use the handout at the end of this lesson as a guide.
2. Go to the website <http://plants.usda.gov/>. This website is designed for use with scientific or common names.
3. Search on the USDA Plants Database website for the common name "thistle." Search options are located on the upper left of the homepage. Type in the word "thistle" and chose the option "common name."
4. How many records are returned (noted at the top of the results page)?
5. How many different genera come up for the name thistle?
6. Scan down the right hand column of common names. Locate "common sowthistle" and write down the scientific name for this plant using proper form.
7. Click on the "common sowthistle" entry to learn more. Would you find this plant in Oregon? Is this plant native or introduced? If introduced, where did it come from (hint: you will need to search further on related links to answer this question)?
8. Look at the pictures on the website. Have you seen this plant before? Examine the pictures and look for it on your walks around town or on trips to the country.
9. Now look specifically at the genus **Cirsium**. How many **Cirsium** species are there in Oregon? Find one species of **Cirsium** that is invasive and one that is native and write their common and scientific names on your worksheet.
10. Now click on the map of Oregon on the website and see if you can find a species of thistle that is found specifically in the county where you live.
11. Investigate the Latin word definitions of the scientific names you found. Look up both the genus and specific epithet. You can use a website such as: <http://www.winternet.com/~chuckg/dictionary.html >. Why do you think it was given the scientific name that it has?

Botanical Latin Tips

from *The Jepson Manual: Higher Plants of California* (pg. 11,12)

Many people avoid using scientific names because they don't feel comfortable pronouncing them. For each new Latin name you encounter, remember that there is commonly more than one way to say it. Botanist William Stearn said, "Botanical Latin is essentially a written language, but the scientific names of plants often occur in speech. How they are pronounced really matters little provided they sound pleasant and are understood by all concerned…" Even professional botanists can be strikingly different in the way they pronounce names. If you feel unsure of yourself, remember a bit of wisdom from a wise botanist, "When someone presumes to correct your pronunciation, a knowing smile is an appropriate response." So be brave, go ahead and say those scientific names!

Quick tips for pronouncing Latin:

- Divide words into syllables (it is safe to assume every vowel belongs to a different syllable)
- Pronounce every syllable
- General practice is
    - **a**: "ah" not "ay"
    - **e**: "eh" not "ee"
    - **i:** "ee" not "eye"
    - **y**: as in "cynic" not "eye"
    - **ae**: "eye" not "ee"
    - **ii**: held longer "eeee"
    - **ti, ci**: "tee" or "cee" not "she"
    - **ch**: generally "k" not as in "ouch"
    - **g**: as in "go" not "gem"

What's in a Name?

Taking it Further

- Do another name search based on a common plant name in your ecoregion (try daisy) or a plant from your field work.
- Research the naming conventions for Latin, base words, prefix/suffixes, and form agreements.
- Research and write a paper on the history of plant taxonomy or a famous botanist (some examples: Carolus Linnaeus, David Douglas, Meriwether Lewis, etc.).

In the Field!

Find all the plants in your area that people call "thistles." A good place to start is by searching the common name "thistle" on the PLANTS Database site. Record your findings. While in the field, take a photo, make a sketch, or make an herbarium specimen in a plant press. In the classroom, identify and label each photo, sketch, or pressing with the scientific name, and write a description of each plant. How many different "thistles" did you find?

Reflection

Now you are familiar with a great botanical internet resource. Brainstorm and describe how databases such as the USDA Plants Database or local databases like the Oregon Flora Project might be used for conservation or scientific projects.

Self Assessments

1. Can you write scientific names in the proper format?
2. Name a situation where it is important to use scientific names and why.
3. Name a situation where using a common name is preferable.

Resources

- USDA/NRCS PLANTS Database home page: http://plants.usda.gov/
- Concise information on scientific names: http://oregonstate.edu/dept/ldplants/sci-names.htm
- Dictionary of botanical epithets: http://www.winternet.com/~chuckg/dictionary.html

What's in a Name?

Names: ______________________________

Go to the website **http://plants.usda.gov/** to start your search.

1 Search for the common name "thistle." How many records are returned? ______________

2 Count the number of different genera with the common name "thistle." How many do you find? ______________

3 Find "common sowthistle." What is the scientific name for this plant? ______________

4 Click on common sowthistle to learn more about this plant. Is this plant found in Oregon? ______________

5 Is it a native plant or introduced species? ______________

6 If introduced, where did it originally come from? ______________

7 Download a picture of the sowthistle with proper photo credits. Have you seen this species? ______________

If so, where did you see it? ______________

8 What is the meaning of the scientific name for the common sowthistle? Use this website **http://www.winter-net.com/~chuckg/dictionary.html**.

____

____

9 Why do you think it was given its scientific name? ______________

____

10 Now do steps 1-9 for the genus **Cirsium**. Write what you find here. Can you find any native species in that genus?

____

____

Plants Have Families Too

I have seen trees as my friends. When they grow along my path, I reach out to them, draw their needles through my hands, and smile. I say their names, an acknowledgment of kinship.

—David Sobel (Contemporary)

Time Estimate:
15 minutes for each plant family (includes time to investigate and discuss findings)

Best Season:
Spring, Summer, Fall

Additional Information

- Elpel, Thomas J. *Botany In A Day: The Patterns Method of Plant Identification*, 5th Edition. 2004. HOPS Press, LLC, Montana. www.hopspress.com

Overview

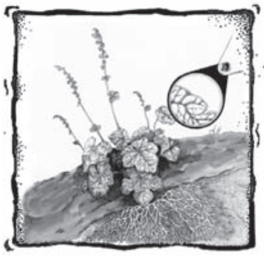
Students learn about the science of taxonomy by observing patterns of plant characteristics of related species of families widely represented in their ecoregion.

Teacher Hints

- Obtain plant specimens on the day before or the day of the activity (be sure to keep the live specimens in a vase of water or in the refrigerator). A list of potential species follows each family description. Plants appropriate for dissection are weedy or common, found along roadsides or in gardens. Free, left over flowers may be available from local florists (be aware that garden and florist plants are often hybrids and may have more flower parts than plants growing in the wild).
- Keep specimens cool and moist. Lay short-stalked flowers between moist sheets of paper toweling in sealed plastic bag; put long-stemmed plants in a vase.
- If plants are no longer blooming, students can investigate fruits, seeds, and seed dispersal mechanisms. As an alternative, collect photos of plants, flowers and fruits to do this activity in winter.
- Number stations (1, 2, …) with representative examples of one plant family at each station. Have enough stations so you have 3-4 students at a station at a time.
- Divide students evenly among the stations. Act as timekeeper, having groups move to next station at 8-10 minutes.

Assessments

1. Give common and Latin name of each plant family learned.
2. List two characteristics for each family that makes that family unique.
3. Indentify one representative for each plant family.



Plants Have Families Too

I have seen trees as my friends. When they grow along my path, I reach out to them, draw their needles through my hands, and smile. I say their names, an acknowledgment of kinship.

—David Sobel (Contemporary)

Overview

Learn about the science of taxonomy by observing patterns of plant characteristics of related species of families widely represented in your ecoregion.

Learning Objectives

- Practice observation skills on multiple scales
- Identify and recognize patterns and characteristics that group plants into families
- Introduction to the science of taxonomy in classifying and naming organisms

Materials Needed

- plant specimens in flower or seed
- hand lens
- observation sheet or field journal
- field guide for your area

Vocabulary Words

- taxonomy
- Lamiaceae
- Asteraceae
- Apiaceae
- Rosaceae
- Poaceae
- Cyperaceae
- Fabaceae
- Liliaceae
- Pinaceae

Background Information

In this lesson you will learn to identify the most common plant families from your area. Why is it important to study plant families as part of plant identification? With over 3000 species of native plants in Oregon, it is helpful to have plant families as a tool to make plant identification easier and to understand the relationships between the species in your area. When you see a plant whose identity you do not know, if you can guess its plant family just by looking at it and making a few observations, you will have narrowed your list of possible candidates to a much smaller group, making the challenge of identification easier. Also, some families have a tendency to have more edible, medicinal, or poisonous plant species than others. By identifying a plant to family, you may get a clue as to some of its uses or a clue to refrain from eating species from families you know tend to be poisonous. Knowing the plant families is a fun way to get more familiar with the wild places around you. Walking down a trail in your local forest, it is always a treat to see plants from common families that you recognize. Even if you don't know the name of the plant itself, just by recognizing the plant as from a familiar family, you will feel more welcome in amazing wild places.

When you have finished this activity indoors, try it outdoors in a natural area. It will help you begin to understand the composition of different plant communities in your ecoregion.

Several plant families common throughout Oregon.

Mint family—Lamiaceae
Daisy family—Asteraceae
Parsley family—Apiaceae
Rose family—Rosaceae
Grass family—Poaceae
Sedge family—Cyperaceae
Pea family—Fabaceae
Lily family—Liliaceae
Pine family —Pinaceae

Plants Have Families Too

Directions

1 Divide into groups to evenly distribute students among the stations to start the activity.

2 Examine the related specimens at your first station. Look for characteristics that are similar that would help you group all these plants into one family. Draw or write descriptions. Spend 8-10 minutes studying your family and then, when instructed, discuss your findings within your group until you are instructed to change stations.

3 Rotate to the next plant family station. Again, observe the new plant family and record your observations, discussing your findings within your small group.

4 After rotating through all plant family stations, gather together to share as a large group. What characteristics are helpful to identify each family? Were there any families in which you found species that didn't seem to quite fit the general family characteristics?

5 Match the shared characteristics that you find on the Plant Family chart to your observed plants. Label your sheet with the family name and add any key traits from the cards that you don't have.

6 Write the family name and important traits into your field journal for reference in the field.

7 Practice your Latin by learning to say and spell the names of the plant families you have just learned.

Taking it Further

- Research the native species for each of the families and create a list for your ecoregion. When you create your list, note what type of habitat characteristics or ecology they prefer to live in (for example: wet, dry, shade). When indentifying plants, the ecology is one more clue that can be used to help you get a positive identification.

Plants Have Families Too

In the Field!

Practice your new taxonomy skills on a plant walk in a natural area. Look for plants that have traits that match the family characteristics that you learned in this lesson. Notice if your plant families tends to be found in one habitat over another (such as sedges, which are mostly found in wet places). If you don't find a match for your families, pick a new plant to look at and record the characteristics you observe. Once you have made your observations, look in a field guide and try to discover which family it belongs to based on the characteristics that you observed.

Science Inquiry

Use your observation skills to gather data about plant families. Look at 2-4 plant specimens from one family. Use a Venn diagram to display the information that you collect. Each circle will represent one of the plant specimens; write down observable traits in that circle. In the overlapping area write any traits that are shared by all the plant specimens.

Reflection

Do you think it will be useful to be able to recognize plant families? Create a poem, riddle, or plant-shaped prose writing about one of the plant families, including the key traits that you learned about this plant family and how you would recognize it in a natural area.

Assessments

1. Give common and Latin name of each plant family you have learned.
2. List two characteristics for each family that makes that family unique.
3. Indentify one representative for each plant family.

Resources

- Elpel, Thomas J. *Shanleya's Quest: A Botany Adventure for Kids Ages 9-99.* 2005. HOPS Press, LLC, 12 Quartz Street, Pony, Montana 59747. www.hopspress.com
- Elpel, Thomas J. *Botany In A Day: The Patterns Method of Plant Identification*, 5th Edition. 2004. HOPS Press, LLC, 12 Quartz Street, Pony, Montana 59747. www.hopspress.com

PLANT FAMILIES CHART

FAMILY NAME	CHARACTERISTICS: GENERAL	CHARACTERISTICS: LEAF	CHARACTERISTICS: FLOWER	CHARACTERISTICS: FRUIT	OREGON NATIVES	COMMON WEEDS	GARDEN OR LANDSCAPE PLANTS
Lamiaceae (lay-mee-AY-see-ee) mint family	aromatic; stem cross-section square	leaves opposite, may be toothed or lobed, but not divided	small flowers in clusters; five petals joined at base, form a tube split into upper and lower lip; stamen number varies; flowers bi-laterally symmetrical (zygomorphic) **Inflorescence**: terminal (on top of the plant) or in whorl (leaves attach to the stem)	single flower produces four nutlets	lance selfheal (*Prunella vulgaris ssp. lanceolata*), field mint (*Mentha arvensis)*	pennyroyal (*Mentha pulegium*); spearmint (*Mentha spicata*)	basil, peppermint, rosemary, thyme, lavender, oregano
Asteraceae (as-ter-AY-see-ee) daisy or sunflower family	some heads have only disk flowers (thistles and snakeroots), others have only ray flowers (dandelions, chicory); many species have both ray and disk flowers (sunflowers, asters); bracts: flower head is subtended by involucral bracts, modified leaves that protect the growing bud	alternate or occasionally opposite; usually toothed, lobed, or divided	small flowers in center called disk flowers, long petal-like flowers are ray flowers; all flowers attach to fleshy area (receptacle) and make up a single inflorescence **Inflorescence**: although may look like single flower, is actually cluster of flowers called a head, which may contain a few to hundreds of individual flowers	achene (small, hard seed, often with a pappus attached to the top for seed dispersal by wind)	Oregon sunshine *(Eriophyllum lanatum)*, big sagebrush (*Artemisia tridentata*)	ox-eye daisy (*Leucanthemum vulgare*); dandelion (*Taxacarum officionale*)	artichoke, lettuce, sunflower, asters, chrysanthemums, chamomile
Apiaceae (ay-pee-AY-see-ee) parsley or carrot family	seeds often aromatic; stems often hollow; some very poisonous; many others are common culinary herbs	alternate, often basal, usually compound, with sheathing leaf bases	5-parted, fused sepals; petals often yellow or white; 5 stamens; ovary inferior (attached beneath the flower parts) **Inflorescence**: simple or compound umbels (umbel is flat or convex and umbrella-like)	schizocarp (dry fruit that splits in two)	cow-parsnip (*Heracleum maximum*), poison hemlock (*Conium maculatum*), desert parsley (*Lomatium spp.)*	Queen Anne's lace, wild Carrot (*Daucus carota*)	carrot, parsley, dill, fennel, parsnip, celery
Rosaceae (row-ZAY-see-ee) rose family	usually two stipules are at base of leaf stalk	alternate, simple, divided or lobed, often toothed	5 sepals, 5 petals, one or many pistils, many have stamens in rings of five; Floral cup: most have a floral cup beneath the flower which may be a shallow saucer, deep bowl, or tube shape	achenes, pomes, drupes, capsules, and follicles; determined by floral cup and fertilization process	wild strawberry (*Fragaria* spp.), Nootka rose (*Rosa nutkana*), antelope bitterbrush (*Purshia tridentata)*	Himalayan blackberry (*Rubus armeniacus*), sulphur cinquefoil (*Potentilla recta*), field rose (*Rosa eglanteria*)	apple, pear, cherry, peach, plum, strawberry, raspberry, apricot, almond, rose, cosmos, echinacea
Poaceae (po-AY-see-ee) grass family	wind pollinated; hollow stem between the nodes	usually long and narrow, with the base of the leaf, the sheath, wrapped around the stem. Leaf attaches to the stem at a ligule, a small membranous part (often important for identification)	small florets on dense spikes or open clusters, three stamens, one pistil, bracts instead of sepals or petals, the grass floret is surrounded by a second pair of bracts called the lemma (on the outside) and palea (tucked inside); **Inflorescence**: upright or drooping spike, raceme, or panicle	a single grain (caryopsis)	Roemer's fescue (*Festuca roemeri*), tufted hair grass (*Deschampsia cespitosa*)	reed canary grass (*Phalaris arundaceae*), false brome (*Brachypodium sylvaticum*), cheat grass (*Bromus tectorum)*	wheat, oats, rice, barley, corn, rye, sugar cane, bamboo

PLANT FAMILIES CHART

FAMILY NAME	CHARACTERISTICS				OREGON NATIVES	COMMON WEEDS	GARDEN OR LANDSCAPE PLANTS
	GENERAL	LEAF	FLOWER	FRUIT			
Fabaceae (fa-BAY-see-ee) bean or pea family	nodules on roots of plants in this family have a special symbiotic relationship with bacteria in the genera Rhizobium and Bradyrhizobium, which acquire food and a protected home in root nodules; in exchange, the bacteria provide the plant with nitrogen	alternate, compound with three to numerous leaflets, two stipules located at base of leaf stalk	5 petals, each with a specific name – one banner on the top, one wing on each side, and two largely fused lower petals called the keel; the keel surrounds 10 stamens fused into a tube or 9 fused and one solitary stamen; flowers are structurally adapted for pollination by bees (the bee lands on the keel, triggering the stamen cluster to be exposed and showering the bee with pollen; **Inflorescence**: flowers are usually borne on a stalk of many flowers called a raceme	a pod that when dried, often splits along the two lengthwise edges or at the joints between each seed (legume)	American vetch (*Vicia americana*), small flowered lotus (*Lotus micranthus*), lupine (*Lupinus* spp.)	common sweet clover (*Melilotus officinalis*), Scotch broom (*Cytisus scoparius*)	peas, beans, peanuts, lentils, alfalfa, clover, honey locust (tree), wisteria
Liliaceae (lil-ee-AY-see-ee) lily family	perennial herbs with bulbs or rhizomes	simple, entire, alternate or in a basal rosette with parallel veins	showy, w/ two whorls of 3 tepals (petals and sepals combined), star shaped (radially symmetric), perfect (both male and female parts), often with stripes or spots, 5 stamens, ovary superior (base of ovary attached to base of tepals) **Inflorescence**: sometimes a raceme (stalk of many flowers), umbel, or often one terminal flower	loculicidal capsule or occasionally a berry	tiger lily (*Lilium columbianum*), large-flowered cluster-lily (*Triteleia grandiflora)*	wild garlic (Allium vineale)	daylily, hyacinth, garlic, onion, chives, asparagus, tulips, daffodils
Pinaceae (pine-AY-see-ee) pine family	mostly trees, evergreen, pollen dispersed by wind	needle-like; borne in whorls on branches	Separate male and female flowers; not showy	seeds borne in a woody cone (no fruits; Gymnosperm means "naked seed")	western hemlock (*Tsuga heterophylla*), Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), western white pine (*Pinus monticola*)	Norway spruce (*Picea abies*) in Hawaii, Scots pine (*Pinus sylvestris*) in Hawaii	blue spruce, stone pine (pine nuts)
Cyperaceae (cy-per-AY-see-ee) sedge family	commonly found in wet areas, though not always true. Stem: three-sided, triangular in cross-section, frequently solid between nodes; roll stem between fingers to feel edges. In largest genus in family, Carex, ovary is surrounded by a persistent sac-like bract called a perigynium, often topped by a beak when mature (part can be very important in identification).	upon first glance, often look like plants in the grass family, but leaves are arranged in three vertical rows along stem and are closed at the base	small, grouped in spikelets; floret is surrounded by bracts (small, modified leaves) and have no petals or sepals; usually three stamens and one pistil with two to three stigmas **Inflorescence**: spike or panicle	a nutlet (a small nut with a hard outer covering)	lateral sedge (*Carex unilateralis*), foothill sedge (*Carex tumulicola*), dense sedge (*Carex densa*)	drooping sedge (*Carex pendula*)	papyrus, water chestnut, ornamental sedges

Mechanics of a Key

TEACHER page

Obstacles don't have to stop you. If you run into a wall, don't turn around and give up. Figure out how to climb it, go through it, or work around it.

—Michael Jordan (1963-present)

Time Estimate:

Part 1: 40 minutes, parts 2 and 3: 20-30 minutes

Best Season:

All

Teacher Hints

- Read background information and become familiar with how a dichotomous key works. Many field guides also have descriptions of how a key works and specifically how the key in that book works. If you are using a specific guide with your students, it may be helpful to read this section. It is usually found at the beginning of the guide.

Assessments

1. Student can explain how to use a dichotomous key
2. Students can work in a cooperative group to construct a simple key
3. Students are able to key out a native plant using one or more dichotomous keys

Overview

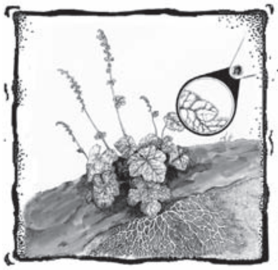
Learn how to identify plants using a dichotomous key by walking through the steps of constructing a key to the students in the classroom. Once students are comfortable with how a key works, they transfer their knowledge to keying out native plants using local field guides.

Preparation

- Be prepared to lead your students in a discussion of what traits are appropriate to use in the student key. The most important thing is to keep it a positive experience. Do not allow students to use sensitive divisions such as weight or complexion. Brainstorm with your students possible categories that will help them move through the activity (for example: male/female, height, head circumference, eye and hair color, shoe size).
- In addition to sensitive divisions, understand that physical characteristics that can easily change should not be used (i.e. hair length, clothes, jewelry)
- Set the stage for this activity by leading a discussion on human diversity and how important diversity is to the health of the community of people. Link this to plant diversity and health of plant ecosystems (a more diverse ecosystem tends to be more resistant to environmental change).
- SENSITIVE SUBJECT WARNING: Keying a classroom of students is a great way for them to apply the concept of the key in an easy to understand format. However, if you feel unsure of your ability to keep it positive without put downs, use alternative objects, such as seeds, stuffed animals, or shoes.
- Parts 2 and 3 introduce students to using two common, but different, versions of a dichotomous tree key. Walk the students through the steps while identifying a native tree.

Additional Information/Reference

- Web based interactive dichotomous tree key: http://oregonstate.edu/trees/ Jensen, Ed. Common Trees of the Pacific Northwest. March 28, 2008. Oregon State University.



Mechanics of a Key

Obstacles don't have to stop you. If you run into a wall, don't turn around and give up. Figure out how to climb it, go through it, or work around it.

—Michael Jordan (1963-present)

Overview

Learn how a dichotomous key works by walking through the steps of creating a key to the students in your classroom. Apply your newly learned keying skills to using a key to native plants and you will be well on your way to identifying native plants.

Learning Objectives

- Learn to use a dichotomous key
- Develop the ability to phrase key questions to construct a key
- Create a key for others to use

Materials Needed

Part 1:

- blank dichotomous key handout
- flexible measuring tapes

Part 2:

- field guide with plant key
- overhead transparency of key page
- native tree species to key out (on school grounds or use pictures if not available)

Vocabulary Words

- dichotomous

Background Information

A dichotomous key is a useful way to identify plants, animals, or just about anything. The word dichotomous comes from the Greek dichotomia, meaning divided (from dicha "in two"). The way a dichotomous key works is by dividing one large group of objects (in our case plants, but this works for other things too) into two smaller groups by characteristics that do not overlap. The wording is written as such that no object can belong to both divisions. The key is put together in steps that you walk through in order, one at a time. Each step will divide the group of objects into smaller and smaller groups until you have just one option and an exact identification.

A great way to learn how to use a key successfully is to construct one of your own. The best test of your key is to give it to others and see if they can successfully identify something with it. A key can be made in many orders and still get to the same end. The nature of the questions and the order that you ask them can vary; it is only critical that the key works to get you to the correct answer.

The key will provide a series of paired statements. Each statement will have only two possible options. Each of the two answers will guide you along a path to another set of statements. Continuing in this manner, you will answer a series of questions about your object and eventually discover its identity.

Follow these simple guidelines to make your key a success:

- Your first grouping of statements should divide the individuals in your class into two categories based on some fairly obvious trait, such as female or male. It does not matter if the two groups have approximately the same number of items in them. Be sure to focus on traits that are commonly shared between several individuals, though it is okay to divide out one or a couple of individuals earlier in the key if they are very obviously different.
- Continue to build your key by asking more questions. The objective of each step should be to identify a clear trait that divides the remaining individuals into only two groups. Remember, it is vital that each statement must be worded so as to have only two possible answers.
- The statement should refer to a trait that is obvious, unambiguous, and observable. Traits that are opinions (coolest, best, most fun, etc.) do not belong in

Mechanics of a Key

Background Information, continued

a dichotomous key.

- Continue to pose questions in your key until all individuals have been identified.
- Once complete, give your key to a partner and see if they can follow it.

Directions

Part 1:

1 Carefully read over the background information before starting and refer to it as needed.

2 This activity will walk you through constructing a dichotomous key that will lead to the identification of each student in the classroom by name.

3 Start with the entire class standing in a large group; this will help you visualize how the key works.

4 The first step of the key will divide the class into two parts by making a statement with only two possible categories. Remember, as you ask these questions you will want to use traits that are obvious (easily seen) and measurable (tape measure included), not subjective (such as funny-looking). Record the first question on your empty key sheet at the top. Now physically move into the two new groupings.

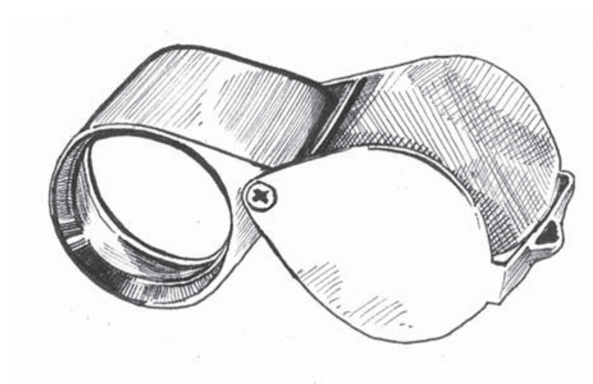
5 Work within your smaller group. The next step is to divide your group again. Here's a hint: notice how this grouping has only two answers; "Divide into those that have brown eyes and those that do not have brown eyes." Notice that the question didn't ask you to divide into those with brown eyes and those with blue eyes, since it is possible that other eye colors, such as green, hazel, amber, gray, violet, or pink may be present. Record your question/statement on your key sheet and physically separate into those groups.

6 Continue to work through the groups until you have been individually identified and named and you are the only one left in your group. Be sure that you have recorded each step on the dichotomous key handout.

7 Once you have completed your key, your teacher will help the class as a whole to compile all the individual keys to create a master key to every student in the class.

8 Once you have a completed key to the entire class, choose a classmate of yours and try to identify them by working through the key. Were you able to properly identify them?

9 Discussion questions: How does the statement "Students (not) wearing a red shirt" work? What if you used this key with the classroom tomorrow? Would the red shirt statement still lead to the same person? For the same reason, the easiest plant keys do not depend on having a flower or fruit visible; you might have one to look at today, but next week is a different story. It is, however, quite common for keys to focus on flower and fruit characteristics, as they are quite often necessary for proper identification.



Mechanics of a Key

Directions, continued

Part 2:

1. Key out a native tree species outside (or from photographs if your school has no native trees) using *Trees to Know in Oregon* book or the *Common Trees of the Pacific Northwest* online key.
2. The first step in this key will ask you if you have an evergreen or deciduous tree. Subsequent steps will help you to narrow down the identity of your native tree.
3. Even if you think you know the name of the tree, work through all of the steps in the key for practice.
4. The dichotomous key in this field guide is a pictorial guide, but the structure is very similar to the key constructed in the classroom in Part One.

Part 3:

1. Look at an example of a plant key in a field guide for your ecoregion (see Appendix I for a list). A good example is *Plants of the Pacific Northwest Coast* by Pojar & MacKinnon, page 28, Keys to Trees. This key is set up with a numbering system; each question/statement has numbered answers (such as 1a. & 1b.). Each answer will lead to another branch of the key. For example 1a. question may lead you to 2a., and 1b. could lead to 5a. Just follow the numbers.
2. Each numbered branch is indented from the last like so.

   1a.
   1b.
      2a.
      2b.
         3a.
         3b.

3. Walk through the steps of the key by following the numbers until you reach a name for your plant.
4. Confirm that you have arrived at the right species by finding a description for the appearance and habitat of your species and making sure that they match with the individual you chose. For example, if you chose a tree from a low wetland and then the species you arrive at lives in the mountains, you know you have made a mistake somewhere in the key. This happens to professional botanists all the time. When this happens, go back to any couplets (pairs of statements) where you were unsure about which statement to choose and choose the one you had not chosen the first time. See where this takes you. Sometimes keying out a difficult species can be a bit of an adventure so have fun with it!
5. Trade species with a classmate and try to key out a second plant. The more you do this, the easier it gets!

Mechanics of a Key

Taking It Further

- Using your field guide, key out two plants from the same plant family. Use plants from one of the following families (see activity "Plant Have Families Too" for native plant species suggestions):

    Lillaceae (lily family)

    Fabaceae (pea family)

    Apiaceae (parsley or carrot family)

    Lamiaceae (mint family)

  For an extra challenge, try:

    Asteraceae (sunflower family) – *Plants of the Pacific Northwest Coast* also contains a genus key for this family.

In the Field!

Using a field guide to identify native plants has been the backbone of this section of the curriculum. You have learned about plant terms, plant families, scientific names, plant keys, and you now have the skills and tools to identify plants. Take a local field guide out into nature and identify the plants you see! Don't forget to look for helpful clues, such as the ecology of your plant. Where does it live? Are you looking at a plant in a wetland, grassland, on a mountain or in a forest? These are all clues that will help you identify the plant you have found. You now have the basic tools to identify plants; it is now your challenge to increase your skills with practice, practice, practice.

Reflection

Each plant you key out may be unique, but it is also a member of a larger ecological grouping. Plants live in communities and are part of an even larger ecosystem. Look at one of the plants that you have identified and write about how the plant you chose belongs to a larger community of interacting species. Think about both the plant and yourself in the context of your communities and in your larger ecosystems. What do you have in common with your plants species? How does your role in your community compare to that of your plant?

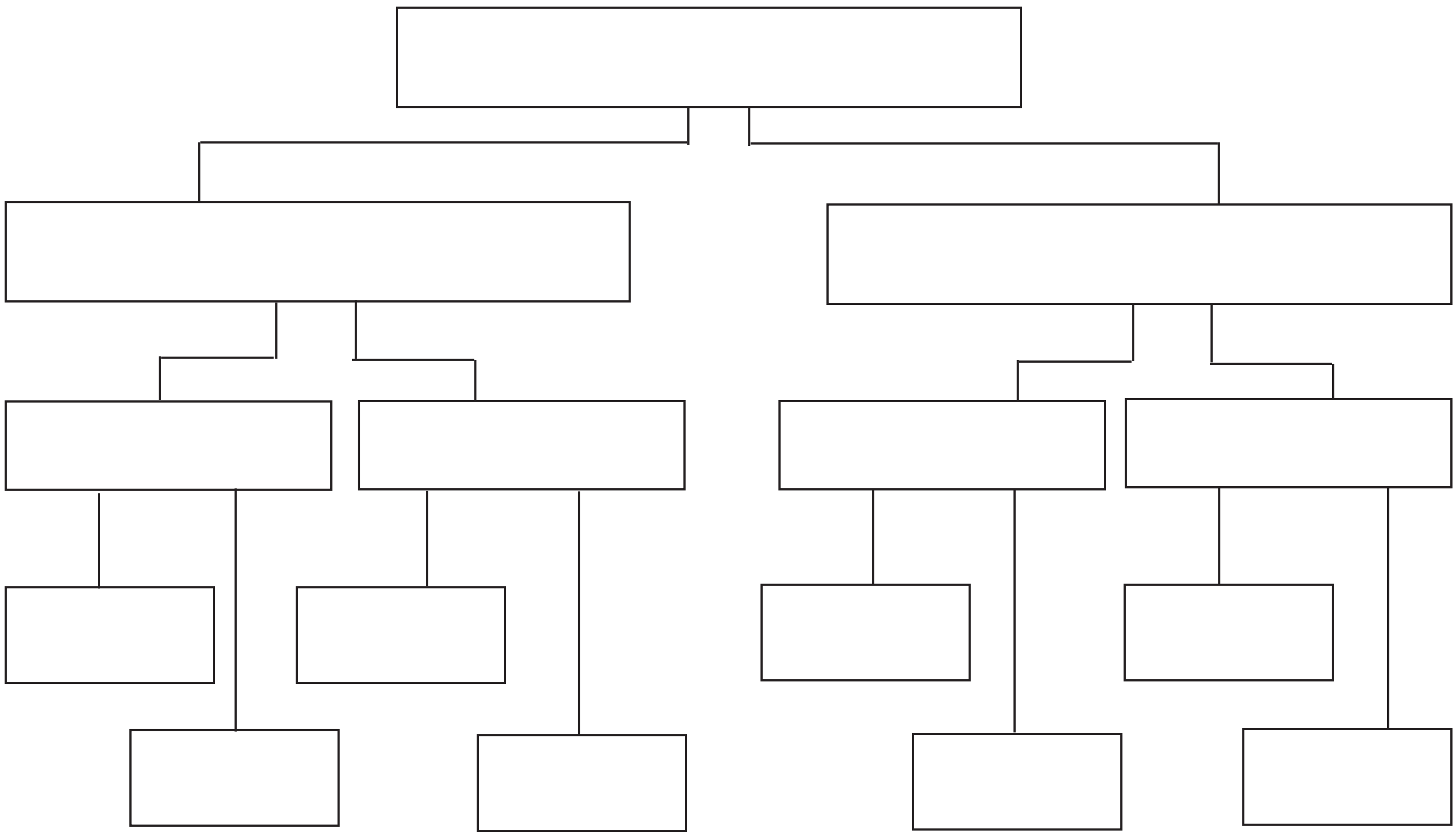
Self Assessments

1. Explain how to use a dichotomous key.
2. Cooperate as a group to construct a simple key, trade keys, and critique the results.
3. Key out a native plant using one or more dichotomous keys from local field guides.

Resources

- Jensen, Edward C. and Charles R. Ross. *Trees to Know in Oregon*, Oregon State University Extension Service, revised 2005. Page 61.
- Web-based interactive dichotomous tree key: Jensen, Edward C., *Common Trees of the Pacific Northwest*. 2008. Oregon State University. http://oregonstate.edu/trees/
- Field guides for your ecoregion (see Appendix I for listings).

Construct a Key



Add more branches and boxes as necessary.

TEACHER page

Make a Field Guide for Your School

The voyage of discovery is not in seeking new landscapes but in having new eyes.

—Marcel Proust (1871-1922)

Time Estimate:

Part 1: 60 min. session

Part 2: Additional field and class sessions needed

Best Season:
Spring, Summer, Fall

Overview

Students culminate the exploration of botanical skills learned in the plant identification section of this curriculum by constructing a field guide to the plants (and more, if desired) of a natural area on or near the school grounds.

Teacher Hints

- Reference “Mechanics of a Key” and “Create-A-Plant” activities in this guide. You and your students will need to understand how a dichotomous key works and how they are constructed as well as the components of a field guide page before beginning this activity.
- The “In the Field!” section below can help your school make a community service connection with a local park or natural area. Identify a location that is accessible to your students and approach the governing organization for permission and input. Explain what your students will be doing and that they will present them with the finished project when completed. Invite a staff person from the organization to get involved and help mentor the students. Invite them to your class and on the field trip to introduce the area, aid in the plant identification, and share the site history.
- To make this lesson more challenging, instruct your students to choose plants for their key that have a lot of physical similarities (i.e. several grass species). To make this lesson easier, have your students choose plants that are obviously very physically different.

Preparation

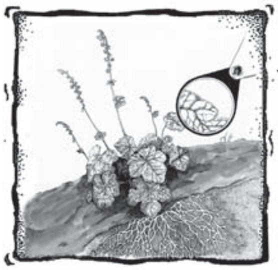
- Before taking students outdoors, scope out a suitable location for this activity, preferably on the school grounds or close by. If possible, use a natural area with a diversity of plant species. If this is unavailable, students may use ornamental landscape plants. Don’t forget that trees are plants, too.
- Divide the students into teams of four or fewer. If possible, give each group a designated area to avoid overlap.

Additional Information

- An educational lesson to make a dichotomous key; includes a wetland plant key: http://watershed.csumb.edu/ron/roncor/cor/did.htm

Assessments

1 Exchange keys among student groups and have each group test other groups’ keys for effectiveness. Write a peer review of the key or guide that others have constructed. The review should be balanced, noting both positive attributes of the guide and giving constructive suggestions for improvement. What works well about the key? Did they include terminology that you could understand? Were the steps of the key easy to follow? What constructive suggestions can you give for improving the ease of use?



Make a Field Guide for Your School

The voyage of discovery is not in seeking new landscapes but in having new eyes.

—Marcel Proust (1871-1922)

Learning Objectives

- Construct a dichotomous key to plants in your area
- Apply plant terminology correctly
- Compare and contrast plant structure and function

Materials Needed

Part 1:

- flagging tape
- dichotomous key handout (Mechanics of a Key lesson)
- clipboard
- pencils
- waterproof marker

Part 2:

- field guide template (Create-a-Plant lesson)
- colored pencils
- digital camera (optional)
- computer (optional)

Vocabulary Words

- Dichotomous key

Overview

Put your new plant identification skills to work. Use your knowledge of dichotomous keys, plant terminology, families, and scientific names to construct a key to a natural area on or near the school grounds.

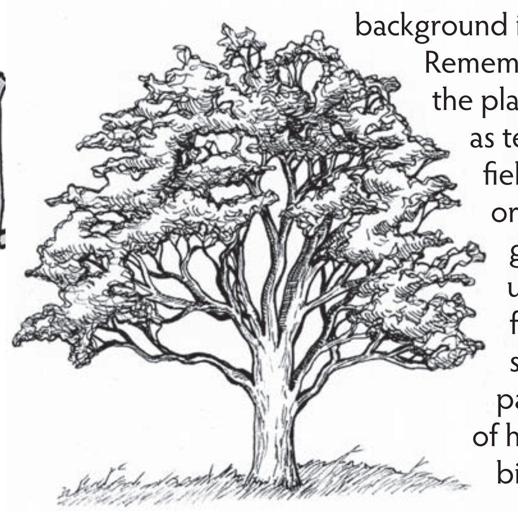
Background Information

In this activity, you will design a field guide to the plants (and more if you like!) on your school grounds or a natural area in your community. A field guide will be an excellent asset to your community and will provide other visitors to the area with important natural history and botanical information. Your teacher may ask that you engage in additional community service opportunities, such as using your field guide as a tool to lead groups on tours, or giving presentations to groups to promote use of the area.

The previous activity, "Mechanics of a Key," gives you the groundwork for constructing a dichotomous key, which will be necessary to include for people to be able to use your field guide.

To ensure the success of your dichotomous key, each question can only have two possible answers. Your key will not function properly if there are more than two answers per question. Read the following pair of statements and find the problem: "Plant is less than 30 cm tall." OR "Plant is more than 30 cm tall." In which category would a plant that is exactly 30 cm tall be placed? This statement needs to be reworded to read: "Plant is less than or equal to 30 cm tall OR plant is more than 30 cm tall." Now there are only two possible options.

The Create-A-Plant activity will give you an idea of the type of information that should be included in a field guide. Review the background information for this activity. Remember to use the other skills from the plant identification section (such as terminology). Each page in your field guide should include a photo or drawing (or both) that shows the general look of the plant with close-ups for distinguishing features. The following information about the species should be included in your page (in parentheses is an example of how this information might look for bigleaf maple (*Acer macrophyllum*).



Make a Field Guide for Your School

Background Information, continued

- **General description:** including height and other general characteristics (large tree, often multi-stemmed, up to 35 m tall; young bark green and smooth, older bark grey brown and ridges, often covered in mosses lichens, and ferns)
- **Leaves:** arrangement, color, size (opposite, deciduous, 5 lobed maple leaves, 15-30 cm across, dark green above, paler below, leaf stalk exudes milky juice when cut)
- **Flowers:** color, number of petals, symmetry, size, arrangement, time of emergence (greenish-yellow, about 3 mm across; numerous on short stalks in a hanging cylindrical cluster; appears with or before the leaves)
- **Fruits:** color, size, description, mode of dispersal (golden-brown, paired winged samaras 3-6 cm long; wings spread in a v-shape)
- **Ecology:** where it lives; with what other species; specific soil types or habitats if relevant (dry to moist sites, often with Douglas-fir, often on sites disturbed by logging; low to middle elevations)
- **Enthonobotany:** how American Indian tribes or other people use this species (First Nations people used bigleaf maple to make canoe paddles, used to treat sore throats, leaves rubbed on a man's face at puberty to prevent thick hair growth, sprouted seeds eaten by some tribes, sap can be used to make a weak syrup)
- **Notes: wildlife habitat or uses, other cool facts:** (bigleaf maple carries a greater load of mosses than any other species in our region, stumps sprout vigorously following fire)

Directions

Part 1: Divide into teams of 4 or fewer.

1 Each team should first select individuals of different plant species from a small area. To make this project more challenging, choose plant species that share more obvious similarities. Place a flag next to each one and number consecutively with a permanent marker. Choose plants with flowers or fruit if they are available. Try to choose plants that are fairly close together for ease of comparison. Carefully examine each of your plants.

2 Devise the first pair of statements for your key. Remember:

- Begin with statements that are broad and general and apply to all of your individuals. For example: "Plants have woody stems" OR "Plants are herbaceous, or non-woody." All paired statements should have only two possibilities. Be sure that none of your options are subjective or relative. For example, you cannot ask if a plant is tall or short. You must give specific measurements.
- Be careful with statements that can vary greatly from one individual plant to the next (such as colors or measurements). In this case, be sure to observe several plants of the same species before deciding to include these in your key.

3 Continue working through your key in this manner until your key directs the user to each individual plant through the series of statements.

4 Fill in your blank key handout when you are confident that the questions you have chosen will lead the reader to the individual plants.

5 When finished, exchange the test keys with another group and try to work through their key, filling in the number of the plants for the answer. When you are done, look at the answer key. How did you do? What parts of their key work well and are clear? What parts are confusing? How would you improve their key?

Part 2:

Make a field guide for a natural area of your schoolyard.

1 Do a complete survey of the plant species in the area you will be describing. Note the habitat and specific locations where each is growing. Record vital information

Make a Field Guide for Your School

Directions, continued

for each of the plants that are in your key on the identification handout. Describe the plants as completely as possible, using correct plant terminology. Include a sketch or photograph the species.

2. Use a published plant field guide to identify your species. If you are unable to make a positive identification, collect a specimen to press (ONLY collect if you have permission) and check with local experts who can help you identify them (check appendix I of this guide for a list).

3. In the classroom, use the internet and other field guides to collect research about your species. Collect additional information on bloom times, flowers, fruits, and the scientific name. Be sure to find out to which plant family your species belongs.

4. Assemble your information together in the form of field guide pages for your species. The first page of your guide should be a dichotomous key to all of the species. Devote a half or whole page of your field guide to each plant. Include a description, drawing or photograph, the common and scientific names, and anything else interesting that you discovered in your research. Use published plant field guides as examples for the type of information that is important to include.

Taking It Further

- Design a brochure or booklet for a natural area at or near your school.
- Use a computer program to design the brochure to advance your technological design skills. Include a simple map, a key for identifying the plants, descriptions, photos, and the common and scientific names for all the plants in the key. If available, include some site history information in your brochure as well. Make your brochure available for others to use by putting up a display at the front of the school, sharing with other classrooms, or giving a presentation to a teacher staff meeting, parent or community group. Better yet, create a kiosk at the natural area and have your brochure available for curious visitors.
- Work with an Elementary School to make a field guide to schoolyard plants. Design a simple key that uses only pictures or drawings. Teach a group of younger students to use it.

Self Assessments

1. Does your key use proper botanical terminology?
2. Is your field guide usable by someone who has never been to the area you are describing?
3. Is your field guide usable by someone who is unfamiliar with how to identify plants or the other species you may have included?
4. Check your paired statements to make sure that they have only two possibilities.
5. Test your key to see if you can easily follow it to the proper plant.

Resources

- Field guides (see appendix I for recommendations)
- A simple, interactive dichotomous key to Oregon trees: http://oregonstate.edu/trees/dichotomous_key.html
- USDA/NRCS PLANTS Database home page for additional plant research: http://plants.usda.gov/

Make a Field Guide for Your School

In the Field!

Volunteer to make a brochure or field guide to be used in a city or county park.

- Have a staff person accompany you on your visit to help define the area for your field guide and to help with identification. Go to the site and choose a short interpretive walk for the field guide. Choose the plants that you would like to include in your field guide. Divide into groups with each group managing a part of the field guide. Different groups can be in charge of making a simple map with identification stops, constructing a key, taking photographs, and writing the descriptions.
- Return to the classroom and use a computer to make a brochure for the park. The brochure should have the name of the park and credit the class as creators of the brochure (example: created by Any School, 8th period biology students, 2008). Ask an expert to review your brochure for accuracy and your teacher to proofread for errors. Print a copy of the brochure and also save it to a CD. Present the park with the finished work for their use.

Science Inquiry

Use your inquiring mind. Design a different way of sorting or classifying plants to identify them. Some field guides divide plants by growth form or flower color or plant family. What other ways can you come up with? No classification system is perfect. What are the advantages and disadvantages of the system you chose?

Reflection

Like most skills, plant identification improves with practice. Do you feel that you have the tools you need to identify plants? Write the steps that you would use to indentify a plant with which you are unfamiliar. Make a list of skills you need to practice or improve on to make plant identification easier for you. This can be called your plan of study for plant identification. Could this planning process help you learn another skill or help with a different subject at school?

Write in your journal. What do you gain by learning the names of plants? Can you connect with and appreciate the plants without learning their names? What are some of the other ways that you can experience plants other than by identifying them? What type of information is gained by learning the name? How else can you get information about plants aside from identifying them?

TEACHER page

Make Your Own Plant Collection

Are we happy to suppose that our grandchildren may never be able to see an elephant except in a picture book?

—Sir David Attenborough (1926-present)

Time Estimate:

1 field session, 1 class session; can be structured as an ongoing project

Best Season: Spring, Summer, Fall

Overview

Construct or purchase a plant press, collect native plants, and create an herbarium for your school. Students learn the skills by assembling a plant press and making their own herbarium specimens. They will learn proper techniques for collecting, pressing, labeling, mounting, and storing plant material. Students will practice their botanical terminology and plant identification skills

Preparation

- Introduce this lesson by discussing what botanists and students can learn from pressed plant specimens. Make sure to cover:
  - allows for observation of plants at different stages of their life cycle (i.e. vegetative, flowering, fruiting)
  - can be used as reference in identify plants
  - provides an official record of plant species found in an area

Teacher Hints

- Have students practice plant collection techniques using weedy species. Then move on to creating a native plant herbarium collection once proficient at collecting and mounting.
- Alternatives to making the cardboard presses in the lesson include: purchase a plant press, make your own from plywood boards, or even use old telephone books with additional weight to press the plants flat.
- For the classroom herbarium purchase or construct a high quality press (search online for "herbarium supplies") and use archival paper for mounting the specimens. Store the mounted specimens lying flat in large boxes or metal cabinets for long life. Monitor periodically for insect damage.

Additional Information

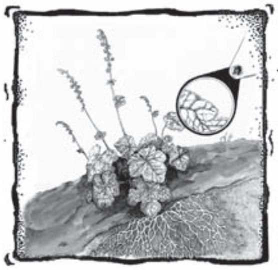
- Oregon Natural Resource Heritage Information Center (ORNHIC): Rare, Threatened, and Endangered Species of Oregon: http://oregonstate.edu/ornhic/publications.html#2007tebook
- ORNHIC: online Rare Plant Basin search divided by watershed basins: http://oregonstate.edu/ornhic/plants/searchspecies_basin.html
- Oregon Flora online mapping of historical herbarium collections: http://www.oregonflora.org/

Assessments

1 Produce 4 herbarium specimens using correct procedures for collecting, pressing, mounting, and labeling each specimen.

2 Record complete field note information when collecting: date, location, plant description, and habitat notes.

3 Label the specimen with common and scientific name using proper form and demonstrate correct use of botanical terminology.



Make Your Own Plant Collection

Are we happy to suppose that our grandchildren may never be able to see an elephant except in a picture book?

—Sir David Attenborough (1926-present)

Learning Objectives

- Learn and demonstrate proper techniques to collect, dry, and preserve, and catalog plant specimens
- Start or contribute to a classroom herbarium with a usable system of organization
- Use botanical terminology as well as common and Latin names to correctly describe a plant specimen (review)
- Practice plant identification skills (review)

Materials Needed

- newspaper
- mounting paper—heavy cardstock for individual specimens; archival paper for class herbarium
- Elmer's glue
- water (to thin out glue)
- small paint brushes
- 5-6 cardboard pieces per student (8 1/2 x 11 inches)
- acid-free resume paper (for labels)
- large rubber bands or webbing straps
- plant pruner for collecting
- shovel or trowel

Vocabulary Words

- herbarium
- herbaria

Overview

Through this activity, you will learn the botanical skills needed to record and preserve plant specimens by creating an herbarium. You will assemble a plant press and make a personal herbarium of local weed species. In doing so, you will learn the proper technique for collecting, pressing, labeling, mounting, and storage of your collection. This will also give you an opportunity to practice using your plant identification skills. Participate in making a classroom herbarium by creating or adding to a collection of native plant specimens for your school.

Background Information

An herbarium is a library of dried, pressed plant specimens that are identified, labeled, and catalogued for posterity. Herbarium specimens can be used for many purposes. Accurate identification of a freshly collected plant can be made by comparison with an herbarium specimen. Herbaria are used by scientists in their studies of plant form, to compare range and measurements, and to help in the construction of guidebooks. More recently, specimens are used in DNA analysis to study plant relationships.

Each specimen in the herbarium is labeled with the name of the plant, the person collecting, date collected, and location of collection. Often the label will include additional helpful information like the plant community the specimen was found in, soil type, pollinators or known uses. Herbarium specimens are treated with the utmost care so that they will survive and be available for study for hundreds of years. These specimens are the historic record of plants, where and when they have grown. Additional applications for the study of herbaria specimens include how climate change has affected plants. For example, specimens can document the range of species, demonstrate change in characteristics over time and across habitats, track the spread of non-native weeds, and confirm the former ranges of now rare plant species.

Herbaria are located around the world and are often housed at museums, botanical gardens, or universities. Many modern day herbaria are available online for access worldwide. The largest herbarium collection in the world is found at the Museum National d'Histoire Naturelle in Paris, France with over 8 million specimens(1). In the United States, The Academy of Natural Sciences in Philadelphia, Pennsylvania houses a very famous herbarium collection from the Lewis and Clark Expedition 1804-1806. This collection is documented so that it can be cross referenced to the dates and locations found in the diary entries of the Expedition.The Museum houses 226 specimens from the Expedition, which are still in amazing condition more than 200 years later (2).

Make Your Own Plant Collection

Background Information, continued

Oregon has several herbaria housed at universities around the state. Oregon State University houses the state's largest with approximately 405,000 specimens. Their focus is on plants of the Pacific Northwest and has 148,000 vascular plant specimen records available online (3).

Herbaria are made up of plant specimens that are dried and pressed so as to highlight features that enhance identification. A specimen will include all parts of a plant, including roots, flowers, and fruit, if possible. The collected plant is carefully positioned on blotter paper, labeled, sandwiched between layers of cardboard, and tightly squeezed within the plant press until dried. Plant collectors will document the location, date, and all other pertinent information in a field book. Once the plant is completely dry, it is mounted on archival quality paper with a detailed label. Herbaria sheets are collected into folders by species and folders are filed alphabetically by family, genus, and specific epithet. The folders are stored lying flat, usually in metal cases or cabinets in climate controlled rooms to help preserve them (4).

Herbaria can be very useful for figuring out where extinct or very rare species previously existed. Written records on specimen labels indicate location and habitat information that can be used by conservation biologists to decide where to relocate species that they are reintroducing. For example, golden paintbrush (*Castilleja levisecta*) is a species that is extinct in Oregon but remains in Washington and British Columbia. By looking through the herbarium records, scientists were able to figure out that large populations of this species once existed in upland prairies throughout the Willamette Valley with many in the Salem area (5).

One more important aspect for consideration in the development of an herbarium is your plant collection ethic. Below is a list of ethics that can guide you. Look them over and discuss them as a class. Should they be expanded? Why or why not?

Ethics of Collecting Guidelines:

- Tread lightly—what does that mean to you?
- Don't take any plants that you will not be pressing.
- Take care not to spread seeds of invasive plants.
- Know your region's rare and endangered plants. If you are lucky enough to find them, take only pictures of these.
- Do not collect a plant if you do not see at least 10 others of that kind in your location. Why is this important?
- Be aware that you may be harmed by your interaction with some plants. Take necessary precautions and watch for plants that can sting, have thorns, or give you rashes.
- Learn the process of collecting, pressing and mounting a plant collection by using readily available local weeds to start. Although pressing plants sounds fairly straightforward it takes attention to detail and careful handling to do it well. Practice the techniques and then move on to developing a school herbarium project.

Make Your Own Plant Collection

Directions

1. Assemble a personal plant press. You will need 5-6 pieces of heavy cardboard, several sections of newspaper, and 4 long, heavy rubber bands. Cut the cardboard pieces the size of a folded newspaper.Use newspaper as your blotter paper to position your plant specimen, plus use additional layers of newspaper between each specimen to help absorb moisture. Use an 81/2 x 11 sheet of paper as a size guide; your finished specimen will be mounted on this size paper.
2. Make a weed collection from your home, roadside or vacant lot (follow the steps below). Collect 4-5 different weed specimens. Do not collect from parks, natural areas, or personal property without the owner's consent. BE RESPONSIBLE; do not spread weeds. Be sure to contain any seeds that may fall off your collections and dispose of extra weedy materials that you bring back to the classroom in the trash.
3. To collect your first plant: carefully dig up a weed. Try to collect a plant that is average size and vigor of nearby plants. This will make a better example of the species than a plant that is the smallest that you can find. Gently crumble the dirt from the roots of the plant.
4. Arrange the plant on the inside of a folded newspaper. Once the plant is dried, you will not be able to move parts around without breaking it. You must be careful to arrange the plant to properly show its leaves, roots, flowers and/or fruits. Lay a leaf out flat so that you can see the shape and show the arrangement along the stem. Include flowers, if possible (flat open and profile) and fruits (be careful to not spread weed seed). Include the roots if you can; crumble the excess dirt off before putting in the press. If your plant is too tall to fit on the newspaper, you will need to bend the stem into a zigzag to make it fit. Another mounting method if your plant is too large for one sheet of paper is to cut the plant and position it on more than one sheet. Number the sheets so that they can be reassembled in the proper order. Try to minimize overlapping plant parts; it can lead to moldy plant parts and makes them hard to see once they are dry.
5. Label each specimen with a number directly on the newspaper and a corresponding numbered entry in your field journal. Include the name of the plant if you know it, the location, date, your name, and any additional information that you can. Additional information may include the names of other plants growing nearby, the type of ecosystem (forest, field, wetland), whether it was growing in the sun or shade, pollinators observed, or notes about the soil.
6. If for some reason you cannot put your plant in the press right away, seal it in a plastic bag and keep it out of direct sunlight until you can place it in the press. Try not to squish it or break any of the branches.
7. Assemble specimens in your press like layers of a sandwich. The cardboard is the bread; add a few layers of newspaper, then your specimen, another couple layers of newspaper, a piece of cardboard for strength, and repeat until the press is full. Finish with a final cardboard piece and bind with 4 large rubber bands in a window pane pattern.
8. Take your press home. Lay it on a flat, dry surface in a warm location to dry (a sunny window, the top of the refrigerator, a furnace room, or a car with the windows rolled up will suffice). Add additional weights (books) to help squeeze the moisture out of the plants. For best results, change the newspapers between the plants on the second day. If you have a very succulent plant, change them every day for the first couple of days.
9. Leave the plants in the press until completely dry. This can range from a couple of days to a couple of weeks, depending on the thickness of the plant material and the air temperature and humidity.
10. Mount the specimen once it is completely dry. Use heavy cardstock paper for display. Carefully remove the specimen from the newspaper by the stem. It might be helpful to use forceps when working with delicate plant material. Arrange the dried plant on the paper and adhere with drops of white glue at multiple points along the stem and the outer leaves. For heavy plants, glue strips of paper over them to hold at key points. Set aside and let the glue dry before handling.
11. Design a label to go on your specimens. Be sure it includes the plant name, date, your name, where it was collected, and any special notes. Glue a label to the bottom right corner of the paper on which you mounted your specimen.
12. Write a habitat description that goes with your pressed plant. Include a general description of the form and identifying features of your species. Specimens will fade with age so be sure to include notes in the description on the flower and leaf color.
13. Contact a plant expert (examples: OSU Extension Service Master Gardeners, local nursery people, local Forest Service or BLM botanist, Native Plant Society) if you are having difficulty identifying your specimen.
14. Visit one of the online herbaria listed in the Resource section to see an example of a mounted plant specimen and label.

Make Your Own Plant Collection

In the Field!

Visit a real herbarium! If you are near a local university or botanical garden, take a field trip and check out their herbarium. Ask to see some specimens from the 1800s and compare them to some more recent specimens of the same species. Are there any noticeable differences?

Create an herbarium for your school. Give the herbarium a theme that can be expanded or added to from year to year (examples: plants on the school grounds, a natural area that the class visits regularly, or a broad ecoregion collection). Offer tours of your herbarium to other science classes or to younger grades in your school.

Be careful not collect too many samples of a single species. Work to fill gaps in the herbarium collection if it is already an ongoing project.

Reread the Ethics of Collecting Guidelines in the Background section before going out to collect.

Every ecoregion in Oregon has plants that are rare or endangered. Learn which ones are in the area from which you will be collecting so that you can avoid collecting them. Over-collection is one of the causes of decline for several rare plant species. Instead take a digital camera and make a visual record of the plant if you are lucky enough to see one. Get an overall photo of the plant, a wider photo showing the habitat, and multiple close-ups of leaves, stems, flowers, and fruit. Mount the photos and include the page in your herbarium.

Science Inquiry

Use an herbarium specimen to form a hypothesis about who pollinates the perennial wildflower common camas. First, research what is already known about the subject. In this case, look at the *Camassia quamash* (Pursh) Greene , web link from the OSU Herbarium (http://oregonstate.edu/dept/botany/herbarium/db.php). To find this genus and species, you will need to know that camas belongs to the lily family (Liliaceae). Now follow the link to the records by family, then genus (*Camassia*) and to species *Camassia quamash*. Take a close look at the digital specimen and read through the description. How might the information about bloom times help you form a hypothesis about camas pollinators? See the pollination activities in this curriculum if you need additional help. With what you now know, write a hypothesis and design a methodology for testing it.

Reflection

What are some of the things that you could learn by developing an herbarium at your school? What would be the benefits to your class? How would a class 10 years from now benefit from your work?

How can you be sure that you are not damaging a rare plant population? Is there a time that taking a rare plant specimen would be acceptable? Justify your reasoning. Can you add at least one additional rule to the Ethics of Collecting plants? What would it be?

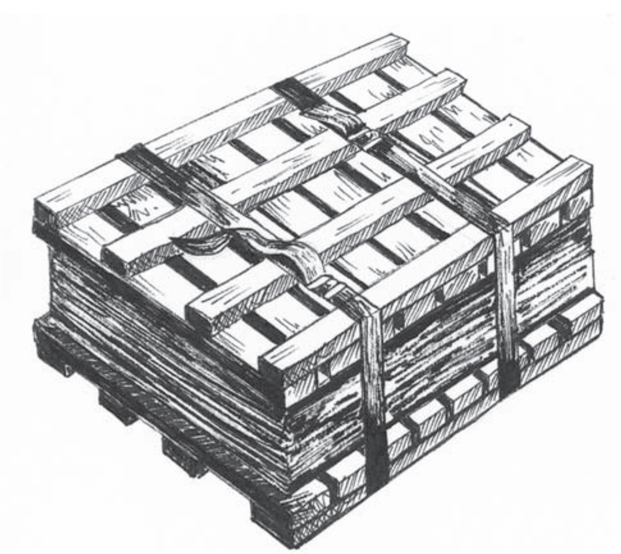
Make Your Own Plant Collection

Taking It Further

- Develop a filing system for the class herbarium. Specimens are commonly organized by family, genus, and specific epithet. Write an explanation of how your system works so that others can follow it.
- Organize a way to track additional records, such as a notebook with a page devoted to each species and a way to enter information about occurrences including the name of the observer, the date, and location. Be sure to make it easy for visitors to access the needed records.

Self Assessments

- Evaluate your pressed plant specimen. Are you happy with the way the pressing turned out? If not, review the procedures. Did you accurately follow them? If you are unhappy with your pressing, try it again, making sure that the plant has as little moisture in it as possible and that you have positioned it carefully.
- Design a label to go on your mounted pressing. Did you collect all the information that was needed to make a good label?
- Evaluate your written description. Did you use proper botanical terminology? This may be important if you need help from a botanist to identify your plant.



Resources

- Oregon State University Herbarium, housing 405,000 specimens and online access to digital records of 148,000 vascular plants. This is a worldwide collection with a focus on the Pacific Northwest: http://oregonstate.edu/dept/botany/herbarium/db.php
- Eastern Oregon University Herbarium, housing 9,500 specimens primarily from Union, Wallowa and Baker Counties. Online access to digital records was not completed at the time of this printing: http://ocid.nacse.org/research/easternoregon/
- Southern Oregon University Herbarium collection, specializing in the Siskiyou Mountains, the wider Klamath Mountain Ranges, the Central and Southern Cascades, and the high desert of central and southeastern Oregon: http://www.sou.edu/biology/herbarium/herbarium.htm
- U.S. Forest Service Herbarium, with 8,700 specimens from the Malheur, Umatilla, and Wallowa-Whitman National Forests of Northeastern Oregon; downloadable into a spreadsheet or database program: http://www.fs.fed.us/r6/w-w/resources/ecology/index.shtml#herbarium
- The New York Botanical Garden herbarium is the largest in the western hemisphere, with over a million and a half digital specimens available online: http://www.nybg.org/bsci/herb/

Create-a-Plant

Imagination is more important than knowledge. For while knowledge defines all we currently know and understand, imagination points to all we might yet discover and create.

—Albert Einstein (1879-1955)

Time Estimate:

45-60 minutes, additional time for detailed plant drawings

Best Season:

Any

Overview

In this lesson, students will demonstrate their accumulated knowledge and understanding of plant identification by creating a fictional plant species. Working from a checklist of possible traits, students will determine the physical characteristics, ecology, habitat, history, and uses of their newly invented species. Students will show their understanding of anatomy and habitat by creating a field guide page with a sketch of their plant and a written description, and will give their plant both a common and scientific name.

Teacher Hints

- Be sure that students have a basic foundation in plant terminology before using this lesson. The "Botanical Terminology Challenge" lesson provides a review or a means of learning this new vocabulary.
- Allow students to use glossary sheets from "Botanical Terminology Challenge" to increase and apply their vocabulary skills. You can also have students complete this lesson without reference materials for assessment purposes.

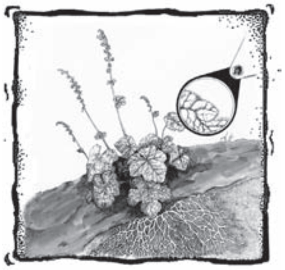
Preparation

- Have a field guide available for students to view. Point out features on the page such as the physical description of the plant, habitat, confusing species, and special characteristics and uses. Show the students photos, drawings, or diagrams of unique aspects of the species, measurements, plant descriptions, and habitat details.
- Information about scientific names can be found in the "What's In a Name?" lesson of this curriculum.
- This activity can be used as an assessment tool at the completion of the Plant Identification Section. Students apply their knowledge of botanical terms, scientific names, habitat, and life history characteristics. Students will make creative connections between the traits of their plant and how the traits help the plant adapt to the habitat they create for it.

Assessments

Students will submit their checklist and field guide page for grading. You may refer to the rubric at the end of the lesson to help you assess your students' work. Check for the following:

1. Does their plant sketch and description match the checklist options?
2. Is the written description complete, using proper botanical terms, and including metric measurements?
3. Did the student use proper format for writing scientific names?
4. Did the student put thought into relating plant anatomy/adaptations to their habitat choice, dispersal mechanism and pollinator?
5. Was the student creative in making a unique species?



Create-a-Plant

Imagination is more important than knowledge. For while knowledge defines all we currently know and understand, imagination points to all we might yet discover and create.

—Albert Einstein (1879-1955)

Overview

Demonstrate your understanding of botanical vocabulary and natural history by inventing a new plant species. You will choose the physical and ecological characteristics of your species from a checklist of traits and give it a common and scientific name. In the end, you will create a page with a detailed sketch of your new species and a written description to be used in a field guide.

Learning Objectives

- Demonstrate knowledge of botanical terminology
- Correlate plant characteristics (form) with adaptation to habitat and life history (function)
- Apply knowledge of scientific and common names
- Engage imagination to advance scientific and critical thinking processes
- Associate visual images with new vocabulary by labeling drawings to accentuate important plant identification characteristics

Materials Needed

- plant creation checklist
- drawing materials
- metric ruler
- blank field guide template
- various field guides to use as examples

Vocabulary Words

- All vocabulary from preceding lessons in the Plant Identification section apply here

Background Information

When you open a field guide, you may see that each species entry is frequently divided into sections. Each section contains information intended to help you indentify your species and understand its natural history. Each field guide is different, but many contain sections with general information, as well as specific information about the leaves, flowers, fruits, ecology, and any special notes that will aid in identification. Plants are an extremely diverse group of organisms; the information presented in field guides organizes this diversity and helps to distinguish one species from another.

This activity will give you a chance to showcase what you already know about plant anatomy and terminology and expand you knowledge. Use your creative side to design a fictional plant.

Remember that plants can appear as simple as a single tiny leaf, such as the pond-dwelling duckweed, or as complex as an elaborate orchid that grows in a tree canopy. Your plant can be large or small, woody or herbaceous. Does it have thorns or chemical defenses to keep it safe from predators? What makes your plant well suited to grow in the habitat you choose for it? Is the habitat dry, wet, hot, cold, or windy? Be sure to give it the adaptations it will need to survive there. When you make your field guide page, be sure to include all the details that someone will need to indentify your plant. Many field guides also contain ethnobotanical information regarding historical human uses of plants. Be sure to add this type of information for your created plant. For example, is your plant used for food, as a tool, or for medicinal purposes? In what other ways could plants be used?

Field guides include not only a written description, but also a photo or drawing. Draw your plant, illustrating the traits that you have chosen. Great artistic skills are not required, but remember that you will be assessed by how well your sketch and description reflects the choices you made on the checklist. Have fun and be creative!

Create-a-Plant

Directions

1 Work through your plant creation checklist. Choose one option from each group to define the characteristics of your plant including leaf shape, leaf arrangement, flower type, flower shape, flower color, fruit type, plant size, habitat, seed dispersal, pollination, and ethnobotanical uses. The list will guide the design of your fictional plant. If you come across an option that you do not understand, consult your terminology glossary, check a field guide or dictionary, or review earlier activities in this book.

2 Begin by choosing a habitat for your plant. Would you find it in the desert, forest, prairie, wetland or? Take a minute to think about what life is like in your chosen habitat; is it dry, wet, shady, sunny, hot, cold, or somewhere in between? Think about your habitat as you work through the checklist; what plant traits do you think would be most successful in your chosen habitat? For example: large flat leaves may lose excess moisture to evaporation and are not well suited to an arid habitat such as a desert but work well in a shady forest understory.

3 When you have completed your checklist, design your field guide page. Use a piece of scrap paper to experiment with design options. When you are comfortable that your drawing shows your checked options, draw it in the box provided. Fill in the smaller boxes with close-up detail of your leaf, flower, and fruit. If you feel that it is important, you can draw your plants' roots as well. Be sure your drawings clearly match your choices on the checklist (earn extra credit if you use color and attempt to show shading).

4 Looking at your plant sketch, follow prompts on the plant creation checklist and write a description for your field guide page. Start with a general description of the plant and progress to the details such as leaf shape, leaf margin, and so forth through the page. Use botanically correct terminology for your descriptions.

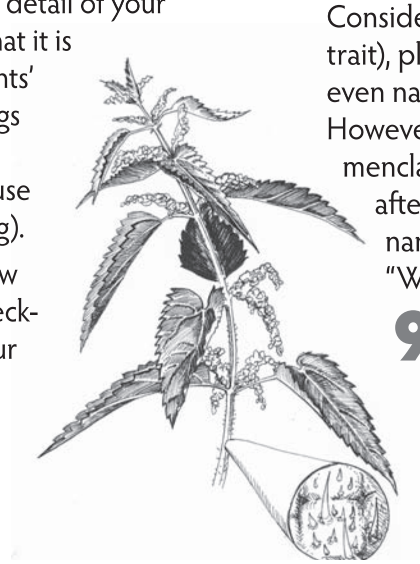
5 A field guide will always include measurements to help in identification. Metric measurements are generally preferred in science. Measurements of greater than 1 meter (m) should be expressed as meters, while those less than 1 meter should be expressed as centimeters (cm), and you might even want to use millimeters (mm) for very small details. Include measurements for your overall plant size, and for individual details. You may show measurements by including a scale bar in your sketch or by including the information in your written descriptions.

6 Write a description of your fictional plant's habitat. Consider light, moisture, elevation, and associated vegetation.

7 Create adaptations in your plant that relate to the habitat type that you picked on your checklist. For example, in a desert, a plant may have small, shiny leaves to minimize evapotranspiration. Explain the adaptation and how it benefits your plant.

8 Give your plant a scientific and common name. As the first person to discover and document your plant, you have the honor of naming it. Consider using a descriptive name (after a plant trait), place name (a specific region found in) or even name it after a friend or local public figure. However, it is against the rules of Botanical Nomenclature (naming plants) to name a species after yourself. Show correct form for writing names. If you need a review, look at the "What's In a Name?" activity.

9 Show off your new species and completed field guide page!



Create-a-Plant

Taking It Further

- Assemble all of the field guide pages for your class into one field guide. Create a dichotomous key to the plants in your field guide. You might even choose to assemble them into fictional plant families, as a class.

In the Field!

This activity is best followed up in the field by making a field guide to a local natural area or your schoolyard (see Make a Field Guide for Your School activity).

Reflection

Tell the story of the discovery of your plant. Where were you when you first found the plant, what were the surroundings, why did you notice this plant? Because you are the first scientist to discover and document this plant, you have the honor of giving it a name. Describe your thought process in assigning a name and what is the meaning of the name? Feel free to write in modern language or put yourself in the shoes of the explorers and pioneers and write as if you were one of them.

Self Assessments

1. Submit checklist and field guide page for assessment.
2. Do the checklist, sketches and description show that you have an understanding of the plant terms used?
3. Is the written description complete, using proper botanical terms, metric measurements, and a scientific name written in the correct format?
4. Did you relate your plant's anatomy to adaptations to its habitat?

Resources

- Pojar and MacKinnon. 1994. *Plants of the Pacific Northwest Coast*. Lone Tree Publishing, Vancouver, Canada, (or other field guides appropriate for your region).
- Harris and Harris. 2001. *Plant Identification Terminology: An Illustrated Glossary*. Spring Lake Publishing, Spring Lake, UT.

Create a Plant

Create-A-Plant Rubric

	Novice Botanist (1)	Apprentice Botanist (2)	Practicing Botanist (3)	Expert Botanist (4)
Plant sketches	Student makes sketches of plant. Sketches contain 3 or more differences from student's checklist.	Student sketch is accurate but limited. Missing some detail but generally following the student's checklist.	Student sketch shows details of leaf attachment, margin, and flower type. The sketch is accurate and complete.	Sketch shows details of leaf attachment, margin, and flower type. Sketch is accurate and complete, shows extra effort in detail, attempts at shading, and uses color.
Plant description	Basic plant description. Uses only terms from "Basic" vocabulary list, has misspellings, omits 2 or more traits from the checklist.	Description is complete covering traits from checklist. Uses 1-3 vocabulary words from the "Expert" list, omits no more than 1 traits from the checklist.	Description is complete and accurate using proper botanical terminology, "Expert" list words where appropriate. All traits from the checklist are included.	Description is complete and accurate, using proper botanical terminology with at least one word from the "Botanist" list, correct spelling. All traits from the checklist are included.
Habitat Connection	Student makes no attempt to show habitat connection in Habitat Clues box.	Student has basic habitat information in Habitat Clues box. Connection to plant trait is not present.	Student answer shows thought process but connection to plant trait not explained.	Student answer shows thought process connecting at least one plant trait to the habitat it lives in well explained.
Scientific Name	Student gives plant one word scientific name not following correct format.	Student gives plant two word scientific name (genus/species) but does not write in correct format.	Student gives plant two word (genus/species) scientific name in correct format.	Scientific name is written in correct format, has a genus and species, and attempted to sound like a Latin term.
Measurements	Student makes reference to measurements, but does not use the metric system. Measurements not well documented in sketch or description.	Student includes metric measurements. Does not follow rules in lesson. Measurements not well documented in sketch or description.	Student includes metric measurements, follows rules in lesson, but does not complete documentation.	Student includes metric measurements that follow rules in lesson, either documenting with a scale in the sketch or referenced in the description.

Create-a-Plant

Plant Creation Checklist

Habitat type (where does your plant live)

- ◇ wetland
- ◇ prairie/grassland
- ◇ forest
- ◇ desert/arid lands
- ◇ alpine peak
- ◇ other _______________

Habitat Clues — adaptations your plant exhibits that make it suited here

Stem

- ◇ single
- ◇ multiple

Leaf Attachment to Stem

- ◇ petiole 
- ◇ sessile 

Leaf Arrangement

- ◇ alternate 
- ◇ opposite 
- ◇ wholed 
- ◇ basal 

Leaf Margin

- ◇ entire
- ◇ serrate
- ◇ lobed
- ◇ other _________________

Leaf Shape

- ◇ cordate
- ◇ ovate
- ◇ lanceolate
- ◇ palmate
- ◇ other ___________________

Leaf Division

- ◇ simple
- ◇ compound (palmate/pinnate)

How does your plant protect itself from predation?

Pollinator (refer to Secret Life… lesson, or learn more in the Native Plant Ecology section)

- ◇ bee
- ◇ butterfly
- ◇ beetle
- ◇ wind
- ◇ bird
- ◇ moth
- ◇ bat
- ◇ other _______________

Create-a-Plant

Plant Creation Checklist

Inflorescence Type

◇ composite  ◇ umbrel 

◇ raceme  ◇ spike 

◇ panicle  ◇ solitary 

Flower

◇ perfect flower ◇ imperfect flower

number of petals ___________________

number of stamens ___________________

Seed Disposal Method (refer to Drupes… lesson)

◇ mechanical/throw ◇ animal - edible

◇ wind/blow or shake ◇ water/float

◇ animal - hitchhike ◇ animal - cache

◇ other _______________

Fruit Type (illustrate)

◇ drupe  ◇ pome 

◇ samara  ◇ nut 

◇ legume  ◇ berry 

◇ other ___________________

Ethnobotanical Use (historical human use)

◇ food ◇ medicinal

◇ fiber ◇ tools

◇ other ___________________

Author _______________________________________

Create-a-Plant

Field Guide Page

Plant Name

Habitat:

Description:

Leaves:

Inflorescence/Flower:

Fruit:

Ethnobotanical use:

Field Notes (include adaptations and defense):

Section 2: Ecoregions of Oregon

TEACHER page

Exploring Oregon's Ecoregions

There is an eternal landscape, a geography of the soul; we search for its outlines all our lives.

— Josephine Hart (Contemporary)

Time Estimate:

1–2 Class sessions

Best Season:

Winter

Overview

Students gain an understanding of the concept of ecoregions. Ecoregions are contiguous geographic areas with similar climate and ecological features. Students investigate Oregon's eights ecoregions by gathering historical climate data, relating it to geography, and using inquiry skills to identify differences in vegetation from one ecoregion to another. Through this process students discover the vast diversity of plant life in their home state.

Additonal Information

View the ecoregion field trip appendix VII.

- Alt, David D. and Donald W Hyndman. 1978. *Roadside Geology of Oregon.* Mountain Press Publishing, Missoula MT
- Bishop, Ellen Morris. 2003. *In Search of Ancient Oregon A Geological and Natural History.* Timber Press, Portland, OR
- Oregon Department of Geology trip guides for the entire state: http://www.oregongeology.com/sub/pub&data/GeoTripGuides.htm
- Contour and Cross Section Skills exercise. Jacaranda Project: https://yr11geography.wikispaces.com/file/view/contour-skills.pdf

  John Wiley & Sons Australia, LTD. 2004. www.jaconline.com.au

Teacher Hints

- This is a two part activity and each section has associated discussion questions provided. These questions are designed to stimulate thought for the subsequent ecoregion lessons.
- Have students practice making and testing hypotheses by having them complete the Science Inquiry section of this lesson after Part 1 of the activity.
- Combine this activity with a study of the geology of Oregon to help students connect Oregon's landforms with the geologic activity that produces them.

Preparation

- Review the Student Resources section to become familiar with the tools and information students will be using.
- If you are not familiar with interpreting maps, check out the additional references for making a cross sectional map before teaching this concept to your students.
- For Part 2 of the activity, have students work individually or divide the class into eight groups. If working in groups, each group can gather data for one ecoregion to share with the entire class.

Assessments

1. Discuss the factors that define an ecoregion.
2. Name and locate the eight ecoregions of Oregon.
3. Explain the connection between geography and climate.

Explore Oregon's Ecoregions

There is an eternal landscape, a geography of the soul; we search for its outlines all our lives.
— Josephine Hart (Contemporary)

Overview

Ecoregions are contiguous areas of similar climate and ecological features. In this lesson you will compare and contrast Oregon's eight ecoregions by gathering historical climate data, relating it to geography, and using inquiry skills to identify differences in ecoregional vegetation. Through this process you will discover the amazing diversity of plant life in your botanically rich state of Oregon.

Learning Objectives

- Locate and name Oregon's eight ecoregions
- Use library and internet resources for research
- Describe and gain understanding about the connections between the geography, climate, and vegetation of Oregon's ecoregions
- Appreciate the variety of Oregon's diverse landscapes and the biodiversity it supports
- Use maps as a tool to gather and correlate information relating topography to climate

Materials Needed

- computer with internet access
- library reference materials
- Oregon topographic map
- Oregon outline map
- Oregon ecoregion map
- graph paper

Background Information

If you were to start at the Pacific Ocean and walk across Oregon, you might cross the coast dunes and make your way into the coastal Sitka spruce forests, ascending the coastal salmon spawning rivers into the Douglas-fir covered coast range, then back down into prairies and oak savannahs of the larger valleys (Willamette and Rogue), followed by a big climb into the Cascades, where you would be greeted by still-active volcanoes! As you descended down the east side through the park-like Ponderosa pine forests you would notice an ever-drying landscape which would eventually become sagebrush and juniper. Depending on where you are, you may run into some of the most amazing and productive wetlands in the west where you would find scores of migrating birds, following east into the dry shrubland of the Great Basin. As you move across the state, you might notice that as you cross different geographic boundaries, vegetation changes distinctly. As biologists, we need a way to identify these important changes so that we can study the flora and fauna and interact with our natural resources appropriately. We call these disparate areas *ecoregions*. An ecoregion is a contiguous geographic area with similar characteristics such as climate, soil, geology, topography, and vegetation. Ecoregions are part of larger defined areas, called biomes (1). Types of biomes include forest, desert, grassland, tundra, marine, and freshwater. The concept of dividing areas into ecoregions originated from the scientific view that similar geographic areas and their interacting functions and species create a whole that is greater than the sum of its parts. This has led to a fundamental change in natural resource management, moving away from managing for individual species and toward managing the watershed as a whole. The word

Exploring Oregon's Ecoregions

Background Information, continued

"ecoregion" is a term that you will encounter frequently in the world of ecology, land management, and in describing plant communities.

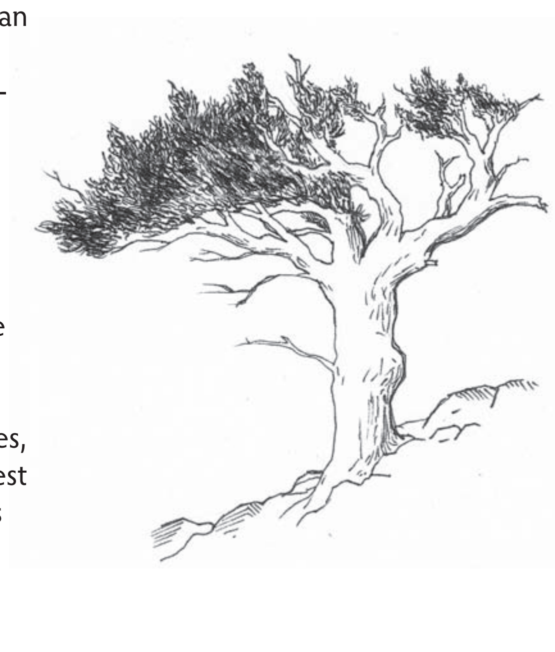
Oregon is one of the most ecologically diverse states in the United States. Western Oregon is marine-influenced by the Pacific Ocean and has high precipitation three seasons of the year. Eastern Oregon, however, is much drier due to a rain shadow effect from the Cascade Mountains. Mountainous areas disrupt the movement of air masses, which affect the movement of moisture and precipitation. When one side of a mountain range (the side closer to the ocean) consistently receives more precipitation than the other, the drier side is typically referred to as being in the rain shadow of that range. In Oregon the Cascade Mountains divide the moist western region from the drier east side of the state. Elevation is another way in which geography influences climate. It can determine the form precipitation takes, and also influences ground-level temperatures.

Federal agencies (specifically, the US Environmental Protection Agency, or EPA) divide Oregon into nine ecoregions, but most of Oregon's state agencies recognize only eight. We will be using eight ecoregions in this activity: Coast Range, Willamette Valley, Cascades, and Klamath Mountains on the west side; and Eastern Cascades slopes and foothills, Columbia Plateau, Blue Mountains, and Northern Basin and Range on the east side. The ninth ecoregion identified by Federal agencies is a small piece of the Snake River Plain (in Idaho) that projects into Oregon. This relatively small area is centered around the town of Ontario, Oregon. If you live in Ontario, you might chose to add the Snake River Plain ecoregion to your studies. Otherwise, for the purposes of this lesson, we have included this ecoregion with the Northern Basin and Range.

Ecoregions do not exist in isolation from each other, but interact and often blend into one another. For example, many roaming animals such as bears and elk, as well as migratory birds, move between ecoregions at different points in their life cycle. Sometimes the transition between one ecoregion and another is abrupt and obvious; for example, the division between the Cascades and Eastern Cascades ecoregions is the ridgeline that runs along the crest of the mountains. But the division between ecoregions is generally more gradual. Because Oregon's climate, geology and geography are so diverse, the state has many ecoregions for its size and, as a result, a great diversity of plants, animals, and other living things. For example, Colorado, which is slightly bigger than Oregon, has only six ecoregions compared to Oregon's eight. Our proximity to the ocean as well as our numerous mountain ranges help create Oregon's ecoregional diversity and corresponding biodiversity. Oregon is ranked fifth of all 50 states in the diversity of plant life, with 3,161 known plant species (2). Can you guess which other states have more plant species than us? (Look up the answer on the internet). This vast number does not include introduced

Vocabulary Words

- ecoregion
- biome
- plant diversity
- topography
- climate
- weather
- precipitation



Exploring Oregon's Ecoregions

Resources

- EPA maps and ecoregion descriptions: http://www.epa.gov/naaujydh/pages/ecoregions/or_eco.htm#Please%20note
- General overview of ecoregions: Native Seed Network Oregon ecoregion map http://www.nativeseednetwork.org/ecomap?state=OR
- Oregon Explorer website: http://www.oregonexplorer.info/index.aspx Click on "Learn about Places" (on left side bar) and then choose by Ecoregion
- Climate data from Oregon State University http://www.ocs.oregonstate.edu/index.html. Navigate by clicking on the Oregon map (right side of home page) for annual average rainfall data. Click on "Climate Data" (left bar) for data by zones. Click on link to Special Climate Report for a summary table of data for cities from all climate zones
- USDA climate data for Oregon http://www.or.nrcs.usda.gov/snow/climate/
- USDA soils information accessed by Oregon county http://www.or.nrcs.usda.gov/pnw_soil/or_data.html

Background Information, continued

landscape, agriculture, or invasive weed plants or the numerous subspecies that are found throughout the state.

