earth partnership

# Restoration Education Guide

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

# Restoration Education Guide

A Publication of

Earth Partnership
at the University of Wisconsin-Madison

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

earth partnership


**Lead Authors**

Cheryl Bauer-Armstrong and Libby McCann

**Contributors**

Greg Armstrong
Laura Barnett
Greg Bisbee
Claire Bjork
Chuck Bomar
Becky Brown
Pat Brown
Rachel Byington
Amy Callies
Barrett Clausen
Frank Court
Astrid De la Cruz
Betty Downs
Carol Edgerton
Magge Ericson
Marian Farrior
Anne Forbes
Miguela Fry
Lainet Garcia-Rivera
Sarah Gilbert
Cynthia Gonzalez
Georgia Gómez-Ibáñez
Pilar Gómez-Ibáñez
Cathy Gottsacker
John Greenler
Robin Greenler
Jane Haag
Rick Hall
Beth Heller
Tera Hollfelder
Jen James
Dylan Jennings
Bill Jordan
Ryan Kesler
Sara Krauskopf
Cindy Kryda
Stephen Laubach
Jody McCoy
Danielle McFarland
Emily Miller
Todd Miller
Kathy Miner
Janet Moore
Maria Moreno
Kathleen Morgen
Molly Fifield Murray
Caitlin O'Connell
Benjamin Orcutt
Kathy Palmer
Liz Penner
Melissa Rosewall
Nancy Schlimgen
David Schultz
Nancy Sheehan
Mary Beth Stevens
Donna Thomas
Dawn Wood-Quast
Brock Woods
Sarah Wortham
Sarah Wright
Fawn YoungBear-Tibbets



**Development of the Earth Partnership curriculum was made possible by:**

Ira and Ineva Reilly Baldwin Wisconsin Idea Endowment
Patrick and Anna M. Cudahy Foundation
Friends of the Arboretum
Howard Hughes Medical Institute
Institute of Museum and Library Service
Institute for Biology Education
Morgridge Center for Public Service
National Science Foundation
Wisconsin Coastal Management Program
Wisconsin Environmental Education Board
Wisconsin ESEA Improving Teacher Quality Program
Wisconsin Sea Grant
U.S. Environmental Protection Agency
U.S. EPA Great Lakes Restoration Initiative


WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON


**Copyright Information**

The intellectual property in the Earth Partnership curriculum is held by the University of Wisconsin Board of Regents. These materials are intended for distribution only as part of an Earth Partnership institute, workshop, in-service or other teacher professional development program. Written permission must be obtained to use, reproduce, distribute or modify the materials in this guide.

## The Challenge Facing Children Today

Today's children are immersed in technology. Television and the Internet have shown them the demise of rain forests and whales, the threat to endangered species and the destruction wrought by hurricanes and earthquakes. They absorb this second-hand information, and the problems seem big and far away, engendering a feeling of hopelessness and helplessness.

Sadly, they have less and less first-hand exposure to the natural environment. Children today do not spend much, if any, time watching clouds move across the sky or examining the contents of a mud puddle. Between soccer games, piano lessons and swimming practice, what child has the time to listen to dried leaves and grasses rustle in the wind? How many know what it feels like to have a fuzzy caterpillar inch its way across their fingers? Serendipitous encounters with nature are disappearing, a phenomenon that has been referred to as the "extinction of experience"[1] or more recently, "nature-deficit disorder."[2]

There is a disconnect between children and the natural environment. The connection between the food, energy and recreation the earth provides has been largely lost and along with it, the perspective needed to understand the science and art of living on earth. How do we empower children and help them develop a sense of wonder and a sense of place in their local environment? How do we encourage in them a responsibility toward life-long stewardship of the natural world?

A crucial piece in the educational puzzle is missing. Who is teaching the next generation the skills needed to become active and scientifically literate citizens? Students need problems to solve that are real and manageable, not far away and hopeless. They need to know how to make a difference, and to understand their place in the environment.

There is hope and progress. There are schools where children have schoolyards rich in native species. They can be seen following butterflies from flower to flower, monitoring their activity. They know how to use a stop watch to record data as part of a small experiment. They use the restored schoolyard as an inspiration for their art and writing. Flowers are in drifts among grasses of the restored prairies that groups of students, parents and community members helped to create under the guidance of teachers. This is happening at Earth Partnership schools across Wisconsin, and from California to New York, Texas to Minnesota, Central America to the Caribbean, where people are healing the land and our relationship to it, while encouraging learning in all areas of the curriculum.