In this activity you will take a virtual journey through Oregon's ecoregions. You will learn about the ecological variety that Oregon encompasses—from the mild marine west to the high deserts in the southeast and all the beautiful places in between.

Directions—Part 1

1. Take a virtual journey through Oregon. Begin by marking your location on the outline map. Try to be as accurate as possible (use a road map if you need help). With a ruler draw a latitudinal line that bisects your town or community. Imagine that you can slice into the earth's crust along that line.
2. Use what you already know about Oregon's geography (from travels or study) to draw a profile or the cross section of this line on a piece of graph paper. (Hint: This will show mountains, river valleys and ground elevations. It is generally easiest to start on the west coast at sea level and work east). Label and locate the western and eastern border of the state.
3. Once you have finished your cross section, find a partner and compare your profile drawings. Discuss how they are they similar or different. With your partner, compare your profiles to a topographic map of Oregon. Modify your drawings to illustrate what the topographic map shows, paying close attention to elevation changes.
4. Natural boundaries such as mountain ranges or changes in elevation can affect climate and often divide ecoregions. Use what you learned making your profile and looking at the topographic map to predict where Oregon's eight ecoregion boundaries fall. Use a pencil to lightly transfer your boundary predictions on to the outline map.
5. Now compare your predictions to the map of Oregon's ecoregions. Were you successful in predicting the locations of some of the boundaries? Add the correct ecoregion boundaries to your outline map over the top of your prediction lines. Label the ecoregions.

Discuss the following:

- Can you correlate geographic characteristics and the ecoregion boundaries?
- How might geographic factors such as landforms and elevation affect ecoregions?
- How might features such as mountain ranges and different elevations affect the climate?

Exploring Oregon's Ecoregions

Directions—Part 1, continued

- Why are ecoregions important to distinguish? What implications could ecoregions have for ecological restoration?
- Name as many species as you can that need more than one ecoregion to complete their life cycle. Why do some species live out their life cycles across multiple ecoregions?

Complete the "Science Inquiry" section (next page) before moving on to part 2.

Part 2

Continue your virtual journey to each of the Oregon's eight ecoregions. Use the handout to collect data using library sources, atlases, and websites. You will need to find the following information about each ecoregion:

- Climate—Average high/low temperatures in January and July, annual precipitation amounts, amount of precipitation that falls as snow, and number of sunshine days
- Elevation range (high, low, and average)
- Overall topography—Write a general description of how the topography of the area you are studying was formed (e.g., volcanic deposits, flood sediments, etc.)

    1. For each of the eight ecoregions, write a short description of the general geography. Ask yourself, "What would I see if I were dropped in the middle of this ecoregion?"

1. Discussion:

- How would you define an ecoregion to someone who had never heard of them?
- Predict how topography influences the plant life of an ecoregion.
- Predict how climate affects the plants and wildlife that live in an ecoregion (e.g., high/low temperatures, poor/good soils, limited/abundant water, etc.).

Self Assessments

- Define an ecoregion and discuss some of the factors that distinguish one from another
- Name and locate the eight ecoregions of Oregon on an outline map
- Explain the connection between geography and climate

Taking it Further

- Assemble a timeline of the geologic history of your ecoregion and how it was formed. Consult the resources listed at the end of this lesson will get you started. Contact the Soil and Water Conservation District (SWCD) in your county for additional information on soils in your ecoregion. The SWCD is also an excellent source of information on how soils are formed.
- Use Google Earth (or a comparable online software) to visit your ecoregion. Locate your community and view vegetation and landforms. Choose a different ecoregion and compare what you see. Choose an ecoregion adjacent to yours and also one that is across the state from you to compare and contrast.

Exploring Oregon's Ecoregions

In the Field

Oregon has extremely diverse landscapes as you traverse from the coast, through the coast range, into the valley, over the Cascades, onto the high desert and across the wetlands and out into the great basin and the eastern mountains ranges. It is sometimes hard to imagine the differences without experiencing them. Take a fieldtrip to an ecoregion that is different from your own. If possible, travel to an ecoregion that has a very different climate than what you are familiar with. Explore the new ecoregion. What is different and what is similar to where you live? Describe the landscape, the weather, and the landforms. Do the plants and wildlife look different? Use one or more of the ecosystem or landscape lessons to learn about this new ecoregion and compare it to your home ecoregion.

Science Inquiry

- Make predictions before moving on to Part 2 of the activity. Use the discussion questions from Part 1 as a starting point by listing your predictions of how topography and geographic formations might affect the overall climate of each ecoregion. Don't forget to include your personal observations in your predictions. Ask yourself, "What is the weather like where I live?" and "What are the significant topographic features here?"
- Ask yourself, "Based on the landforms in my Ecoregion, and my position in the state, what climate might I expect for this area?" Form a hypothesis to answer your question. Your hypothesis should be based on known or researched information that can be tested. Take the information from the background (e.g., the description of a rain shadow) and add your own observations and previous knowledge. Make a written statement (hypothesis) about what you think the climate will be like in the ecoregion (e.g., its temperatures, and type and amount of precipitation).
  - Return to Part 2 of the activity to gather data to test your hypothesis.
  - The final step is to analyze the collected data. Does it support your hypothesis? Either way is okay, it is the scientific process that is important. If your data does not support your hypothesis, what did you learn?

Reflections

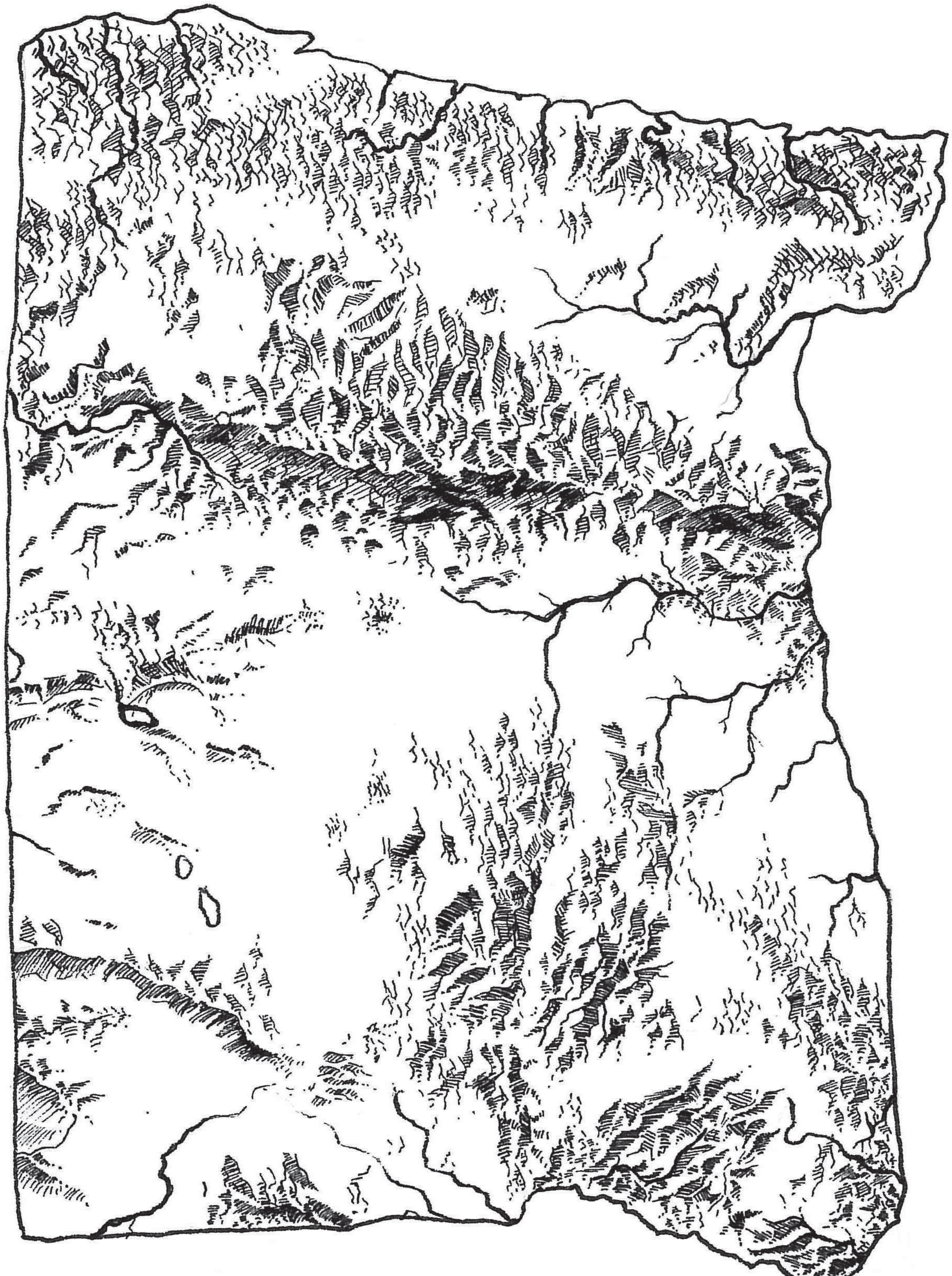
Take a real or virtual trip to an ecoregion in a state with which you are not familiar. Make a travel diary entry to describe what your visit is like. Imagine that you are out camping in a wilderness area (or do it for real!) and write an account of your day. What do you find there? What is the geography like? What season is it when you visit? What is the weather like? What does the landscape look like? What plants and wildlife do you see? What do you do while you are there? What do you hear, smell, or touch? Do you like where you are? How is it different from where you live? Add a picture, if you find it helpful.

Exploring Oregon's Ecoregions

	ECOREGIONS OF OREGON							
	COAST RANGE	WILLAMETTE VALLEY	CASCADES	EASTERN CASCADES SLOPES & FOOTHILLS	COLUMBIA PLATEAU	BLUE MOUNTAINS	KLAMATH MOUNTAINS	NORTH BASIN & RANGE
AVERAGE JANUARY TEMP.								
AVERAGE JULY TEMP.								
AVERAGE ANNUAL PRECIPITATION								
AMOUNT OF PRECIPITATION THAT FALLS AS SNOW								
ELEVATION RANGE								
NUMBER OF SUNSHINE DAYS								
DESCRIBE MAJOR GEOGRAPHIC FEATURES								

Exploring Oregon's Ecoregions

Oregon Topography



Exploring Oregon's Ecoregions

Oregon Ecoregions

The Place I Call Home

Life is like a landscape. You live in the midst of it but can describe it only from the vantage point of distance.
—Charles Lindbergh (1902-1974)

Time Estimate:

1 session
(30-45 min)

Best Season:

Winter

Additional Information

- Environmental Protection Agency ecoregion map for Oregon: http://www.epa.gov/naaujydh/pages/ecoregions/or_eco.htm#Please%20note
- Oregon Conservation Strategy (OCS), Oregon Department of Fish & Wildlife: http://www.dfw.state.or.us/conservationstrategy/
- Conservation Opportunity Area (COA) mapping tool on OCS website—lets you look at strategy habitat areas on a map for each of the ecoregions: http://nrimp.dfw.state.or.us/website/coaexplorer/viewer.htm
- Database of plant information: http://plants.usda.gov/
- For noxious weed profiles for Oregon invasive plants: http://www.oregon.gov/ODA/PLANT/WEEDS/statelist2.shtml
- A species mapping tool: http://www.oregonflora.org/

Overview

In this lesson, students will take an in-depth look at their home ecoregion. Exploring further what makes their ecoregion different from its neighbors and the rest of Oregon, students will discover the human influences, land use, and a few of the threatened and invasive species that reside there. Students will use the Oregon Conservation Strategy from the Oregon Department of Fish and Wildlife (ODFW), available online or in hard copy, to gather information needed in this lesson.

Teacher Hints

- The Oregon Conservation Strategy (OCS) website's interactive mapping tool, Conservation Opportunity Area Explorer, allows further study of ecoregions. Students can use this tool to locate conservation areas, waterways, elevations, roads and other map-able features listed by ecoregion.
- As an alternative you may chose to divide the class into 8 groups; each group studying one of Oregon's ecoregion. Information can be shared among groups by creating an Oregon ecoregion bulletin board. One possible format would be to hang an ecoregion map and have students display the information connected to that ecoregion with yarn and paper/photos, etc. Encourage students to use creative ways to display their information and include pictures of a typical landscape from their ecoregion.

Preparation

- Student teams will need access to the Oregon Conservation Strategy (OCS). The OCS is available from the Oregon Department of Fish & Wildlife at: http://www.dfw.state.or.us/conservationstrategy/. The entire strategy is available in PDF online for printing or hard copies can be located at many libraries or can be ordered from the ODFW.

Assessments

1. Name one or more rare plant species found in your ecoregion.
2. Name two or more invasive plant species that are a problem in your ecoregion.
3. Locate on a map one nature-based recreation area from your ecoregion and describe in general the ecosystems found there.
4. Describe the general land use categories for your ecoregion (visually or verbally).

The Place I Call Home

Life is like a landscape. You live in the midst of it but can describe it only from the vantage point of distance.
—Charles Lindbergh (1902-1974)

Overview

In this lesson, take an in-depth look at your home ecoregion. Explore what makes your ecoregion different from its neighbors; find out about human influences, land use, and a few of the rare and invasive species that reside there. Use the Oregon Conservation Strategy from the Oregon Department of Fish and Wildlife (ODFW), as well as an online mapping tool, to gather information.

Learning Objectives

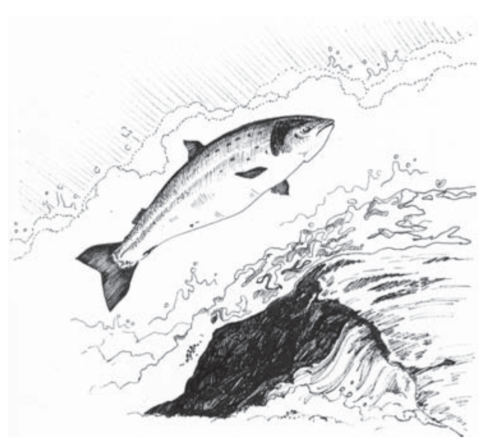
- Gain knowledge of the components of the ecoregion where you reside
- Gain awareness of nature-based recreation areas in your ecoregion
- Name and discuss two rare and two invasive plant species that are an issue in your ecoregion
- Understand the human impacts on the ecology of your ecoregion
- Develop skills to use technology such as online databases, mapping tools, and digital images to do research about your state

Materials Needed

- access to the Oregon Conservation Strategy, either online or with a hard copy of your ecoregion's section for each team
- optional: computer access for the interactive mapping tool

Background Information

What makes your ecoregion special? Whether you have lived in your ecoregion for a long or short time, it holds many surprises of which you might not be aware. As you will discover, each of Oregon's ecoregions has a diversity of geography, habitats, and species that make it unique. Is your ecoregion home to any endangered species? Are there any invasive species that threatened the health of the native ecosystems around you? Does your community grapple with conflict between human desires and native ecosystems? In addition to being home to a great diversity of ecosystems and species, each ecoregion faces the challenge of maintaining and preserving unique native ecosystems while providing habitat for the people that reside and recreate there. Gaining an awareness and understanding the conservation challenges in your ecoregion empower you to contribute to the stewardship of our state's natural beauty and resources.



The Oregon Conservation Strategy (OCS) is a publication from the Oregon Department of Fish and Wildlife, that presents the issues, opportunities, and recommended actions to help balance the needs of conservation and human development in Oregon. We will use the Oregon Conservation Strategy to learn the intricacies of your ecoregion. The foreword to the OCS states,

As a guide to conserving the species and habitats that have defined the nature of Oregon, this strategy can help ensure that Oregon's natural treasures are passed on to future generations.

Although the OCS covers the entire state of Oregon, it is further broken into separate sections for

The Place I Call Home

Vocabulary Words

- native
- invasive
- rare
- endangered
- species of concern

Background Information, continued

each of Oregon's eight ecoregions. The OCS has gathered a multitude of information for your research. The data is available through other resources as well, but the OCS gathers it in one convenient location. The ecoregion sections will give you a snapshot of life in each of Oregon's unique areas. For any of Oregon's ecoregions, it can help you:

- Learn about the plants and wildlife that are considered at risk or "strategy species"
- Find out which invasive species are threatening native ecosystems and species
- Learn about conservation actions that have been targeted for future conservation actions
- Discover the human influences that contribute to the uniqueness of your ecoregion

Directions

1. Work in teams or individually to discover some of the unique challenges and opportunities that influence the natural areas in your ecoregion. Use the Oregon Conservation Strategy from the Oregon Department of Fish & Wildlife as your primary source of information. An online version is accessible at http://www.dfw.state.or.us/conservationstrategy/ or your teacher may make hard copies available for you.
2. For the online version follow the link above, scroll down to the heading "Review the Strategy" and click on "Ecoregions." Then click on the ecoregion you are researching. Most of the information that you will need is contained in the summary section titled *"At a Glance"—Characteristics and Statistics* and is found on the second page.
3. Work together to answer all the questions on the worksheet. Most questions are easily answered from the reading material.
4. The worksheet requires you to make a pie graph that illustrates the land use data for your ecoregion. Percentages are given to you by the OCS, but you create the graph. You can create pie graphs using visual estimations, and shade each part of the pie with different colors. Your graph should include a title and labels for the reader to interpret the data presented. You can also use a spreadsheet computer program to create your pie graph.
5. Look in the *"important nature-based recreation areas"* contained in the *"At a Glance"* section of the OCS to locate a natural area that is close to where you live. Use the interactive mapping tool (available on the website) or maps to help you locate these areas.

The Place I Call Home

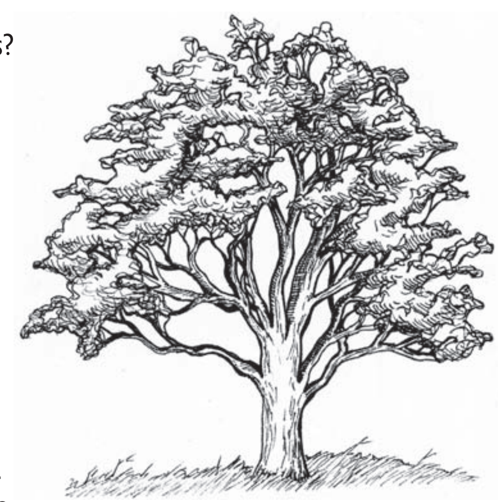
Directions, continued

6 Conduct further research into the rare and endangered plants listed on your worksheet. Find a picture and write a description for two of the plant species listed as "Strategy Species". Use these suggested sites to complete your research—USDA Plants database: http://plants.usda.gov/, or an online search of the scientific name. In addition, visit the Oregon Flora Project website: http://www.oregonflora.org/ and click on the Oregon Plant Atlas link to create a map for your two rare species. To create the map you will need the scientific name of your plant, choose the option of showing the ecoregion map, and print out your results (preferably on a color printer). Look at the historical locations of the species you chose versus where they can be found today.

7 Select and research two known invasive, non-native plant species from the list for your ecoregion. Find a picture and a write a description including where the invader is originally from and the plant's range in Oregon (Oregon Department of Agriculture: http://www.oregon.gov/ODA/PLANT/WEEDS/statelist2.shtml.

Class Discussion:

- How does human activity impact your ecoregion now? How do you expect it to change in the next 10 years? The next 50 years?
- In what way are humans impacting your ecoregion positively/negatively? Be sure to be sensitive to others' feelings and ways of life as you answer this question. Many families rely on Oregon's natural resources for their livelihood.
- What actions can you take to minimize harmful impacts and enhance the positive human impacts to your local natural areas?



Taking it Further

- Prepare a presentation on a rare or invasive plant species listed for your ecoregion. Include factors that contributed to the plant becoming rare, or where the invasives come from and the story behind their arrival, as well as descriptions, photos, and range maps. Present the information to your class.
- Do a presentation about an "important nature-based recreation area" from your ecoregion. Most of these sites are public lands, parks, forests, or wilderness areas and will have information available through state or federal agencies. Include maps of location, what you would find there, and pictures. Inform the viewer of reasons why they might like to visit this spot.

The Place I Call Home

In the Field!

- Take a field trip to one of the “important nature-based recreation areas” or a local natural area in your ecoregion. If possible, arrange to have an expert give a presentation or guided walk at the site. Ask your expert to discuss local issues such as rare & endangered species, geology, wildlife, native plant communities, and invasive species that are a problem.
- Create an invasive species scavenger hunt for your field visit to the natural area. Use the invasive species listed for your ecoregion. Make a bingo card containing the name and photo of different plants in each square. Make the center square a “free” square. Challenge other student teams to compete or work cooperatively to help others. Those that find the highest number can win a prize.
- Work with a local organization or agency to do a service project at one of your local natural areas, pulling invasive species or helping to plant natives.

Science Inquiry

Design an experiment that will test control methods for an invasive plant species that is a problem in your area. Start by brainstorming possible ways to limit the further spread of the plant. Think outside the box to create new, more effective, environmentally friendly methods that could be used for control. Narrow your ideas to ones that you can test. Write a proposal and submit it to your teacher. The proposal should outline what invasive species you will be controlling, what is the method that you will be testing, and how you will set up the experiment.

Reflection

Why does your ecoregion rock? What sets your ecoregion apart from the others around it? What makes it a special place? Think about what you like about the different seasons: winter, spring, summer and fall. Are there things that you enjoy doing outdoors that are enhanced by or only possible in your ecoregion? Do you have a special place that you like to visit? Describe it. If you don’t have a particular special place, think about characteristics that would make an outdoor place special to you—describe it. What are some things that you can do to help the conservation efforts in your community, ecoregion, state?

The Place I Call Home

Resources

- Oregon Conservation Strategy (OCS), Oregon Department of Fish & Wildlife: http://www.dfw.state.or.us/conservationstrategy/
- COA mapping tool on OCS website—lets you look at strategy habitat areas on a map for each of the ecoregions: http://nrimp.dfw.state.or.us/website/coaexplorer/viewer.htm
- Database of plant information: http://plants.usda.gov/
- Noxious weed profiles of Oregon invasive plants: http://www.oregon.gov/ODA/PLANT/WEEDS/statelist2.shtml
- Species locations mapping tool for Oregon: http://www.oregonflora.org/

Self Assessments

1 Name two or more rare plant species found in your ecoregion.

2 Name two or more invasive plant species that are a problem in your ecoregion.

3 Name and locate one (or more!) nature-based recreation area from your ecoregion.

4 Describe the general land use categories for your ecoregion.

The Place I Call Home

Names ______________________________ Ecoregion ______________________

Land use (percentage)	
Agriculture	%
Forest & woodland	%
Other (lakes, wetlands, cliffs, etc.)	%
Range, pasture, & grassland	%
Town & rural residential	%
Urban & suburban	%

Make a land use pie graph with a legend

What percent of the land ownership is private/public ?	Private %	Number of square miles		
		Number of counties		
	Public %	Number of cities / towns		
Human Factors	**Natural Factors**			
Estimated population of my ecoregion:	List 1 (or more!) Important natural area that is close to where you live. What ecosystems can be found there? How many acres is it?			
Contains what % of Oregon's population:				
List 3 major crops from your ecoregion	1.	2.	3.	
List two important industries from the ecoregion	1.		2.	
List 2 rare or endangered plants from your ecoregion	1.		2.	
List 2 invasive, non-native plants from your ecoregion	1.		2.	
List 2 rare or endangered animals from your ecoregion	1.		2.	
List 2 invasive, non-native animals from your ecoregion	1.		2.	
List the ecoregions that border yours and note whether they are North, South, East, or West of you				

Data source: Oregon Conservation Strategy http://www.dfw.state.or.us/conservationstrategy/

TEACHER page

Ecosystem Comparisons

Between every two pines is a doorway to a new world. —John Muir (1838-1914)

Time Estimate:
1 hour, or more—can be divided into 2 sessions

Best Season:
Fall, Spring

Overview

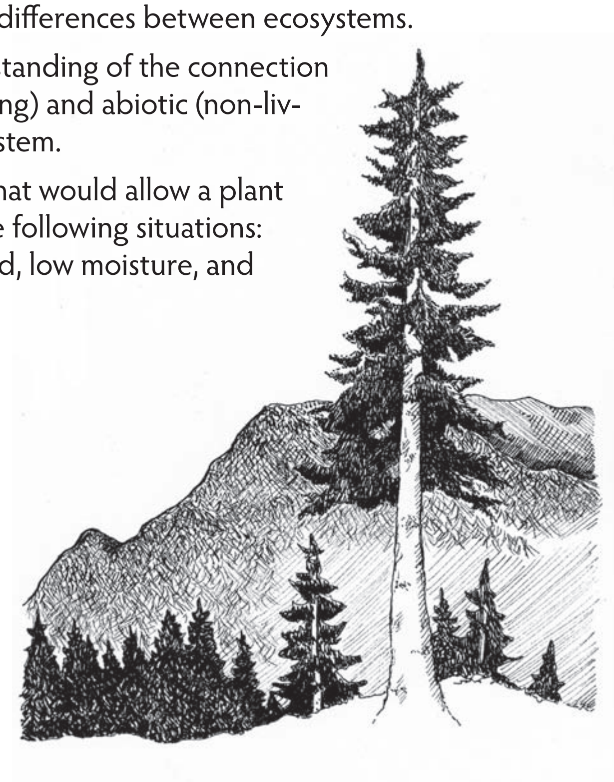
In this lesson you will collect data to compare and contrast two or more ecosystems in your ecoregion. Using your data, you will identify key adaptations that plants have evolved to survive the conditions in different ecosystems.

Teacher Hints

Students will choose two distinctly different ecosystems, such as a prairie and a forest, and compare biotic and abiotic factors in those areas. Since students will be learning about biotic and abiotic factors and their influence on ecosystems, consider supplementing this lesson with other lessons on soils and natural cycles, such as energy, water or nutrients.

Assessments

- Create visual displays of student-collected data (e.g., graphs, tables) comparing observations from different ecosystems.
- Explain similarities and differences between ecosystems.
- Demonstrate an understanding of the connection between the biotic (living) and abiotic (non-living) factors of an ecosystem.
- Name a characteristic that would allow a plant to survive in each of the following situations: low light, high light, wind, low moisture, and high moisture.



Additional Information

- Basic website on studying ecosystems: http://scienceaid.co.uk/biology/ecology/
- Pidwirny, M. (2006). Plant Succession. *Fundamentals of Physical Geography, 2nd Edition:* http://www.physicalgeography.net/fundamentals/9i.html
- Missouri Botanical Garden, Biology of Plants, Plant Adaptations. http://www.mbgnet.net/bioplants/adapt.html
- Raven, P. H., Evert R.F., & Eichhorn, S.E. (1992). *Biology of Plants* (5th ed.). New York: Worth Publishers.
- Adapted with permission from: Earth Partnership for Schools. (2007). *K-12 Curriculum Guide*. Madison, WI: University of Wisconsin-Madison Arboretum.

Ecosystem Comparisons

Between every two pines is a doorway to a new world. —John Muir (1838-1914)

Overview

In this lesson you will collect data to compare and contrast two or more ecosystems in your ecoregion. Using your data, you will identify key characteristics that plants have used to adapt to conditions in different ecosystems.

Learning Objectives

- Collect and evaluate ecosystem data
- Observe differences and similarities between two ecosystems
- Identify plant phenotypes (plant characteristics) adapted to specific environmental conditions
- Identify connections between biotic (living) and abiotic (non-living) things

Materials Needed

Each team needs:

- clipboard, pencil, & data sheet
- thermometer suitable for air and soil temperature readings
- jar of bubbles
- meter square or hula hoop
- trowel
- small metric ruler
- compass

Background Information

Through careful observation of different ecosystems, an ecologist can study how plants adapt to different environmental conditions. In this lesson you will identify key ecosystem properties and compare them between ecosystems in the region. You will investigate questions such as: How do soils differ in a forest, grassland, and wetland? Do plants in one ecosystem have different characteristics than plants in another ecosystem? As you study and compare ecosystems, learn how plants and animals adapt to their environment, and what conditions they need to survive.

Ecosystems are self-sustaining systems in nature that include all the living organisms and the nonliving elements within them. Ecosystems are dynamic; energy, nutrients and water constantly cycle through. Within each ecosystem there are communities made up of biotic (living) organisms, including flora (plants) and fauna (animals). Interactions between all the organisms tie the ecosystem together into a functional unit.

Plants take part in these interactions in many ways. In a mutualism, two species both benefit from their interaction with each other. The relationships between nitrogen fixing bacteria and legume plants, and between pollinators and flowering plants are two examples of mutualisms. The opposite of mutualism is competition, when two organisms struggle to acquire the same resource. Competition is generally costly to both organisms. Plants often compete for sunlight, water, and nutrients. They employ several methods for this—they shade out the competition, send out far reaching roots, and sometimes even produce chemicals (allelopathy) to poison their competition. Other interactions can occur between herbivores and plants (predation), and parasites and plants (parasitism).

All ecosystems change over time in an orderly process called succession. Succession can be rapid or slow, but is a continuous process that occurs in all types of ecosystems. The successional "clock" can be reset after an ecosystem is disturbed. Naturally occurring disturbances can include fire, flood, landslides, or volcanic eruptions. Manmade disturbances may result from habitat restoration, logging, farming, or any activity that clears away the natural vegetation, as well as removing a myriad of fungi, bacteria, and

Ecosystem Comparisons

Background Information, continued

microorganisms key to ecosystem function. In the absence of a disturbance, succession generally occurs so slowly that it is difficult to observe or detect it. This type of succession is illustrated when grassland changes to forest, or when a pond fills in over time. If no disturbances interrupt the succession cycle, it eventually comes to a near standstill, a point where the ecosystem is hardly changing at all. This standstill is referred to as the climax community.

In this lesson you will examine abiotic (nonliving) factors such as air, water, and sunlight and observe how they affect biotic (living) factors in two distinctly different ecosystems. By making detailed site observations, you will connect plants' phenotype (physical characteristics) to the characteristics of the ecosystem in which they live. For example, plants are adapted to different levels of sunlight, moisture, temperature, and wind. Low-light environments frequently include plants with larger leaf surface areas to capture more sunlight for photosynthesis. In high-light environments, leaves tend to be narrow to reduce surface area and minimize the loss of moisture through evaporation. Look for these types of patterns when you make your observations. Think of other leaf adaptations plants could exhibit. Look at leaf margins (edges), surface area characteristics (e.g., shape, texture, and size) as well as the angle of the leaf to sunlight. How might plants adapt to other conditions and challenges, such as drought, flood, fire, wind, and limited space? Keep in mind that plants must also defend against predation and attract pollinators—all at the same time, and all in the name of survival.

Individual plants cannot adapt to conditions within their own lifetime. However, over time, many generations, and through natural selection, the most "fit" phenotypes (the ones best suited to the environment) will be more successful, and increase in frequency and numbers. For example, if a narrow-leaved plant germinates in a heavily shaded environment, it is unlikely that the plant will secure enough light to survive and reproduce. If this phenotype is unable to reproduce, it will not persist in this environment.

Vocabulary Words

- ecosystem
- adaptation
- biotic
- abiotic
- quadrat
- communities
- succession
- disturbance
- climax community
- allelopathy
- mutualism
- competition
- parasitism
- predation
- phenotype
- natural selection

Ecosystem Comparisons

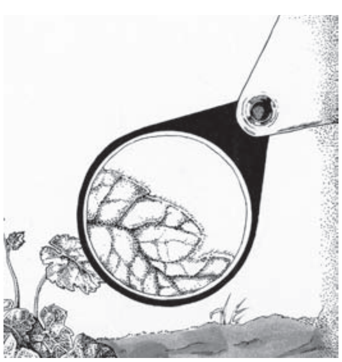
Directions

Compare two different ecosystems (e.g., forest vs. grassland, woodland vs. wetland), by examining air and soil temperatures, soil moisture, surface litter, wind speed, canopy cover (shading), plant community composition, plant characteristics, evidence of wildlife, and how all these factors come together to make up an ecosystem.

1 Divide into teams. For 30-45 minutes, following steps 2 through 10, collect and record data about your first ecosystem.

2 On your data sheet, record the date, time, general weather conditions (e.g., sunny, cloudy), and a simple site description.

3 Use a square meter or hula-hoop as a quadrat. Place the meter square or gently toss the hula-hoop into a section of the ecosystem. Wherever it lands marks where you will collect your data. If there are trees or shrubs where you are, use a tennis ball or small object to toss and place the top left corner of the frame where it lands. To avoid any bias, put the frame north from the object you tossed. Calculate in centimeters the total area of your quadrat, then figure out the dimensions of 1%, 5% and 10% of the total area (e.g., what % of the total area does your hand take up of this paper?). For example, in a one square meter plot, is 1% 10 cm by 10 cm or 5 cm by 5 cm or 2 cm by 2 cm? This will help you estimate later. Use the data sheet to record your observations as you work through the steps outlined below.



4 Air temperature: take a reading 1 meter from the ground. Allow 3 minutes for the thermometer to register the correct reading.

5 Light levels: estimate how much sunlight reaches the ground in your quadrat. To do this look up and figure out what % of the sky you can see through the canopy. Use a percentage to record this information.

6 Wind speed and direction: estimate wind speed on a scale of 0 (no wind) to 10 (strong wind). Use a jar of bubbles to help you "see" the wind strength and direction. Take a compass reading on the direction the bubbles travel.

7 Soil studies:

- Place your hand on the soil to feel for moisture levels. Stick your finger in 2 cm to check if it is different from the surface. Is it wet (mud on your hand), moist (dark color, cool), or dry?
- Surface litter: examine the dead material and decomposition (such as leaves, stems, dead insects, etc.) on the surface of the soil. List what you see and measure the depth (thickness) of the litter layer in centimeters.
- Take soil temperature readings at 3 cm and 10 cm depths. With a trowel, slice into the soil layer to 3 cm, insert your thermometer and tuck the soil back around it, leaving it for 3 minutes before recording the reading. Repeat this process at 10 cm.

8 Plant studies:

- Canopy cover: Estimate the percent of your quadrat that is covered by overhead vegetation (trees or tall shrubs). Imagine that you are lying on the ground with your head in the quadrat and look at the sky. Zero percent (0%) cover would mean that no overhead vegetation is visible; complete cover (100%) would mean that you cannot not see the sky.
- Percent ground cover: estimate the percent of your quadrat that is covered in vegetation. Can you see bare ground, rocks, or woody debris between the vegetation? Record in percent the makeup of the ground cover (e.g., forbs/herbs, grasses, moss, etc.) as indicated on the data sheet.
- Plant observations: how many different species of plants do you see in your quadrat? It is not necessary to identify

Ecosystem Comparisons

Directions, continued

the specific plants by name. Count the number of different plant species with leaves that: are very narrow (grass-like), narrow (less than 6 cm), and broad (6 cm or wider). Record the total number of species you see. Estimate the height of each type/layer of plant cover (e.g., herbaceous, shrub, tree). Note leaf characteristics (e.g., waxy, fuzzy, smooth), leaf margin type (e.g., wavy, toothed, smooth), and life cycle stage (e.g., blooming, fruiting, shedding leaves) for each type of plant.

9. Evidence of wildlife:
   - Look in your quadrat for insects, spiders and other invertebrates. Describe the different types that you find or if you are feeling "buggy," try to identify them. Make a quick sketch and record what they were doing, (e.g. eating, flying, sitting under leaves).
   - Look closely for evidence of animals you don't see. Are there chewed leaves, webs, tracks, or frass (insect droppings) or scat (animal droppings) visible?

10. Aesthetics: Describe any patterns you observe in textures, colors, or contrasts at your site. When looking for patterns it can be helpful to "soften" your gaze; try not to focus on any one thing but view the landscape as a whole.

11. Spend another 30-45 minutes repeating steps 2-10 in a different ecosystem, then analyze the results of your two studies.

Discussion questions

- In what ways are the two ecosystems alike? How are they different? What causes the similarities and differences between the two ecosystems?
- What are some connections between biotic (living) and abiotic (non-living) things in each ecosystem?
- How do you think plants in each of the ecosystems influence the light, temperature, and soils around them? How is this different in the two ecosystems you visited?
- What characteristics, such as leaf size, leaf shape, and blooming time, did plants exhibit to adjust to their environment?
- How do you think plants in each of the two ecosystems interact or affect each other?
- In what ways are plants and animals likely to interact in one or both ecosystems? Consider at least three examples.
- What method(s) did you use to estimate heights or percents in your data collection? Did they work well? If not, how would you change them next time?

Assessments:

- Create visual displays of data (e.g., graphs, tables) comparing observations between the ecosystems.
- Explain similarities and differences between the ecosystems you studied.
- Demonstrate an understanding of the connection between the biotic (living) and abiotic (non-living) factors of an ecosystem.
- Name adaptations plants might have to survive in each of the following situations: low light, high light, wind, low moisture, and high moisture.

Ecosystem Comparisons

Science Inquiry

Can you make any inferences about how the individual plant phenotypes, the makeup of plant communities and the ecosystem characteristics are all related? Use your data to examine this subject further.

- Organize and display your data in a graphic format.
- Analyze your data in the graphic format to visualize possible patterns.
- From your data and analysis, propose a question or hypotheses that can be tested to support your inference. Work with your team members to write your hypotheses.

Reflection

Pick one of the ecosystems and make a mind map for it. Put the name of the ecosystem in a circle at the center of a page; add the biotic and abiotic factors, listing each in circles that surround and attach to the center circle. Search for relationships between the factors and connect the circles with lines. Write the connection or interaction along the line. Use the discussion questions as prompts, if needed. Write about one of the interactions from your organizer in detail. Explore all the possible connections between the two interacting elements, as well as what abiotic factors might influence them. How have the organisms adapted to be successful in the ecosystem?

Taking It Further

- Compare other ecosystems, looking for the connecting patterns of biotic and abiotic factors. More specific ecosystem types include: deciduous woodland, conifer forest, wetland, wet prairie, dry prairie, shrublands, desert, high alpine, lawn, or different successional stages of any of these examples.
- Develop your own questions and data sheet to better understand your ecosystems.
- Collect information over time and through different seasons to create a phenology history of the site.

Resources:

- Basic website on styding ecosystems: http://scienceaid.co.uk/biology/ecology/
- Pidwirny, M. (2006). Plant Succession. *Fundamentals of Physical Geography,* 2nd Edition. http://www.physicalgeography.net/fundamentals/9i.html
- Missouri Botanical Garden, Biology of Plants, Plant Adaptations. http://www.mbgnet.net/bioplants/adapt.html
- Raven, P. H., Evert R.F., & Eichhorn, S.E. (1992). *Biology of Plants* (5th ed.). New York: Worth Publishers.

Ecosystem Comparisons

Team Members ____

Date ____________________

Baseline Data	Details	Site 1	Site 2
Location/site & weather description	Time		
	Site location description		
	Overall weather description		
Weather Data	Air temperature		
	Light		
	Wind		
Soil	Soil temperature		
	Moisture		
	Surface litter		
	Additional observations (color, consistency)		
Percent Cover	Canopy cover/type and percent		
	Ground cover/type & percent		
Plant Observation (characteristics)	# plants with very narrow/ grass-like leaves		
	# plants with narrow leaves (less than 6 cm wide)		
	# plants w/broad leaves (more than 6 cm wide)		
	Total number of species		
	Height herbaceous layer		
	Height shrub layer		
	Height tree layer		
	Additional observations for each type of plant (leaf characteristics, life cycle stage)		
Wildlife: Direct Observations or Evidence			
Aesthetic –visual patterns	Texture:		
	Color		
	Contrasts		

Ecosystem Comparisons

Site Analysis:

1. Which site had the greater number of plants?

2. How are the plants similar at the two sites?

3. How are the plants different at the two sites?

4. How do you explain the difference between the plants at the two sites?

5. How do you think the abiotic elements affect the plants growing at each site?

6. What connections did you observe between living and non-living things in each environment?

TEACHER page

An Ecosystem Through an Artist's Eye

Nature is painting for us, day after day, pictures of infinite beauty.

—John Ruskin (1819-1900)

Time Estimate:

1–1.5 hours

Best Season:

Any, repeat in all seasons

Overview

Students will use drawings to understand the different perspectives gained from making observations on different ecological scales. Students will focus on the local habitat by drawing three different views, one landscape view, one smaller scale view, and one magnified close-up view. This activity encourages aesthetic appreciation for the local landscape while exercising flexible thinking skills and hand-eye coordination.

Additional Information

- Sandelin, R., *This Week in the Woods*: http://share3.esd105.wednet.edu/rsandelin/NWnature/NWNature.htm
- Lavender, D. (Ed.) (1972). *The Oregon Journals of David Douglas, of his Travels and Adventures Among the Traders and Indians*. Ashland: The Oregon Book Society.
- Houle, M. (2007). *The Prairie Keepers: Secrets of the Zumwalt.* Corvallis: Oregon State University Press.
- Paetzel, M (1998). *Spirit of the Siskiyous; The Journals of a Mountain Naturalist.* Corvallis: Oregon State University Press.
- Assorted nature writings of John Muir, Aldo Leopold, Henry David Thoreau, Rachel Carson, and others.

Teacher Hints

- Encourage doing this activity in pen for the upper grades; it discourages editing. The object is to practice observation skills and gain appreciation for their surroundings, rather than to produce a perfect drawing.
- Stress to students that this exercise is to help observe what is around them, rather than to judge their drawing abilities. If students are drawing-phobic, have them make blind contour drawings, drawing by not watching their hand on the paper. Give students permission to be less than perfect (this seems to be more of a problem with older students).
- Read quotes from literature of historical descriptions of landscape perspectives (see Resource section).
- Repeat this activity in different landscapes (prairie, forest, wetland), or in the same place during different seasons. This activity is more challenging in a forested setting with a limited landscape or vista view.
- Between each drawing session, regroup and share what they saw, as well as their feelings about what they saw at each step. This is a good way to keep students on schedule—for some will become so involved in one drawing that they won't finish the activity.
- Have students use their 5x7 frame to draw a template on their paper for each of the three drawings before starting. Stress that their drawing should fill this frame. Also, encourage them to spend the entire 20 minutes drawing. If they finish drawing before the activity is over, they can go back and add more to it.

An Ecosystem Through an Artist's Eye

Nature is painting for us, day after day, pictures of infinite beauty.

—John Ruskin (1819-1900)

Overview

You will begin to understand the different perspectives gained from making observations on different scales. You will focus on the local habitat by drawing three different views, one landscape view, one smaller scale view, and one magnified close-up view. This activity encourages aesthetic appreciation for the local landscape while exercising flexible thinking skills and hand-eye coordination.

Learning Objectives

- Practice observation skills on multiple scales
- Translate observations to paper through illustration
- Interpret and compare multiple views of the same landscape
- Encourage flexible thinking skills

Materials Needed

- 5" x 7" viewing frame from photo mat board, cardboard or poster board
- pencil or pen
- hand lens or magnifying glass
- optional colored pencils

Vocabulary Words

- abiotic
- landscape
- macro
- microscopic
- perspective
- ecosystem
- perspective

Background Information

By making observations on three different scales, a macro or landscape view, a close-up view, and a microscopic view, you can observe patterns in nature from many perspectives. A nimble mind that can make observations on multiple scales and from many perspectives will be able to approach complex problems with greater ease.

As we observe the form of the landscape at different ecological scales, we can contemplate the functioning or processes that occur at those different levels to make our ecosystems funtion as a whole.

For example, at the landscape scale, we might observe patterns related to processes such as climate, nutrient and water cycling, and soil formation. At a human scale, we can examine wildlife habitat, erosion, herbivory, and many other functions. On a microscopic scale, we can focus on photosynthesis, pollination, and decomposition.

As you observe patterns in each of the three scales, you will also observe the work of the natural processes that occur at these scales. At the landscape scale, larger patterns and processes are at work. Look for patterns in the vegetation and ponder the environmental factors such as climate, soil type, geology, landforms, and water that create the patterns you see in your frame. In the close-up view, do you see plants growing in clusters or individually, do you have different layers of plants (ground level and canopy)? What kind of colors, textures, and contrasts do you see? Can you see things moving (such as insects) in your view? In the microscopic view, look very closely at one part of one plant (such as the underside of the leaf). Look for patterns and textures, colors and contrasts. Think about what types of processes might create the patterns you see.

When looking at patterns within a landscape, be aware of large scale abiotic patterns creating what you see, and also notice the micro-abiotic factors that create patterns. Looking for these small scale patterns can explain why a certain plant grows in one place but is absent from a similar looking area just meters away. Look for patterns and textures, colors and contrasts. Think about what types of processes might create the patterns you see. What patterns and processes might you find at all three scales?

An Ecosystem Through an Artist's Eye

Background Information continued

Patterns we observe in vegetation can be directly linked to abiotic factors of the ecosystem, be it on a macro or microscopic scale. In this activity, focus on the abiotic factors you see at a human scale. For example, with a large rock or boulder in a meadow, we might ask how does this rock affect the plants that grow in the meadow? Plants growing close to the rock could take advantage of differences in microclimate, such as moisture trapped by the shade on the north side, additional heat stored in the rock to keep the plant warm through the night, shade on the roots, cooler morning sun/afternoon shade (or the opposite). If the rock is located on a slope, the rock could channel water towards or away from certain areas. The rock could provide relief from harsh winds. The warmth and protection of the rock could be a benefit to insects. All of these changes could be taking place in the space of a couple meters. What other abiotic factors could affect plants growing nearby (examples: slope, soil type, light, water, wind, temperature variances)?

Directions

1. Discuss what things you might notice in a landscape or macro view. Looking clear to the horizon, close your eyes and listen to your teacher read an inspiring quote from literature. Imagine how the scene must have looked to the writer.

2. Spread out. Look through your viewing frame at arm's length, select a spot, and draw the landscape view you see in your frame on your paper. Take your time to observe before beginning. Look for and include in your drawing patterns of color, texture and contrast. Regroup and share your drawings and feelings while looking at the landscape.

3. Discuss the process at work in a close-up view and listen to your teacher read a quote. Now select a spot to observe and draw the detail of your landscape close-up. Use your viewing frame to look at an area at your feet and draw what you see. Look for details, differences in size, color, shapes. Regroup and share your drawings and feelings while making observations at the close-up scale.

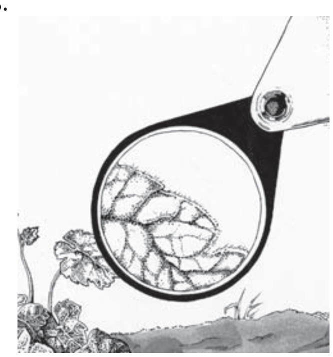
4. In the microscopic view, pick one plant to look at in greater detail. Isolate an area of the plant by looking through a hand lens and explore in close detail what you see. Fill your drawing frame with what you see in the hand lens. Pay particular attention to patterns, textures, and colors as you draw. Look at your subject, then take a minute to draw, and then look again. Repeat this process until you have suffcient detail. Fill your entire frame with what you see! Regroup and share. Did this view turn up any surprises? What processes are at work to create what you see at this scale?

5. Return to the same location and repeat this exercise during each season and look for changes throughout the year.

Assessments

1. Summarize the activity by comparing and contrasting views, and discussing the processes associated with different ecological scales.

2. Participate in the activity; work independently and join discussions.



An Ecosystem Through an Artist's Eye

In the Field!

Use this activity as a companion to the "Ecosystem Comparisons." This activity will help you connect your visual observations with the biotic and abiotic factors of a site. With practice and over time, this will allow you to analyze the patterns you are seeing and infer the processes that you have observed.

Science Inquiry

- Draw a microscopic view of a leaf and use it to explore plant adaptations through your drawing and inquiry thinking skills. Draw a 5" x 7" frame and fill it with what you see in the magnifying glass or hand lens view.
- Write and answer this question, "What other thing, in nature or man-made, does this remind me of?" Ask yourself, "Why does it remind me of this?" Was it because it had hairs or fuzz, what about the vein pattern, or margin? Add this to your answer.
- Now ask yourself, "Could the function of the leaf be similar to what it reminds me of?"
- Analyze your idea. Could this function help the plant adapt to the environment in which it is found? How would this help the plant to survive or reproduce? For example, say your leaf has tiny hairs or fuzz, maybe it reminds you of a fuzzy blanket. What is the function of a fuzzy blanket? What does this tell you about fuzz on a leaf? What other functions could a fuzzy leaf serve?

Reflection

Use your drawings as a source of inspiration for a journal entry. Think back to the readings that you teacher used to get you in the mood for this exercise. Describe one of your views in such detail like the author your teacher read to you. Describe your landscape so that the reader can imagine exactly what you experienced. Don't forget to include the smells, weather, and sounds that made your spot special. Which scale do you like the most and why?

Taking it Further

- Leaf drawing tips: Measure the long axis of your leaf. Multiply this number by 2 (assuming they're small leaves). Draw a faint line on the page that is this long. Measure the width of the leaf and multiply this number by two. Draw a faint line this long across your first line so that each line crosses the other in its middle (like a plus sign). These lines will guide how wide and long to draw your leaf and help you draw on the correct scale. Other parts of the leaf (petiole, distance between veins, etc.) can also be drawn to scale by measuring and multiplying by 2. Then include a scale bar in your drawing. If you are working with a big leaf use the same method to make a cross but divide the measurement by 2 to get the length and width.
- Inferring processes: Have each person share their landscape picture with a friend or with the class. Compare and contrast each drawing. What processes are emphasized in one drawing versus another?

Section 3:
Ecology of Native Plants

TEACHER page

What's Goin' Down Underground

We know more about the movement of celestial bodies than about the soil underfoot.

— Leonardo da Vinci (1452-1519)

Time Estimate:
45-60 minutes
in classroom or lab

Best Season:
Spring,
Summer, Fall

Additional Information

- USDA Natural Resource Conservation Service: http://soils.usda.gov/education/
- Soil Science Society of America: https://www.soils.org/about-soils/lessons/resources
- USDA Natural Resource Conservation Service. The Soil Biology Primer: http://soils.usda.gov/sqi/concepts/soil_biology/biology.html
- Portland State University, Ecoplexity: http://ecoplexity.org/

Assessments

1. Name and describe at least one interaction between plants and microorganisms that occurs under the soil surface.
2. Cooperate in a group to make observations, record data, and discuss findings.
3. Define the term *rhizosphere* and list at least three processes that take place there.

Overview

Students explore soils by learning about the living relationships that connect the cycles of nutrients, microorganisms, and plants. They examine nitrogen fixation and mycorrhizal associations, and how plants, bacteria, and fungi interact underground in the soil. Students observe evidence of interactions, gain understanding of the roles bacteria and fungi play in the ecosystem, and the benefits of bacteria and fungi in the soil.

Preparation

- Collect an assortment of root samples (or have students collect) — include at least one legume, conifer tree, and bunch grass. Collect root ends from conifers (cedars, pines, firs, spruces or hemlocks) in a healthy forest; trees in a landscape setting may or may not have mycorrhizal fungi. Several legumes—such as clover, lupine, and vetch—are commonly found in lawns or weedy areas. To find a bunch grass, the easiest place to go is a prairie or wetland. Bunchgrasses are grasses whose stems are joined in a clump or bunch rather than appearing as individual stems like in a lawn. It is beneficial to leave the stems and leaves on your root samples, when possible. It may also be helpful to students to label species of tree roots.
- Arrange lab: prepare a root sampling bag for each lab group. Use a gallon zip lock bag to contain an assorted sample of the roots mentioned above. Gently knock off excess soil; the roots do not need to be completely clean. Each group will need: hand lenses, data sheets, and dissecting microscopes. Microscopes can be shared between groups.
- Allow students time to carefully examine their root samples. After initial observations, encourage them to look closer using the microscopes. They can gently wash root tips in distilled water and dissect root sections and nodules, exposing additional interesting colors and tissue structure.

Teacher Hints

- Soil biology is an important and complex subject and this lesson only scratches the surface of the knowledge a good botanist will need. Consider expanding this lesson to study the chemical and physical characteristics of soil, nutrient cycling, and the soil food web and how they relate to native plants. For supplementary curriculum materials, see the "Additional Information" section.

What's Goin' Down Underground

We know more about the movement of celestial bodies than about the soil underfoot.

— Leonardo da Vinci (1452-1519)

Overview

In this lesson you will explore soils by learning about the relationships that connect nutrients, microorganisms, and plants. You will study how plants, bacteria, and fungi work together in mutualistic processes that take place in the soil underground. You will use hands-on skills to observe evidence of these interactions on the roots of plants, gain an understanding of the roles bacteria and fungi play in the ecosystem, and explore some of the benefits of having bacteria and fungi in the soil.

Learning Objectives

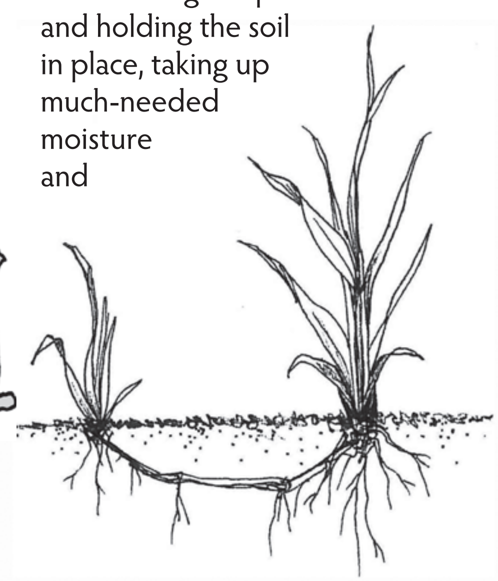
- Gain understanding of soil microorganisms
- Gain understanding of the nitrogen cycle
- Use visual observations to find plant/microorganism interactions
- Describe the processes that you observe on plant roots
- Diagram and explain the soil food web
- Describe a mutualism as a biological interaction

Materials Needed

- root samples (a random sampling that includes nitrogen fixing nodules, mycorrhizae, and roots)
- gallon zip lock bags
- hand lens
- dissecting microscope
- ruler

Background Information

As a species, humans are often enamored with plants due to the beauty and utility of the parts we see and interact with most often—the parts above ground: stems, leaves, flowers, and fruits. These parts provide structure, energy (photosynthesis through the leaves) and sexual reproduction (transmission of pollen through the flowers). Underground are the hidden parts of plants—the roots. The roots and their interactions with the soil are equally important to plants, their function in ecosystems, and their utility to humans and other species. Although roots are often underappreciated, they provide essential services such as anchoring the plant and holding the soil in place, taking up much-needed moisture and essential mineral nutrients, and providing reproduction by some asexual methods. In addition, roots provide homes to symbiotic bacteria and fungi in the soil that are critical to the survival of plants and all species that depend of them (that's pretty much every living thing!).



The most common types of root systems are fibrous roots and taproots. Fibrous roots have multiple branches that are similar in size. This type of root system is found on grasses and other monocots (plants with a single seed leaf or cotyledon). Taproots consist of an enlarged main root with extremely fine branching roots. Most dicots (plants with two seed leaves or cotyledons) have taproots. A dicot that you are probably very familiar with is the carrot. Although most roots are found underground there are exceptions, such as adventitious roots. Adventitious roots grow off the stem and sometimes help support the stem (as in prop roots) or start a new plant by anchoring an arching branch where it touches the ground. Something that all roots share is their lack of nodes (small bumps where new leaf or stem growth begins).

What's Goin' Down Underground

Vocabulary Words

- fibrous roots
- taproot
- adventitious root
- corm
- tuber
- rhizome
- bulb
- monocot
- dicot
- nitrogen fixing
- legume
- rhizobia bacteria
- *Frankia* bacteria
- mycorrhizal fungi
- hyphae
- mycelium
- ectomycorrhizae
- endomycorrhizae
- rhizosphere
- symbiotic
- mutualistic

Background Information, continued

Sometimes adaptive stem growth is found underground and can be mistaken for roots. Corms, rhizomes, and tubers are all types of stems. A corm is an underground structure covered with papery leaves (fawn lily); a rhizome is an underground horizontal stem (Oregon iris); and a tuber is a thickened rhizome adapted to store food (potato). A bulb is another underground structure that is actually a bud with thickened, fleshy layers called scales. Onions are bulbs you eat, and an important Oregon native species, camas, grows from a bulb. Although all of these are root-like structures that even perform root-like functions, they are actually stem tissue growing underground.

Most plants require soil as a medium for growth and to provide moisture and mineral nutrients. Soil is teaming with life and activity! Within the rhizosphere (an area approximately one millimeter thick surrounding plant roots) the biological activity is ten times greater than in the remaining soil. Microorganisms are attracted to and feed on the sugars and other organic compounds that seep from plant roots. In turn, the microorganisms in the rhizosphere layer help to break down and decompose dead plant cells. The respiration of these microorganisms produces carbon dioxide that acidifies alkaline soils. The microorganisms also produce gummy substances that hold soil particles together. These activities benefit plants, but the rhizosphere can also harbor microorganisms carrying diseases such as "damping off" or microorganisms acting as parasites and producing galls. The rhizosphere hosts many very important symbiotic associations, two of which we will study in this lesson: nitrogen fixation and mycorrhizal associations.

Nitrogen Fixation

Nitrogen is a macronutrient, an essential nutrient for plant growth. Although nitrogen gas makes up the majority of the atmosphere (80%), nitrogen gas is unavailable for plant use. Plants can only take up nitrogen in the form of ammonium (NH_4^+) or nitrate (NO_3^-). In the rhizosphere, bacteria inhabit the roots of plants and form nitrogen fixing nodules that capture nitrogen from the air and convert it to a form that plants can use. Nitrogen fixation is the process by which atmospheric nitrogen gas is converted into ammonia by a group of bacteria called rhizobia. The ammonia created by this process is subsequently available for many important biological molecules such as amino acids, proteins, vitamins, and nucleic acids (to form DNA). In the rhizosphere, the roots of specific species provide the bacteria with a home (the nodule), water, and carbohydrates. In return, the plant receives nitrogen in a useable form right next to its roots. Nitrogen-

What's Goin' Down Underground

Background Information, continued

fixing bacteria are host specific, meaning they have the ability to infect and nodulate only the roots of certain plant species. One of the most common of these associations is between plants of the legume family (e.g., peas, beans, clover, vetch, and lupine) and the group of bacteria called rhizobia (in the genera *Rhizobium* and *Bradyrhizobium*). It is a common agricultural practice to harvest crops and then plant a species of legume to add nitrogen back into the soil. The legume family contains many plants we commonly eat (e.g., peas, beans, and soybeans) or grow for livestock food (e.g., clover and alfalfa), as well as a number of native lupine plants found in Oregon. Nitrogen fixing rhizobia bacteria are commonly added to agricultural legume seed crops and backyard garden plantings to maximize their nitrogen fixing effects. In native ecosystems, nitrogen fixers provide the majority of the available nitrogen for other plants to uptake as well as for wildlife to consume in the vegetation they eat, providing critical building blocks for proteins and DNA in their bodies. Because nitrogen is constantly being lost from the soil and it is primarily replace by N-fixers (and fires), nitrogen-fixing species are critical to Oregon's native ecosystem function, especially in prairies, where soils are nitrogen poor. However, as we restore native ecosystems, it is possible that the presence of an overabundance of nitrogen fixers could result in a greater amount of nitrogen in the soil, making it possible for non-native species that cannot tolerate our nitrogen poor soils to invade (1).

Although the legume/rhizobia bacteria association is well known and managed by human activity, there is another nitrogen-fixing relationship. Also common in Oregon are *Frankia* bacteria that live on the roots of many native shrubs, such as rabbitbrush and trees, the most significant in Oregon's ecosystems being alders. In fact, sometimes in reforestation projects, you may find alders being inter-planted with Douglas-fir, to help the Douglas-firs establish in soils with more nitrogen availability.

Mycorrhizal associations

The second important below-ground association we will examine is between plant roots and mycorrhizal fungi. These fungi, which form an underground net of white cottony threadlike connections between the roots of plants, help capture needed but hard to find nutrients for the plants with which they grow, such as phosphorous and zinc, among others. Some nutrients do not move readily through soil, so plants may have a hard time finding sufficient levels needed for optimal growth within their own root system. Mycorrhizal fungi inhabit the roots of plants to get food (carbohydrates), and in return their hyphae (thin, thread-like growths that spread through the soil) absorb nutrients that the fungi share with their host plant. This association allows plants to mine larger areas to obtain the nutrients they need. The mycorrhizal hyphae form interconnecting networks between soil particles and the roots of plants, and will often network between the roots of many neighboring plants. You can see evidence of some types of mycorrhizae in their above ground reproductive structure—a mushroom! Although, not all mushrooms are the fruiting bodies of mycorrhizae and not all mycorrhizae produce large visible reproductive structures.

Mycorrhizal associations occur on almost all plants with the excep-

What's Goin' Down Underground

Background Information, continued

tion of a few species, like crucifers such as broccoli and dame's rocket, and are not as species-specific as nitrogen fixing associations. However, it is still unknown for many crucial native species whether or not they form mycorrhizal associations. It appears that plants with many fine root hairs are not as dependent on this symbiotic association as plants with tap roots (2). The mycorrhizal fungi are present in sufficient quantities in most native soils to be sufficient for plants' needs. Mycorrhizal fungi can also be purchased to add to the soil and are sometimes added to nursery plantings that are potted in sterilized soils or for ecological restoration purposes.

Directions

1. Form small groups or teams (2-3) for the lab section. Each group will receive a sample of plant roots to examine.
2. Remove root samples from the bag and spread out on a piece of paper. Observe the roots closely, and divide them into similar looking groups. On your data sheet give each group a sample number.
3. Note the roots' general characteristics such as shape, color, texture (woody vs. fleshy), length, girth, with nodules or without. Record a description, including any patterns (e.g., branching, simple), length in centimeters, color, and any other characteristics to help you differentiate the root samples. Use words or sketches to produce a complete description that would help someone identify which roots are which.
4. Examine your root samples more closely using some of the tools available in your classroom. Use a hand lens or dissecting microscope to get a closer look at the details of your roots: root hairs, root tips, color changes, root thickness changes, unusual branching patterns, foreign material attached, and anything else that you observe. Add your observations to your data sheet. As you do this, imagine the jobs your roots need to do, such as taking up water and nutrients, and holding your plant and soil in place. Think about how the roots you are looking at might be adapted for accomplishing these tasks in the environment in which they are found.
5. Read the background information from this activity. Discuss with your group whether any of your root samples exhibit characteristics associated with rhizobia (nitrogen-fixation) or mycorrhizal relationships. Add this to the "relationship observed" column, and include a quick sketch of what the nodules or hyphae look like.
7. Dissect roots to try to understand abnormalities from the inside. What do they look like? How are they different from normal looking sections of the root?
8. Share your team's findings with the class. Did the teams have similar findings or were the results different? Did the root samples come from a variety of plants? Look at the plant tops. If the root samples came from a variety of plants, did they show evidence of nitrogen fixing or mycorrhizal relationships across different types of plants?

What's Goin' Down Underground

Resources

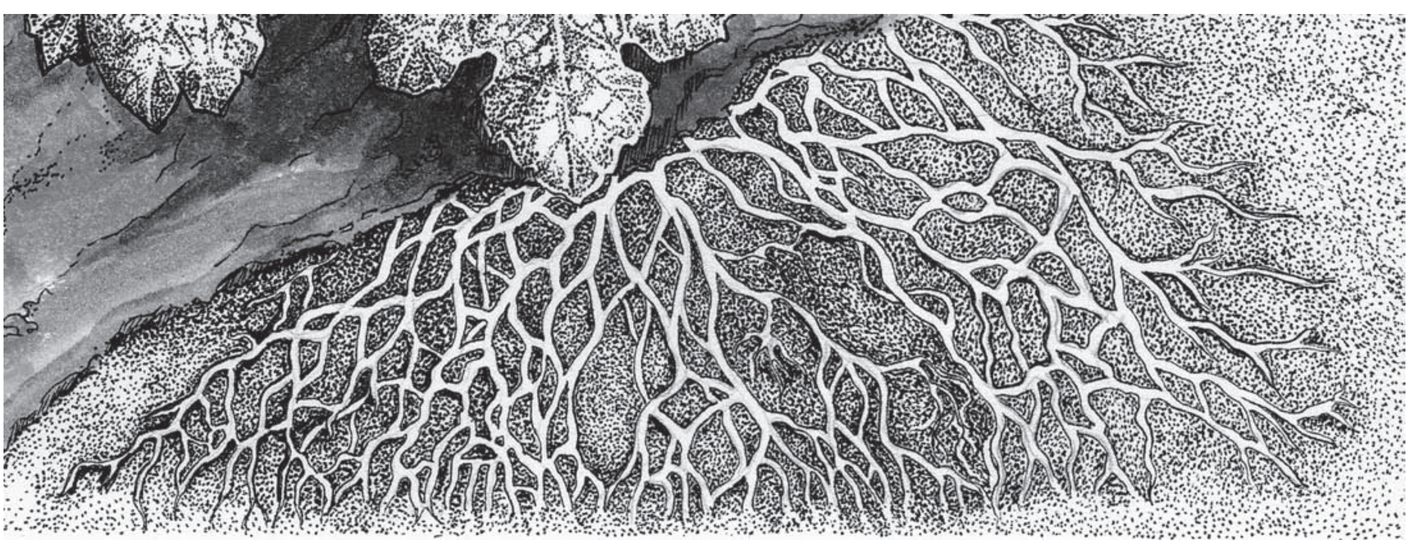
- Soil and Water Conservation Society (SWCS). 2000. *Soil Biology Primer*. Rev. ed. Ankeny, Iowa:
- Soil and Water Conservation Society. 2010: http://soils.usda.gov/sqi/concepts/soil_biology/biology.html

Self Assessments

1. Name and describe two interactions between plants and microorganisms that take place at the soil level.
2. Work as part of a cooperative group to make observations, record data, and discuss findings.
3. Define the term *rhizosphere* and list two or more processes that take place there.

Taking It Further

- Learn more about soils, which are a key factor in plant growth and distribution. Look into the chemical and physical properties of soil and how they affect plant growth. Additional soil characteristics that are important to plant growth include: pH, nutrient cycles, particle size, organic matter, and water infiltration.
- Study the components of the soil food web and how they work together. Diagram a simple web.
- View a worm composting bin and diagram the soil food web you find there.



What's Goin' Down Underground

In the Field!

Collect legume plant samples for the Science Inquiry project. Collect one sample of the same species of legume from different habitats. Clovers, lupines, vetches, and peavines are common legumes that are found in many habitats and lend themselves well to this project. Collect samples from as many different habitat types as possible. Try to gather samples from natural areas (with a minimum of human disturbance), a lawn, weedy lot, roadside, and any others that you can find. For each sample, dig the entire plant with as much of an intact root system as possible. Gently shake or crumble excess soil from the roots. Place each sample in a separate zip lock baggie and label with the species, habitat type, site location, and date. Samples should be refrigerated if they will be stored for more than a couple of hours. Proceed to the Science Inquiry section.

Science Inquiry

Study plant environmental influences on rhizobia. Develop a question and related hypothesis that relates to how environment influences nitrogen-fixing bacteria, that can be tested in the field. Gather data by comparing your collected root samples. Analyze the root samples in a lab setting to look for evidence of rhizobium infection (nodules). Count and record the nodules from each sample. Make a graph comparing the number or density (number of nodules per centimeter of root) of root nodules per plant and the location that the plant was found. For example you could compare sun vs. shade plants, wetland vs. prairie plants, roadside vs. away from the road plants, or plants in disturbed human environments vs. natural areas. Combine or compare your data with other groups to increase the data set. What kind of observations/conclusions can you make? Do all environments show the same level of rhizobia? Why do you think you have these findings? Are there environmental factors that could influence rhizobia activity? Take into consideration temperatures and herbicide/pesticide use as well as the influx of nitrogen that comes from manure and ferilizers in agricultural fields. How might all this added nitrogen into the soil affect N-fixers and the plants in these environments? Research this topic further in scholarly journals or online.

Reflection

How would a restoration ecologist need to consider nitrogen–fixing plants and mycorrhizae when planning to restore a native ecosystem? Would this be different in a prairie versus a forest? How might this differ in your ecoregion versus another ecoregion in Oregon?

What's Goin' Down Underground

Root Sample Data Sheet

Sample number	**General root characteristics** (root hairs, tips, thickness, foreign material attached)	Observations	Relationship observed
Color Branching structure Length			
Color Branching structure Length			
Color Branching structure Length			
Color Branching structure Length			

TEACHER page

Survival Quest: A Pollination Game

Bugs are not going to inherit the earth. They own it now. So we might as well make peace with the landlord. —Dr. Thomas Eisner (1929–present)

Time Estimate:
1 session
(30-45 min)

Best Season:
Spring

Overview

In this lesson, students gain a basic understanding of co-evolution as it applies to native plants and their pollinators by studying local flowers.

Teacher Hints

- Use the list of native plants from your ecoregion (Appendix II) as a starting point for this activity. If you have started a native wildflower garden at your school, this is a good opportunity to connect insect diversity to different types of pollinators.
- The second part of this activity should be completed in a natural area. If you don't have access to a natural area, an alternate activity can be completed using the USDA Plants Database (see Resources section for the website address).
- Supply students with a basic guide to insect identification. They will not need to know specific species of insects but it will be helpful for them to classify insects by order (i.e., beetle, fly, and bee) and to differentiate between a moth and butterfly.
- Create a monitoring log and record pollinator observations from year to year in a native wildflower garden at your school.

Additional Information

- Oregon Public Broadcasting and PBS, American Field Guide: pollinator evolution lessons for grades 9-12: http://www.pbs.org/americanfieldguide/teachers/insects/insects_sum.html plant/

Assessments

1. Explain biological mutualism in relationship to flowers and pollinators.
2. Gain understanding of co-evolution, and be able to explain the process as it relates to plants and pollinators.
3. Relate flowers' traits to specific pollinators that they attract; make predictions of possible pollinators by looking at flowers.

Preparation

- Use this lesson in conjunction with the lesson "Secret Life of Flowers" for students that need a refresher on flower anatomy and for additional background information.
- The discussion in the "Taking it Further" section asks students for strategies a pollinator may use if it is unable to find a food source. Some avenues to explore with students are that pollinators have different life stages that don't require feeding, that they change what they eat, or that they migrate. Your students will probably come up with more.
- Field component hints for observing pollinators:
  - Have students wear neutral colored clothing and ask them not to use scented products (perfumes, hair gels, etc.).
  - Schedule observations for midday on a sunny day with low wind.
  - Supply binoculars, if possible.

Survival Quest: A Pollination Game

Bugs are not going to inherit the earth. They own it now. So we might as well make peace with the landlord. —Dr. Thomas Eisner (1929–present)

Overview

In this lesson you will explore co-evolution as it applies to native plants and their pollinators by examining flowers out in the field.

Learning Objectives

- Explore the concept of co-evolution of flowers and pollinators
- Define a mutualism and describe how flowers and pollinators demonstrate this concept
- Increase your appreciation for the value of pollinators
- Examine one of the interconnections between plants and animals within ecosystems

Materials Needed

- botanical field guide
- insect field guide
- clipboard and pencil for each team
- hand lens
- binoculars (optional)
- pipe-cleaner

Vocabulary Words

- co-evolution
- mutualism
- pollination
- generalist
- specialist

Background Information

Have you ever heard someone mention the phrase "the birds and the bees"? Do you know where that phrase comes from? It comes from plants and how they reproduce! Birds and bees play a key role as pollinators in plant reproduction, by transferring the genetic material from flower to flower. Pollination is the transfer of pollen from male flower parts (stamen) to the female flower parts (stigma) and is how plants reproduce sexually. Through co-evolution, plants and their pollinators have developed a mutually beneficial relationship, adapting their form and function to make both their lives more successful. As such, the lives of plants and their pollinators are tightly intertwined. Without pollinators, the health of our native plants and ecosystems would falter. In addition, pollination also greatly benefits humans. Estimates suggest that one third of the human food supply is dependent on the work of pollinators to produce crops such as blueberries, almonds, melons, pears, apples, and even chocolate!

However, not all plants are pollinated by birds or bees. In other, more tropical locations, bats are important pollinators, although in Oregon our bat species are all insect eaters and there are no known bat-pollinated plant species here. Also, many plants are pollinated by wind, such as grasses and willows, along with many others. Some plants, such as the peanut, are self-pollinating and may not even require a pollinator, although this is rare in nature.

Plants and their pollinators have developed an intimate ecological relationship during the process of co-evolution. Plants, being stationary organisms (no legs!), need a means to transport their pollen to other plants for sexual reproduction. For many plant species, animal pollinators visit flowers in order to get food in the form of pollen and nectar and in the process, unwittingly transfer pollen to other plants in their travels to other flowers for another feast. Picture a bee diving into a flower, going head first deep down

Survival Quest: A Pollination Game

Background Information, continued

to reach the nectar glands at the bottom of the flower. Stamens (the hanging male parts) hang down from above, dangling dusty pollen, which brushes the hairy back of the bee as it forages for sweetness. As the bee leaves, it unintentionally carries that pollen to the next flower, where it dives down to forage again, dropping the pollen it carries there onto the sticky stigma, pollinating the flower. The bee is an innocent bystander, and does not know of the important evolutionary act in which it has just participated.

So, what might a flower look like that does not need to attract a pollinator because it is wind-pollinated? First, it generally has no petals or very tiny petals since petals are for attracting insects and they might block the flow of wind. Second, wind-pollinated flowers generally have long-dangling stamens with tons of pollen so that when it is carried randomly on the wind it has a better chance of landing on a flower of the same species.

Flowers have evolved an amazing array of scents, colors, markings, and shapes that make them attractive to specific pollinators and facilitate the transfer of pollen to the pollinator. Some plants have evolved physical barriers that restrict the access to their nectar to one specific type or species of pollinator. For example, trumpet shaped flowers favor the extended beak of the hummingbird; these flowers position their pollen to be deposited on the birds' head. A special petal on lupine flowers acts as a trapdoor, limiting access to all but the heaviest of insects, the bumblebees.

Pollinators in return have adapted physical characteristics that allow them to gather and transport pollen as they seek food. Some insects have fuzzy hairs that brush against a flower's anthers and carry pollen away, while other bees have structures on their legs called pollen baskets specifically for transporting the protein rich pollen back to the hive.

Flowers, in return for receiving pollen transportation services, reward the pollinator with high quality food. Some pollinators pursue nectar, the highly nutritious sugary substance at the base of some flowers. Others consume the protein-rich pollen itself, and still others seek the fatty oils, resins, or waxes that certain plants produce. Flowers have evolved certain colors, shapes, markings, and scents to attract a particular type of pollinator. By attracting only certain types of pollinators (pollinator loyalty), a plant increases the likelihood that its pollen will be carried from its flowers to the flowers of another plant of the same species. Attracting specific pollinators ensures that the flower's valuable pollen is not wasted by landing on a flower from a different species. By restricting the type of pollinator that accesses its flowers, the plant is also is ensuring an adequate food source for its loyal pollinator. Pollination is beneficial to the plant

Taking it Further

Design a native plant garden with one or more pollinators in mind. Choose flowers with the traits that attract the intended pollinator. Look up bloom times and try to include flowers that will bloom in succession over a long period of time. Manage your site for pollinators by refraining from using pesticides, leaving older growth standing to provide habitat for over-wintering insects, and allowing plants to reseed themselves. Monitor the site and create an observation log for future students to assess pollinator activity over time in the garden area.

Survival Quest: A Pollination Game

Background Information, continued

as well as the pollinator. We call this type of mutually beneficial relationship a mutualism.

Plants have developed many interesting and unique methods of attracting pollinators. Some orchids have developed flowers that look or smell like female insects, using sight and/or scent to trick male insects into visiting and pollinating the flower. Some Oregon orchids, such as, the mountain ladyslipper *(Cypridedium montanum)* and the fairyslipper *(Calypso bulbosa)* have a pouch-shaped flower part, which is easy to enter but, because of strategically located small hairs, limits the pollinator to a single exit, forcing the pollinator to walk directly through the pollen (1). Moth-pollinated flowers tend to be pale colored or white and highly scented, many times only opening or releasing their scent at night to attract the night flying moth. Some flowers smell like rotten meat to attract flies as their pollinators. In many cases, these flowers bloom early in the season before other insects are active. Skunk cabbage *(Symplocarpus foetidus)*, a plant of forested wetlands, is one example of this in Oregon. Each pollinator is attracted to a different style of flower and the flowers are engineered to reproduce successfully, in partnership with their pollinator.

Directions

Part 1:

1. Your quest is to find a local native flower that will attract each of the listed pollinators on the table. Use the Flower Trait Chart for guidance in flower shape, color, and other features needed to attract the target pollinator. Work in teams of two to complete the pollinator data table.

2. Look in local field guides (or better yet, in the field) for flowers that display the traits you are seeking to complete your sheet (color, shape, scent, etc.)
3. If you need additional information about bloom times or flower photos, check out http://plants.usda.gov/ and access flowers by scientific or common name.
4. Try to locate two different native plant flower sources for each pollinator in your chart.

Part 2: The Survivor Quest Challenge

1. Choose an insect or bird pollinator (not wind) from the data sheet. Your challenge will be to feed it for the entire season!
2. Research your pollinator to find out when it is active in your area. For example, a migratory hummingbird might be in Oregon from March to September, or a butterfly may have two hatch periods with adults flying in May and July. These will be the target times for you to feed your pollinator.
3. Armed with this knowledge, find flowers that will match the traits that the pollinator is attracted to <u>and</u> will be blooming in the time periods needed. If the pollinator is active for a long period, you will probably need multiple flowers with staggered bloom times to make it through the season.
4. Discussion: What might happen if you (and the pollinator) are unable to find the flowers needed at the proper times? What are some of the possible options for the pollinator? What will happen to the plants whose pollinators cannot locate them?

Survival Quest: A Pollination Game

In the Field!

1 Put your pollinator knowledge to the test. Work in teams, spread out from other teams, and pick one flower or group of flowers to observe. Use the pollinator observation sheet and start by filling in the "flower traits" section.

2 Now back away from your flower and sit quietly observing. One team member can watch through the binoculars while the other acts as recorder. Switch half way through your observation period. Closely observe your flower for 15-20 minutes.

3 After the observation period, answer the remaining questions on your sheet.

4 Pollinators can be affected by weather conditions. Try observing flowers at different times of the day or evening (possibly even at night!). Most insects will be active at midday on a warm day; wind can discourage butterflies and moths. Hummingbirds tend to be more active in early morning and late evening. Moths and bats are more active at night. What if you are not able to observe any pollinators? What does this tell you?

5 Finish by taking a pipe-cleaner and trying to collect pollen from your flower. Take note of where you find it, distances, amounts, and hidden avenues to access it. Does this fit with the rest of your observations?

Science Inquiry

Now that you have a background in understanding pollination services, investigate the reproduction of insectivorous (insect eating) plants. As a class or in small groups make a list of "I wonder" questions you would like to investigate about insectivorous plants and pollination. Choose one question to investigate further. If you are fortunate to have access to an insectivorous plant, carry out your investigation in person and make first-hand observations. Otherwise you will need to conduct your investigation through research. Oregon is home to several insectivorous species, such as the cobra lily *(Darlingtonia californica)*, common butterwort *(Pinguicula vulgaris)*, round-leaved sundew *(Drosera rotundifolia)*, and common bladderwort *(Utricularia macrorhiza)*.

For background on carnivorous plants:

Botanical Society of America. http://www.botany.org/carnivorous_plants/

International Carnivorous Plant Society. http://www.carnivorousplants.org/

Survival Quest: A Pollination Game

Reflection

Create a unique flower/pollinator relationship. Choose a species to be your pollinator—it could be a bear, human, slug, alien, or whatever you choose, even a bicycle. Now design a flower that will attract your pollinator and only your pollinator. Describe in writing or sketch what your flower looks like. Whta might a bicycle-pollinated plant look like? List how it attracts the pollinator, how it limits access to the pollen to only your pollinator, and how the pollen is carried for transfer to the next flower. Remember to make it a mutualistic relationship—what will your pollinator receive in return?

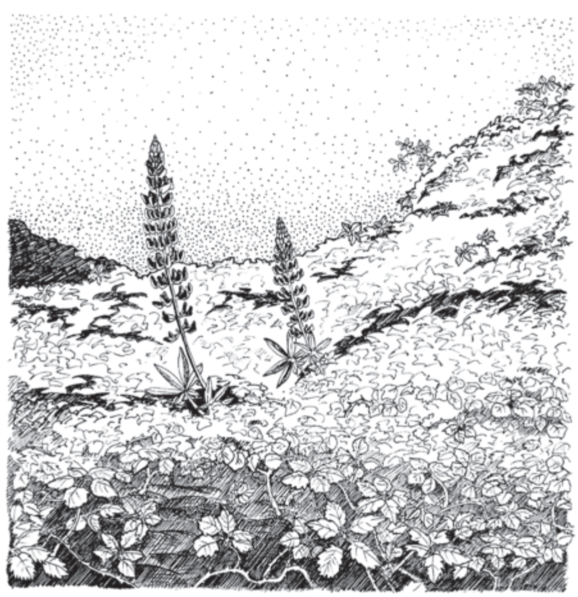
Also consider the following: scientists predict that plant pollinator relationships may be greatly affect by climate change. How might climate change affect the plant pollinator relationship?

Resources:

- US Forest Service, Celebrating Wildflowers Website: http://www.fs.fed.us/wildflowers/index.shtml
- Assorted wildflower field guides for your region—see Appendix I.
- USDA Plants Database http://plants.usda.gov/ for flower photos and information
- Selecting Plants for Pollinators: a Regional Guide. Includes Cascade Mixed Forest, Coniferous Forest, and Alpine Meadow Province, Oregon and Washington. Pollinator Partnership and NAPPC http://www.pollinator.org/pdfs/CascadeMixed.rx7.pdf

Self Assessments

1. Define the word mutualism and explain how plant-pollinator interactions are a mutualistic relationship.
2. Explain the concept of co-evolution and how it relates to plants and pollinators.
3. Understand what floral traits are associated with different pollinators. Group flowers by traits to predict their pollinators.



Survival Quest: A Pollination Game

Survival Quest: Pollinator Data Table

Native Plant	Bloom dates	Pollinator
1.		Bee
2.		
1.		Hummingbird
2.		
1.		Butterfly
2.		
1.		Fly
2.		
1.		Wind
2.		
1.		Beetle
2.		
1.		Moth
2.		

Survival Quest: A Pollination Game

Pollinator Observation Sheet (In the Field section)

Names:____Date:__________________Time:________________________

General Weather Conditions:____

Location of Plant Observed:____

Name of Plant:____

Sketch your flower:

Predict the pollinator for this flower? ________________________________

Flower traits that indicate which pollinators:

1.

2.

3.

Observations of the flower:

Visitors observed? (record all seen)	What were they doing (watch carefully)?	How long did they stay?	Where did they go when they left?	Name or sketch of visitor

Did your observations support your pollinator prediction?

What questions do you still have after your observations?