[1] *Nabhan, G. and Trimble, S. (1995). The geography of childhood: Why children need wild places. Boston, MA: Beacon.*
[2] *Louv, R. (2005). Last child in the woods: Saving our children from nature-deficit disorder. Chapel Hill, NC: Algonquin.*

## The Earth Partnership Solution

Earth Partnership collaborates with diverse communities to create vibrant outdoor learning spaces using a 10-step ecological restoration process. Through facilitated relationship-building and dialogue, communities identify their shared stewardship vision and the ways Earth Partnership can help make it a reality. Ecological restoration and stewardship inspire students as they learn while participating in activities in all subject areas that relate to their local environment, thus encouraging them to develop attitudes, knowledge and skills necessary to become environmentally literate citizens.

### Mission

To engage educators and learners of all ages and backgrounds in community-based ecological restoration for healthy environments.

### Vision

For communities across the world to be actively engaged in ecological restoration that connects people to the land and each other through a commitment to stewardship.

# earth partnership

## 10 Restoration Education Steps

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

### Connect
community resources and partners

### Study
native species, habitats and ecosystems

### Investigate
written and oral site history and landscape patterns, past and present

### Analyze
soil, water, slope, sun/shade, vegetation, physical and aesthetic qualities

### Plan
a butterfly garden, rain garden, grassland, woodland or wetland restoration

### Prepare
the site: remove existing vegetation, layout the design

### Plant
sow seeds, transplant seedlings and celebrate!

### Manage
remove invasive species; create signage

### Research
ask questions, make observations and use evidence to answer

### Learn
language arts, science, math, social studies,music, art, life skills, love of nature

# A Note about Earth Partnership Curriculum

Audience

Earth Partnership (EP), originally known as "Earth Partnership for Schools," began in 1991 as a way for teachers to engage students in living the land ethic embodied by Aldo Leopold and the UW-Madison Arboretum. While involving people in learning and stewardship is still the foundation of EP, the program has continued to evolve. EP now works to more intentionally include diverse cultural perspectives on stewardship and restoration and to offer learning opportunities that are valuable to learners of different ages, languages and ecological and cultural places.

Earth Partnership is not limited to learning in schools. Engaging the community in the restoration process is a vital step, and we encourage community educators, families and individuals to use this guide to help learn more about restoration and approaches to teaching stewardship to others. Some elements, such as learning objectives, educational standards and assessments will be most valuable to K-12 educators. Activities are written with the audience being referred to as "students," although there is no reason that these activities cannot be shared with adults and learners of all ages.

Earth Partnership's model for multicultural engagement emphasizes the "4R's" (Respect, Reciprocity, Relationship, and Responsibility), which formed the development of Indigenous Arts and Sciences, Latino Earth Partnership, and ¬Global Earth Partnership.

Earth Partnership: Indigenous Arts & Sciences (IAS) delivers culturally responsive informal science education to inspire youth to pursue STEM interests and tribal careers in collaboration with Red Cliff, Bad River, Lac du Flambeau, Lac Courte Oreilles, and Ho-Chunk Nations. IAS integrates indigenous knowledge and community cultural connections to reframe and reclaim science learning in tribal communities. The project convenes tribal educators, elders, and natural resource personnel with university social, physical, and life scientists. Partners design, implement, and test learning sequences incorporating indigenous processes of restoring, preserving, and connecting to the land. IAS engages communities in providing relevant science learning through community dialogues, relationship building, informal-formal educator collaborations, and educator professional development centered on responsive science teaching and learning.

Earth Partnership: Latino Earth Partnership (LEP) integrates culturally relevant Earth Partnership place and project-based curricula and resources with school- and community-identified priorities. LEP employs resource, asset, and strength-based approaches that engage youth in environmental stewardship through the integration of Spanish language, cultural perspectives and experience, and hands-on experiences with ecological restoration education.

This Earth Partnership Ecological Restoration Curriculum Guide follows a 10-step process (see diagram on preceding page) for restoring ecological communities on schoolyards, public lands and natural areas. The guide weaves environmental knowledge and skills into core curriculum and assessment leading to the development and of a native restoration and outdoor space for learning. The lessons are complete with education standards and student assessment ideas. Each activity in the guide includes objectives, a background section, directions, assessment ideas, relevant field sheets, as well as options for extensions.

Earth Partnership curriculum includes additional lessons and companion guides focused on woodland restoration, water stewardship, rain gardens, pollinator habitat, ecology, and art. In many activities, you will see other EP activities referenced. Some will be in this guide, but others will not. To access these other activities, visit the EP Curriculum Dropbox online. There, you can find complete versions of companion guides as well as an alphabetical directory of all EP activities. You can also find additional printable activity materials referenced in the guide.