Pollinator Chart

Flower Trait	Bats	Bees	Beetles	Birds	Butterflies	Flies	Moths	Wind
Color	Dull white, green, or purple	Bright white, yellow, blue, or UV	Dull white or green	Scarlet, orange, red, or white	Bright including red and purple	Pale and dull to dark brown or purple; flecked with translucent patches	Pale and dull red, purple, pink, or white	Dull green, brown, or colorless; petals absent or reduced
Nectar guides	Absent	Present	Absent	Absent	Present	Absent	Absent	Absent
Odor	Strong musty; emitted at night	Fresh, mild, pleasant	None to strongly fruity or fetid	None	Faint but fresh	Putrid	Strong sweet; emitted at night	None
Nectar	Abundant; somewhat hidden	Usually present	Sometimes present; not hidden	Ample; deeply hidden	Ample; deeply hidden	Usually absent	Ample; deeply hidden	None
Pollen	Ample	Limited; often sticky and scented	Ample	Modest	Limited	Modest in amount	Limited	Abundant; small, smooth, and not sticky
Flower Shape	Regular; bowl shaped—closed during day	Shallow; have landing platform; tubular	Large bowl-like, Magnolia	Large funnel like; cups, strong perch support	Narrow tube with spur; wide landing pad	Shallow; funnel like or complex and trap-like	Regular; tubular without a lip	Regular; small and stigmas exerted

*Pollinator chart taken from: US Forest Service, Celebrating Wildflowers website, May 16, 2008, http://www.fs.fed.us/wildflowers/pollinators/syndromes.shtml U.S. Forest Service Rangeland Management Botany Program, 1400 Independence Ave., SW, Mailstop Code: 1103, Washington DC

TEACHER page

Plant Wars: A Tale of Offense and Defense

"We can complain because rose bushes have thorns, or rejoice because thorn bushes have roses." —Abraham Lincoln (1809-1865)

Time Estimate:

1 session
(30-45 min)

Best Season:

Spring,
Summer, Fall

Overview

Students will explore how plants defend themselves from herbivores using physical (thorns, waxy leaves) and chemical (poison) defenses. Students will read, research, discuss, observe, and speculate about the chemical defenses of plants, how they work, and how humans use them. They will also look at how other species counteract these chemicals in the intricate dance of co-evolution.

Teacher Hints

- Use this lesson in conjunction with your studies of evolution.
- See the ethnobotany section of this curriculum for more about plant medicine.
- Take time to explore the "Science Inquiry" section for project ideas related to plant chemicals.

Assessments

1. Explain the difference between physical and chemical plant defenses.
2. Describe how co-evolution between plants and herbivorous insects can occur.
3. Make detailed observations and use them to make inferences.

Preparation

- Locate suitable outdoor sites for plant observations.
- Introduce the plant observations with class discussion. Ask students to brainstorm: "How do plants defend themselves from insects and browsing animals?" Keep a list of their ideas.
- Conduct the plant observations during class or assign them for outside of class time. Without giving students any additional background information, have them complete the plant defense observations. Copy only the activity directions for students to carry in their field journal to guide their observation session.

Additional Information

- The Natural History Museum of London. History and uses of plants used by humans. Search by plant name, use type, or geographical distribution. Seeds of Trade: http://www.nhm.ac.uk/jdsml/nature-online/seeds-of-trade/index.dsml
- Smithsonian Institution's National Museum of Natural History, lesson using poinsettias to test plant defenses (have similar milky sap as milkweed). *Plant Defenses—Plant-Insect Interactions (Without the Insect):* http://insectzoo.msstate.edu/Curriculum/Activities/defense.html
- University of Colorado at Boulder, Biological Science Initiative. Two lessons on plant chemical defenses (high school); allelopathy investigation, and plant chemical defenses for herbivory: http://www.colorado.edu/Outreach/BSI/k12activities/chem_ecology.html
- Science Daily video and article, additional background on plant chemicals and insect herbivory. *Plants Under Attack Plant Biologists Discover Plant Defenses Against Insects:* http://www.sciencedaily.com/videos/2007/0906-plants_under_attack.htm

Plant Wars: A Tale of Offense and Defense

"We can complain because rose bushes have thorns, or rejoice because thorn bushes have roses." —Abraham Lincoln (1809-1865)

Overview

In this lesson you will explore how plants defend themselves from herbivores using physical (thorns, waxy leaves) and chemical (poison) defenses. You will read, research, discuss, observe, and speculate about the chemical defenses of plants, how they work, and how humans use them. You will also look at how other species counteract these chemicals in the intricate dance of species co-evolution.

Learning Objectives

- Hone observation skills; record data and discuss findings
- Understand different methods of plant defenses against herbivory
- Describe the process of co-evolution
- Increase understanding of interactions between species in plant communities
- Explore human interactions with plant chemicals

Materials Needed

- field journal
- copy of observation guidelines

Vocabulary Words

- co-evolution
- herbivory
- allelopathy
- phytochemical
- phytotoxin
- antioxidant
- angiosperm

Background Information

Plants may not be able to get up and run to flee from predators, but they have evolved physical and chemical strategies to defend themselves from attacks from hungry herbivores. Herbivory is the process of animals and insects eating plants. If you have ever gone blackberry picking and had your arms and hands shredded by giant thorns, you know that consuming blackberries comes with a price! The thorns on blackberries are just one of several types of defenses that plants have evolved to deter herbivory.

Some of the physical defenses that protect plants' vulnerable and valuable parts include thorns, hairs, and spines, among others. The effectiveness of each depends on the type of herbivore attempting to consume the plant. Large thorns may be more effective against mammalian herbivores such as deer, while hairs may act as sufficient deterrents to some insect herbivores. Some plants also produce compounds such as waxes and resins that physically alter the external texture of the plant, making feeding challenging. In such cases, an insect may have difficulty gaining traction on a leaf surface or physically biting through the leaf cuticle. Other plants attract and/or house insects that defend the plant. A particularly famous example of this is the *Acacia*-ant symbiosis, in which ants live inside the large, hollow thorns of the *Acacia* tree and deter herbivores. Still other plants, such as some species of gooseberries, produce armored fruits that deter animals from consuming the seed (1).

While all plants share the same basic chemical processes that support growth and metabolic functions such as photosynthesis and respiration, many species have gone a step further to produce secondary chemicals to defend themselves. These secondary chemicals act as toxins that can disrupt an herbivore's metabolism or make the plant indigestible.

When talking about plant defenses you may encounter terms like phytochemical and phytoxin (phyto- meaning plant). In order to compete with other plants for space, sunlight, nutrients, and water, some plants have devised some very crafty schemes to keep other plants out of their way. Some plants produce phyto-

Plant Wars: A Tale of Offense and Defense

Background Information, continued

chemicals that disrupt the growth, reproduction, or survival of other plants. This process is called allelopathy. One example of this is the black walnut tree, *Juglans nigra*, which produces a chemical, juglone, that suppresses or kills other plants under its canopy by inhibiting their respiration. If you have a black walnut tree in your yard or on your school grounds, see if you can find any other plants growing underneath it. However, not all phytochemicals are used for defense. Plants also use chemicals for beneficial interactions with insects, such as producing the colors, scents, and nectar essential to attract and support pollination.

The evolution of angiosperms, or flowering plants, coincides in geologic time with an explosion in the diversity of insect species on Earth. Insects have continually taken advantage of their plant companions over millions of years and vice versa. The fossil record shows insects have repeatedly adapted their eating behaviors to evolve with changing plant characteristics though time. For example, early insects had mandibles (jaw and mouth parts) for biting and chewing primitive vegetation, but as more complex vascular plants evolved, insects adapted more specialized features, such as sap-sucking mouth parts, that could collect the sugary fluids flowing through the more advanced plant tissues. Most recently, with the evolution of flowering plants, we find insects with mouth parts adapted to feed on flower nectar (2). This process of two species adapting in response to each other is called co-evolution.

The diversification of insects likely provided the selective evolutionary pressure that led to plant defense (and offense) adaptations. For example, some plants have adapted to produce chemicals that inhibit the absorption of nutrients in the digestive tracts of herbivores or act as poisons to kill the herbivore directly. In turn, some caterpillars have adapted their metabolism to continue to feed on poisonous plants, in spite of the plant's attempt to deter them with chemical defenses. Such changes come at a cost—some butterfly larvae have become such specialized feeders that they are limited to eating just a single species of plant! One such example is Oregon's endangered Fender's blue butterfly *(Icaricia icarioides fenderi).* Its larvae feed only on a few types of poisonous lupine plants, primarily on Kincaid's lupine *(Lupinus oreganus* var. *kincaidii*), a threatened species in the Willamette Valley. The plant still gains some benefit from its poisons, since very few herbivores can tolerate eating it. The butterfly benefits from the very limited competition for food. Can you think of other benefits of this limited relationship to the plants or butterfly? What about the downsides? What happens to these specialized butterflies when their host plant declines?

Some butterfly larvae eat a wider variety of plants, but are still limited to species from a single plant family. A common butterfly, the cabbage white, is such an example. The cabbage white larvae feed only on plants in the *Brassicaceae*, or mustard family, such as cabbage and broccoli. This butterfly is often found in gardens and agricultural fields, and is considered a pest since its food needs put it in direct competition with agricultural productivity.

Still other butterflies are generalists, feeding on a much broader range of host plant species. The painted lady is a generalist whose larvae are known to feed on more than 100 different plants from three or more families. Generalists usually have a broad habitat range. The painted lady is found in Africa, North America, South America, Asia, and Europe. It may seem that a generalist has the best survival

Plant Wars: A Tale of Offense and Defense

Background Information, continued

strategy, but such a lifestyle has its downsides. A generalist must compete for food with many other herbivores, and therefore might need to travel widely to secure enough resources for its needs.

A further twist on plant chemicals is that some butterflies that have adapted to eating poisonous plants are able to store the phytotoxins in their own body for their defense, making them poisonous or unpalatable to predators. The larvae of the monarch butterfly feed on the milkweed plant, storing toxic chemicals found in the plant's sap. The toxic chemicals are passed from the larval stage to the adult butterfly stage. This makes the monarch butterfly (and larvae) foul tasting and toxic to its predators. Birds quickly learn to avoid the orange and black pattern of the monarch butterfly.

Restoration ecologists take advantage of some insect-plant interactions to control invasive weeds. In Oregon, tansy ragwort *(Senecio jacobaea)*, an invasive weed, has three different insect species that feed on it: the cinnabar moth *(Tyria jacobaeae)*, the tiny golden ragwort flea beetle *(Longitarsus jacobaeae)*, and the ragwort seed fly *(Botanophila seneciella)*. Efforts to control tansy ragwort involve increasing the populations of its insect predators.

Phytochemicals also affect humans since we can also be herbivores. Over time, through knowledge passed down through generations of native peoples to the work of scientists worldwide, we have figured out how to use these amazing phytochemicals for both pleasure and pain. Some plant chemicals exhibit addictive properties—from opium in heroin to nicotine in tobacco to the caffeine found in chocolates, colas, and coffee (3). Other plant chemicals contain essential oils like citronella, menthol, and toxic compounds found in latex and resins. The anti-cancer drug Taxol, originally isolated from the Oregon native tree Pacific yew (*Taxus brevifolia)*, also falls in this category (4). Yet another group of chemicals contain flavonoids that make up red, blue, yellow and white color pigments. The flavonoids act as antioxidants, which are understood to be beneficial to human cells. Blueberries, red grapes and strawberries, foods known for high antioxidant levels, contain color pigments from flavonoids. Many plant chemicals are also known for their antiseptic, antiviral, and antibacterial properties, all of which are important to humans (5).

Plant Wars: A Tale of Offense and Defense

Directions

Observing plant defenses

1 Choose an area to observe for plant defenses; it could be located in your schoolyard, home garden, or a natural area. Create a journal page or data sheet of your own. Find one plant exhibiting evidence of physical defenses and one that you think has some chemical defenses. Record the date and location; include the scientific names of your plants and a detailed description, including the habitat.

2 A plant's quest is to survive and reproduce in a dangerous world. Other organisms have similar needs, which leave your plant open to being preyed upon. Answer the following: How do you think your plant defends itself? Add sketches if needed. Now start your careful observations. Look for any physical characteristics that you think might be used to deter herbivores. Examine the plant for textures that might be unappealing, like fuzzy leaves or physical structures that could be used to shield vulnerable parts like buds. Make notes on what you find. What kind of herbivore do you think is being deterred? Small herbivores like insects may need different deterrents than larger herbivores like mammals. Take these both into consideration.

3 Pick one leaf from your plant. **CAUTION -Some plants contain skin irritants and toxins. <u>Do not</u> touch the sap to your skin or taste anything!** Do you observe any oozing or liquid material coming from the damaged leaf or branch? Note whether it is clear or milky. Smear the substance on a piece of paper. Is it sticky? What is its color and texture? Rip a piece of the leaf or cut across the surface. What do you see? Crush your leaf with a rock on your paper. Grind it well (but don't rip the paper), and smell it. How would you describe the odor? What pigments or colors do you observe on the paper?

4 Does the plant show any signs of wildlife use? Describe any chew marks, leaf tunnels, unusual growth, scars on the stems, or insect eggs. Note their location on the plant. Make predictions or direct observations of what caused these signs. Do you see any evidence of plant defenses (e.g., sealing off wounds, unusual growth patterns)? Use sketches to help record your observations.

5 Look at the immediate area around your plant. Does your plant seem to be successfully competing with neighboring plants for resources? Look for excessive crowding from other plants. Does your plant look droopy, wilted or show unusual coloring (leaves yellowing, purplish or brown colored areas)? If your plant appears robust and healthy without crowding from neighboring plants, why do you think it is not crowded? Maybe you have a landscape plant that people have weeded. If you are in a natural area, how do you think your plant competes for space?

6 Return to the classroom and re-read through the background information.

7 Discuss these questions in class: What types of defenses did you observe? Did the background reading help you understand your observations? Do you think plants exhibit physical or chemical defenses? See if you can confirm this with additional internet research.

Plant Wars: A Tale of Offense and Defense

Resources:

Major types of chemical compounds in plants and animals. Armstrong, Wayne P., *Wayne's Word On-line Textbook of Natural History.* Palomar College Arboretum. http://waynesword.palomar.edu/chemid1.htm

Self Assessments

1 Explain the difference between physical and chemical plant defenses and name two of each.

2 Describe how co-evolution between plants and herbivorous insects can occur.

3 Make detailed observations and use your observations to make inferences.

Taking It Further

Several Oregon native plants are known to be toxic in one way or another to humans, wildlife, or livestock. Choose one plant or plant family from the list below (or find your own), and carry out additional research on its toxicity to humans. Find the category of chemical it contains and describe its effects on mammals. Some plants store poisonous chemicals in only certain parts (e.g., seeds), while others contain the compounds throughout the entire plant. Include this type of information in your research.

Ranunculaceae (Buttercup family) — many in this family

Fabaceae (Pea family) — many of the lupines, *Lupinus* sp.

Apiaceae (Carrot family)—water-hemlock (*Cicuta maculata)*, and poison-hemlock (*Conium maculatum)*, Pacific water-parsley (*Oenanthe sarmentosa)*

Liliaceae (Lily family) — many including Death camas (*Zigadenus venenosus,* Stinging nettle (*Urtica dioica),* Western St. Johns-wort or Klamath weed (*Hypericum perforatum),* Milkweeds (*Asclepias sp., A.speciosa* and others), Native sagebrush species *(Artemisia sp.),* Bleeding heart (*Dicentra formosa),* Poison-oak (*Rhus toxicodendron),* Western Yew (*Taxus brevifolia),* Pacific Rhododendron (*Rhododendron albiflorum, R. macrophyllum)*

Plant Wars: A Tale of Offense and Defense

In the Field!

An ability to identify poisonous plants can be important to your health and comfort. Go on a field trip and take your local field guide to identify as many poisonous plants as you can find. Use the poisonous native plant list from above to start. Many invasive plants also contain poisonous compounds, such as Scotch broom (*Cytisus scoparius)* and giant hogweed (*Heracleum mantegazzianum)* to identify. Several of the plants from the list can cause severe skin reactions when touched, so keep your distance! In your poisonous plant search, continue to look for signs of herbivory, and note any signs in your field journal. Remember that insects may have adapted to tolerate chemicals found in these plants.

Science Inquiry

- Allelopathy is the word for how plants use phytochemicals to interact with other organisms. Allelopathy may be a factor in the enormous success of many invasive plant species. Design an inquiry project to test this theory using a local invasive plant.
- Make detailed observations of an invasive plant in its natural surroundings. Do you see evidence that it suppressing competition from neighboring plants? Look at the diversity of species around your non-native plant as compared to a similar habitat where your species has not invaded.
- Plants can manufacture phytochemicals in specific plant parts or throughout their entire system. How can this knowledge help you set up your inquiry project?
- Formulate a hypothesis or question statement about the allelopathic properties of the invasive plant.
- Test your hypothesis. One possible way to do this is to water seedlings with slurry made from the invasive plant and water. Make the slurry by blending the entire plant or a specific part of it (e.g., the leaves) with water. How might the slurry affect the results of your test? Determine how frequently you will water the plants, as well as how long you will collect your data.
- Gather data. What will you measure? What methods will you use to collect data? How often and how long will you collect data?
- Analyze your data. Does it support your hypothesis? Many inquiry projects identify a need for additional testing. How could you improve or narrow the focus of your hypothesis or testing next time? Example: If your study showed that Canada thistle suppressed radish seedlings, could this be extrapolated to Canadian thistle suppresses all plant growth? Why or why not? Work with a peer and brainstorm ways to improve your inquiry project.

Reflection

Humans, as part of the ecosystem, participate in many different biological interactions with plants. Name two plant-human interactions in which you participate. Analyze one in depth. How would it affect the ecosystem if the plant you interact with were no longer part of the environment? How would it affect you? What changes could ripple through the ecosystem? What other organisms would be negatively affected? Would any organisms be positively affected? Identify one way that you can positively affect plants in your day-to-day life.

TEACHER page

What is a Plant?

It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change.

—Charles Darwin (1809-1882)

Time Estimate:
1-2 hours

Best Season:
Spring/Fall

Assessments

1. Compare and contrast major differences in structure and reproduction between two of the groups of organisms studied.
2. Write a definition of a plant.
3. Explain the evolutionary relationships and progression of plant and plant-like organisms.

Overview

Explore the diversity among plants and plant-like organisms, such as algae, fungi and lichens. This lesson will emphasize the structural and reproductive differences between the groups and the relationships between these organisms within an evolutionary context.

Hints

- To simplify life cycles, emphasize the similarities and differences in the haploid and diploid generations and modes of reproduction.

Preparation

- Collect examples of the different groups of organisms represented in this lesson. Try to have at least three species of each type.
  - Fungi available year round: spring/fall offer most conspicuous diversity.
  - Lichens available year round
  - Bryophytes available year round: sporophytes more likely to be present in spring.
  - Algae available year round; may be limited when their habitat is frozen.
  - Some ferns have evergreen leaves, but many are deciduous (lose their leaves in winter); best collected in spring/fall.
  - Seed-bearing plants can be found in flower year round; variety may be limited in the middle of the winter.
- Reproductive structures are easier to observe when magnified. Have students use a dissecting microscope or a hand lens.
- Print out the appropriate life cycle diagram to include at each station, except for lichens. The lichen life cycle is omitted because much remains to be understood about lichen reproduction. See Additional Information section or biology text books for sources.

Additional Information

- Algae—http://www.resnet.wm.edu/~mcmath/bio205/diagrams/botun05d.gif
- Angiosperms—http://www.mun.ca/biology/scarr/Angiospermae.html
- Bryophytes—http://apbiosemone-finalreview.pbworks.com/f/29_08-MossLifeCycle_3-L.jpg
- Ferns—http://apbiosemone-finalreview.pbworks.com/f/29_13FernLifeCycle_3-L.jpg
- Fungi— http://www.baileybio.com/plogger/images/ap_biology/powerpoint_-_kingdom_fungi/basidiomycete_life_cycle.jpg
- Gymnosperms—http://www.mun.ca/biology/scarr/Gymnospermae.html
- Sporophyte and gametophyte relationship in bryophytes, ferns, and seed plants. http://www.baileybio.com/plogger/images/ap_biology/powerpoint_-_introduction_to_plants/alternation_of_generations_-_evolution.jpg.

What is a Plant?

It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change.

—Charles Darwin (1809-1882)

Overview

In this lesson, you will explore the diversity among plants and plant-like organisms, such as algae, fungi and lichens. We will emphasize the structural and reproductive differences between the groups. The lesson will explain the evolutionary relationships between these organisms.

Learning Objectives

- Learn the differences and similarities between algae, fungi, lichens, bryophytes, ferns/fern allies, and seed-bearing plants
- Explore plant and plant-like diversity within an evolutionary context
- Effectively use a hand lens and/or microscope to explore anatomical diversity

Materials Needed

- hand lenses or microscopes
- three species from each category of organisms
- datasheet
- paper for drawings

Golden chanterelle, ©Barbara Gleason. Used with permission.

Background Information

Have you ever looked at a soft, moist, fuzzy piece of green growing on a tree or on the ground and wondered what it is? Is it a plant? Maybe it is a moss or a lichen or algae. What is the difference and how do you know? What about a mushroom? It is growing out of the soil. Does that make it a plant? What is a plant, anyway?

What makes a plant a plant? First, almost all plants make their own food and produce oxygen by ingesting carbon dioxide and water through a process called photosynthesis. Second, all plants have cell walls around their cells to help support them, which animals do not have, but some other organisms do. Third, plants have a cuticle, or waxy coat on their stems and leaves to protect them from drying out. You will notice that the plant-like organisms share some but not all of these traits.

The astounding diversity of plants and plant-like organisms in Oregon likely arises from the wide variety of habitats and climates across the state, from coastal marshes to alpine meadows to dry, salt-encrusted ancient lake beds; from rainforest humidity to the parched, dry air of our eastern deserts. Each habitat provides a unique set of characteristics for plants and plant-like organisms to contend with, thus yielding an incredible diversity of vascular plants, lichens, mosses, algae, ferns, and fungi.

As you learn about plants and plant-like organisms, pay special attention to the similarities and differences that lend to our understanding of the evolutionary relatedness of these organisms. Keep in mind that evolution takes time, lots and lots of time. No moss has ever turned into a fern in one generation. This is a gradual process, over hundreds of millions of years. Nothing happens quickly when it comes to plant evolution!

Plant-like, but not really plants…

Fungi

Are mushrooms plants? Mushrooms are not plants but an easily recognizable fungus, with their typical cap and stalk form, but there are also many other type of fungi including cup, jelly, teeth, coral, and crust fungi, plus rusts, smuts, and unicellular yeasts. Frequently, the part that you recognize as a fungus above the ground is only a very small fraction of the entire fungus. The rest of the

What is a Plant?

Background Information, continued

fungus is growing in the soil, tree, leaf, insect, dead wood, or other substrate on which the fungus grows. This part of the fungus that you rarely notice exists as very thin, elongate strands known as **hyphae**. Collectively the hyphae are known as a **mycelium**. The mycelium is like an apple tree, with its trunk and all its branches and leaves which form connections between the apples or fruits; the "fruiting body" of the fungus that you see is like the apple itself.

Surprisingly, fungi are likely more closely related to animals than they are to plants. True, like plants, fungi have a cell wall (animals do not) and lack locomotion. However, the cell wall of many fungi is made of chitin, the same compound in the exoskeleton of insects and crustaceans. Unlike plants, fungi can reproduce via the production of **spores**. Fungi also lack chlorophyll and cannot photosynthesize, therefore they have adapted three main means of nutrition: (1) **saprophytes** that live off of dead and decaying matter, (2) **mycorrhizae** ("fungus-root") that exchange nutrients directly with plant roots, and (3) **parasites** that live off of other living tissue.

Ecologically, fungi play a critical role in the recycling of nutrients in the environment. Fungi are also a principal food source for a variety of organisms, making them a major player in the maintenance of biodiversity on Earth.

Lichens

Lichens come in diverse forms, sizes and live in diverse habitats, from the desert to the ocean. Some lichens are leaf-like (foliose), others have a bunch of shrubby stalks (fruticose), and others look like a crust on rocks, trees, or soil (crustose). Lichens lack roots and must obtain moisture and nutrition from the air. Lichens can be found in different hues of gray, greenish gray, and brown, but can also be red, orange, and yellow. When you see an oak covered hillside that still appears green-ish in winter once the leaves have dropped, those are the beautiful bodies of lichens draping over the branches.

Lichens are a perfect example of a symbiosis. They are actually two or sometimes three organisms living together so intertwined they are only distinguishable as separate with a microscope. Lichens are made up of a fungus plus an alga or occasionally a cyanobacteria. The fungus provides a moist habitat for the algae or cyanobacteria, which in turn perform photosynthesis, creating energy in the form of sugars for the fungus to use.

Lichens provide habitat for invertebrates and food for many animal species. Because they are rootless and receive all of their water and nutrients from the atmosphere, lichens can be biological indicators of air pollution. Many species of lichens produce a tremendous amount of nitrogen in their bodies which they add to the forest soil through their decomposition after they fall from trees. One species in old Douglas-fir forests, *Lobaria pul-*

Vocabulary Words

- lichen
- spore-bearing plants
- seed-bearing plants
- moss
- hyphae
- sporophyte
- mycelium
- saprophyte
- mycorrhizae
- parasite
- foliose
- fruticose
- crustose
- spore
- rhizoid
- cuticle
- stomata
- vascular
- angiosperm
- gymnosperm

What is a Plant?

monaria, has been called by some "the lungs of the forest" because of the vast amount of oxygen it produces through photosynthesis.

The in-between…

Algae

Algae are generally aquatic and lack true roots and leaves. They are usually bathed in water and supported by the water column. Thus, specialized structures for water conservation found in plants (a cuticle and stomata), and specialized cells for structural support and water transport, are unnecessary. Algae reproduce by dispersing spores into the water; they do not produce flowers or seeds. Like plants, algae photosynthesize to obtain energy and as a result, many are green, though others are reddish or brownish. Algae are widely considered to be the evolutionary precursor to land plants. In recent years, genetic analysis has supported this idea.

Algae are found in virtually every aquatic habitat on earth, and also live in extreme environments, including hot springs, salt pans, and beneath thick sheets of ice. Plankton, which includes several types of algae, plays a key ecological role as the base of the marine food chain.

Now for the real plants…Bryophytes

Bryophytes are small plants that live closely packed in cushions or mats on rock, soil, and trees and on human-made substrates such as asphalt and concrete. They are found in a wide diversity of habitats around the globe. Mosses are the most common and familiar type of bryophyte, but the group also includes some of the funniest named plants out there, the liverworts and hornworts.

Unlike other plants, bryophytes lack the specialized vascular tissue used to conduct water. Without these tissues, bryophytes must remain small because water cannot be transported once it is taken in. Bryophytes also have no roots. Instead they have **rhizoids** that serve to anchor the plant to the substrate on which it is growing. The entire body of the bryophyte absorbs water, including the rhizoids. Bryophytes also lack a waxy cuticle that prevents water loss and only a few have stomata; this generally means they must live in moist habitats, such as those found in the ancient forests of the Pacific Northwest.

Like other spore-bearing plants, bryophytes do not produce flowers but instead develop a reproductive structure called a sporophyte that releases spores for reproduction. During one reproductive stage of bryophytes, a sperm from a male organ swims through the watery film on the leaves to a female organ on the same or a different plant. The sperm is entirely exposed to the environment during this time, which limits the distribution of bryophytes to moist environments, and limits the distance they can disperse.

Bryophytes play many valuable ecological roles. In the forests of Oregon, bryophytes regulate humidity, absorbing and releasing water into the atmosphere. Bryophytes also have extensive wildlife value, hosting a number of small invertebrates and acting as food for others, and providing nesting and bedding material for birds and small mammals. Even some large animals, such as the mountain goat, rely on bryophytes for a portion of their diet.

Ferns & fern allies

In Oregon, ferns and fern allies (we will refer to them as "ferns", though they include clubmosses, spikemosses, quillworts, whiskferns, and horsetails) frequently exist in shady forests. Some ferns are aquatic and live in symbiosis with bacteria, while others survive on rock faces, the forest floor, trunks of trees (epiphytes), and in open meadows.

Fern reproduction requires a moist environment, because as with bryophytes, ferns are spore-bearing, reproducing by means of spores instead of seeds. One stage of their reproduction requires a sperm to swim to an egg on a tiny leaf. Like the bryophytes, ferns

What is a Plant?

never produce flowers or seeds. However, unlike bryophytes, ferns have complex vascular tissue to conduct water throughout their tissues, and like higher plants, usually have a thin cuticle (waxy coating) to reduce desiccation as well as stomata that allow gas exchange to occur. Many ferns possess thick-walled spores that allow persistence in drier conditions.

Ecologically, ferns play a valuable role by providing a moist, shaded environment that supports tree seedling growth, and they anchor moist soils, slowing erosion. They also provide habitat and food for a variety of organisms that live within and amongst their fronds.

Seed-bearing plants

Seed-bearing plants are sometimes referred to as the "higher plants" because they are a more recent branch on the botanical evolutionary tree. This group includes everything from the smallest herbaceous plants like the pond-dwelling duckweed, which is the size of a lentil, to the 300 foot tall coast redwood trees. Both the conifers, or cone-bearing plants, (**gymnosperms**) and flowering plants (**angiosperms**) are seed-bearing.

Seed-bearing plants have many adaptations that make them the most successful plants on land. They have complex vascular systems for water transport (Did you ever think about how water defies gravity to get from the soils to the top of a 300 foot tall redwood tree?), a waxy cuticle on leaf surfaces to decrease water loss from transpiration, and stomata to help exchange gases during photosynthesis and respiration. Seed-bearing plants also have pollen, which can carry enclosed sperm for very long distances. They use entirely internal fertilization, eliminating the need for a watery environment in which sperm can swim to the egg. As a result, these plants have been able to colonize most corners of the globe, including very harsh environments with blasting heat and very little water.

Ecologically, seed-bearing plants are the foundation of the terrestrial food web that feeds humans and all other animals on the earth. The ecological roles of seed-bearing plants are as incredibly diverse as can be imagined. From habitat to food resources to soil stabilization to atmospheric cleansing, plants do it all!

Directions

Your teacher has established 6 stations. Each highlights one of the plant or plant-like groups. Visit the stations in the following order: fungi, lichens, algae, bryophytes, ferns and their allies, and seed-bearing plants. Working in this order will help you follow the evolutionary advances from one group to the next. Use the following directions at each station.

1. Read the background information. Note the key defining structures for the group. What do those structures tell you about the evolutionary relationship between this group and the previous group(s)?
2. Sketch the example organisms provided. Be sure to include and label the key structures that set this group apart from the others. Refer to the background information for clues about the structures to watch for.
3. Choose one example organism and examine the reproductive parts through a hand lens or dissecting microscope. Sketch a close up of what you see and label the structures.
4. At each station, use the specimens provided and the background material to fill out the boxes in the attached datasheet. The datasheet summarizes the major characteristics used to differentiate these groups.
5. Pick two key structural characteristics of the group, and explain how these characteristics help define the way of life for this organism.

What is a Plant?

Taking It Further

Using the Tree of Life internet project site found at http://tolweb.org/tree/phylogeny.html, click on "Root of the Tree" on the left side of the main page. Choose one organism from each of the plant or plant-like groups. Click through the links in the Tree of Life and try to follow it to the end. It is unlikely that your actual organism will be represented on the Tree of Life webpage, but you may be able to follow the tree to a closely related organism. Note at which point the fungi and lichens split off. Notice that the algae are split into multiple groups. Note when bryophytes and ferns split off from the higher plants.

In the Field!

Go to a habitat on or near your school grounds with a diverse assemblage of organisms, native or otherwise. With a partner, find an organism from each of the groups discussed in this lesson. When you find each organism, ask yourself the appropriate question. What makes this is a fungus? Why is this a bryophyte? What makes this an algae? Review what you know about each group of organisms. Get out some field guides for these more obscure groups and see if you can match the ones you are finding to the photos in the book.

Science Inquiry

Lichens can be indicators of air quality, and they can also indicate areas with excess nutrients. Complete some basic research and design a simple field investigation to evaluate the effects of air quality or pollution on patterns in lichen diversity.

Pick three or more different locations to collect data. Try to sample along what you think is a gradient in pollution. Extremes might be an industrial area (be sure to look for crustose lichens on pavement and buildings) and an old-growth forest. If you live in a more rural setting, try comparing the lichens present on fenceposts in a heavily used livestock yard to the lichens on nearby trees. Any setting can work, just look closely and try to find a gradient in land use (past or present).

- Take photos or draw pictures of the lichens you see in each area.
- Are there any lichens present in all of your sample areas? Are there any found just in more polluted areas? Are others found just in more pristine areas?

Reflection

Draw a colorful picture of plant evolution. Include algae, bryophytes, ferns, and seed-bearing plants. Recall that all plants had aquatic origins. Be sure to depict each group of organisms in an appropriate habitat. Lichens and other fungi occupy a completely different branch on the evolutionary tree; you do not need to include them in your drawing.

What is a Plant?

Self Assessments

1. Which group of organisms is best adapted to dry, terrestrial environments and why?
2. How do fungi differ from plants?
3. How do algae differ from plants?
4. Describe how lichens are an excellent example of a biological symbiosis.

Resources

- Arora, D. (1986). *Mushrooms Demystified* (2nd ed.). Berkeley, CA: Ten Speed Press.
- Brodo, I. M., Sharnoff, S.D., & Sharnoff, S. (2001). *Lichens of North America*. New Haven, CT: Yale University Press.
- Background information on marine algae: http://www.seaweed.ie/index.html
- Bryophytes and their ecology: http://www.bryoecol.mtu.edu/
- Bryophytes: http://bryophytes.plant.siu.edu/index.html
- Diagram the evolutionary relationship between groups of organisms: http://tolweb.org/tree/
- *Tree of Life Web Project.* The University of Arizona, College of Agriculture and Life Sciences and University of Arizona Library.
- Lichen biology and identification: http://ocid.nacse.org/lichenland/

What is a Plant?

Data/Handout Sheets

	Use Photosynthesis?	True leaves?	True roots?	Spores or seeds?	Specialized vascular tissue?	Cuticle and stomata?	Unicellular or multicellular?	Internal or external fertilization?
Fungi								
Lichens								
Algae								
Bryophytes								
Ferns and fern allies								
Seed-bearing plants								

What is a Plant?

Teacher Answer Key

	Use Photosynthesis?	True leaves?	True roots?	Spores or seeds?	Specialized vascular tissue?	Cuticle and stomata?	Unicellular or multicellular?	Internal or external fertilization?
Fungi	N	N	N	spores	N	N	both	
Lichens	Y	N	N	spores	N	N	multi	
Algae	Y	N	N	spores	N	N	both	external
Bryophytes	Y	Y	N	spores	simple	some liverworts	multi	external
Ferns and their allies	Y	Y	Y	spores	complex	Y	multi	external
Seed-bearing plants	Y	Y	Y	seeds	complex	Y	multi	internal

Section 4:
The Good, The Bad, and The Ugly
Native, Non-native, and Invasive Plants

TEACHER page

Field Journaling:
Observations from a Special Spot

To see a wren in a bush, call it "wren," and go on walking is to have (self-importantly) seen nothing. To see a bird and stop, watch, feel, forget yourself for a moment, be in the bushy shadows, maybe then feel "wren"— that is to have joined in a larger moment with the world.

— Gary Snyder, Language Goes Two Ways, (1930–present)

Time Estimate:

95 minutes introduction activity

Best Season:

Year 'round

Assessments

1 Record one observation in detail or several small observations.

2 Make observations using more than one sense.

3 Remain on task and not be disruptive of fellow students.

Additional Information

- http://www.your-nature-journal.com/grinnell-system.html

Overview

A field journal can be used to record observations and questions, to explore feelings, to make drawings, and to pursue ideas. A field journal can be a place to record lists, poetry, data, and sketches. This lesson is an introduction to using a field journal for all of these things and more. Students can use their field journal to support their study of Oregon native plants and ecosystems. It can be a handy reference for places they have visited, new terms that they have learned, and plants that they have identified.

Teacher Hints

- Begin your unit of study on native plants by introducing students to writing about personal observations in nature. The field journal can become an important tool for nature study, fostering writing skills, as a portfolio of information, a source of questions for scientific study, an inspiration for future projects, and a place for reflection.
- Share some plant related field journal entries from Lewis & Clarks' Voyage of Exploration or other naturalists with your students. Show them journal entries for them to see how drawings are used to enhance Lewis and Clark's writings.
- Encourage non-writers to express themselves through drawing. Ask them to add a few words about the drawing, maybe notes on size or color. Ask them to record the weather and the date. Each time have them include a little bit more written detail about their drawing. Pretty soon they will be writing!
- When you take students outdoors for journal writing, act as the timekeeper. Have them observe quietly for 10 minutes before they start to write. Then allow them 20 minutes to write. Give them a couple minute's warning before time is up, to allow them to gradually return to the group after their time alone. Allow 15 minutes for class sharing.
- Have students record journaling prompts from the directions and have students tape these to the inside cover of their journal. Encourage them to refer to this list whenever they have trouble starting.
- A field journal is an excellent way to cross subject barriers to integrate science with language, history and art study.

Field Journaling:

Observations from a Special Spot

To see a wren in a bush, call it "wren," and go on walking is to have (self-importantly) seen nothing. To see a bird and stop, watch, feel, forget yourself for a moment, be in the bushy shadows, maybe then feel "wren"— that is to have joined in a larger moment with the world.

— Gary Snyder, Language Goes Two Ways, (1930–present)

Overview

A field journal can be used to record observations and questions, to explore your feelings, to make drawings, and to pursue ideas. A field journal can contain lists, poetry, data, and sketches. This lesson is an introduction to using a field journal for all of these things and more. You can use your field journal to support your study of Oregon's native ecosystems. It can be a handy reference for places you have visited, new terms that you have learned, and plants that you have identified.

Learning Objectives

- Practice observation skills using sight, sound, smell and touch
- Use multiple styles of writing to record nature observations
- Promote awareness of seasonal changes and patterns through observations over time
- Use a field journal as a tool to gather, analyze, and interpret date in field research

Materials Needed

- field journal
- pencil
- colored pencils, crayons, or paints

Vocabulary Words

- observation
- journal

Background Information

Developing observation skills takes practice. Using a field journal regularly can help you hone your observation skills as well as reflect on the experiences you have in the natural world. You can use writing and drawing, and take photographs to make entries and guide the observation process. There is no right or wrong way to keep a field journal—each person will use his or her own unique style. The more time you spend recording in your field journal, the more you will see and notice around you, and the more fun it will become! If you keep detailed notes, you will be able to record seasonal and annual changes going on around you. Practice using your field journal throughout your native plant study and it can become a very useful reference.

A field journal is a great place to record observations you make in the natural world. Many of the great naturalists and scientists throughout history have kept extensive field journals. For example, the journals of Lewis and Clark have provided excellent information and illustrations of the flora and fauna and climate of our region over 100 years ago. The famous naturalist Henry David Thoreau's journals have been used to track environmental history as the climate changes, as well as to inspire naturalists and to inform scientists. Use your journal as a portfolio to contain information learned in studying nature, a place to record "I wonder" questions to pursue, and for inspiration in your writing and art work. As you get older, your field journal will be a great place to look for fond memories of cool places you have visited, interesting critters you have observed, and poetic thoughts you have recorded. In addition, looking back on your journal is a great way to track how many new things you have learned as time flies by. Your journal may be an excellent record of your history when you become a famous scientist but first and foremost, your journal is for you.

Field Journaling:
Observations from a Special Spot

Directions

Make your journal:

1 Create a field journal to collect your work and to record your thoughts, questions, and observations while studying nature. Use a composition book, spiral bound book, "Rite in the Rain" journal, or better yet, make your own journal.

2 Personalize your journal by decorating the cover and include your name and dates the journal will cover.

3 Always bring your field journal to class with you to add your thoughts, discoveries, and questions. In addition, take it on field trips, and you can even record your observations when you are outside of class.

4 With every journal entry, always begin exploring on your own, recording the date, time of day, location, and the weather.

Choose a special spot:

5 Your first field journal entry will be in a natural area, close to the school, or near your house; a special spot you can visit throughout the year. Select a spot by yourself and take note of where you are so that you can return at a later date. Settle into your spot and quietly spend at least 10 minutes just observing, without writing. Really get to know your spot; look at it, smell it, feel it, and listen. Who else is there with you?

6 Look closely at a leaf margin or bit of soil, far away at the horizon and distant movements; and in the nooks and crannies in between.

7 Listen carefully for loud and softer sounds, to the wind, insects, and birds. What else do you hear?

8 What sensations do you feel; coolnes or warmth, something soft, hard, sharp, fuzzy?

9 Explore the smells—of the ground, plants, the breeze.

10 What feelings do you have while you sit in your spot?

11 What is happening at your spot; are there processes or food webs you can observe?

12 Who or what has been at your spot before you? What signs show you they were there?

13 How is your spot part of a larger area surrounding it?

14 Enter your observations in any form that you want; you can make lists, write an essay, jot down thoughts, write a poem, or create a drawing.

15 Finish your journal entry by noting the date, time, and the location of your special spot so you can return for later observations.

16 Gather as a class and share your observations. How were they similar or different? Did you discover anything new about your spot that surprised you?

Taking it Further

- Visit your special spot monthly (or more often if you like) and create a record of changes over time. If you can visit your spot for more than one year: look for recurring patterns and differences from prior years.
- Identify 2-3 plants (or more!) at your spot. Explore some of the reasons that you think they are well suited to your spot.

Field Journaling:
Observations from a Special Spot

In the Field!

Take your field journal on all your field trips. When you first arrive, make general observations and record them in your journal. During your trip, focus in on one thing that catches your eye to write about further. At the end of your trip look over your entry and add any details that you would like to remember about your trip. Don't forget to record the date and add general information about the location and weather.

Science Inquiry

While at your spot, use an "I wonder" statement to generate ideas to investigate further (for example: I wonder why there is only one oak tree in the field?)

Now jot down some possible explanations for your question (e.g. there is only 1 oak tree because someone planted it, deer ate the others, fire burned all but one oak acorn).

Try to generate ways to test your explanations or research the answer to your question. Enlist your teacher for help if needed.

Reflection

Create a story based on your observations. Write from the perspective of something living at your spot (such as: an insect, a tree, moss, or a bird).

Assessments

1. Record one observation in detail, using words, drawing, and/or photos.
2. Make observations using more than one sense.
3. Remain on task and be courteous of other students working.

Resources

- The journals of the Lewis and Clark expedition online (see actual journal entries): http://lewisandclarkjournals.unl.edu/
- The journals of Henry Thoreau (typewritten excerpts): http://www.library.ucsb.edu/thoreau/project_main.html
- National Wildlife Federation article about Thoreau and phenology: http://www.nwf.org/nationalwildlife/article.cfm?issueID=117&articleID=1510
- Great visual examples of nature journals: http://www.newhorizons.org/strategies/environmental/matsumoto.htm
- Leslie, Claire Walker and Charles E. Roth. 2000. *Keeping a Nature Journal: Discover a Whole New Way of Seeing the World Around You.* Storey Publishing, North Adams, MA.
- Field journal resource: http://www.amnh.org/nationalcenter/youngnaturalistawards/resources/fieldjournal.html

TEACHER page

Nurture a Native Garden Project
Part I: Research and Planning

Why try to explain miracles to your kids when you can just have them plant a garden.
—Robert Brault, gardener (contemporary)

Time Estimate:
several class sessions

Best Season:
fall/winter

Overview

Explore the definition of the term “wildflower” and explore people’s perceptions of the word. Research native flowering plants for your local habitat. In this lesson, students embark on a native plant garden project by working through the planning stages in the first of three lessons. This lesson offers service-learning opportunities to share knowledge with your community.

Teacher Hints

- For your planting projects use local sources for seed, and native plants whenever possible. Beware of wildflower mixes; many contain species not native to your ecoregion.
- Continue this lesson as a multiyear project. Classes can add to the garden and do long term monitoring on the project. Gather data and survival rates from past planting to assess the long term results. Results can be repeated and compared from year to year, or work with a different plant species. Students can collect seed from the garden for future seedling projects or as a fundraiser to sell.

Assessments

1. Give the common and scientific name of 2-3 wildflowers that grow in your ecoregion.
2. Give one reason to conserve native plant species.
3. Work as part of a group to prepare a project presentation (example: oral, report, or poster).

Additional Information

- Ecoregion species lists (see Appendix II for your ecoregion), as well as sources from the resource section

Preparation

- Collect plant species lists from natural areas and field guides for you ecoregion. Consult with natural resource agencies, Native Plant Society of Oregon, parks and natural areas, and OSU Extension offices for additional help with species lists.
- Assemble a variety of wildflower seed packets or labels for student teams to use in research. Packets can be found at garden centers, plant nurseries, and mail order. Find mixes that state the species contained.
- Site preparation is covered in Nurture a Native Garden Project Part II. It is best to start this process as early as possible, once a site has been identified.

Nurture a Native Garden Project
Part I: Research and Planning

Why try to explain miracles to your kids when you can just have them plant a garden.

—Robert Brault, gardener (contemporary)

Overview

What is a wildflower? Explore the definition of "wildflowers" and people's perceptions of the word. Put together a journal page of 8-10 native flowers that you like. Work as part of a team to plan a native garden for your schoolyard. Share your project as a community service activity.

Learning Objectives

- Gain appreciation for local flowering species and their place in the ecosystem
- Use research skills to compile a list of 8-10 native flowering plants from your ecoregion
- Increase plant knowledge and identification ability over time
- Work as part of a team to plan a native plant garden

Materials Needed

- plant species lists and field guides for your ecoregion
- computer/internet
- wildflower seed mix packets with ingredients lists
- graph paper
- clipboard
- compass
- measuring tape

Vocabulary Words

- native species
- wildflower
- invasive

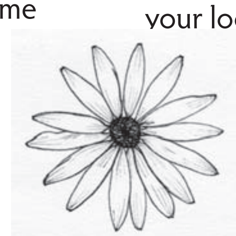
Background Information

"Wildflower" is a term with different meanings for different people. To some wildflower describes the mix of weeds blooming in a vacant lot, to others the beauty of the flowers produced by native plants, and to still others a cultivated mix of small flowering plants. This activity will help to define the term "wildflower" as well as view the word "wildflower" with a critical eye.

Garden stores, mail order suppliers, and upscale gift shops are all sources of "wildflower" seed mixes. Unfortunately these mixes are often the source of seeds that can become invasive in your region. Some wildflower mixes are labeled Eastern or Western, but rarely are they specially mixed for one state let alone one ecoregion within a state, or even better yet one plant community. The problem arises with the way the seed mixes are used. Manufacturers of these seed mixes are probably intending them for yards and flower beds, but many times they are not used for these intended purposes. Many people view wildflowers as something beautiful and at the same time beneficial to the environment. They end up being spread at country weddings, memorial services, to beautify pasture land, or to re-seed construction sites. In these cases the seed is left to spread into unintended locations and natural areas, and possibly start invasive plant problems where previously none existed. Oxeye daisy (*Leucanthemum vulgare*), an introduced species from Eurasia, is such a plant; it has become naturalized in many of the native prairies locations in Oregon.

Why should you care about introduced wildflowers? Introduced plants can crowd out native species, affect critical ecosystem interactions, and disrupt the balance of nature. Not all introduced plants cause problems, but some easily become naturalized in the temperate Oregon climate, and yet others have the capacity to become invasive. The average person does not usually weigh these factors when deciding whether to spread wildflower seed.

How can you help raise awareness in your community? One step your class can accomplish is to start a native plant garden at your school, as a demonstration for your local community. Why create a native plant garden? It can supply the aesthetics of beautiful flowers, and become an integral part of a restored ecosystem.



Nurture a Native Garden Project
Part I: Research and Planning

Background Information, cont'd

A schoolyard native plant garden may not supply the complexity or diversity of a natural ecosystem, but it will support the local ecology by providing habitat for pollinators and other invertebrates, small mammals, birds, and some reptiles and amphibians. A well-planned native garden will require few outside resources (e.g., water, fertilizer) once it is established. Creating the garden and maintaining and monitoring the site over time will supply an outdoor laboratory site for continued classroom use and research. Establish the garden in a highly visible location and it can be a demonstration garden, promoting the beauty and function of native plants to your school and community.

Directions

Part 1: Research

1 What is a native wildflower? Write a definition using your present knowledge. Save this definition to consult again at the end of the lesson.

2 Make a pictorial bouquet of native flowers specific to your local ecosystem. Follow the steps below to identify 8-10 native flowering plants to include. Choose flowers that you find attractive, in a variety of colors and shapes.

3 Start by compiling lists of native plants found in your ecoregion. Sources of species lists may come from the Native Plant Society of Oregon, Native Seed Network ecoregion species lists, local natural resource agencies (US Forest Service, BLM, OSU Extension, State Parks and County Natural Areas), and regional field guides. Check the range of your species by using the online USDA/NRCS Plants Database or Oregon Flora Project.

4 Narrow your list to species that are well suited to grow in your local ecosystem. Look at the ecology or cultural information sections of field guides for help.

5 Assemble a field journal type page to showcase your 8-10 flowering species in a pictorial bouquet. Draw the flowers or use color photos (taken yourself or printed from copyright-free digital library sources). Arrange and adhere your bouquet in the middle of the page, and arrange field notes around the outside of the bouquet. Give the common and scientific name, habitat information, and pollinator if known for each of your species (example: Oregon Iris, *Iris tenax*, upland prairie, road sides, woodlands).

6 Now compare your native plant flowering bouquet with the species lists found in purchased wildflower seed mixes.

7 Work in teams to research one of the purchased wildflower seed mix packets. List the flower species from the ingredients list. Research each plant's range, and note whether it is a native plant to your ecoregion. When finished, create a simple bar graph that shows the number of native to non-native species results. Share with the class and discuss: how many of the different wildflower seed packets would be suitable to plant in your ecoregion?

8 Revisit your definition of a native wildflower. Has your definition changed? Rewrite a definition to better represent your current knowledge.

9 Class discussion: "wildflower" can be a misleading term that is open to interpretation. How would you change the term or the image to better define it? How would you educate the public of your image change and why it is necessary?

Part 2: Creating a Native Plant Garden—Site Planning

1 Divide into teams that will each perform a task: (1) map the school grounds, (2) create species list for your native garden, (3) identify native garden sites, (4) perform baseline plant survey of sites, (5) market project to school administrators, and (6) locate seed or plant sources for your garden.

2 Team 1: Map the school grounds, identifying locations of possible garden sites. If you have a small area to

Nurture a Native Garden Project
Part I: Research and Planning

Part 2: Creating a Native Plant Garden, cont'd

work with use measuring tapes and graph paper to make a scale map. If you have a large area you might use pacing to make an estimated map or approach the school office to see if they have a school map that you could use as a template. Create a master map (by hand drawing or on the computer); make several copies.

3. Team 2: Research flowering native plants to include in your garden. Create a list of 10-15 native plants that are suited for your schoolyard ecosystem. Look at sun/shade, moisture levels, and soils. Additional criteria could include species that are commonly available in your area, grow relatively easily from seed, are aesthetically pleasing, and are important nectar sources for local pollinators.

4. Team 3: Identify one or two suitable sites for the native garden. Sites could be a little-used patch of grass, an underutilized corner, neglected garden spot, or the entrance to your school. Try to make it a place that people will visit and consider if it is a spot that teachers will allow students to visit alone. Make sure to find out if the school has plans for a new building or ball field and do not put your garden there. Check with the maintenance staff at your school and make sure they are on board. You don't want them to mow your garden! Observe and make detailed notes on each of your target sites. How much direct sunlight does it get, and for how many hours a day? What are the soil moisture levels at wet and dry times of the year? Make special notes about building overhangs or water sources nearby. In addition, look for a site that can be enjoyed and appreciated by the student body and school visitors. Mark your two top choices on a copy of the map created by the mapping team.

5. Team 4: Conduct a baseline plant population survey of the two sites identified by the site location team. Identify plant species presently growing at the site. Add the location of all native plants (if there are any) to the map created by the mapping team. Include a key of plant species on the map.

6. Team 5: Market the native wildflower garden to the principal and the school groundskeeper. Give them an overview of the benefits of a native wildflower garden, your class's planning work, and a proposal for taking on a native wildflower garden project. Use PowerPoint or visuals during your presentation. Conclude your presentation by asking for their approval to continue with the native plant garden.

7. Team 6: Using the list of 10-15 native wildflower species, locate sources of native seed or potted plants. Native plant nurseries, seed sellers, and local plant growers can all be sources. Contact the sources in person, by phone, or by email to introduce yourself and your school. Give them a brief introduction about your project and what you hope to accomplish. Many providers will donate or give discounts to school projects. If you receive a donation, be sure to follow up with a thank you note.

8. After all the teams have completed their projects, come together as a class to make decisions. Each team should share their work with the group. As a group, pick your final choice for site and species to include. Keep the school groundskeeper apprised of your final site location and ask for their continued support.

Taking It Further

Take on a community service aspect for this project:

- Write and submit a news article for your school or community paper about native wildflowers and your school native wildflower garden project. Make the article informational by stressing the importance of native plant communities for local pollinators or benefits of a native wildflower garden.
- Educate the public about the drawbacks associated with wildflower mixes used in wild areas. Create a marketing campaign to get the word out. Posters, letter to the editor, and speaking to community groups, are some possible ways of getting out your message.

Nurture a Native Garden Project
Part I: Research and Planning

In the Field!

Plan a follow-up field trip to a natural area to view native wildflowers blooming in the spring. Many U.S. Forest Service offices have lists of wildflower hikes in the area. Inquire about peak viewing dates to guide your planning. Ask also if they have a species list for the area. Inquire into the possibility of having their local botanist lead the hike. Take your field journal and/or a camera to record your flower observations.

Science Inquiry

Take baseline monitoring information for your native wildflower garden site. Observe and record soil moisture levels, diversity of plant populations, and insect and wildlife observations or signs. This information can be used in future monitoring and science inquiry projects. Do this in both fall and spring and compare your data. Is your site more diverse in the fall or spring? Try doing this type of monitoring in two different habitats. Are some habitats better to monitor in fall and some in spring? What about summer? What do you think? Design a study to test this.

Reflection

Choose your favorite native wildflower and document all the connections between the plant and the local ecosystem that you can confirm or even imagine. How did the seed get to where it started? What does it need to grow? What kind of pollinators does it support? How does the flower connect to you? Did learning about native wildflowers increase their appeal to you? Do you have any feelings of connection to the ecosystem you live in? Can you identify 1 or 2 things that you can do personally to promote native plant conservation?

Assessments

1. Give the common and scientific name of 2-3 wildflowers that grow in your region.
2. Give one reason to conserve native plant species.
3. Team participation in the project; working together with other members, finishing assigned duties, and helping out where needed.

Resources

- U.S. Forest Service Celebrate Wildflowers website: http://www.fs.fed.us/wildflowers/index.shtml
- Native Seed Network species list for Oregon by ecoregion: http://www.nativeseednetwork.org/ecomap?state=OR
- Native Plant Society of Oregon. Follow links to your local chapter: http://www.npsoregon.org/
- USDA Plants Database: http://plants.usda.gov/
- Oregon Flora Project (has plant ranges, photos, and locations in Oregon): http://www.oregonflora.org/
- University of Washington, Burke Museum online plant field guide: http://biology.burke.washington.edu/herbarium/imagecollection.php

TEACHER page

Nurture a Native Garden Project
Part II: Starting Seeds and Growing Plants

The creation of a thousand forests is in one acorn.

—Ralph Waldo Emerson (1803–1882)

Time Estimate:
6-8+ weeks
(continuing project)

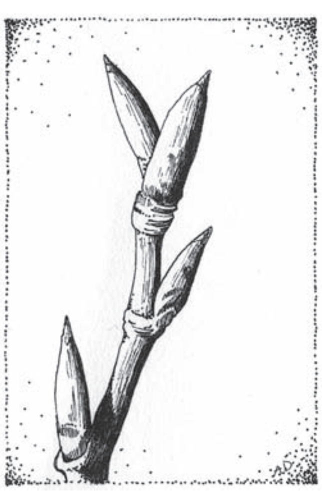
Best Season:
winter/spring

Overview

Part two of this native garden project will focus on starting seeds and growing plants for your native plant garden. In the process students will learn about seed germination techniques and basic plant care. Potted plants grown by the students will be the basis of a science inquiry project that will contribute to a knowledge base for future seed projects.

Assessments

1. Improve knowledge of seeds, seed germination, and adaptations as they apply to local species.
2. Participate in an experiment, gaining skills in science inquiry steps.
3. Follow through on a long term project requiring attention to detail.
4. Submit a written report of the science inquiry project.



Teacher Hints

- Review appropriate background information for each section before starting (seed treatments, planting, plant care, hardening off, and transplanting).
- Set up a student watering schedule for potted plants.
- Extend the science inquiry section by requiring students to write up a scientific report on their experiment. The reports can be saved or summarized for future classes to re-test or build on the experiments and contribute to the ongoing research for this activity.

Preparation

- Gather or purchase supplies needed well in advance of starting this project. Potting soil can sometimes be hard to locate in the winter months.
- Keep potted plants in trays to minimize watering messes.

Additional Information

- A Partnership for Plants in Canada – additional lessons about growing native plants: http://www.bgci.org/canada/edu_act_class/
- *Wild Ones: Native Plants, Natural Landscapes Landscaping with Native Plants Guide* – reasons, ethics, design, seed treatments, planting, local genetics: http://www.epa.gov/greenacres/wildones/wo_2004b.pdf
- *American Horticultural Society Plant Propagation: The Fully Illustrated Plant-by-Plant Manual of Practical Techniques*. Alan Toogood, editor. DK Publishing, Inc. New York.

Nurture a Native Garden Project
Part II: Starting Seeds and Growing Plants

The creation of a thousand forests is in one acorn.

—Ralph Waldo Emerson (1803–1882)

Overview

Part two of this native plant project will focus on starting seeds and growing plants for a native wildflower garden at your school. Learn about preparing seed, germinating, planting, and how to care for plants. Your potted plants will be the basis of a science inquiry project that will contribute to a knowledge base for future projects in the garden.

Learning Objectives

- Understand the biology of seeds, seed dispersal, forces of nature that work on seeds, and seed adaptations
- Start and grow native plants from seeds
- Prepare a site and plants for a native plant garden
- Set up a science inquiry project using native plant

Materials Needed

- native wildflower seeds
- ziplock bags
- permanent marking pen (e.g. Sharpie)
- pots
- trays
- potting medium
- watering wand
- fertilizer

Background Information

Seeds are the reproductive parts of flowering plants. They are typically made up three parts: the embryo (immature plant), endosperm (stored food supply), and seed coat (outer covering). The function of a seed is to protect and nourish the embryo and to assist in the dispersal of plants to new locations.

Seeds require optimal conditions for new plant growth to germinate. They may require warmth, cold, moisture, or certain levels of light, and these factors vary by plant species and habitat conditions. Most plant seeds mature in late summer or fall, but seed will not germinate until the following spring when weather conditions are favorable. This lag time between when a seed is produced and seed germination is called dormancy. Dormancy protects seeds from germinating at the wrong time of year to ensure the new plant will have the best chances for survival.

Seed dispersal is important for both the new seedling and the parent plant to have optimal growing conditions. If all seeds fell right at the base of the parent plant, the area would become too crowded for all the plants to survive and the mother plant "wants" her offspring to survive so it is successful in passing on its genes, its main mission in life. For a plant population to remain healthy it is dependent on moving new plants into favorable growing conditions. This is called seed dispersal. Plants exhibit many different methods of dispersing seed, using wind, water, animals' fur, birds, feet, or insects to get from place to place. This can be seen in many wetland plants, which have seeds that float to disperse along water corridors. Some seeds are even fire dependent, requiring high temperatures or in some cases, smoke, to release them from the resinous materials

Vocabulary Words

- seed
- embryo
- endosperm
- seed coat
- dormancy
- scarification
- stratification
- harden off

Nurture a Native Garden Project
Part II: Starting Seeds and Growing Plants

Background Information, continued

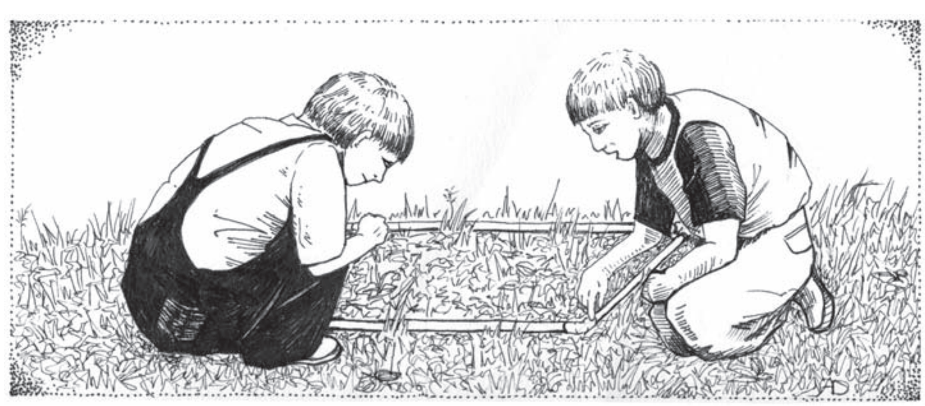
that protect them. Can you think of any plants that use humans as their primary dispersal agents?

Under natural conditions seeds will germinate when they are ready, but for seeds started indoors we can manipulate conditions to prompt seeds to germinate at other times. Seed treatments are used, when propagating seeds, to mimic natural processes for breaking dormancy and to eliminate the barriers to germination. There are three general types of treatments (and many variations) used to break seed dormancy of Oregon native plants: 1) cold-moist stratification; 2) scarification; and 3) other special treatments including heat, switching back and forth from warm to cold, harvest timing, and the use of chemical plant hormones. These last methods are only used in special circumstances and won't be addressed in this lesson. Some seeds have double dormancy and require combinations of these treatments.

1. **Cold-moist stratification** is a technique used to fool plants into "thinking" spring has arrived and it is time to germinate. Because Oregon's winters are cold and moist, followed by a spring that is warm and moist, that is what we must give many Oregon plants in order to convince them it is time to germinate. To do this, you can put seed in a mixture of moist sand, peat, soil, or vermiculite in a cooler or if it is cold enough, outside, in a temperature of about 5 degrees Celsius. Much cooler and the seed will freeze; much warmer and it might not receive enough chill to germinate. They should begin to germinate in 1-2 weeks. Thus, the seed is stored under native habitat temperature conditions commonly mimicking local winter conditions. The moisture level should be similar to a damp sponge. It is common to use a 30 day period of cold-moist stratification, although some species may need as little as 1 day or as much as 90 days or up to 6 months for some alpine species. Following the time in the cold, transfer your seeds to a warm (20 degrees Celcius) environment mimicking Oregon's spring and continue to keep them moist. Most Oregon native plants such as sedges, buttercups, native lilies, and many others require cold-moist stratification.

2. **Scarification** is the act of breaking through the seed coat. This can be accomplished by rubbing sandpaper across the seed coat, by pouring hot water onto the seeds, using an acid to break through the seed coat, or using a razor blade to nick the seed coat. Different scarification techniques are used depending on the permeability and thickness of the seed coat. More often than not, scarification is an easy process of gently scratching the seed coat with sandpaper. Acid scarification is used for seeds with tough, thick seed coats. The acid acts as a mimic of the conditions the seed encounters when passing through an animal's digestive tract. Soaking seed in near-boiling water apparently breaks down the waxy cuticle associated with some species. Oregon plants such as lupines and checkermallows, among many others, benefit from this method. When directly planting seeds in the ground in the fall, this process is not required because nature takes care of the process on its own. How do you think it does this?

It can be very important when



Nurture a Native Garden Project
Part II: Starting Seeds and Growing Plants

Background Information, continued

germinating and growing native plant seeds in artificial conditions to work in as clean an environment as possible to minimize failures due to rot and diseases. To start, always wash your hands before handling seed. It is advisable to buy sterile media (e.g. peat, potting soil) or if unavailable, sterilize it yourself in a 400 degree oven for one hour. Seed boxes, pots, and trays should be washed and soaked in a bleach/water solution for one hour, then air dried before use.

By physically treating the seed to conditions that mimic nature, we are able to accelerate the germination process when growing seeds in the classroom or greenhouse setting. If the seed were planted in the field in the fall, the physical and biological processes they encountered on the soil will naturally break dormancy to allow the germination process the following spring. Sometimes it will take a seed two to three years to break dormancy in nature.

Directions

Growing Native Plants from Seed:

1. Identify local native plants to grow from Nurture a Native Plant Garden Part 1. Locate sources of seed to purchase or ask for a donation.

Seed Treatment

1. Follow the general guidelines below or any specific instructions you received from the source of your seed. Consult www.nativeplantnetwork.org for specific treatments for your species.
2. Seeds planted directly outdoors in the fall will not need pre-treatment.
3. Scarification—Only if your species requires scarification (does it have a hard, impermeable seed coat?), lightly rub your seeds with sandpaper until you have a small spot where water can get into the seed. You do not need to (and should not) remove the entire seed coat. Check for a breach in the seed coat with a hand lens.
4. Stratification--For cold-moist stratified seed. For very large or very small seed: fill a ziplock bag 2/3 full with sterilized sand, vermiculite or peat and moisten so it is damp but not flooded. Mix seeds in with the saturated medium in the bag and seal. Be sure your medium stays moist the whole time. Medium and large seed that you will want to plant in individual pots should be stratified in germination boxes with moist blotter paper.
5. Label the bags with a permanent marker and include species name, date, treatment regimen, and seed source.
6. Refrigerate the bags for at least 30 days unless the instructions you found for your species indicate otherwise.
7. If you don't know the preferred method of treatment, do an experiment with several different methods (i.e. scarified vs. not, 14 days of cold vs. 30 vs. 60) and compare the results from your experiment to determine the best technique. Write down and save your protocols for future classes.
8. Continue to the planting directions below.
9. Discussion questions: What natural process are we imitating by using sandpaper to penetrate the seed coat? How does seed scarification link to the food web? Which seeds require moist-cold stratification and which do not? What is the shortest length of time required for stratification and what is the longest? How long can you keep seeds in cold-moist storage? How can you relate what the seed needs to the local climate patterns?

Nurture a Native Garden Project
Part II: Starting Seeds and Growing Plants

Directions, continued

Planting Seeds

1 Fill 4" pots with damp potting medium. Plant one or two seeds in each pot. Carefully cover the seed and gently press it into the potting medium. You will need two pots each for the science inquiry section. If you are starting extremely small seed, too small to work with individually, use the following method. Once the seed has been through stratification, gently spread the seed mixture on the top of your potting media in a tray to make soil contact. Be careful to not cover your seed with potting soil.

2 Label your pots with your name on a plant tag or masking tape.

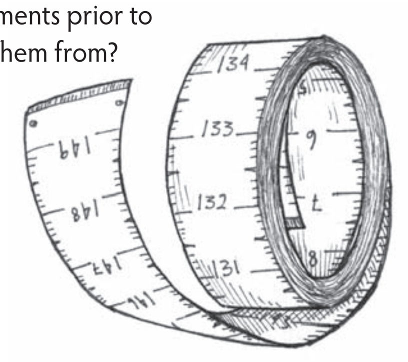
3 Place your pots in trays and gently water with a fine mist.

4 Place plants in a greenhouse if available, a south-facing window, or under florescent lights for 12 hours per day.

5 Check your plants daily, keeping them moist but not wet. If your plants are in a greenhouse make a watering schedule and take turns with your classmates.

6 Watch for germination, and adjust your watering schedule to your plant's recommendation once they are established. Wetland plants will need more moisture than upland plants.

7 Discussion: Compare germination rates for those species that require treatment to those that do not require treatment. Can seeds be planted too close together, or too far apart? If you grow multiple species, which germinated the fastest? Did they require all treatments? How do you think the seeds receive these treatments in nature? Why is it important evolutionarily for seeds to require these treatments prior to germination? What does it protect them from?



Harden-Off Plants

8 A couple weeks before planting out the seedlings, prepare them for the outdoors by a process called hardening off. Plan your outdoor planting date after the last frost date for your region. Gradually move plants outdoors into a protected area two weeks prior to your planting date. Bring them back in at night or cover them with frost cloth for the first couple of nights, and on nights that you expect a frost. Slowly introduce the plants to direct sunlight by increasing the hours they are exposed over the two week period. At the end of the hardening off process the plants should be accustomed to the number of hours of sunlight that they will be exposed to in the garden (this will vary from shade to full sun).

9 Your seedlings are now ready to plant out in the wildflower garden.

Taking It Further

- Chart the growth of your plants: when did they germinate, get their first true leaves, reach a certain height? Compile the information in graphs with labels.
- Explore seed germination rates. Count out a specific number of seeds and write down the number (100 seeds makes for easy math but this can be done with any number). Keep track of the number that germinate and record that number. What percentage of your seeds germinated? What trends do you see? Do some of the seeds germinate faster than others? If so, why? Why do some species have high germination rates while others have low germination rates?

Nurture a Native Garden Project
Part II: Starting Seeds and Growing Plants

In the Field!

Start the native garden preparation for your transplants. Draw a map of the garden area on graph paper. Indicate which areas you will plant with each species. Check online to find out the full size of the species that you will be planting in the garden, so your spacing will be right when they are full grown. An overcrowded garden can be a frustrating maintenance project in the long run. Mark on the map where to place the plants. Use this map on planting day to guide where to plant. You can always adjust the map as inevitable changes are made on planting day. Begin site preparation as early as possible. If you start in the fall, cover the site with overlapping pieces of cardboard or several thicknesses of newspaper. Hold this down with a generous layer of compost or fall leaves. This will smother the weeds and grass, and amend the soil in preparation for your transplants in the spring.

Science Inquiry

Design a science inquiry project:

1. As a class, brainstorm growing protocols for native species that could be scientifically tested. Examples of variables that could be tested are: types of soils, fertilization amounts and types, seed chilling or stratification methods, scarification and methods, temperatures, lighting conditions, addition of mycorrhizae or microbes, or come up with your own ideas. Narrow your choice to one variable to test.
2. Design a question to be tested based on the one variable. Work with two groups of 10 or more plants, one group to test your variable and the other to act as a control. Label the groups with your name and treatment or control.
3. Using your prior knowledge and simple research, formulate a hypothesis or a statement of what you expect to happen. Write down your hypothesis and include your reasoning. This is the beginning of your scientific report.
4. Design a sheet to collect your data. As a class, decide what data you will be collecting (plant height, number of leaves, largest leaf dimension, and others) and the frequency that you will collect it. Date each collection of data and use metric measurements when gathering data. Data can be recorded manually or on a computer spreadsheet program.
5. The experiment can conclude at outplanting or be continued outside.
6. At the conclusion, write up your results in a scientific report. Start with your hypothesis, outline the steps of your experiment, graph your data, analyze your results, and state your conclusion. Did your experiment support your hypothesis or not? Did the experiment lead to any new questions to test?
7. Pool the class data and analyze as a whole. Were your individual results consistent with the class results? If not, why might they be different? Did the experiment produce clear results? Did the class results prove your hypothesis or not? What challenges did you have? How could the experiment be improved?

Nurture a Native Garden Project
Part II: Starting Seeds and Growing Plants

Reflection

This project requires many steps, covers a great deal of time, and requires working in pairs and teams in a cooperative environment. What part of this project did you find the most fun or rewarding? What parts did you find most difficult? What did you learn about your strengths and weaknesses during this project? What did you learn about your working style over the course of this project? How does this fit with working in a team environment? What do you think are the benefits and weaknesses of working as part of a group? What could you do to make this a more positive experience? How do you feel your project will impact future generations?

Self Assessments

1. Discuss your understanding of seeds and their adaptations to the local environment.
2. Successfully participate in a group science inquiry experiment. Develop a hypothesis, gather and analyze data, make conclusions.
3. Submit a well-written report of your science inquiry project. Discuss individual and classroom data and its significance.

Resources

- Wild Ones: Native Plants, Natural Landscapes Landscaping with Native Plants Guide: http://www.epa.gov/greenacres/wildones/wo_2004b.pdf

TEACHER page

Nurture a Native Garden Project
Part III: Planting and Celebration

The more you praise and celebrate your life, the more there is in life to celebrate.

—Oprah Winfrey (contemporary)

Time Estimate:

2 or more sessions

Best Season:

spring

Overview

Plant out the fruits (or flowers) of your labor in your native plant garden! Students learn transplanting techniques, how to organize and carry out the planting day, and planning a garden celebration. The third stage of this project connects students with community through a service-learning project.

Teacher Hints

- Empower your students by offering them specific leadership roles in this stage of the project.
- Facilitate leadership by guiding students into planting day committees, working with students to outline individual duties, and helping them create reasonable timelines. Act as an advisor or mentor to the project. Be sure everyone is included and has a role that feels good.
- Additional community service connections: buddy up with an elementary school class and use the student storyboards to help instruct the young students in transplanting.
- Continue this project from year to year; hold a garden birthday party where everyone adds gifts to the garden through art projects, new plantings, or general maintenance. Extend the project by working with other schools or natural areas to add wildflower areas at their site. Collect and use your own seed. Sell seed or transplants as a fundraiser for the garden.

Assessments

1. Students draw and describe in a cartoon storyboard, or write out simple step-by-step directions, how to plant a transplant in the garden.
2. Students write a job advertisement and description for their role in the planting day celebration as if they were going to hire someone to do the job they did. Be sure to have a list of qualities that would make someone good for the job (e.g. organized, attention to detail, experience with native plants, etc.).
3. Students discuss the benefits of their project to the local ecosystem and to the community.

Additional Information

- Wild Ones: Native Plants, Natural Landscapes Landscaping with Native Plants Guide – goes into reasons, ethics, design, seed treatments, planting, local genetics: http://www.epa.gov/greenacres/wildones/wo_2004b.pdf

Preparation

- Prepare for pre-planting activity by making a copy of transplanting steps (see copy page at end of lesson), cut into strips, and placed in an envelope for each team of students. The transplanting steps are listed in the correct order on the copy page. You may wish to refer to this list as a key when helping students.
- Encourage your students to create transplanting storyboards as part of a community service-learning project, as well as to reinforce their learning.

Nurture a Native Garden Project
Part III: Planting and Celebration

The more you praise and celebrate your life, the more there is in life to celebrate.

—Oprah Winfrey (contemporary)

Overview

Plant the fruits (or flowers) of your labor in your native plant garden! Learn transplanting techniques, organize, and plant your garden area. Take a leadership role by organizing project committees and a garden celebration. Share your project with your community through your celebration, media coverage, or working on a planting project with a buddy class at an elementary school.

Learning Objectives

- Work as a group: form committees, plan project, outline individual responsibilities, create a timetable, and complete your planting project
- Learn and demonstrate proper planting technique
- Creatively share the project with other students and the community
- Increase your knowledge of the local ecosystem

Materials Needed

- transplanting sequence instruction slips
- storyboard template
- drawing materials
- shovels
- pin flags
- gloves
- water
- mulch
- celebration supplies

Vocabulary Words

- transplant
- mulch

Background Information

In the Nurture a Native Garden Project thus far you have learned about local native flowering plants, seed starting techniques, and how to grow transplants. In this third and final lesson you will plant your garden and celebrate your hard work and the birth of this garden with your community.

By creating a native plant garden that is adapted to local conditions, you are helping local ecosystems and the critters who use them. The native garden will provide habitat for wildlife and pollinators, and use fewer resources, such as water and fertilizer, than a garden of non-native ornamental plants. Native plants are adapted to local soils and climatic conditions (although these are changing as the climate changes). Like all new gardens, the newly planted native plants will appreciate a little added care the first year or two and will always require weeding and maintenance as vigorous non-natives try to invade. Learn and follow proper planting techniques so you will maximize the chances that your plants will survive. To protect the new plants from competition, hold moisture in the soil, and make new plants easier to find, be sure to mulch or spread a protective layer of compost, leaves, or other natural materials around the base of your plant. Don't forget to water throughout the first and possibly second summer, to establish healthy plants for the future.

There are several things that you can do to ensure the long term success for your project. Work with your teacher to create a plan for continued maintenance. Future classes can water, weed, and mulch established plants. Native gardens can use help defending against competition from invasive plant species. You can also collect seed and increase plantings each year by growing additional transplants. Work with the grounds maintenance staff and come up with a long-term plan to keep the garden happy and healthy. Encourage them to eliminate pesticide use on your schoolyard to protect local pollinators and wildlife that will be attracted to your plantings.

No matter the size of your project, planting day should be a celebration of your successes and a dedication for your native plant garden. Consider including a nature reading, original poetry, a song or art work at your celebration.

Nurture a Native Garden Project
Part III: Planting and Celebration

Background Information, continued

A large celebration could extend to the entire school or even be a community event. Invite guests such as your parents, principal, superintendent, the mayor, retired teachers, and your City Council and encourage them to help with the planting. Use the celebration as a service to educate the community on the benefits of a native plant garden. Create a guide to the native plants in the garden, or design a mural of the blooming plants to be enjoyed year round. Invite the media to cover your event and take pictures and submit a story to your school paper. Don't forget to acknowledge donors or volunteers that have helped make your project possible. Also remember to have fun! Your native plant garden is a great accomplishment and contribution to your native ecosystems and to your community!

Directions

Pre-planting activity:

1. Work in teams of 2-4 students.
2. Each team will receive an envelope of transplanting steps. Work as a team to arrange the slips in the correct order. When you are finished, check your order against the teacher's key.
3. Create a cartoon storyboard of transplanting steps to use with elementary students. Draw a simple illustration and number each step of the process in the boxes of the storyboard. Laminate the storyboard for outdoor use. Use the storyboards during a community planting or donate them to a young elementary class for a gardening project.

Organizing the planting:

1. Assemble a planting map. Use the maps from Part I, and add an overlay that marks the planting locations for your transplants. Take into consideration the mature size of the plants and space the planting sites accordingly. Mark the sites on the ground with pin flags (color coded flags if transplanting assorted species), making sure they correlate to the map.
2. Gather needed supplies: shovels, watering containers, mulch, pin flags, gloves, and planting map.

Planting Day:

1. Plant out your plants in spring when soils are dry enough to work. If you are unsure of timing, consult with local gardening experts (e.g. Extension Service, or garden nursery staff). Harden off transplants starting 2 weeks before your proposed planting date (see Nurture a Native II for instructions).
2. Gather all supplies and plants in the garden area. Review planting steps and walk through a planting demonstration.
3. Use the planting map to match the species to the planting location. Color coded pin flags will help you locate exact spots.
4. Start with planting sites in the middle of the garden and work towards the outer edges. This will help to prevent accidently trampling plants. Return the colored pin flag next to the new planting to help people avoid stepping on them.
5. Label plants with plant tags and mark the locations on the garden map. An accurate map will be essential for future monitoring of the site.
6. Set up a student watering schedule to help the new plants establish and get them through the dry summer months. Check with the groundskeeper; they may be willing to help over summer break.
7. Some native plants can be started by direct seeding in the fall or early spring. Use this method to supplement your plantings or if you are working in a very large area. Also, bulbs such as camas should be planted in the fall.

Nurture a Native Garden Project
Part III: Planting and Celebration

Directions, continued

Celebration:

1 Make planting day a celebration or plan a garden dedication. As with most large projects, they can be easier if broken into smaller parts. Divide the class into committees and delegate responsibilities. Keep the celebration simple; pick and choose what best fits your class and resources. Below are ideas you might consider, plus add your own.

- Invite the media to your planting day or act as your own press coverage. Take photos and submit an article to your local paper. Don't forget to include the who, what, where, when, and why.
- Have a ribbon cutting ceremony and invite the school board, school administrators, and staff. Choose a class representative and an invited guest to cut the ribbon together.
- Make a sign for your garden site.
- Create a local wildflower booklet or brochure to go with your garden.
- Videotape or photograph before, during, and after, write a summary, and put together a project scrapbook.
- Conduct a fundraiser for future garden maintenance expenses. Make and sell packets of native wildflower seed mix to parents and teachers. Include an information sheet with the seeds that explains the importance of using local native plants. Include a list of the plant species in the mix.
- Can you think of other ways to commemorate your project?

Taking It Further

Suggestions for a long-term commemoration of the project:

- Adopt a buddy class from an elementary school and invite them to your planting day and celebration. Alternately, visit their school and help them plant a native plant garden. Lead a wildflower craft project or create a game to use for the day.
- Commemorate your garden project artistically: create a mural (paint on a wall that is adjacent to the garden area, or on canvas to hang indoors), make mosaic stepping stones, build a bench or a cob garden art structure, make a fabric or paper artwork quilt for the school hall, make a scrapbook and include student garden-inspired art work, hold a poetry contest.

Nurture a Native Garden Project
Part III: Planting and Celebration

In the Field!

Grow extra transplants and share with the community by planting in parks and public natural areas. Approach your city, county, or state parks offices first. Explain your project and the benefits to the local ecosystems. Ask for permission and guidance to locate proper planting locations. You might even find that if you approach the parks department before starting your project they might donate money, supplies, or knowledge to help you.

Science Inquiry

Investigate different mulching materials. Set up a test plot in your garden area that has similar soil and sunlight conditions. Plant a row or transect of 24 plants of the same species and condition, 2-3 feet apart depending on the size of the plants. Test 6 different mulching materials using four plants along the transect for each material. Mulch ideas might include: woodchips, compost, cardboard, plastic, straw, and others. Be sure that all the test plants receive the same amount of added water over the test period. Monitor for several months, or years, if possible. Gather data on the size and vigor of the plants, as well as the effectiveness of excluding weed growth at the base of plants.

Reflection

Read the section from *A Sand County Almanac* by Aldo Leopold that corresponds to the month you are in. Aldo Leopold was attuned to the natural world and appreciated even the smallest parts of his ecosystem. Write about your environment, tuning into the smallest pieces. What did you learn about your environment in this project? What is happening in your garden right now? How does the native wildflower garden connect you to the larger ecosystem? Something will be happening in your garden every moment of the year. Even when it appears that very little is happening, challenge yourself to find something. Remember to think about processes that you cannot see, inside plants or below the soil's surface.

Self Assessments

1. Rate yourself as a committee member. Did you participate in making decisions, volunteer for a task, complete your task by the timetable, and work well with others?
2. Give instruction or demonstrate the steps to transplanting plants into the garden.
3. Describe the benefits of the native plant garden to the local ecosystem.

Resources

- Leopold, Aldo. 1949. *A Sand County Almanac.* Oxford University Press, USA.

Nurture a Native Garden Project
Part III: Planting and Celebration

Preplanting activity. Transplanting sequence instruction slips: make a copy, cut into strips, and place in an envelope for each team of students.

- Dig a hole (as deep as and wider than the pot) and place the soil carefully to the side.
- Support the top of the plant with your hand across the top of the pot, being careful not to crush the plant, and turn the pot upside down.
- Gently squeeze or tap the pot to release the plant.
- Tease the roots out, if they are tightly coiled around in a circle, loosen the roots to encourage new growth.
- Place the plant in the ground so that the crown (where the stem and roots meet) is right at the soil surface, not above or below.
- Make sure the roots are pointing down and out (not up) especially at the tips.
- Refill the hole with the dirt removed when digging, making sure to fill in all around the roots.
- Gently press the dirt around the plant to fill air holes and completely cover the roots.
- Mulch around the base of the plant to conserve moisture and suppress weed competition.
- Water.
- Stand back and admire your work. Wish your plant luck out there in the wild!

Nurture a Native Garden Project
Part III: Planting and Celebration

Storyboard Template

TEACHER page

Weed Explosion

A weed is a plant whose virtues have not yet been discovered.

—Ralph Waldo Emerson (1803-1882)

Time Estimate:

Classroom: 1 session. Hands-on: 3-4 sessions over 2-week period.

Best Season:

Spring, Fall

Overview

Students will learn the characteristics of invasive plants, how they affect species and ecosystems, and the human impacts of their invasion. Students will examine a widespread Oregon weed, bull thistle, and study its affects using a mathematical simulation to track a bull thistle introduction and expansion. Students will explore what happens when one seed of bull thistle lands in a vacant lot, create a data table, and graph the growth of the adult population over a five-year period.