EP Curriculum Dropbox Link: http://go.wisc.edu/b02p69

# Contents

# Contents

# Contents

earth partnership

# Connect

community resources and partners

# Section Introduction: CONNECT

Connecting with the community and engaging them in the restoration process is one of the most important steps in ensuring that the process will be successful ecologically, educationally, and in terms of helping bring people together around shared stewardship action.

Although connections will happen in different ways for each group and each project, anyone doing restoration education can benefit from considering the needs, values, and goals of their communities and adapting the restoration to them. How do you know what those are? First, you must ask - and listen to what people tell you - through dialogues with the community.

For schools, an important starting point often involves coordinating with administration and other building staff. What are the ways that students are currently interacting with and learning from their surroundings ("The Hidden and Informal Curriculum")? Think about how to frame restoration education in a way that speaks to each individual or a particular group, and adapt your communication style depending on with whom you're speaking. For some, stressing the benefits of project-based approaches for science, math, and language learning are key. For others, the opportunities for environmental action, volunteering, and civic development are great motivators. Others may be interested in the opportunities for family and culture connections, using the school grounds as a context for sharing different traditions, perspectives, and practices in gardening and land care. If you're unsure of the different potential benefits of restoration-based education, make sure you have reviewed activities from each section of this guide, to get a sense of how diverse the learning opportunities can be.

In the process of examining the physical site and social groups involved with that place, you will begin to refine what is really meant by the "community," or likely, the layered "communities" who care about and who are involved in the restoration. Who holds a stake in the ecological health of the site? Who holds a stake in the learners and their development? Who can help provide resources, skills, and encouragement ("Community Assets Mapping")?

Connecting with the community is an important starting point, and it remains important throughout the entire process. In order to keep the restoration ecologically sustainable and a source of continued learning and engagement in the community, others need to learn about what you are doing and why ("Telling the Restoration Story"). You may find that more and more people want to get involved in the important work of restoration education!


© Earth Partnership • University of Wisconsin-Madison

# The Hidden and Informal Curriculum

**Activity Overview**
Students investigate their school grounds, create photos of those design elements they prefer and do not prefer, and write a short paragraph describing how they feel about the area.

**Objectives**
Students will:

• Document their school ground preferences with photographs

• Design visual presentations of their personal school ground design preferences

• Create writing samples describing their preferences

**Subjects Covered**
Language Arts and Social Studies

**Grades**
K through 12

**Activity Time**
1 hour

**Season**
Any

**Materials**
Clipboards, pens, pencils, camera, poster board

## Background

The "hidden curriculum" of school grounds influences how children think, act, and feel at school. Wendy Titman wrote in her 1994 book Special Places, Special People: The Hidden Curriculum of School Grounds that children read the elements of school grounds as signifiers of a school's culture. Schoolyards convey a complex web of unstated but assumed messages and meanings that affect students' behaviors and influence how schools operate as well.

For many children, school grounds are their primary experience with the outdoors. Most schools require children to go outside for certain parts of the day, either for physical education, recess, or lunch breaks. During these times, children are in an environment unlike most other school environments, where they are with other children of varied ages and sizes in a space that is primarily theirs.

Titman's research, sponsored by Learning Through Landscapes (United Kingdom), found that children prefer schoolyards that simultaneously provide a place for doing, thinking, feeling, and being. If a schoolyard fulfills some of their needs, students perceive that the school values their well-being. School grounds that do not meet students' needs cause a perception that the school doesn't care about their well-being.

The environmental design of schoolyards can help fulfill students' physical, emotional, and cognitive needs through the incorporation of the following elements:

- Animals, ponds, and other living things
- Natural color, diversity, and change
- Surfaces that don't hurt
- Places for sitting or leaning, where students can find shelter and shade; a landscape that provides different levels, nooks, and crannies; spots to make dens or find structures and materials that can be changed, either actually or through the imagination.

The presence of such natural elements enhances how children feel about the intentions of school administrations in terms of what children should or should not do on their school grounds.

## Activity Description

Suppose you could have a schoolyard environment that perfectly fulfills your needs. Take some time to discuss how that would look and how it would make you feel. (Students could also interview each other to answer the questions.)

Go outside with a camera. Take one picture of a favorite part of the schoolyard and another of a least favored area. When everyone has taken their pictures, put your two pictures together on a poster, and describe how your schoolyard makes you feel. The photos could also be combined to create a Web page or other computer-generated display.

Write a short paragraph to describe your personal feelings about the schoolyard, or summarize in a paragraph how the class as a whole feels about the school grounds.