Teacher Hints

Taking it Further hints:

- Noxious weeds are defined under the Oregon Revised Statutes. Students can explore Oregon's laws regarding invasive species and learn about the different invasive classifications
- The Oregon Department of Agriculture website also has a weed mapping feature that allows students to view reported infestations of different species of noxious weeds by county.

Science Inquiry hints:

- Look for dandelion seed heads during spring and early fall. They should be readily available on the school grounds, nearby disturbed areas, roadsides, or gardens.
- Review dandelion identification; it is important that all students collect the same species of weed seeds. Other common yard weeds have flowers and/or seed heads that look similar and can be mistaken for dandelions.

Preparation

- Introduce students to the factors that limit the spread of plants: natural limits (e.g. disease, predators, geographic, soil, and climatic limitations) as well as human limits (e.g. herbicides, pulling). Brainstorm with your students to create your own definition of a weed, and discuss the related terms from the vocabulary list. What makes a weed an invasive plant? Are all weeds invasive? Are all non-native species weeds? Are there any native species that are weeds? Lead the class into listing the characteristics of what makes a plant a weed. Do invasive plants have the same limiting factors as native plants, why or why not?

Additional Information

- Alien Invasion Curriculum, an invasive plant K-12 curriculum: http://www.weedinvasion.org/weeds/weed_home.php
- Cornell Environmental Inquiry Program, science inquiry program for high school age students—Invasion Ecology: http://ei.cornell.edu/
- Oregon State University Dept. of Rangeland Resouces. (2004). Weedmapper: Bull thistle. Retrieved from: http://www.weedmapper.org/civu.html
- Vaccaro, Lynn. *Breaking into the Seed Bank*, High School Lesson: http://csip.cornell.edu/curriculum_resources/CSIP/Vaccaro/Vaccaro_Seed.asp

Assessments

1. Use math skills to complete data tables, figure percentages, and graph data
2. Name 4-5 characteristics of invasive plants
3. Discuss the difference between eradication and control and where each is appropriate
4. Identify several ways that invasive plants are introduced and strategies to prevent their spread

Weed Explosion

A weed is a plant whose virtues have not yet been discovered.

—Ralph Waldo Emerson (1803-1882)

Overview

What is a weed and what makes a weed an invasive plant? Learn how invasive plants affect Oregon's ecosystems, how to prevent invasive species introductions, and how introductions are being managed statewide. Look at one invasive species, bull thistle, found throughout the state of Oregon. Use a simulation to model a bull thistle introduction and create a graph to show its growth and spread over a five year period.

Learning Objectives

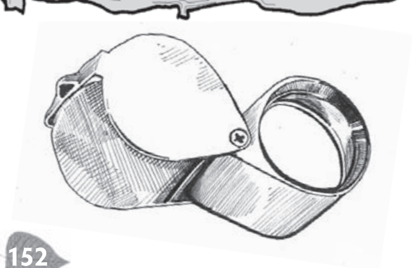
- Become familiar with weedy vocabulary
- Gain insight into the traits that allow a species to become an invasive
- Identify ways that invasive plants can disrupt the balance of an ecosystem, as well as cause economic damage
- Use mathematical skills in making predictions, data collection, and graphing

Materials Needed

- bull thistle worksheets
- graph paper
- colored pencils
- calculator

Science Inquiry section

- shallow planting tray
- sterile potting soil
- dandelion data sheet
- zip lock bag



Background Information

Invasive plants are a growing threat to native plant populations worldwide. Disturbances to ecosystems can result from natural causes such as wildfires, disease, or normal succession cycles, as well as from human causes. Whenever land is disturbed (by cultivating, logging, housing developments, or road maintenance) then left bare, there is an opportunity for invasive plants to take hold.

Due to our modern mobile, global society, people are the prime cause of the spread of invasive plants. Humans often contribute to the spread of invasive plants without even being aware. Exotic plants are brought into gardens from all parts of the world, with little knowledge of the consequences of the plants' impact on the local ecosystem. Seeds can travel embedded in the tread of car and bike tires, and even on the bottom of your shoes. Humans are not the only means of spreading seeds. Wildlife and pets can carry seeds on their fur, eat and deposit them in their feces; and birds deposit seeds along fence rows and under trees where they perch. Seeds can even catch a long ride on the feathers and feet of migrating birds.

It is very difficult for scientists to predict which plants will become invasive and which will not. However, not all introduced plants become invasive. Many that do are generalists, tolerating a wide range of growing conditions. Often, they are able to reproduce quickly, tend to produce abundant seed, and disperse their seeds with ease—all traits that give them a jump on slower growing native plants. Their large numbers of seeds frequently overwinter in the top layers of soil to form a seed bank that can remain viable for years. The seeds in the seed bank wait until the conditions are ideal for germination, and then grow rapidly. Introduced plants that become invasive also have few natural population controls in their new environment. By colonizing a new place, they leave behind the diseases, parasites and predators that may have helped to control their population in their native ecosystem. In fact, many species that become invasive are rare in their homeland, but once they escape disease and predators in their newly invaded home, their population can explode under the right conditions.

There are many terms to describe

Weed Explosion

Background Information, continued

introduced species that often can be misleading or confusing. Invasive, introduced, weed, non-native, exotic, and noxious are all words that are frequently used to describe plants that are not native to an ecosystem. However, not all of these plants become invasive and cause problems. Most landscaped yards are filled with beautiful plants that do not endanger native ecosystems; these plants can be called introduced, non-native, or exotic. Weed is a generic term that is commonly used to refer to troublesome plants, but the term weed can also be used to describe any plant that grows where you do not want it. Many native plants could be consider weeds if they grow where people do not want them. For example, a Douglas fir or bracken fern growing in the middle of a prairie can be considered invasive, despite the fact that they are native to the surrounding area. The term "noxious plant" actually has a legal definition: "any plant designated by a Federal, State, or county government as injurious to public health, agriculture, recreation, wildlife, or property" (1).

Why should we be concerned about invasive plants? Invasive weeds have been identified by many land management agencies as the number one obstacle to promoting healthy ecosystems (2). Invasive plant populations can rapidly expand to dominate natural plant communities, destroy wildlife habitat, reduce plant and animal diversity, and cost millions of dollars to control or in losses of land productivity. Not all weeds are bad however, depending on who you ask. If you ask the endangered Taylor's checkerspot butterfly, it will tell you it is quite fond of English plantain *(Plantago lancebiata)*, an introduced species on which it nectars. Although researchers are not sure, it is possible this butterfly once nectared on the sweetness produced by golden paintbrush *(Castilleja levissecta),* which was once common in Willamette Valley prairies but is now extinct in Oregon.

Invasive plant management, conducted to slow the economic and environmental effects of weeds is usually broken into two categories, control or eradication. In many instances invasive plants that you are familiar with, Himalayan (armenian) blackberry *(Rubus armeniacus)* and Scotch broom *(Cytisus scoparieus),* for example, are so common and widespread that there is little hope of eradicating them from the Oregon landscape. Instead the focus on these species is on maintaining control, limiting new expansions and eliminating them where possible or needed for restoration purposes. Early detection of new invasive species is handled differently. Such plants have been targeted because they are problems in neighboring states, but not yet a major problem in Oregon. For example, at the time of this writing garlic mustard *(Allaria petiolata),* a

Vocabulary Words

- native
- non-native
- germination rate
- weed
- noxious
- invasive
- exotic
- introduced
- seed bank
- germination
- eradication
- biennial
- perennial
- annual
- viable
- colonize
- biocontrol

Weed Explosion

Background Information, continued

common invasive in the northeastern U.S., is being discovered here and there in western Oregon. By training people to recognize these species early, and with sufficient effort to remove them when they are found, eradication (complete elimination) may be possible.

Methods to control invasive plants can be grouped into four categories: prevention, mechanical (mowing and fire), biological (releasing insect or disease predators and parasites), and chemical (herbicides) control. Prevention is the least expensive and the least harmful to the environment but involves extensive coordination throughout the state to be sure that all are aware when a plant species is a threat. Mechanical methods of control generally involve interrupting some stage of plant life cycle by hoeing, mowing, cutting, burning, or mulching to kill the plant or to prevent seed production. Biological control methods often use herbivory to the plant, such as grazing or insect control, or disease causing organisms to control specific plants (bio-control). Chemical control uses herbicides to kill the plant or chemical means to suppress seed germination. Challenge yourself to identify ways that you may inadvertently spread invasive plants, and what steps you could take to prevent the spread.

Taking It Further

- Visit the Oregon Dept. of Agriculture website: http://oregon.gov/ODA/PLANT/WEEDS/ and compile a list of invasive plant species for your ecoregion. Oregon has an "A" and "B" list of noxious weeds; what is the difference between the two? Click on the "Profiles—noxious weed" link to view a county range map and locate invasive plants in your county. Educate others at your school or in the community by creating a weed guide on a school bulletin board with photos and descriptions.

Directions

Observe plant defenses:

1. Work with a partner or individually.
2. Read through the Bull Thistle Introduction Scenario, then fill in the life history table. Bull thistle is a biennial, a plant that lives for two years, and does not produce seed until the second year. For our calculations, the mature plant dies the second year after producing seed. This information is key to your calculations.
3. Use the life history table to compute the formulas for the worksheet. Double check your formulas before continuing.
4. Year 0 on the worksheet represents the bull thistle introduction (a seed arriving in hay) and is filled in for you. Use your formulas to complete the remaining years on the worksheet.
5. Graph your results. Make a line graph showing the size of the adult plant population over time as well as the accumulating seed bank. Add a caption to your graph, and label the axes to show units and scale.
6. Map how far the bull thistle could spread over a 5-year period, if wind disperses the seed. Use graph paper and place a dot on the midpoint of your paper to represent your first plant. Assume there are no landscape barriers to seed dispersal. How far could the thistle's offspring spread from the original parent plant? Use an appropriate scale for your graph paper and draw a circle around your initial plant showing the distance that the seeds will travel each of the five years of the model. Your map will show circles that

Weed Explosion

Directions, continued

enlarge each year as the seeds travel outward. Use meters as the scale to compute this spread.

7 Looking at your graph, compute the total square meters that the bull thistle could cover at the end of the 5-year model. How does this compare to the size of a football field?

8 Discussion questions: What happened to the numbers of adult bull thistle plants over the 5 year period? What happened to the number of seeds in the seed bank? What kind of growth curve do the graphs show? Can you explain the pattern in the numbers in the early years? Do you think you would see a similar growth pattern in perennial or annual species? What advantages or disadvantages do you see for plants that are annuals, biennials, and perennials? What would happen if some students came in year three and helped out by pulling half of the adult plants? How would that change the spread of the species?

In the Field!

Take part in an invasive weed removal project. Local parks or public lands are in need of your assistance. Think how a class full of energetic weed pullers can make a difference. And, you won't have to take any tests or quizzes while you are out there! Consider making it a long-term project. Adopt an area and return for monthly weed patrols, and you will make a lasting difference for your community!

Science Inquiry

Part I

- Use the common dandelion *(Taraxacum officinale)* to compute germination rates on your own. Dandelions have a spring blooming season and a secondary fall bloom period. Proper plant identification is important; review your plant identification before collecting seed heads. Other common yard weeds can have similar seed heads that can be mistaken for dandelions.
- Working with a partner, locate and carefully pick an entire mature dandelion seed head and place in a Ziploc bag to prevent seed loss. Count the number of buds, flowers, and seed heads present on the plant and record the number.
- Return to the classroom. Make a prediction of how many seeds are on your seed head (each person should make their own prediction) and record your predictions.
- Carefully remove from the baggie and count the seeds (save all the seeds!) and record the number. Work on a sheet of dark colored paper to make seeds easier to see. Use forceps, a toothpick, or a pencil point to push them to the side as you count them. Make a tally mark for each 10 seeds and then total your tallies at the end. Compare your actual count to your prediction. How close was your prediction?
- Compare your seed count numbers with the rest of the class; are the numbers similar or do they vary greatly? What could be some of the reasons for this?

Weed Explosion

Science Inquiry

Part 2

1 Plant all of the seeds from your seed head into a shallow planting tray: Mark the tray with your name(s). Fill a pan halfway with moist, sterile potting soil. Spread the seeds evenly over the soil surface, firmly patting the seeds into the soil. The seeds will need good contact with the soil to germinate but should not be covered. Mist with a water bottle to make the soil damp but not soggy. Place plastic wrap over the tray to retain moisture. Why might you want to use sterile potting soil instead of garden soil?

2 Place your trays in a sunny windowsill. Keep them moist and check periodically for sprouting seeds. Keep a tally of the seeds that germinate and remove them with a tweezers. This will ensure that you do not count the sprouts more than once. Record the number each time you remove sprouts. Continue gathering sprout data for 2-3 weeks. Dispose of the seedlings responsibly—don't spread invasive plants!

3 Tally the final number of seedlings. Calculate the germination rate, or percentage of the seeds that germinated using the total number of seeds planted.

4 Use your germination rate to make additional predictions. Take the number of buds, flowers, and seed heads from your original plant to predict the how many seeds one mature plant could produce. Record the number. Why is this number a prediction and not concrete data?

5 Extend the activity to monitoring one dandelion plant for an entire season. Flag your plant and visit daily, pick all flower heads and buds, and keep a tally of how many you collect. How many seedlings can one mature dandelion plant produce? Calculate this by multiplying the number of flower heads by the number of seeds per flower head, then multiply the result by your germination rate. How did this compare to your predicted number (see #4)? Is this an accurate number, why or why not?

6 Class discussion: Compare your data. How much variance was there? What could be the reason for differences? How many seedlings do you think would actually survive outside, and why? How could you gather data on total yearly production? How could you test the seedlings for survival rates? What else do you wonder about?

Reflection

Ask yourself, why should you be concerned about invasive weeds? What are some ways to prevent invasive weeds from spreading? What are some natural factors that might limit the growth of weeds? How do humans inadvertently spread weed seeds? Are all invasive species bad? What are some situations when they might benefit humans or an ecosystem?What could you do to help prevent the spread of weeds? What are some of the ecological consequences of the spread of invasive weeds? What are some of the economic consequences? Name some factors that might limit the viability of seeds in the seed bank? Can you think of any reasons weeds are beneficial?

Weed Explosion

Self Assessments

1 Use mathematical skills to compute weed germination rates, survival rates, and to make graphs.

2 Name 5-6 characteristics of invasive plants.

3 Discuss the difference between eradication and control and where each is appropriate.

4 Explain two ways that invasive plants can damage an ecosystem.

5 Identify one way that people spread invasive plants and one or two strategies to prevent that spread.

Resources

- USDA PLANTS database for pictures: http://plants.usda.gov/
- Oregon Dept. of Agriculture noxious weed site: http://oregon.gov/ODA/PLANT/WEEDS/ view noxious weed profiles to find species that are a problem in your area of the state
- California Dept. of Food and Agriculture. Encycloweedia Data Sheets, *Thistles.* http://www.cdfa.ca.gov/phpps/IPC/weedinfo/cirsium.htm

Bull Thistle *(Cirsium vulgare)*

Introduction Scenario

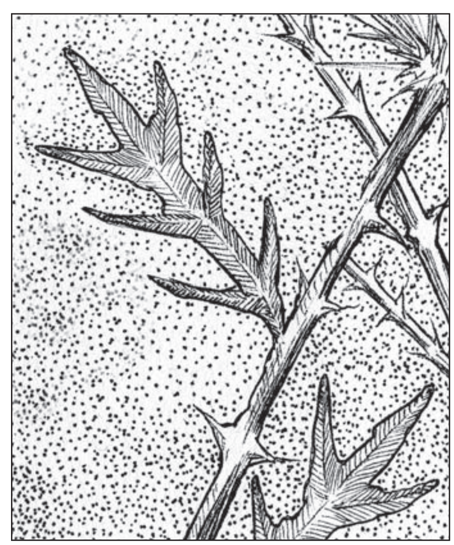
Description:

Bull thistle *(Cirsium vulgare)* is native to Eurasia and is now widely established across North America. It has large spines on hairy leaves and large purple flower heads. Bull thistle can be found in all parts of Oregon and is thought to have been accidently introduced multiple times through contaminated seed sources. It is commonly found in disturbed areas and will spread into farmland, pasture, rangeland, and recently logged sites. Found in sunny locations, it can displace native and cultivated grasses and forbs. Bull thistle is a biennial and produces seed on mature second year plants. After seed production the plant dies.

Introduction Scenario:

A bull thistle was introduced to Oregon in a bale of hay brought in to supplement winter elk feed on the grasslands in the northeast part of the state. The bale was considered high quality hay, but accidently contained one mature bull thistle plant. Bull thistle seed heads contain anywhere from 100 to 300 seeds each and plants can produce anywhere from 1 to 400 seed heads. These figures depend on many factors such as nutrition, soil, competition, and water available to the plant throughout its life.

In our model, bull thistle is introduced to a healthy grassland ecosystem. In this scenario, the thistle will have to compete for several resources and will produce only 20 seed heads per adult plant. Research shows that 95% of the seeds that bull thistle produces are viable and capable of germinating. In our grassland, only 15% will germinate the first season. This reduced germination rate could result from a healthy vegetation



Weed Explosion

Introduction Scenario, continued

layer covering the ground that prevents many seeds from coming into contact with soil. In this environment, only 1% of seeds that germinate will survive the rigors of nature to become tiny seedlings. Survival can be challenging even for invasive plant species. All plants need sufficient water, sunlight, and nutrients to make it through the summer, and in our model, only half will live through that first summer. The seedlings that do survive will start to grow and make a rosette (whorl of basal leaves), increasing their footprint and giving the plant more space to collect the necessary resources. Once a bull thistle becomes a rosette, it develops sharp spines on the leaves that deter many animals from eating it. These spines help to increase the chance of survival, and 97% of these rosette stage plants will now survive to maturity and produce seed.

Bull thistle seeds have feathery appendages to allow for wind dispersal, but easily detach when the seed is mature. This means the vast majority of mature seeds fall near the parent plant, but some of the seeds are transported by wind and establish plants in new locations. Scientists who study invasive plants use advanced models to calculate distances that seeds can travel under optimal conditions. These studies suggest that up to 10% of bull thistle seeds may travel more than 27 meters with relatively little wind.

What happens to the remaining viable seeds that did not germinate? Under the correct conditions, this seed can be stored in the upper layers of the soil or thatch, waiting to sprout when the conditions are right. This natural storehouse of seeds is called the seed bank. Seeds may remain dormant in the seed bank for different durations, depending on physical factors such as the seed coat and exposure to the elements. Some invasive plants such as field bindweed have seeds that can survive in the seed bank for 60 years or more! Bull thistle seeds have a relatively short life in the seed bank, remaining viable for no more than five years. In our model, 50% of the seeds in the seed bank will germinate in the following year; while the other 50% will remain in the seed bank.

Use the information in the text above to complete the life history table.

Weed Explosion

Life History Table

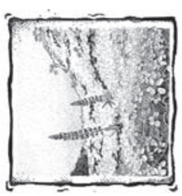
Topic/question	Answers
1. Plant life history (annual, biennial, perennial)	
2. Average number of seeds in a seed head	
3. Number of seed heads per adult plant in this model	
4. Percentage of new seeds that are viable	
5. Percentage of viable seeds that will germinate	
6. Percentage of germinated seed that will establish seedlings	
7. Percentage of seedlings to survive 1st year to become rosettes	
8. Percentage of rosettes that become 2nd year adult plants	
9. Distance that seeds can travel by wind on relatively calm day	
10. Percentage of seed bank seeds that will germinate each year	

Data taken from: http://www.fs.fed.us/database/feis/plants/forb/cirvul/all.html

References: Zouhar, Kris. 2002. *Cirsium vulgare*. *In:* Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2008, November 5].

Answer Key Life History Table

Topic/question	Answers
1. Plant life history (annual, biennial, perennial)	Biennial
2. Average number of seeds in a seed head	200
3. Number of seed heads per adult plant in this model	20
4. Percentage of new seeds that are viable	95%
5. Percentage of viable seeds that will germinate	15%
6. Percentage of germinated seed that will establish seedlings	1%
7. Percentage of seedlings to survive 1st year to become rosettes	50%
8. Percentage of rosettes that become 2nd year adult plants	97%
9. Distance that seeds can travel by wind on relatively calm day	27 meters
10. Percentage of seed bank seeds that will germinate each year	50%



Weed Explosion

Bull Thistle Introduction Model

(Year 0 is filled in for you)

year	(1) #new seeds	(2) #viable new seed	(3) #new seeds germinate	(4) #of seeds in seed bank	(5) # seed bank seeds germi-nate	(6) total # of seeds that germinate	(7) Become seedling	(8) #rosette plants	(9) #adult plants
0	4000	3800	570	0	0	570	5	2	0
1									
2									
3									
4									
5									

Formulas: (Use figures from the Life History Table)

Column 1 = Calculate the # of seeds from one adult plant = Column 9 x (# of seed heads per plant) x (the average # of seeds per seedhead)
Column 2 = How many of those seed are viable? = Column 1 x (% of new seeds that are viable)
Column 3 = # of viable seeds that will germinate in our grassland = Column 2 x (% of viable seeds that germinate)
Column 4 = # of seeds in the seed bank = (previous year column 2 – previous year column 3) + (previous year column 4 – previous year column 5)
Column 5 = # of seeds in the seed bank that germinate this year = Column 4 x (the % of seeds in seed bank that germinate)
Column 6 = Total # of seeds that germinate this year = Column 3 + Column 5
Column 7 = # of germinated seeds that become seedlings = Column 6 x (% of germinated seed that will establish seedlings)
Column 8 = # of seedlings that establish year old rosette plants = Column 7x (% of seedlings to survive first year)
Column 9 = Total # of 2 year old adult plants = previous year column 8 x (% of rosettes that become 2nd year plants)

Weed Explosion

Bull Thistle Introduction Model

(Answers Key)

year	(1) #new seeds	(2) #viable new seed	(3) #new seeds germinate	(4) #of seeds in seed bank	(5) # seed bank seeds germi-nate	(6) total # of seeds that germinate	(7) Become seedling	(8) #rosette plants	(9) #adult plants
0	4000	3800	570	0	0	570	5	2	0
1	0	0	0	3,230	1,615	1,615	16	8	1
2	4,000	3,800	570	1,615	807	1,377	13	6	7
3	28,000	26,600	3,990	4,037	2,018	6,008	60	30	5
4	20,000	19,000	2,850	24,628	12,314	15,164	151	75	29
5	116,000	110,200	16,530	28,464	14,232	30,762	307	153	72

Formulas:
Column 1 = column 9 x 4,000
Column 2 = column 1 x .95
Column 3 = column 2 x 0.15
Column 4 = (previous year column 2 minus previous year column 3) + (previous year column 4 minus 5)
Column 5 = column 4 x 0.5
Column 6 = sum of column 3 and column 5
Column 7 = column 6 x 0.01
Column 8 = column 7 x 0.5
Column 9 = previous year column 8 x 0.97

Column 1 - Figure the number of seeds from one adult plant (column 9 x 4,000 or 1 x 200 x 20=4,000)
Column 2 - How many of those seed are viable (column 1 x 0.95)
Column 3 - What percent of viable seed will sprout in our grassland (column 2 x 0.15)
Column 4 – Number of seeds in the seed bank (previous year column 2 minus column 3 + previous year column 4 minus 5)
Column 5 – The number of seeds in the seed bank that germinate this year (column 4 x 0.5)
Column 6 – The total number of seeds that germinate this year (sum of column 3 and column 5)
Column 7 – The number of germinated seeds that become seedlings (column 6 x 0.01)
Column 8 – The number of seedlings that establish year old rosette plants (column 7 x 0.5)
Column 9 – The total number of 2 year old adult plants (previous year column 8 x 0.97)

Measuring and Monitoring Plant Populations

An experiment is a question which science poses to Nature, and a measurement is the recording of Nature's answer.
— Max Planck (1858–1947)

Time Estimate:

15-30 minute introduction,
60 minute field session

Best Season:

spring/
summer

Overview

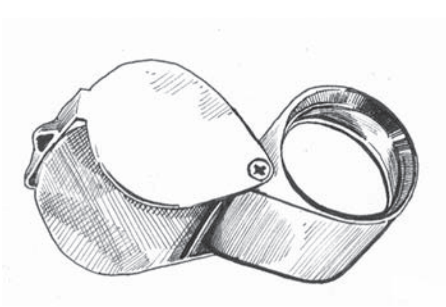
When botanists and ecologists work in the field, it is not practical or possible for them to count and measure every plant. If this is the case, how do they collect accurate data on plant populations? Field biologists use different methods of sampling portions of a larger population or plant community to collect data that is representative of the whole. The data can then be used to describe the overall population or habitat. This lesson will introduce you to several methods of sampling plant populations and the different types of data that can be collected.

Teacher Hints

- Differential education—ways to adjust the level of this lesson:
- To introduce more difficulty, add additional sampling methods for more advanced students to compare.
- To simplify the lesson, reduce the sample size or reduce the types of data collected.

Assessments

1. Students can explain what sampling is and discuss the strengths and weaknesses of using sampling as compared to a census to measure plant populations.
2. Students can describe two or more methods of sampling plant populations and discuss their applications.
3. Students can describe two or more types of data to collect and their applications.



Preparation

- Students should complete the exercises in the Estimating Percent Cover worksheet before attempting the lesson.
- Students will conduct a plant population survey to sample one common (abundant) and one uncommon (rare) plant within the survey area. Choose an area to support such a set up. A natural meadow would supply an area for several student teams to work.
- Break the class into teams of two to four students. Each team will conduct a survey in the same general area. Students can then compare and discuss results.

Additional Information

- Elzinga, C. L., Salzer, D.W., & Willoughby, J.W. *Measuring and Monitoring Plant Populations.* Bureau of Land Management. BLM technical reference manual 1730-1, BLM/RS/ST-98/005+1730: http://www.blm.gov/nstc/library/pdf/MeasAndMon.pdf (this document is large and takes time to download)
- Cornell University and Penn State University, Environmental Inquiry for high school students, Invasive Species: http://ei.cornell.edu/ecology/invspec/

Measuring and Monitoring Plant Populations

An experiment is a question which science poses to Nature, and a measurement is the recording of Nature's answer.
— Max Planck (1858–1947)

Overview

When botanists and ecologists work in the field, it is not practical or possible for them to count and measure every plant. If this is the case, how do they collect accurate data on plant populations? Field biologists use different methods of sampling portions of a larger population or plant community to collect data that is representative of the whole. The data can then be used to describe the overall population or habitat. This lesson will introduce you to several methods of sampling plant populations and the different types of data that can be collected.

Learning Objectives

- Become familiar with methods of sampling plant populations and their applications
- Explore different plant population attributes that can be measured (e.g., percent cover, presence/absence, counting individual plants) and their applications
- Use a sampling protocol to collect different types of data and compare two plant populations
- Analyze data and interpret results

Materials Needed

- metric measuring tapes
- quadrat frames (directions to make meter squares in Appendix VIII)
- clipboard/data sheet/pencil
- wooden stakes
- compass
- field guides

Background Information

Botanists and ecologists sample plant populations to achieve several objectives, including monitoring or "keeping tabs" on a population of rare plants, comparing the results of habitat treatments in an experiment, or determining the impact of an activity (e.g., building a new road through a sensitive habitat, wildfire, or grazing) on a plant population.

When you are out in the field there are many things you can measure and monitor. For example, on an individual plant, you could measure its height, the number of leaves, flowers, or fruits it has, or the number of other species within a certain distance of it. For a population of a certain species, you could record the total number of individuals, the amount of land it covers, how many reproductive individuals versus those not reproducing, and many other traits. For a community, you could measure the number of species, how many individuals of each species there are, how those species are distributed over the land, the slope of the land, the azimuth (which direction the slope faces), and many other traits. So, given limited amounts of time and money, and with specific objectives, how does an ecologist decide which types of data to collect and how and when to collect them? It depends on the question of interest for the study or experiment. Some common types of data collection to meet different objectives are listed below.

Presence/absence: Is the species of interest present or not? This is likely the fastest and easiest type of data to collect; however, it only lets the researcher know if the species is present or absent. It does not provide information about its abundance, dominance, or distribution within the habitat.

Vocabulary Words

- transect
- plot
- quadrat
- percent cover
- plant population
- frequency
- azimuth

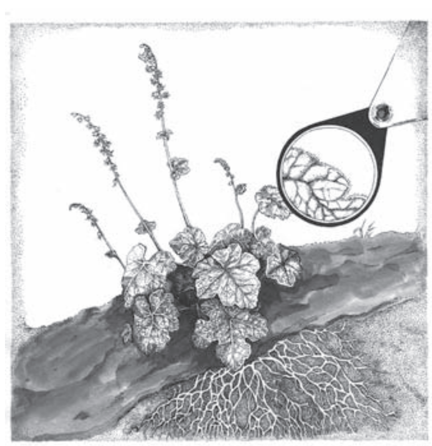
Measuring and Monitoring Plant Populations

Background Information, continued

Frequency: This tells us the percentage of plots within a larger sample in which the species is present. For example, if ten plots are placed in a meadow, and species A is present in one of the ten, it has 10% frequency. This measure of the plant population does not indicate how abundant the plant is. In the example above, even if there are five of species A in one out of ten plots, species A's frequency within the sample is still only 10%. Similarly, if species A is found in only one plot of ten, its frequency will be the same regardless of if it takes up 100% of the area in that plot, or is just found taking up less than 1% in a little corner. Advantages of frequency data are that it is quick to collect, easy to compare between species, and similar results can be obtained in different seasons of the year (e.g., if a seedling of species A or a mature plant of species A is present, the data will be the same).

Percent cover: This is a measure of the proportion of the ground (often within a plot or transect) covered by the body of a plant (from a bird's eye view). This method is extremely useful for plants that spread clonally (e.g., grasses or aspen), or for plants that may produce multiple stems that appear to be multiple plants or where counting individuals is unreasonably time consuming. This is a very useful measure for comparing the abundance of different species. A drawback of measuring cover is that it can vary drastically for an individual plant over the course of the growing season and can be more difficult for researchers to make an objective and accurate measure. This measure is commonly used in plant community research involving multiple species. This method works best for species that are evenly distributed through the area to be sampled and works less well for species that are very patchy or found only along the edges.

Population estimates: If a population is too large in extent or number to feasibly measure or count every individual, sampling is used to estimate the size of the population without actually counting every plant. During sampling, a representative portion of the population is counted and then this data is extrapolated to estimate the size of the entire population. For this method to be legitimate, the part of the population that is counted (the sample) must be selected carefully, in an unbiased manner and must also be representative of the rest of the population as a whole. Frequently, randomization is used to choose the sample, so that every part of the population has an equal chance of being chosen for sampling.



Census (complete population counts): This is the preferred method when possible. No statistical analysis is required and therefore any changes in counts from year to year are real. A drawback to this method is that it can be extremely costly in person power, time, and money.

What determines which sampling method one should use and the type of data to collect? Factors including population size and distribution, the area to survey, the time available, and the ecosystem characteristics (e.g., density of vegetation, slope, etc.) must be considered. The researcher may select one of many possible sampling methods and layouts to use during the survey, including the following:

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

Measuring and Monitoring Plant Populations

Background Information, continued

initial (baseline) photos to evaluate change over time.

Transects: These can be long, narrow strips or wide belts that traverse the landscape. The area within the boundary of the transect is sampled and transects are placed randomly or in intervals across the area to be sampled. Target species within the transect can be counted or percent cover of any or all species present can be assessed. Transects can also be a line (essentially, a very narrow belt); in this case, often the presence of all species that occur along the line or at specific intervals along the line are recorded. Long transects may be easier to establish in some habitats (e.g., prairie) than others (e.g., dense forest). The longer a transect is, the more likely it is to capture variation within your population. Transects are especially useful when the target species you are trying to monitor is patchy on your landscape. Transects are usually placed parallel to one another on the landscape and then run at the same azimuth (angle). The number of transects needed to describe a larger area will depend on how variable the habitat is, the size of the transect, and the size of the area to be sampled.

Plots: Plots are often square, although they can also be round or rectangular, areas within which data are collected. Square plots are often called quadrats. The size of plots can vary with sampling method, though one meter square plots are common. As with a transect, if the purpose of the plots is to describe a larger area, the plots need to be randomly placed (e.g., using a set of random numbers as coordinates to position plots in a grid overlain on the site). The number of plots needed to describe a larger area will depend on how variable the habitat is, the size of the plot, and the size of the area to be sampled.

Once you have collected your data, the next step is data analysis. Until you do this you just have a bunch of numbers on a piece of paper. Your analysis will be guided by the objectives of your study. If the purpose is to compare two (or more) parts of a plant population, perhaps to test a hypothesis, the data collected needs to be evaluated to determine if a statistically significant difference exists, and how likely it is that any observed difference has not just occurred by chance.

Directions

1. Work in teams of 3-4 students.
2. Choose one common and one less common plant species that you will sample in your survey or decide to sample all species. Make sure you can recognize younger and older or flowering and non-flowering individuals. Decide as a class whether the entire class will use the same two plants, or whether each group will do different ones.
3. Set up a 50 meter long transect in your study area. Make sure you are not biasing the placement of your transect. In your groups, develop a method to randomize the direction (azimuth) of your transect. Use a compass to lay out your transect. Be sure that your transect intersects populations of your common and uncommon plants.
4. Once your transect is established, collect data every 5 meters starting at the 5 meter mark along the transect line, by placing the bottom left corner of a 1 meter square quadrat frame at the meter mark and lining it up with the tape (if the bottom left corner is at 0 m, the bottom right corner should line up at 1 m, etc).
5. At each sample point (5 m, 10 m, etc.) collect three types of data (presence/absence, percent cover, and a complete census) for both the common and uncommon plant species. Collect your last data at 50 m, so you have a total of ten samples.

Measuring and Monitoring Plant Populations

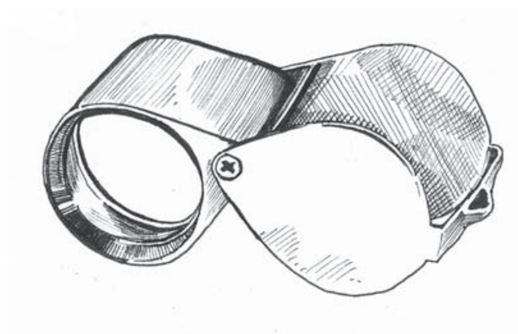
Directions, continued

6 Compile your data in a spreadsheet. Calculate the frequency (% of plots in which your species is found) at which each species was present in your sample of ten plots. Calculate the average, maximum and minimum percent cover for each species. Average your census data for each species. Do the same techniques yield similar or different results?

7 Discuss your results as a class. Which type of data most accurately represents the difference you think you observed between the common and uncommon plants? Weigh the efficiency and speed of data collection against the usefulness of the information you collected. Which methods were best for the plants you studied? How could you change your methods to collect more accurate data?

Taking It Further

Create a visual display to illustrate the differences between the three types of data. Create bar graphs comparing the data from each of the three methods with a bar for the percentage of that species estimated using each of the three techniques. Do this for each species you studied. Are the three bars similar or is there a big difference in the percentage each estimated? How do the three differ for rare versus common species? Do you think your results would change if you sampled more plots?



Measuring and Monitoring Plant Populations

In the Field!

Conduct a plant population survey on your school grounds. The object of your survey will be to compare native plant populations to non-native plant populations. As a class, decide to focus on percent cover, frequency, number of species (species richness), or some other population measure. Consider your survey objective and the topography of the area to be surveyed to choose the most appropriate sample method to use and type of data to collect. Make sure you can differentiate between all the plants you will encounter in your survey. You can learn to identify them or just give them your own names as long as you can tell them apart consistently. Divide into teams with each team surveying a different area of the school grounds. Collect your data, and then come together as a class to do the analysis.

Science Inquiry

Put your new knowledge to work. Work in teams to design a science inquiry project that uses a plant sampling technique to gather data. Observe the plants around your school and find something that interests you to form your inquiry question. Perhaps you are curious if more species of plants grow within 5 meters of the parking lot as opposed to 5-10 meters from the parking lot; how many weeds are present on the soccer field; what percent of the vegetative cover is made up of native trees, versus shrubs, versus herbs, versus grasses; if the presence of trees (shade) influences the number and type of plants found in an area; or in what area invasive species are more prevalent on your school grounds. Decide on the sampling protocol you will use and the type of data you will collect. Conduct your survey, gather data, and analyze your results. Did your results answer your initial question? In what way do you think that your results would differ if you had used a different sampling protocol? Share with your class and get to know your schoolyard.

Reflection

What did you learn about measuring plant populations? Why do you think there are so many different methods used? Why would you want to change the sampling protocol to best fit a situation? Should the sampling method influence your interpretation of the data? Would you have greater confidence in some methods of data collection than others?

Measuring and Monitoring Plant Populations

Self Assessments

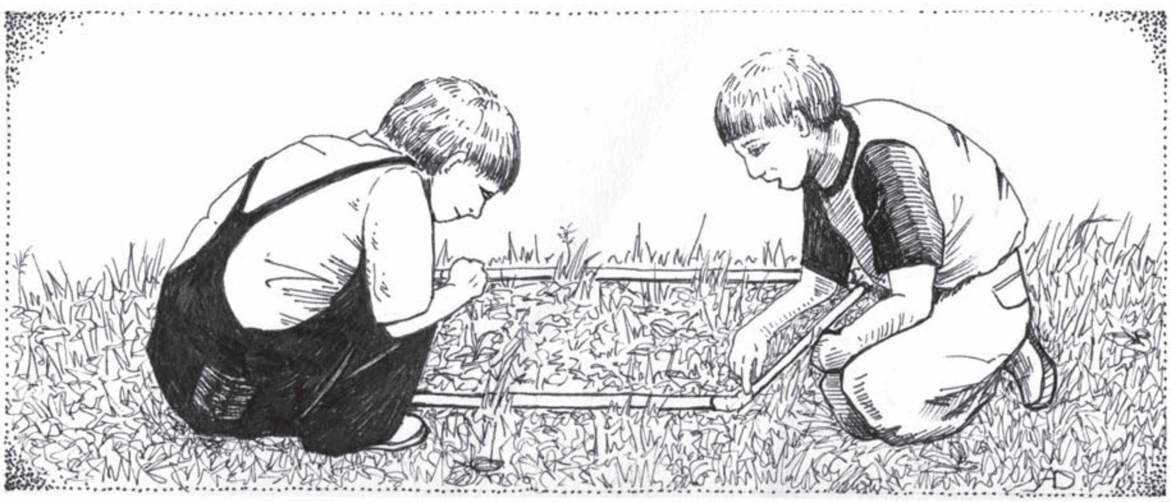
1 Explain what sampling is and discuss the strengths and weaknesses of using sampling as opposed to a census to measure plant populations.

2 Name two or more methods of sampling plant populations and discuss their applications.

3 Name two or more types of data that can be collected and their applications.

Resources

- Elzinga, C. L., Salzer, D.W., & Willoughby, J.W. Measuring and Monitoring Plant Populations. Bureau of Land Management. BLM technical reference manual 1730-1, BLM/RS/ST-98/005+1730: http://www.blm.gov/nstc/library/pdf/MeasAndMon.pdf (this document is large and takes time to download)
- Cornell University and Penn State University, Environmental Inquiry for high school students, Invasive Species: http://ei.cornell.edu/ecology/invspec/



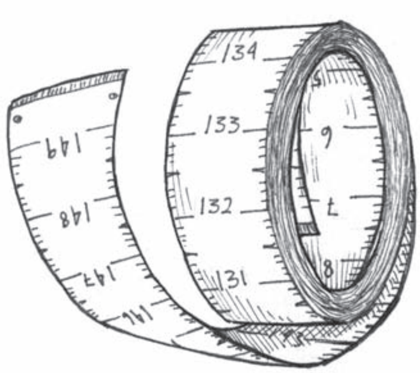
Measuring and Monitoring Plant Populations

Estimating Percent Cover

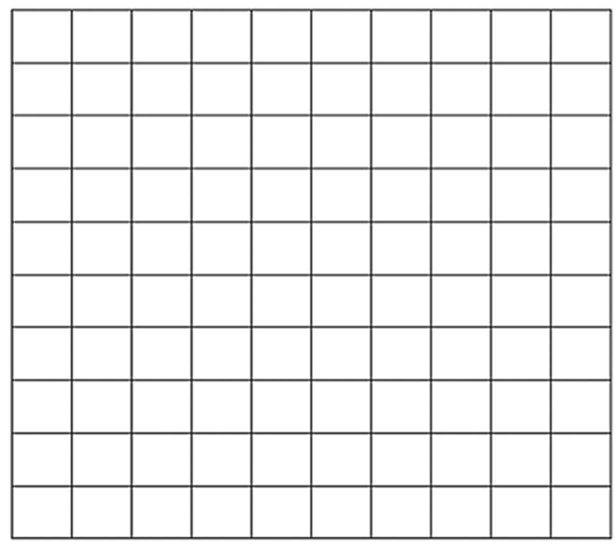
Percent cover is a measurement used by botanists and ecologists to describe and quantify plant communities and habitat. It refers to the proportion of the ground that is covered by a specific habitat component, which could be a certain plant species, or bare ground, or the canopy of a tree overhead. Because percent cover is not tied to a specific measurement unit (like inches or centimeters), it is easy to compare across different sample unit sizes and shapes.

A good starting point is to evaluate the percent cover of plant species or types of plants within a 1 meter x 1 meter quadrat frame (see diagram). The first step is to orient yourself to the proportion of the area in the quadrat that equals 1%, 5%, or 10%. For a 1 meter x 1 meter (100 cm x 100 cm) frame, the total area is 10,000 square centimeters. Therefore:

- 1% of 10,000 is 100 cm2, or the area of a square that is 10 cm x 10 cm in size.
- 5% of 10,000 is 500 cm^2, or about the area of a square that is just over 22 cm x 22 cm in size.
- 10% of 10,000 is 1000 cm^2, or the area of a square that is 31.5 cm x 31.5 cm in size.



Example: 1 meter x 1 meter quadrat



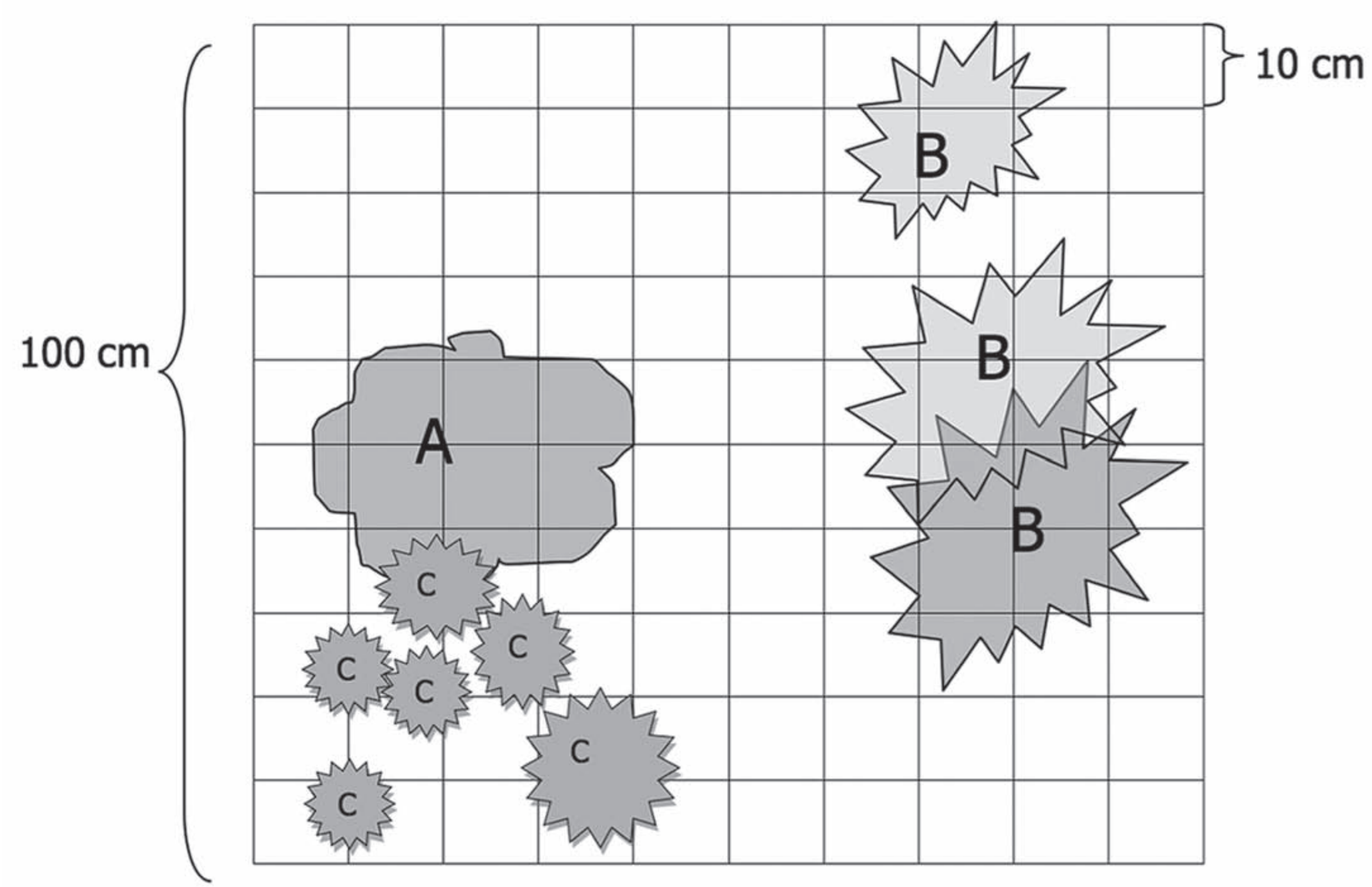
Each square is 10 cm x 10 cm, or equal to 1% cover.

Try measuring the dimensions of your hand, then figure out the percent cover it would occupy in your one meter square. What percentage would a typical 8.5” x 11” piece of paper such as your datasheet be?

Now, apply what you’ve learned to estimate the actual percent cover of plants on the ground. Using the diagram on the next page, estimate the cover of the three plants, A, B, and C, within the quadrat. Again, remember that this quadrat has guidelines that are 10 cm apart, or in a 10 cm grid. Plants are never square, so you will have to visually move around and mentally “squish” the plant area into the grid to estimate its cover.

Measuring and Monitoring Plant Populations

Estimating Percent Cover, continued



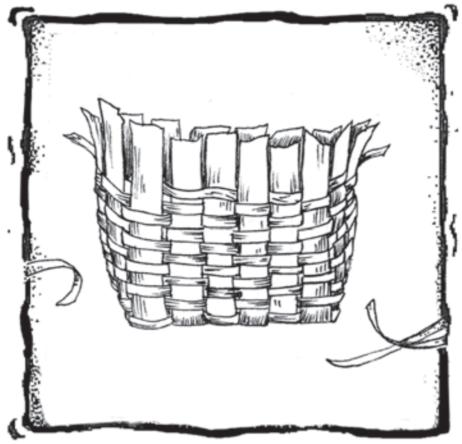
What percent cover do you estimate for Plant Species A? ________________________________

What % cover do you estimate for Plant Species B? ________________________________

What % cover do you estimate for Plant Species C? ________________________________

What is the total % vegetative cover for the plot? ________________________________

As you get more practice in estimating the percent cover of plants of different shapes and sizes, you will get much faster at the process. In some cases you may have overlapping plant layers, and you may end up with a total cover that exceeds 100%.



Section 5: Ethnobotany

TEACHER page

Who Walked Here Before Me

…Long ago only Indians lived in this country. They did not labor so as to find their food. It merely grew on the prairies, in the hills.

—William Hartless (Kalapuya Texts,1945)

Time Estimate:

2 class sessions, plus outside research time

Best Season:

winter

Assessments

1 Name one important food plant from your ecoregion and describe in detail its role within the culture of people historically and today.

2 Describe the concept of a seasonal round or harvest year and diagram an example as it applies to your ecoregion.

3 Describe the connection between at least one native plant, the ecosystem, and human use.

Overview

Learn about American Indian cultures of Oregon, both past and present, by studying their connection with the natural world through food, fiber, and other traditions. Using the metaphor of weaving a basket, students will weave a plant story incorporating the land, its natural resources, and the people who use them. Connect students to a sense of place by exploring the culture, the people, the plants, and the ecoregions of Oregon and how they are entwined in a delicate and beautiful dance together.

Teacher Hints

- It is helpful to have completed at least one of the ecoregion activities prior to this lesson, to gain a framework for understanding many of the concepts in this activity.
- This activity lends itself to individual or team projects. Give students ample time to do research.
- Expand this lesson beyond food usage by adding native plants used for fiber.
- See the ethnobotany plant list in Appendix III for species lists for your ecoregion.

Preparation

- Review the key characteristics of your ecoregions with your students, or complete this lesson after the ecoregion section. The ecoregion background will help your students make connections between climate, geography, and plant communities that are a key part of this activity.
- Print out or display on screen a map of Indian ranges in Oregon. Mention that ranges are approximate and that boundaries shift adn overlap: http://www.native-languages.org/oregon.htm

Additional Information

- Ethnobotany document: http://unesdoc.unesco.org/images/0014/001458/145847e.pdf
- National Museum of the American Indian, Smithsonian Institute, Native American collections research: http://www.americanindian.si.edu/searchcollections/home.aspx
- See Appendices III, IV, V and VI for ethnobotany plant species lists and Oregon tribal website resources
- American Indian Tribes of Oregon, source of map and language: http://www.native-languages.org/oregon.htm

Who Walked Here Before Me

…Long ago only Indians lived in this country. They did not labor so as to find their food. It merely grew on the prairies, in the hills.

—William Hartless (Kalapuya Texts, 1945)

Overview

Learn about American Indian cultures of Oregon, both past and present, by studying their connection with the natural world through food, fiber, and other traditions. Using the metaphor of weaving a basket, you will weave a plant story incorporating the land, its natural resources, and the people who use them. Connect to a sense of place by exploring the culture, the people, the plants, and the ecoregions of Oregon and how they are entwined in a delicate and beautiful dance together.

Learning Objectives

- Define ethnobotany and understand the ethnobotanical resources of Oregon native plants
- Gain insight into the connection between people, ecosystems, traditional knowledge, and resource management where you live
- Develop a greater understanding of and respect for other cultures by examining their connection with ecosystems and plants in particular
- Explore native plants used for food and fiber
- Learn the concept of a seasonal round as it applies to a tribe from your ecoregion
- Identify how native people manage landscapes to promote resource availability historically and in the present day
- Identify tribes in Oregon, their present day locations, and historical range

Background Information

Historically, American Indian groups lived in all ecoregions of what is now the state of Oregon. The knowledge and stories of the Indian tribes of Oregon are keys to understanding how Oregon's ecosystems once functioned and how they have changed through time. Oregon's Indians were, and still are, masters of knowing and exploring which plants were available in their home area and how to use them. Oregon ecosystems vary greatly from the Pacific Ocean in the west to the high deserts of southeast, containing vastly different plant communities. Those ecosystems have been shaped by geography and climate, but equally important in determining their present day composition and function is the actions of their earliest human inhabitants, American Indians, Oregon's first people. Indians of the Oregon coast lived among abundant, dense forests and the resources of the Pacific Ocean. Inland valley people maintained their open prairie landscape using fire to promote beneficial plants and improve hunting habitat. Tribes in the drier eastside landscape followed seasonal travel routes that traced changing water resources to coincide with optimal harvest times for berries, roots, and other key plant species for their diet and other resources such as clothing, baskets, weapons, and many other things.

Although many native stories and traditions are timeless, time has changed many of these ethnobo-

Materials Needed

- Oregon map with historical American Indian ranges
- computer with internet access
- field guides with ethnobotanical information

Vocabulary Words

- ethnobotany
- traditional knowledge
- culture
- seasonal round
- famine food
- fiber plant
- staple food

Who Walked Here Before Me

Background Information, continued

tanical resources and patterns. Indians across Oregon were uprooted and moved to reservations, often far from their homes and the familiar plants on which they traditionally thrived. As time passed, and native people and habitats were destroyed, grocery stores and pharmacies provided more modern food distribution systems and the intricate plant knowledge that was once essential to fulfill everyday needs became less important, and was slowly lost, even from native communities. However, in these modern times, we, as a culture, are beginning to realize how important retaining this traditional knowledge is, not only for the Indian culture from which it came, but as skills and knowledge essential to the survival of all humans in an uncertain future.

For Indians, collecting their food and fiber plants was not as simple as exploring the landscape and harvesting what they needed. Oregon's native people were wildland managers that used generations of acquired skills to manage and sustain what grew around them and to create habitat for species that were essential to their culture's survival. Most foods were not cultivated and grown in agricultural settings, but nurtured and tended with a mind for the future. Important species were managed with techniques that would ensure sustainable harvests for generations to come, to provide food, shelter, medicine, fiber, dye, and wax needed every day. The chart below shows some of the management techniques used by early Oregonians and explains the purpose of each technique.

Traditional Resource Plant Management Techniques

Management techniques	Used for
Fire	Keep fields open for hunting and berries and camas, decrease competition, increase fertility/stimulate new growth, facilitate harvesting, control insects, recycle nutrients
Weeding, clearing brush and rocks from cultivated sites	Remove poisonous look alike plants (death camas), reduce competition for desirable plants, facilitate bulb and root digging
Pruning	To promote long straight new growth for basketry
Sowing seeds	Spreading extra seed at harvest, broadcasting after burning, waiting to harvest until after seed production to facilitate plant increase
Tilling or cultivation	Using digging sticks to harvest roots, tubers, and bulbs, leaving the small bulbs for future harvesting
Seasonal round/controlled harvesting/selective harvest/	Travel to harvest sites as resources become available, limit collecting to maintain sustainable levels, leaving small bulbs for future collecting
Selective breeding	Transplanting "better" bulbs to improve or for new beds

As you can imagine, for cultures entwined with the rhythms and cycles of the natural world, the gifts of nature were highly cherished. The land was cared for by all; for if the land was over-harvested or depleted it could mean hardship for many generations. How is this different from how land is managed today? Can you think of any lands today that are managed for common good? How does the management of these lands change over time? (Federally owned lands are an example of community owned land, but the management of the lands changes frequently depending on the politics of the current administration.) Do you think that public land today is valued by people

Who Walked Here Before Me

Background Information, continued

as highly as land that is privately owned? Why or why not? Think about how present American culture influences how we value land today.

Some tribes still practice traditional management techniques and cultural practices to maintain their connection with the land. Many also employ modern land management technologies such as using GPS and GIS to help map and monitor traditional resource gathering sites. Before European immigration, tribes would often travel great distance to gather the plant materials that they needed. Today private land ownership often limits the areas that Indians can use for gathering, but securing access to continue traditional gathering is a high priority for many tribes. This may take the form of collaborating with public land agencies to secure gathering rights, as well as purchasing lands to set aside for this purpose. Limited access is only one impediment to gathering plants. Others that you might not readily think of include environmental hazards such as toxic chemicals and herbicides. One surprising environmental hazard is lead shot from hunting found in wetlands, causing high lead levels in plant species that grow in these waters. By far, the most common problem limiting ability of native people and others to gather plants is loss of suitable plant habitat from draining of wetlands, land development, and the introduction and spread of invasive weeds. Gathering and using plants remains an integral part of many Indian cultures today. Often cultures mark important plant harvest events with celebration ceremonies. These ceremonies connect culture, spirituality, and the land.

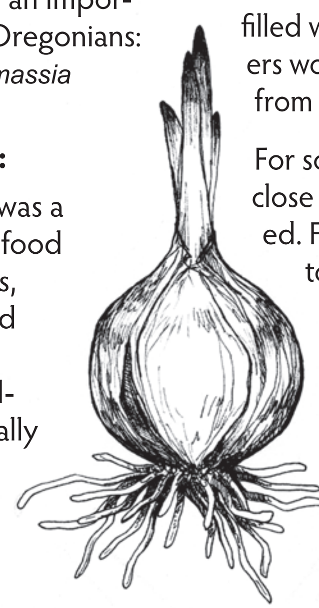
Ethnobotany is a word that you will commonly hear to describe people's use of plants. The word can be broken down into the root words, "ethno" meaning culture and "botany" which is the study of plants, hence the study of people and plants. This word can encompass the historical uses of plants, as well as the present day use. The use of plants may have changed over time, but plants still play a very important role in providing people with food, fiber, building materials, and medicines.

In this lesson, we will take an ethnobotanical look at one Oregon plant that was and is an important plant food for Oregonians: common camas *(Camassia quamash).*

Camas historically:

Traditionally camas was a highly prized staple food of Northwest Indians, harvested and stored for year round use. Intricate plant knowledge was passed orally between generations, which allowed people to distinguish the prized camas from the similar but poisonous death camas. Bulbs were harvested with fire-hardened digging sticks. Family groups would often travel distances and spend several days at a site harvesting, digging the larger bulbs and replanting the small bulbs for future harvest. Earthen pit ovens were dug and the bulbs would be steam roasted for 24 hours or more. Long slow roasting is required to convert the starches of this bulb to make them more palatable and digestible. The resulting food is extremely sweet and was often mixed in with other foods. Bulbs would be eaten immediately after roasting, or dried and stored for future use. Celebration ceremonies often followed the first harvest of the season or larger successful harvests.

Large camas patches thrived extensively in the wet prairies of the Northwest. In spring when camas blooms, these large patches filled with the blue-purple flowers would resemble lakes of water from a distance.



For some tribes, camas grew close by and was easily harvested. For others, they would need to travel great distances to find and harvest it. Camas bulbs where also prized by Indian tribes outside of the plant's native range, and therefore was a valuable commodity item used in trade. Camas was the food that

Who Walked Here Before Me

Background Information, continued

native people fed Lewis and Clark as they were near starvation when they completed their crossing of the Rocky Mountains.

Camas now:

The draining of wet prairies, conversion of land to agriculture, and land development has dramatically cut into the once abundant native habitat of camas. Enhancing and restoring camas prairies with access to harvesting bulbs are priorities for many of Oregon's Indian peoples. Purchasing camas-producing lands and collaborating with government agencies to access public camas sites are two methods of increasing camas availability (2). Practicing sound collecting and management techniques will go a long way to preserving native plants for humans and wildlife use, as well as helping to preserve native ecosystems. Traditional resource management techniques such as limited and/or selective harvesting, harvesting after seed production, and periodic clearing by prescribed burning can be used to help increase camas populations. You can help by treating the land with respect and practicing sustainable harvest methods. Think first and be mindful of your actions, and always remember past and future generations when you walk in a camas prairie.

Directions

1. Study native plants used as food in your local area from both a historical and present day perspective. Break into teams and each team should research one food plant from your ethnobotany list for your ecoregion.
2. Use the data collection sheet provided to research the answers to all the questions. Some of the questions will be difficult and might even be beyond the resources that you have readily available to use. Work with a research librarian for local sources, contact historical societies, local museums, and Oregon's Federally recognized tribes' websites which generally have information listed under cultural resources (see Appendix VI). Don't forget to look for some of this information in comprehensive plant field guides for Oregon. In some instances you may find additional information that you would like to include. This too can be woven into your story.
3. Weave a story for your plant, much like the weaving of a basket. Your plant is the base structure and each part of your research is like the strands that weave back and forth to complete the basket or story. Take note of the way the story weaves between human culture and ecosystem knowledge.
4. When you have completed your research, come together as a class to connect the story of these plants in relationship with each other and the cultures that use them. Each plant story will now become part of a larger seasonal picture that highlights how native plants can be an important part of a peoples' diet and how this works into the greater story of culture. Take a look at how an historic American Indian culture would manage their food system.
5. Across the top of a white board make a column for each month of the year. Under each month write the name of the plants that would be harvested at that time, and the ecosystem that the plant would be found in (i.e. May/June, camas, wet prairie). In this way you have a idea of the general ecosystem where the tribe would be, at what time of year.
6. To be complete, add other food sources in addition to plants to your calendar (fishing, hunting, mushrooms).
7. Use the information that you have gathered and think about where each food comes from inside of and outside of your ecoregion. How far apart is the wet meadow for collecting camas root from the mountainous site to

Who Walked Here Before Me

Directions, continued

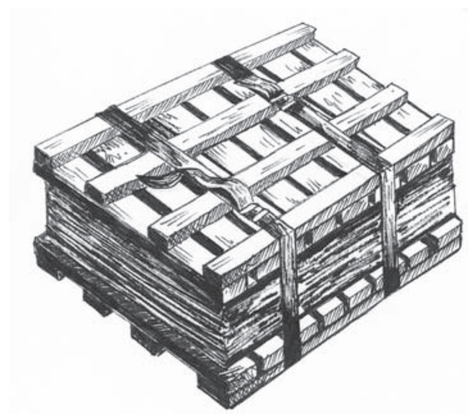
collect summer huckleberry? This basic information will give you a glimpse of what would encompass the seasonal round or travel and trade routes a local tribe might follow to fulfill its needs.

8 Use your creativity to put together a visual calendar of the harvest year (from information on the white board). Document ecosystems of the different resources and when the tribe would have to move to that area to harvest. A circular calendar, which represents an unending cycle, is often used to depict the harvest year. You can also choose another creative way to portray the cycle.

9 Discussion questions: Historically how did tribes know when it was time to move to a new area for harvesting? What would happen if it was a bad growing year and the harvest was scant or non-existent? Were some foods more valuable than others? How did tribes know which plants to eat and which to avoid? Do you think you could be resourceful enough to hunt and gather a nutritional diet to avoid illness? What would you need to learn in order to do this? Can you give at least one reason why it would be important to really know about your food today even though you do not gather it yourself?

Taking it Further

- Create an ethnobotanical herbarium of plants used by local tribes. Preserve specimens for future classes to use. Collect one sample to put in a plant press (only collect if the plant is common—follow guidelines in the plant press activity). If plants are unavailable or rare, assemble the herbarium with pictures. Include the researched ethnobotany information on the herbarium sheets.



Self Assessments

1 Name one important native plant from your ecoregion and describe in detail how it fits within the culture of the people historically and today.

2 Describe the concept of a seasonal round (harvest year) and diagram an example as it applies to your ecoregion.

3 Describe the connection among a native plant, the ecosystem and human use.

Resources

- Cressman, L. S. (1981). *The Sandal and the Cave: The Indians of Oregon*. Corvallis, OR: Oregon State University Press.
- Berg, L. (Ed.). (2007). *The First Oregonians* (2nd ed.). Portland, OR: Oregon Council for the Humanities.

- Appendix III: Oregon Ethnobotany Plants and Their Uses; Appendix IV: Ethnobotany Plant Lists and Resources; Appendix VI: Tribe Contacts.

Who Walked Here Before Me

In the Field!

Invite a local native plant food forager to take your class on a plant walk in a natural area. Ask your speaker to share plant uses, names, and stories. Listen carefully, do you hear them verbalize or allude to some of the ethical plant collecting attributes that you discovered in your research? Can you observe the environmental ethic of taking care of the land for your children's children and their children too?

Science Inquiry

Science inquiry is a term used in education and research today, but the concept has been practiced by people for a very long time. How did first people use inquiry skills?

Skills that may have been used:

- Observation—is this plant good to eat, do others eat it (human or wildlife)? If you observe wildlife eating it does that make it safe for humans? Is it similar to another plant that we eat?
- Testing—how could observations be tested (ideas that would minimize dangers of using poisonous plants)? How were the doses of plant medicines determined?
- Data Collection and Analysis—how was information organized, stored and used (traditional knowledge from elders, storytelling, medicinal knowledge used by healers)?

Reflection

One way that traditional knowledge about plants was passed from generation to generation was through stories told by elders. These stories often included animal figures and a moral. Create a story for your plant that will grow respect for your species for generations to come. Convey the importance of your plant (see worksheet questions) as you weave in a creative story with characters, a setting, and a moral. Your story can be written or a more traditional oral story. If you choose an oral story, you may want to make a simple storyboard to help you remember all the parts. Think about ways a storyteller can make a story more interesting for the audience (using different voices for the characters, props, costumes, or a twist ending).

Who Walked Here Before Me

Weaving the Story of ______________________________

(put your plant name here)

Look at native plants used for food and fiber in a historical and present day context and use the information to weave a story used in the lesson.

Question	Historical answer	Present day answer
Plant name (scientific, common, and tribal language)		
Plant description (from field guide)		
Habitat and range (habitat type, common or rare)		
What part(s) of the plant are used?		
What is the plant used for? (can be multiple uses)		
What time of year is the plant harvested in your ecoregion?		
Harvesting tools or methods used		
How the plant is prepared (gathering, cooking, serving methods)?		
Storage methods		
Plant cultivation and management		
Local concerns with gathering this plant (pollution, limited access, etc.)		
What steps are local American Indian populations taking to maintain or increase use and access of the plant?		
How does this plant fit into the ecosystem? (consider: wildlife, invertebrates, pollinators, soil life, decomposition, nutrients, sunlight, water, habitat) Ask the question, "What does this plant depend on, and, who depends on this plant?"		
Think to the future —can you identify ways to preserve the use of your plant or improve access to it?		

Who Walked Here Before Me

Look at your native plant in the context of American Indian cultures and your ecoregion. Look at your own food ceremonies to gain context in the cultural significance of food.

Question	Ecoregional answer
Historically what is the name of the tribe that occupied the ecoregion (area) that you live in?	
Are there any stories or cultural ceremonies associated with the plant? (e.g. First Foods)	
What is the significance of the ceremony?	
How was the plant acquired (collected, where harvested, or traded for)	
What signs of nature signify the time to travel to harvesting sites? (phenology signs)	
Does the plant have additional human uses (e.g., medicinal)?	

Look at your own food practices or ceremonies in the context of your own life: Thanksgiving Day, saying grace, Passover Seder meal, significance of Easter eggs, Japanese tea ceremony, and others.

Name one (or two) food ceremonies that you take part in	
What is the significance of the ceremony?	
What special food is associated with the ceremony?	
What is the cultural origin of the ceremony?	

Information sources:

- Ethnobotany section of field guides (e.g., *Plants of the Pacific Northwest Coast* by Pojar and Mackinnon)
- University of Michigan—Dearborn, Native American Ethnobotany. A Database of Foods, Drugs, Dyes and Fibers of Native American Peoples, Derived from Plants. http://herb.umd.umich.edu/
- USDA NRCS Plants Database: http://plants.usda.gov/ and associated links
- Appendix VI: Tribe Contacts—cultural resources links on websites
- Appendix IV: Ethnobotany Plant Lists and Resources

TEACHER page

My Burden Basket:

How Native Plants Are Used For Fiber

He breathed on her and gave her something that she could not see or hear or smell or touch, and it was preserved in a little basket, and by it all the arts of design and skilled handwork were imparted to her descendants. —Kotai'aqan (Columbia River Basketry, 1994)

Time Estimate:

1-2 sessions

Best Season:

spring/fall

Assessments

1. Name several traditional uses for basketry.
2. Describe what properties make some plant materials useful as fiber plants.
3. List two native plant materials that are valued for their fiber.
4. Define cordage, how it is constructed, and some of its uses.
5. Identify and describe the two primary basketry techniques used by Oregon tribes.

Additional Information

- The Language of Native American Baskets from the weaver's view. http://www.nmai.si.edu/exhibitions/baskets/subpage.cfm?subpage=intro
- University of Oregon digital basketry collection pages: http://www.uoregon.edu/~mnh/Pages/digital_collections.html
- Appendix III: Oregon Ethnobotany Plants and Their Uses; Appendix V: American Indian Resources MAterials

Overview

This lesson introduces native plant fibers and their uses, with a focus on cordage, baskets, and decorative techniques. Students will look at traditional weaving materials and techniques, and gain an appreciation for basket function and design. Students will then collect, prepare, and construct cordage or a simple burden basket practicing techniques and using various plant materials.

Teacher Hints

- Complete Who Walked Here Before Me? lesson prior to doing this activity to get background understanding of the cultural importance of native plants in the lives of first peoples.
- Invite a traditional basket weaver to visit your class. Ask them to share their baskets, techniques, and materials collecting tips. In return, share your project with your guest.

Preparation

- Scope out locations to take the students on a gathering trip. Materials can be found in many locations—long grasses collected from vacant lots or roadsides, cattail and sedges from wet areas. Challenge the students to make use of what they can find growing locally. City gathering requires creative thinking. English ivy may be readily available in urban areas. Ask permission before collecting any plants, or ask students to collect plant material from home to bring into class.
- WARNING: Make sure everyone can identify harmful plants (e.g. poison oak, stinging nettles, giant hog weed, etc.) if they grow in your collecting area.
- Work with students to create ethical collecting guidelines for the class to use. Be sure that the students discuss such things as: responsible harvesting, cutting rather than pulling plant materials (unless it is invasive), over-collecting, and asking permission from landowners.

My Burden Basket:

How Native Plants Are Used For Fiber

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Overview

This lesson introduces native plant fibers and their uses, with a focus on cordage, baskets, and decorative techniques. Look at traditional weaving materials and techniques, and learn an appreciation for basket function and design. Now jump in and try it yourself! Go on a collecting walk to gather materials and then construct a simple burden basket, practicing the techniques and using various plant materials.

Learning Objectives

- Learn what makes some plants useful for baskets and cordage
- Gain an appreciation of the history of baskets and cordage used by Oregon's first people
- Understand the role of management in utilizing fiber plants
- Sample hands-on techniques using plant materials to make cordage and basketry
- Gain appreciation for the decorative designs used to personalize baskets (dyes, colored plant materials, motifs) as well as the techniques that create them
- Understand that ecosystems influence available plant fiber materials

Background Information

For millennia, people have used plant fibers to meet the needs of daily life, from making simple twine to bind things to building entire houses. Traditionally, plant fiber has played a large role in many cultures, but with the proliferation of manmade materials like plastics, this need has diminished as have the skills that go with it. At one time plants provided the materials for food storage containers, clothing, utensils, tools, and adornments. A woman who needed water from a stream would use a basket made from tree bark and waterproofed with plant waxes. Today, we just reach for the nearest bucket. Although modern society still depends on plants to supply fiber for paper, cloth, and lumber for building materials, much has changed in just the last couple of centuries, making our relationship with the plants around us very different than it once was.

What makes some plants useful as fiber plants? First, the plant must include fiber cells. These cells tend to be long, thin, and tapered on the ends. All plant cells have cell walls, making them tougher than animal cells, but fiber cells have extra thick cell walls that are reinforced with a substance called lignin. Lignin is a compound that makes fiber cell walls stronger, more waterproof, and resistant to attack by fungi, bacteria and animals. Fiber cells are one of many plant structures that help support plants, letting them grow to reach sunlight, supporting their vascular tissue (water and sugar transporting cells), and providing them with protection from other organisms. Fiber cells are often present in the wood or bark of hardwoods, including oak (*Quercus*), ash (*Fraxinus*), and maple (*Acer*). The stems of some plants such as flax (*Linum*) and jute (*Chorcorus*) also have fiber cells, which make these plants useful for fabrics like linen and weaving items like floor mats and tote bags. Fiber cells are also present in the leaves of many grass or grass-like plants, such as sisal (*Agave*), which is used for twine and rope.

Traditionally, American Indians living throughout the Pacific Northwest used fiber from native plants, as well as other natural materials, to meet their needs for baskets, rope, fishing traps and

My Burden Basket:
How Native Plants Are Used For Fiber

Materials Needed
- pruners/clippers
- plastic bags
- gloves
- dish pan
- spray bottle
- old towels
- colored raffia or yarns for decorative design
- project direction sheet(s)

Vocabulary Words
- fiber cell
- lignin
- cordage
- coiling
- twining
- weft
- warp
- burden basket
- tumpline
- open weave
- overlay

Background Information, continued

nets, cooking containers, water jugs, garments, and houses! Nature supplied everything they needed. Although many of these traditional plant uses have declined, people, Indian and otherwise, still find time to gather materials and produce objects made from plants. In our busy modern times, creating a useful beautiful object with your own hands from materials collected yourself can be very fulfilling. What are some of the things you would need to know about fiber plants, design, and construction techniques to be able to make your own containers?

To begin, you might analyze the form and function of each container's design. One common container design is called a burden basket. Traditionally this type of basket was used by Indian tribes throughout Oregon and beyond. Sturdy burden baskets were frequently worn on the back much like today's backpacks. Burden baskets were made for carrying heavy items such as firewood, or for when the wearer needed their hands free such as while harvesting. Such baskets were often cone shaped and outfitted with a tumpline, a strap over the forehead or shoulders, and used for hands-free transporting. The cone shape fits comfortably, while distributing the weight on the wearer's back. The large opening at the top allowed for easy filling by throwing items over the shoulder, and the cone shape discouraged thrown items from bouncing out. The tumpline left the user's hands free for work. Tumplines were a tightly woven strap made of soft pliable materials for the wearer's comfort. The baskets were often made of an open weave to hold bulky items while contributing a minimum of weight in basket material to carry. At times, baskets were quickly woven on site to transport materials back to camp. Coastal tribes would use the open weave burden baskets for collecting clams, which would allow the user to rinse and drain the clams in one container. Tightly woven burden baskets were used to harvest small seeds and berries. The burden basket is just one of many designs perfectly suited for its jobs (1). Studying other basket types, you will find they too were designed to perform the function needed in an equally efficient manner.

Cordage is another essential tool of native people that uses plant fiber. Cordage is made by twisting multiple fiber strands together into strong cords that can in turn be used in ropes, nets, and baskets. Several native plants are prized for making strong cordage and these vary by ecoregion. One interesting fiber plant is the Oregon iris (*Iris tenax*), a beautiful purple wildflower whose leaves are said to

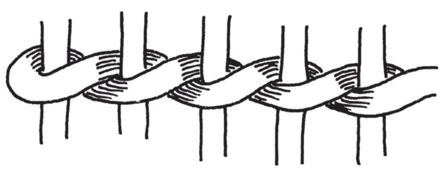
My Burden Basket:
How Native Plants Are Used For Fiber

Background Information, continued

make cordage so strong that it was used to snare elk and bear!

cordage

Plant fibers can be used as cordage, bundled, or in their natural form as weaving material. Local traditions generally used two techniques of making baskets, twining and coiling. The twining method uses two pliable "weft" strands that are twisted around a more rigid "warp" or foundation structure. This method was used to make some of the specialized baskets like water jugs, cooking containers, and soft hats. In the second technique, coiling, the base foundation is a spiral of materials that are sewn together with a pliable fiber thread. Although the coiling method is evident in some of Oregon's traditional basketry history, twining was more common.



twining

Baskets can be constructed of many different native plant materials, but some species stand out for their superior fiber or weaving attributes. Shoots of hazel and willow, spruce roots, the inner bark of cedar, and the stems and leaves of rushes and grasses are all prized materials. Cattails and rushes can be woven into mats with many historical uses (e.g.. clothing, sleeping, house siding, and even canoes!). Traditionally, baskets were used in all aspects of life; some were plain and quickly made for immediate use. Other baskets show painstaking attention to detail and were intricately decorated. Some baskets show geometric patterns that are woven in or overlaid in contrasting colors. Plant materials supply the colors for these designs. For example, black often came from maidenhair fern stems, white came from bear grass, and reds were made with a dye from the inner bark of alder. Highly decorated baskets are cherished, culturally important, used in ceremonies, and passed down from generation to generation.

coiling

Different plant species have different optimum times for harvest. Tree and shrubs are often harvested early in the year when new growth is lush and supple. Reeds and grasses are typically harvested later in the season when their growth becomes more fibrous. Preparation for use can include softening fibers, stripping bark, or splitting larger canes.

Traditionally, fire was used by many Oregon tribes as a management technique to promote long, straight plant re-growth for harvest. This traditional management method has become more difficult to use with changing times although it is still employed in natural areas around the state. Lack of regular burning has left high levels of woody materials and underbrush that could now fuel large wildfires. As populations have changed, so have land management techniques. It is now more common to use pruning or mowing than fire to manage plant growth.

Gathering native plant materials requires ethical collecting practices to ensure access for future generations as well as to protect significant natural ecosystems and species. Ethical collecting includes preventing over-collection to minimize population damage. When gathering plant material, one should avoid damage to the parent plant by cutting and removing only a small section of plant, not disturbing the roots, and never taking whole plants. Collect only from large plant populations and allow plants to reproduce between collections. Using thoughtful practices can allow you to harvest plants fibers without hurting plant populations. Think also about actions you can take to protect or enhance native plant population for the future. Imagine the connection you would have to your environment if you used plants to supply all your needs from containers to clothes!

My Burden Basket:
How Native Plants Are Used For Fiber

Directions

1 Think of all the containers that you come into contact in a day: food storage, cooking, eating, backpacks, purses, boxes, water bottles, to egg cartons, we are surrounded by containers of all uses, shapes, and sizes. Make a list of 10 containers that you commonly use in a day. Take 5 from your list and brainstorm ways that you could construct an adequate replacement container using materials found in nature. Share your best ideas with the class.

2 **Class discussion**: How often did baskets come up as a container in the brainstorming session? What are the pros and cons of using traditional vs. present day container materials? Be sure to address such things as: individual vs. mass production, knowledge of materials, cost, time, and skills. Don't forget to include sustainability issues and environmental concerns.

3 Challenge yourself to learn some of the traditional art of using native plants to make utilitarian as well as decorative objects. Choose one of the project sheets from this lesson and learn a new skill.

4 Go on a gathering walk to collect materials needed for your project (cordage and/or baskets). Work with a partner or in a small team. Each team will need pruners/clippers, a plastic bag, and gloves.

5 Spring is a good time to collect flexible young twigs from willows. Grasses are best collected in summer once they have gone to seed and just as they begin to lose their green color. Cattail is best collected in fall, when the leaves have dried and are less fleshy.

6 Review responsible gathering guidelines and how to identify plants to be avoided (e.g. stinging nettle, poison oak). Collect in an area where you have permission (the teacher will guide you), and take precautions to avoid damaging the plants; cut rather than pull out or tear your materials, don't over collect or gather more than you need. Use gloves to protect your hands while collecting.

7 Traditionally most fiber materials are collected when they are green and are dried before use. This helps to keep the basket weaving tight, because green materials will shrink as they dry, and may disrupt the weave. This might not be important factor in a large gathering basket, but it is critical in a basket used to hold water. We will be using green, un-dried materials for this project because of time limitations, and the fact that green materials are easier to work with.

8 Once you return to the classroom, organize your collected materials. Separate like materials into piles with all grasses in one pile, the willow in another, and so on. Prepare your materials by removing leaves, cutting off seed heads, etc. Store materials in a folded damp towel to keep them moist and pliable until you are ready to use them.

9 If you are working with dried materials, soak them in water for several hours to make them more flexible before working with them.

10 Consult the project sheets for directions to make your specific project.

Taking It Further

- Gain additional appreciation for the beautiful baskets created with native plants by Oregon's native peoples, past and present. View online collections listed in the resources section. When observing the collections, analyze the basket for their form and function, as well as decorative patterns and techniques. Challenge yourself to identify the weaving technique employed, and speculate as to the intended use, before reading any caption information.
- Add to the "Who Walked Here Before Me?" activity by adding fiber plants to the seasonal round calendar created in that lesson. Include where they were collected, at what time of year, special handling or preparations, and what they were used for.
- Research other historical and modern uses of plant fibers. What other cultures of the past depended on plant fibers for everyday items? What items do you use on a regular basis that include plant fibers?

My Burden Basket:
How Native Plants Are Used For Fiber

In the Field!

- Take a field trip to a museum with basket collections, or contact the cultural resources department of one of the Oregon tribes (see Appendix VI) to inquire about viewing their collections. Take your field journal and sketch your favorite piece, including information on the materials used. Cross-reference the plant materials in a local field guide, and include other plant history and ethnobotany in your journal entry.
- Examine baskets that you have at home or in stores. Look closely at the weaving. Mass produced baskets tend to be woven using a different technique than the traditional methods you learned in this lesson. Can you identify how they are different?

Science Inquiry

Fiber plant materials are valued for many attributes, including strength, durability, availability, and beauty. Fiber was used for cordage to make rope, snares, fishing line, and nets, where strength was critical. Design a way to test the strength of cordage materials. Make cordage from several different fiber sources and compare their strength. Write up a simple analysis of your trials. Explain how you control for different variables in your testing. Consider testing for other qualities such as strength when wet, durability, and ease of working with.

Reflection

Cultures throughout time have used their skills and talents to decorate their homes and belongings. How would you decorate a basket to express what is important to you? Design a basket that you would call beautiful. Share it either through making it, drawing it, or writing a detailed description. If you feel artistically challenged in this activity, try using small square graph paper and color in the squares to display your pattern. Geometric patterns lend themselves well to this technique.

Self Assessments

1. Describe what makes some plant materials more useful as fiber plants.
2. List two native plant materials that are valued for their fiber.
3. Define cordage, explain how it is constructed, and list some of its uses.
4. Identify and describe the two primary basketry techniques used by native people in Oregon.
5. Name several traditional uses for basketry.

Resources

- University of Oregon Natural History Museum digital basketry collection pages: http://www.uoregon.edu/~mnh/Pages/digital_collections.html
- Entwined with Life, Native American Basketry. Exhibit and website for the Burke Museum of Washington: http://www.washington.edu/burkemuseum/baskets/index.html. Search by culture to view basketry exhibits (many Oregon tribe cultures are well represented).

My Burden Basket:

How Native Plants Are Used For Fiber

Make a Simple Burden Basket

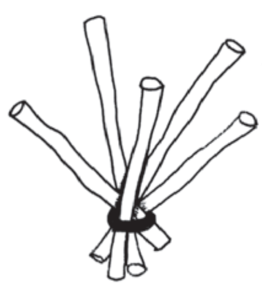
Gather, prepare plant materials, and make a simple cone shaped burden basket using the twining technique.

Materials Needed

- plant fibers for weaving (see Appendix III for traditional fiber plants, or improvise, experiment, and try found plant materials that may have been available in your area)
- thin, flexible, straight twigs (5 or more per student)
- rubber bands
- pruners
- optional: colored raffia or yarns for design work

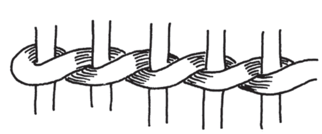
Directions

1 Make a rigid form for your basket out of straight, supple twigs of uniform size. Use a minimum of 5 twigs, approximately the diameter of a pencil and 10—12 inches in length. Using additional sticks or longer sticks will make a larger basket. Bundle the twigs together with a rubber band approximately 1 1/2 inches up from the bottom.



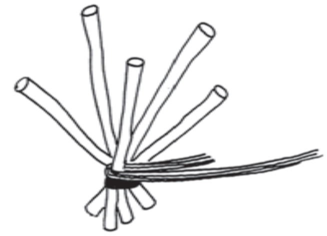
2 Fan out the longer end of the twigs to make a cone shaped form for your weaving.

3 Prepare your plant weaving materials. If you are using green, supple materials, little preparation is necessary. The drawback is these materials will shrink as they dry and can leave your weaving loose. If you have collected dry materials, presoak them before using to make them flexible and less prone to breaking. Wrap the fibers in a warm wet towel, and leave for 30 – 60 minutes before using. Raffia must also be presoaked.



twining

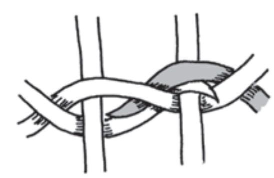
4 Prepare your weaving strands. In the twining technique you will use two strands of the material, each one passing on either side of the twig form and then twisting between the sticks, alternating as you work around the basket.