## Extensions

- Discuss how you think the school's teachers and administrators feel about the school grounds.
- Write a simple question or two to ask teachers, custodians, and parents to find out how they feel about the school grounds.
- What parts of the schoolyard do adults think are attractive or special?
- How do your responses compare with how your class feels about the schoolyard?
- Create a class photo album to document students' schoolyard preferences and the changes made as your restoration site takes shape.
- By using pictures from magazines or by drawing pictures, show what you would like your school grounds to look like.

## Assessments

- Make a portfolio containing the posters and visuals.
- Write a short essay describing how the school grounds make you feel.
- Make presentations of your individual and/or collective schoolyard preferences, as well as proposed changes to the design.
- Conduct peer reviews of these reports.


© Earth Partnership • University of Wisconsin-Madison

# Community Assets Mapping

**Activity Overview**
Students will begin to learn how to identify and activate the assets of the community that may help their restoration project.

**Objectives**
Students will:

- Interpret maps
- Identify and describe resources in their community
- Write letters and communicate with local residents

**Subjects Covered**
Social Studies and Language Arts

**Grades**
3 through 12

**Activity Time**
2 hours minimum

**Season**
Any

**Materials**
Street maps of the area around the school (adjacent streets or whole town, city or school district), community resource lists (available from chamber of commerce, school districts or similar agencies), clear plastic overlay, clipboards, pens, paper, markers, Internet access

## Background

Students need many types of information to make decisions about their schoolyard restoration project. Site maps show existing features such as utilities, vegetation, water features, pervious/impervious surfaces and buildings. Area maps show watersheds, roads, parks and other outside physical influences. Students' own drawings of the school and adjacent land reveal student feelings about the "hidden curriculum" (the message students get from the landscape). Community assets mapping provides students with information about who they can involve in their schoolyard project to help make it a reality.

Community assets mapping is traditionally used to focus on a community's strengths. Community planners and others have come to recognize that too much focus is often placed on what is "wrong" in communities rather than their strengths. A community assets approach looks at the supports and opportunities in a community and how they can be used effectively. It recognizes that every person in the community has skills, knowledge, wisdom and gifts to help build a strong community. This same approach can be used to help achieve the goals of a schoolyard project.

Once local assets—people, places and things—are identified, they can be connected to each other in ways that multiply their power and effectiveness. This approach works! Sometimes, all one needs to do is ask.

## Activity Description

The objective of community assets mapping is to document the supports and opportunities that exist in the community for your schoolyard project. The first step is to identify your goals and the support you need for your project. Once you have a list of needs, you can find out who can help get it accomplished. In this process, you will create a community assets map by surveying the surrounding neighborhood. You can define this area according to your goals—it may be just the streets adjacent to your school, or it could include the entire neighborhood, town, city, or school district. For areas outside walking distances, you will use the Internet and local resource materials.

Steps in the process include:

1. Divide the school's neighborhood map into sections. Assign a section to each team of students and adult volunteer.
2. As you walk along your route, make an inventory of potential resources in your community that can strengthen your schoolyard project. Take clipboards and pencils and note potential resources you see during your walk such as:
    - Homes with native plantings (rain gardens, butterfly gardens, etc.) or rain barrels
    - Senior citizen apartments, retirement centers, etc.
    - Public services such as police and fire departments, libraries and other schools
    - Public agencies such as local extension agents, Department of Natural

Resources employees, etc.

- Organizations such as neighborhood associations, grassroots environmental groups, religious organizations, service clubs, athletic clubs, youth groups, garden clubs, historical societies, etc.
- Parks and other public spaces where people meet
- Businesses with work similar to what needs to be done on the school project. These can include:
    - Landscaping companies and nurseries that can provide labor, tools, native plants and design ideas
    - Restaurants that can donate refreshments for your planting celebration
    - Printing businesses, which can donate signage and/or other publicity
    - Local newspapers that can provide free publicity and highlight your project

3. When you return to the classroom, mark these resources on a master map.
4. Discuss how each of these identified resources might help the project.
5. Write letters/emails to people, businesses and organizations explaining the project and asking if they would like to help. You can identify specific needs if you know them (e.g., sod removal, snacks for work days). You may also ask individuals how they would like to help. Sometimes they will offer support in a way that was not considered.
6. Report back to the class what you discovered through your communications.

## Extensions

- After you identify assets and resources, conduct interviews with people involved in those organizations to learn more about your community and how they are willing to support your project - and also discover ways that you can support other community projects.

## Assessments

- Develop a presentation from what you learned through letter writing or other communications with potential resource contacts.
- Describe the route you took surveying the neighborhood using compass directions from start to finish.
- Write a complete letter to a community member including a heading, salutation, introduction, body, conclusion, closing, signature and contact information.


© Earth Partnership • University of Wisconsin-Madison

# Telling the Restoration Story

**Activity Overview**
Students create a photographic essay to document the restoration effort.

**Objectives**
Students will:

- Engage in team production of an integrated project
- Conceptualize, organize and create a multimedia presentation of a complex subject

**Subjects Covered**
Language Arts

**Grades**
6 through 12

**Activity Time**
Depends on project design; might be spread across entire school year

**Season**
Any

**Materials**
Camera, computer, paper and supplies for displays

## Background

Engaging in a restoration of a native ecosystem on the school grounds can be a far-reaching, school-wide project. There are multiple layers of meaning to such a project. On the simplest level, it is restoring a piece of land to a pre-settlement state. In doing this, the restorationists will be helping to increase biodiversity, creating habitat for rare and endangered species, and beginning to heal some of the parts of the ecosystem (such as soil, insect populations, and the seed bank in the soil) that have been mistreated in recent history.

In addition to the biological effects of the restoration, the students are creating a much more interesting and aesthetically varied landscape for their school. They may be starting a project that serves as a hook to engage the broader community that reaches beyond their classroom. The project can provide an opportunity for positive and hopeful environmental action. The restoration project may begin to give students a sense of their own place and the history of their place. And of course, as the restoration is used to teach various subjects, the project will be used to enhance the school's curriculum.

All of these layers of meaning invite us to tell interesting stories. Through a combination of photos, video and text, students can tell the part of the restoration process that they see as important, relevant, and exciting.

## Activity Description

As a class, create a vision for the photo essay. Consider the following questions:

*What is the product?* Do you want to create a photo essay with lots of photographs that largely speak for themselves and minimal text? Are you interested in a book that tells a story through the written word and has photographs to supplement the text? Do you envision a wall display, slide show, book, blog, or a different format?

*What is the story that you want to tell?* What do you want to focus on? Some of the potential angles might include the biological background of the restoration, the site work, the planning behind the work, the educational uses and plans for the prairie, the involvement of different ages of students, community involvement, planting day or the impact of the project. Your project should reflect what you think is the important story.

Divide up into production teams of 5-7 students. Each group will work on a different chapter of the final product. The team should consist of approximately 1-3 photographers, 1-3 writers, 1-3 researchers to gather background information and 1-2 who can do layout of the essay and text into the final presentation format.

Within the teams, develop a detailed outline of what you want to cover, what you want to convey and a timeline for your work.

## Extensions

- Create a video documentary of the restoration effort in a manner similar to that described above. The teams should consist of photographers, script writers, researchers, an interviewer and a narrator.
- A photo essay or a video documentary could be set up so that a new chapter could be added each year documenting the activity and changes in the new year.
- The final product for this production could be Web pages for the school Web site. The site could be regularly updated to involve other students to include photographs, be interactive or could incorporate extensive links to other resources.

## Assessments

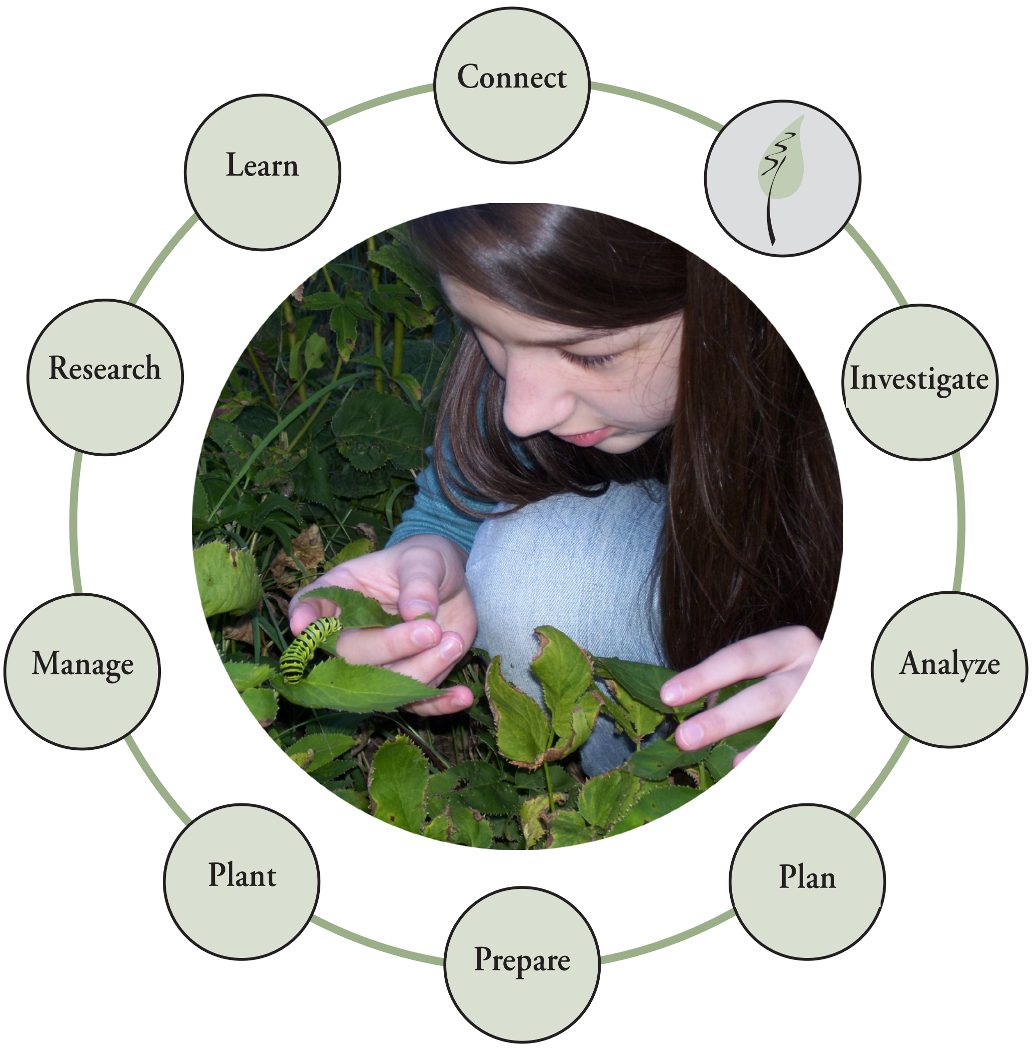
- Develop a rubric for content, clarity, mechanics, innovation and aesthetic of the final presentation.
- Critique the team's ability to support a collaborative team approach, maintain clear roles and responsibilities and work effectively together.