5 Start by taking an 18 to 24 inch strand of fiber and folding it loosely about one third from one end. This way you will stagger the ends, making it easier to add new weaving material smoothly. Place the fold around one of the twigs at the bottom of the basket form (near the rubber band) and start. Don't forget to make the twining weave, the double strands need to cross between each twig.

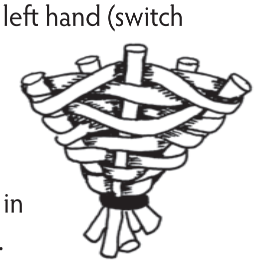
6 Continue weaving your strands around the twig form, twisting your fiber to alternate back to front at each twig.

7 When you start to run out of weaving material, add a new strand by laying the new strand overlapping the old one 3-4 inches. This is called splicing them together. Then continue weaving as before.



8 After each course around your twig form, be sure to push the weaving materials down to fill in empty spaces.

9 Hints: To keep your cone shape basket form, start weaving with thinner materials (e.g. grasses). As you work up the cone, use weaving material of thicker diameter or double-up the fiber strands. Additionally, if you are right-handed, hold your left hand (switch if you are left-handed) in a fist in the center of your basket to maintain the spread shape as you weave. This will keep your basket spread and keep you from pulling in the twigs in by weaving too tightly.



My Burden Basket:
How Native Plants Are Used For Fiber

Make a Simple Burden Basket, continued

10 To finish the edge of your basket, make a loop knot around the last twig and tuck the ends into the weaving below. An experienced weaver can finish their basket so you cannot even find the ends of the strand. Don't expect this for your first attempts. You have just finished a very simple twining weave basket. Don't expect your first weaving attempts to be uniform or tight. If you find this interesting, try a more detailed how-to book or take a basketry class.

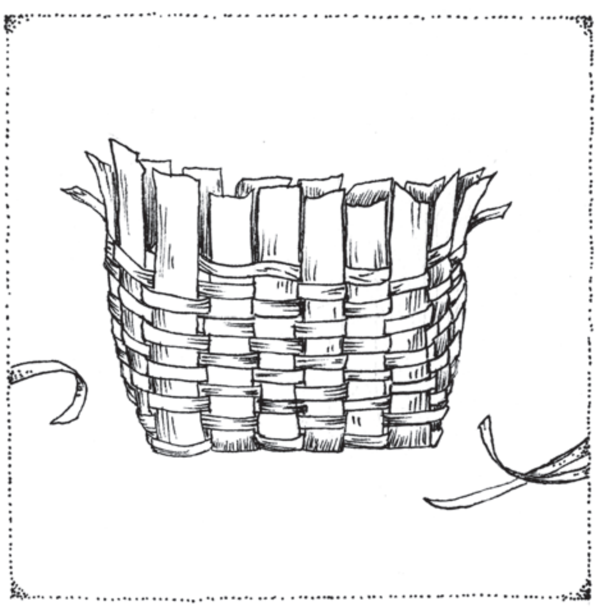
Add a Design (for ambitious basket weavers)

11 Design by texture: Use different textured fibers or weaving materials. Experiment with leaving the leaves or seed heads on your plant fibers or using different diameter strands for twining.

12 Design by color: Traditionally designs were created from naturally colored fiber (e.g. black from maidenhair fern, white from bear grass) or dyed materials (e.g. red from the inner bark of alder, yellow from the inner bark of Oregon grape). You can add color with yarn or raffia fiber worked into your design.

References

- Jensen, Elizabeth. *Baskets from Nature's Bounty.* Interweave Press, Loveland, Colorado USA 1991. ISBN 0-9340226-69-9
- Tutorials on gathering, preparing, and basketry techniques: http://basketmakers.org/topics/tips/tipsmenu.htm



My Burden Basket:

How Native Plants Are Used For Fiber

Making Fiber Cordage

Materials Needed

- one-foot section of two-ply twisted natural twine (jute, sisal, or hemp)

- plant fibers—cattail is one of the easiest to identify and find, other traditional plant fiber can be found in Appendix III.

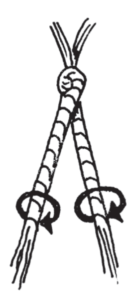
Directions:

1 Get a feel for cordage by investigating a piece of ready-made twine. Observe the twisting pattern that you see. Unravel it slowly and note how the cord twists as you pull it apart. Look for the direction of the twist. If you stop pulling the twine and give it slack, it will most likely re-twist slightly. The twisting motion is what holds the twine together and makes it strong. Most twine is made by machines. Your early cordage attempts will not be as uniform, but with practice your skills will improve.

2 Prepare your plant fibers. Remove extra leaves, seed heads, or outer bark. Plant fibers will need to be free from chafe and pithy interior materials. Roll or rub the fiber by hand, or *lightly* pound it with a rock to divide the fibers. Divide larger leaves such as cattails by standing on the leaf tip and pulling the ends apart, making several smaller strands out of one leaf. Prepare fibers of uniform size to produce a higher quality product. Green fibers can be used soon after collecting but may shrink when dried. If working with dry fibers, wrap them in a damp towel to make them pliable. For dry cattails, soak them about 15 minutes before working; other types of fibers may need longer soaking times.

3 Take 2 strands of different lengths and tie them together with a knot in one end. This makes it easier to add new materials as you add to your cord.

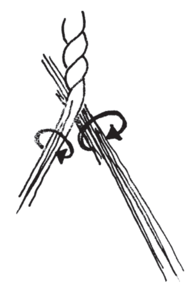
4 Have a partner hold the knot or clip it to a stationary object to hold while you are twisting. Take a fiber strand in each hand about 6" from the knot. Twist both strands tightly to the right.



5 Once you have the two strands twisted, pass your right hand over your left and switch the bundles in your hands. This will produce the double twist.

6 Continue twisting the individual strands to the right for another 6" and cross your hands again, right over left and switch bundles. Continue in this pattern to make your cord as long as needed. Make sure you are always twisting and crossing your hands in the same direction.

7 When you come to the last 3-4 inches of your fiber strand, you will need to splice in a new fiber piece to continue. Overlap the thinnest end of the new fiber with the old, and just twist the two together as you work.



8 You may end up with some fiber "hairs" sticking out but these can be trimmed off when you are completed. If you staggered the ends of your initial fiber these spliced joints will come at different spots on your cord.

9 When your cord reaches your desired length, end by tying an overhand knot including both ends.

10 Use your cordage to tie things together, make a handle for a basket, or add beads and turn it into a friendship bracelet.

Resources:

- US Bureau of Land Management, Salem Oregon. *Exploring Oregon's Past: A Teacher's Activity Guide.* Salem office 503-375-5646
- Native American Cordage: http://www.nativetech.org/cordage/ by Tara Prindle, 1994. The website of Native American Technology & Art.
- Jensen, Elizabeth. *Baskets from Nature's Bounty.* Interweave Press, Loveland, Colorado USA 1991. ISBN 0-9340226-69-9
- Cordage and other basketry directions: http://basketmakers.org/topics/tutorials/cordagea.htm

TEACHER page

Plants as Medicine

Make Your Own Herbal Salve

In all things of nature there is something of the marvelous.

–Aristotle (384 BC—322 BC)

Time Estimate:

1 field session,
2 classroom sessions

Best Season:

winter/spring

Overview

Students learn about common medicinal products that are derived from plants found in Oregon, and research medicinal properties of plants in a historical context. Students will study the medicinal properties of black cottonwood *(Populus balsamifera ssp. trichocarpa)*, a common native tree associated with rivers, streams, and lakes throughout the state. Students put their knowledge to work by making their own healing salve from cottonwood buds.

Teacher Hints

- To collect cottonwood buds, look in early spring (February/March) and collect before the buds open but are resinous to the touch. Cottonwoods commonly grow in wet areas: along waterways, drainage ditches, streams, rivers, lakes, and wetlands. Finding fallen branches from storms is the easiest way to access the buds.
- Self-heal *(Prunella vulgaris)* may be used as an alternative if cottonwood is not available.
- Additional information about phytochemicals is included in the Ecology of Native Plant Ecology section in Plant Wars lesson, and is a good companion lesson.
- Your study of medicinal ethnobotany could be expanded by having each student group research a different native plant with medicinal uses.

Assessments

1. Define phytochemical and explain one or two environmental processes that prompt plants to produce secondary chemicals.
2. Debate the ownership of the intellectual rights to historical ethnobotanical medicinal plants.

Additional Information

- Moore, M. (1993). *Medicinal Plants of the Pacific West.* Santa Fe, NM: Red Crane Books.
- Black Cottonwood *(Populus balsamifera L. ssp. Trichocarpa)* Plant Guide. USDA-NRCS: http://plants.usda.gov/plantguide/pdf/cs_pobat.pdf

Preparation

- Additional discussion questions can be found at: Herbal Medicines Topic of World-Wide Discussion: http://advancement.sdsu.edu/marcomm/Fall97news/Herbal.html
- Alternative lesson format - combine class discussions and collecting cottonwood buds into one session, assign the remainder of the lesson as homework, and use a second session for students to make their salve. Infuse the herbal oil one day ahead (this should only take a few minutes to start). Oil can be re-warmed in a double boiler before adding the beeswax.

Plants as Medicine

Make Your Own Herbal Salve

In all things of nature there is something of the marvelous.

–Aristotle (384 BC—322 BC)

Overview

In this lesson, you will redefine what medicine is and learn about common medicinal properties and products from plants found in Oregon. Study the medicinal properties of black cottonwood *(Populus balsamifera)*, a common native tree closely associated with water. Put your ethnobotanical knowledge to work through collecting cottonwood buds and making a healing salve.

Learning Objectives

- Basic understanding of plants used as medicine, highlighting American Indian uses in Oregon
- Define phytochemical, understand the purpose of secondary biochemicals in responses to the environment, and learn how humans harness phytochemicals for their medicinal properties
- Examine the connections between plant biodiversity, potential future discoveries in plant medicine, and untested plant compounds
- Study the historical uses of a native tree, including its biochemical properties, and modern uses
- Participate in collecting and producing a plant medicine (cottonwood bud healing salve)

Background Information

Plants are one of the oldest sources of medicine. The history of humans using plants as medicine goes far back before writing even existed to record it. Much of the early history of ethnobotany, or the human uses of plants, is patched together from early pictographs recorded in rock. It is generally thought that the first depictions of plants used for medicinal purposes are from the cave paintings of Lascaux in France, which are radiocarbon dated to be from 13,000-25,000 BC (1). Early written records of the use of herbs for medicine come from Sumerian tablets (3500 BC), ancient Egyptian writings (1000 BC), and the Old Testament of the Bible. Herb use has also been documented in the early cultures of India (1900 BC) and China (2700 BC). Many enthnoecologists suspect that the use of plants as medicine extends much farther back in human history, but there are no records to prove this. Plants have been such an important part of medicine that botany was considered a branch of medicine until about 150 years ago, at which time the use of chemical treatments and synthetic medicines began to gain popularity. However, many of the medicines that are used in conventional medicine today are derived from phytochemicals that originated in plants and now can be synthesized in laboratories. In recent years there has been a growing resurgence of interest in the use of herbs to prevent and treat illness. This has led to a renewed interest in looking at the world's plants as a storehouse of medical wealth.

The indigenous people of Oregon have a long history of using plants, fungi, and other bits of nature for healing. In earlier times, people had a general knowledge of which plants were used for treating common illnesses and even rare or serious conditions. This information was passed down orally from generation to generation from the wisdom of the tribal elders through stories. Many cultures also had (and many still have) a designated healer with specialized training in plant medicine, who can also invoke ceremonies or intervention of the spirits to help with healing. Generations of observations, trial and error testing, and plant knowledge has been passed on in this way for millennia.

Plants as Medicine

Make Your Own Herbal Salve

Materials Needed

Classroom session

- internet access for ethnobotany and phytochemical research
- plant field guides with ethnobotany information

Salve making supplies

- quart size glass jar with lid
- olive oil
- crockpot (for quick method)
- old pan and spoon to mix salve
- latex gloves
- candy thermometer
- glass measuring cup
- strainer
- beeswax (2-3 oz. for each pint of infused oil)
- small salve containers (e.g. lip gloss containers, very small jars, baby food jars), enough for all the students
- labels for salve
- vitamin E capsules or oil (optional)

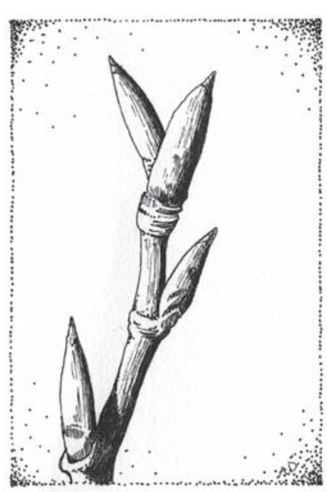
Vocabulary Words

- phytochemical
- biochemical
- analgesic
- herbalist
- pheromones
- antibacterial
- ubiquitous
- medicine

Background Information, continued

The wealth of indigenous people's plant knowledge locally and worldwide is immense, but with changing societies and cultures much of the information is being lost. Still, worldwide it is estimated that 80% of indigenous people use plant remedies (2). At the same time, relatively few plants have been investigated for possible medicinal use. Modern science has yet to explore the phytochemical properties of countless plant species, and many of those species that have not been studied are being lost to extinction. The loss of any one species may be a lost opportunity for a future medical breakthrough that could cure a deadly disease or the common cold (3). Twenty-five percent of all prescriptions in this country contain one or more plant-extracted or derived ingredients (2).

Are you aware that many common medicines used today are linked to plants that you find growing in Oregon? One of the most common is aspirin (acetylsalicylic acid), which is made in a laboratory today, but which got its start from salicin, a naturally occurring compound in the leaves and bark of native willow trees. Others with which you may be familiar are menthol, the aromatic compound derived from plants in the mint family, used for its decongestant and topical analgesic (pain-killing) properties, and Pacific yew, which has produced the potent anticancer drug Taxol. Foxglove, a landscape flower that has become an invasive problem in some Oregon forests, is responsible for the cardiac drug Digitalis. Don't just go chewing on this plant though—it contains powerful toxins! As a medication it is used in tiny and precise doses; an incorrect dosage can cause the opposite, cardiac arrest and death!



So why are plants chock full of so much medicine? All plants produce chemical compounds in their metabolic activity to help them absorb nutrients, photosynthesize, and produce color pigments. Plants also produce secondary chemicals in response to their environment. Many of the herbs and spices used by humans to season food yield useful medicinal compounds through their secondary compounds. These secondary chemicals can act as toxins to help the plant defend itself from herbivores, disease, fungus, and even competition from other plants. In addition, plants can produce chemicals that act as pheromones (insect-attracting smells) and to produce different pigments to attract specific pollinators such as bees, birds, butterflies, and flies. Because of the variety of environmental

Plants as Medicine

Make Your Own Herbal Salve

Background Information, continued

conditions and organisms to which the great diversity of plants must respond, there are a wealth of secondary chemicals found in nature that have been the human pharmacy for millennia. As we lose biodiversity from the Earth, many of the undiscovered medicines are lost forever.

Directions

Part 1—Research medicinal plant uses

1. As a brainstorm or discussion session explore the following concepts as a class. What makes a substance medicine? How do you make personal judgments on what medicines you use? Do you feel all medicines need a doctor's prescription? If you believe that you don't need a prescription, who should be responsible for correct usages? When you buy unregulated herbal medicines, how do you know you are getting the real thing? Much of our medicinal plant knowledge comes from indigenous people. Who owns the rights to the knowledge of and the use of these plant medicines? If more people used plant medicines by collecting plant materials in the wild, how would we protect the resources?
2. Work in small teams to investigate an Oregon native tree, black cottonwood *(Populus balsamifera ssp. trichocarpa),* for its medicinal properties and historical uses. Find and record on your data sheet 5 historical medicinal uses for your plant, what part of the plant is used (e.g., resin, bark, leaves), and the type of preparation (e.g., tea, salve, poultice). This information can be found in field guides that contain ethnobotany information, or use online sources (see resource section).
3. Research the phytochemicals found in the black cottonwood. To do this, access the online website Dr. Dukes Phytochemical and Ethnobotanical Databases at http://www.ars-grin.gov/duke/. Look under Plant Searches and click on "chemicals and activities in a particular plant". On this screen click "scientific name" and then type in *Populus balsamifera* and select "submit query".
4. This brings up a Pharmacy query page. On this page select "Search based on non-ubiquitous chemicals only" box, "Print activities with chemicals", and "Include full references at end of document" then click on "submit query".
5. The resulting search will list the phytochemicals found in *P. balsamifera* followed by their location in the plant (e.g., leaf, bark, essential oil). Scan the list to look for the plant parts you have listed on your handout. Enter up to 3 phytochemicals with their biological actions (e.g., 2,6-DIMETHOXY-P-BENZOQUINONE Bark, antibacterial, fungicide, pesticide) that match the ethnobotanical uses listed on your handout sheet.
6. Define the biological activity you have recorded in simple terms. For example, antibacterial: destroys or suppresses bacterial growth.
7. When your team has completed the data sheet, discuss your findings within your group. Write a conclusion to your research. Can you support the historical medicinal uses with the phytochemical analysis? Why or why not? Why do you think black cottonwood buds would make a good medicinal salve?

Part 2—Make a healing salve from resinous cottonwood buds for minor skin irritations such as cuts, scrapes, and chapped skin

1. See "In the Field" section for directions to collect cottonwood buds. Smell the buds. Does the scent remind you of anything?
2. Lay the cottonwood buds out to dry for a day before proceeding. Water on the buds does not mix well with the oil and can lead to mold in your finished product.
3. Use clean sterilized containers for all the steps of the process. Wear latex gloves to maintain the purity of your finished product.

Plants as Medicine

Make Your Own Herbal Salve

Directions, continued

4 Make an herb-infused oil by one of the two following methods:

- (Traditional method) Fill a sterile pint jar with the cottonwood buds. Fill the remainder of the jar with olive oil, leaving no head room or air space, and cap. Place the jar in a bowl or container to collect any overflow. Locate in a warm place for 4-6 weeks. Periodically check to add more oil as needed; the twigs will absorb some oil and heat can also cause expansion and overflow.
- (Quick method) Spread the cottonwood buds in the bottom of a Crockpot and just cover with olive oil (at least a pint of oil). Heat the mixture, trying to maintain it near 100°F for 4-5 hours. Suspend a candy thermometer from a straw that rests across the top of the pot to measure the temperature. Let the mixture reach 120°F, then turn off the pot and let it cool to 100°F before turning on the pot again. Repeat this procedure for 4-5 hours.

5 When the infused oil mixture is finished (from either method), strain the oil into a clean pan.

6 To make a salve, take the warm infused oil and gradually stir in shredded beeswax. Use the large holes of a cheese grater to shred the wax. Warm the oil slightly in a double boiler and heat just enough to cause the wax to melt. A general guide is to use 1 1/2 ounce of beeswax to a pint of infused oil. To test consistency, remove a spoonful of the mixture and put in the refrigerator to cool to room temperature. If it is too soft add small amounts of beeswax to thicken. If it is too hard add a small amount of infused oil.

7 Vitamin E can be added to the salve at this point to act as a natural preservative. Empty 2-6 capsules into the salve and stir.

8 When the salve is finished, pour into sterile small containers and leave to cool. Cap the containers when the mixture has cooled to room temperature. Label with the name of the salve, the ingredients, and the date.

Taking It Further

1 Class critical thinking activity—How can modern society ethically benefit from exploring new uses of medicinal plants? Explore the subject from each of the following perspectives: American Indians with historical plant medicinal knowledge, drug company executive, the consumer (or patient), conventional doctor, pharmacist, alternative medicine doctor, public lands manager, and a farmer growing medicinal herbs. There are no right or wrong answers and all points of view should be heard with respect.

2 Investigate a global perspective on the issues of regulating herbal medicines—look into the report: Regulatory Situation of Herbal Medicines—A Worldwide Review (4). This document is easily accessed with quick links to herbal regulations in many countries of the world: http://www.who.int/medicinedocs/en/d/Jwhozip57e/4.2.8.html

3 Use Google Scholar to find an article on the medicinal use of *Populus balsamifera.* Write a summary of the article and include proper citation and the website link to the article.

Plants as Medicine

Make Your Own Herbal Salve

In the Field!

Collect your own cottonwood buds to make salve. Cottonwoods generally grow in wet areas, along rivers and streams, wetlands, lake edges, and wet ditches. You will need to collect enough buds to fill a pint size jar (one jar for the entire class). Early February is a good time to collect in the Willamette Valley; higher elevations will be later. Collect buds when they are large or swollen in appearance and may be dripping resin. At this point they will be easy to break from branches. Cottonwood trees will often lose branches in windy conditions, so go collecting soon after blustery weather to find many branches knocked to the ground. Take a field guide on your trip to help you with tree identification if needed. For winter tree identification concentrate on looking for the shape of the tree (tall, somewhat columnar), the bark of mature trees (dark gray, and deeply furrowed), the location of the leaf buds on the branches (alternate), and sticky resinous buds. Also check underneath the tree for old fallen leaves to help confirm your identification.

Science Inquiry

Exploring the medicinal properties of plants is a fascinating subject with many avenues for science inquiry projects. The following are two suggestions that would fit well with this lesson. They will require additional class sessions to study background information, learn procedures, carry out the experiment, and write up the findings.

- Leaf Chromatography Lab: Separate chemical compounds from leaves to compare between different plants. Compare and contrast by testing plants with known topical medicinal properties against others with the same or different properties, or plants with no known properties. The following lab will give you procedures for setting up the experiment: http://www.pbs.org/wnet/secrets/previous_seasons/lessons/lp_zulu_handout1.html
- Testing for Antibacterial Properties of Plants: Research the ethnobotanical uses of Oregon plants with antibacterial properties or plants that were historically used on wounds. Test plants with known antibacterial properties, as well as a couple of others. The following lab will give you procedures for setting up an experiment: http://www.actionbioscience.org/biodiversity/lessons/plotkinlessons.pdf. Lichens can also be used or substituted for plants in this experiment. Research using several Oregon lichen species can be referenced below:
  - Paper on lichen's antibacterial properties: http://lichens.science.oregonstate.edu/antibiotics/lichen_antibiotics.htm
  - Article on lichen's role in traditional medicine: http://www.ispub.com/ostia/index.php?xmlFilePath=journals/ijam/vol5n2/lichen.xml

Plants as Medicine

Make Your Own Herbal Salve

Reflection

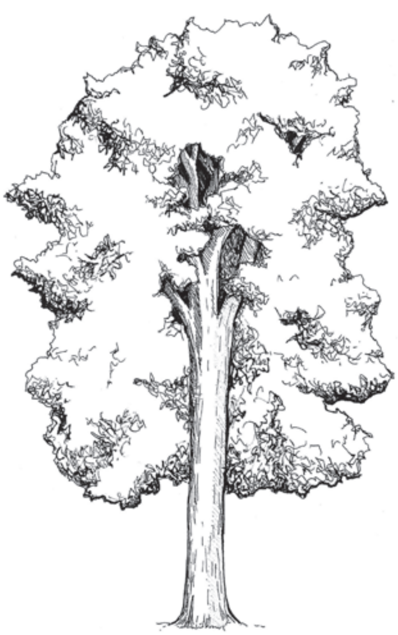
Write about the ethnobotanical knowledge in your family. Record it in paragraph form, charts, or stories. Include what you use and how you use it. Search your memory or, better yet, interview your parents or grandparents to record your family's ethnobotanical history. Think of foods you might eat to stay healthy, such as carrots for good eyesight (why?). What does your family do for a sore throat, coughs, or stomach ache? The plants you list could be ones you eat, drink as teas, or use in other ways. Don't forget to check your medicine cabinet for such things as aspirin, menthol, or herbal throat lozenges. Be mindful of the plants that you use in your daily life.

Also examine the advantages of traditional or alternative nature-based medicine versus conventional medicine. Which do you prefer? Do you see a role for both in our society? If so, how can both be employed to optimize health for human beings and the planet?

Self Assessments

1 Define phytochemical and explain one or two environmental processes that prompt plants to produce secondary chemicals.

2 Debate an opinion on the ownership of the intellectual rights to historical ethnobotanical medicinal plants.



Resources

- Phytochemical and Ethnobotanical Databases. Click on Plant Searches, Chemicals and Activities in a particular plant: http://www.ars-grin.gov/duke/
- Moerman, D. E. (2000). *Native American Ethnobotany*. Portland, OR: Timber Press.
- Foster, S. & Hobbs, C. (2002). *The Peterson Field Guide Series: A Field Guide to Western Medicinal Plants and Herbs*. New York, NY: Houghton Mifflin Co.
- *Green Pharmacy*, Dr. Jim Duke's Botanical Desk Reference. http://www.green-pharmacy.com/
- USDA-NRCS Plant Guide. Black Cottonwood *Populus balsamifera L.* ssp. *Trichocarpa*— http://plants.usda.gov/plantguide/pdf/cs_pobat.pdf

Plants as Medicine

Make Your Own Herbal Salve

Name(s)

Plant name (common and scientific)

Ethnobotany Information Source Used (column A & B)

A	B	C	D
Historical Use	**Plant Part Used**	**Phytochemicals in Plant Part**	**Phytochemical Biological Activity**
		1. 2. 3.	1. 2. 3.
Historical Use	**Plant Part Used**	**Phytochemicals in Plant Part**	**Phytochemical Biological Activity**
		1. 2. 3.	1. 2. 3.
Historical Use	**Plant Part Used**	**Phytochemicals in Plant Part**	**Phytochemical Biological Activity**
		1. 2. 3.	1. 2. 3.
Historical Use	**Plant Part Used**	**Phytochemicals in Plant Part**	**Phytochemical Biological Activity**
		1. 2. 3.	1. 2. 3.

Use the following web link for column C & D http://www.ars-grin.gov/duke/

Pick one of the ethnobotanical uses from your chart, use phytochemical research to support or deny the plant's medicinal use.

Section 6:
Climate Change and Phenology

TEACHER page

Phenology:
Tracking the Seasons in Your World

If you want an adventure, take the same walk that you took yesterday, and do so again tomorrow.
—John Burroughs (1837-1921)

Time Estimate:

Regular short observation periods covering several weeks before and after a seasonal change

Best Season:

Fall equinox or Spring equinox

Assessments

1. Describe how plants and animals respond to seasonal changes based on first hand observations.
2. Show basic understanding of natural cycles and how they are affected by temperature and day-length.
3. Explain how the study of phenology can be applied to climate change research.

Additional Information

- Citizen science monitoring projects and additional education resources. National Phenology Network USA: http://www.usanpn.org/
- Haggerty, Brian P. and Susan J. Mazer. *The Phenology Handbook: A Guide to Phenological Monitoring by Students, Teachers, Families and Nature Enthusiasts.* 2008 University of California, Santa Barbara. http://www.ucsbphenology.christophercosner.com/The_Phenology_Handbook-Haggerty_Mazer_2008_v1.pdf

Overview

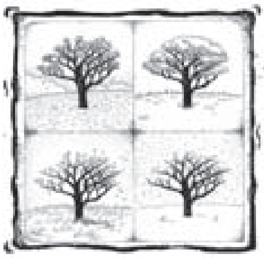
Introduce the science of phenology, the study of biological changes as the seasons unfold. Students use observational skills to track seasonal changes, collect data, and learn real world applications. They will relate nature observations to climate and examine how global change is affecting species, habitats, and ecosystems. Students will learn about the connections between phenology observations and the study of climate change and have the opportunity to participate in a citizen science program to contribute to a national database of climate change information.

Teacher Hints

- Encourage students to make this a long term project, tracking the unfolding events of the seasons for an entire year or multiple years in their field journal.
- Have students practice their prediction skills by holding a contest to choose the date of the first spring flower on the school grounds. Have each student record their predictions by writing their name on their chosen date on a calendar. The winning prediction should have an incentive (a prize, extra credit, whatever will motivate your students). Remind students weekly to be watching for the first flower. Now the hunt is on. Set up ground rules; the plant must be found on the school grounds, the flower be left in place, the teacher must verify the find, and determine how to handle a tie. Extend this to predict other significant events such as the return of the first migrating turkey vulture or the date a schoolyard tree will leaf out.
- "In the Field"— match the citizen science programs available to your classroom situation (abilities and time required). The National Phenology Network runs programs available to all levels, kindergarten through graduate students. Print out and use The Phenology Handbook they provide for program protocols (see Additional Information).

Preparation

- Introduce the activity by leading a discussion to enable students to explore and review what they know about the seasons: what causes them, how plants (and other organisms) react to seasonal changes, what triggers those changes in living organisms to happen (daylight hours, temperatures, calendar dates, weather), and what do those seasonal changes tell us. Use this discussion for the students to throw out ideas or make statements of what they already know or believe. Facilitate the students' exploration of the answers to these questions and more throughout the activity.



Phenology:
Tracking the Seasons in Your World

If you want an adventure, take the same walk that you took yesterday, and do so again tomorrow.
—John Burroughs (1837-1921)

Overview

Everyone takes notice of the seasons around them to some degree, even if only to soak in the first warm sunny days of spring. Now you can discover more about nature and the place you live by studying phenology, the study of the unfolding of nature's events through the seasons. Use your observation skills and your senses to track the seasonal changes of species and habitats and create a phenology journal. Participate in a citizen science program to create a national database of phenology information for researchers studying climate change.

Learning Objectives

- Make observations and record data on natural cycles
- Acquire basic understanding of nature's seasonal cycles and what influences those changes
- Explain how knowledge of phenology has been used by humans in the past
- Gain understanding of how phenology observations can be used in future science
- Participate in a citizen science program

Materials Needed

- phenology journal
- drawing materials
- optional: camera, binoculars, hand lens, field guides for your area

Vocabulary Words

- phenology
- equinox
- solstice
- day-length
- photoperiod

Background Information

Phenology is the study of natural events that reoccur periodically in relation to climate and seasonal change. Examples include bird migration and the changing of leaf color in autumn. The word phenology comes from the Greek words "phainestain" (to appear) and "logos" (to study). Life on earth has long been intimately tied to observations of (or instinctual or innate reactions to) phenological cycles. Before weather stations, humans needed to keep track of natural cycles to predict when to hunt, gather edible fruits and nuts, and plant their crops. Many native peoples linked natural events with cycles of the moon, the re-appearance of a migrating bird, or the timing of many other natural events. Today, people observe and record natural events to stay in tune with the seasons and keep time with the natural order. Other animals are cued in to phenological cycles as well, albeit on a more instinctual level.

The annual discovery of the first bloom of a plant was an event treasured and recorded by conservationist and naturalist Aldo Leopold. In *A Sand County Almanac*, he wrote, *Every week from April to September there are, on average ten wild plants coming into first bloom. In June, as many as a dozen plants may burst their buds on a single day* (1949:44). (1). Leopold kept daily journals of observations whenever he happened to be in the natural world. These journals held the keys to understanding patterns among plants, animals, weather, water, soil, and land. By recording natural events on a regular basis, particularly those events occurring on family walks, Leopold and his children would compare changes from year to year, as they learned about the natural world.

Author and naturalist Henry David Thoreau was one of the first to record extensive phenology data in the United States. He kept detailed journals that recorded bloom time data for over 500 wildflowers that grew in the area he lived near Concord, Massachusetts between 1852 and 1858. His work was continued by botanist Alfred Hosmer in 1878 and 1888-1902. Recently, scientists have collected data on the same wild-

Phenology:
Tracking the Seasons in Your World

Background Information, continued

flowers in the same location to make comparisons that might be related to climate change. Their comparative studies show that plants are blooming an average of one week earlier than in Thoreau's time. (2)

As global climate changes, phenological records are proving a reliable way to track the effects of changing climate on the life cycles of organisms. This activity focuses on the phenology of plants but others are tracking phenology as it applies to wildlife, insects, fungi and nearly every type of life on Earth.

What do the seasons look like where you live? Pick a place around your home, the schoolyard, or a favorite place you like to visit. Walk the same route in spring, summer, fall, and winter and tune in your senses to what is occurring around you. You do not need to travel a great distance to study phenology; it is happening all around you. You just need to tune in to what is happening wherever you are.

Directions

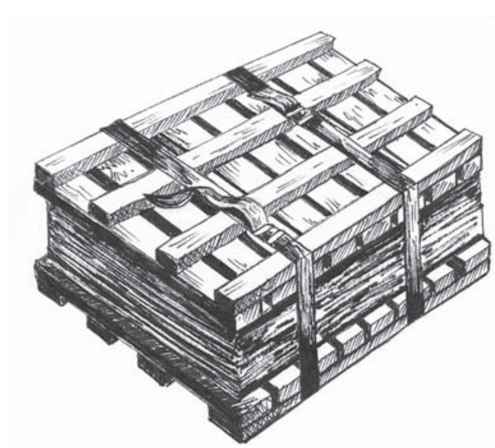
1. A phenology journal is a place to record the changes that you observe in the natural world. The following questions are appropriate things to record in your journal. Choose a particular plant and monitor it over time. When do the first flowers open on your plant? What flowers are blooming the week of March 20th in your area? Look for when ripe seeds appear on the plants. What happens to the seeds? Do they fall on the ground, are they eaten by birds, or do they catch on your socks? What other changes do you notice about your plant as the days pass?

2. Track at least one seasonal change in your journal (before and after an equinox or solstice). Make time at least once a week to look for changes in the natural world around you. Pick a place or area to observe, a place that you visit on a regular basis; your backyard, the school grounds, and the walk to school are all good places.

3. For your first journal entry, write a thorough description of your spot. Next, draw a map of your place and describe what plants you find there. Pick one special plant to examine and add it to your map.

4. Describe your special plant in detail. What do the leaves look like (size, amount, color)? Does your plant have buds, flowers, or seeds? How does your plant interact with its environment? Do you observe any activity around your plant (insect, birds, squirrels, other)? Look closely!

5. Watch your plant on a regular basis; make at least one journal entry each week for your plant. Weekly journal entries should focus on changes you observe about your plant and the world around it. At first you may have a hard time noticing changes. You may observe changes in leaf size, color, insects that appear, a bird eating berries, a bud that swells, bite marks on a leaf, or a branch broken in the winter wind, to name a few.



Phenology:
Tracking the Seasons in Your World

Directions, continued

6 Note what is happening around your plant. Is the ground wet or dry? What is the weather like? What other plants are near your plant? What animal signs are at your spot? Spend at least 10 minutes closely observing your plant (time yourself!), and then spend an additional 5-10 minutes recording your observations in your journal. Add to your journal entries with sketches and photographs if you want.

7 Track the growth of a new leaf. Flag a new leaf with a piece of yarn and take regular measurements (use metric scale) of length and width. Each time you make an entry in your journal, update the measurements of your leaf. How long did it take for the leaf to reach its maximum size? Compare these numbers with your classmates studying a different species. Is your plant a fast grower or does it grow more slowly?

8 Always note the date and time of each journal entry and add weather information including wind direction, cloud cover, and temperature. Visit the websites in the resource section to add day-length and climate data for your observation days.

9 Things to think about: If you kept a phenology journal from year to year, how accurate do you think your predictions could become? What do you think it would show? Can you think of ways the information could be useful for you? What ways could the information be useful to others?

Taking it Further

- Class Phenology Log-- Make a permanent phenology log for the classroom by setting up a notebook with index dividers for each month and a sheet of notebook paper for each day of the month. Record the date but not the year itself (i.e. January 1 but not January 1, 2008) at the top of each page, add the year to the left margin, and then make notes about what occurs each day. Everyone in the class can share their observations in the same book. The log can be added to each year; just add the current year in the left margin and place the new observations underneath. Add additional pages when needed. Look for the same events to occur (for example, first flower on the Oregon grape in your native garden) year after year. Note whether those same events occurred on the same day, earlier, or later in the year and think about why those changes may have occurred. This document will become more valuable with added years and may indicate possible relationships between climate change and biological cycles in your schoolyard and town.

Phenology:
Tracking the Seasons in Your World

In the Field!

Participate in the National Phenology Network citizen science program and help researchers at the National level track changes in key native species that may tell us about the changing climate. Visit http://www.usanpn.org/ and click on the link to "participate." This will take you to a listing of the different programs that they have available (Project BudBurst, NPN Core protocols, Honeysuckle/Lilac program). Pick the program that best meets the needs of your class based on available time and technical knowledge. Participating will require identifying native plants that you can monitor and a time commitment to making the observations. Connect your work to a natural area on the school grounds, nearby, or a frequently visited field trip site to make observations easy.

Science Inquiry

What do you think causes the seasonal changes that you observe in plants; could it be the hours or angle of the sunlight, temperature, amount of rainfall, or something entirely different? Narrow your predictions to one prediction, or hypothesis to test. Do an initial search to find information that might support your hypothesis. Design an experiment that would test your hypothesis. Your experiment could be in the classroom, in a greenhouse, or out in the field. Think about how you would control for other factors that may influence your results. Write a proposal describing your hypothesis, the testing protocol, and how your experiment will control for outside factors. If you have the time and resources, carry out your experiment.

Reflection

What seasonal changes do you go through? Think about how you react to temperature, light and dark. What signs in your body and outside tell you that fall is approaching? How do your senses help you detect these changes? What new sounds, smells, and colors occur? What signs tell you that winter, spring and summer are approaching? What is your favorite season and why?

Assessments

1. Describe how plants can respond to seasonal changes using your observations.
2. Explain how natures cycles are affected by temperature and day-length.
3. Explain how the study of phenology has been used in the past and its implications for the future.

Phenology:
Tracking the Seasons in Your World

Resources

- National Phenology Network—an organization that is collecting citizen science information on plants and climate change. They have monitoring projects that are available for your participation on three different levels, depending on your abilities or your commitment: http://www.usanpn.org/
- *The Phenology Handbook A Guide to Phenological Monitoring by Students, Teachers, Families and Nature Enthusiasts* by Brian P Haggerty and Susan J. Mazer, 2008 University of California, Santa Barbara for the UCSB Phenology Stewardship Program: http://www.ucsbphenology.christophercosner.com/The_Phenology_Handbook-Haggerty_Mazer_2008_v1.pdf
- Journey North: A Phenology Website: http://www.learner.org/jnorth/
- Leopold, Aldo. *The Sand County Almanac*. 1949 Oxford University Press, New York.

Phenology:
Tracking the Seasons in Your World

Phenology Journal Page

Date _______ Season _________Location _______________Weather______________________________

Sunrise time ___________ Sunset time _____________ Day length ________________

Minimum temperature ____________ Maximum temperature ______________

Last precipitation date __________ Form (rain/snow) ____________How much _________

Soil moisture: dry ____ moist _____ saturated _____

Plant life cycle stage (check all that apply):

dormant _____ in bud _____ leaf opening ____ flower buds ____ in bloom ____ full leaf ______ leaf drying _____ leaf drop ______

Special Spot Observations
(e.g. plant, wildlife, bird, insect, and fungi observations)

Special Spot Sketches

I wonder? (questions that your observations generate)

Plant Migration Game:
A Race Between Plants and Climate Change

Climate is what we expect, weather is what we get.

—Mark Twain (1835 – 1910)

Time Estimate:

45 minutes

Best Season:

winter

Overview

Students are bombarded daily with news of climate change and the impacts of their "global footprint" on the environment, but little information is out there about how climate change is projected to affect plants, especially native plants. In this lesson, students will play a game to explore some of the potential impacts and challenges of climate change on plant life in the Pacific Northwest.

Assessments

1. Discuss the impacts that affected their species' success or decline during the game.
2. Name three potential negative impacts of a changing climate on plants.
3. Identify one or more positive impacts of a warmer climate on plants.
4. Describe why certain types of plants may be more adaptable than others to changing climatic conditions.

Additional Information

- Climate Literacy: The Essential Principles of Climate Sciences: http://globalchange.gov/resources/educators/climate-literacy
- NOAA Office of Education - climate change information and curricula for educators: http://www.education.noaa.gov/tclimate.html

Teacher Hints

- Students should have a general background in climate change science to fully appreciate this lesson and explore the potential impacts on plants. See "Additional Information" for resources.

Preparation

- The game will be played in groups of 4-5 students. Photocopy and enlarge enough game boards and gather additional materials for the entire class in advance. Bowls of sunflower seeds or other small treats can act as the seed bank or currency. Two handfuls of seeds per group should be sufficient.
- Photocopy and cut out plant cards. Plant cards are drawn at the end of the game to assess the final fate of your plant.
- Gather or make pieces to move around the board (one for each player). Pieces can be objects (paper clips, rocks) or as simple as colored paper squares.
- Consider having students color and laminate the boards for long term use.

Plant Migration Game:

A Race Between Plants and Climate Change

Climate is what we expect, weather is what we get.

—Mark Twain (1835 – 1910)

Overview

Almost daily we hear about climate change and its likely impacts for humans, but how will climate change affect plants, especially native plants? Changes in our native flora as a result of climate change will have lasting impacts on wildlife, water, nutrient cycling, and on humans as well. In this lesson you will play a board game to explore some of the potential impacts and challenges of climate change on Pacific Northwest plant life.

Learning Objectives

- Explore potential impacts of climate change on plants
- Gain insight into predicted climate shifts for the Pacific Northwest and their effects on ecosystems
- Speculate how different species will adapt to climate change based on their life history strategies
- Learn how climate change can affect plant conservation and invasive species issues

Materials Needed

- *Game of a Plant's Life* board
- one die
- sunflower seeds with shells
- container for seeds
- player pieces
- plant cards

Background Information

Shifts in climate have altered the earth's ecosystems throughout geologic time. Nonetheless, evidence is rampant that the earth's climate is changing at an accelerated rate due to the human-caused accumulation of greenhouse gases. Scientists can sample air bubbles in ancient polar ice to investigate the characteristics of the atmosphere from thousands of years ago. While there have been periodic climate shifts throughout the history of the earth, in recent years scientists have noticed a distinct warming trend that is strongly correlated with human activities. When our society industrialized, we began to combust large amounts of fossil fuels and wood for energy, releasing carbon dioxide (CO_2) into the earth's atmosphere. Carbon dioxide is considered a greenhouse gas because it traps solar radiation in the lower atmosphere, effectively heating the earth. While this greenhouse effect is critical to maintain warmth to support life on earth, the added greenhouse gasses generated by humans enhance the effect. Scientists have developed very complex models to predict how the earth's systems may react to further increases in CO_2 concentrations. Modeling is useful on a global scale and to some extent on a regional scale, but local microclimates are so varied that it is impossible to accurately predict the effects of climate change on a precise local level.

Recent modeling has generated regional predictions of climate change for the Pacific Northwest (PNW). Scientists are particularly interested in patterns of temperature and precipitation; they have identified a trend of rising temperatures in the PNW, with an increase of 1.5˚F between 1920 and 2003 (2). It is important to differentiate between climate and weather to understand the concept of climate change. Weather is what we experience on a short

Vocabulary Words

- climate
- weather
- greenhouse gas
- microclimate
- seed dispersal
- assisted migration
- carbon sink

Background Information, continued

time scale, whereas climate refers to the long-term average of weather patterns (2). Climate modeling for the PNW predicts overall temperature increases in the future, with the largest increases occurring during the summer months (1). The best estimates suggest a rapid rate of warming in the PNW, with a temperature increase of 0.5˚F per decade (1). Most precipitation models for the PNW show little change in the annual average precipitation, but tend to show decreases in crucial summer precipitation and slight increases in the proportion of winter precipitation falling as rain rather than snow (1,3). The river systems throughout the PNW generally depend on snowpack to store water, thus reduced snow may mean that summer river flows will decrease. This trend may increase the water stress that PNW plants and animals already face during dry summers.

While animals and humans have the option of relocating in response to climatic shifts, individual plants cannot move and dispersal through seeds is slow and often random (not necessarily in the direction of better climate). Shifts in temperature and precipitation patterns will be the main drivers of potential impacts on vegetation. Due to the great variability in microclimates across the landscape, conditions may improve for plants in some areas and decline in others. As plants respond to stress, they may shift their energy allocation to focus on growth or reproduction. While under stress, plant metabolic processes are already overtaxed, which reduces their ability to resist diseases or insect infestations. The stresses each individual faces will affect its ability to survive and reproduce.

Because temperature drives many ecosystem processes, shifts in temperature may cause widespread disruption. Increased temperatures can cause phenological changes, such as spring bud burst, to happen earlier in the year than usual. Why does this matter? Such alterations in timing may cause disruptions in a plant's intricate relationships with co-evolved insect pollinators. If the pollinators emerge at the normal time, they may miss the earlier flowering of their target species. In another example, several species of herbivorous insect pests are currently controlled by cold winter temperatures that kill most of their larvae. If winters warm, more of the pest larvae may survive to adulthood, and some pest species may even complete two life cycles in one season, causing twice the damage to plants. Rising average temperatures are also strongly correlated with wildfire frequency, even when precipitation is held constant (3). A warmer climate will be more conducive to frequent wildfires.

The effects of climate change on individual plants' fitness will vary over their range, but what will the effects be on entire plant populations? Perhaps the most important consideration in predicting a species' success in the face of climate change is its seed dispersal strategy. Species that disperse large quantities of seed over great distances, potentially reaching sites with more favorable conditions, will likely be more successful than long-lived perennial plants that only produce a few seeds. Ironically, because invasive plants generally have strong seed dispersal ability and can rapidly colonize new areas, they may be better suited than native plants to shift or expand their range to cope with climate change. Species that are rare in their current range are less likely to adapt well to climate change. These species already have very low population numbers

Plant Migration Game:

A Race Between Plants and Climate Change

Background Information, continued

and often use less successful seed dispersal strategies.

Forest conservation plays an important role in climate change discussions. Trees assimilate atmospheric carbon dioxide during photosynthesis, and as trees grow, they act as carbon sinks. Planting trees and protecting existing stands may help sequester excess carbon that has already entered the atmosphere. While climate change presents many challenges for plant life, there are still steps we can take to slow the rate of greenhouse gas emissions and mitigate the effects of climate change on native species.

Climate shifts will likely have an impact on lands already set aside for conservation. Current habitat preserves may see new species move in, while the original target conservation species may migrate to new regions. Land managers and preserve designers are beginning to consider these potential shifts in habitat and species compositions as they manage existing preserves and plan new ones. It is important to predict where species of concern may be able to find suitable habitat in order to identify and conserve potential refuges in a changing climate. Restoration ecologists are also considering the impacts of climate change on their projects. As they try to restore degraded habitats to their natural state, ecologists should consider how future climate shifts may affect the habitat. Assisted migration is a new and controversial topic of conversation among restoration ecologists--should restoration ecologists relocate species to new habitats that will be suitable in the face of climate change, assisting them in survival? These and other questions make native plant conservation in the face of a changing climate more challenging. They will require conservation biologists to work creatively, and hedge bets by conserving more plants than would be necessary without climate change. They also make our efforts to reduce greenhouse gases and slow climate change that much more important.

Directions

1. Read over the background information to get a working understanding of climate change and its potential impacts on plant life.

2. Set up your *Game of a Plant's Life* board. Shuffle the Plant Cards, place them face down in the center, and select your game piece.

   Rules for the game:

   - Each player starts with 3 seeds from the Seed Bank
   - Roll a single die on your turn to move forward
   - At the start of the game, you may select one of the two paths for germination
   - Once the two paths merge, you have germinated and become a representative of the entire population of your species
   - You must stop at the STOP spaces, even if you still have more spaces to move, and wait for your next turn to proceed
   - When you reach a STOP space, you get one seed for successfully navigating another year —pay close attention to how the conditions change at STOP spaces
   - As you move around the board, you will pick up or return seeds to the bowl as your space instructs
   - The object of the game is to accumulate as many seeds as possible
   - If you run out of seeds during the game, your species has gone extinct and you are out
   - Once you reach the end of the board, draw a Plant Card

Plant Migration Game:
A Race Between Plants and Climate Change

Directions, continued

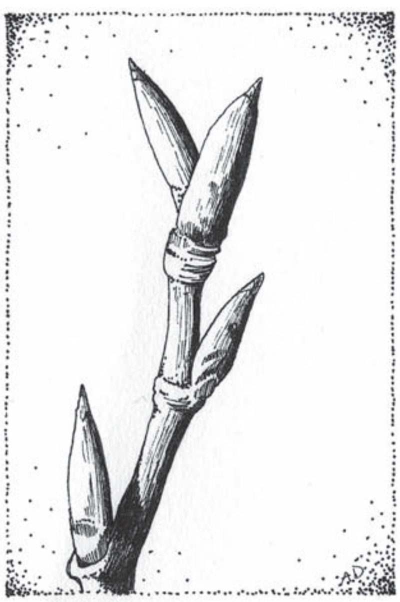
- Your Plant Card explains how many seeds you need to survive—if you do not have enough seeds, your plant doesn't survive
- To win, a player must have enough seeds to fulfill their Plant Card requirement AND have the most seeds overall

3 It is hard to predict how individual plant species will be affected by climate change. Plant life cycle strategies can help you start to speculate.

4 Class discussion: Do you think all plants will be affected by changing climate equally? Why or why not? Do you think humans should move plants to expand their range, or into new types of habitats, in an attempt to help plants cope with climate shifts? If so, how far would you be comfortable with moving them? Or is there a measure other than distance you would use to determine where to move plants? What about moving endangered plants? How might moving plants affect ecosystems? Do you have any new ideas on how restoration ecologists might help native plants survive climate change?

Taking It Further

Research and report back to the class about the plant group on your Plant Card. New scientific research is giving us updated information all the time. What news can you find out about how climate change is affecting this specific plant species or general plant type (e.g., wetland plants)?



Plant Migration Game:
A Race Between Plants and Climate Change

In the Field!

Look for a native plant population that appears to be limited to growing within specific micro-abiotic factors on the landscape (read about micro-abiotic factors in the background information in *An Ecosystem Through an Artist's Eye* lesson). How might this plant population be enhanced or inhibited by climate change? Is it possible that this plant could expand/contract its population at this site because of changing climate? Be prepared to support your ideas.

Science Inquiry

Climate change data is being recorded daily by citizen scientists throughout the world in one of several phenology observation programs (see *Phenology: Tracking the Seasons in Your World* lesson). The records kept by Henry David Thoreau at Walden Pond in the mid 1800's have proven to be invaluable for climate change scientists who have used them to discover that not all species in a given area respond the same way to climate change. Research the results that have been found from Thoreau's observations and use them to inspire you to collect your own data that may become very relevant to scientists and decision makers someday. Consider adopting your favorite native plant or natural area and observing and recording its phenology data over a long period of time. Keep your data in a special field journal devoted to this plant. Try to observe the start and end date of bud break, bloom, seed set, and leaf fall or dormancy. It will be extremely important to keep record of the location where you collected your data, and to continue to collect data every year for as long as possible. Though your sample size will be very small (only one plant!), in future years your data could help track plant species range changes, as well as climate related phenology changes. If you are able to collect data over a long period of years or decades, watch for trends in your data and share them with others.

Reflection

Choose a native species from your area. It can be your favorite, or just one you would like to learn more about. Write a paragraph that describes how you think it might respond to climate change. Through observation or research find out how your plant is pollinated, how it disperses seeds, and what conditions it lives in. All of these factors can be used to support your idea. Write how you feel about climate change and the fact that nature as we know it is changing during your lifetime because of human impacts. How does this make you feel? Does it motivate you to live in a certain way?

Plant Migration Game:
A Race Between Plants and Climate Change

Self Assessments

1. Discuss the impacts that affected the success of your species during the game.
2. Name three potential impacts of a warmer climate on plants.
3. Identify one or more positive impacts of a warmer climate on plants.
4. Describe why certain types of plants may adapt more rapidly than others to changing conditions.

Resources

- U. S. Global Change Research Program, Climate Literacy: The Essential Principles of Climate Sciences: http://globalchange.gov/resources/educators/climate-literacy
- University of Washington Climate Impacts Group, information about climate change in the PNW: http://cses.washington.edu/cig/
- U.S. Global Change Research Program, general and regional climate information: http://globalchange.gov

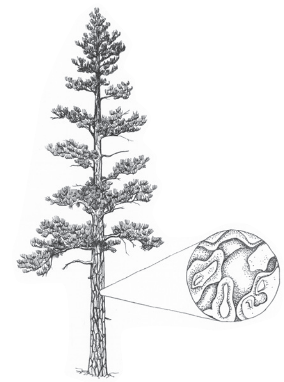
Pitcherplant
Darlingtonia californica

Status: rare
Habitat: bog
Seeds needed to survive and reproduce - 13

Bull thistle
Cirsium vulgare

Status: invasive
Habitat: open areas
Seeds needed to survive and reproduce - 1

Ponderosa pine
Pinus ponderosa



Status: common
Habitat: dry forest
Seeds needed to survive and reproduce - 9

Tufted hairgrass
Deschampsia cespitosa

Status: common
Habitat: wetland
Seeds needed to survive and reproduce - 8

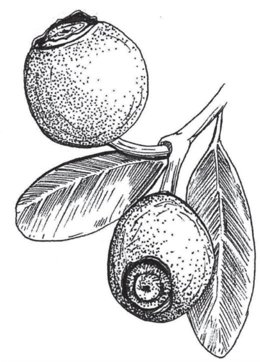
Partridgefoot
Luetkea pectinata

Status: common
Habitat: alpine meadow
Seeds needed to survive and reproduce - 7

Oregon oak
Quercus garryana

Status: common
Habitat: dry upland
Seeds needed to survive and reproduce - 10

Evergreen huckleberry
Vaccinium ovatum

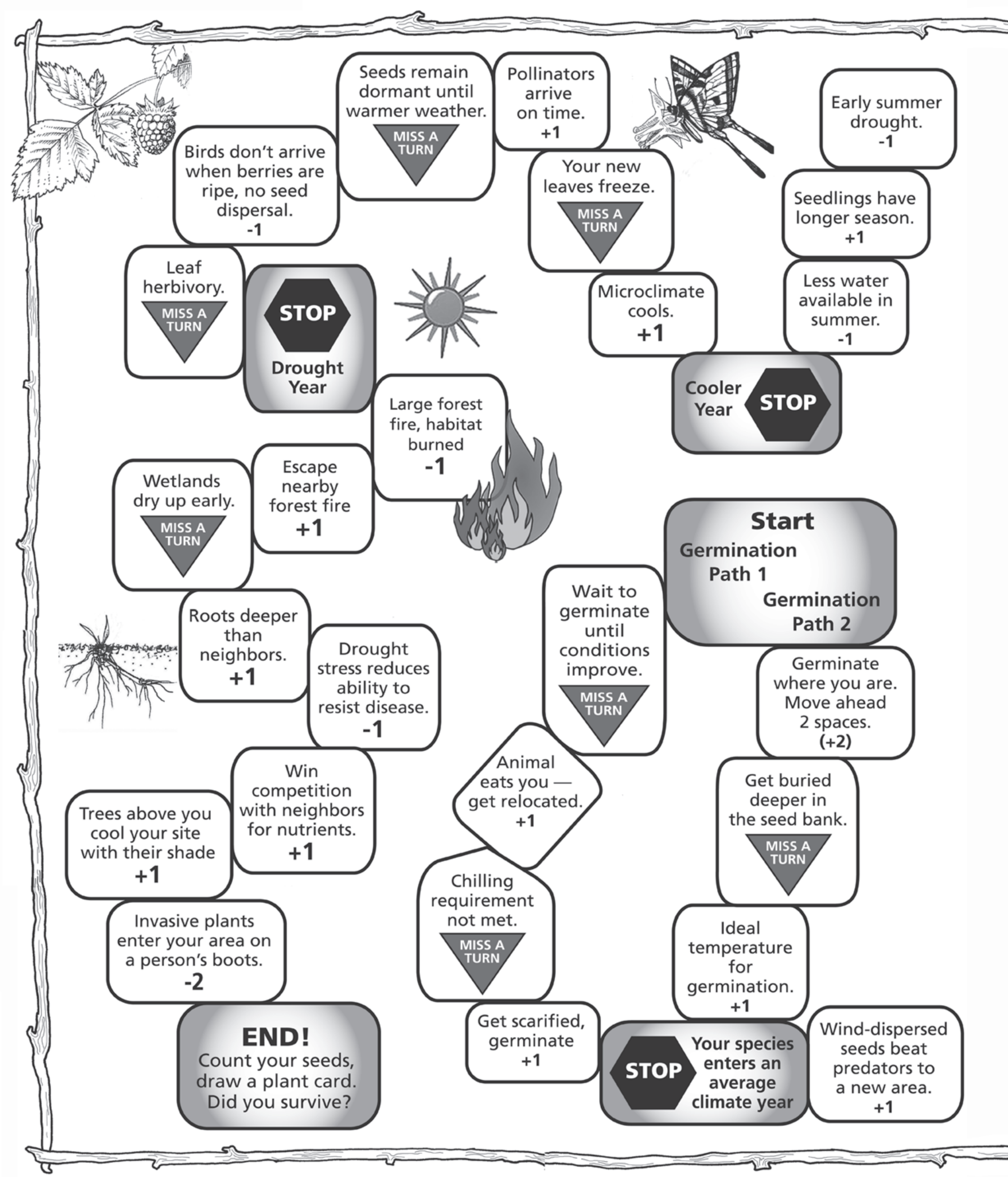


Status: common
Habitat: coniferous forest
Seeds needed to survive and reproduce - 6

Trillium
Trillium ovatum

Status: common
Habitat: moist woods
Seeds needed to survive and reproduce - 5

Game of a


Seeds remain dormant until warmer weather.
MISS A TURN
Pollinators arrive on time. +1
Early summer drought. -1
Birds don't arrive when berries are ripe, no seed dispersal. -1
Your new leaves freeze.
MISS A TURN
Seedlings have longer season. +1
Leaf herbivory.
MISS A TURN
STOP
Drought Year
Microclimate cools. +1
Less water available in summer. -1
Cooler Year
STOP
Large forest fire, habitat burned -1
Wetlands dry up early.
MISS A TURN
Escape nearby forest fire +1
Start
Germination Path 1
Germination Path 2
Wait to germinate until conditions improve.
MISS A TURN
Roots deeper than neighbors. +1
Drought stress reduces ability to resist disease. -1
Germinate where you are. Move ahead 2 spaces. (+2)
Animal eats you — get relocated. +1
Win competition with neighbors for nutrients. +1
Trees above you cool your site with their shade +1
Get buried deeper in the seed bank.
MISS A TURN
Chilling requirement not met.
MISS A TURN
Invasive plants enter your area on a person's boots. -2
Ideal temperature for germination. +1
END!
Count your seeds, draw a plant card. Did you survive?
Get scarified, germinate +1
STOP
Your species enters an average climate year
Wind-dispersed seeds beat predators to a new area. +1

Plant's Life

Spring arrives early.
+1

Seeds reach soil and germinate early.
+1

Larger insect populations lead to more herbivory.
-1

Increased CO2 concentrations increase photosynthesis rates.
+1

STOP
Low Snowpack Year

Increase transpiration rate, need more water.
-1

Longer growing season
+1

Insect larvae survive a warm winter and eat your leaves.
-1

You're adapted to warmer conditions.
+2

Late summer drought.
MISS A TURN

Bloom early — miss pollinators, no seed set.
-1

Bud burst occurs early.
+1

Bud chilling requirement not met.
-1

Hot weather— only seeds on the north slope germinate.
-1

STOP
Warmer Year

More water available to your roots.
+1

Your range moves out of conserved area.
MISS A TURN

Flooding — seeds swept to better habitat.
-1

Birds don't eat all caterpillars, insect herbivory increases
-1

Flooding — neighbors are better adapted.
MISS A TURN

Seasonal wetland stays wet year-round.
+1

Invasives reach your habitat.
-1

More moisture in your microclimate.
+1

STOP
Wet year

Increased early successional habitat.
+1

Slightly warmer — some insects complete two life cycles.
-1

Fall comes later.
+1

Temperature variability increases.
-1

You have strong seed dispersal ability.
+2

Weevil attack! Seed predation.
-2

Section 7:
The Future of Native Plants

TEACHER page

Nobody Right, Nobody Wrong: A Role-Playing Game

You must be the change you wish to see in the world.

—Mahatma Gandhi (1869–1948)

Time Estimate:

45-60 minutes

Best Season:

all

Assessments

1 Students participate in role-playing in a positive and productive way.

2 Students state their opinion on a controversial environmental subject and give one or more reasons to back up their opinion.

3 Students demonstrate empathy by listening to differing viewpoints and demonstrate respectful disagreement.

Additional Information

Resource lists included with each of the three scenarios

Overview

This is a role-playing game based on issues in Oregon ecosystems management and conservation. Three scenarios are available to explore different issues that pertain to different ecoregions of the state. Students develop roles, form an opinion that reflects their position, and defend their position during the game. This game exposes students to understanding and cultivating empathy for differing viewpoints on controversial issues, and helps prepare students for future stewardship decisions.

Teacher Hints

- Scenarios are designed to be relevant for different geographic areas of the state. We suggest the following: eastside non-forest land, *To Fence or Not to Fence.* Forested sites all ecoregions, *Forests and Humans: Balancing Current and Future Generations.* Urban areas, western valleys, and coastal areas, *Land Use Planning vs. Endangered Species.*
- To make role-playing productive: keep discussion focused and make objectives clear to the students. Students need productive feedback from the teacher and/or peers, and the freedom to explore alternate roles. Students need to listen to other viewpoints, weigh all sides of the issue, and form an opinion. The goal is that students will come to have empathy for all sides of each issue, regardless of their position.
- Establish clear guidelines of acceptable behavior in role-playing games. Controversial issues can and often do lead to strong feelings and arguments; it is important that no one feels intimidated. As part of the debriefing at the end of the game, consider adding discussion about handling such issues in real life situations.
- For larger groups, print out multiple copies of roles or create additional roles of your own. For smaller groups leave out some roles, but be sure to balance both sides of the issue. Students reluctant to participate in oral projects could pair up as teams.

Preparation

- Print out the roles and character worksheet for each student.
- Have students read, or read aloud the role playing scenario completely before starting.
- Extend this lesson with additional research, and writing a persuasive paper in support of your opinion.

Nobody Right, Nobody Wrong: A Role-Playing Game

You must be the change you wish to see in the world.

—Mahatma Gandhi (1869–1948)

Overview

Explore a local issue surrounding ecosystem management and conservation topics through a non-judgmental role-playing game. Develop and play your role at a mock planning meeting and in the end, weigh all sides and form your own opinion. Scenarios are: *Land Use Planning vs. Endangered Species, To Fence or Not to Fence: Grazing and Riparian Areas*; and *Forests and Humans: Balancing Current and Future Generations.*

Learning Objectives

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

Materials Needed

- role handouts
- scenario sheets

Background Information

If you read, listen or watch the news you can't help but hear stories of conflict over environmental issues (e.g., the Endangered Species Act, water quality issues, or climate change) which are frequently out in front of the public. In your community, there may be conflict over the management of native ecosystems that have people with very strong opinions pitted against one another in what seems like a feud of monumental proportions. How do these issues become such conflicts? In Oregon, with our natural resource and agriculturally-based economy and our incredible biodiversity, conflicts can arise when the livelihood or safety of people feels threatened by the conservation of natural resources and vice versa.

There are no right or wrong answers to the issues in this activity. The main purpose of this role-playing game is to provide an opportunity to explore viewpoints on controversial environmental issues in a non-judgmental atmosphere. Begin by considering what environmental stewardship means. It is generally defined as the concept of responsible caretaking, or management of the environment for future generations. Under this definition of stewardship we are all responsible for natural resource management and each decision we make can consider all kinds of future impacts, including economic, social, cultural, and environmental. It is said that native peoples took into consideration the impact of all decisions on the next seven generations. How do we form our opinions when making stewardship decisions? Often we fall back on our values—an individual's standard of right and wrong, or those of our families. Factors such as economics, education, politics, spiritual beliefs, and culture all go into forming our values. As you can

Vocabulary Words

- stewardship
- riparian
- clearcut
- fuels reduction
- forest thinning
- wildfire
- prescribed burn
- urban growth boundary (UGB)
- Endangered Species Act (ESA)

Nobody Right, Nobody Wrong: A Role-Playing Game

Background Information, continued

imagine, this complex stew of values can make reaching an agreement on environmental issues difficult, and often requires diplomacy and compromise between all the parties involved. Practice listening to the viewpoints of others; understand that they bring different values to the table, and that most people generally want to do what they feel is the "right" thing.

How does role-playing help you to work through controversial subjects? This role-playing exercise will give you time to organize your thoughts, listen to different sides of the issue, and weigh all the information before forming your own opinion on a controversial environmental subject.

Directions

1. This activity has no right or wrong answers. It is designed to help you evaluate your own feelings, and form your own personal viewpoint while listening to and weighing the differing viewpoints of others. You will gain the most by participating fully, but relax and view the role-playing as a learning experience. Ask questions as needed to clarify your understanding, but respect the opinions of others. The purpose of this activity is to get everyone involved and thinking about the friction that can arise over environmental concerns between different segments of our society and how you will address and resolve these issues in your future.

2. Student roles:
   - 3-5 students will act as the planning board (decision makers), with one appointed or elected chairperson for the group
   - remaining students will be the audience participants

3. Read over the scenario and clarify any questions within your class before starting. You will be handed a role and a worksheet; take 10 minutes to develop your character's background and values. You can work individually or discuss this with others, but the background sheet should reflect your character and not your personal viewpoint. Play your role as accurately as possible; realize that it may not mirror your own viewpoint, but do your best to empathize (walk in your character's shoes).

4. Start the game: the setting is a planning board or task force meeting (the board will sit together as a panel). Audience participants sit facing the panel. The chairperson will call the meeting to order, read the scenario, and explain rules of the meeting. Audience members will give a brief (3-4 minutes) presentation representing their character's opinion on the issue and how they feel it should be resolved. Commissioners can ask questions and take notes to help them make a final decision at the end of the meeting.

5. At the conclusion of the meeting, call a brief recess. At this time the board will meet privately to reach their joint decision. During the board recess, conduct a poll of audience members. Vote as you would personally (not your character) decide, after weighing all the presentations during the meeting.

6. Have the board announce their final decision and reasons. Tally the audience vote; does it agree or disagree with the board decision?

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

Nobody Right, Nobody Wrong:
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Taking It Further

- Read a current article about a controversial environmental issue taking place in your community. Analyze the article for bias; is it a balanced portrayal of the issue or is it written from one perspective? Identify other positions that might not have been addressed.
- Become involved with a local issue. Participate in public hearings, and planning commission meetings, or write a letter to your government representative or the local paper. Express your opinion, back your opinion with examples, propose a solution(s) to the problem – don't just complain.

In the Field!

Get involved with planning in your town. Take a tour of your town's urban growth boundary (UGB). Invite someone from the planning department to go with you or make a stop at the planning department as part of your trip. Ask them to talk about the UGB, when was it last expanded, what criteria is used to identify new lands, and has there been any controversy surrounding the UGB in your town? Ask them to show you maps of present, past, and proposed changes. Or, study the current issues that your local watershed council or local land use planning council is exploring. Attend a council meeting and testify on behalf of any positions you feel strongly about.

Science Inquiry

Read and analyze a scientific paper based on an endangered species monitoring study. Ask your librarian to help locate a paper, or search websites such as Google Scholar using the genus and species names of your species of interest. Read the paper with an analytical eye; identify the question or hypothesis of the research, how the hypothesis was tested, and what procedures they followed. Read the results and conclusion. Write a short summary of the research and your analysis. Was the research well done or not? Explain your reasoning. Was the conclusion supported by the data? Explain your reasoning.

Reflection

Reflect on the definition of stewardship: what does it mean to you personally? Do you feel that you have a responsibility as a citizen to help make decisions on land management issues? How can an individual's actions make a difference to their community; to the world? Identify a stewardship decision you make that could affect someone in another part of the world. Do you think the role-playing activity will change the way that you make decisions in the future? Explain your reasoning.

Nobody Right, Nobody Wrong: A Role-Playing Game

Self Assessments

1. Participate in the role-playing activity in a positive and productive way; researching, presenting, and discussing material within your character's role.
2. Listen and weigh others' opinions and demonstrate respectful disagreement.
3. State your opinion on the subject and give at least one reason to back up the opinion.

Resources

See individual scenarios for recommended resources

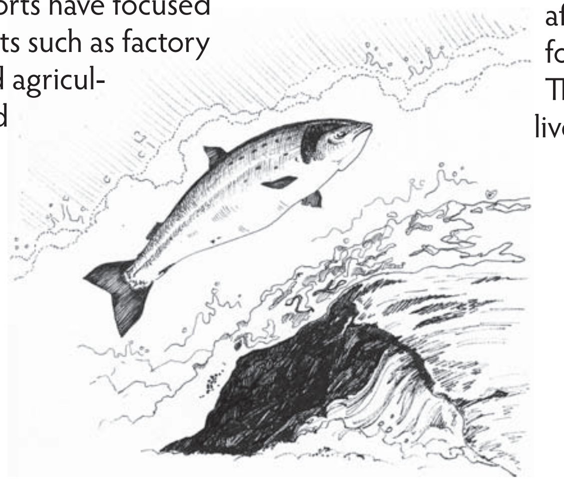
Nobody Right, Nobody Wrong:
A Role-Playing Game

Scenario 1
To Fence or Not to Fence: Grazing and Riparian Areas

Setting:
A government task force to discuss regulating livestock access to streams.

Background:
Sage City is a small town (population 2,000) in rural Eastern Oregon that is home to a mix of people, both inside city limits and in the surrounding rural areas. Citizens include workers from a wood products manufacturing business that has attracted new families to the area, the ranching community, and needed service and support people. The city is served by a school district that draws both from the town and from rural constituents. In recent years, Sage City has attracted a growing retired population, which has relocated to enjoy the outdoor recreation opportunities.

Problem:
Riparian areas throughout much of the open rangeland in the area lack suitable vegetation critical for stream bank stabilization and to provide shade, which strongly influences water quality and therefore fish and wildlife habitat. Vegetation can filter chemical pollutants, prevent erosion and excess particulate matter, and modify stream temperatures, all which are important for clean water and suitable fish habitat. Past water quality improvement efforts have focused on controlling large source pollutants such as factory discharge, erosion from logging and agriculture, and sewage. This has improved overall water quality, but further improvements have stalled. More recent efforts have focused on non-point source pollution (run off from urban, suburban, and rural locations). Livestock grazing has been identified as a major non-point source pollutant for eastern Oregon. Livestock tend to congregate around water sources, grazing and trampling stream bank vegetation. This can cause gullies at stream crossings, promote erosion, and increase water temperatures by reducing shade.



Differing Viewpoints
In recent years, a conservation organization has purchased a couple of old ranches in the Sage City area, with plans to restore the native ecosystems. Its priority is to restore riparian areas and improve water quality in the streams that run through the properties. The restoration will provide habitat for fish, wildlife and songbirds, with the long-term goal to improve stream water quality and fish populations.

The ranching community is in favor of improved stream quality, but has concerns with the methods the organization is proposing. By implicating their livestock as the cause of damage, they feel they are being unfairly blamed for the problem. In addition, ranchers fear that the restoration efforts will encourage predatory wildlife such as wolves and coyotes that will harass and kill their livestock. Management efforts to keep livestock out of riparian areas could require fencing off riparian areas, and potentially developing new water sources for their livestock. This is a financial burden that many of the ranchers feel they cannot afford with present meat prices, forcing them to stop ranching. This is a problem not only with livestock on ranches but also livestock on federal land under grazing leases. In fact, public lands may be more affected because there is little or no incentive to upkeep the land.

The Community:
At present there are no state or federal laws regulating

Nobody Right, Nobody Wrong:
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Scenario 1: To Fence or Not to Fence: Grazing and Riparian Areas, *continued*

livestock damage to streams. Both the manufacturing and timber industries are required to comply with water quality regulations, so Sage City's wood products manufacturing is regulated as is the timber industry that supplies them. Other connections can be through properties that generate taxes for services or supply businesses, and recreational income that comes into the area. Everyone in the community is connected in one way or another and decisions will have a ripple effect throughout.

The Decision:
Should livestock access to riparian areas be regulated? Yes or no. If so, what should the regulations be?

Stakeholders

Science and Government:
- BLM rangeland manager
- Oregon Department of Fish and Wildlife biologist
- teacher with a spouse/partner that is a rancher
- invasive species specialist

Business and Labor:
- local livestock feed store owner
- sheep rancher with federal grazing lease
- fly fishing and rafting guide
- small business grocery store owner
- owner of wood products manufacturing business
- large animal veterinarian
- local organic farmer

Landowners/managers:
- retired small acreage homesteader
- tribal land manager – with interest in restoring fish populations
- cattle rancher/landowner
- wheat farmer
- homeowner (in town) employed in manufacturing

Recreational Interest:
- outdoor recreationist (canoeing and camping)
- hunter

Conservation Groups:
- restoration ecologist from conservation organization
- member of conservation organization – retired school principal
- member of a group protesting land use limitations

Other Interests:
- high school student (graduating senior)
- wild card – make your own role

Resource Information:
- Negative Effects of Livestock Grazing Riparian Areas: http://ohioline.osu.edu/ls-fact/0002.html
- Public Rangelands: Some Riparian Areas Restored But Widespread Improvement Will Be Slow: http://archive.gao.gov/d16t6/136218.pdf
- Oregon Dept. of Environmental Quality-water quality pages: http://www.oregon.gov/DEQ/WQ/
- Do an internet search to find current information on your chosen topic.

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Scenario 2
Land Use Planning vs. Endangered Species: Expanding the Urban Growth Boundary (UGB)

Setting:
A city planning commission meeting

Background:
Oak Valley is a town with a population of 100,000 in the densely populated area of Western Oregon. The city has been growing at a steady rate and at the last review of the City's comprehensive plan, it was decided that they needed to expand the urban growth boundary (UGB). The UGB is an Oregon Land Conservation and Development Commission (LCDC) program designed to limit urban sprawl, and protect agricultural and forest lands from development. It requires cities to designate a boundary of future growth, within which there is sufficient land to meet residential, industrial, commercial, and recreational needs for a projected 20 year plan of development. The city is required to revisit their development plan every 5-7 years and to adjust their UGB to reflect the changes from these periodic reviews. The town has determined the UGB needs to be expanded. It has financed an extensive study to identify appropriate lands to include in the expansion. It has considered the cost and feasibility of extending city services, included enough buildable land (both residential and commercial), and incorporated the city transportation plans to handle twenty years of projected growth.

Problem:
The new land planned for inclusion into the UGB includes a rather large population of a threatened plant species that is the host plant for an endangered butterfly found only in this region. Surveys have not found any butterflies associated with the host plants on this particular property, but a known population does exist within a two-mile radius of the site, within the flight range of the endangered butterfly. This means that the threatened plant population could be key to the endangered butterfly's recovery. It also could mean that future discovery of the butterfly on lands within the UGB would require development to comply with the Federal Endangered Species Act (ESA). This could result in restrictions on development, or complications, and added cost to development.

Differing Viewpoints:
The city would like to approve the UGB and continue on with their expansion plans. They have already spent thousands of dollars to work on feasibility studies and feel they have put together the best plan for the city. To modify or change their plans at this point would require spending additional tax money which could be better used to supply much needed social services (e.g., schools, police).

On the flip side, environmental groups are frustrated that the city would makes plans that risk damaging critical butterfly habitat. They feel the city should cut their losses and start over in their UGB planning. They feel that the expenses are minimal to protect endangered species and are prepared to fight this issue.

The Community:
Everyone in this community is connected in one way or another to this issue, and decisions will have a ripple effect throughout Oak Valley. Limiting future growth could discourage new employers, limit tax revenue, and impact social services. Taking away potential butterfly habitat could irreparably damage the species' chances for recovery, permanently removing a key species from the local ecosystem. Allowing future growth could permanently degrading the environment as well as create

Nobody Right, Nobody Wrong: A Role-Playing Game

Scenario 2: Land Use Planning vs. Endangered Species*, continued*

sprawl, reducing the rural character of the outskirts of the city. If the issue is not resolved, it may require court action that potentially could be very costly for all parties and persist for years. Time is of the essence for both parties.

The Decision: Should the urban growth boundary (UGB) expansion be approved or not?

Stakeholders

Science and Government:

- Oak Valley city planning commission member
- US Fish and Wildlife biologist
- Oak Valley Mayor
- LCDC commission member

Business and Labor

- solar panel manufacturer with a new business hoping to locate in the UGB
- restaurant owner
- small business owner that needs to expand but cannot find a location
- housing developer

Landowners/managers:

- land owner within the proposed UGB
- land owner outside of UGB
- tribal land manager from adjacent lands

Recreational Interest:

- naturalist, local birder, and hiker
- community parks advocate
- skate park skateboarder

Conservation Groups:

- national wildlife organization representative
- land conservancy non-profit representative

Other Interests:

- high school student
- attorney that defends one of the parties interest
- land zoning advocate
- wild card – make your own role

Resources Information:

- US Fish and Wildlife Endangered Species page: http://www.fws.gov/endangered/pubs/index.html
- Inside the Boundaries—pamphlet on Oregon zoning laws: http://www.flu.oregon.gov/LCD/docs/publications/insideboundaries.pdf
- Putting the People in Planning; a Primer on Public Participation in Planning: http://www.lcd.state.or.us/LCD/docs/publications/putting_the_people_in_planning.pdf
- Do an internet search to find current information on your chosen topic.

Nobody Right, Nobody Wrong:
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Scenario 3: Forests and Humans: Balancing Current and Future Generations

Choose a topic that best fits a current forest issue in your ecoregion.

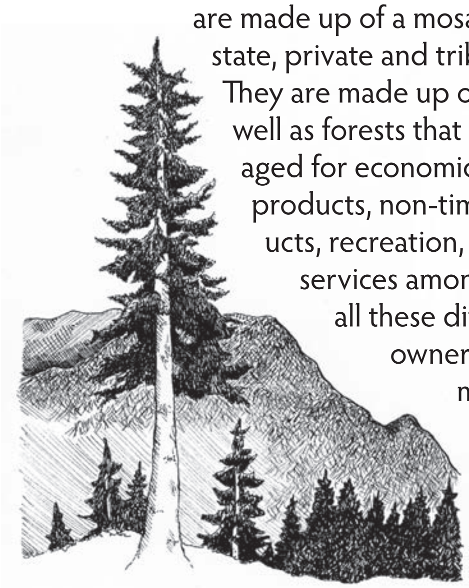
Topic Ideas:

- Is Thinning Essential to Forest Health?
- Forest Wildfires: Suppression or Let it Burn?
- After a Fire: Replanting or Natural Revegetation?
- Clearcutting: Healthy or Unhealthy?
- Sustainable Forest Harvest: Short-term vs. Long-term Gains

Other current topics could include: protection of old growth forests, protecting watersheds, managing ecosystems, forest fragmentation, road building, and carbon sequestering to buffer climate change.

Setting:
a town hall style debate

Background:
Oregon is a state of abundant forests. These forests are made up of a mosaic of federal, state, private and tribal ownerships. They are made up of natural areas, as well as forests that are actively managed for economic gains from wood products, non-timber forest products, recreation, and ecosystem services among others. With all these different factors of ownership and management, forests have in recent years have often been at the center of controversy.



Problem:
Resolve conflicting ideas in managing forests for multiple uses.

Differing Viewpoints:
For years there have been bitter arguments over forest management in the Pacific Northwest, pitting industry against conservation. Hot button topics have revolved around endangered species such as the northern spotted owl; marbled murrelet; salmon; fire; old growth forests; and the economic uses of the forest.

Historic forest management practices have come into question with new scientific discoveries. Is clear cutting a good idea? Is reforesting by planting single tree species sustainable? Wood products are essential to our everyday lives, and forests supply jobs, but how do we manage them to maintain health and resources for future generations?

In more recent years the public is becoming more aware of the vast array of ecosystem services that forests provide, including water filtration, air purification, carbon sequestration, climate moderation, and erosion control, among others. Forests are also valued for recreation, cultural, and aesthetic values. This adds up to a lot of potentially conflicting uses for a finite resource.

The Community:
Everyone in Oregon, directly or indirectly, has a stake in the decisions that are made to manage our forests. These decisions affect jobs, the local economy, forest health and safety, a clean environment, and human enjoyment.

The Decision:
What is the best way to manage our forests for current and future generations?

Nobody Right, Nobody Wrong: A Role-Playing Game

Scenario 3: Forests and Humans: Balancing Current and Future Generations, *continued*

Stakeholders:

Science and Government

- U.S. Forest Service employee
- Oregon Department of Forestry fire suppression manager
- restoration ecologist
- local town planning commission member
- BLM logging contract advisor
- US Fish and Wildlife biologist
- Oregon State University forestry researcher

Business and Labor

- logging company owner
- paper mill manager
- outdoor store employee
- international wood products company board member

Landowner/manager

- homeowner on the forest/town interface
- tribal land manager of adjacent tribe-owned land
- small woodland owner

Recreational Interests

- wilderness hiker and camper
- avid fly fisher
- outdoor photographer
- deer/elk hunter

Conservation Groups

- radical conservationist/tree sitter (e.g. Earth First!)
- moderate conservation club member (e.g. Sierra club, Nature Conservancy)

Other Interests:

- wild cards"—make up your own role that represents your community

Resource Information:

- Environmental Issues in Pacific Northwest Forest Management. National Academy of Science: http://www.nap.edu/openbook.php?isbn=0309053285
- Oregon Forests Values and Beliefs Study, June 2010: http://www.oregonohv.org/ODF/BOARD/docs/OFRI_VB_Study_2010/OFRI_2010_VB_Executive_Summary_June_2010.pdf?ga=t
- Oregon Department of Forestry: http://www.oregon.gov/ODF/index.shtml
- Do an internet search to find current information on your chosen topic.

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Role Development Sheet

Your Name________________________________ Scenario Title ________________________

Name of your character:	Age:	Gender:

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

Role Development Sheet

Your Name________________________________ Scenario Title ________________________

Name of your character:	Age:	Gender:

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

Biodiversity and Ecosystem Services: Can't Live Without 'Em

TEACHER page

Uniformity is not nature's way; diversity is nature's way.

—Vandana Shiva (1952-present))

Time Estimate:

one or two sessions (45-90 minutes)

Best Season:

spring/fall

Assessments

1. Define biodiversity and describe why it is important.
2. What is a biodiversity hotspot? What is the nearest biodiversity hotspot to where you live?
3. Demonstrate or describe a method of measuring and calculating plant diversity.
4. Compare and analyze the results of two or more plant diversity surveys.

Additional Information

- *Ecosystem Services: A Primer.* Links to ecosystem services background articles and lessons appropriate for high school students: http://www.actionbioscience.org/environment/esa.html
- Nature's Services, article about the value of ecosystem services:

  http://www.rand.org/scitech/stpi/ourfuture/NaturesServices/section1.html

Overview

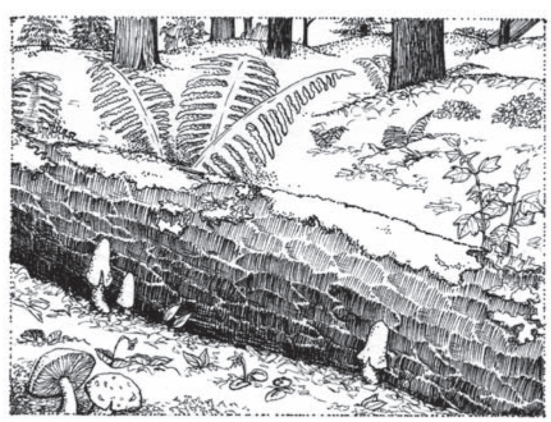
In this lesson students will explore biodiversity, global endemic hotspots and ecosystem services. Students will conduct a schoolyard plant diversity survey. Extend or build on the activity to learn about ecosystem service concepts and to explore a science inquiry question about biodiversity.

Teacher Hints

- Have students work in teams of two, with one spotter and one recorder, for conducting a plant diversity survey on the school grounds. Assign student teams to work in different areas to get a good representation of plant life on the school grounds.
- For step #5 of the student directions: follow the protocols in the Plant Press activity or use green leaves and adhere them to the butcher paper with contact paper.

Preparation

- Use a map to help the students visualize the entire schoolyard.
- Decide on areas of the school grounds to use for the plant diversity survey. Mark particular sites or areas for students to choose from. Spread the surveys over an assortment of vegetation types (landscaped, lawn, weedy, or others if you have them). To make the calculations of different types of diversity easier, select areas likely to have between 5 and 15 species present. Pre-mark these sites on a map or help the students to locate their site on the map when they return.



Biodiversity and Ecosystem Services: Can't Live Without 'Em

Uniformity is not nature's way; diversity is nature's way.

—Vandana Shiva (1952-present))

Overview

In this activity, you will explore biodiversity, global endemic hotspots and ecosystem services. Conduct a schoolyard plant diversity survey and learn about the concept of ecosystems services while exploring a science inquiry question about biodiversity.

Learning Objectives

- Define the terms biodiversity and hotspot
- Conduct a simple plant diversity inventory
- Gather, analyze, and present data
- Understand the concept of ecosystem services, name several, and discuss their biological and economic values

Materials Needed

- map of the schoolyard
- 4-meter string loop (one for each survey team)
- clipboard and data sheet
- butcher paper
- optional: toothpicks, field guides, plant press, adhesive contact paper

Vocabulary Words

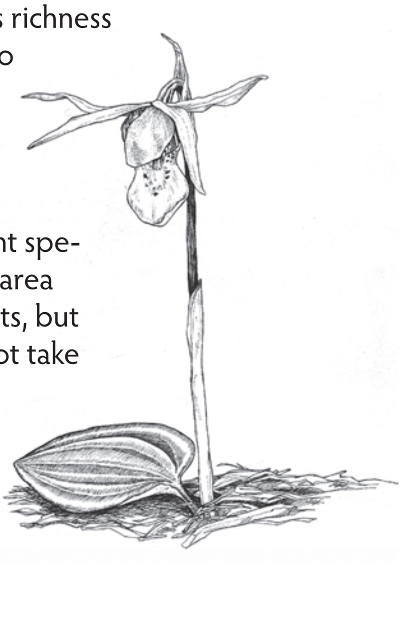
- biodiversity
- endemic
- hotspot
- ecosystem services
- percent cover

Background Information

Have you ever considered that the food you eat for breakfast is brought to you each morning by the wind that pollinated the grasses that produced the grains that make up your cereal, or that the clear, cold, clean water you drink every day may have been purified for you by a wetland or perhaps the root system of an entire forest? Trees in your schoolyard capture dust, dirt, and harmful gases from the air you breathe. The bright fire of oak logs you light to keep warm on cold nights and the medicine you take to quell the pain of a headache come to you from nature's warehouse of services. Natural ecosystems perform fundamental life-support services upon which human civilization depends. Unless human activities are carefully planned and managed, valuable ecosystems will continue to be impaired or destroyed. Through the intricate processes in ecosystems, biodiversity provides clean air, water, food, medicine, shelter and a wealth of interactions between species that keep an ecosystem functioning and healthy. In addition, biodiversity provides us with recreational opportunities, aesthetic beauty, and cultural and spiritual connections for the human soul.

Biodiversity encompasses the variety of all living things and includes the diversity of species, the genetic diversity within species, and the diversity of ecosystems that these species call home. Scientists estimate that the Earth is home to 10-30 million species, but have named and cataloged only a fraction of that number so far. Oregon alone is home to an estimated 4,000 species(1). Advances in DNA sequencing and knowledge of the genetic code continue to open up new worlds of organisms that have yet to be identified.

How do scientists measure biodiversity? They evaluate the two primary components of diversity in the field, which are species richness and species evenness. Species richness refers to the total number of different species an area supports, but does not take into account the num-

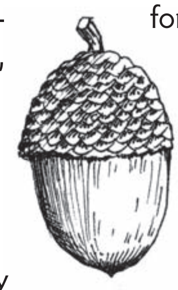


Biodiversity and Ecosystem Services: Can't Live Without 'Em

Background Information, continued

ber of individuals of each species. In this measure, a single individual carries as much weight as a species with many individuals. Species evenness refers to the relative abundance of each species present. Consider a meadow with 30 species present. It has a species richness of 30. Its species evenness would be assessed by how many individuals of each of the 30 species were present. If there were 1,000 of one species, and only one of each of the other 29 species, the meadow would have low species evenness. A community with one or two species dominating is considered less diverse than a community in which all 30 species have a similar abundance. As species richness and evenness increase, so does species diversity.

How do biodiversity and healthy ecosystems provide ecosystem services? Let's use the example of plants. They provide the oxygen that we need to breathe, and they take up and store carbon from the atmosphere. We depend on plants to provide our food, either directly (such as fruits, vegetables, and grains) or indirectly, as food for animals that provide meat and dairy products. Plants can work to mitigate the impacts of drought by helping to hold moisture within the soil, and moderate floods through plant roots stabilizing soil to prevent erosion and landslides. Plants also filter our water by taking up pollutants and trapping them in their biomass. These services, as well as pollination, climate modification, nutrient cycling, and many more, are collectively called ecosystem services. They are provided by rich biodiversity, the interactions between species, and healthy ecosystems. Essential ecosystem services are listed below.



- water filtration
- carbon sequestration
- flood control
- drought mitigation
- air purification
- nutrient cycling
- recreation
- pollination of crops and native species
- moderation of weather extremes
- moderation of climate
- medicine sources
- maintain genetic diversity
- disperse seeds
- prevent erosion
- decompose wastes
- renew soil fertility
- protection from harmful ultraviolet rays
- control of agricultural pests
- regulate disease-carrying organisms
- capture energy through photosynthesis

Assigning monetary values to ecosystem services can be challenging. For example, what if acid rain or another disaster sterilized the soil over a large area of farmland or forestland, eliminating soil fungi and microorganisms essential for decomposition and nutrient cycling? Soil fertility would no longer be naturally renewed. If farming or timber production in the area were necessary, what would it cost to remove materials that would not be broken down and to continuously apply fertilizer? Alternatively, if pollinators declined dramatically, what would it cost cherry farmers that are dependent on having their trees pollinated to produce a crop?

Studying the fossil record, paleontologists have noted continual extinctions of species over the history of the earth, but recently the extinction rate appears to be rapidly increasing. This loss of biodiversity could have huge impacts on the ecosystem services on which humans rely. What factors lead to biodiversity loss? Habitat loss, in which humans change natural ecosystems by farming, filling wetlands, changing water courses, and generally expanding the human footprint, is a primary cause. Habitat loss can also occur naturally through volcanic activity, wildfire, and individual species loss to disease or competition. Additional factors that diminish biodiversity include climate change, the proliferation of invasive species, the overuse of resources, and pollution (2).

In the discussion of worldwide biodiversity loss, you may come across the term "biodiversity hotspot". To be designated a biodiversity hotspot, an area must be home to

Biodiversity and Ecosystem Services: Can't Live Without 'Em

Background Information, continued

a high level of biodiversity, including more than 1500 endemic plant species, and it must have lost 70% or more of the original vegetation, putting it under significant threat. The global non-profit organization Conservation International lists 34 hotspots worldwide. The California Floristic Province is a biodiversity hotspot in North America. This hotspot extends from Baja California into southern Oregon, in the Klamath Mountain ecoregion, also called the Siskiyou Mountains (3). In addition, the World Wildlife Fund named the Siskiyou Bioregion as one of 200 global hotspots on Earth. The Klamath-Siskiyou area alone is home to 131 native plants found nowhere else. The region is likely so diverse because it is a mixing pot between 5 major biotic regions: the Great Basin, Coast Range, Cascades, Sierra Nevada and Central Valley of California(4).

Although the concept of a biodiversity hotspot may sound grim, there is much that can be done to protect the biodiversity that we have, beginning at home. You can contribute to preserving biodiversity by choosing to live a more sustainable life, decreasing use of fossil fuels, conserving water, recycling, and gardening. Become an informed citizen and use your voice and vote to educate and lead. On a community-wide level, protect wild areas, work to restore degraded habitats, and support ecological education and sustainable development.

Directions

1 Discussion: What does "biodiversity" mean? (Hint: Break the word into parts to help formulate a definition). Why do you think biodiversity is important in an ecosystem? How is biodiversity an indicator of the health of the environment? Explain your reasoning. How does the reduction of biodiversity harm the environment? How is it bad for humans? Can you think of any positive things that come from the reduction of biodiversity? Think about your own habitat. Would you consider it biodiverse; why or why not?

2 For this activity, focus on measuring plant diversity in your schoolyard. Work in teams of two to measure the diversity of plants using a meter square (or a 4-meter string tied into a loop and staked into a square) (See Appendix VIII). Each team will measure a different area of the schoolyard that will yield different results.

3 Spread the square-meter plot on the ground and estimate the percent cover of different species of plants or plant-like organisms that are living within the square. For this it might be easiest to have one person estimate cover and the other record the results. It is not essential to know the name of the plants (although this is helpful). To record the species, take a digital photo or draw a sketch to ensure you only measure percent cover for each species once. Alternately, you can use a marker like a toothpick stuck in the ground or yarn tied to the plant to designate the species that you have already measured. Include mosses and lichens.

4 Calculate the Simpson's diversity index (D) for your plot. Use the following equation for Simpson's index of diversity:

$$\text{Diversity (D)} = 1 - \{\text{sum}\ (p(i)2)\}$$

where $p(i)$ = the proportional abundance of species i

You can use either decimal or percentage values; both will come out the same. If species i has cover of 78% and the total cover is 140%, then $p(i)$ is 78/140 = 0.55 or 0.78/1.40 = 0.55

Square each $p(i)$ value, add up all the $p(i)2$'s, subtract the total from 1, and you have your diversity index.

In this index of species diversity, D ranges from 1 to 0, with 1 representing infinite diversity and 0 representing no diversity(1). In the example in the table below, you may have the following species composition in your plot, where you found one grass, two things that looked like daisies but were clearly two different species, and one shrub:

Biodiversity and Ecosystem Services: Can't Live Without 'Em

Directions, continued

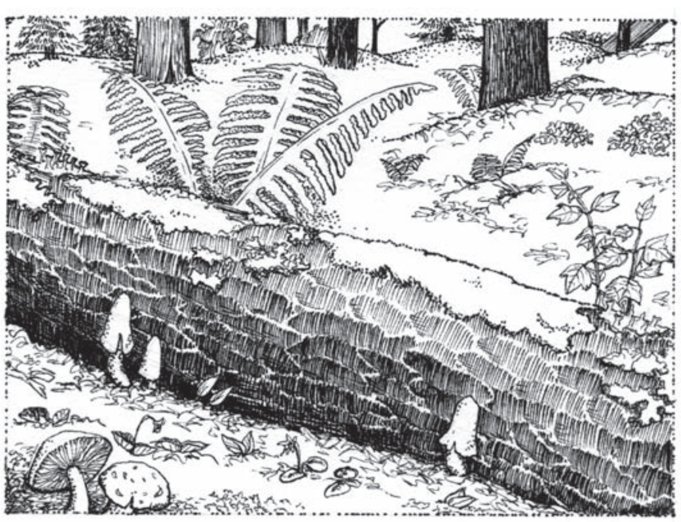
Species	Percent cover	p(i)	p(i)^2
grass #1	40 %	(40/130)=0.307	$(0.307)^2$=0.094
daisy #1	15 %	(15/130)=0.115	$(0.115)^2$=0.013
daisy #2	40 %	(40/130)=0.307	$(0.307)^2$=0.094
shrub #1	35 %	(35/130)=0.269	$(0.269)^2$=0.072
Sum	130%		0.273

1 - 0.273 = 0.727

Diversity (D) = 0.727

The final number may seem abstract but remember this is a relative measure. It lets you know how diverse your plot is between no diversity (0) and infinite diversity (1). In our case, our diversity is 0.727. This may seem high since we only had four species but evenness plays a role as well. Note that our species composition was relatively even, with no one species dominating completely. For comparison, use the same four species but change it so one species is at 91% and the other three are at 3% and see how your diversity index changes.

5 You may also collect plant specimen samples in a plant press. Use butcher paper to make a large chart of your findings. Hang all the plot sample charts for the class to compare results. A simple way to classify your findings is to divide the plants by category and press a leaf specimen from each. Record the results by grouping types of plants together: tree, shrub, grasses, broadleaf herbaceous, mosses, and so on, with the sample of the leaves.



6 **Extra Credit**: Identify the plants at your site. Label with scientific and common name. Are they native or non-native?

7 Return to the classroom and add your site location to the schoolyard map. Record the species richness and species diversity of your plot on the map. When all the teams have added their data to the map, discuss the results. Do the most diverse plots also have the greatest species richness? Discuss the difference between diversity and richness.

8 Make a graph of the class results (plot number, species diversity, and species richness). Which teams have the highest diversity? Which the lowest? Do the numbers correlate to any patterns that you observed on the school grounds (landscaped areas vs. native areas)? Do humans influence the abundance or diversity of plant life? Explain your reasoning. Do you think native plant diversity and exotic plant diversity show the same patterns? Explain why or why not.

Taking It Further

The ecosystem services concept puts an economic value on the services that nature provides us (such as clean air, clean water, nutrient cycling, and so on) and from which we benefit. If people see the economic value of ecosystems, they will be more inclined to conserve and preserve them.

- Research one of the ecosystem services listed in the background material for this lesson. Make a flashcard for your service using a 4x6 card. Write the name of the service on the front of the card. Answer the following questions on the back: 1) How does the service work in the natural world? 2) How does the service benefit humans? 3) What part do plants play in the service? 4) How much do you think this service is worth? Pool all the flashcards and create a game for the class to play.
- Advanced discussion: Conservation policies often seem to be at odds with economic growth.

Biodiversity and Ecosystem Services: Can't Live Without 'Em

Taking It Further, continued

How could environmental policy and economic growth work together to sustain biodiversity? How would this help focus conservation efforts on biodiversity hotspots? What could be done to preserve biodiversity in your ecoregion?

What kind of ecosystem services does your schoolyard provide? Can you calculate what these services may be worth? What do you think the benefits and drawbacks are to assigning monetary values to nature?

In the Field!

Conduct an additional plant inventory to compare with your schoolyard inventory. Choose an invasive weedy site, a park, a natural area, an agricultural field, your backyard, or another area. Hang a large map of the local area and mark spots that have been surveyed. Compared to these additional sites, how diverse do you think your schoolyard is?

Science Inquiry

Ask a question about a nearby landscape that can be investigated using the plant diversity survey protocol. Questions can be related to the plant forms that are associated with certain locations, the number of invasive plants found in cultivated and uncultivated locations, or the plant leaf forms found in sunny vs. shady locations. These are just examples of some of the questions that could have been generated by the schoolyard studies. See if you can come up with your own. Now write your question in a form that can be tested. Provide detail about the testing process (depending on your question) and if possible, follow through with the testing.

Reflection

Should we be concerned about species extinctions? Why or why not? What is the status of biodiversity in your region, and are you concerned about it? Why? Do you think you should be concerned with the loss of species in remote biodiversity hotspots that most people will never see or visit? Explain your reasoning in an essay or poem or illustrate the result in a drawing or painting. Feeling musical? Write a song about biodiversity!

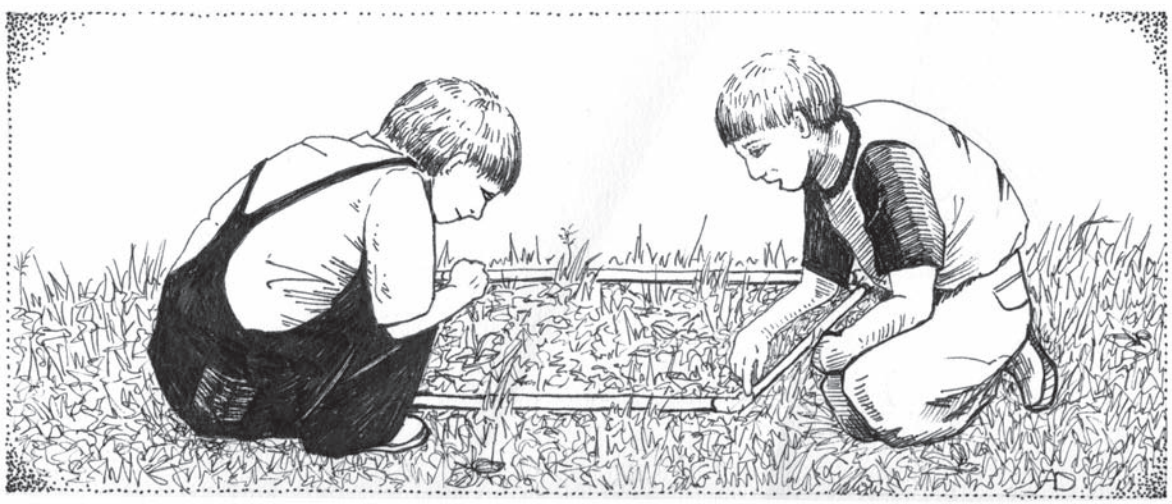
Biodiversity and Ecosystem Services: Can't Live Without 'Em

Self Assessments

1. Define biodiversity and describe why it is important.
2. What is a biodiversity hotspot? What is the nearest biodiversity hotspot to where you live?
3. Demonstrate or describe a method of measuring and calculating plant diversity.
4. Compare and analyze the results of two or more plant diversity surveys.

Resources

- Information about worldwide biodiversity hotspots: http://www.biodiversityhotspots.org/Pages/default.aspx
- "Estimating Percent Cover" worksheet from the *Measuring and Monitoring Plant Populations* lesson in this guide



TEACHER page

Saving Oregon's Treasures:
Threatened and Endangered Plants

What we plant in the soil of contemplation, we shall reap in the harvest of action.

—Meister Eckhart (1260-1328)

Time Estimate:

2 sessions

Best Season:

winter /
year 'round

Assessments

1 Demonstrate a basic knowledge of the ESA and understand how citizens can be involved in shaping regulation of endangered species.

2 Students recognize that threatened and endangered plants and wildlife live in their ecoregion, and can name at least one T & E plant species with which they share habitat.

3 Write a supported opinion of the Endangered Species Act (ESA).

Additional Information

- The Citizen's Guide to the Endangered Species Act: https://www.givengain.com/unique/esc/upload/citizens_guide_esa.pdf
- Extinct and Extirpated Plants of Oregon: http://www.npsoregon.org/kalmiopsis/kalmiopsis03/kagan_vrilakas.pdf.
- United States Fish & Wildlife Service. Endangered species home page: http://www.fws.gov/endangered/index.html

Overview

Do any endangered species live in your backyard? Or perhaps we should say, do you live in the habitat of any threatened or endangered species? This lesson introduces the Endangered Species Act (ESA) through the threatened, endangered, and rare plants of Oregon. Students learn how to influence government decisions and voice opinions on local rare species issues.

Teacher Hints

- See http://www.jigsaw.org/ for tips on implementing the jigsaw model. It is designed to reduce conflict, improve motivation, and increase enjoyment of the learning experience.
- In Part 2, use the field guide template sheet from the Create a Plant lesson. Can also be adapted to include threatened and endangered wildlife species.

Preparation

- Jigsaw activity set-up: assign students to core groups of four students. Groups need to include a mix of abilities, gender, and backgrounds. Have the members of the group count off by fours and these will become the secondary expert working groups.
- Each expert group will be a research team. Give them class time to work together, making sure all members of the group participate.
- Conduct a pre-activity class discussion to assess prior knowledge and opinions of endangered species conservation.

Discussion ideas: Explore personal opinions on the conservation of rare species. Ask if students can name any of Oregon's rare species. Do they know of any species from Oregon that have gone extinct in the last 100-200 years? What, if anything, happens in an ecosystem when an animal or plant species becomes extinct? Should we do anything to protect and recover endangered species? How much effort and money should we spend to keep species from going extinct? Explore possible reasons to protect rare species (e.g., aesthetics, moral reasons, ecosystem services, future medical discoveries).

Saving Oregon's Treasures:
Threatened and Endangered Plants

What we plant in the soil of contemplation, we shall reap in the harvest of action

—Meister Eckhart (1260-1328)

Overview

Do any endangered species live in your backyard? How would you feel if they did? This lesson introduces you to endangered, threatened and rare plants of Oregon. You will collaborate with your classmates to become familiar with the basics of the Endangered Species Act (ESA). You will learn how you can influence government decisions, and voice your opinions on local rare species issues.

Learning Objectives

- Explore the federal Endangered Species Act (ESA).
- Learn how the public input process works in government actions (ESA process of listing a species).
- Find out about state laws and conservation organizations that work to preserve rare species.
- Learn about rare plant species in your ecoregion.
- Increase your technology based research skills.

Materials Needed

- computer with internet access for research
- copies of the ESA readings for jigsaw group activity
- jigsaw question sheets

Background Information

We often hear in the news of high profile near-extinction wildlife species: the polar bear, California condor, and gray wolf to name a few. Did you know that there are threatened, endangered and at-risk species in Oregon too? All of Oregon's ecoregions contain at least one, and in most cases several, rare plant species. People living near rare species are frequently unaware that these species exist, and are often uninformed as to what has put the species in jeopardy. Species rarity is often linked to habitat loss among other things, and shares the same causes that fuel the biodiversity decline.

Federal and state laws protect species that are listed as endangered or threatened. The primary protection comes under the Federal Endangered Species Act (ESA), which is administered by the United States Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS). The USFWS has the primary responsibility for terrestrial and freshwater organisms, while the NMFS takes the lead on critical marine species such as whales and anadromous fish such as salmon.

As with most laws, the ESA can be challenging to parties on all sides of the issue. Private landowners with rare species on their property are often concerned about losing the right to use their land as they like and fear that their property values will decline if endangered species are present on their land. Conservation organizations are working to save rare species and their habitats and private lands provide critical habitat for many species. Is there a middle ground where private land-

Vocabulary Words

- extinct
- endangered species
- threatened species
- candidate species
- rare
- extirpated
- species of concern
- endemic
- de-listing
- down-listing

Saving Oregon's Treasures:
Threatened and Endangered Plants

Background Information, continued

owners can feel safe from regulations and species can still be saved? Investigating how the ESA works, how public input can affect species listings, and your role in shaping public policy is a way to learn about where policy and science meet to work to recover endangered species. During the first part of this activity you will gain a basic understanding of the history of the ESA, its components, and how it works to protect species. You will also have an opportunity to design a better law that may be more effective at saving species than the ESA.

Directions

Part I: Jigsaw Activity

1 You will be divided into groups of 4 students—your core group for the jigsaw activity. Each person in the core group will be responsible for learning one section of the information needed for the group as a whole. The success of the group depends on each person doing their part.

2 In your core group count off 1, 2, 3, and 4. All the number ones in the class will form an expert group on the ESA Basics and History, twos will be the ESA Species Listing Process, threes will be ESA Critical Habitats and Habitat Conservation Plans, and fours will be ESA Recovery and Delisting.

3 Each expert group will work together in class to research its topic and answer a set of questions. Use the USFWS endangered species page http://www.fws.gov/endangered/index.html as a starting point. Each expert group may work on the questions together or divide them up. Keep your answers brief and concise. Come up with a creative way to share what you learned (draw a diagram, create a game, etc.) when you return to your core group.

4 Return to your core group and take turns teaching each other the key points you learned in your expert group. Encourage your core group to ask questions during the presentations so everyone benefits from your research!

5 Be prepared to have your teacher test your knowledge on the basics of the ESA.

6 Discussion Extension—discuss the merits and pitfalls of the ESA and any changes you think would improve it. Common arguments about the ESA include: the law values endangered species over humans; the law does not do enough to protect endangered species; the ESA listing process is too slow, allowing species to lose critical numbers during the wait, and the program is too costly. What do you think and why? Should money be spent saving individual endangered species or should it be spent to preserve and enhance entire ecosystems in peril?

Part II: Apply your ESA knowledge to Oregon

1 There are rare plants in all of Oregon's ecoregions. Many are listed under the Federal ESA, some are in the process of applying for listing now, and yet others are listed under the State of Oregon ESA. Do you know what rare plants grow in your ecoregion?

2 Create a list of rare plants in your ecoregion. Include the name of the plant (scientific and common) and its status under the Federal and/or State ESAs. A good resource for creating this list is: http://oregonstate.edu/ornhic/plants/searchspecies_basin.html. This website lists rare plants by water basins. You can use an ecoregion map to find the water basins in your ecoregion.

On the webpage, each water basin has a drop down list of T & E plant species with scientific and common names. Select "get field guide information" to get information about the plant and its regulatory status.

3 Create a field guide page for one rare plant from your ecoregion (use the template from Create-a-Plant). Have everyone in the class cover at least one species so the class will end up with a field guide to all the rare plants of your ecoregion.

Saving Oregon's Treasures:
Threatened and Endangered Plants

Directions: Part II, continued

4 As with any research project, be sure that you cite your sources both for written content and photos. Write the citation information directly on your field guide page. Keep track of the sources of your information as you conduct your research.

- Additional sources: Oregon Threatened or Endangered Plant Field Guide http://oregonstate.edu/ornhic/plants/index.html-- click on Oregon Threatened or Endangered Plant Field Guide and search by scientific name. This guide uses challenging vocabulary in the descriptions and may require you to look up unfamiliar botanical terms.
- Search by scientific name on the internet. Many rare plants that are Federally listed or are in the listing process will have extensive records of research, public hearings, etc. associated with them. Use this information to fill in the missing parts of your field guide. Include the reasons why the plant is rare and a summary of the steps to downlisting or delisting if a recovery plan has been completed.

5 Use easy to understand language and define unfamiliar terms in your field guide so it will be easy for the general public to use.

6 Complete your field guide page with a high-quality picture (with proper copyright credits) or a color drawing and references.

7 Assemble everyone's pages to create a rare plant field guide for your ecoregion.

Taking It Further

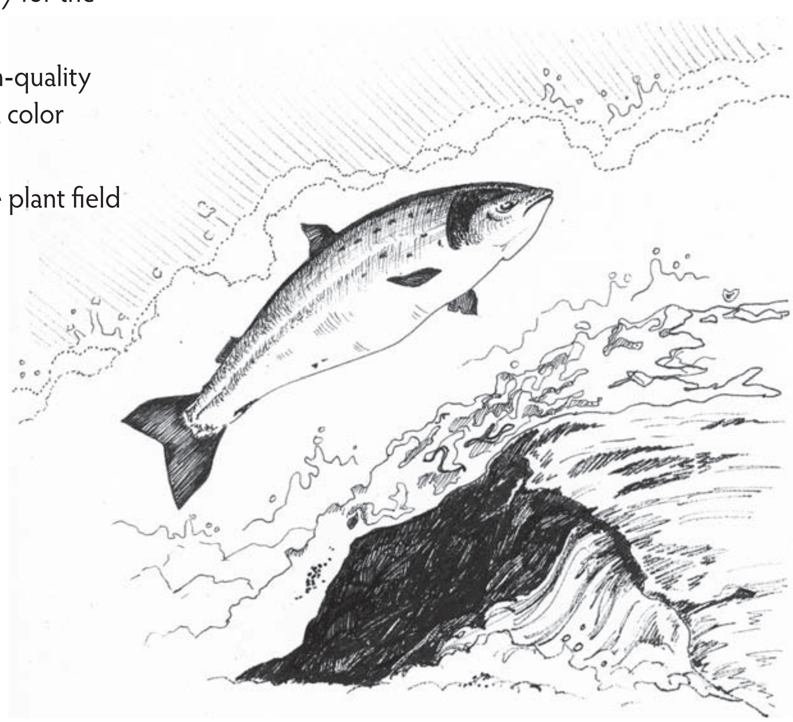
- Explore the Oregon Flora Project Atlas online mapping tool at http://www.oregonflora.org/ and map locations where your rare plant occurs. The mapping tool will give you general locations that will be sufficient for your purposes. Print out a map of your plant using the ecoregions base map and answer these questions: Does the plant occur in more than one ecoregion? Are the sites clustered in certain areas, or widely distributed over vast areas? See resource section for additional website tools to use for research and mapping.

Assessments

1 Demonstrate a basic working knowledge of the ESA. How can the public get involved in species listings?

2 Write a paragraph expressing your opinion on an aspect of the Endangered Species Act. Support your opinion with evidence or examples.

3 Name one (or more) threatened or endangered plant species from your ecoregion.



Saving Oregon's Treasures:
Threatened and Endangered Plants

In the Field!

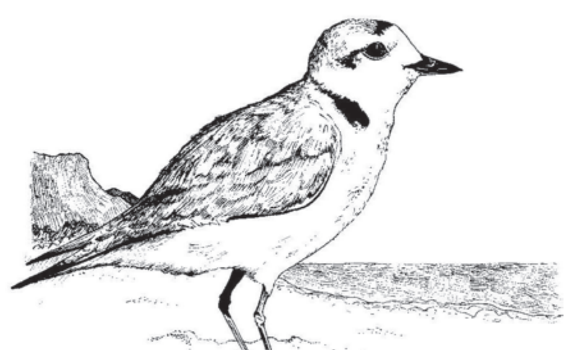
Invite a restoration ecologist to give your class a tour of a local restoration project. Ask them to tell you about the biodiversity of the area with special attention to rare or endangered species. What is the history of the area? How has it changed? Does the area support any endangered plants? What are some of the threats to ecosystems? How are local restoration projects working to support biodiversity?

Science Inquiry

Read a scientific paper about the Endangered Species Act or endangered species monitoring as it pertains to an Oregon species (flora or fauna). Read the paper critically. Does it cite other references? What is the quality of the referenced material? Has the paper been peer reviewed? Oregon has at least two high profile species (Northern spotted owl and Chinook salmon), but there are others. Generate some research questions that could improve the successes of endangered species conservation efforts.

Reflection

Should we protect endangered species? What can you do to influence endangered species protections? What are some of the most common reasons that species become endangered? What role does human activity play? What kinds of people, groups, or institutions do you know of that are helping to protect endangered species today? How do you think these efforts are funded? Do you think that protecting endangered species is worthwhile? Why or why not, and to what extent? What have you done or are you doing to help protect your local ecosystems? Can you do one additional thing to help? What have you learned about critical habitat, the importance of biodiversity, and ecosystem conservation? How has this activity changed your views on endangered species protections? Why?

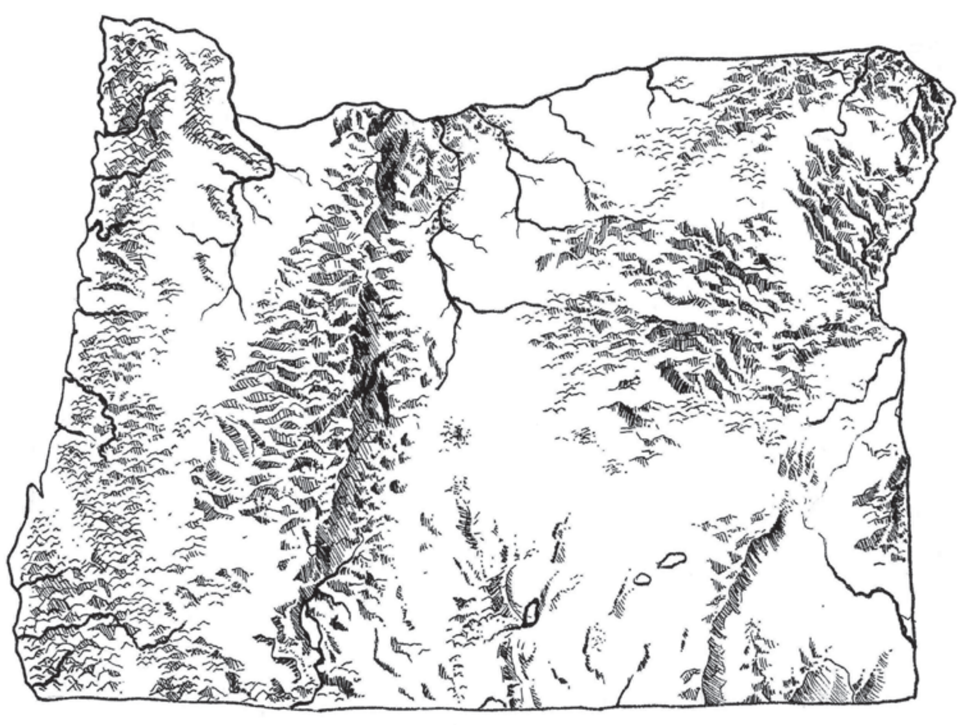


Saving Oregon's Treasures:

Threatened and Endangered Plants

Resources

- Oregon Natural Heritage Information Center: http://oregonstate.edu/ornhic/plants/index.html
- Oregon Flora Project, the Oregon Plant Atlas (interactive mapping tool) and the Rare Plant Guide: http://www.oregonflora.org/
- US Fish & Wildlife Service. Find species listed under Federal ESA as well as species of concern: http://www.fws.gov/oregonfwo/species/
- Oregon Department of Agriculture. State list of protected plants: http://www.oregon.gov/ODA/PLANT/CONSERVATION/statelist.shtml
- Oregon Natural Heritage Information Center, Lists and rankings of Oregon's rare invertebrates and non-vascular plants, lichens, and fungi: http://orbic.pdx.edu/
- Oregon Explorer, Oregon map with links to counties and listings of rare species: http://www.oregonexplorer.info/Wildlife/about/threatenedEndangered.aspx?Res=17431
- Oregon Department of Fish & Wildlife, list of state protected vertebrate species: http://www.dfw.state.or.us/wildlife/diversity/species/threatened_endangered_candidate_list.asp
- Oregon Department of Fish & Wildlife. Oregon Conservation Strategy: http://www.dfw.state.or.us/conservationstrategy/



Saving Oregon's Treasures:
Threatened and Endangered Plants

Expert Group 1

Endangered Species Act (ESA)—Basics and History

Questions:

1. What is the purpose of the ESA?
2. Who administers the ESA?
3. What species are eligible for protection under the ESA?
4. The ESA protects species by prohibiting "take." Define "take" as it applies to wildlife in the ESA.
5. Do the same "take" prohibitions apply to plants, and if not, how are they different?
6. Describe how the Federal government works with State governments in regard to the ESA.
7. In what year did Congress pass the Endangered Species Act into law as we know it?
8. Has the ESA been changed since it first became law?
9. From its start, Congress authorized funding the ESA through 1992. How has the ESA been funded since 1992?

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Expert Group 2

Endangered Species Act (ESA)—Species

Listing Process

Questions:

1. What are candidate species?
2. What are the two ways that species can become listed under the ESA? Give a short explanation of both.
3. What are the five basic factors that influence whether a species is listed?
4. When enough scientific information has been submitted to consider a species for listing under the ESA, biologists at the USFWS draft a proposed listing rule. What is included in the listing proposal?
5. The ESA requires a final determination on the listing of a species to be completed within what time period?
6. Outline the process for public input into an ESA listing proposal.
7. ESA listing decisions are required to be based on best scientific principles. In this process they solicit peer review. Explain this process.
8. If all the steps are completed and the species listing is approved, what happens next?

Saving Oregon's Treasures:
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Expert Group 3

Endangered Species Act (ESA)—Critical Habitat and Habitat Conservation Plans

Questions:

1. What is critical habitat?
2. What is the purpose of designating critical habitat?
3. How is critical habitat determined?
4. What are Habitat Conservation Plans (HCPs)?
5. What do HCPs do?
6. Many HCPs require mitigation to offset take of endangered species authorized by incidental take permits; mitigation is completed through specific conservation strategies that are manageable and enforceable. List several examples of mitigation practices.

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Expert Group 4

Endangered Species Act (ESA)— Species Recovery and Delisting

Questions:

1. The USFWS uses many techniques to recover endangered species; list 3-5 such techniques.
2. What does recovery mean?
3. Give an example of a partnership that the USFWS has made to help recover endangered plant species.
4. Define the terms delisting and downlisting, as used in the ESA.
5. What happens after a species has been delisted?

Saving Oregon's Treasures:
Threatened and Endangered Plants

Answer Key
Expert Group 1— ESA Basics and History

1 What is the purpose of the ESA?—The ESA protects and recovers imperiled species and their ecosystems.

2 Who administers the ESA? It is administered by the Interior Department's U.S. Fish and Wildlife Service (USFWS) and the Commerce Department's National Marine Fisheries Service (NMFS).

3 What species are eligible for protection under the ESA? —All species of plants and animals, except pest insects, are eligible for listing as endangered or threatened.

4 The ESA protects species by prohibiting "take." Define "take" as it applies to wildlife in the ESA. —Take is "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." Take may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

5 Do the same "take" prohibitions apply to plants, and if not, how are they different?—Listed plants are not protected from take under the Federal ESA, although it is illegal to collect or maliciously harm them on Federal land. Protection from commercial trade and the effects of Federal actions do apply for plants. State Endangered Species Acts may provide additional protection for plants on some land ownerships.

6 Describe how the Federal government works with State governments in regard to the ESA?— The Federal government encourages states to develop and maintain conservation programs for threatened and endangered species. Federal funding is available to promote state participation. Some state laws and regulations are even more restrictive than the Federal ESA in granting exceptions or permits.

7 In what year did Congress pass the Endangered Species Act into law as we know it?—1973.

8 Has the ESA been changed since it first became law?—Significant changes to the law have been added in the form of amendments but the basic structure of the 1973 Act has been preserved.

9 From its start, Congress authorized funding the ESA through 1992. How has the ESA been funded since 1992? Congress has appropriated funds annually.

Saving Oregon's Treasures:

Threatened and Endangered Plants

Answer Key
Expert Group 2: ESA Species Listing Process

1 What are candidate species?—Species for which the USFWS has sufficient information on their biological status and threats to propose them as endangered or threatened under the Endangered Species Act (ESA), but for which development of a proposed listing regulation is precluded by other higher priority listing activities.

2 What are the two ways that species can become listed under the ESA? Give a short explanation of both. —1. The petition process—any interested person may petition the Secretary of the Interior to add a species, or 2. Through the candidate assessment process—USFWS biologists identify species as candidates for listing.

3 What are the five basic factors that influence whether a species is listed? —1. The present or threatened destruction, modification, or curtailment of the species' habitat or range; 2. Overutilization for commercial, recreational, scientific, or educational purposes; 3. Disease or predation; 4. The inadequacy of existing regulatory mechanisms; and 5. Other natural or manmade factors affecting the species' continued existence.

4 When enough scientific information has been submitted to consider a species for listing under the ESA, biologists at the USFWS draft a proposed listing rule. What is included in the listing proposal? —Background information on the species (taxonomy, historic and current range, population information, habitat requirements, etc.), a summary of the threats faced by the species, a determination and/or designation of critical habitat if appropriate, examples of available conservation measures, and a preview of actions that would be prohibited (as well as actions that would *not* be prohibited) if the species were to be listed.

5 The ESA requires a final determination on the listing of a species to be completed within what time period?—A decision on whether to make the proposed listing final must be completed within 12 months from when the proposal is published.

6 Outline the process for public input into an ESA listing proposal.—1. Press release announcing the proposal is published in area newspapers, and personal contacts are made by Field Office, Regional Office, and Washington, D.C. Office personnel. 2. Direct notification of cities and counties, State agencies, Federal agencies, Congressional offices, local organizations, and others. 3. A 60-day public comment period begins once a listing proposal is published in the *Federal Register*. 4. A public hearing must be held if one is requested within 45 days of publication of the proposed rule. 5. Public meetings also may be held in areas where the species occurs to provide the public with information about the species and the proposed listing. 6. The public comment period may be extended or reopened at any time; however, extensions must be within reason.

7 ESA listing decisions are required to be based on best scientific principles. In this process they solicit peer review. Explain this process. —The USFWS contacts several peer reviewers during the open comment period, provides them with the listing proposal, and asks them to review the document for scientific accuracy. Current USFWS policy requires at least three independent reviewers to be contacted. The reviewers are free to comment on any aspect of the proposal, but they may also be asked to consider specific questions regarding the species' taxonomy or biology.

8 If all the steps are completed and the species listing is approved, what happens next? —The rule becomes effective 30 days after publication (to allow Congress to review the listing) and the species is officially added to the Federal Endangered and Threatened Species List.

Saving Oregon's Treasures:
Threatened and Endangered Plants

Answer Key

Expert Group 3: ESA—Critical Habitat and Habitat Conservation Plans

1 What is critical habitat?—Specific geographic area(s) that contain(s) features essential for the conservation of a threatened or endangered species and that may require special management and protection. Critical habitat may include an area that is not currently occupied by the species but that will be needed for its recovery.

2 What is the purpose of designating critical habitat?—Federal agencies are required to consult with the USFWS on actions they carry out, fund, or authorize to ensure that their actions will not destroy or adversely modify critical habitat. In this way, a critical habitat designation protects areas that are necessary for the conservation of the species.

3 How is critical habitat determined?—Biologists consider physical and biological features needed for life processes and successful reproduction of the species, including: 1. Space for individual and population growth and for normal behavior; 2. Cover or shelter; 3. Food, water, air, light, minerals, or other nutritional or physiological requirements; 4. Sites for breeding and rearing offspring; and 5. Habitats that are protected from disturbances or are representative of the historic geographical and ecological distributions of a species.

4 What are Habitat Conservation Plans? —HCPs are planning documents required as part of an application for an incidental take permit. They describe the anticipated effects of the proposed taking; how those impacts will be minimized, or mitigated; and how the HCP is to be funded.

5 What do HCPs do?—In developing habitat conservation plans, people applying for incidental take permits describe measures designed to minimize and mitigate the effects of their actions— to ensure that species will not be jeopardized.

6 Many HCPs require mitigation to offset take of endangered species authorized by incidental take permits; mitigation is completed through specific conservation strategies that are manageable and enforceable. List several examples of mitigation practices. —Mitigation practices include, but are not limited to, payment into an established conservation fund or bank; preservation (via acquisition or conservation easement) of existing habitat; enhancement or restoration of degraded or former habitat; establishment of buffer areas around existing habitats; modifications of land use practices; and restrictions on access.

Saving Oregon's Treasures:
Threatened and Endangered Plants

Jigsaw Groups Answer Key

Expert Group 4: ESA—Species Recovery and Delisting

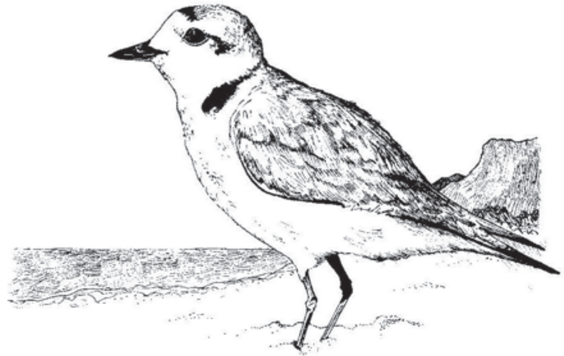
1 The USFWS uses many techniques to recover endangered species; list 3-5 such techniques.—Techniques include restoring and acquiring habitat, removing introduced animal predators or invasive plant species, conducting surveys, monitoring individual populations, and breeding species in captivity and releasing them into their historic range.

2 What does recovery mean?— Recovery is the process by which the decline of an endangered or threatened species is arrested and threats are removed or reduced, ensuring the long-term survival of the species in the wild. At that point the species is recovered, and protection under the ESA is no longer necessary.

3 Give an example of a partnership that the USFWS has made to help recover endangered plant species.— A national partnership with the Center for Plant Conservation, which has expertise in conserving plants. Founded in 1984, the Center is supported by a nationwide consortium of 29 botanical gardens and arboreta. With about one of every 10 plant species in the United States facing potential extinction, the Center is the only national organization dedicated exclusively to conserving rare native plants.

4 Define the terms delisting and downlisting as used in the ESA.—To delist species, the USFWS is required to determine that threats have been eliminated or controlled, based on several factors, including population sizes and trends and the stability of habitat quality and quantity. When the USFWS reclassifies species from endangered to threatened, a less dire status, they downlist them. If some of the threats have been controlled and the population has met recovery objectives for downlisting, the USFWS may consider changing the status of an endangered species to threatened.

5 What happens after a species has been delisted?— The Endangered Species Act requires the USFWS, in cooperation with the states, to monitor species for at least five years in order to assess their ability to sustain themselves without the protective measures of the Act. If, within the designated monitoring period, threats to the species change or unforeseen events change the stability of the population, the USFWS may extend the monitoring period or relist the species.



TEACHER page

Oregon's Native Ecosystems:
Design a Habitat Restoration Plan

Never doubt that a small group of thoughtful committed citizens can change the world; indeed, it is the only thing that ever has. —Margaret Mead (1901-1978)

Time Estimate:

2 class sessions

Best Season:

year 'round

Assessments

1. List the component parts of a successful habitat restoration plan.
2. List and explain two tools used in each: planning, site prep, restoring vegetation, and monitoring in habitat restoration projects.
3. Work as part of a team using engineering design principles to complete a habitat restoration project proposal.

Additional Information

- The SER International Primer on Ecological Restoration: http://www.ser.org/content/ecological_restoration_primer.asp
- Native Seed Network: http://www.nativeseednetwork.org/

Overview

This lesson introduces the basics of habitat restoration through exploring restoration concepts, terminology, and methods. Students will work as part of a team using design principles to plan, budget, and market a habitat restoration plan to a land management agency.

Teacher Hints

- This lesson includes many aspects of the Engineering Design Standards: defining a problem and stating a goal, brainstorming solutions, comparing solutions using the concept of trade-offs, then creating, analyzing and refining a plan within set criteria, identifying strengths and weaknesses, and describing how it is better than alternative plans.
- Team projects can be run as a class competition. Invite local land management agency personnel (e.g., US Forest Service, Bureau of Land Management, City, County, or State Parks/Natural Areas Department), other teachers, or an ecologist, botanist or forester to act as judges.
- Use this lesson to introduce a service learning project. Partner with your local watershed council or other natural resource agency on a nearby habitat restoration project. Ask to view their restoration plan, or to be involved in creating it.
- For advanced students add an additional layer to the restoration plan. Have them research appropriate plant species for a local habitat restoration site. Find and price seed, plug, or plant material cost to include in their plan Use figures to calculate total costs.

Preparation

- Class discussion: brainstorm what it means to "restore a native ecosystem". Have the class formulate a definition. Discussion questions: What part do humans play in restoration? Can restoration happen naturally? How and when? When is a restoration complete? Explore other associated words: reclamation, mitigation, reintroduction, conservation, degrade, disturbance, native, non-native, and invasive species.
- Create a class word bank list to collect terms and definitions associated with habitat restoration.

Oregon's Native Ecosystems:
Design a Habitat Restoration Plan

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Overview
This lesson introduces the basics of habitat restoration through exploring restoration concepts, terminology, and methods. Learn about common restoration tools and weigh the tradeoffs land managers juggle when planning a restoration project. Work as part of a team using design principles to plan, budget, and market a restoration plan to a land manager.

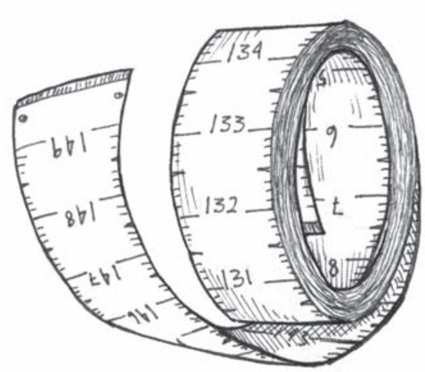
Learning Objectives
- Increase understanding of habitat restoration terminology.
- List several restoration tools used in projects.
- Use engineering design process skills to create a habitat restoration plan.
- Practice persuasive writing skills to market a habitat restoration proposal.

Materials Needed
- budget worksheet
- site map
- tracing paper for overlays
- colored pencils

Vocabulary Words
- restoration
- disturbance
- reference ecosystem
- reintroduction
- rehabilitate
- reclamation
- mitigation
- re-establish

Background Information
What do you think habitat restoration is? The Society for Ecological Restoration (SER) International defines it as "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (1). Many questions are still being debated between scientists in the habitat restoration community and on-the-ground restoration practitioners. A prime pending question is how to select the end result (ecosystem and community type) to restore a site to. In North America should we be restoring to conditions thought to have occurred before Euro-American settlement? What about ecosystems that have been influenced by human cultures prior to European contact> The indigenous people of Oregon manipulated ecosystems with fire for thousands of years; how should that be taken into account? Can we really recreate an ecosystem known from hundreds of years ago and do we have the data needed to do so? Since ecosystems are constantly changing through the process of succession, what stage of succession should a restoration project strive to reach?

Humans are altering natural ecosystems at an accelerating rate, frequently through resource extraction or urbanization. In an attempt to counteract some of this habitat destruction, the process of mitigation has been introduced by government regulatory agencies. How does the mitigation system work? If a wetland, for example, is destroyed to build a new shopping mall, the mall builders must create (or pay to create) a new wetland in another location to compensate for the loss of the wetland now under the shopping mall. The theory behind wetland mitigation is that there is no net loss of habitat. Do you think creating or enhancing an existing wetland in a different location can fully compensate for the loss of a naturally existing wetland?



Oregon's Native Ecosystems:
Design a Habitat Restoration Plan

Background Information, continued

Mitigation can extend beyond wetlands. In some cases, clean-up and restoration of an extremely polluted or degraded site is considered mitigation. At many mining sites the topography, hydrology and soils of a site have been so altered that it is impossible to restore them to their original condition. In that case, the goal is often merely to reduce pollution from the site and rehabilitate it into useable land. This is described using the term reclamation. In some northwest forests that have been intensively harvested in the past and have had natural fire suppressed, we debate whether or not to thin or remove crowded trees and underbrush to mimic the ecosystem that might have existed with natural fire return intervals and less human intervention. Does this qualify as restoration? Can you think of other ways humans have altered natural ecosystems and are now trying to restore them?

Could restoration have a role in trying to react to climate change? Future restoration debates may center on how climate change may affect plant communities and species ranges. Should we attempt to restore new habitats for species outside their current range to plan for the future? What ethical questions may come about when people move plants (assisted migration) to maintain plant communities in a changing climate? Should humans protect some species but not others?

Challenge yourself to define additional terms related to habitat restoration. Some words that you might see used in restoration project discussions are: re-establish, rehabilitate, and reintroduce. Can you find others?

Habitat restoration is a complex process with many steps. All restoration projects include some similar components, including: defining current and desired future conditions, setting goals and objectives, planning, seeking public involvement and input, establishing work timelines, long term monitoring, and continued management. Good recordkeeping is essential and helps guide the project over the long term. Restoration projects are not completed in a season or even a year, but require many years. The end goal is a self-sustaining ecosystem which resembles a model or reference ecosystem from a similar site.

The chart below includes restoration tools land managers use to accomplish restoration objectives. This is not an all-inclusive list, but it covers many restoration tools commonly used in Oregon. Use the information in the chart to help guide your own decisions as you work through your restoration plan.

Oregon's Native Ecosystems:
Design a Habitat Restoration Plan

Restoration Tool	Explanation	Benefit	Challenges
Part 1: Planning—Long term success of restoration			
Conduct baseline inventory	To describe current conditions, create list of plant and wildlife species present, note dominant species & rare species	Needed for long term comparison	Can be costly when inventorying a large site
Pick a model or reference ecosystem (What is the desired future condition?)	Study a nearby site with habitat to act as a model of what the restoration is attempting to achieve	Planning tool for species composition	Possibly no similar sites nearby to use as reference
Use historical data	Search original land surveyor records, explorer's journals to learn about the site's historical conditions	Information can give overview of the major species present prior to development changes	Records may be difficult to locate, hard to read, not complete
Create master plan	Written plan to guide each step of the restoration	A document that all parties can use to guide activities	Plan needs to be kept current with modifications, timetable and monitoring data
Part 2: Restore historical topography and hydrology			
Earthmoving	Large machinery to restore historic topography	Restore natural hydrology	Disturbs soils, may interfere with native plants and wildlife
Drain tile removal	Remove drain tile, ditches, and culverts	Restore natural hydrology; most common at wet sites	May affect neighboring property & local flooding
Dam or water diversion removed	Take out earthen dams and swales that restrain or channel water	Restore natural hydrology	May affect neighboring property & local flooding
Part 3: Site Prep - Control unwanted vegetation (encroaching trees/shrubs, invasive species, other unwanted plants), open areas for planting, reduce competition for seedlings and transplants			
Hand pulling, digging, or cutting	Manually pull or dig out individual plants, cut larger shrubs and trees by chainsaw	Good control for small infestations, generally low impact to the environment	Labor intensive, may disturb the soil
Herbicide	Chemical control through spot spraying (individual plants) or broadcast spraying (large infestations)	Good for large areas, fast, relatively inexpensive	Timing is crucial for application, need chemical applicators license, leave chemical residues in environment, spray can drift off property, not suitable near water, can have negative effect on pollinators and wildlife
Mowing	Cutting vegetation close to ground level	Prevents plants from producing seed, good control of annuals	Weather or terrain may not be suitable, correct timing essential, repeat mowing will be necessary
Prescribed burning	Low intensity, controlled burn of ground level vegetation	Mimics historical disturbance regimen, encourages growth of grasses and flowering plants, discourages shrubs and trees	High cost, permits required, specialized equipment and trained staff needed, weather can be an issue
Part 4: Restore Natural Vegetation - Seeding and Planting			
Local seed collection	Hand collect seed from plants at your site or nearby areas	Seed source is well adapted for your site	Labor intensive; plant identification & seed collecting knowledge needed, seed storage may be required

Purchase regional seed collected from similar ecotype	Seed grown for regional restoration projects	Genetics similar to the plants native to the region of interest	Locating the needed seed may be difficult or impossible
Plant propagation	Start and grow plants from seed	Can use local collected seed, plants available when needed	May require greenhouse, specialized seed starting knowledge, time to care for plants
Plant relocations	Move plants from local areas slated for development	Saves plants that might otherwise be destroyed, and ensures local plants are used at the new site	May be labor intensive, and can only occur at certain times of year
Purchase plant plugs from local native plant nurseries	Small plants in small rocket shaped pots	Relatively inexpensive, good availability, easy to plant	More expensive than seeding, plants are small
Purchase bareroot plant materials	Started plants with established roots for planting when dormant	Relatively inexpensive, easy to plant	Need to be planted when dormant, weather & accessibility issues
Purchase potted plant materials	Plants in pots of varying sizes	Established plants	Relatively expensive, will probably need watering for first year
Natural re-establishment of native plants and wildlife	Allow native plants and animals to recolonize on their own. Many times when the native plants and food sources have been reestablished, native animals return on their own	Useful at sites with a minimum of destruction to be repaired, uses local plants	Slow, leaves areas open for establishment of invasive plants
Part 5: Evaluation—Monitoring			
Mapping	Create a data library. Maintain map of site plantings, locate invasive problems, can use GPS	Guides restoration, essential in communicating with partners	Need to keep updated with changes over time
Photo points	Photos taken from permanently marked fixed points (e.g., a fence post) on a regular basis for long term monitoring	Time saving, general view of restoration, easy to duplicate, cost savings	Gives only a general overview, no specific numerical data, limited use when following specific plant populations
On the ground data collection	Counting (sampling, percent cover, complete counts)	Can give more detailed information, good for tracking specific plant populations	Labor intensive, costly
Part 6: Long Term Maintenance—Simulating natural disturbance cycle and controlling problem species			
Prescribed burning	Low intensity, controlled burn of ground level vegetation	Mimics historical disturbance regime, encourages growth of grasses and flowering plants, discourages shrubs and trees	Expensive, permits required, specialized equipment and trained staff needed, can only occur under correct weather conditions
Mowing	Uses large machinery to limit height of vegetation or prevent invasive plants from setting seed	Replace disturbance regimen to control unwanted vegetation	Equipment can spread weed seeds from other sites, cut material (thatch) may accumulate over time and require removal (e.g., raking)
Livestock grazing	Run cattle, sheep, goats, or other livestock for part of the year	Can control height of vegetation, browsers (goats) can target brush, browsers (goats) or grazers (cows) can target grasses	Animals may feed indiscriminately on all plant material, overgrazing can be harmful, trampling of sensitive species, uncontrolled access to water can denude stream banks, may spread exotic and invasive species

Oregon's Native Ecosystems:
Design a Habitat Restoration Plan

Directions

Restoration Scenario:

1. A local landowner recently left a ten acre rural property to a conservation group, Ecosystem Protection Services. The donation came with the stipulation that the land be restored back to prairie to enhance habitat for native plants and wildlife and increase local biodiversity. Previously the site was used for livestock grazing, and it is currently a mixture of non-native grasses and invasive weeds. The site historically supported open prairie that was maintained by Native American tribes who routinely burned the area. The topography is a combination of upland and lowland that is bisected by a standing or slow moving water course during the wet season.

2. Work in teams of 2-4 students to create a restoration plan packet. Your plan will be submitted to the conservation group, Ecosystem Protection Services, as a bid proposal to do the actual restoration work. The plan needs to cover the first year of work including site prep, restoring natural vegetation, and monitoring. You need to balance the restoration goals, current conditions at the site, environmental concerns you identify, and the costs of your project. There is no single right answer. Use your proposal letter to justify your team's decisions.

3. Identify your restoration goal from the scenario. Write it in your own words and but use the appropriate restoration terminology. Be sure to extract all the useful information from the scenario for your plan.

4. Use the site map to help design your restoration plan. The map identifies topography, current vegetation, and other factors that you need to take into consideration (e.g., water, neighboring housing). Use one or more map overlays to diagram your restoration plan.

5. Write out a restoration plan to accompany your map. Use your student budget worksheet to guide you in the steps needed. Include the tools you will use in site prep, restoring vegetation, and monitoring. The site may dictate using more than one method or tool to reach your plan goals.

6. Make a budget using the budget rate sheet. Keep in mind the individual rate sheet units and the size of your site. Remember that the costs are generally per acre and you are working at a ten acre site. Give an itemized cost for each restoration tool used and calculate the grand total cost for the entire project.

7. Sell your proposal by writing a persuasive letter to accompany your bid. Your letter should include why you think your plan describes the best option. The letter should be signed by all the members of your team and addressed to the proper organization.

8. Your completed bid proposal packet will be used to assess your entire team's grade (see rubric at end of lesson).

Taking It Further

Partner with a local land management agency to participate in a habitat restoration project. A restoration project is a long term commitment. By partnering with a local project run by a natural resource agency, the class can take as small or as large a part as time allows. Work with your partnering agency to identify lessons that will make this project a true community service learning experience.

Oregon's Native Ecosystems:
Design a Habitat Restoration Plan

In the Field!

Take a field trip to view a restoration project in progress. Ask the managers of the restoration project to talk to the class about what they are doing at the site, including their restoration goals, how the site was selected, what historical data they used, the steps of the project, and where they are in the restoration process. If available, visit restoration sites in various stages of completion (beginning, middle and finished). —Make observations in your field journal at each of the sites. Compare the sites- how do they differ, not only in ecosystem type but progress toward their desired future conditions.

Science Inquiry

Collecting monitoring data to assess restoration site conditions before, during and after a restoration project lets land managers learn what restoration techniques are most effective. They can then use the information to improve future restoration work. Ask if you may be involved in any monitoring that goes along with the restoration site. Talk to the agencies involved to find out what methods they use and what they hope to learn.

Many natural areas have been historically maintained by fire at some frequency. Today, using prescribed fire can frequently come into conflict with present day policies. Air quality regulations, public perceptions, and safety concerns can all make using prescribed fire a challenge. Brainstorm alternative methods for maintaining a restoration site. How would you test your methods?

Reflection

This activity has touched on some of the philosophical difficulties associated with habitat restorations. Use what you know to evaluate the ways environmental ethics, public opinion, scientific work, and/or government policy impact your environment and society. Explore your own personal views on one of these topics.

Oregon's Native Ecosystems:
Design a Habitat Restoration Plan

Self Assessments

1. List the component parts of a successful restoration plan.
2. List and explain two tools used in each: planning, site prep, restoring vegetation, and monitoring in restoration projects.
3. Work as part of a team using engineering design principles to complete a restoration project proposal.

Resources

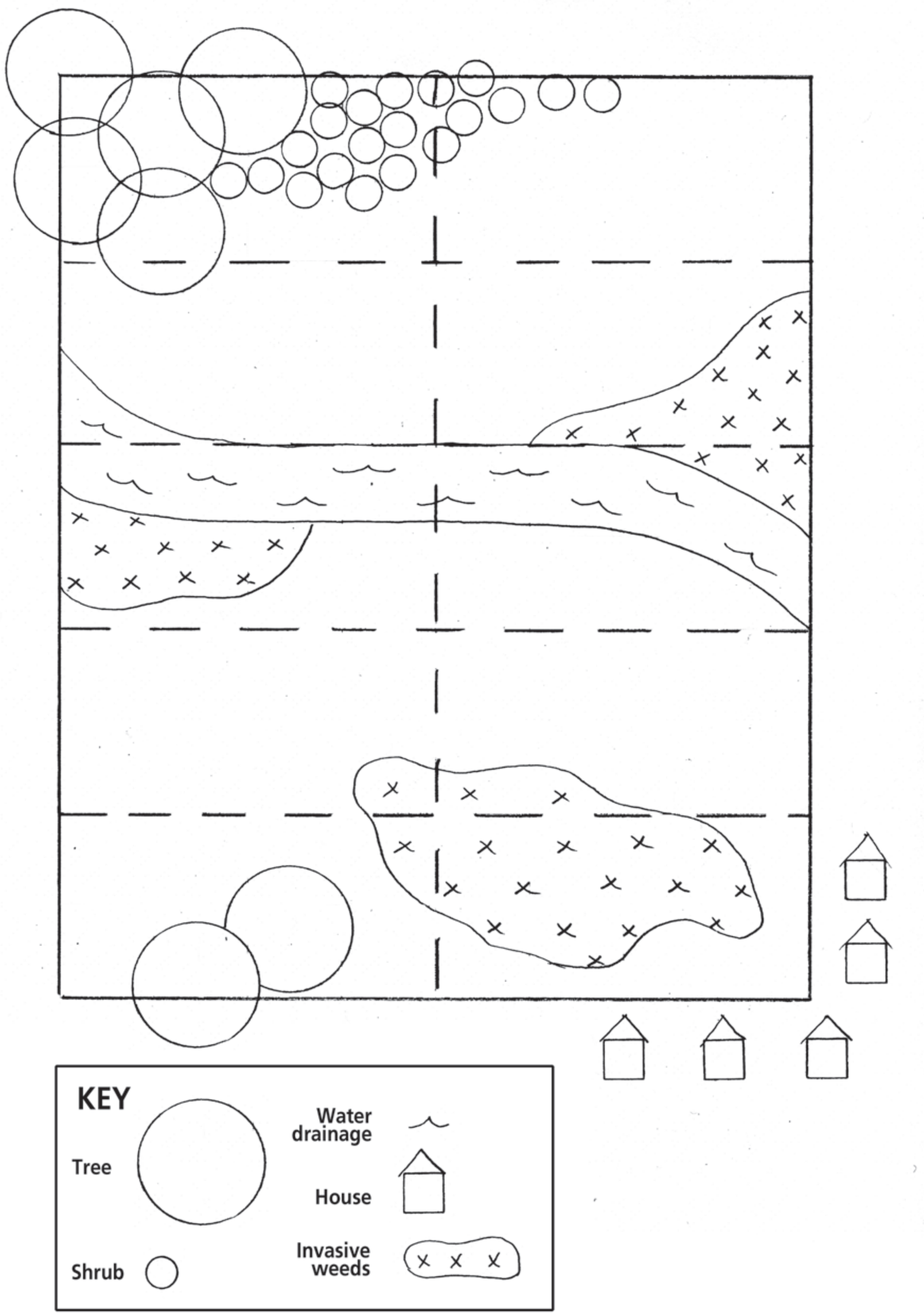
- *The SER International Primer on Ecological Restoration:* http://www.ser.org/content/ecological_restoration_primer.asp
- Apostol, Dean, and Marcia Sinclair. (2006.) *Restoring the Pacific Northwest: The Art and Science of Ecological Restoration in Cascadia*. Island Press.
- A Guide to Prairie and Wetland Restoration in Eastern Nebraska: http://www.prairieplains.org/assets/files/restoration_manual_1.pdf

Prairie Restoration Project Rubric

CATEGORY	Novice (1)	Apprentice (2)	Crew leader (3)	Professional (4)
Restoration Goal	Written in complete sentences, but copied from scenario. No attempt to use restoration terminology.	Written in complete sentences. Includes some factors from scenario, and uses at least one restoration terminology word.	Written using student's words, missing only one or two components, and uses one or more restoration terminology words.	Written in student's own words, encompasses all components from scenario, written in complete sentence form, and showing proper usage of restoration terminology.
Site Map With Overlay	Site map missing overlay. Incomplete key, or map and key do not match restoration tools from plan.	Site map with overlay. Missing one or two restoration tools from plan, or key is not complete or clear.	Site map with overlay. Missing one restoration tool from plan, or key is not complete or clear.	Site map with one or more overlays. Overlay shows all restoration tools used from plan, includes clear and complete key to match plan.
Restoration Plan	Plan is incomplete, missing one or more of the restoration tools needed, or plan does not include entire year.	Plan complete but does not include entire year in logical form, or is missing one of the required restoration tools needed.	Plan complete and addresses all restoration tools needed. Logical plan format could be improved.	Plan is logical to follow, written in paragraph or outline form. Includes one year timetable for site, and addresses all the restoration tools needed.
Budget Sheet	Budget sheet is not complete, missing tools from plan, mistakes in math, or does not include total project costs.	Budget sheet has one or more errors in matching plan, or errors in math, or total project costs.	Budget sheet matches plan, specifies tools used. Math has one or two errors in figuring tool costs.	Budget sheet matches plan and specifies tools used. Math is correct for individual tools and extended for entire job. Total cost of project figured correctly.
Bid Proposal in Persuasive Letter	Letter sloppy, not properly addressed, not signed, or not in proper letter format. Letter does not explain decisions made in plan.	Letter is neat and in proper format. Letter explains some but not all decisions made in plan.	Letter is neat and in proper format. Letter is persuasive in selling the proposal and explains most of the decisions made in the plan.	Letter neat, written in proper format, addressed to company name and signed by all team members. Demonstrates persuasive writing in selling proposal, and explaining all decisions made in plan.

Oregon's Native Ecosystems:
Design a Habitat Restoration Plan

Map – 10 acre site



Oregon's Native Ecosystems:
Design a Habitat Restoration Plan

Budget Worksheet

Rate Sheet

Activity	Cost per acre	Hourly rate	Cost per pound	Cost per plug	Cost per site	Additional notes
Prescribed burn					$3 – 5,000.00	Range for site includes complexity, location, fuels, & permits
Brush clearing (mechanical)		$91.00				Figure 1 hour per acre for your site
Spot spray		$61.00				Figure 1 hour per acre for your site
Broadcast spray	$55.00					Need to be aware of drift issues close to water and housing
Hand pulling		$25.00				Figure 4 hours per acre for your site
Tractor work (seeding, mowing)		$75.00				
Plug planting (100 plugs per hour)		$50.00				
Grass seed (rate of 5# per acre)			$25.00			
Wildflower seed (forbs) (rate of 3-5# per acre)			$100.00			
Grass & grass-like plug cost (1210/per acre planted 6 ft. apart)				$.45		
Wildflower plug (forbs) cost (1210/per acre planted 6 ft. apart)				$1.40		
Monitoring		$75.00				Range depending on complexity and size of site. 1 hr. for photo point, 8 hours for sampling, 24 hours for complete count

Oregon's Native Ecosystems:
Design a Habitat Restoration Plan

Student Budget

	Tool Used	Cost Per Unit (Acre/Hour)	Total Cost for 10 Acre Site
Site prep			
Restoring Natural Vegetation			
Project Monitoring			
Total Project Costs			

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SECTION 1: PLANT IDENTIFICATION

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SECTION 6: CLIMATE CHANGE AND PHENOLOGY

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Glossary

abiotic .... the non-living elements of an ecosystem. Example: rocks, water

accessory fruit .... a succulent fruit developing from the receptacle instead of the pistil. A strawberry is an example, with the ripened ovaries' small achene on the fruit surface.

achene .... a simple, dry, indehiscent fruit with a single, small seed that attaches to the ovary wall at only one point, as in the fruit of a sunflower

adaptation .... a process over multiple generation in which an organism changes to better fit the habitat. Example: Natural selection would favor the deeper-rooted plants during climate shifts that cause drought conditions.

adventitious root...... a root structure developing in an unusual location, such as growing from a stem

aggregate fruit .... a cluster of small fleshy fruit, as in the cluster of drupelets that make up a raspberry. Arising from several pistils in a single flower, each producing a single drupe that when connected, form a cluster

allelopathy .... the process whereby one plant species produces biochemicals to inhibit the growth of other plant species

alternate .... a leaf pattern where one leaf grows from each node on the stem, alternating sides of the stem

analgesic .... a medicinal pain reliever

angiosperm .... a flowering plant that produces seeds in a fruit

annual .... a plant that completes its entire life cycle in the same year; germinate, flower, set seed and die

anther .... the enlarged, pollen-bearing part of the stamen; located at the tip of the filament

antibacterial .... a medicinal that inhibits or destroys bacteria

antioxidant .... a substance that slows oxidation. In the human body it counteracts the negative effects of oxidation on body tissues.

assisted migration .... deliberately moving members of a species from their present habitat to a new location with the intent of permanent establishment. Most commonly used in response to habitat loss and climate change

axil .... the angle point between the stem and the leaf growing from it

azimuth .... a description of a location as it relates to North in degrees, minutes, and seconds

basal .... leaves growing from the base of the plant stem

berry .... a simple, fleshy, indehiscent fruit with many seeds, like a tomato or blueberry; commonly applied to any fruit that is fleshy throughout, though not botanically correct

biennial .... a plant that takes two years to complete its life cycle; usually forming a rosette of leaves the first year, and producing flowers and fruit the second year

binomial nomenclature
a two-part scientific system of naming organisms. Example: Camassia quamash

biochemical .... a chemical process in living organisms

biodiversity .... the variation of all life forms within an ecosystem; often used to measure the health of a given ecosystem.

biome .... the world's major ecological communities, defined by the predominant flora and climate, and covering large geographic areas. Examples: desert, forest, grassland, tundra

biotic .... the living elements that make up an ecosystem

botany .... the scientific study of plants

bract .... a small, leaf-like part at the base of a flower or along the flowering stem

bud .... undeveloped (or baby) stem or flower; covered with scales

bulb .... a short, vertical, thickened underground stem such as an onion; NOT a root

burden basket .... a woven basket, usually conical-shaped with pointed or flattened bottom, made in an assortment of sizes and weaves to accommodate the load to be carried

Glossary

calyx.............................the outermost whorl of flower parts
candidate species......plant and animal species that are proposed for addition to the Federal Endangered Species Act (ESA)
capsule.........................a dry, dehiscent fruit with more than one carpel
carbon sink.................places of carbon accumulation, such as in large forests (organic compounds) or ocean sediments (calcium carbonate); carbon is thus removed from the carbon cycle for moderately long to very long periods of time [1]
carpel...........................one section of an ovary [2]
caryopsis.....................a simple, dry, indehiscent fruit with a single seed that is firmly attached to the ovary wall on all sides and found in grasses; a grain
circumscissile capsule . a capsule which separates into horizontal top and bottom sections
classification...............In biological science, a method to group and categorize organisms
clearcut........................a method of harvesting timber in which all the trees are removed, and then the entire plot is replanted
climate..........................the long term predictable weather; the average weather conditions of a particular place over a long period of time. Climate is what allows you to predict what the weather conditions will be next year
climax community......the final stage of succession, in which there is a relatively stable plant community with many complex interactions between organisms
coevolution ....the process in which species exert selective pressure on each other and gradually evolve new features or behaviors as a result of those pressures1
coiling...........................a basket-making technique in which coils of materials are stitched together in a spiraling pattern; designs are made by using different color stitching material
common name...........a name by which a species is known to the general public, rather than its scientific or taxonomic name; can vary by region or country
community..................all the organisms within a particular habitat, interacting in a complex food web
competition ....an interaction between organisms or species for a limited supply of one or more resources (such as food, water, and territory) that are used by both
composite flower......the clustering of numerous small flowers together on a single flower base (receptacle)
compound.................a leaf divided into two or more separate leaflets
conservation biology......
the scientific study of nature and biodiversity, with the focus on protecting species, their habitats, and ecosystems through stewardship of entire biological communities
cordage ....several strands of fiber twisted together to make string or rope
cordate ....heart-shaped
corm ....a short, enlarged, vertical underground stem covered with papery leaves
corolla ....all the petals of a flower
cotyledon ....the first leaf of a plant embryo; sometimes called a seed leaf
crustose ....a crust-like growth form that is closely attached to the substrate, like paint, generally adhering by all of the lower surface [3]
cultural landscape......a landscape created by people and their culture; a product of nature and of human interaction with nature, that the associated people define as heritage resources [4]
culture..........................a system of beliefs, values, and assumptions about life that guide behavior and are shared by a group of people. It includes customs, language, and material artifacts. These are transmitted from generation to generation, rarely with explicit instructions.[5]
cuticle...........................a waxy layer found on leaves or stems
day-length ....duration of the period from sunrise to sunset [6]
dehiscent.....................a type of fruit that opens or releases seed when mature
delisting.......................the process of removing an animal or plant species from the Federal Endangered Species Act (ESA) [7]

Glossary

dichotomous ....a splitting of a whole into exactly two non-overlapping parts; from "dichotomy"

dichotomous key.......a tool to identify objects (such as plants,); a succession of paired choices that progressively lead to a final identification

dicot ....a plant that sprouts two seed leaves or cotyledons; "di" meaning two, and "cot" referring to cotyledon

disturbance................a temporary pronounced change in an ecosystem. This can be a natural disturbance such as fire or flood, or a human-caused disturbance such as clearcutting

dominant species ......the most numerous and vigorous species. Ecological communities are described and defined by their dominant species.

dormancy....................a temporary non-growing period in the life cycle of a plant or seed

drupe ....a simple, fleshy, indehiscent fruit with a single seed with a stony covering, such as a peach or cherry

ecoregion....................Ecoregions denote areas within which ecosystems (and the type, quality, and quantity of environmental resources) are generally similar. Ecoregions classify patterns and the composition of biotic and abiotic phenomena using geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. Examples: Willamette Valley; Northern Basin and Range [8]

ecosystem...................an interacting system of biotic and abiotic elements

ecosystem services ....the life-sustaining services provided by healthy diverse ecosystems. Examples: flood control; water and air purification; pollination; nutrient cycling

ectomycorrhizae.........mycorrhizal fungi that grow on the surface layers of the roots and are commonly associated with trees [9]

embryo........................the un-sprouted young (baby) plant contained within the seed

endangered species .....an animal or plant species in danger of extinction within the foreseeable future throughout all or a significant portion of its range (see also ESA) [7]

Endangered Species Act (ESA)
The Endangered Species Act of 1973 is federal legislation, intended to provide a means to conserve the ecosystems upon which endangered and threatened species depend, and to provide programs for the conservation of those species, thus preventing extinction of plants and animals. The law is administered by the Department of Interior's Fish and Wildlife Service (FWS) and the Commerce Department's National Oceanic and Atmospheric Administration (NOAA) Fisheries, depending on the species protected. [7]

endemic.......................found in a specific geographic area

endocarp ....the innermost layer of a fruit

endomycorrhizae .....mycorrhizal fungi that grow within the root cells and are commonly associated with grasses, row crops, vegetables, and shrubs [9]

endosperm.................the food tissue contained with the embryo within the seed

entire...........................a margin of a leaf that is not toothed, notched or divided

equinox.......................two times during the year (spring/fall) when the sun crosses the plane of the earth's equator and day and night are of equal length [10]

eradication ....elimination, complete destruction. [10] Example: The widespread eradication of a species can lead to extinction.

ethnobotany ....the study of the relationship between people and the plants in their environment

exocarp ....the outermost layer of a fruit

exotic...........................introduced, not native

extinct ....a species that no longer exists (see also ESA)

extirpated...................a species that no longer survives in regions that were once part of its range, but that still exists elsewhere in the wild or in captivity (see also ESA)

famine food................a readily available food source strongly associated with hardship

fauna............................the animal life of a given area or region

Glossary

fiber cell .... a plant cell with a thickened wall that gives structure
fiber plant.................. a plant used or cultivated for its fibers; fibers used to make or manufacture products
fibrous root .... a root system where the roots are all approximately the same thickness; a system of small, branching roots
fibrous......................... resembling fibers
field journal .... a place to record one's observations, interpretations, and data while working in or enjoying the outdoors, used by scientists and naturalists
filament....................... a thread-like stalk that supports the anther
flora............................. the plant life of a given area or region
flower .... the reproductive part of some plants, used to help make seeds; often colored and showy
foliose.......................... a lichen growth form with lobes, loosely or tightly attached to the substrate; leaf-like [3]
follicle.......................... a dry, dehiscent fruit with a single carpel opening on a single side
forest thinning .... a forest management practice of removing trees to allow more space between trees, to maximize growth, and/or to protect from fire and diseases
Frankia bacteria .... a bacteria the converts atmospheric nitrogen gas into ammonia in a process known as nitrogen fixation. Frankia bacteria live in root nodules of some woody plants.[11]
frequency .... the number of occurrences within a given time period [10]
fruit .... ripened flower part that contains the seeds
fruticose .... a three-dimensional growth form of a lichen, not differentiated into upper and lower surfaces, and including pendulous and stringy, upright, or bushy forms [3]
fuels reduction.......... using management tools such as thinning, brush removal, and prescribed burns to reduce the amount of surface fuels, to prevent or lessen the severity of wildfires
funiculus .... the stem-like stalk of a seed, connecting ovule to the placenta
generalist species...... an organism able to thrive in a wide variety of environmental conditions and with varied resources
genus/genera (plural) a group of species with similarcharacteristics or relationship; within the taxonomic classification system following "family." It forms the first word of a scientific name; always Capitalized and italicized.
germination............... the process whereby seeds or spores sprout and begin to grow.[10]
greenhouse gas......... gases that trap heat in the atmosphere. Some occur naturally and are emitted in natural processes; others are generated by human activity.[12]
gymnosperm .... a plant that produces seeds in a cone-like structure, instead of contained in the ovary of a fruit
habitat......................... an area that provides a plant or animal with a suitable combination of nutrients, water, shelter, and living space
harden off .... a process in which plants grown in a greenhouse are slowly exposed to natural conditions (temperatures, sunlight, water) before being planted outdoors
herbaceous................ a plant with no woody stems; leaves and stems may die down to soil level at the end of the growing season or may persist year round Can be annual, biennial, or perennial
herbalist .... someone that uses herbs for healing and medicinal purposes
herbarium/herbaria (plural) a collection or library of preserved plant specimens. Specimens are dried and mounted or preserved in alcohol for studying taxonomy or geographic distribution; they act as a historical record of change over time.
herbivory .... the consumption of plants by animals, including insects
hesperidium.............. a fleshy fruit with a tough outer skin or rind. Examples: oranges, lemons
hip .... a berry-like fruit containing many achenes. Example: rose hip

Glossary

hotspot........................In reference to biodiversity, hotspot refers to a region that must meet two strict criteria: it must contain at least 1,500 species of vascular plants (>0.5 percent of the world's total) as endemics, and it has to have lost at least 70 percent of its original habitat. Twenty five biodiversity hotspots have been identified worldwide. [13]

hyphae.........................microscopic fungi cells that usually grow as long threads or strands [9]

imperfect flower.......a single-sex flower; containing pistils or stamens but not both

indehiscent.................not opening upon maturity

inflorescence.............a cluster of flowers

internode....................the part of the stem between nodes

introduced ....a species that is brought in to an ecosystem by humans (whether accidentally or on purpose) and becomes established there. If the presence of this species causes negative effects in its new location, it is considered "invasive."

invasive ....a species, typically non-native, that causes harm to the environment, economy, or human health

lanceolate....................a lance- (or sword-) shaped leaf, much longer than wide, with the widest part of the leaf towards the base or bottom

landscape.................... the visible expanse of an area of land, encompassing physical elements (landforms, water bodies), biotic elements (dominant flora and fauna), and human elements (buildings, roads, farms) [14]

leaf margin..................the edge of a leaf

leaf ....flattened, above-ground piece of a plant attached to a stem, usually green during the growing season; uses sunlight to make food for the plant (photosynthesis)

leaflet ....a division of a compound leaf that is similar to a leaf but is attached to a leaf vein instead of the stem

legume.........................a simple, dry, dehiscent fruit that opens along both long edges, as in the fruit of a member of the pea family

lignin.............................a natural polymer found in plant cells, that binds cellulose fibers to harden and strengthen cell walls of plants 10

lobed............................with rounded segments on the margin, such as an Oregon white oak leaf

locule............................the cavity, in the ovary that contains the seed or the anther that contains pollen

loculicidal capsule....a dehiscent fruit that dispenses seed through the locule cavity

macro ....very large in scale, scope, or capability[10]

margin..........................used to describe the edge of a leaf

mesocarp ....the middle layer of a fruit

micro-abiotic ....a small-scale look at an ecosystem's abiotic elements. Example: Small-scale topography (such as cliff, boulder) can affect soils, wind, moisture and other factors that influence plant growth or plant selection in a given spot.

microclimate ....small local atmospheric zones in which the climate differs from the surrounding area. Example: a protected place that remains warmer than the surrounding temperatures

microscopic................so small as to be invisible without a microscope

mitigation....................steps taken to avoid or minimize negative environmental impacts. Mitigation can include taking protective steps, repairing, restoring, or compensating by replacing. [15]

monocot......................a plant that sprouts one seed leaf or cotyledon; "mono" meaning one, and "cot" referring to cotyledon

mulch............................a protective coat put over soil to inhibit evaporation or weed growth, to control soil temperature, to enrich the soil, or to prevent the dispersal of pathogens

multiple fruit..............a fruit formed from several separate flowers on a single axis, as in a pineapple

mutualism .... a symbiotic relationship between two different species in which each gains benefits from the other; they are interdependent [10]

mycelium.....................large mass of fungi hyphae [9]

mycorrhizal fungi......a type of fungi that colonizes plant roots. They form a mutualistic relationship in which plants supply carbon for the fungi and fungi bring soil nutrients

Glossary

(phosphorus, nitrogen, micronutrients, and perhaps water) to the plant.[9]

native .... a plant that is naturally found in an area, as opposed to a plant that people introduce into an area; see "introduced"

naturalized .... introduced species, now established in a natural landscape and integrated into the ecosystem

natural landscape .... a landscape unaffected by humans

natural selection .... a process of evolution that acts on variation within a population. Organisms with traits favored within a given set of environmental circumstances have a selective advantage over individuals with different traits; favored traits are only advantageous within a particular situation and may not aid survival in other circumstances. [16]

nectar .... a sweet liquid produced in flowers to attract pollinators. Pollinators benefit from the nutrient source and the plant benefits from their pollination services

nitrogen fixing .... a process in which bacteria converts atmospheric nitrogen gas, which is unavailable for plant use, into ammonia, that can then be taken up by plants. This mutualistic interaction takes place underground in the roots of plants, in the legume family and in some woody plants.