© Earth Partnership • University of Wisconsin-Madison

earth partnership

# Study

## native species, habitats, and ecosystems



# Section Introduction: STUDY

Ecological restoration is a term with many meanings, and it can be applied to different kinds of projects depending on who is doing the restoration and what their goals are. However, a common factor in all approaches to restoration is that it involves some kind of study of the natural world (native plant communities in particular) as a source of information about how people can care for the land and use their influence to promote healthy functioning in their ecosystem.

Studying the natural world requires a kind of attention that modern society does not tend to nurture, especially in young people, who are increasingly disconnected from their natural surroundings. Structured time for observation and reflection ("Observations from a Single Spot") can help learners develop or rekindle a sense of how to connect with the world around them.

It is also important to understand the species and ecological conditions on a site. However, this doesn't mean that learners have to possess special scientific knowledge. For example, getting to know the plants on your site can be viewed as a sensory exploration, and a get-to-know-one-another opportunity, for plants and people alike ("Botany Bouquet"). And extensive plant knowledge is not needed to understand the concept of biodiversity, or what a diversity-rich plant community looks like, and why it is important to encourage such communities ("What's Green and Grows All Over?").

In order to understand the lessons that native plant communities can have for planning, implementing, and caring for a restoration, it is also important to understand the variation that exists between communities, and why ("Ecosystem Observations," "Ecosystem Comparisons"). Knowing about the different types of ecosystems helps in exploring the different restoration opportunities at your site, and determining which ecosystem type or types are the best models for your particular restoration.

Deeper knowledge about plants is accessible for learners at many stages, and can involve a progression from understanding the broad characteristics of different plant classifications ("Plant Families") to learning how to use field guides to identify plants at the species level ("Taxonomy and Field Guide Warm-Up"). Watershed dynamics are also explored, as learners investigate how water moves in general and how it is moving across the landscape of their site in particular ("Waterdrop Journeys," "Water in the Watershed," "Follow the Drop").

Studying the site from multiple perspectives is an important way to gain a rich understanding of what is going on in a particular place. Learning about the differences in ecosystems and plant species is important, as is taking a step back and looking at a site from the "big picture" perspective, attending to its aesthetic and experiential character ("Visual Assessment").


© Earth Partnership • University of Wisconsin-Madison

# Observations from a Single Spot

### Activity Overview
Students observe a single spot and record impressions of it. Later, they return to note the changes in the spot.