node .... swelling or knob where new growth originates

non-native .... a plant introduced, purposely or accidently, by human activity

nonvascular .... plants lacking a system of tubes to transport water and nutrients

noxious .... plant classified as injurious, to public health, agriculture, recreation, wildlife, or any public or private property[17]

nut .... indehiscent fruit; hard and dry, usually with one seed

nutlet .... a small nut

observation .... the act of noticing or paying attention, using one's senses. 10 In science, a basic method of collecting data or of developing an understanding of a system

open weave .... a basket-weaving technique which leaves openings between the weaving; allows water to drain, or used for carrying large items such as firewood

opposite .... a leaf pattern where two leaves grow across from each other at the same node on the stem

organism .... an individual living thing that can react to stimuli, reproduce, grow, and maintain homeostasis. Can be a virus, bacterium, protist, fungus, plant, or animal[15]

ovary .... the enlarged base of the pistil that contains the developing seed

ovate .... oval or egg-shaped, widest at the base

overlay .... a technique used to add color designs on twined baskets. The colored weaving fiber is woven on the inside of the basket and brought to the front with a half twist to replace the standard weaving fibers as the design calls for. The colored fiber will replace the standard fiber and the weaving will slant in the same direction as the rest of the twining.

ovule .... the immature seed

palmate .... a shape and vein pattern that is divided from a central point into lobes; similar to a hand with spread fingers

panicle .... a flower arrangement with a central stalk and branched side stalks, with multiple flowers that mature from the base to the tip

parasite .... an organism that grows, feeds and is sheltered on or in a different organism while contributing nothing to the survival of its host [18]

parasitism .... a relationship between two different types of organisms in which one benefits (the parasite) at the expense of the other (host)

parthenocarpy .... fruit developed without seed production or fertilization taking place

pedicel .... the stalk of a single flower attached in an inflorescence or a grass

peduncle .... the stalk of a single flower

pepo .... an indehiscent fruit; fleshy with many seeds and a tough outer rind/skin or exocarp

Glossary

percent cover............percent of measured area (for example: ground, sky) covered by a target species; a method of collecting data when monitoring plant populations
perennial.....................a plant that lives three or more years
perfect flower ....a flower that has both male (stamen) and female (pistil) reproductive parts
pericarp ....the outer wall of a fruit
perspective................the appearance of things relative to one another as determined by their distance from the viewer. 10 This term used in the lesson "Ecosystem through an Artist's Eye."
petal ....the inside layer of modified flower leaves; usually the brightly-colored, showy part of the flower
petiole ....a stalk that attaches the leaf to the stem
phenology..................the study of the timing of life cycle events in plants and animals in relation to changes in season and climate[19]
phenotype ....the observable traits or characteristics of an organism
pheromones ....a chemical substance secreted externally by some animals (especially insects) that influences the physiology or behavior of other animals of the same species [10]
photoperiod..............the duration of daily exposure to light, either naturally or artificially [20]
phytochemical...........a plant-derived chemical
phytotoxin..................a chemical produced by a plant that is toxic to other plants or animals
pinnate.........................leaves or veins emerging from a central stalk or vein
pistil..............................the female reproductive part of the flower, including the stigma, style, and ovary
plant community ......all the different plant populations existing within a certain area or habitat
plant diversity ....the number of plant species per unit of area [21]
plant population ......a group of individuals, usually of the same species, within a specific area and at a given time
plot ....a small area (frequently a meter square) used to give a representative sample within a larger study site
pollination ....the process of transfering pollen between anther and stamen
pome............................a simple, fleshy, indehiscent fruit with a leathery or papery core, such as an apple
poricidal capsule......a dehiscent fruit that opens at pores
precipitation.............water falling from clouds in any form, such as rain, snow, or sleet
predation....................a symbiotic relationship between two different species in which one, the predator, feeds on the other, the prey
prescribed burn ....a management tool used in forestry and ecosystem restoration to clear land of excess organic ground material, get rid of unwanted vegetation, prepare a site for planting, and/or encourage the growth of favorable species
quadrat........................a square frame used for sampling
raceme ....a flower arrangement with a central stalk and single, individually-stalked flowers that branch from the central stalk and generally mature from the base to the tip
rare...............................infrequent or uncommon within a sampling site; or scarce within a species' habitat range
receptacle...................structure at the end of the flower stalk where the flower parts attach
reclamation ....working to bring disturbed land back to its natural state; reclamation of mining sites
rehabilitation ....to make habitable or useful again; to return to original condition
reintroduction...........to return members of a species to their historical range. This strategy is sometimes used when a species has become locally extinct or if its population is threatened. [22]
restoration..................the act, process, or result of returning a degraded or former habitat to a healthy, self-sustaining condition that resembles as closely as possible its pre-disturbed state [23]
restoration ecology .the application of the principles of ecology to the restoration of derelict, degraded and fragmented ecosystems [24]
rhizobia bacteria ......the nitrogen-fixing organism associated with root nodules on legumes[15]

Glossary

rhizoid.........................a root-hair-like structure found on moss, liverworts, and some vascular plants [25]
rhizome.......................an underground stem that travels between plants; differs from a root by the presence of nodes
rhizosphere ....the microhabitat immediately surrounding plant roots [15]
riparian ....the transitional ecosystem between land and water; the land directly influenced by water along rivers, lakes, and streams [15]
root..............................part of a plant without leaves; usually found underground. Roots anchor the plant and take up nutrients (food) and water.
samara.........................a simple, dry, indehiscent fruit with wings, as in the fruit of a maple
saprophyte.................an organism that lives on dead or decaying organic matter
scarification ....process of cutting or softening of the seed coat to hasten germination [25]
schizocarp...................an indehiscent fruit; dry; at maturity, splits into one-seed segments
scientific name...........the two-part Latin name assigned to a species under the system of binomial nomenclature established in the 1700s by Swedish botanist Carl Linnaeus [26]
seasonal round..........the annual pattern followed in the production or collection of food [27]
seed coat....................the outer covering on a seed
seed dispersal ....methods by which plants spread their seeds. Examples: animal ingestion, wind, water [28]
seed.............................a mature or ripened ovule
seed-bank...................a place where seeds are stored for long term preservation; seeds that are present in or on the soil
seed leaf.....................the embryo's first leaf; cotyledon
sepal ....the green, leaf-like parts of a flower that usually sit directly below the petals
septa............................the tissue separating the locules
septicidal capsule.....a fruit that disperses seed through the septa
serrate.........................a leaf margin with teeth like a saw
sessile ....without a stalk, stem, or petiole
silique..........................a dehiscent fruit; dry, longer than wide, and separating into two halves
simple leaf..................an undivided leaf that is not separated into individual leaflets, but may still be lobed
simple fruit ....a fruit developing from a single ovary
solitary flower...........occurring singly and not in a cluster
solitary ....single
solstice ....one of the two times of the year (summer/winter) when the sun is at its greatest distance from the equator [10]
specialist species .....an organism that can only thrive in a limited or narrow range of environmental conditions and resources
species ....a group of organisms that share a unique set of common characteristics and that (usually) can reproduce among themselves but not with other such groups.[15] A species is the basic unit in taxonomic classification, under genus.
species of concern...an informal term referring to a species that might be in need of conservation action. Such species receive no legal protection and use of the term does not necessarily imply that a species will eventually be proposed for listing under the Endangered Species Act (ESA). [7]
spike ....a flower arrangement with an unbranched, central stalk and single, un-stalked flowers that mature from the base to the tip
spore ....a walled reproductive cell body capable of giving rise to a new individual, either directly or indirectly
stamen ....the male reproductive part of the flower, including the anther and filament
staple food................a food making up the dominant part of the diet, that supplies a major part of a person's nutritional needs for survival; readily available
stem ....part of the plant that supports the leaves and buds; usually grows above ground
stewardship...............the responsibility to care for our natural resources sustainably, that is, in a way that preserves them for future generations
stigma..........................the portion of the pistil that is receptive to pollen

Glossary

stomata .... the pores or openings which allow the exchange of gasses

storyboard .... a graphic organizer; a series of panels, of rough sketches outlining a sequence of actions. Borrowed from the film-making industry

stratification .... the process of exposing seeds to low temperatures to mimic nature and improve germination rates

structure .... Structure is a fundamental and sometimes intangible notion covering the recognition, observation, nature, and stability of patterns and relationships of entities. [14]

style .... narrow part of the pistil that connects the stigma to the ovary

substrate .... a surface on which an organism grows or is attached [10]

succession .... in ecology, the gradual and orderly process of change in an ecosystem brought about by the progressive replacement of one community by another until a stable climax is established[10]

symbiosis .... a long-standing relationship between two different species. Usually understood to mean mutualism (beneficial to both); but can also take the form of commensalism (beneficial to one, neutral to the other) or parasitism (beneficial to one, costly or damaging to the other) [15]

taproot .... a large central root from which smaller roots branch off, such as a carrot

taxonomy .... in biology, the study of the general principles of scientific classification; a classification of organisms into groups based on similarities of structure, origin, or other characteristics [10]

tepal .... common term for sepals and petals when both look very much alike [29]

threatened species .. an animal or plant species likely to become endangered within the foreseeable future throughout all or a significant portion of its range (see also ESA) [7]

topography .... detailed study of the earth surface features of a region [10]

traditional knowledge .... knowledge gained through long-standing traditions and practices of regional indigenous communities

transect .... a line on the ground along which sample plots or points are established for collecting data [30]

transplant .... in plants, a technique of moving a plant from one location to another, as in planting a potted plant in the ground

tuber .... a fleshy, thickened, underground stem. A plant structure used to store nutrients for plant re-growth during the next growing season. Also a means of asexual reproduction

tumpline .... a woven or leather strap, worn across the forehead or shoulders, attached to a burden basket for hands-free carrying

twining .... a basketry weaving technique using two or more weft strands are passed around the warp structure and twisted. By using different color, size, or texture weft strands, this technique lends itself to intricate decorative design.

ubiquitous .... being present everywhere at once [10]

umbel .... a flat-top or convex umbrella-like inflorescence with multiple small flowers; individual flower stalks arise from approximately the same point

urban growth boundary (UGB)
a management tool used to contain urban areas and limit their expansion. It divides land that is urban—to be used for housing, shops, factories—from land that is non-urban and to be used for purposes such as conservation, agriculture, mineral extraction, airports and the like. An urban growth boundary encourages urban consolidation and protects valued non-urban areas from urban development. [31]

vascular tissue .... tissue that conducts water and nutrients through the plant body in higher plants [10]

vein .... transports water, sugars, and minerals within the leaf blade; can be seen radiating throughout the leaf

Glossary

warp .... in reference to basketry, the vertical elements that the weft fibers weave around; commonly the elements that give a basket structure

weather........................ the atmospheric conditions at a given time, as in rain or sunshine

weed............................ any plant out of place, unwanted where it is growing, difficult to get rid of, with an ability to spread [32]

weft.............................. the horizontal weaving fibers of a basket or mat

whorled .... a leaf arrangement in which three or more leaves are growing from the same node on the stem

wildfire......................... a rapidly spreading fire, often occurring in wildland areas, that is out of control [24]

wildflower.................. wild or uncultivated flowering plant[10]

woody.......................... made of, containing, or resembling wood; made hard like wood as the result of the deposition of lignin in the cell walls. Examples: woody plants; perennial herbs with woody stems [10]

SOURCES:

A good general reference: Online Illustrated Glossary of Floral Terms, US Geological Survey Northern Prairie Wildlife Research Center: www.npwrc.usgs.gov/resource/plants/florawe/gloss.htm

Endnotes

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2 Horticulture and Crop Science, online glossary of plant parts, Ohio State University: hcs.osu.edu/hcs300/glossary/gloss1.htm

3 Epiphytes and Forest Management, online glossary, Oregon State University: people.oregonstate.edu/~mccuneb/glossary.htm

4 Sonoran Desert Educational Center, online kids' glossary: www.pima.gov/cmo/sdcp/kids/gloss.html

5 Building Bridges: A Peace Corps Classroom Guide to Cross-Cultural Understanding: www.peacecorps.gov/wws/publications/bridges/pdf/BuildingBridges.pdf

6 National Weather Service Glossary: www.nws.noaa.gov/glossary/index.php

7 US Fish & Wildlife Service Endangered Species Program, online glossary: www.fws.gov/endangered/about/glossary.html

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10 WordNet, Princeton University: wordnet.princeton.edu/

11 Frankia and Actinorhizal Plants: web2.uconn.edu/mcbstaff/benson/Frankia/FrankiaHome.htm

12 Climate Change—Greenhouse Gas Emissions, U.S. Environmental Protection Agency: www.epa.gov/climatechange/emissions/index.html

13 Biodiversity Hotspots, Conservation International: www.biodiversityhotspots.org/xp/Hotspots/hotspotsScience/pages/hotspots_defined.aspx

14 Wikipedia, the Free Encyclopedia: en.wikipedia.org

15 Biology-Online.org: www.biology-online.org/dictionary

16 Understanding Evolution, University of California Museum of Paleontology: evolution.berkeley.edu/evolibrary/article/evo_01

17 Noxious Weed Policy and Classification System 2000, Oregon Department of Agriculture Noxious Weed Control Program: www.oregon.gov/oda/plant/weeds/docs/weed_policy.pdf?ga=t

18 Todar's Online Textbook of Bacteriology: www.textbookofbacteriology.net/NHPR.html

19 Project Budburst: www.budburst.ucar.edu/phenology.php

20 Glossary of Meteorology: amsglossary.allenpress.com/glossary/browse?s=p&p=25

21 Celebrating Wildflowers, U.S. Forest Service: www.fs.fed.us/wildflowers/rareplants/howmany.shtml

22 National Geographic's Strange Days on Planet Earth, glossary: www.pbs.org/strangedays/glossary/R.html

23 Water Habitat Restoration; Air, Water, and Climate Change; Executive Office of Energy and Environmental Affairs, Mass.gov: www.mass.gov/eoeea

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27 Definitions of Anthropological Terms, Oregon State

Glossary

University: oregonstate.edu/instruct/anth370/gloss.html
28 Jean-Michel Cousteau Ocean Adventures, PBS, online glossary: www.pbs.org/kqed/oceanadventures/glossary/
29 Key to the Common Spring Wildflowers, glossary, Victoria College, Texas: www2.victoriacollege.edu/dept/bio/flower/key/terms/Glossary.htm
30 The Science Behind Algonquin's Animals online glossary, Algonquin Provincial Park: www.sbaa.ca/glossary.asp
31 The Victorian Coastal Strategy 2008, online glossary, Victorian Coastal Council, Melbourne, Australia: www.vcc.vic.gov.au/2008vcs/glossary.htm
32 Alien Invasion: Plants on the Move, curriculum glossary: weedinvasion.org/weed_html.php?page=vocabulary

Oregon Education Standards Correlations

SCIENCE	1. Botany Bouquet	2. Botanical Term. Challenge	3. Secret Life of Flowers	4. Drupes, Pomes, & Locul	5. What's in a Name	6. Plants Have Families Too	7. Mechanics of a Key	8. Making a Field Guide	9. Make Your Own Plant Press	10. Create a Plant	11. Explore OR's Ecoregions	12. The Place I Call Home	13. Ecosystem Comparison	14. Ecosystem through Artist's Eye	15. What's Goin' Down Underground	16. Survival Quest: Pollination Game	17. Plant Wars: Offense and Defense	18. What is a Plant	19. Field Journaling: Observation	20. Nurture Native Garden Project	21. part I	22. part II	23. part III	24. Invasive Weed Explosion	25. Conduct Compar. Plant Survey	26. Who Walked Here Before Me	27. Burden Basket: Plant Materials	28. Making Plant Medicine	29. Phenology: Tracking Seasons	30. Plant Migration Game	31. Nobody Right, Nobody Wrong	32. Biodiversity & Ecosys Services	33. Saving Oregon's Treasures	34. OR Ecosystems: Design a. Plan
H.2.L.1 Explain how energy & chemical elements pass…											■		■		■		■																	
H.2L.2 Explain how ecosys-tems change in response…										■	■	■	■	■	■	■	■				■			■			■		■	■	■		■	■
H.2L.3 Describe how asexual and sexual reproduction…			■													■		■																
H.2L.4 Explain how biological evolution is consequence of…																		■																
H.2E.1 Identify and predict the effect of…													■		■																			
H.2E.2 Explain how Earth's atmosphere, geosphere…																														■				
H.2E.4 Evaluate impact of human activities on…												■	■			■	■						■	■	■		■			■	■		■	■

H.2 Interaction and Change—The components in a system can interact in dynamic ways that may result in change. In systems, changes occur with a flow of energy and/or transfer of matter

H.2.L.1 Explain how energy and chemical elements pass through systems. Describe how chemical elements are combined and recombined in different ways

H.2L.2 Explain how ecosystems change in response to disturbances and interactions. Analyze the relationships among biotic and abiotic factors in ecosystems.

H.2L.3 Describe how asexual and sexual reproduction affect genetic diversity.

H.2L.4 Explain how biological evolution is the consequence of the interactions of genetic variation, reproduction and inheritanc, natural selection, and time.

H.2E.1 Identify and predict the effect of energy sources, physical forces, and transfer processes that occur in the Earth system. Describe how matter and energy are cycled between system components over time.

H.2E.2 Explain how Earth's atmosphere, geosphere, and hydrosphere change over time and at varying rates. Explain techniques used to elucidate the history of events on Earth.

H.2E.4 Evaluate the impact of human activities on environmental quality and the sustainablility of Earth systems. Describe how environmental factors influence resource management.

SCIENTIFIC INQUIRY

	1. Botany Bouquet	2. Botanical Term. Challenge	3. Secret Life of Flowers	4. Drupes, Pomes, & Locul	5. What's in a Name	6. Plants Have Families Too	7. Mechanics of a Key	8. Making a Field Guide	9. Make Your Own Plant Press	10. Create a Plant	11. Explore OR's Ecoregions	12. The Place I Call Home	13. Ecosystem Comparison	14. Ecosystem through Artist's Eye	15. What's Goin' Down Underground	16. Survival Quest: Pollination Game	17. Plant Wars: Offense and Defense	18. What is a Plant	19. Field Journaling: Observation	20. Nurture Native Garden Project	21. part I	22. part II	23. part III	24. Invasive Weed Explosion	25. Conduct Compar. Plant Survey	26. Who Walked Here Before Me	27. Burden Basket: Plant Materials	28. Making Plant Medicine	29. Phenology: Tracking Seasons	30. Plant Migration Game	31. Nobody Right, Nobody Wrong	32. Biodiversity & Ecosys Services	33. Saving Oregon's Treasures	34. OR Ecosystems: Design a. Plan
H.3S.1 Formulate a …	■		■	■		■			■		■	■		■	■	■	■	■	■			■		■	■			■	■		■			
H.3S.2 Design & conduct…			■	■		■			■		■	■			■	■	■					■		■	■			■	■		■			
H.3S.3 Analyze data…			■			■			■		■	■			■	■	■					■		■	■			■			■			
H.3S.4 Identify examples…			■		■	■	■		■							■	■																	
H.3S.5 Explain how…					■				■																									
H.4 Engineering Design is…																																		
H.4D.1 Define a problem…																					■				■		■			■				■
H.4D.2 Create and test …																					■				■		■							■
H.4D.3 Analyze…																					■				■		■							■
H.4D.4 Recommend…																					■				■									■
H.4D.6 Evaluate ways…																					■													■

H.3 Scientific inquiry is the investigation of the natural world by a systematic process that includes proposing a testable question or hypothesis and developing procedures for questioning, collecting, analyzing, and interpreting multiple forms of accurate and relevant data to produce justifiable evidence-based explanations and new explorations.

H.3S.1 Based on observations and science principles formulate a question or hypothesis that can be investigated through the collection and analysis of relevant information.

H.3S.2 Design and conduct a controlled experiment, field study, or other investigation to make systematic observations about the natural world, including the collection of sufficient and appropriate data.

H.3S.3 Analyze data and identify uncertainties. Draw a valid conclusion, explain how it is supported by the evidence, and communicate the findings of a scientific investigation.

H.3S.4 Identify examples from the history of science that illustrate modification of scientific knowledge in light of challenges to prevailing explanations.

H.3S.5 Explain how technological problems and advances create a demand for new scientific knowledge and how new knowledge enables the creation of new technologies.

H.4 Engineering Design is a process of formulating problem statements, identifying criteria and constraints, proposing and testing possible solutions, incorporating modifications based on test data, and communicating the recommentdations.

H.4D.1 Define a problem and specify criteria for a solution within specific constraints or limits based on science principles. Generate several possible solutions to a problem and use the concept of trade-offs to compare them in terms of criteria and constraints.

H.4D.2 Create and test or otherwise analyze at least one of the more promising solutions. Collect and process relevant data. Incorporate modifications based on data from testing or other analysis.

H.4D.3 Analyze data, identify uncertainties, and display data so that the implications for the solution being tested are clear.

H.4D.4 Recommend a proposed solution, identy its strengths and weaknesses, and describe how it is better than alternative designs. Identify uncertainties, and display data so that the implications for the solution being tested are clear.

H.4D.6 Evaluate ways that ethics, public opinion, and government policy influence the work of engineers and scientists, and how the results of their work impact human society and the environment.

CIVICS AND GOVERNMENT

Standard	1. Botany Bouquet	2. Botanical Term. Challenge	3. Secret Life of Flowers	4. Drupes, Pomes, & Loculi	5. What's in a Name	6. Plants Have Families Too	7. Mechanics of a Key	8. Making a Field Guide	9. Make Your Own Plant Press	10. Create a Plant	11. Explore OR's Ecoregions	12. The Place I Call Home	13. Ecosystem Comparison	14. Ecosystem through Artist's Eye	15. What's Goin' Down Underground	16. Survival Quest: Pollination Game	17. Plant Wars: Offense and Defense	18. What is a Plant	19. Field Journaling: Observation	20. Nurture Native Garden Project	21. part I	22. part II	23. part III	24. Invasive Weed Explosion	25. Conduct Compar. Plant Survey	26. Who Walked Here Before Me	27. Burden Basket: Plant Materials	28. Making Plant Medicine	29. Phenology: Tracking Seasons	30. Plant Migration Game	31. Nobody Right, Nobody Wrong	32. Biodiversity & Ecosys Services	33. Saving Oregon's Treasures	34. OR Ecosystems: Design a Plan
SS.HS.06 Government policies and…																												X			X		X	
SS.HS.GE.01 Understand …											X	X	X	X												X							X	X
SS.HS.GE.02 Interpret & evaluate…									X		X	X		X							X												X	X
SS.HS.GE.04 Analyze changes…									X			X	X	X										X		X			X				X	
SS.HS.GE.07 Understand …											X	X			X	X					X		X	X			X	X	X	X	X	X		
SS.HS.GE.08 Identify…												X	X				X				X		X	X	X	X		X	X	X	X	X	X	X
SS.HS.HS.07.01 understand events…									X																	X	X			X	X			
SOCIAL SCIENCE ANALYSIS																																		
SS.HS.SA.01 Define, research…																					X			X		X	X	X	X	X	X	X	X	
SS.HS.SA.02 Gather …																					X			X		X		X	X		X		X	
SS.HS.SA.03 Understand …																					X	X		X				X	X		X		X	
SS.HS.SA.04 Analyze…	X													X		X			X							X	X	X			X		X	
SS.HS.SA.05 Analyze…														X		X			X		X	X		X			X	X	X	X	X	X	X	
SS.HS.SA.06 Propose …																					X	X		X	X			X			X		X	

SS.HS.06 Understand how government policies and decisions have been influenced and changed by individuals, groups, and international organizations.

SS.HS.GE.01 Understand and use geographic information using a variety of scales, patterns of distribution, and arrangement
SS.HS.GE.02 Interpret & evaluate information using complex geographic representations
SS.HS.GE.04 Analyze changes in the physical and human characteristics of places and regions, and the effects of technology, migration, and urbanization on them
SS.HS.GE.07 Understand human modifications of the physical environment and analyze their global impacts and consequences for human activity
SS.HS.GE.08 Identify and give examples of changes in a physical environment, and evaluate their impact on human activity in the environment.
SS.HS.HS.07.01 Identify and understand significant events, developments, groups, and people in the history of Oregon after 1900.
SS.HS.SA.01 Define, research, and explain an event, issue, problem, or phenomenon and its significance to society
SS.HS.SA.02 Gather, analyze, use and document information from various sources, distinguishing facts, opinions, inferences, biases, stereotypes, and persuasive appeals
SS.HS.SA.03 Understand what it means to be a critical consumer of information
SS.HS.SA.04 Analyze an event, issue, problem or phenomenon from varied or opposed perspectives or points of view
SS.HS.SA.06 Propose, compare, and judge multiple responses, alternatives, or solutions; then reach a defensible, supported conclusion

STANDARDS—MATHEMATICS

Standard	1. Botany Bouquet	2. Botanical Term. Challenge	3. Secret Life of Flowers	4. Drupes, Pomes, & Locul	5. What's in a Name	6. Plants Have Families Too	7. Mechanics of a Key	8. Making a Field Guide	9. Make Your Own Plant Press	10. Create a Plant	11. Explore OR's Ecoregions	12. The Place I Call Home	13. Ecosystem Comparison	14. Ecosystem through Artist's Eye	15. What's Goin' Down Underground	16. Survival Quest: Pollination Game	17. Plant Wars: Offense and Defense	18. What is a Plant	19. Field Journaling: Observation	20. Nurture Native Garden Project	21. part I	22. part II	23. part III	24. Invasive Weed Explosion	25. Conduct Compar. Plant Survey	26. Who Walked Here Before Me	27. Burden Basket: Plant Materials	28. Making Plant Medicine	29. Phenology: Tracking Seasons	30. Plant Migration Game	31. Nobody Right, Nobody Wrong	32. Biodiversity & Ecosys Services	33. Saving Oregon's Treasures	34. OR Ecosystems: Design a. Plan
H.2A.1 Identify, construct…																								■	■									
H.3A.2 Given a table or graph…																								■										
H.3G.3 Apply a scale factor…			■											■																				
H.1S.1 Given a context, determine…													■	■	■	■	■					■		■	■				■			■		■
H.1S.2 Evaluate data-based reports…												■				■						■		■	■		■					■		
H.1S.3 Compare and draw conclusions…													■		■									■	■				■			■		
H.2S.1 Identify, analyze and use…																						■		■	■									

H.2A.1 Identify, construct, extend, & analyze linear patterns and functional relationships that are expressed contextually, numerically, algebraically, graphically, in tables, or using geometric fugures

H.3A.2 Given a table or graph that represents a quadratic or exponential function, extend the pattern to make predictions

H.3G.3 Apply a scale factor to determine whether two-& three-dimensional figures are similar. Compare & compute their respective areas and volumes of similar figures

H.1S.1 Given a context, determine appropriate survey methods, analyze the strengths and limitations of a particular survey, observational study, experiment, or simulation, and the display of its data.

H.1S.2 Evaluate data-based reports by considering the source of the data, the design of the study, and the way the data was analyzed and displayed.

H.1S.3 Compare and draw conclusions about two or more data sets using graphical displays or central tendencies and range

H.2S.1 Identify, analyze, and use experimental and theoretical probability to estimate and calculate the probability of simple events

STANDARDS LANGUAGE ARTS—READING

STANDARDS LANGUAGE ARTS—READING	1. Botany Bouquet	2. Botanical Term. Challenge	3. Secret Life of Flowers	4. Drupes, Pomes, & Locul	5. What's in a Name	6. Plants Have Families Too	7. Mechanics of a Key	8. Making a Field Guide	9. Make Your Own Plant Press	10. Create a Plant	11. Explore OR's Ecoregions	12. The Place I Call Home	13. Ecosystem Comparison	14. Ecosystem through Artist's Eye	15. What's Goin' Down Underground	16. Survival Quest: Pollination Game	17. Plant Wars: Offense and Defense	18. What is a Plant	19. Field Journaling: Observation	20. Nurture Native Garden Project	21. part I	22. part II	23. part III	24. Invasive Weed Explosion	25. Conduct Compar. Plant Survey	26. Who Walked Here Before Me	27. Burden Basket: Plant Materials	28. Making Plant Medicine	29. Phenology: Tracking Seasons	30. Plant Migration Game	31. Nobody Right, Nobody Wrong	32. Biodiversity & Ecosys Services	33. Saving Oregon's Treasures	34. OR Ecosystems: Design a. Plan
EL.HS.RE.01 Read at…	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
EL.HS.RE.02 Listen to…	X		X	X	X	X	X	X	X		X	X	X	X	X	X	X	X			X	X		X	X	X	X	X	X	X	X	X	X	X
EL.HS.RE.04 Demon-strate…				X		X	X	X			X	X	X	X	X	X	X	X			X			X		X	X			X	X	X	X	X
EL.HS.RE.06 Under-stand & draw upon…	X		X	X	X					X	X	X	X		X		X	X		X	X		X	X	X	X	X	X		X	X	X	X	X
EL.HS.RE.08 Understand, learn…	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X			X	X		X	X	X	X	X	X	X	X	X	X	X
EL.HS.RE.10 Deternine …	X		X		X								X		X	X	X	X			X	X					X	X					X	X
EL.HS.RE.13 Use…		X		X	X								X		X			X										X						
EL.HS.RE.14 Understand…			X	X	X	X		X	X	X	X		X		X	X	X	X				X		X	X		X	X	X	X		X	X	X
EL.HS.RE.15 Read…	X	X	X	X	X		X		X		X	X			X	X	X	X			X	X		X	X	X	X	X	X	X	X	X	X	X
EL.HS.RE.16 Synthesize…		X				X	X	X	X		X	X	X	X	X	X	X	X			X		X	X	X	X	X	X	X	X				X
EL.HS.RE.19 Identify…																					X	X	X	X			X	X		X				
EL.HS.RE.24 Analyze …			X	X	X	X	X	X	X	X	X			X	X	X	X	X	X		X	X	X	X	X			X	X	X	X		X	X
EL.HS.RE.27 Differentiate…							X	X							X	X	X									X		X	X	X	X			

EL.HS.RE.01 Read at an independent and instructional reading level appropriate to grade level
EL.HS.RE.02 Listen to, read, and understand a wide variety of informational and narrative text (...refernece materials, online information)
EL.HS.RE.04 Demonstrate listening comprehension of more complex text through class and-or small group interpretive discussions across the subject area
EL.HS.RE.06 Understand & draw upon a variety of comprehension strategies as needed-re-reading, summarizing,class& group discussions, generating & responding to essential questions, making predictions, & comparing information from several sources.
EL.HS.RE.08 Understand, learn, & use new vocabulary that is introduced and taught directly through informational text, literary text, and instruction across the subject areas
EL.HS.RE.10 Deternine the meaning of words using contextual & structural clues
EL.HS.RE.13 Use general dictionaries, specialized dictionaries, glossaries, thesauruses, or related references to increase vocabulary.
EL.HS.RE. 14 Understand technical vocabulary in subject area reading
EL.HS.RE.15 Read textbooks; biographical sketches; letters; diaries; directions; procedures; magazines; essays; prinary source historical documents; editorials; news stories; periodicals; bus routes; catalogs; technical directions; consumer, workplace, and public documents
EL.HS.RE.16 Synthesize information found in various parts of charts, tables, diagrams, glossaries, or related grade-level text to reach supported conclusions.
EL.HS.RE.19 Identify and/or summarize sequence of events, main ideas, facts, supporting details, & opinions in informational & pratical selections.
EL.HS.RE.24 Analyze implicit relationships, such as cause-and-effect, sequence-time relationships, comparisons, classifications, and generalizations
EL.HS.RE.27 Differentiate among reasoning based on fact versus reasoning based on opinions, emotional apppeals, or other persuasive techniques.

STANDARDS LANGUAGE ARTS

	1. Botany Bouquet	2. Botanical Term. Challenge	3. Secret Life of Flowers	4. Drupes, Pomes, & Locul	5. What's in a Name	6. Plants Have Families Too	7. Mechanics of a Key	8. Making a Field Guide	9. Make Your Own Plant Press	10. Create a Plant	11. Explore OR's Ecoregions	12. The Place I Call Home	13. Ecosystem Comparison	14. Ecosystem through Artist's Eye	15. What's Goin' Down Underground	16. Survival Quest: Pollination Game	17. Plant Wars: Offense and Defense	18. What is a Plant	19. Field Journaling: Observation	20. Nurture Native Garden Project	21. part I	22. part II	23. part III	24. Invasive Weed Explosion	25. Conduct Compar. Plant Survey	26. Who Walked Here Before Me	27. Burden Basket: Plant Materials	28. Making Plant Medicine	29. Phenology: Tracking Seasons	30. Plant Migration Game	31. Nobody Right, Nobody Wrong	32. Biodiversity & Ecosys Services	33. Saving Oregon's Treasures	34. OR Ecosystems: Design a Plan
WRITING																																		
EL.HS.WR.01 Use strategies …					X		X	X		X			X			X	X		X		X	X	X	X		X		X	X		X		X	X
EL.HS.WR.04 Choose form…	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
EL.HS.WR.23 Write analytical…					X																	X						X						
LISTENING																																		
EL.HS.SL.10 Formulate…			X				X	X	X	X			X	X		X	X	X						X	X			X	X	X	X		X	
EL.HS.SL.11 Follow complex…			X	X	X	X	X	X	X		X		X	X	X	X		X			X	X	X	X	X		X	X	X			X		X

WRITING

EL.HS.WR.01 Use a variety of strategies to prepare for writing, such as brainstorming, matking lists, mapping, outlining, grouping related ideas, using graphic organizers, & taking notes.

EL.HS.WR.04 Choose the form of writing that best suits the intended purpose--personal letter, letter to the editor, review, poem, report, or narrative

EL.HS.WR.23 Write analytical essays and research reports.

LISTEINING

EL.HS.SL.10 Formulate judgments about ideas under discussion, & support those judgments with convincing evidence

EL.HS.SL.11 Follow complex verbal instructions that include technical vocabulary & processes.

STANDARDS—TECHNOLOGY

	1. Botany Bouquet	2. Botanical Term. Challenge	3. Secret Life of Flowers	4. Drupes, Pomes, & Locul	5. What's in a Name	6. Plants Have Families Too	7. Mechanics of a Key	8. Making a Field Guide	9. Make Your Own Plant Press	10. Create a Plant	11. Explore OR's Ecoregions	12. The Place I Call Home	13. Ecosystem Comparison	14. Ecosystem through Artist's Eye	15. What's Goin' Down Underground	16. Survival Quest: Pollination Game	17. Plant Wars: Offense and Defense
TG.02 Select and …	■	■			■	■			■		■	■	■		■	■	
TG.03 Access, organize…					■				■		■	■				■	
TG.04 Use technology…					■			■			■	■				■	
TG.05 Design…	■							■								■	
TG. 06 Extend communication…	■							■	■								

	18. What is a Plant	19. Field Journaling: Observation	20. Nurture Native Garden Project	21. part I	22. part II	23. part III	24. Invasive Weed Explosion	25. Conduct Compar. Plant Survey	26. Who Walked Here Before Me	27. Burden Basket: Plant Materials	28. Making Plant Medicine	29. Phenology: Tracking Seasons	30. Plant Migration Game	31. Nobody Right, Nobody Wrong	32. Biodiversity & Ecosys Services	33. Saving Oregon's Treasures	34. OR Ecosystems: Design a. Plan
TG.02 Select and …				■					■	■	■	■	■	■		■	
TG.03 Access, organize…				■					■	■	■	■	■	■		■	
TG.04 Use technology…				■					■	■	■	■	■	■		■	
TG.05 Design…				■		■			■	■						■	
TG. 06 Extend communication…									■			■					

TG.02 Select and use technology to enhance learning and problem solving

TG.03 Access, organize and analyze information to make informed decisions, using one or more technologies

TG.04 Use technology in an ethical and legal manner and understand how technology affects society

TG.05 Design, prepare, and present unique works using technology to communicate information and ideas

TG. 06 Extend communication and collaboration with peers, experts, and other audiences using telecommunications

CAREER-RELATED LEARNING STANDARDS

	1. Botany Bouquet	2. Botanical Term. Challenge	3. Secret Life of Flowers	4. Drupes, Pomes, & Locul	5. What's in a Name	6. Plants Have Families Too	7. Mechanics of a Key	8. Making a Field Guide	9. Make Your Own Plant Press	10. Create a Plant	11. Explore OR's Ecoregions	12. The Place I Call Home	13. Ecosystem Comparison	14. Ecosystem through Artist's Eye	15. What's Goin' Down Underground	16. Survival Quest: Pollination Game	17. Plant Wars: Offense and Defense
Personal Management	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Problem Solving	■			■		■	■	■	■	■	■	■	■		■	■	■
Communication	■					■	■	■				■	■	■	■	■	
Teamwork	■		■				■	■			■	■	■	■	■	■	
Employ. Foundations		■			■	■							■			■	

	18. What is a Plant	19. Field Journaling: Observation	20. Nurture Native Garden Project	21. part I	22. part II	23. part III	24. Invasive Weed Explosion	25. Conduct Compar. Plant Survey	26. Who Walked Here Before Me	27. Burden Basket: Plant Materials	28. Making Plant Medicine	29. Phenology: Tracking Seasons	30. Plant Migration Game	31. Nobody Right, Nobody Wrong	32. Biodiversity & Ecosys Services	33. Saving Oregon's Treasures	34. OR Ecosystems: Design a. Plan
Personal Management	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Problem Solving	■			■	■	■	■	■			■	■		■		■	■
Communication				■	■	■	■	■	■	■	■		■	■	■	■	■
Teamwork			■	■	■			■			■		■	■	■	■	■
Employ. Foundations				■	■	■	■	■				■		■	■		■

Personal Management: Exhibit appropriate work ethic and behaviors in school, community, and/or workplace

Problem Solving: Apply decision-making and problem-solving techniques in school, community, and/or workplace

Communication: Demonstrate effective communication skills to give and receive information in school, community, and/or workplace

Teamwork: Demonstrate effective teamwork in school, community, and/or workplace

Employment Foundations: Demonstrate academic technical, and organizational knowledge and skills required for successful employment

Recommended Botanical Field Guides for Oregon Ecoregions

The starred (**) field guides are organized by plant families and contain dichotomous keys to help in plant identification. We recommend using these guides when possible.

EAST SIDE OREGON: includes Blue Mountains, Columbia Plateau, Eastern Cascades Slopes and Foothills, and Northern Basin and Range ecoregions.

*******Plants of Southern Interior British Columbia and the Inland Northwest*. Roberta Parrish, Ray Coupe, and Dennis Lloyd. 1996. Ministry of Forests and Lone Pine Publishing, Canada.

***Plants of the Rocky Mountains*. Linda Kershaw, Andy MacKinnon, and Jim Pojar. Lone Pine Field Guide. 1998. Lone Pine Publishing, Canada.

A Field Guide to the Common Wetland Plants of Western Washington & Northwest Oregon. Sarah S. Cooke, editor. 1997. Seattle Audubon Society, Trailside Series.

Common Plants of the Upper Klamath Basin. Edited by Sarah Malaby. 2007. Oregon Native Plant Society Klamath Basin Chapter and Rabe Consulting. Download at: www.npsoregon.org/chapters/kb.html

Desert Wildflowers of North America. Ronald J. Taylor. 1998. Mountain Press Publishing Company, Missoula, Montana. (Great Basin Desert region of Oregon)

Great Basin Wildflowers: A Guide to Common Wildflowers of the High Deserts of Nevada, Utah and Oregon. Laird R. Blackwell. 2006. Falcon Guide, Morris Book Publishing, LLC. Helena, Montana.

Noxious Weeds of Klamath County. Andrea Rabe, Michael Calonje, and Christopher Calonje. Rabe Consulting. Online at: www.rabeconsulting.com/pdf/weed_book.pdf

Wildflowers of the Pacific Northwest. Mark Turner and Phyllis Gustafson. 2006. Timber Press, Inc., Portland, Oregon.

Trees to Know in Oregon. Edward C. Jensen. 2010 Oregon State University, Corvallis Oregon

WEST SIDE OREGON: includes Cascades, Coast Range, and Willamette Valley ecoregions

***Plants of the Pacific Northwest Coast: Washington, Oregon, British Columbia, & Alaska*. Jim Pojar and Andy MacKinnon. 1994. B.C. Ministry of Forests and Lone Pine Publishing, Canada.

A Field Guide to the Common Wetland Plants of Western Washington & Northwest Oregon. Sarah S. Cooke, editor. 1997. Seattle Audubon Society, Trailside Series.

Wetland Plants of Oregon and Washington. Jennifer B. Guard. 1995. Lone Pine Press, Edmonton, Alberta, Vancouver, British Columbia and Redmond, Washington.

Wildflowers of the Pacific Northwest. Mark Turner and Phyllis Gustafson. 2006. Timber Press, Inc., Portland, Oregon.

Trees to Know in Oregon. Edward C. Jensen. 2010 Oregon State University, Corvallis Oregon

Specialized plants found in coastal dunes and estuaries:

Plants of the Oregon Coastal Dunes. Alfred M. Wiedemann, La Rea J. Dennis, and Frank H. Smith. 1999. Oregon State University Press, Corvallis, Oregon.

Shore Wildflowers of California, Oregon and Washington. Philip A. Munz. 1964. University of California Press, Berkeley and Los Angeles, California.

KLAMATH MOUNTAINS ecoregion, including the Siskiyou Mountains:

A Field Guide to the Common Wetland Plants of Western Washington & Northwest Oregon. Sarah S. Cooke, editor. 1997. Seattle Audubon Society, Trailside Series.

Wildflowers of the Pacific Northwest. Mark Turner and Phyllis Gustafson. 2006. Timber Press, Inc., Portland, Oregon.

Recommended Botanical Field Guides for Oregon Ecoregions

Flowers of the Table Rocks, Susan K. MacKinnon. Self published, applicable to most of Jackson and Josephine Counties: http://www.flowersofthetablerocks.com/index.html

Pacific States Wildflowers, Peterson Field Guide. Theodore F. Nichaus and Charles L. Ripper. 1976. Houghton Mifflin Company, New York.

Trees to Know in Oregon. Edward C. Jensen. 2010 Oregon State University, Corvallis Oregon.

FOR ALL ECOREGIONS:

A "flora" is a book (or electronic work) that describes the plant species occurring in an area with the aim of identification. Floras usually consist of a dichotomous key, and require botanical knowledge to use effectively. If illustrated, they generally have only line drawings (not photographs) to show detail, and they depend heavily on written descriptions using botanical vocabulary. For the more adventurous, try:

Flora of the Pacific Northwest. C. Leo Hitchcock and Arthur Cronquist. 1973. University of Washington Press, Seattle, Washington.

Manual of the Grasses of the United States. A.S. Hitchcock. 1935. U.S. Government Printing Office, Miscellaneous Publication #200.

Vascular Plants of the Pacific Northwest. C. Leo Hitchcock, Arthur Cronquist, Marion Ownbey, and J.W. Thompson. 1969. University of Washington Press, Seattle, Washington. In five volumes.

Appendix II

Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
BLUE MOUNTAINS					
Mountain big sagebrush					
	Forb/herb				
		Achillea millefolium var. occidentalis	western yarrow	Perennial	Asteraceae
		Astragalus filipes	basalt milkvetch	Perennial	Fabaceae
		Balsamorhiza sagittata	arrowleaf balsamroot	Perennial	Asteraceae
		Balsamorhiza incana	cut-leaf balsamroot	Perennial	Asteraceae
		Eriogonum heracleoides	parsnipflower buckwheat	Perennial	Polygonaceae
		Eriogonum umbellatum	sulphur-flower buckwheat	Perennial	Polygonaceae
		Hedysarum boreale	boreal sweetvetch	Perennial	Fabaceae
		Penstemon speciosus	Royal penstemon	Perennial	Scrophulariaceae
		Penstemon deustus	hot rock penstemon	Perennial	Scrophulariaceae
		Sphaeralcea coccinea	scarlet globemallow	Perennial	Malvaceae
		Sphaeralcea grossulariifolia	gooseberryleaf globemallow	Perennial	Malvaceae
		Eriophyllum lanatum	Oregon sunshine	Perennial	Asteraceae
	Graminoid				
		Achnatherum hymenoides	Indian ricegrass	Perennial	Poaceae
		Bromus carinatus	California brome	Perennial	Poaceae
		Elymus elymoides	squirreltail	Perennial	Poaceae
		Festuca idahoensis	Idaho fescue	Perennial	Poaceae
		Poa secunda	Sandberg's bluegrass	Perennial	Poaceae
		Pseudoroegneria spicata	bluebunch wheatgrass	Perennial	Poaceae
		Clarkia pulchella	pinkfairies	Annual	Onagraceae
	Shrub				
		Artemisia tridentata ssp. vaseyana	mountain big sagebrush	Perennial	Asteraceae
		Purshia tridentata	antelope bitterbrush	Perennial	Rosaceae
	Tree	Juniperus occidentalis	western juniper	Perennial	Cupressaceae
Ponderosa pine					
	Forb/herb				
		Achillea millefolium var. occidentalis	western yarrow	Perennial	Asteraceae
		Astragalus filipes	basalt milkvetch	Perennial	Fabaceae
		Balsamorhiza sagittata	arrowleaf balsamroot	Perennial	Asteraceae
		Eriogonum heracleoides	parsnipflower buckwheat	Perennial	Polygonaceae
		Eriogonum umbellatum	sulphur-flower buckwheat	Perennial	Polygonaceae
		Hedysarum boreale	boreal sweetvetch	Perennial	Fabaceae

Appendix II

Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
BLUE MOUNTAINS					
***Ponderosa pine**, continued*					
	Forb/herb				
		Penstemon palmeri	Palmer's penstemon	Perennial	Scrophulariaceae
		Potentilla glandulosa	sticky cinquefoil	Perennial	Rosaceae
		Penstemon speciosus	royal penstemon	Perennial	Scrophulariaceae
		Penstemon deustus	hot-rock penstemon	Perennial	Scrophulariaceae
		Solidago canadensis	Canada goldenrod	Perennial	Asteraceae
	Graminoid				
		Achnatherum hymenoides	Indian ricegrass	Perennial	Poaceae
		Bromus carinatus	California brome	Perennial	Poaceae
		Elymus elymoides	squirreltail	Perennial	Poaceae
		Festuca idahoensis	Idaho fescue	Perennial	Poaceae
		Poa secunda	Sandberg's bluegrass	Perennial	Poaceae
		Pseudoroegneria spicata	bluebunch wheatgrass	Perennial	Poaceae
	Shrub				
		Cercocarpus ledifolius	curlleaf mountain mahogany	Perennial	Rosaceae
		Purshia tridentata	antelope bitterbrush	Perennial	Rosaceae
		Philadelphus lewisii	mock orange	Perennial	Hydrangeaceae
Wet and semiwet meadows					
	Forb/herb				
		Achillea millefolium var. occidentalis	western yarrow	Perennial	Asteraceae
		Penstemon rydbergii	Rydberg's penstemon	Perennial	Scrophulariaceae
		Penstemon attenuatus	sulpher penstemon	Perennial	Scrophulariaceae
		Potentilla glandulosa	sticky cinquefoil	Perennial	Rosaceae
	Graminoid				
		Deschampsia caespitosa	tufted hairgrass	Perennial	Poaceae
		Leymus cinereus	basin wildrye	Perennial	Poaceae
		Carex sheldonii	Sheldon's sedge	Perennial	Cyperaceae
		Carex pachystachya	chamisso sedge	Perennial	Cyperaceae
CASCADES					
Mesic, open sites					
	Forb/herb				
		Achillea millefolium	common yarrow	Perennial	Asteraceae
		Anaphalis margaritaceae	pearly everlasting	Perennial	Asteraceae
		Chamerion angustifolium	fireweed	Perennial	Onagraceae
		Fragaria vesca	woodland strawberry	Perennial	Rosaceae

Appendix II

Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
CASCADES					
***Mesic, open sites**, continued*					
	Forb/herb				
		Fragaria virginiana	broadpetal strawberry	Perennial	Rosaceae
		Lupinus latifolius	broadleaf lupine	Perennial	Fabaceae
		Lupinus rivularis	riverbank lupine	Perennial	Fabaceae
	Graminoid				
		Bromus carinatus	California brome	Perennial	Poaceae
		Danthonia californica	California oatgrass	Perennial	Poaceae
		Deschampsia caespitosa	tufted hairgrass	Perennial	Poaceae
		Elymus glaucus	blue wildrye	Perennial	Poaceae
		Hordeum brachyantherum	meadow barley	Perennial	Poaceae
	Shrub	Holodiscus discolor	oceanspray	Perennial	Rosaceae
Shaded sites					
	Forb/herb				
		Geum macrophyllum	large leaved avens	Perennial	Rosaceae
	Graminoid				
		Bromus sitchensis	Alaska brome	Perennial	Poaceae
		Bromus vulgaris	Columbia brome	Perennial	Poaceae
		Elymus glaucus	blue wildrye	Perennial	Poaceae
	Shrub				
		Cornus sericea	red osier dogwood	Perennial	Cornaceae
	Tree	Alnus rubra	red alder	Perennial	Betulaceae
COAST RANGE					
Douglas fir forests					
	Forb/herb				
		Achlys triphylla	sweet after death	Perennial	Berberidaceae
		Aquilegia formosa	crimson columbine	Perennial	Ranuculaceae
		Clintonia uniflora	bride's bonnet	Perennial	Liliaceae
		Erythronium oreganum	fawn-lily	Perennial	Liliaceae
		Lilium columbianum	tiger lily	Perennial	Liliaceae
		Linnaea borealis	twinflower	Perennial	Caprifoliaceae
		Trientalis latifolia	broadleaf starflower	Perennial	Primulaceae
		Trillium ovatum	pacific trillium	Perennial	Liliaceae
		Viola sempervirens	redwood violet	Perennial	Violaceae
	Graminoid				
		Bromus vulgaris	Columbia brome	Perennial	Poaceae
		Elymus glaucus	blue wildrye	Perennial	Poaceae

Appendix II

Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
COAST RANGE					
***Douglas fir forests**, continued*					
		Festuca occidentalis	western fescue	Perennial	Poaceae
		Festuca subuliflora	Coast Range fescue	Perennial	Poaceae
		Hierochloe occidentalis	california sweetgrass	Perennial	Poaceae
		Luzula parviflora	small -flowered woodrush	Perennial	Juncaceae
		Melica subulata	Alaska oniongrass	Perennial	Poaceae
	Shrub				
		Acer circinatum	vine maple	Perennial	Aceraceae
		Berberis nervosa	Oregon grape	Perennial	Berberidaceae
		Gaultheria shallon	salal	Perennial	Ericaceae
		Holodiscus discolor	ocean spray	Perennial	Rosaceae
		Rhamnus purshiana	Cascara buckthorn	Perennial	Rhamnaceae
		Rhododendron macrophyl-lum	rhodendron	Perennial	Ericaceae
		Ribes sanguineum	red flowering currant	Perennial	Grossulaceae
		Rubus spectabilis	salmonberry	Perennial	Rosaceae
	Tree				
		Alnus rubra	red alder	Perennial	Betulaceae
Dunes					
	Forb/herb				
		Abronia latifolia	coastal sand verbena	Perennial	Nyctaginaceae
		Camissonia cheiranthifolia	beach evening primrose	Perennial	Onagraceae
		Crambe maritima	sea kale	Perennial	Brassicaceae
		Fragaria chiloensis	beach strawberry	Perennial	Rosaceae
		Lathyrus japonicus	beach pea	Perennial	Fabaceae
		Lathyrus littoralis	silky beach pea	Perennial	Fabaceae
		Lupinus littoralis	seashore lupine	Perennial	Fabaceae
		Platystemon californicus	cream cups	Annual	Papaveraceae
		Trifolium wormskioldii	cows clover	Perennial	Fabaceae
	Graminoid				
		Carex lenticularis var. lim-nophila	coastal shore sedge	Perennial	Cyperaceae
		Carex macrocephala	largehead sedge	Perennial	Cyperaceae
		Festuca rubra	red fescue	Perennial	Poaceae
		Juncus lesueurii	salt rush	Perennial	Juncaceae
		Leymus mollis	American dunegrass	Perennial	Poaceae
		Poa macrantha	seashore bluegrass	Perennial	Poaceae

Appendix II

Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
COAST RANGE					
Marshes					
	Forb/herb				
		Gentiana spectrum	king's gentian	Perennial	Gentianaceae
		Jaumea carnosa	marsh jaumea	Perennial	Asteraceae
		Potentilla pacifica	Pacific silverweed	Perennial	Rosaceae
		Sisyrinchium californicum	golden eyed grass	Perennial	Iridaceae
	Graminoid				
		Carex lyngbyei	Lyngbye's sedge	Perennial	Cyperaceae
		Carex macrocephela	large-headed sedge	Perennial	Cyperaceae
		Carex obnupta	slough sedge	Perennial	Cyperaceae
		Deschampsia caespitosa	tufted hairgrass	Perennial	Poaceae
	Shrub				
		Ledum glandulosum	Labrador-tea	Perennial	Ericaceae
		Lonicera involucrata	twinberry honeysuckle	Perennial	Caprifoliaceae
		Malus fusca	Oregon crab apple	Perennial	Rosaceae
		Salix hookeriana	Hooker's willow	Perennial	Salicaceae
		Spiraea douglasii	Douglas's spiraea	Perennial	Rosaceae
Prairies					
	Forb/herb				
		Achillea millefolium	common yarrow	Perennial	Asteraceae
		Anaphalis margaritacea	western pearly everlasting	Perennial	Asteraceae
		Angelica hendersonii	Henderson's angelica	Perennial	Apiaceae
		Angelica lucida	seacoast angelica	Perennial	Apiaceae
		Brodiaea coronaria	crown brodiaea	Perennial	Liliaceae
		Brodiaea elegans	harvest brodiaea	Perennial	Liliaceae
		Camassia quamash	small camas	Perennial	Liliaceae
		Clarkia amoena	farewell to spring	Annual	Onagraceae
		Erigeron glaucus	seaside fleabane	Perennial	Asteraceae
		Fragaria chiloensis	beach strawberry	Perennial	Rosaceae
		Fragaria vesca	wood strawberry		Rosaceae
		Heracleum lanatum	common cowparsnip	Perennial	Apiaceae
		Lathyrus japonicus	beach pea	Perennial	Fabaceae
		Ranunculus occidentalis	western buttercup	Perennial	Ranunculaceae
		Sanicula arctopoides	footsteps of spring	Perennial	Apiaceae
		Scrophularia californica	California figwort	Perennial	Scrophulariaceae
		Sidalcea malviflora	dwarf checkerbloom	Perennial	Malvaceae
		Sisyrinchium bellum	blue-eyed grass	Perennial	Iridaceae

Appendix II

Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
COAST RANGE					
***Prairies**, continued*					
		Solidago canadensis	Canada goldenrod	Perennial	Asteraceae
		Tanacetum douglasii	dune tansy	Perennial	Asteraceae
		Toxicoscordion (Zigadenus) fremontii	death camas	Perennial	Liliaceae
		Viola adunca	hookedspur violet	Perennial	Violaceae
	Graminoid				
		Calamagrostis nutkaensis	Pacific reedgrass	Perennial	Poaceae
		Danthonia californica	California oatgrass	Perennial	Poaceae
		Deschampsia caespitosa	tufted hairgrass	Perennial	Poaceae
		Elymus glaucus	blue wildrye	Perennial	Poaceae
	Shrub				
		Arctostaphylos columbiana	hairy manzanita	Perennial	Ericaceae
		Baccharis pilularis	coyote brush	Perennial	Asteraceae
		Rubus parviflorus	thimbleberry	Perennial	Rosaceae
		Rubus spectabilis	salmonberry	Perennial	Rosaceae
		Viburnum edule	highbush cranberry	Perennial	Caprifoliaceae
Sitka spruce/western hemlock forests					
	Forb/herb				
		Claytonia perfoliata	miner's lettuce	Perennial	Portulacaceae
		Claytonia sibirica	Siberian miner's lettuce	Perennial	Portulacaceae
		Clintonia uniflora	bride's bonnet	Perennial	Liliaceae
		Maianthemum dilatatum	false lily of the valley	Perennial	Liliaceae
		Oxalis oregana	redwood sorrel	Perennial	Oxalidaceae
		Petasites frigidus	colts foot	Perennial	Asteraceae
		Polypodium scouleri	leathery polypody fern	Perennial	Polypodiaceae
		Polystichum munitum	sword fern	Perennial	Dryopteridaceae
		Stachys mexicana	Mexican hedgenettle	Perennial	Scrophulariaceae
		Trientalis latifolia	broadleaf starflower	Perennial	Caprifoliaceae
		Trillium ovatum	trillium	Perennial	Liliaceae
		Viola sempervirens	evergreen violet	Perennial	Violaceae
	Shrub				
		Berberis nervosa		Perennial	Berberidaceae
		Gaultheria shallon	salal	Perennial	Ericaceae
		Lonicera involucrata	twinberry honeysuckle	Perennial	Caprifoliaceae
		Rubus spectabilis	salmonberry	Perennial	Rosaceae
		Vaccinium ovatum	evergreen huckleberry	Perennial	Ericaceae

Appendix II

Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
COLUMBIA PLATEAU					
Sagebrush steppe					
	Forb/herb				
		Achillea millefolium var. occidentalis	western yarrow	Perennial	Asteraceae
		Astragalus filipes	basalt milkvetch	Perennial	Fabaceae
		Astragalus purshii	woollypod milkvetch	Perennial	Fabaceae
		Balsamorhiza sagittata	arrowleaf balsamroot	Perennial	Asteraceae
		Chaenactis douglasii	dusty maiden	Biennial / Perennial	Asteraceae
		Crepis acuminata	tapertip hawksbeard	Perennial	Asteraceae
		Eriogonum heracleoides	parsnipflower buckwheat	Perennial	Polygonaceae
		Eriogonum umbellatum	sulphur-flower buckwheat	Perennial	Polygonaceae
		Linum lewisii	blue flax	Perennial	Linaceae
		Lupinus caudatus	tailcup lupine	Perennial	Fabaceae
		Lupinus lepidus	Pacific lupine	Perennial	Fabaceae
		Macarantha canescens	hoary aster	Perennial	Asteraceae
		Penstemon deustus	scabland penstemon	Perennial	Scrophulariaceae
		Penstemon speciosus	royal penstemon	Perennial	Scrophulariaceae
		Sphaeralcea munroenna	scarlet globemallow	Perennial	Malvaceae
		Trifolium macrocephalum	big headed clover	Perennial	Fabaceae
	Graminoid				
		Achnatherum hymenoides	Indian ricegrass	Perennial	Poaceae
		Achnatherum thurberianum	Thurber's needlegrass	Perennial	Poaceae
		Elymus elymoides	squirreltail	Perennial	Poaceae
		Festuca idahoensis	Idaho fescue	Perennial	Poaceae
		Hesperostipa comata	needle and thread grass	Perennial	Poaceae
		Leymus cinereus	giant basin wildrye	Perennial	Poaceae
		Poa sandbergii	Sandberg bluegrass	Perennial	Poaceae
		Pseudoroegneria spicata	bluebunch wheatgrass	Perennial	Poaceae
	Shrub				
		Artemisia arbuscula	low sagebrush	Perennial	Asteraceae
		Artemisia tridentata	big sagebrush	Perennial	Asteraceae
		Chrysothamnus nauseosus	gray rabbitbrush	Perennial	Asteraceae
		Chrysothamnus viscidiflorus	green rabbitbrush	Perennial	Asteraceae
		Purshia tridentata	antelope bitterbrush	Perennial	Rosaceae
		Ribes cereum	wax current	Perennial	Grossulariaceae

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Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
COLUMBIA PLATEAU					
Sagebrush steppe					
		Symphoricarpos albus	common snowberry	Perennial	Caprifoliaceae
	Tree				
		Juniperus occidentalis	western juniper	Perennial	Cupressaceae
Palouse prairie					
	Forb/herb				
		Achillea millefolium	common yarrow	Perennial	Asteraceae
		Allium acuminatum	tapertip onion	Perennial	Liliaceae
		Anaphalis margaritacea	western pearly everlasting	Perennial	Asteraceae
		Asclepias speciosa	showy milkweed	Perennial	Asclepiadaceae
		Balsamorhiza sagittata	arrowleaf balsamroot	Perennial	Asteraceae
		Camassia quamash	small camas	Perennial	Liliaceae
		Castilleja miniata	giant red Indian paintbrush	Perennial	Scrophulariaceae
		Collomia grandiflora	grand collomia	Annual	Polemoniaceae
		Crepis acuminata	tapertip hawksbeard	Perennial	Asteraceae
		Eriogonum heracleoides	parsnipflower buckwheat	Perennial	Polygonaceae
		Lupinus polyphyllus	bigleaf lupine	Perennial	Fabaceae
		Potentilla gracilis	slender cinquefoil	Perennial	Rosaceae
		Prunella vulgaris	common selfheal	Perennial	Lamiaceae
		Solidago canadensis	Canada goldenrod	Perennial	Asteraceae
	Graminoid				
		Bromus carinatus	California brome	Perennial	Poaceae
		Bromus vulgaris	Columbia brome	Perennial	Poaceae
		Elymus elymoides	squirreltail	Perennial	Poaceae
		Festuca idahoensis	Idaho fescue	Perennial	Poaceae
		Leymus cinereus	basin wildrye	Perennial	Poaceae
		Pseudoroegneria spicata	bluebunch wheatgrass	Perennial	Poaceae
	Shrub				
		Philadelphus lewisii	mock orange	Perennial	Hydrangeaceae
		Prunus virginiana	chokecherry	Perennial	Rosaceae
		Rhus glabra	smooth sumac	Perennial	Anacardiaceae
		Ribes aureum	golden current	Perennial	Grossulariaceae
		Ribes cereum	wax current	Perennial	Grossulariaceae
		Rosa woodsii	Woods' rose	Perennial	Rosaceae
Ponderosa pine					
	Forb/herb				
		Achillea millefolium var. occidentalis	western yarrow	Perennial	Asteraceae

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Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
COLUMBIA PLATEAU					
***Ponderosa pine**, continued*					
		Antennaria	rosy pussytoes	Perennial	Asteraceae
		Arnica cordifolia	heartleaf arnica	Perennial	Asteraceae
		Astragalus filipes	basalt milkvetch	Perennial	Fabaceae
		Balsamorhiza hookeri	Hooker's balsamroot	Perennial	Asteraceae
		Balsamorhiza sagittata	arrowleaf balsamroot	Perennial	Asteraceae
		Eriogonum heracleoides	parsnipflower buckwheat	Perennial	Polygonaceae
		Fragaria virginiana	Virginia strawberry	Perennial	Rosaceae
		Geum triflorum	red avens	Perennial	Rosaceae
		Linum lewisii	Lewis flax	Perennial	Linaceae
		Potentilla glandulosa	sticky cinquefoil	Perennial	Rosaceae
		Solidago canadensis	Canada goldenrod	Perennial	Asteraceae
	Graminoid				
		Achnatherum occidentalis	western needlegrass	Perennial	Poaceae
		Bromus carinatus	California brome	Perennial	Poaceae
		Carex geyeri	elk sedge	Perennial	Cyperaceae
		Elymus elymoides	squirreltail	Perennial	Poaceae
		Elymus glaucus	blue wildrye	Perennial	Poaceae
		Festuca idahoensis	Idaho fescue	Perennial	Poaceae
		Koelaria nitida	prairie junegrass	Perennial	Poaceae
		Pseudoroegneria spicata	bluebunch wheatgrass	Perennial	Poaceae
	Shrub				
		Amelanchier alnifolia	Saskatoon/serviceberry	Perennial	Rosaceae
		Arctostaphylos nevadensis	pinemat manzanita	Perennial	Ericaceae
		Arctostaphylos uva-ursi	glossyleaf manzanita	Perennial	Ericaceae
		Berberis repens	creeping Oregon grape	Perennial	Berberidaceae
		Ceanothus velutinus	snowbrush ceanothus	Perennial	Rhamnaceae
		Physocarpus malvaceus	mallow ninebark	Perennial	Rosaceae
		Purshia tridentata	antelope bitterbrush	Perennial	Rosaceae
		Ribes cereum	wax current	Perennial	Grossulariaceae
		Rosa gymnocarpum	baldhip rose	Perennial	Rosaceae
		Symphoricarpos albus	common snowberry	Perennial	Caprifoliaceae
	Tree				
		Cercocarpus ledifolius	mountain mahogany	Perennial	Rosaceae
		Pinus ponderosa	ponderosa pine	Perennial	Pinaceae
Wet and semiwet meadows					
		Aquilegia formosa	red columbine	Perennial	Ranunculaceae

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Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
COLUMBIA PLATEAU					
Wet and semiwet meadows					
		Camassia quamash	common camas	Perennial	Liliaceae
		Geum macrophyllum	large leaf avens	Perennial	Rosaceae
		Iris missouriensis	Rocky Mountain iris	Perennial	Iridaceae
		Mimulus guttatus	seep monkeyflower	Annual / Perennial	Scrophulariaceae
		Potentilla glandulosa	sticky cinquefoil	Perennial	Rosaceae
		Potentilla gracilis	slender cinquefoil	Perennial	Rosaceae
		Vicia americana	American vetch	Perennial	Fabaceae
	Graminoid				
		Calamagrostis canadensis	bluejoint	Perennial	Poaceae
		Carex aquatilis	water sedge	Perennial	Cyperaceae
		Carex nebrascensis	Nebraska sedge	Perennial	Cyperaceae
		Deschampsia caespitosa	tufted hairgrass	Perennial	Poaceae
		Elymus glaucus	blue wildrye	Perennial	Poaceae
		Festuca rubra	red fescue	Perennial	Poaceae
		Hordeum brachyantherum	meadow barley	Perennial	Poaceae
		Juncus balticus			Juncaceae
		Leymus cinereus	basin wildrye	Perennial	Poaceae
		Scirpus microcarpus	panicled bulrush	Perennial	Cyperaceae
	Shrub				
		Craetagus douglasii	hawthorn	Perennial	Rosaceae
		Potentilla fruticosa	shrubby cinqufoil	Perennial	Rosaceae
		Salix spp	willow spp	Perennial	Salicaceae
EASTERN CASCADE SLOPES AND FOOTHILLS					
Mountain big sagebrush					
	Forb/herb				
		Achillea millefolium var. occidentalis	western yarrow	Perennial	Asteraceae
		Astragalus filipes	basalt milkvetch	Perennial	Fabaceae
		Balsamorhiza sagittata	arrowleaf balsamroot	Perennial	Asteraceae
		Eriogonum heracleoides	parsnipflower buckwheat	Perennial	Polygonaceae
		Eriogonum ovalifolium	cushion buckwheat	Perennial	Polygonaceae
		Eriogonum umbellatum	sulphur-flower buckwheat	Perennial	Polygonaceae
		Eriophyllum lanatum	Oregon sunshine	Perennial	Asteraceae
		Hedysarum boreale	boreal sweetvetch	Perennial	Fabaceae
		Linum perenne var. lewisii	western blue flax	Perennial	Linaceae
		Penstemon spp.		Perennial	Scrophulariaceae

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Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
EASTERN CASCADE SLOPES AND FOOTHILLS					
***Mountain big sagebrush**, continued*					
	Forb/herb				
		Sphaeralcea coccinea	scarlet globemallow	Perennial	Malvaceae
		Sphaeralcea grossulariifolia	gooseberryleaf globemallow	Perennial	Malvaceae
	Graminoid				
		Achnatherum hymenoides	Indian ricegrass	Perennial	Poaceae
		Achnatherum lettermanii	Letterman's needlegrass	Perennial	Poaceae
		Achnatherum thurberianum	Thurber's needlegrass	Perennial	Poaceae
		Bromus carinatus	California brome	Perennial	Poaceae
		Elymus trachycaulus	slender wheatgrass	Perennial	Poaceae
		Festuca idahoensis	Idaho fescue	Perennial	Poaceae
		Hesperostipa comata	needle and thread	Perennial	Poaceae
		Leymus cinereus	basin wildrye	Perennial	Poaceae
		Poa secunda	Sandberg bluegrass	Perennial	Poaceae
		Pseudoroegneria spicata	bluebunch wheatgrass	Perennial	Poaceae
	Shrub				
		Artemisia tridentata ssp. vaseyana	mountain big sagebrush	Perennial	Asteraceae
		Purshia tridentata	antelope bitterbrush	Perennial	Rosaceae
Ponderosa pine					
	Forb/herb				
		Achillea millefolium var. occidentalis	western yarrow	Perennial	Asteraceae
		Aquilegia formosa	western columbine	Perennial	Ranunculaceae
		Astragalus filipes	basalt milkvetch	Perennial	Fabaceae
		Balsamorhiza sagittata	arrowleaf balsamroot	Perennial	Asteraceae
		Eriogonum heracleoides	parsnipflower buckwheat	Perennial	Polygonaceae
		Eriogonum ovalifolium	cushion buckwheat	Perennial	Polygonaceae
		Eriogonum umbellatum	sulphur-flower buckwheat	Perennial	Polygonaceae
		Hedysarum boreale	boreal sweetvetch	Perennial	Fabaceae
		Lathyrus lanszwertii	aspen pea	Perennial	Fabaceae
		Linum perenne var. lewisii	western blue flax	Perennial	Linaceae
		Lupinus leucophyllus	velvet lupine	Perennial	Fabaceae
		Lupinus polyphyllus	bigleaf llupine	Perennial	Fabaceae
		Paeonia brownii	Brown's peony	Perennial	Paeoniaceae
		Penstemon spp.	Penstemon	Perennial	Scrophulariaceae
		Potentilla glandulosa	sticky cinquefoil	Perennial	Rosaceae
		Rudbeckia occidentalis	western coneflower	Perennial	Asteraceae

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Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
EASTERN CASCADE SLOPES AND FOOTHILLS					
Ponderosa pine					
		Solidago canadensis	Canada goldenrod	Perennial	Asteraceae
	Forb/herb				
		Thalictrum occidentale	western meadowrue	Perennial	Ranunculaceae
		Vicia americana	American vetch	Perennial	Fabaceae
	Graminoid				
		Achnatherum hymenoides	Indian ricegrass	Perennial	Poaceae
		Achnatherum occidentale ssp. occidentale	western needlegrass	Perennial	Poaceae
		Bromus carinatus	California brome	Perennial	Poaceae
		Elymus elymoides	squirreltail	Perennial	Poaceae
		Elymus glaucus	blue wildrye	Perennial	Poaceae
		Elymus trachycaulus	slender wheatgrass	Perennial	Poaceae
		Festuca idahoensis	Idaho fescue	Perennial	Poaceae
		Festuca occidentalis	western fescue	Perennial	Poaceae
		Hesperostipa comata	needle and thread	Perennial	Poaceae
		Pseudoroegneria spicata	bluebunch wheatgrass	Perennial	Poaceae
	Shrub				
		Arctostaphylos patula	greenleaf manzanita	Perennial	Ericaceae
		Berberis aquifolium	Oregon grape	Perennial	Berberidaceae
		Purshia tridentata	antelope bitterbrush	Perennial	Rosaceae
		Ribes cereum	wax current	Perennial	Grossulariaceae
KLAMATH MOUNTAINS					
Chaparral shrubland					
	Forb/herb				
		Achillea millefolium	common yarrow	Perennial	Asteraceae
		Erythronium hendersonii	Henderson's fawn lily	Perennial	Liliaceae
		Dodecatheon hendersonii	shooting star	Perennial	Primulaceae
		Ranunculus occidentalis	western buttercup	Perennial	Ranunculaceae
		Cynoglossum grande	hound's tongue	Perennial	Boraginaceae
		Eriophyllum lanatum	wooly sunflower	Perennial	Asteraceae
	Graminoid				
		Achnatherum lemmonii	Lemmon's needlegrass	Perennial	Poaceae
		Elymus elymoides	squirreltail	Perennial	Poaceae
	Shrub				
		Ceanothus cuneatus	buckbrush	Perennial	Rhamnaceae

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COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
KLAMATH MOUNTAINS					
Chaparral shrubland					
	Shrub				
		Amelanchier alnifolia	Saskatoon/serviceberry	Perennial	Rosaceae
		Arctostaphylos spp.	manzanita/bearberry	Perennial	Ericaceae
		Berberis aquifolium	Oregon grape	Perennial	Berberidaceae
Low-elevation forests, mixed evergreen/hardwood					
	Forb/herb				
		Achillea millefolium	common yarrow	Perennial	Asteraceae
		Collomia grandiflora	grand collomia	Annual	Polemoniaceae
		Achlys triphylla	vanilla leaf	Perennial	Berberidaceae
		Fragaria vesca	woodland strawberry	Perennial	Rosaceae
		Linnaea borealis	twin flower	Perennial	Caprifoliaceae
		Trillium ovatum	trillium	Perennial	Liliaceae
		Whipplea modesta	whipple vine	Perennial	Hydrangeaceae
		Lonicera hispidula	hairy honeysuckle	Perennial	Caprifoliaceae
		Disporum hookeri	Hooker's fairybells	Perennial	Liliaceae
		Smilacina stellata	false lily of the valley	Perennial	Liliaceae
		Lilium columbianum	tiger lily	Perennial	Liliaceae
	Graminoid				
		Achnatherum lemmonii	Lemmon's needlegrass	Perennial	Poaceae
		Achnatherum occidentale	western needlegrass	Perennial	Poaceae
		Elymus elymoides	squirreltail	Perennial	Poaceae
		Festuca roemeri	Roemer's fescue	Perennial	Poaceae
		Festuca occidentalis	western fescue	Perennial	Poaceae
	Shrub				
		Amelanchier alnifolia	Saskatoon/serviceberry	Perennial	Rosaceae
		Symphoricarpos mollis	creeping snowberry	Perennial	Caprifoliaceae
		Corylus cornuta	beaked hazelnut	Perennial	Betulaceae
Oak woodlands					
	Forb/herb				
		Achillea millefolium	common yarrow	Perennial	Asteraceae
		Erythronium hendersonii	Henderson's fawn lily	Perennial	Liliaceae
		Dodecatheon hendersonii	shooting star	Perennial	Primulaceae
		Lomatium nudicaule	bare stem lomatium	Perennial	Apiaceae
		Ranunculus occidentalis	western buttercup	Perennial	Ranunculaceae
		Cynoglossum grande	hound's tongue	Perennial	Boraginaceae
		Iris chrsophylla	yellow-leaved iris	Perennial	Iridaceae

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COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
KLAMATH MOUNTAINS					
Oak woodlands					
	Graminoid				
		Achnatherum lemmonii	Lemmon's needlegrass	Perennial	Poaceae
		Elymus glaucus	blue wildrye	Perennial	Poaceae
		Festuca roemeri	Roemer's fescue	Perennial	Poaceae
		Elymus elymoides	squirreltail	Perennial	Poaceae
		Danthonia californica	California oatgrass	Perennial	Poaceae
Riparian					
	Forb/herb				
		Aquilegia formosa	columbine	Perennial	Ranunculaceae
		Geum macrophyllum	largeleaf avens	Perennial	Rosaceae
		Trillium spp.	trillium	Perennial	Liliaceae
		Viola glabella	yellow wood violet	Perennial	Violaceae
	Graminoid				
		Deschampsia caespitosa	tufted hairgrass	Perennial	Poaceae
		Elymus glaucus	blue wildrye	Perennial	Poaceae
		Glyceria elata	manna grasses	Perennial	Poaceae
	Shrub				
		Cornus stolonifera	red-osier dogwood	Perennial	Cornaceae
		Salix lasiolepis	arroyo willow	Perennial	Salicaceae
Serpentine woodlands					
	Forb/herb				
		Achillea millefolium	common yarrow	Perennial	Asteraceae
		Achlys triphylla	vanilla leaf	Perennial	Berberidaceae
		Arnica cordifolia	heartleaf arnica	Perennial	Asteraceae
		Linnaea borealis	twinflower	Perennial	Caprifoliaceae
		Horkelia daucifolia	carrotleaf horkelia	Perennial	Rosaceae
		Trifolium eriocephalum	woollyhead clover	Perennial	Fabaceae
		Silene hookeri	Hooker's silene	Perennial	Caryophyllaceae
	Graminoid				
		Achnatherum lemmonii	Lemmon's needlegrass	Perennial	Poaceae
		Deschampsia caespitosa	tufted hairgrass	Perennial	Poaceae
		Festuca roemeri	Roemer's fescue	Perennial	Poaceae
		Danthonia californica	California oatgrass	Perennial	Poaceae
		Melica subulata	oniongrass	Perennial	Poaceae
	Shrub				
		Ceanothus pumilus	dwarf ceanothus	Perennial	Rhamnaceae

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Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
KLAMATH MOUNTAINS					
Serpentine woodlands					
	Shrub				
		Whipplea modesta	common whipplea	Perennial	Hydrangeaceae
		Ceanothus cuneatus	buckbrush	Perennial	Rhamnaceae
		Garrya buxifolia	dwarf silktassel	Perennial	Garryaceae
		Arctostaphylos viscida	sticky whiteleaf manzanita	Perennial	Ericaceae
Wet prairie					
	Forb/herb				
		Camassia quamash	small camas	Perennial	Liliaceae
		Viola hallii	Hall's violet	Perennial	Violaceae
		Fragaria virginiana	Virginia strawberry	Perennial	Rosaceae
		Geum macrophyllum	largeleaf avens	Perennial	Rosaceae
		Prunella vulgaris	common selfheal	Perennial	Lamiaceae
	Graminoid				
		Agrostis exarata	spike bentgrass	Perennial	Poaceae
		Danthonia californica	California oatgrass	Perennial	Poaceae
		Deschampsia caespitosa	tufted hairgrass	Perennial	Poaceae
		Hordeum brachyantherum	meadow barley	Perennial	Poaceae
	Shrub				
		Spiraea douglasii	Douglas spiraea	Perennial	Rosaceae
NORTHERN BASIN AND RANGE					
Arid west freshwater marsh					
	Forb/herb				
		Achillea millefolium	common yarrow	Perennial	Asteraceae
		Camassia quamash	small camas	Perennial	Liliaceae
		Cirsium scariosum	meadow thistle	Perennial	Asteraceae
		Potentilla glandulosa	sticky cinquefoil	Perennial	Rosaceae
		Potentilla gracilis	slender cinquefoil	Perennial	Rosaceae
		Ranunculus occidentalis	western buttercup	Perennial	Ranunculaceae
		Senecio integirrimus		Perennial	Asteraceae
		Senecio triangularis	arrowleaf ragwort	Perennial	Asteraceae
		Sidalcea oregana	Oregon checkerbloom	Perennial	Malvaceae
		Vicia americana	American vetch	Perennial	Fabaceae
	Graminoid				
		Bromus carinatus	California brome	Perennial	Poaceae
		Carex douglasii	Douglas' sedge	Perennial	Cyperaceae
		Deschampsia caespitosa	tufted hairgrass	Perennial	Poaceae

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Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
NORTHERN BASIN AND RANGE					
Arid west freshwater marsh					
	Graminoid				
		Elymus glaucus	blue wildrye	Perennial	Poaceae
		Hordeum brachyantherum	meadow barley	Perennial	Poaceae
		Leymus cinereus	basin wildrye	Perennial	Poaceae
		Leymus triticoides	beardless wildrye	Perennial	Poaceae
Sagebrush steppe					
	Forb/herb				
		Achillea millefolium	common yarrow	Perennial	Asteraceae
		Agoseris grandiflora	bigflower agoseris	Perennial	Asteraceae
		Allium acuminatum	tapertip onion	Perennial	Liliaceae
		Anaphalis margaritacea	western pearly everlasting	Perennial	Asteraceae
		Astragalus filipes	basalt milkvetch	Perennial	Fabaceae
		Astragalus lentiginosus	freckled milkvetch	Perennial	Fabaceae
		Astragalus purshii	woollypod milkvetch	Perennial	Fabaceae
		Balsamorhiza hookeri	Hooker's balsamroot	Perennial	Asteraceae
		Balsamorhiza sagittata	arrowleaf balsamroot	Perennial	Asteraceae
		Chaenactis douglasii	Douglas' dustymaiden	Perennial	Asteraceae
		Collomia grandiflora	grand collomia	Annual	Polemoniaceae
		Crepis acuminata	tapertip hawksbeard	Perennial	Asteraceae
		Erigeron filifolius	threadleaf fleabane	Perennial	Asteraceae
		Erigeron linearis	desert yellow fleabane	Perennial	Asteraceae
		Erigeron pumilus	shaggy fleabane	Perennial	Asteraceae
		Eriogonum heracleoides	parsnipflower buckwheat	Perennial	Polygonaceae
		Eriogonum ovalifolium	cushion buckwheat	Perennial	Polygonaceae
		Eriogonum sphaerocephalum	rock buckwheat	Perennial	Polygonaceae
		Eriogonum umbellatum	sulphur-flower buckwheat	Perennial	Polygonaceae
		Eriophyllum lanatum	Oregon sunshine	Perennial	Asteraceae
		Packera cana	woolly groundsel	Perennial	Asteraceae
		Penstemon speciosus	royal penstemon	Perennial	Scrophulariaceae
		Sphaeralcea munroana	Munro's globemallow	Perennial	Malvaceae
	Graminoid				
		Achnatherum hymenoides	Indian ricegrass	Perennial	Poaceae
		Achnatherum occidentale	western needlegrass	Perennial	Poaceae
		Carex filifolia	threadleaf sedge	Perennial	Cyperaceae
		Elymus elymoides	squirreltail	Perennial	Poaceae

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Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
NORTHERN BASIN AND RANGE					
***Sagebrush steppe**, continued*					
	Graminoid				
		Festuca idahoensis	Idaho fescue	Perennial	Poaceae
		Hesperostipa comata	needle and thread	Perennial	Poaceae
		Leymus cinereus	basin wildrye	Perennial	Poaceae
		Poa secunda	Sandberg bluegrass	Perennial	Poaceae
		Pseudoroegneria spicata	bluebunch wheatgrass	Perennial	Poaceae
		Sporobolus cryptandrus	sand dropseed	Perennial	Poaceae
	Shrub				
		Artemisia tridentata ssp. wyomingensis	sagebrush	Perennial	Asteraceae
		Purshia tridentata	antelope bitterbrush	Perennial	Rosaceae
		Ribes cereum	wax current	Perennial	Grossulariaceae
		Salvia dorrii	puple sage	Perennial	Labiatae
Semi-desert grassland					
	Forb/herb				
		Achillea millefolium	common yarrow	Perennial	Asteraceae
		Agoseris grandiflora	bigflower agoseris	Perennial	Asteraceae
		Allium acuminatum	tapertip onion	Perennial	Liliaceae
		Asclepias speciosa	showy milkweed	Perennial	Asclepiadaceae
		Astragalus purshii	woollypod milkvetch	Perennial	Fabaceae
		Balsamorhiza hookeri	Hooker's balsamroot	Perennial	Asteraceae
		Balsamorhiza sagittata	arrowleaf balsamroot	Perennial	Asteraceae
		Crepis acuminata	tapertip hawksbeard	Perennial	Asteraceae
		Erigeron filifolius	threadleaf fleabane	Perennial	Asteraceae
		Erigeron linearis	blue dwarf fleabane	Perennial	Asteraceae
		Erigeron pumilus ssp. intermedius	shaggy fleabane	Perennial	Asteraceae
		Eriogonum heracleoides	parsnipflower buckwheat	Perennial	Polygonaceae
		Eriogonum ovalifolium	cushion buckwheat	Perennial	Polygonaceae
		Lotus unifoliolatus var. unifoliolatus	American bird's-foot trefoil	Annual	Fabaceae
		Potentilla gracilis	slender cinquefoil	Perennial	Rosaceae
		Sidalcea oregana	Oregon checkerbloom	Perennial	Malvaceae
		Vicia americana ssp. americana	American vetch	Perennial	Fabaceae
	Graminoid				
		Achnatherum hymenoides	Indian ricegrass	Perennial	Poaceae
		Achnatherum thurberianum	Thurber's needlegrass	Perennial	Poaceae

Appendix II

Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
NORTHERN BASIN AND RANGE					
Semi-desert grassland*, continued*					
	Graminoid				
		Bromus carinatus	California brome	Perennial	Poaceae
		Elymus elymoides	squirreltail	Perennial	Poaceae
		Elymus trachycaulus	slender wheatgrass	Perennial	Poaceae
		Festuca idahoensis	Idaho fescue	Perennial	Poaceae
		Hesperostipa comata	needle and thread	Perennial	Poaceae
		Leymus cinereus	basin wildrye	Perennial	Poaceae
		Pseudoroegneria spicata	bluebunch wheatgrass	Perennial	Poaceae
Western juniper woodlands					
	Forb/herb				
		Achillea millefolium	common yarrow	Perennial	Asteraceae
		Allium acuminatum	tapertip onion	Perennial	Liliaceae
		Anaphalis margaritacea	western pearly everlasting	Perennial	Asteraceae
		Astragalus filipes	basalt milkvetch	Perennial	Fabaceae
		Astragalus lentiginosus	milkvetch	Perennial	Fabaceae
		Astragalus purshii	woollypod milkvetch	Perennial	Fabaceae
		Balsamorhiza sagittata	arrowleaf balsamroot	Perennial	Asteraceae
		Calochortus macrocarpus	sagebrush mariposa lily	Perennial	Liliaceae
		Collomia grandiflora	grand collomia	Annual	Polemoniaceae
		Crepis acuminata	tapertip hawksbeard	Perennial	Asteraceae
		Erigeron filifolius	threadleaf fleabane	Perennial	Asteraceae
		Erigeron linearis	desert yellow fleabane	Perennial	Asteraceae
		Erigeron lonchophyllus	shortray fleabane	Perennial	Asteraceae
		Erigeron pumilus ssp. intermedius	shaggy fleabane	Perennial	Asteraceae
		Eriogonum ovalifolium	cushion buckwheat	Perennial	Polygonaceae
		Eriogonum sphaerocephalum	rock buckwheat	Perennial	Polygonaceae
		Eriogonum umbellatum	sulphur-flower buckwheat	Perennial	Polygonaceae
		Eriophyllum lanatum	Oregon sunshine	Perennial	Asteraceae
		Hieracium cynoglossoides	hound's tongue hawkweed	Perennial	Asteraceae
		Nothocalais troximoides	sagebrush false dandelion	Perennial	Asteraceae
		Penstemon deustus	scabland penstemon	Perennial	Scrophulariaceae
		Penstemon speciosus	royal penstemon	Perennial	Scrophulariaceae
		Phacelia linearis	threadleaf phacelia	Annual	Hydrophyllaceae
		Phlox hoodii	spiny phlox	Perennial	Polemoniaceae
		Sidalcea oregana	Oregon checkerbloom	Perennial	Malvaceae

Appendix II

Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
NORTHERN BASIN AND RANGE					
Western juniper woodlands					
	Forb/herb				
		Viola purpurea	goosefoot violet	Perennial	Violaceae
	Graminoid				
		Achnatherum hymenoides	Indian ricegrass	Perennial	Poaceae
		Achnatherum occidentale	western needlegrass	Perennial	Poaceae
		Achnatherum thurberianum	Thurber's needlegrass	Perennial	Poaceae
		Bromus carinatus	California brome	Perennial	Poaceae
		Carex filifolia	threadleaf sedge	Perennial	Cyperaceae
		Elymus elymoides	squirreltail	Perennial	Poaceae
		Festuca idahoensis	Idaho fescue	Perennial	Poaceae
		Hesperostipa comata	needle and thread	Perennial	Poaceae
		Koeleria macrantha	prairie Junegrass	Perennial	Poaceae
		Leymus cinereus	basin wildrye	Perennial	Poaceae
		Poa cusickii	Cusick's bluegrass	Perennial	Poaceae
		Poa secunda	Sandberg bluegrass	Perennial	Poaceae
		Pseudoroegneria spicata	bluebunch wheatgrass	Perennial	Poaceae
	Shrub				
		Artemisia tridentata ssp wyomingensis	Wyoming big sagebrush	Perennial	Asteraceae
		Cercocarpus ledifolius	curl-leaf mountain mahogany	Perennial	Rosaceae
		Purshia tridentata	antelope bitterbrush	Perennial	Rosaceae
		Ribes cereum	wax current	Perennial	Grossulariaceae
		Salvia dorrii	purple sage	Perennial	Labiatae
WILLAMETTE VALLEY					
Oregon white oak woodlands					
	Forb/herb				
		Achillea millefolium	common yarrow	Perennial	Asteraceae
		Allium amplectens	narrowleaf onion	Perennial	Liliaceae
		Aquilegia formosa	western columbine	Perennial	Ranunculaceae
		Camassia leichtlinii ssp. suksdorfii	Suksdorf's large camas	Perennial	Liliaceae
		Camassia quamash ssp. maxima	small camas	Perennial	Liliaceae
		Collomia grandiflora	grand collomia	Annual	Polemoniaceae
		Eriophyllum lanatum	Oregon sunshine	Perennial	Asteraceae
		Fragaria vesca	woodland strawberry	Perennial	Rosaceae
		Fragaria virginiana	Virginia strawberry	Perennial	Rosaceae

Appendix II

Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
WILLAMETTE VALLEY					
Oregon white oak woodlands					
	Forb/herb				
		Geranium oreganum	Oregon geranium	Perennial	Geraniaceae
		Geum macrophyllum var. macrophyllum	largeleaf avens	Perennial	Rosaceae
		Potentilla gracilis var. gracilis	graceful cinquefoil	Perennial	Rosaceae
		Prunella vulgaris ssp. lanceolata	lance selfheal	Perennial	Lamiaceae
		Ranunculus occidentalis var. occidentalis	western buttercup	Perennial	Ranunculaceae
		Sidalcea malviflora ssp. virgata	dwarf checkerbloom	Perennial	Malvaceae
	Graminoid				
		Bromus sitchensis	Alaska brome	Perennial	Poaceae
		Elymus glaucus	blue wildrye	Perennial	Poaceae
		Festuca occidentalis	western fescue	Perennial	Poaceae
		Festuca roemeri	Roemer's fescue	Perennial	Poaceae
Upland prairies and savannas					
	Forb/herb				
		Achillea millefolium	common yarrow	Perennial	Asteraceae
		Allium amplectens	narrowleaf onion	Perennial	Liliaceae
		Aquilegia formosa	western columbine	Perennial	Ranunculaceae
		Asclepias speciosa	showy milkweed	Perennial	Asclepiadaceae
		Aster hallii	Hall's aster	Perennial	Asteraceae
		Camassia leichtlinii ssp. suksdorfii	Suksdorf's large camas	Perennial	Liliaceae
		Clarkia amoena	farewell to spring	Annual	Onagraceae
		Collomia grandiflora	grand collomia	Annual	Polemoniaceae
		Eriophyllum lanatum	Oregon sunshine	Perennial	Asteraceae
		Fragaria vesca	woodland strawberry	Perennial	Rosaceae
		Fragaria virginiana	Virginia strawberry	Perennial	Rosaceae
		Geranium oreganum	Oregon geranium	Perennial	Geraniaceae
		Gilia capitata	bluehead gilia	Annual, Perennial	Polemoniaceae
		Lupinus rivularis	riverbank lupine	Perennial	Fabaceae
		Potentilla gracilis	slender cinquefoil	Perennial	Rosaceae
		Prunella vulgaris ssp. lanceolata	lance selfheal	Perennial	Lamiaceae
		Ranunculus occidentalis	western buttercup	Perennial	Ranunculaceae

Appendix II

Schoolyard Species List

COMMUNITY NAME	GROWTH HABIT	SCIENTIFIC NAME	COMMON NAME	DURATION	FAMILY
WILLAMETTE VALLEY					
Upland prairies and savannas					
	Forb/herb				
		Sidalcea campestris	meadow checkerbloom	Perennial	Malvaceae
		Sidalcea malviflora ssp. virgata	dwarf checkerbloom	Perennial	Malvaceae
	Graminoid				
		Bromus carinatus	California brome	Perennial	Poaceae
		Bromus sitchensis	Alaska brome	Perennial	Poaceae
		Danthonia californica	California oatgrass	Perennial	Poaceae
		Elymus glaucus	blue wildrye	Perennial	Poaceae
		Festuca roemeri	Roemer's fescue	Perennial	Poaceae
Wet prairies					
	Forb/herb				
		Achillea millefolium	common yarrow	Perennial	Asteraceae
		Allium amplectens	narrowleaf onion	Perennial	Liliaceae
		Asclepias speciosa	showy milkweed	Perennial	Asclepiadaceae
		Aster hallii	Hall's aster	Perennial	Asteraceae
		Camassia leichtlinii	large camas	Perennial	Liliaceae
		Camassia quamash	small camas	Perennial	Liliaceae
		Clarkia amoena	farewell to spring	Annual	Onagraceae
		Eriophyllum lanatum	Oregon sunshine	Perennial	Asteraceae
		Fragaria virginiana ssp. platypetala	Virginia strawberry	Perennial	Rosaceae
		Geranium oreganum	Oregon geranium	Perennial	Geraniaceae
		Grindelia integrifolia	Puget Sound gumweed	Perennial	Asteraceae
		Lotus unifoliolatus var. unifoliolatus	American bird's-foot trefoil	Annual	Fabaceae
		Lupinus polyphyllus	bigleaf lupine	Perennial	Fabaceae
		Lupinus rivularis	riverbank lupine	Perennial	Fabaceae
		Potentilla gracilis	slender cinquefoil	Perennial	Rosaceae
		Prunella vulgaris ssp. lanceolata	lance selfheal	Perennial	Lamiaceae
		Ranunculus occidentalis	western buttercup	Perennial	Ranunculaceae
		Ranunculus orthorhynchus	straightbeak buttercup	Perennial	Ranunculaceae
		Sidalcea campestris	meadow checkerbloom	Perennial	Malvaceae
	Graminoid				
		Agrostis exarata	spike bentgrass	Perennial	Poaceae
		Danthonia californica	California oatgrass	Perennial	Poaceae
		Deschampsia caespitosa	tufted hairgrass	Perennial	Poaceae
		Hordeum brachyantherum	meadow barley	Perennial	Poaceae

Appendix III

Oregon Ethnobotany Plants and Their Uses

This list is organized by American Indian Cultural Divisions (rather than Ecoregion).

Scientific names are provided where available. In many cases a plant used by a tribe is known by a common name, and is not necessarily the same species as a plant used elsewhere, though known by the same common name. For example, there is more than one species of camas (*Camassia quamash* and *Camassia leichtlinii*) found in Oregon.

COASTAL – Coos, Tillamook:

Food plants:

- berries—black, black-cap, blue, currant , elder, huckle, salal, salmon, straw, thimble
- camas
- crabapple
- other edible roots—bracken fern, cattail, chocolate lily, Pacific silverweed, shore lupine, springbrook clover, wapato
- skunk cabbage—a famine food

Common fiber plants used for cordage and basketry:

- bear grass—white designs
- cattail
- hazel shoots
- maidenhair fern—black designs
- purple-tinged grasses—for designs
- red cedar
- reeds
- rushes
- sea grass
- spruce root
- tule (*Scirpus lacustris*)—a sedge
- willow

Common dye plants or sources:

- mud—browns
- Oregon grape roots/inner bark—yellow
- red alder—orange-red from inner bark
- wolf moss *(Letharia vulpina)*—yellow

INTERIOR VALLEYS:

Food plants – Rogue Valley:

- berries—black, elder, goose, Manzanita, service, thimble, three-leaf sumac
- black and white acorns
- camas
- chokecherries
- grass seeds
- hazelnuts
- ipos
- miner's lettuce
- ponderosa pinenuts
- tarweed seed
- wild celery
- wild parsley
- wild sunflower seed

Food plants—Willamette Valley: Grand Ronde, Kalapuya:

- acorns
- berries
- camas
- chittam bark (cascara tree)
- chokecherry
- cow parsnip
- hazelnuts
- ipos (Perideridia organa)
- Sego lily *(Calochortus)*
- tarweed seed
- wapato

Common fiber plants used for cordage and basketry:

- bear grass white designs
- cattail
- grasses
- hazel shoots
- juncus
- maidenhair fern—black designs
- nettle fiber
- slough sedge
- spruce roots
- tule *(Scirpus lacustris)*—a sedge
- willow

Common dye plants:

- willow charcoal—black for tattoos

GREAT BASIN:

Food plants – Klamath:

- camas
- huckleberry
- ipos *(Perideridia organa)*
- pond lily—wokas seed *(Nuphar polysepala)*
- Jeffrey (yellow) pine cambium—famine food

Appendix III

Oregon Ethnobotany Plants and Their Uses

Food plants – Burns Paiute:

- biscuitroot *(Lomatium* spp.*)*
- bitterroot *(Lewisa rediviva)*
- buckberry
- camas—lowland meadows
- chokecherry
- huckleberry
- Indian potato *(Tsuga)*
- Indian ricegrass *(Oryzopsis hymenoides)*
- pigweed seeds
- piñon pine nuts—some Great Basin Paiute groups
- saltbrush seeds
- wada seeds *(Suaeda calceoliformis)*

Common fiber plants used for cordage and basketry:

- bear grass white designs
- bracken fern root
- cattail
- hazel
- Jeffrey (yellow) pine
- juniper bark
- maidenhair fern—black designs
- redbud *(Cercis occidentalis)*
- sagebrush
- spruce root
- tule *(Scirpus lacustris)*—a sedge
- willow

Common dye plants:

- alder—orange from inner bark
- chokecherry juice—green from inner bark, red/purple from fruit

Other fiber plants:

- piñon pine *(Pinus edulis)* resin—for waterproofing baskets

COLUMBIA PLATEAU:

Food plants – Umatilla, Warm Springs:

- biscuitroot *(Lomatium cous)*
- bitterroot *(Lewisa rediviva)*
- black moss *(Alectoria species)* a lichen used as famine food
- camas
- Canby's desert parsley *(Lomatium canbyi)*
- chokecherry *(Prunus demissa)*
- field mint *(Mentha arvensis)*
- huckleberry
- Indian ("wild") celery *(Lomatium nudicaule)*
- Indian carrot or false caraway *(Perideridia gairdneri)*
- kowsh *(Lomatium* sp.*)*

Common fiber plants used for cordage and basketry:

- bear grass—white designs
- bitter cherry bark
- cedar bark and root (from gathering trips)
- corn husk
- Indian hemp (common dogbane—*Apocynum cannabinum*)
- tule *(Scirpus lacustris)*—a sedge
- willow

Common dye plants or sources:

- mud—black/brown dye
- Oregon grape—yellow

SOURCES:

Cultural resources information on the websites of Oregon federally-recognized tribes; see Appendix VI: Tribe Contacts.

The First Oregonians, 2nd Edition. Laura Berg, Editor. 2007. Oregon Council for the Humanities, Portland, Oregon.

Siletz: Survival For an Artifact. Leone Letson Kasner. 1980. Itemizer-Observer, Dallas, Oregon.

Websites listed in Appendix IV: Ethnobotany Plant Lists and Resources

Primitive Ways website: http://primitiveways.com/

Appendix IV

Ethnobotany Plants Lists and Resources

This list is organized by American Indian Cultural Divisions of Oregon (rather than by ecoregions).

Common Name	Scientific Name	Edible Plant Part	Website
COASTAL—COOS, TILLAMOOK			
blackberry	*Rubus ursinus*	berry	http://www.fs.fed.us/database/feis/plants/shrub/ruburs/introductory.html
black-cap raspberry	*Rubus leucodermis*	berry	
blueberry	*Vaccinium ovalifolium*	berry	
bracken fern	*Pteridium aquilinum*	rhizomes	http://www.fs.fed.us/database/feis/plants/fern/pteaqu/all.html
cattail	*Typha latifolia*	root?	http://plants.usda.gov/plantguide/pdf/cs_tyla.pdf
chocolate lily	*Fritillaria lanceolata*	bulbs	
common camas	*Camassia quamash*	bulb	http://plants.usda.gov/plantguide/pdf/cs_caquq.pdf and http://www.plant-materials.nrcs.usda.gov/pubs/orpmctn250300.pdf
crabapple	*Malus fusca*	fruit	
currant	*Ribes sanguineum*	berry	http://www.plant-materials.nrcs.usda.gov/pubs/orpmcfs8194.pdf
elderberry	*Sambucus racemosa ssp. pubens*	berry	http://plants.usda.gov/factsheet/pdf/fs_sara2.pdf and http://www.plant-materials.nrcs.usda.gov/pubs/orpmcfs7536.pdf
huckleberry	*Vaccinium parvifolium*	berry	http://plants.usda.gov/plantguide/pdf/cs_vapa.pdf
Pacific silverweed	*Potentilla anserina ssp. pacifica*	roots	
salal	*Gaultheria shallon*	berry	
salmonberry	*Rubus spectabilis*	berry	http://plants.usda.gov/plantguide/pdf/cs_rusp.pdf
shore lupine	*Lupinus littoralis*	roots	
skunk cabbage	*Lysichiton americanum*	famine food	
springbank clover	*Trifolium wormskioldii*	rhizomes (harvested in fall)	http://plants.usda.gov/plantguide/pdf/cs_trwo.pdf
strawberry	*Fragaria chiloensis*	berry	http://plants.usda.gov/plantguide/pdf/cs_frch.pdf
thimbleberry	*Rubus parviflorus*	berry	http://www.fs.fed.us/database/feis/plants/shrub/rubpar/introductory.html
wapato	*Sagittaria latifolia*	tubers and rhizomes	http://plants.usda.gov/plantguide/pdf/cs_sala2.pdf
INTERIOR—ROGUE VALLEY			
beaked hazelnut	*Corylus cornuta*	nut	http://plants.usda.gov/plantguide/pdf/pg_coco6.pdf
black oak	*Quercus kelloggii*	nut	http://plants.usda.gov/plantguide/pdf/cs_quke.pdf
blackberry	*Rubus ursinus*	berry	http://www.fs.fed.us/database/feis/plants/shrub/ruburs/introductory.html
camas	*Camassia quamash*	bulb	http://plants.usda.gov/plantguide/pdf/cs_caquq.pdf and http://www.plant-materials.nrcs.usda.gov/pubs/orpmctn250300.pdf

Appendix IV

Ethnobotany Plants Lists and Resources

Common Name	Scientific Name	Edible Plant Part	Website
INTERIOR—ROGUE VALLEY			
chokecherry	*Prunus virginiana*	berry	http://plants.usda.gov/plantguide/pdf/cs_prvi.pdf
elderberry	*Sambucus* spp.	berry	http://plants.usda.gov/factsheet/pdf/fs_sara2.pdf and http://www.plant-materials.nrcs.usda.gov/pubs/orpmcfs7536.pdf
gooseberry	*Ribes oxyacanthoides*	berry	http://www.fs.fed.us/database/feis/plants/shrub/riboxy/all.html
ipos (Oregon yampah)	*Perideridia oregana*		http://www1.dnr.wa.gov/nhp/refdesk/fguide/pdf/perore.pdf
manzanita	*Arctostaphylos* spp.	berry	http://plants.usda.gov/plantguide/pdf/pg_arco3.pdf
miner's lettuce	*Claytonia perfoliata*		
Oregon white oak	*Quercus garryana*	nut	http://plants.usda.gov/plantguide/pdf/pg_quga4.pdf
ponderosa pine	*Pinus ponderosa*	nut	http://plants.usda.gov/plantguide/pdf/pg_pipo.pdf
serviceberry	*Amelanchier* spp.	berry	http://www.plant-materials.nrcs.usda.gov/pubs/orpmrtn280401.pdf
tarweed	*Madia elegans*	seed	http://plants.usda.gov/plantguide/pdf/cs_mael.pdf
thimbleberry	*Rubus parviflorus*	berry	http://www.fs.fed.us/database/feis/plants/shrub/rubpar/introductory.html
three-leaf sumac	*Rhus trilobata*	berry	http://plants.usda.gov/plantguide/pdf/cs_rhtr.pdf
wild celery	*Apium graveolens*		
wild sunflower	*Helianthus annuus*	seed	http://plants.usda.gov/plantguide/pdf/cs_hean3.pdf
manzanita	*Arctostaphylos* spp.	berry	http://plants.usda.gov/plantguide/pdf/pg_arne.pdf
manzanita	*Arctostaphylos* spp.	berry	http://plants.usda.gov/plantguide/pdf/pg_arpa6.pdf
INTERIOR—GRANDE RONDE (KALAPUYA)			
acorns	*Quercus garryana*	nut	http://plants.usda.gov/plantguide/pdf/pg_quga4.pdf
beaked hazelnut	*Corylus cornuta*	nut	http://plants.usda.gov/plantguide/pdf/pg_pipo.pdf
camas	*Camassia quamash*	bulb	http://plants.usda.gov/plantguide/pdf/cs_caquq.pdf and http://www.plant-materials.nrcs.usda.gov/pubs/orpmctn250300.pdf
cascara	*Rhamnus purshiana*	Chittam bark	
chokecherry	*Prunus virginiana*	berry	http://plants.usda.gov/plantguide/pdf/cs_prvi.pdf
cow parsnip	*Heracleum maximum*	young shoots	http://www.wsdot.wa.gov/Environment/CulRes/herbs.htm#Heracleum
ipos	*Perideridia oregana*		http://www1.dnr.wa.gov/nhp/refdesk/fguide/pdf/perore.pdf
sego lily	*Calochortus nuttallii*	bulbs	
tarweed	*Madia elegans*	seed	http://plants.usda.gov/plantguide/pdf/cs_mael.pdf
wapato	*Sagittaria latifolia*	tubers and rhizomes	http://plants.usda.gov/plantguide/pdf/cs_sala2.pdf
camas	*Camassia quamash*	bulb	http://plants.usda.gov/plantguide/pdf/cs_caquq.pdf and http://www.plant-materials.nrcs.usda.gov/pubs/orpmctn250300.pdf
huckleberry	*Vaccinium parvifolium*	berry	http://plants.usda.gov/plantguide/pdf/cs_vapa.pdf
ipos	*Perideridia oregana*		http://www1.dnr.wa.gov/nhp/refdesk/fguide/pdf/perore.pdf

Appendix IV

Ethnobotany Plants Lists and Resources

Common Name	Scientific Name	Edible Plant Part	Website
GREAT BASIN—KLAMATH			
Jeffrey (yellow) pine	*Pinus jeffreyi*	cambium	http://plants.usda.gov/plantguide/pdf/pg_pije.pdf
pond lily (wokas)	*Nuphar polysepala*	seed	http://plants.usda.gov/plantguide/pdf/pg_nulu.pdf
GREAT BASIN—BURNS (PAIUTE)			
biscuitroot	*Lomatium*		
bitterroot	*Lewisia rediviva*		http://plants.usda.gov/plantguide/pdf/cs_lere7.pdf
camas	*Camassia quamash*	bulb	http://plants.usda.gov/plantguide/pdf/cs_caquq.pdf and http://www.plant-materials.nrcs.usda.gov/pubs/orpmctn250300.pdf
cascara	*Rhamnus purshiana*		
chokecherry	*Prunus virginiana*	berry	http://plants.usda.gov/plantguide/pdf/cs_prvi.pdf
fourwing saltbush	*Atriplex canescens*	seeds	http://plants.usda.gov/plantguide/pdf/pg_atca2.pdf
huckleberry	*Vaccinium parvifolium*	berry	http://plants.usda.gov/plantguide/pdf/cs_vapa.pdf
Indian ricegrass	*Oryzopsis hymenoides*		http://plants.usda.gov/plantguide/pdf/pg_achy.pdf
pigweed		seeds	
pinon pine	*Pinus monophylla*	nuts	http://plants.usda.gov/plantguide/pdf/cs_pimo.pdf
wada	*Suaeda calceoliformis*	seeds	
wapato	*Sagittaria latifolia*	tubers and rhizomes	http://plants.usda.gov/factsheet/pdf/fs_sala2.pdf
PLATEAU—UMATILLA, WARM SPRINGS			
biscuitroot (kowsh)	*Lomatium cous*		
bitterroot	*Lewisa rediviva*		http://plants.usda.gov/plantguide/pdf/cs_lere7.pdf
black moss	*Alectoria (lichen)*		
camas	*Camassia quamash*	bulb	http://plants.usda.gov/plantguide/pdf/cs_caquq.pdf and http://www.plant-materials.nrcs.usda.gov/pubs/orpmctn250300.pdf
Canby's desert parsely	*Lomatium canbyi*		http://www.wsdot.wa.gov/Environment/CulRes/herbs.htm#LomatiumCanbyi
choke cherry	*Prunus virginiana*		http://plants.usda.gov/plantguide/pdf/cs_prvi.pdf
field mint	*Mentha arvensis*		
huckleberry	*Vaccinium parvifolium*	berry	http://plants.usda.gov/plantguide/pdf/cs_vapa.pdf
Indian carrot	*Perideridia gairdneri*		
wild celery	*Lomatium nudicaule*		

Appendix IV

Ethnobotany Plants Lists and Resources

MAIN SOURCES:

Fact Sheets and Plant Guides, USDA Natural Resources Conservation Service: plants.usda.gov/java/factSheet and www.plant-materials.nrcs.usda.gov

Fire Effects Information System, USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory: www.fs.fed.us/database/feis/index

FIBER USES

Common Name	Scientific Name	Utilized Plant Part/ Dye Color	Website	Source
Coastal				
Fiber				
Western red cedar	*Thuja plicata*	inner bark	http://plants.usda.gov/plantguide/pdf/cs_thpl.pdf	USDA NRCS. Nesom, Guy. *Plant Guide: Western Redcedar (Thuja plicata)*. NRCS, Aug. 2006. Web. 16 April 2010.
bear-grass	*Xerophyllum tenax*	leaves	http://www.fs.fed.us/database/feis/plants/forb/xerten/all.html	Crane, M. F. 1990. Xerophyllum tenax. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2010, May 4].
maidenhair fern	*Adiantum aleuticum*	black stem		
tule	*Scirpus lacustris*	leaves		
spruce	*Picea* spp.	root		
beaked hazelnut	*Corylus cornuta*	shoots	http://plants.usda.gov/plantguide/pdf/pg_coco6.pdf	USDA NRCS. Nesom, Guy. *Plant Guide: Beaked Hazelnut (Corylus cornuta)*. NRCS, June 2006. Web. 15 April 2010.
willow	*Salix* spp.	shoots & bark		
cattail	*Typha latifolia*	leaves	http://plants.usda.gov/plantguide/pdf/cs_tyla.pdf	USDA NRCS. Stevens, Michelle, and Chris Hoag. *Plant Guide: Broad-Leaved Cattail (Typha latifolia)*. NRCS, May 2006. Web. 15 April 2010.
Dye				
red alder	*Alnus rubra*	orange-red from inner bark	http://plants.usda.gov/plantguide/pdf/cs_alru2.pdf	USDA NRCS. Favorite, Jammie, and Diana Immel. *Plant Guide: Red Alder (Alnus rubra)*. NRCS, May 2006. Web. 16 April 2010.
wolf moss	*Evernia vulpine*	yellow		
grasses		purple tinges		
mud dyes		browns		

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Ethnobotany Plants Lists and Resources

Common Name	Scientific Name	Utilized Plant Part/ Dye Color	Website	Source
Interior Valleys				
Fiber				
willow	*Salix* spp.	bark		
tule	*Scirpus lacus-tris*	leaves		
cattail	*Typha latifolia*	leaves	http://plants.usda.gov/plant-guide/pdf/cs_tyla.pdf	USDA NRCS. Stevens, Michelle, and Chris Hoag. *Plant Guide: Broad-Leaved Cattail (Typha latifolia)*. NRCS, May 2006. Web. 15 April 2010.
beaked hazel-nut	*Corylus cor-nuta*	shoots	http://plants.usda.gov/plant-guide/pdf/pg_coco6.pdf	USDA NRCS. Nesom, Guy. *Plant Guide: Beaked Hazelnut (Corylus cornuta)*. NRCS, June 2006. Web. 15 April 2010.
spruce	*Picea* spp.	roots		
beargrass	*Xerophyllum tenax*	white leaves	http://www.fs.fed.us/database/feis/plants/forb/xerten/all.html	Crane, M. F. 1990. Xerophyllum tenax. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2010, May 4].
maidenhair fern		black - stem		
slough sedge	*Carex ob-nupta*	leaves	http://plants.usda.gov/plant-guide/pdf/cs_caob3.pdf	USDA NRCS. Stevens, Michelle, and Chris Hoag. *Plant Guide: Slough Sedge (Carex obnupta)*. NRCS, May 2006. Web. 16 April 2010.
nettle	*Urtica dioica*	fiber		
grasses		leaves		
juncus	*Juncus* spp.	leaves		
Dye				
willow	*Salix* spp.	charcoal—black for tattoos		
Great Basin				
Fiber				
tule	*Scirpus lacus-tris*	leaves		
sagebrush	*Artemisia* spp.	bark		
bracken fern	*Pteridium aquilinium*	roots		
beargrass	*Xerophyllum tenax*	leaves	http://www.fs.fed.us/database/feis/plants/forb/xerten/all.html	Crane, M. F. 1990. Xerophyllum tenax. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2010, May 4].

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Ethnobotany Plants Lists and Resources

Common Name	Scientific Name	Utilized Plant Part/ Dye Color	Website	Source
Great Basin				
Fiber				
hazel	*Corylus cornuta*	shoots	http://plants.usda.gov/plantguide/pdf/pg_coco6.pdf	USDA NRCS. Nesom, Guy. *Plant Guide: Beaked Hazelnut (Corylus cornuta)*. NRCS, June 2006. Web. 15 April 2010.
Jeffrey (yellow) pine	*Pinus jeffreyi*	bark	http://plants.usda.gov/plantguide/pdf/pg_pije.pdf	USDA NRCS. Moore, Lincoln, and Walker Wilson, Jeffrey. *Plant Guide: Jeffrey Pine (Pinus jeffreyi)*. NRCS, Aug. 2006. Web. 15 April 2010.
juniper		bark		
maidenhair fern		black		
redbud	*Cercis occidentalis*	shoots & bark	http://plants.usda.gov/plantguide/pdf/cs_ceor9.pdf	USDA NRCS. Anderson, M. Kat. *Plant Guide: Western Redbud (Cercis orbiculata).* NRCS, May 2006. Web. 16 April 2010.
spruce	*Picea* spp.	roots		
willow	*Salix* spp.	shoots & bark		
Dye				
alder	*Alnus* spp.	orange from inner bark		
chokecherry		green from inner bark, red/purple from fruit	http://plants.usda.gov/plantguide/pdf/cs_prvi.pdf	USDA NRCS. Crowder, Wayne, Wayne Geyer, and Patrick Broyles. *Plant Guide: Chokecherry (Prunus virginiana)*. NRCS, July 2008. Web. 16 April 2010.
Other				
Pinon pine	*Pinus monophylla*	resin for waterproofing baskets	http://plants.usda.gov/plantguide/pdf/cs_pimo.pdf	USDA NRCS. Anderson, M. Kat, and Roberts, Warren. *Plant Guide: Singleleaf Pinyon (Pinus monophylla)*. NRCS, Aug. 2006. Web. 16 April 2010.
Columbia Plateau				
Fiber				
tule	*Scirpus lacustris*	leaves		
Indian hemp (common dogbane)	*Apocynum cannabinum*	stem fiber	http://plants.usda.gov/plantguide/pdf/cs_apca.pdf	USDA NRCS. Stevens, Michelle. *Plant Guide: Indian Hemp (Apocynum cannabinum)*. NRCS, May 2006. Web. 16 April 2010.
bitter cherry	*Prunus emarginata*	bark	http://plants.usda.gov/plantguide/pdf/cs_prem.pdf	USDA NRCS. Favorite, Jammie. *Plant Guide: Bitter Cherry (Prunus emarginata)*. NRCS, Aug. 2006. Web. 16 April 2010.
Western red cedar	*Thuja plicata*	bark and roots	http://plants.usda.gov/plantguide/pdf/cs_thpl.pdf	USDA NRCS. Nesom, Guy. *Plant Guide: Western Redcedar (Thuja plicata)*. NRCS, Aug. 2006. Web. 16 April 2010.
corn		husks		
willow	*Salix spp.*	shoots & bark		

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Ethnobotany Plants Lists and Resources

Common Name	Scientific Name	Utilized Plant Part/ Dye Color	Website	Source
Columbia Plateau				
Fiber				
Dye				
Oregon grape	*Mahonia nervosa*	yellow	http://www.fs.fed.us/database/feis/plants/shrub/berner/all.html# INTRODUCTORY	Tirmenstein, D. A. 1990. Berberis nervosa. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2010, May 4].
mud		black/ brown		

Appendix V

American Indian Ethnobotanical Resource Materials

WEBSITES	Grades	Website
CURRICULUM		
Alaska Native Knowledge Network (for educators)—curriculum, ethnobotany resources, game	all	http://www.ankn.uaf.edu/index.html
Project Willow—Nevada Great Basin curriculum with plant-based lesson	K to 5	http://www.unr.edu/nnap/index.htm
Wisdom of the Elders—curriculum lessons and audio programs	K to 12	http://www.wisdomoftheelders.org/curriculum/index.html
Plant ethnobotany lesson—learning about & making a plant collection	3 to 5	http://www.proteacher.com/cgi-bin/outsidesite.cgi?id=8353&external=http://www.halcyon.com/marcs/na-theme.html&original=http://www.proteacher.com/090077.shtml&title=Native%20American%20Theme%20Unit
Oregon tribes based on language groups—map and information pages	4	http://www.chenowith.k12.or.us/tech/subject/social/natam_or.html
Educator resources—Tamástslikt Cultural Institute, Pendleton, Oregon	4 to 7	http://www.tamastslikt.org/teachers.cfm
Ethnobotany Curriculum (71 pages)—Evergreen, Canada education site	4 to 7	http://www.evergreen.ca/docs/res/Patterns-Relationships-Ethno-botany.pdf
Lewis & Clark curriculum/plants lessons—Nez Perce—camas	6 to 12	http://www.lewisandclarkexhibit.org/4_0_0/page_4_1_3_2_0.html
Ethnobotany lesson—researched-based guided questions	MS	http://www.agriculture.purdue.edu/fnr/stoutwoods/edu_act/Intro-duction%20to%20Ethnobotany.pdf
Indians in Oregon Today curriculum—seasonal pattern lesson	MS/HS	http://www.ode.state.or.us/opportunities/grants/nclb/title_vii/indi-ansinoregontoday.pdf
Ethnobotanicals lesson	HS	http://www.accessexcellence.org/AE/ATG/data/released/0179-JohnNorton/description.html
Native plant medicinal use—one research-based lesson	HS	http://schoolgardens.unl.edu/EthnobotanyFeurer.pdf
RESOURCES		
Kalapuya, pyroculture, and the Willamette Valley—background information		http://www.oregon-archaeology.com/theory/pyroculture/
Oregon museums with Native American collections		http://native-american-history.suite101.com/article.cfm/oregon_museums_of_native_culture - list of Oregon Museums that have Native American artifacts
Native Americans of the Willamette Valley—information & maps of tribes and bands		http://www.usgennet.org/usa/or/county/clackamas/indiobiblio.html
Tillamook Indians and extensive information about plant uses—paper		http://www.vetmed.wsu.edu/org_NWS/NWSci%20journal%20ar-ticles/2002%20files/Issue%204/v76%20p304%20Zobel.pdf
Native Americans of the Pacific Northwest—information links		http://www.archaeolink.com/indian_tribes_of_the_pacific_nor.htm#Cow
Nez Perce education guide, including maps for entire Northwest	K to 5	http://www.nps.gov/nepe/forteachers/curriculummaterials.htm
Nez Perce Museum—lesson, photos of baskets, clothing etc., seasonal round		http://www.nps.gov/history/museum/exhibits/nepe/index.html
Oregon History Projec— coastal Indians—Indian plant names list		http://www.ohs.org/education/oregonhistory/narratives/subtopic.cfm?subtopic_ID=511

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American Indian Ethnobotanical Resource Materials

WEBSITES	Grades	Website
American Indians of the Pacific Northwest, The Library of Congress American Memory, Digital archives		http://memory.loc.gov/ammem/collections/pacific/subjectK.html
PrimitiveWays Skills—making cordage		http://www.primitiveways.com/cordage.html
PrimitiveWays Skills—basket weaving techniques		http://www.primitiveways.com/basketry2.html
Nez Perce National Historic Trail, USDA Forest Service		http://www.fs.fed.us/npnht/life/
Lewis & Clark—tribes along route, traditional culture, maps		http://www.trailtribes.org/
Cayuse people—traditional culture information		http://www.cr.nps.gov/history/online_books/hh/37/hh37i.htm
MEDICINAL USE OF PLANTS		
Power of Potions, OPB—lab—leaf chromatography, African tribal medicine	MS/HS	http://www.pbs.org/wnet/secrets/previous_seasons/lessons/lp_zulu.html
Searching for Nature's Medicines—many lesson and resource links	MS/HS	http://www.actionbioscience.org/biodiversity/plotkin.html#educator
North America Ethnobotany—research uses by plant name/uses		http://herb.umd.umich.edu/
Projects, and one lab based on medicinal uses of rainforest plants	HS	http://www.actionbioscience.org/biodiversity/lessons/plotkinles-sons.pdf
Researching herbal meds and interactions with conventional meds	HS/col-lege	http://www.redorbit.com/news/health/262291/natures_pharmacy_do_you_have_a_green_tongue/
About.com: Drugs from Plants—a resource of plants and chemical properties		http://chemistry.about.com/library/weekly/aa061403a.htm
Alternative Nature Online Herbal—index of me-dicinal herbs		http://www.altnature.com/gallery/
Cottonwood properties and salve instructions, part 1		http://www.wildernesscollege.com/Alderleaf_eNewsletter-cotton-wood-salve-part-one.html
Cottonwood properties and salve instructions, part 2		http://www.wildernesscollege.com/Alderleaf_eNewsletter-cotton-wood-salve-part-two.html
Cottonwood resin—medicinal properties		http://www.goodnaturedearthling.com/cottonwood_resin.htm
Dr. Duke's Phytochemical and Ethnobotanical Databases		http://www.ars-grin.gov/duke/
Lewis & Clark Bicentennial Exhibit—cultural aspect of plants		http://www.lewisandclarkexhibit.org/4_0_0/page_4_1_0_0.html
Major Types of Chemical Compounds in Plants and Animals—college course notes		http://waynesword.palomar.edu/chemid1.htm
Making herbal salve—use as reference for making cottonwood bud salve		http://ridleyfamily.org/cora/herbalcrafting/salve/
Origins of Plant Derived Medicines—background information paper		http://www.siu.edu/~ebl/leaflets/maridass.htm
Wildcrafting guide with ethical gathering guidelines and lists of plants		http://7song.com/files/Wildcrafting%20for%20the%20Practic-ing%20Herbalist.pdf

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American Indian Ethnobotanical Resource Materials

BOOKS
Reference
American Indian Basketry: Traditional Arts of the Indians of Western Oregon. John M Gogol, Editor. 1984. American Indian Basketry magazine Volume 4, No. 2, Whole Issue No. 14
Baskets from Nature's Bounty. Elizabeth Jensen. 1991. Interweave Press, Loveland, Colorado. (information on techniques, plants, when to collect, how to prepare)
Columbia River Basketry: Gifts of the Ancestors, Gift of the Earth. Mary Dodds Schlick. 1994. Washington Univ. Press, Seattle.
First Oregonians, The, 2nd Edition. Laura Berg, editor. 2007. Oregon Council for the Humanities, Portland, Oregon.
Indian Basketmakers of California and the Great Basin. Larry Dalrymple. 2000. Museum of New Mexico Press, Santa Fe, New Mexico
Native American Ethnobotany. Daniel E. Moerman. 1998. Tinber Press, Portland, Oregon.
Natural History of Medicinal Plants, The. Judith Sumner. 2000. Timber Press, Portland, Oregon.
Sandal and the Cave, The: The Indians of Oregon. Luther S. Cressman. 1981. Northwest Reprints, Oregon State Univ. Press, Corvallis, Oregon.
Siletz, Survival for an Artifact. Leone Letson Kasner. 1980. Itemizer-Observer, Dallas, Oregon.
Tending the Wild: Native American Knowledge and the Management of California's Natural Resources. M. Kat Anderson. 2005. Univ. of California Press, Berkeley or Los Angeles, California.
The Kalapuyans: a Sourcebook on the Indians of the Willamette Valley, Second Edition. Harold Mackey. 2004. Mission Mill Museum Association, Inc., Salem, Oregon

Appendix VI

Oregon Tribe Contacts

Note: Check websites below for specific "Cultural Resources" or "Cultural and Heritage" Information. Contact to find out the availability of classroom speakers.

Burns Paiute Tribe
www.burnspaiute-nsn.gov
Burns, OR

Clatsop-Nehalem Confederated Tribes
www.clatsop-nehalem.com
Seaside Oregon

Confederated Tribes of Coos, Lower Umpqua & Siuslaw Indians
www.ctclusi.org/CTCLUSINEW
Coos Bay OR

Confederated Tribes of Grand Ronde
www.grandronde.org
Grand Ronde, OR

Confederated Tribes of Siletz Indians
ctsi.nsn.us
Siletz, OR

Confederated Tribes of the Umatilla Indian Reservation (Cayuse, Umatilla and Walla Walla Tribes)
www.umatilla.nsn.us
Pendleton, OR

Confederated Tribes of the Warm Springs Reservation (Warm Springs, Wasco & Paiute)
www.warmsprings.com
Warm Springs, OR

Coquille Indian Tribe
www.coquilletribe.org/
North Bend, OR

Cow Creek Band of Umpqua Tribe of Indians
www.cowcreek.com
Roseburg, OR

Klamath Tribes (Klamath, Modoc & Yahooskin)
www.klamathtribes.org/
Chiloquin, OR

The Nez Perce Tribe
www.nezperce.org/content/index.html
Lapwai, ID

Appendix VII

Contacts for Service-learning Partners and Field Sites

Listed by Oregon ecoregion

Contact government agencies, watershed districts, soil and water conservation districts, land trusts, and environmental organizations to partner on service-learning or restoration projects. Contact government agencies that manage lands (e.g., BLM, USFW) and education organizations for help with planning and supplying expert guides or educational programs for field site trips. This list is only a beginning, be sure to contact city and county parks and natural area departments also.

Note: We have tried to supply website addresses where possible, run a web search to find links not included.

STATE-WIDE

Governmental Agencies

BLM

Statewide BLM Environmental Education Programs
http://www.blm.gov/or/education/index.php

BLM Heritage Education

http://www.blm.gov/wo/st/en/res/Education_in_BLM/Learning_Landscapes/For_Teachers/Heritage_Education.html

USFWS

Oregon National Wildlife Refuges
http://www.fws.gov/refuges/refugeLocatorMaps/Oregon.html

ODFW

Headquarters
3406 Cherry Ave NE, Salem, OR 97303
(503) 947-6000 • (800) 720-6339
Local offices: www.dfw.state.or.us/agency/directory/local_offices.asp

Oregon State Parks

http://www.oregon.gov/OPRD/PARKS/index.shtml
http://www.oregonstateparks.org/searchpark.php

Environmental Organizations and Education Sites

Hands on the Land

http://www.handsontheland.org

The Nature Conservancy – Main Office

821 S.E. 14th Avenue, Portland, Oregon 97214
(503) 802-8100

The Nature Conservancy Oregon Preserves

http://www.nature.org/wherewework/northamerica/states/oregon/preserves/

Oregon Land Trusts

http://www.opb.org/programs/oregonstory/land_trusts/resources/page_2.html

BLUE MOUNTAINS

Governmental Agencies

BLM

Prineville
3050 NE 3rd St., Prineville, OR 97754
(541) 416-6700

Baker
3285 11th St., PO Box 947, Baker City, OR 97814
(541) 523-1256

Oregon Trail Interpretive Center

http://www.blm.gov/or/oregontrail/

USDA Natural Resources Conservation Service

Baker City Service Center

3990 Midway Dr., Baker City, OR 97814
(541) 523-7121

John Day Service Center

721 S Canyon Blvd., John Day, OR 97845
(541) 575-1274

La Grande Service Center

1901 Adams Ave. Suite 5, La Grande, OR 97850
(541) 963-4178

Enterprise Service Center

88401 Hwy 82, Enterprise, OR 97828
(541) 426-4521

Warm Springs Service Center

2416 Warm Springs St., Warm Springs, OR 97761
(541) 553-2009

Redmond Service Center

625 SE Salmon Ave. Bldg. A, Redmond, OR 97756
(541) 923-4358

USFWS

La Grande Field Office

3502 Hwy 30, La Grande, OR 97850
(541) 962-8584

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Contacts for Service-learning Partners and Field Sites

US Forest Service

Malheur National Forest
431 Patterson Bridge Rd., PO Box 909, John Day, OR 97845
(541) 575-3000

Ochoco National Forest
3160 NE 3rd St., Prineville, OR 97754
(541) 416-6500

Wallowa-Whitman National Forest
1550 Dewey Ave, PO Box 907, Baker City, OR 97814
(541) 523-6391

OSU Extension Service

Baker County ES
2610 Grove St., Baker City, OR 97814
(541) 523-6418

Wallowa County ES
668 NW 1st, Enterprise, OR 97828
(541) 426-3143

Union County ES
10507 McAlister Rd. Rm. 9, LaGrande, OR 97850
(541) 963-1010

Grant County ES
201 S Humboldt Suite 190, Canyon City, OR 97820
(541) 575- 1911

Wheeler County ES
PO Box 407, Fossil, OR 97830
(541) 763-4115

Crook County ES
498 SE Lynn Blvd., Prineville, OR 97754
(541) 447-6228

Jefferson County ES
34 SE D St., Madras, OR 97741
(541) 475-3808

Warm Springs ES
1110 Wasco St., PO Box 430, Warm Springs, OR 97761
(541) 553-3238

Deschutes County ES
3893 SW Airport Way, Redmond, OR 97756
(541) 548-8697

Wasco County ES
400 E Scenic Dr. Suite 2.278, The Dalles, OR 97058
(541) 296-5494

Soil and Water Conservation Districts

Baker Valley SWCD
3990 Midway Dr., Baker City, OR 97814
(541) 523-7121 x100

Burnt River SWCD
3990 Midway Dr., Baker City, OR 97814
(541) 523-7121 x100

Deschutes SWCD
625 SE Salmon Ave. Suite 7, Redmond, OR 97756
(541) 923-2204

Eagle Valley SWCD
3990 Midway Dr., Baker City, OR 97814
(541) 523-7121 x100

Keating SWCD
3990 Midway Dr, Baker City, OR 97810
(541) 523-7121 x100

Monument SWCD
311 Wilson St., PO Box 95, Monument, OR 97864
(541) 934-2141

Wallowa SWCD
88401 Hwy 82, Box B, Enterprise, OR 97828
(541) 426-4588 x4

Wheeler SWCD
38289 Hwy. 19-207, PO Box 431, Fossil, OR 97830
(541) 468-2990

Crook County SWCD
498 SE Lynn Blvd., Prineville, OR 97754
(541) 447-3548

Deschutes SWCD
625 SE Salmon Ave. Suite 7, Redmond, OR 97756
(541) 923-2204

Grant SWCD
721 S Canyon Blvd., John Day, OR 97845
(541) 575-0135 x3

Jefferson County SWCD
625 SE Salmon Ave. Suite 6, Redmond, OR 97756
(541) 923-4358 x101

Union SWCD
10507 N. McAlister Rd. Rm. 7, La Grande, OR 97850
(541) 963-0724

Appendix VII

Contacts for Service-learning Partners and Field Sites

Watershed Councils

Powder Basin WC
3990 Midway Dr., Baker City, OR 97814
(541) 523-712 x119
www.bakercounty.org/Watershed/home.html

Grande Ronde Model WC
1114 J Ave., La Grande, OR 97850
(541) 663-0570
www.grmw.org

Umatilla Basin WC
PO Box 1551, Pendleton, OR 97801
(541) 276-2190

North Fork John Day WC
PO Box 444, Long Creek, OR 97856
(541) 421-3018

Mid-John Day WC
PO Box 431, Fossil, OR 97830
(541) 468-2990

Bridge Creek WC
PO Box 431, Fossil, OR 97830
(541) 468-2990

Middle Deschutes WC
625 SE Salmon Ave., Redmond, OR 97756
(541) 937-9800 • www.deschuteswatersheds.org/tcwc/

Crooked River WC
498 SE Lynn Blvd., Prineville, OR 97754-2
(541) 447-8567 • www.deschuteswatersheds.org/crwc/

Upper Deschutes WC
PO Box 1812, Bend, OR 97709
(541) 382-6103 • www.deschuteswatersheds.org/udwc/

John Day Fossil Beds (National Park Service)
http://www.nps.gov/joda/index.htm

Environmental Organizations and Education Sites

Four Rivers Cultural Center
http://www.4rcc.com/index.html

OMSI Outdoor Science Schools
Hancock Field Station, Contact: OMSI Program Sales and Registration, Portland, OR 97214
(503) 797-4661

The Nature Conservancy, Northeast Oregon Office
P.O. Box 386, Enterprise, OR 97828-0386
Phone: (541) 426-3458

Wallowa Resources – Wallowa Mountain Institute
http://www.wallowaresources.org/wmi.php

CASCADES

Governmental Agencies

USDA Natural Resources Conservation Service

Redmond Service Center
625 SE Salmon Ave. Bldg. A, Redmond, OR 97756
(541) 923-4358

Oregon City Service Center
221 Molalla Ave., Oregon City, OR 97045
(503) 655-3144 x108

Salem Service Center
650 Hawthorne Ave SE Suite 130, Salem, OR 97301
(503) 399-5741

Tangent Service Center
33630 McFarland Rd., Tangent, OR 97389
(541) 967-5925

Eugene Service Center
780 Bailey Hill Rd., Eugene, OR 97402
(541) 465-6443

Klamath Falls Service Center
2316 S 6th St. Suite C, Klamath Falls, OR 97601
(541) 883-6924

Roseburg Service Center
2240 NW Troost #200, Roseburg, OR 97471
(541) 673-6071

Medford Service Center
573 Parsons Dr. Suite 101, Medford, OR 97501
(541) 776-4270

US Forest Service

Mount Hood National Forest
16400 Champion Way, Sandy, OR 97055
(503) 668-1700

OSU Extension Service

Deschutes County ES
3893 SW Airport Way, Redmond, OR 97756
(541) 548-8697

Appendix VII

Contacts for Service-learning Partners and Field Sites

Clackamas County ES
200 Warner Milne Rd., Oregon City, OR 97045
(503) 655-8631

Wasco County ES
400 E Scenic Dr. Suite 2.278, The Dalles, OR 97058
(541) 296-5494

Hood River County ES
2990 Experiment Station Dr., Hood River, OR 97031
(541) 386-3343

Marion County ES
3180 Center St. NE, Room 1361, Salem, OR 97301
(503) 588-5301

Linn County ES
104 4th Ave. SW, PO Box 765, Albany, OR 97321
(541) 967-3871

Klamath County ES
3328 Vandenberg Rd, Klamath Falls, OR 97603
(541) 883-7131

Douglas County ES
1134 SE Douglas Ave., PO Box 1165, Roseburg, OR 97470
(541) 672-4453

Soil and Water Conservation Districts

Clackamas County SWCD
221 Molalla Ave. Suite 102, Oregon City, OR 97045
(503) 655-3144

Douglas SWCD
2741 W. Harvard Ave. , Roseburg, OR 97470
(541) 957-5061

Hood River SWCD
3007 Experiment Station Dr., Hood River, OR 97031
(541) 386-4588

Linn SWCD
33935 Hwy 99E Suite C, Tangent, OR 97389
(541) 926-2483

Marion SWCD
650 Hawthorne Ave. SE Suite 130, Salem, OR 97301
(503) 391-9927

Upper Willamette SWCD
780 Bailey Hill Rd. Suite 5, Eugene, OR 97402
(541) 465-6436 x3

Watershed Councils

Middle Fork Willamette WC
PO Box 27, Lowell, OR 97452
(541) 923-4358 • www.mfwwc.org

McKenzie River WC
PO Box 70166, Eugene, OR 97401
(541) 687-9076 • www.mckenziewatershedcouncil.org

North Santiam WC
311 N Third Ave., Stayton, OR 97383
(503) 930-8202 • www.open.org/~nsantiam

Sandy River Basin WC
PO Box 868, Sandy, OR 97055
(503) 668-1646 • www.sandyriver.org

Clackamas River WC
PO Box 1869, Clackamas, OR 97015
(503) 558-0973 • www.clackamasriver.org

Environmental Organizations and Education Sites

Opal Creek Ancient Forest Center
http://www.opalcreek.org/default.aspx

COAST RANGE

Governmental Agencies

BLM

Coos Bay
1300 Airport Ln., North Bend, OR 97459
(541) 756-0100

Tillamook
4610 Third St., Tillamook, OR 97141
(503) 815-1100

Yaquina Head Outstanding Natural Area
http://www.blm.gov/or/resources/recreation/yaquina/index.php

USDA Natural Resources Conservation Service

St. Helens Service Center
2514 Sykes Rd., St. Helens, OR 97051
(503) 397-4555

Tillamook Service Center
6415 Signal St., Tillamook, OR 97141
(503) 842-2848

Appendix VII

Contacts for Service-learning Partners and Field Sites

COAST RANGE

Governmental Agencies

USDA Natural Resources Conservation Service

Newport NRCS
23 N Coast Hwy, Newport, OR 97365
(541) 265-2631

Coquille Service Center
376 N Central Blvd., Coquille, OR 97423
(541) 396-2841

USFWS

Coastal Oregon Field Office
2127 SE Marine Science Dr., Newport, OR 97365
(541) 867-4550

US Forest Service

Siuslaw National Forest
4077 SW Research Way, Corvallis, OR 97333
(541) 750-7000

Cape Perpetua Interpretive Center

http://www.fs.fed.us/r6/siuslaw/recreation/tripplanning/capeperpetua/index.shtml

OSU Extension Service

Clatsop County ES
2001 Marine Dr, Room 210, Astoria, OR 97103
(503) 325-8573

Columbia County ES
505 N. Columbia River Hwy, St. Helens, OR 97051
(503) 397-3462

Tillamook County ES
2204 Fourth St , Tillamook, OR 97141
(503) 842-3433

Lincoln County ES
29 SE 2nd St., Newport, OR 97365
(541) 574-6534

Coos County ES
Ohlsen Baxter Building, 631 Alder St.
Myrtle Point, OR 97458
(541) 572-5263

Douglas County ES
1134 SE Douglas Ave., PO Box 1165, Roseburg, OR 97470
(541) 672-4453

Curry County ES
Curry County Fair Grounds
29390 Ellensburg (Hwy 101), Gold Beach, OR 97444
(541) 247-6672

Soil and Water Conservation Districts

Clatsop SWCD
750 Commercial St. Room 207, Astoria, OR 97103
(503) 325-4571

Columbia SWCD
2514 Sykes Rd., St. Helens, OR 97051
(503) 397-4555 x3

Coos SWCD
371 N. Adams St,, Coquille, OR 97423
(541) 396-6879

Curry County SWCD
94181 4th St., Gold Beach, OR 97444
(541) 247-2755

Lincoln SWCD
23 North Coast Hwy., Newport, OR 97365
(541) 265-2631

Polk SWCD
580 Main St. Suite A, Dallas, OR 97338
(503) 623-9680 x101

Siuslaw SWCD
1525 12th St. Suite 10A, Florence, OR 97439
(541) 997-1272

Tillamook County SWCD
6415 Signal St., Tillamook, OR 97141
(503) 842-2240 x 114

Umpqua SWCD
47088 State Hwy. 38, Reedsport, OR 97467
(541) 271-2611

Yamhill SWCD
2200 SW 2nd St., McMinnville, OR 97128
(503) 472-1474 x3

Watershed Councils

Lower Columbia WSC
12589 Hwy 30, Clatskanie, OR 97016
(503) 728-9015 • www.lcrwc.com

North Coast Watershed Association
750 Commercial St. Rm. 205, Astoria, OR 97103
(503) 325-0435 • www.clatsopwatersheds.org

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Contacts for Service-learning Partners and Field Sites

COAST RANGE

Watershed Councils

Necanicum WSC
PO Box 249, Nehalem, OR 97131
(503) 717-1458 • www.necanicumwatershed.org

Lower Nehalem WSC
PO Box 249, Nehalem, OR 97131
(503) 368-7424 • www.nehalemtel.net/~lnwcouncil

Upper Nehalem WSC
919 Bridge St., Vernonia, OR 97064
(503) 429-0869 • www.nehalem.org

Tillamook WSC
605 Garibaldi Ave., Garibaldi, OR 97118
(503) 322-0002
www.tillamookbaywatershedcouncil.net

Nestucca Neskowin WSC
PO Box 255, Hebo, OR 97122
(503) 392-6134 • www.oregoncoast.com/nnwc

Midcoast WSC
23 North Coast Hwy, Newport, OR 97365
(541) 265-9195 • www.midcoastwatershedcouncil.org

Siuslaw WSC
PO Box 4222, Mapleton, OR 97453
(541) 268-3044 • www.siuslaw.org

Smith River WSC
PO Box 114, Reedsport, OR 97467
(541) 271-2223

Tenmile Lakes Basin Partnership
PO Box, Lakeside, OR 97449
(541) 759-2414 • tlbp.presys.com

Coos WA
PO Box 5860, Coos Bay, OR 97420
(541) 888-5922 • www.cooswatershed.org

Coquille WA
55135 Picture Valley Rd., Coquille, OR 97423
(541) 571-2541 • www.coquillewatershed.org

South Coast WC
PO Box 666, Gold Beach, OR 97444
(541) 247-2755 • www.currywatersheds.org

Northwest Outdoor Science School (public school district)
www.nwresd.k12.or.us/instrserv/noss/index.html

South Slough National Estuarine Research Reserve
http://www.oregon.gov/DSL/SSNERR/

Tillamook Forest Center (Oregon Dept. of Forestry)
http://www.tillamookforestcenter.org/

Environmental Organizations and Education Sites

OMSI Outdoor Science Schools
Camp Kiwanilong, Camp Magruder, Contact: OMSI Program Sales and Registration, Portland, OR 97214
(503) 797-4661

The Nature Conservancy Oregon Coast Office
750 Commercial Street, Suite 212, Astoria, OR 97103
(503) 325-3896

Tillamook County Outdoor School
http://www.outdoorschool.org/

COLUMBIA PLATEAU

Governmental Agencies

USDA Natural Resources Conservation Service

The Dalles Service Center and Wy'East RC&D
2325 River Rd. Suite 3, The Dalles, OR 97058

Moro Service Center
302 Scott St., Moro, OR 97039
(541) 565-3551

Condon Service Center
333 S Main St., Condon, OR 97823
(541) 384-2281

Heppner Service Center
430 Heppner Lexington Hwy, Heppner, OR 97836
(541) 676-9011 x113

Pendleton Service Center
200 SE Hailey Ave. Suite 112, Pendleton, OR 97801
(541) 278-8049

USFWS

La Grande Field Office
3502 Hwy 30, La Grande, OR 97850
(541) 962-8584

US Forest Service

Columbia Gorge National Scenic Area
902 Wasco St, Ste. 200, Hood River, OR 97031
(541) 308-1700

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Contacts for Service-learning Partners and Field Sites

USFWS

US Forest Service

Umatilla National Forest
2517 SW Hailey Ave., Pendleton, OR 97801
(541) 278-3752

ODFW

Northeast Region Office
107 20th Street, LaGrande, OR 97850
(541) 963-2138

OSU Extension Service

Wasco County ES
400 E Scenic Dr. Suite 2.278, The Dalles, OR 97058
(541) 296-5494

Sherman County ES
409 Hood St., Moro, OR 97039
(541) 565-3230

Gilliam County ES
333 South Main, PO Box 707, Condon, OR 97823
(541) 384-2271

Morrow County ES
54173 Hwy 74, PO Box 397. Heppner, OR 97836
(541) 676-9642

Umatilla County ES
418 North Main St., Milton-Freewater, OR 97862
(541) 938-5597

Umatilla County ES
2411 NW Carden Ave. , Umatilla Hall
PO Box 100, Pendleton, OR 97801
(541) 278-5403

Soil and Water Conservation Districts

Gilliam County SWCD
333 S Main St., Condon, OR 97823
(541) 384-2672

Morrow SWCD
430 Linden Way, Heppner, OR 97836
(541) 676-5452

Sherman County SWCD
302 Scott St., Moro, OR 97039
(541) 565-3216 x3

Umatilla County SWCD
200 SE Hailey Ave. Suite 108, Pendleton, OR 97801
(541) 276-8131

Wasco County SWCD
2325 River Rd. Suite 3, The Dalles, OR 97058
(541) 296-6178 x3

Watershed Councils

Umatilla Basin WC
PO Box 1551, Pendleton, OR 97801
(541) 276-2190

Wasco County WC
2325 River Rd. Suite 3, The Dalles, OR 97058
(541) 296-6178

Walla Walla Basin WC
PO Box 68, Milton Freewater, OR 97862
(541) 938-2170 • www.wwbwc.org

Gilliam-East John Day WC
PO Box 106, Condon, OR 97823
(541) 701-8391

Middle Deschutes WC
625 SE Salmon Ave., Redmond, OR 97756
(541) 937-9800
www.deschuteswatersheds.org/tcwc/

Sherman County WC
PO Box 405, Moro, OR 97039

Bonneville Lock and Dam (US Army Corps of Engineers)
http://www.nwp.usace.army.mil/op/b/home.asp

Columbia Gorge Discovery Center (National Scenic Area)
http://www.gorgediscovery.org/

Columbia River Gorge National Scenic Area
http://www.fs.fed.us/r6/columbia/

Environmental Organizations and Education Sites

Columbia Gorge Ecology Institute
http://www.gorgeecology.org/default.htm

The Nature Conservancy
Columbia Plateau Office
P.O. Box 314, The Dalles, OR 97058
(541) 298-1802

EASTERN CASCADES SLOPES AND FOOTHILLS

Governmental Agencies

BLM
Lakeview
1301 S. G Street, Lakeview, OR 97630
(541) 947-2177

Appendix VII

Contacts for Service-learning Partners and Field Sites

EASTERN CASCADES SLOPES AND FOOTHILLS

Governmental Agencies
BLM

Klamath Falls
2795 Anderson Ave., Bldg. #25, Klamath Falls, OR 97603
(541) 883-6916

USDA Natural Resources Conservation Service

Klamath Falls Service Center
2316 S 6th St. Suite C, Klamath Falls, OR 97601
(541) 883-6924

Lakeview Service Center
17612 Hwy 395, Lakeview, OR 97630
(541) 947-2367

Redmond Service Center
625 SE Salmon Ave. Bldg. A, Redmond, OR 97756
(541) 923-4358

Warm Springs Service Center
2416 Warm Springs St., Warm Springs, OR 97761
(541) 553-2009

The Dalles Service Center and Wy'East RC&D
2325 River Rd. Suite 3, The Dalles, OR 97058

USFWS

Klamath Falls Fish and Wildlife Office
1936 California Ave., Klamath Falls, OR 97601
(541) 885-8481

Bend Field Office
20310 Empire Ave, Ste. A-100, Bend, OR 97701
(541) 383-7146

US Forest Service

Deschutes National Forest
1001 SW Emkay, Bend, OR 97702
(541) 383-5531

Deschutes and Ochoco National Forests
http://www.fs.fed.us/r6/centraloregon/

Fremont-Winema National Forest
1301 South G Street, Lakeview, OR 97630
(541) 947-6201

OSU Extension Service

Klamath County ES
3328 Vandenberg Rd, Klamath Falls, OR 97603
(541) 883-7131

Lake County ES
103 South E St., Lakeview, OR 97630
(541) 947-6054

Hood River County ES
2990 Experiment Station Dr., Hood River, OR 97031
(541) 386-3343

Jefferson County ES
34 SE D St., Madras, OR 97741
(541) 475-3808

Deschutes County ES
3893 SW Airport Way, Redmond, OR 97756
(541) 548-8697

Wasco County ES
400 E Scenic Dr. Suite 2.278, The Dalles, OR 97058
(541) 296-5494

Soil and Water Conservation Districts

Hood River SWCD
3007 Experiment Station Dr., Hood River, OR 97031
(541) 386-4588

Jefferson County SWCD
625 SE Salmon Ave. Suite 6, Redmond, OR 97756
(541) 923-4358 x101

Klamath SWCD
2316 S. 6th St. Suite C, Klamath Falls, OR 97601
(541) 883-6932 x101

Lakeview SWCD
17612 Hwy. 395, Lakeview, OR 97630
(541) 947-5855

Wasco County SWCD
2325 River Rd. Suite 3, The Dalles, OR 97058
(541) 296-6178 x3

Watershed Councils

Hood River WC
3007 Experiment Station Dr., Hood River, OR 97031
(541) 386-6063 • www.hoodriverswcd.org

Wasco County WC
2325 River Rd. Suite 3, The Dalles, OR 97058
(541) 296-6178

Upper Deschutes WC
PO Box 1812, Bend, OR 97709
(541) 382-6103
www.deschuteswatersheds.org/udwc/

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Contacts for Service-learning Partners and Field Sites

Klamath WC Partnership
700 Main St, Suite 202, Klamath Falls, OR 97601
(541) 850-1717

Lake County WC
17612 Hwy 395, Lakeview, OR 97630
(541) 947-2336

Malheur WC
710 SW 5th Ave., Ontario, OR 97914
(541) 881-1417 x107

Harney WC
450 N Buena Vista, Burns, OR 97720
(541) 573-8199
www.angelfire.com/or3/hcwatershedco

Owyhee WC
106 Owyhee St., PO Box 275, Adrian, OR 97901
(541) 372-5782

Crater Lake National Park
http://www.nps.gov/crla/index.htm

Environmental Organizations and Education Sites

Central Oregon Environmental Center
http://envirocenter.org/

High Desert Museum
http://www.highdesertmuseum.org/

OMSI Outdoor Science Schools
Cascade Science School, Contact: OMSI Program Sales and Registration, Portland, OR 97214
(503) 797-4661

Sunriver Nature Center
http://www.sunrivernaturecenter.org/index.html

Oregon Paleo Lands Institute (OPLI)
http://www.paleolands.org/find/time/here

Klamath Outdoor Science School
http://www.klamathoutdoorschool.org/

The Nature Conservancy
Central Oregon Office
115 NW Oregon Avenue, Bend, OR 97701
(541) 388-3020

Klamath Basin Office
226 Pine Street, Klamath Falls, OR 97601
(541) 273-0789

KLAMATH MOUNTAINS (includes Siskiyou Mountains)

Governmental Agencies

BLM

Roseburg
777 NW Garden Valley Blvd., Roseburg, OR 97471
(541) 440-4930

Medford
3040 Biddle Road, Medford, OR 97504
(541) 618-2200

Grants Pass Interagency Office
2164 NE Spalding Ave, Grants Pass, OR 97526
(541) 471-6500

USDA Natural Resources Conservation Service

Southwest Oregon RC&D
576 NE E St., Grants Pass, OR 97526
(541) 476-5906

Medford Service Center
573 Parsons Dr. Suite 101, Medford, OR 97501
(541) 776-4270

Roseburg Service Center
2240 NW Troost #200, Roseburg, OR 97471
(541) 673-6071

USFWS

Roseburg Field Office
2900 NW Stewart Parkway, Roseburg, OR 97471
(541) 957-3470

US Forest Service

Rogue River-Siskiyou National Forest
6040 Biddle Rd., Medford, OR 97504
(541) 618-2200

Umpqua National Forest
2900 NW Stewart Parkway, Roseburg, OR 97470
(541) 957-3203

ODFW

Southwest Region Office
4192 N. Umpqua Highway, Roseburg, OR 97470
(541) 440-3353

Appendix VII

Contacts for Service-learning Partners and Field Sites

OSU Extension Service

Josephine County ES
215 Ringuette St., Grants Pass, OR 97527
(541) 476-6613

Douglas County ES
1134 SE Douglas Ave., PO Box 1165, Roseburg, OR 97470
(541) 672-4453

Soil and Water Conservation Districts

Curry County SWCD
94181 4th St., Gold Beach, OR 97444
(541) 247-2755

Douglas SWCD
2741 W. Harvard Ave. , Roseburg, OR 97470
(541) 957-5061

Illinois Valley SWCD
102 S. Redwood Hwy., Cave Junction, OR 97523
(541) 592-3731

Jackson SWCD
573 Parsons Dr. Suite 102, Medford, OR 97501
(541) 734-3143

Josephine SWCD
1440 Parkdale Dr., Grants Pass, OR 97526
(541) 474-6840

Watershed Councils

Elk Creed WC
PO Box 676, Yoncalla, OR 97499
(541) 836-7206

Partnership for the Umpqua Rivers
1758 NE Airport Rd., Roseburg, OR 97470
(541) 673-5756 • www.umpquarivers.org

Upper Rogue WC
PO Box 1434, Shady Cove, OR 97539
(541) 210-0670
www.restoretherogue.org/councils/roguebasin_council.html

Middle Rogue WC
543 NE E St. Suite 201, Grants Pass, OR 97526
(541) 474-6799

Lower Rogue WC
PO Box 666, Gold Beach, OR 97444
(541) 247-2755 • www.currywatersheds.org

Seven Basins WC
PO Box 909, Gold Hill, OR 97525
(541) 261-7796 • www.sevenbasins.org

Illinois Valley WC
PO Box 352, Cave Junction, OR 97523
(541) 592-3731

Williams Creek WC
PO Box 94, Williams, OR 97544
(541) 846-9175

Applegate River WC
6941 Upper Applegate Rd, Jacksonville, OR 97530
(541) 889-9982 • www.arwc.org

Bear Creek WC
PO Box 1548, Medford, OR 97501
(541) 840-1810 • www.bearcreek-watershed.org

Little Butte Creek WC
PO Box 89, Eagle Point, OR 97524
(541) 646-1684
www.restoretherogue.org/councils/little_butte.html

Douglas County Museum of Natural and Cultural History (Roseburg)
http://www.co.douglas.or.us/museum/default.asp

North Mountain Park Nature Center (City of Ashland)
http://www.northmountainpark.org/

Oregon Caves National Monument (National Park Service)
http://www.nps.gov/orca/index.htm

Siskiyou Environmental Education Center (Southern Oregon University)
http://www.sou.edu/biology/enved/seec/index.html

Environmental Organizations and Education Sites

Siskiyou Field Institute
http://www.thesfi.org/index.asp

The Nature Conservancy
Southwest Oregon Office
33 N. Central Avenue, Suite 405, Medford, OR 97501-5939
(541) 770-7933

Appendix VII

Contacts for Service-learning Partners and Field Sites

NORTHERN BASIN AND RANGE

Governmental Agencies

BLM

Burns
28910 Hwy 20 West, Hines, OR 97738
(541) 573-4400

Vale
100 Oregon St., Vale, OR 97918
(541) 473-3144

USDA Natural Resources Conservation Service

Lakeview Service Center
17612 Hwy 395, Lakeview, OR 97630
(541) 947-2367

Hines Service Center
530 Hwy 20 S, Hines, OR 97738
(541) 573-6446

Ontario Service Center
2925 SW 6th Ave., Ontario, OR 97914
(541) 889-9689

Vale Soil Survey Office
100 Oregon St., Vale, OR 97918
(541) 473-6243

USFWS

Bend Field Office
20310 Empire Ave, Ste. A-100, Bend, OR 97701
(541) 383-7146

Malheur Wildlife Refuge
http://www.fws.gov/malheur/education.html

ODFW

High Desert Region Office
61374 Parrell Road, Bend, OR 97702
(541) 388-6363

OSU Extension Service

Lake County ES
103 South E St., Lakeview, OR 97630
(541) 947-6054

Harney County ES
450 N. Buena Vista, #10, Burns, OR 97720
(541) 573-2506

Malheur County ES
710 SW 5th Ave., Ontario, OR 97914
(541) 881-1417

Soil and Water Conservation Districts

Curry County SWCD
94181 4th St., Gold Beach, OR 97444
(541) 247-2755

Douglas SWCD
2741 W. Harvard Ave., Roseburg, OR 97470
(541) 957-5061

Illinois Valley SWCD
102 S. Redwood Hwy., Cave Junction, OR 97523
(541) 592-3731

Jackson SWCD
573 Parsons Dr. Suite 102, Medford, OR 97501
(541) 734-3143

Josephine SWCD
1440 Parkdale Dr., Grants Pass, OR 97526
(541) 474-6840

Harney County Museum
http://www.burnsmuseum.com/

Environmental Organizations and Education Sites

High Desert Museum
http://www.highdesertmuseum.org/

Malheur Field Station
http://www.malheurfieldstation.org/

Sunriver Nature Center
http://www.sunrivernaturecenter.org/index.html

WILLAMETTE VALLEY

Governmental Agencies

BLM

Salem
1717 Fabry Rd. SE, Salem, OR 97306
(503) 375-5646

Eugene
3106 Pierce Parkway, Suite E, Springfield, OR 97477
(541) 683-6600

USDA Natural Resources Conservation Service

Portland Service Center
2701 NW Vaughn St. Suite 450, Portland, OR 97210
(503) 326-3941

Portland National Water and Climate Center
1201 NE Lloyd Blvd. Suite 900, Portland, OR 97232
(503) 414-3031

Appendix VII

Contacts for Service-learning Partners and Field Sites

WILLAMETTE VALLEY

Governmental Agencies

USDA Natural Resources Conservation Service

Hillsboro Service Center
1080 SW Baseline Suite B2, Hillsboro, OR 97123
(503) 648-3174

Oregon City Service Center
221 Molalla Ave., Oregon City, OR 97045
(503) 655-3144 x108

McMinnville Service Center
2200 SW 2nd St. , McMinnville, OR 97128
(503) 472-1474

Dallas Service Center
580 Main St. Suite D, Dallas, OR 97338
(503) 623-2396 x2

Salem Service Center
650 Hawthorne Ave SE Suite 130, Salem, OR 97301
(503) 399-5741

Corvallis Plant Materials Center
3415 NE Granger Ave., Corvallis, OR 97330
(541) 757-4812

Tangent Service Center
33630 McFarland Rd., Tangent, OR 97389
(541) 967-5925

Eugene Service Center
780 Bailey Hill Rd., Eugene, OR 97402
(541) 465-6443

USFWS

Oregon Fish and Wildlife Office
2600 SE 98th Ave, Ste. 100, Portland, OR 97266
(503) 231-6179

ODFW

Northwest Region Office
17330 S.E. Evelyn Street, Clackamas, OR 97015
(971) 673-6000

US Forest Service

Portland Regional Office
333 SW First Ave., Portland, OR 97204
(503) 808-2468

Willamette National Forest
211 East 7th Ave, Eugene, OR 97401
(541) 225-6300

Oregon Department of Agriculture

Natural Resources Division
635 Capitol St. NE, Salem, OR 97301
(503) 986-4700

OSU Extension Service:

Metropolitan Office
Institute of Portland Metropolitan Studies
PO Box 751, Portland, OR 97207
(541) 737-2713

Washington County ES
18640 NW Walker Rd. #1400, Beaverton, OR 97006
(503) 821-1150

Clackamas County ES
200 Warner Milne Rd., Oregon City, OR 97045
(503) 655-8631

North Willamette Research Center
15210 NE Miley Rd., Aurora, OR 97002
(503) 678-1264

Marion County ES
3180 Center St. NE, Room 1361, Salem, OR 97301
(503) 588-5301

Yamhill County ES
2050 NE Lafayette Ave., McMinnville, OR 97128
(503) 434-7517

Polk County ES
182 SW Academy, Suite 102, Dallas, OR 97338

Benton County ES
1849 NW 9th St., Corvallis, OR 97330
(541) 776-6750

Linn County ES
104 4th Ave. SW, Albany, OR 97321
(541) 967-3871

Douglas County ES
1134 SE Douglas Ave., Roseburg, OR 97470
(541) 672-4453

Soil and Water Conservation Districts

Benton SWCD
305 SW C Ave. Suite 1, Corvallis, OR 97333
(541) 753-7208

Clackamas County SWCD
221 Molalla Ave. Suite 102, Oregon City, OR 97045
(503) 655-3144

Appendix VII

Contacts for Service-learning Partners and Field Sites

Soil and Water Conservation Districts

East Multnomah SWCD
5211 N Williams Ave., Portland, OR 97217
(503) 222-7645

Linn SWCD
33935 Hwy 99E Suite C, Tangent, OR 97389
(541) 926-2483

Marion SWCD
650 Hawthorne Ave. SE Suite 130, Salem, OR 97301
(503) 391-9927

Polk SWCD
580 Main St. Suite A, Dallas, OR 97338
(503) 623-9680 x101

Tualatin SWCD
1080 SW Baseline St. Suite B-2, Hillsboro, OR 97123
(503) 648-3174 x4

Upper Willamette SWCD
780 Bailey Hill Rd. Suite 5, Eugene, OR 97402
(541) 465-6436 x3

West Multnomah SWCD
2701 NW Vaughn St. Suite 450, Portland, OR 97210
(503) 238-4775

Yamhill SWCD
2200 SW 2nd St., McMinnville, OR 97128
(503) 472-1474 x3

Watershed Councils

Columbia Slough WC
7040 NE 47th Ave., Portland, OR 97218
(503) 281-1132 • www.columbiaslough.org

Scappoose Bay WC
57420-0 Old Portland Rd., Warren, OR 97053
(503) 397-7904

Johnson Creek WC
1900 SE Milport Rd., Milwaukie, OR 97222
(503) 652-7477 • www.jcwc.org

Sandy River Basin WC
PO Box 868, Sandy, OR 97055
(503) 668-1646 • www.sandyriver.org

Clackamas River WC
PO Box 1869, Clackamas, OR 97015
(503) 558-0973 • www.clackamasriver.org

Greater Oregon City WC
PO Box 927, Oregon City, OR 97045
(503) 427-0439 • www.gocwc.org

Tualatin River WC
PO Box 338, Hillsboro, OR 97123-0
(503) 846-4810 • www.trwc.org

Molalla River Watch
PO Box 474, Molalla, OR 97038
www.molallariverwatch.org

Yamhill Basin WC
PO Box 1517, McMinnville, OR 97128
(503) 474-1047 • www.co.yamhill.org.us/ybc

Pudding River WC
PO Box 242, Aurora, OR 97002
(503) 873-5439

Spring Valley WC
4780 Brush College Rd., Salem, OR 97304
(503) 371-6552

Mid-Willamette Watershed Alliance
PO Box 548, Salem, OR 97308
(541) 954-0435

Glenn Gibson Creeks WC
580 Main St. Suite A, Dallas, OR 97338
www.glenngibsonwatershedcouncil.org

Rickreall WC
580 Main St. Suite A, Dallas, OR 97338
(503) 623-9680 x112
www.rickreallwatershedcouncil.org

Luckiamute WC
245 N Monmouth Ave. WOU, Monmouth, OR 97631
(503) 302-4913 • luckiamute.watershedcouncils.net

North Santiam WC
311 N Third Ave., Stayton, OR 97383
(503) 930-8202 • www.open.org/~nsantiam

South Santiam WC
4331 Hwy 20, Sweet Home, OR 97386
(541) 367-5564 • www.sswc.org

Marys River WC
PO Box 1041, Corvallis, OR 97339
(541) 758-7597 • www.mrwc.net

Calapooia WC
PO Box 844, Brownsville, OR 97327
(541) 812-7622

Appendix VII

Contacts for Service-learning Partners and Field Sites

Watershed Councils

McKenzie River WC
PO Box 70166, Eugene, OR 97401
(541) 687-9076 • www.mckenziewatershedcouncil.org

Long Tom WC
751 S Danebo Ave., Eugene, OR 97402
(541) 683-6578 • www.longtom.org

Middle Fork Willamette WC
PO Box 27, Lowell, OR 97452
(541) 923-4358 • www.mfwwc.org

Coast Fork Willamette WC
28 South 6th St. Suite A, Cottage Grove, OR 97424
(541) 767-9717 • www.coastfork.org

Bonneville Lock and Dam (US Army Corps of Engineers)
http://www.nwp.usace.army.mil/op/b/home.asp

Center for Research in Environmental Sciences and Technologies (Wilsonville) (public school district)
http://www.crest.wlwv.k12.or.us/

End of the Oregon Trail (Oregon City)
http://www.historicoregoncity.org/HOC/

Hoyt Arboretum (City of Portland)
http://www.portlandonline.com/parks/

Jackson Bottom Wetlands Preserve (Hillsboro Parks and Rec.)
http://www.jacksonbottom.org/

John Inskeep Environmental Learning Center (Clackamas Community College)
http://depts.clackamas.cc.or.us/elc/

Multnomah County Outdoor School (public school district)
www.mesd.k12.or.us/os/OutdoorSchool/Welcome.html

Oxbow Regional Park (Metro Regional Government)
www.oregonmetro.gov/index.cfm/go/by.web/id=150

Rock Creek Environmental Studies Center (Portland Community College)
http://spot.pcc.edu/rcesc/

Silver Falls State Park
http://www.oregonstateparks.org/park_211.php

Slough School (Columbia Slough Watershed Council)
www.columbiaslough.org/sloughschool/index.htm

Smith and Bybee Wetlands (Metro Regional Government)
www.oregonmetro.gov/index.cfm/go/by.web/id=153

Tryon Creek State Natural Area
http://www.oregonstateparks.org/park_144.php

Tualatin Hills Nature Park
http://www.thprd.org/facilities/naturepark/home.cfm

University of Oregon Museum of Natural and Cultural History
http://www.uoregon.edu/~mnh/

West Eugene Wetlands Education Center
http://www.wewetlands.org/

Environmental Organizations and Education Sites

Mount Pisgah Arboretum
http://mountpisgaharboretum.org/

Oregon Garden
http://www.oregongarden.org/

Oregon Museum of Science and Industry (OMSI)
http://www.omsi.edu/

The Nature Conservancy Willamette Valley Office
87200 Rathbone Road, Eugene, OR 97402
(541) 343-1010

World Forestry Center
http://www.worldforestry.org/

Appendix VIII

Make Your Own Quadrat Frame

Option 1:

- 4 – 1 meter x ½ inch PVC tubing pieces, 4 right angle elbows, and PVC adhesive

Build a one-meter-square quadrat frame using PVC tubing. Affix one elbow to each 1-meter piece with PVC adhesive. Transport frame as 4 pieces. Assemble the frame at monitoring site by joining the 4 pieces into a square.

Option 2:

- 4 – 1 meter sticks or lathe, 4 screws with wing nuts

Overlap the meter sticks at the end in a right angle. Have someone hold while you drill through both sticks. Insert screw and wing nut, attaching the two. Repeat for the other two meter sticks. Now overlap the ends of the two pieces and drill making a square. Wing nuts can be loosened to fold up the square for easier transporting.

Option 3:

- 2 – 1 meter x ½ inch PVC tubing sleeves, 4+ meters of non-stretch twine or light rope, 1 small snap

Thread the two tubing sleeves onto the twine and tie a small loop in the end of the twine. Measure 4 meters of twine, plus an inch or two more, and cut. Tie the snap onto this end. The final length of your twine should measure 4 meters from the end of the loop to the end of the snap. Attach the snap to the small loop of twine to make an overall 4-meter loop. Stretch the loop using the tubing, making a square shape, and lay on the ground. This is best used with stakes or flags to secure the corners into a rigid square. (Hint: double check twine measurement after tying; you may need to adjust your knots to make a 4-meter loop)

Using your quadrat frame:

Make sure that your quadrat can be taken apart or folded up for carrying. It is best to leave one corner of the quadrat unattached so you can unfold the quadrat and slide it under the vegetation into place. If all four sides are fixed, you must place the quadrat over the vegetation, which can be difficult with tall plants, shrubs, or trees.