### Objectives
Students will:

- Practice observation skills
- Create expressive writing in response to direct observation
- Perceive seasonal and/or phenological changes in a natural setting

### Subjects Covered
Science, Language Arts and Social Studies

### Grades
K through 12

### Activity Time
30 minutes in a natural area; 15 minutes in class

### Season
Any

### Materials
Journal, pen or pencil, clipboards

## Background
Developing observational skills is both an art and a science. Artist and naturalist writer Clare Walker Leslie once stated that "the goal of journaling should be to capture one exceptional moment each day." Making observations from a single spot helps you to recognize those exceptional moments as you take the time, space and effort to enjoy a special place, observing both the large and small details of the area. You can use your senses to smell the richness of the soil, feel the roughness of a leaf or perhaps glimpse a hawk soaring overhead. By revisiting a single spot over time, you can witness seasonal changes that occur each year at about the same time. Focusing on the natural world can also be a springboard for personal reflection.

## Activity Description
Go out to a natural area and select a spot. You will need to sufficiently describe this spot so you can return to it at a later date.

Settle into your place for at least ten minutes without writing. Your teacher will tell you when ten minutes are up. You can begin writing at any time after that.

Get to know your spot. Think, observe and experience it. Write down the things you sense or your thoughts as you sit. Write in any way that you want. You can list observations, write an essay, sketch what you see, compose some poetic lines or just jot down thoughts as they come to you.

Following are some things you may wish to consider:

- What do you see? Look close-up, far away and in between. Examine the soil grain, leaf margin, and decomposing fibers. Examine the waving landscape, distant horizon and things between the two.
- What do you hear? Listen to sounds close-up and far away, loud and soft. Put your ear to the ground and listen to the minute rustlings and hold your head high and listen to the wind.
- What do you feel? Feel the small, big, soft and hard things around you; feel the cool leaf, wet detritus, sharp grass blade, hot wind and hard ground.
- What do you smell? Tune into different smells. Try to smell the soil and the water drops, as well as the breeze, the plant community and the earth.
- What feelings do you have as you sit in your spot?
- What processes are happening on your spot?
- Who or what has been at your spot?
- How is your spot a part of the larger area surrounding it?
- What words describe your spot?

Return and share your observations and insights with others in the class. How were your observations similar and different? Pay attention not just to how things look but how they smell and sound. Try not to overlook the small things that might be staring you in the face. Those are important observations, too.

## Extensions

- Create a personal journal for recording your observations over time.
- Draw a picture of the spot. The drawing can capture a close-up or vista view (see EP activity "Visual Assessment: A Landscape Through an Artist's Eye").
- Create a poem about the spot. The poem could be in haiku, cinquain, diamante or other appropriate form (see EP activity "Schoolyard Poetry").
- Visit your spot monthly and create a record of the changes.
- Make a calendar that describes the changes you witness along with the observations of classmates.

## Assessments

- Create a short story based on your single spot observations.
- Keep a nature journal or portfolio of observations over time.
- Make oral presentations to your peers of your observations and related writings.
- Develop two to three scientific explanations for possible connections among biological and physical things observed in a single spot over time.
- Name two to three plants, animals or insects observed in your "single spot" and then explain how those organisms may have adapted to their environment.


© Earth Partnership • University of Wisconsin-Madison

# Botany Bouquet

### Activity Overview
A warm-up activity which introduces various plant species from the same or different ecosystems and encourages observational, organizational, and taxonomic skills.

### Objectives
Students will:

- Use their observational skills
- Learn how plants differ structurally from one another
- Increase their understanding of plant diversity
- Understand plant names and relationships

### Subjects Covered
Science and Language Arts

### Grades
1 through 12

### Activity Time
30-45 minutes

### Season
Any

### Materials
Sample plant cuttings from one or more ecosystems, representative of native plants that grow (or will grow) on your school grounds

## Background
There are almost 7,000 languages spoken around the world. In North America, you can find many different languages, including English, Spanish, Hmong, French, German, Ojibwe, Ho-Chunk, Arikara, Gwich'in, Onondaga, and many others. Scientific names are another language system, which is based on Latin. For a long time scientists were confronted with the challenge that one plant or animal species could have many different names, depending on what language was spoken. This made it difficult for scientists from different parts of the world to talk about their research.

In 1758 a Swedish biologist, Carl Linnaeus, proposed that everyone should use the same name to describe a given species and proposed a universal naming system now known as "binomial nomenclature" (bi = two, nomen = name, calo = call, so it translates as "two-name name-calling"). The system gives each species two names, based on a group of living things ("genus") and a specific descriptor ("species"). Scientific names are always written with the genus capitalized, the species in lowercase, and the whole name in italics or underlined.

Species within a particular genus are all related. For example, the scientific name for red maple is *Acer rubrum.* "Acer" means maple, and all maples share certain characteristics. There are at least a dozen different kinds of maples in North America though, so "rubrum," which means red, helps describe a specific kind of maple. *Acer saccharum* is sugar maple (*Acer* means maple, *saccharum* means sugar).

Scientific names are helpful for people around the world to communicate with each other about plants, but it is also important to know what people call plants locally. These are known as "common" names, because they are the ones that are used more often when people talk to each other about plants. There are many different common names for any one plant species.

Common names may differ depending upon geography and culture, but they are all useful ways of referring to the same plant. For example, *Artemisia ludoviciana* is known as *nookwezigan* ("soothing grandmother medicine") in Ojibwe, because it is used for spiritual purification and as a healing medicine. In English, it is called different descriptive things by different people, too, depending on where they live and how they use the plant: white sage, silver wormwood, Louisiana sage, Mexican sage, and Garfield tea are all names for this same plant. Of course, other languages may have their own names for this plant as well, depending on where it grows, and what languages are spoken there.

Native American Ojibwe speakers gave native plants names based on the plant's appearance, utility or function, medicinal purpose, food source or spiritual use. The carnivorous pitcher plant (common English name) is named *omakakiiwidaasan*, which means "frog leggings," describing the tubular shape of the leaf. Black ash is called *aagimaak* or "snowshoe-making tree." The edible wild rice is named *menomin*, which translates into "the good seed."

The following activity will help students understand different naming processes and familiarize them with the diversity and unique attributes of species they plant in native plant restorations. Students will learn to closely observe the variety of patterns and shapes of plant parts. The next step can be applying names to what they observe in terms of plant structure (see EP activities "Plant Families" and "Taxonomy and Field Guide Warm-up").

This activity could be a good introduction to a plant unit, or it could be used as a creative and interactive "icebreaker" among a group of students who do not know each other well.

## Pre-Activity Preparation

Prepare a bouquet of plant species representing one or more ecosystems. You will need multiple samples of plants from a handful of different species. Choose three to four species to use and determine the number of samples of each needed for an equal number of students (roughly) to get ther own sample of one of those plants. For example, a group of twenty students might break into four smaller groups of five, which would require five samples each from four different plant species.

## Activity Description

1. Mix the bouquet well and pass out one plant to each person.
2. Those who know the names of the plants being passed out should not share that information until the end of the activity.
3. With plant in hand, students should find others who have the same plant and form a small group. They should introduce themselves if they do not know one another.
4. In the small groups, come up with a creative description of your plant based on close observations. Try to describe it in a way that would help others identify the plant.
5. Come up with a creative name for your plant.
6. Representative(s) from each group should present their plant's creative name and description to the class. If possible, ask one student to describe it in another language.
7. Once each small group has shared their creative name and related plant description, ask the entire group if they know names of the plant. If the name is unknown, share common and Latin names and a further description (especially ecological and human connections) of each plant.

After this activity, discuss as a group why plants have common and scientific names. Robin Wall Kimmerer, an enrolled member of the Citizen Potawatomi Nation and a Botanist, points out in her book, *Gathering Moss: A Natural and Cultural History of Mosses*, that "Latin names we give them [plants] are only arbitrary constructs. If I don't know the official name I give it a name that makes sense to me... What seems to me to be important is recognizing them, acknowledging their individuality. In indigenous ways of knowing, all beings are recognized as non-human persons, and all have their own names. It is a sign of respect to call a being by its name, and a sign of disrespect to ignore it. Words and names are the ways we humans build relationship, not only with each other, but also with plants."

## Extensions

- Select a plant, write its name and four observations, describe your plant in botanical terms, and explain where it lives and its role in the ecosystem.
- Visit the library to further research the plants used in this activity, their habitat preferences, and their human uses. Expand on the activity to include different plants and animals that would be found in the habitat you are restoring on your school grounds.
- Complete EP activity "Plant Families" to learn more about plant structure and identification.


© Earth Partnership • University of Wisconsin-Madison

## Assessments

- Investigate a species with many common names.  Find the origin of those names to discover what they have in common.
- Create a mobile with drawings illustrating various plants and their unique physical characteristics. Include the scientific and common names on the mobile.
- Write a short story describing a plant species used in this activity, the human uses of the plant (e.g., medicinal uses), common names, and the root words of the plant's scientific name.
- Research a plant species. Describe its characteristics, the habitat where the species is most likely found, and common human uses. Make an oral report and conduct peer reviews.

*Educators examining plants during Botany Bouquet at the 2014 LEP institute in Madison, WI. Photo: Maria Moreno.*

# What's Green and Grows All Over? Studying Ecosystem Biodiversity

**Activity Overview**
Students compare the biodiversity of a natural or restored ecosystem with a lawn or other cultivated "ecosystem."

**Objectives**
Students will:

- Understand issues related to species biodiversity and distribution
- Collect and interpret data to answer a question
- Graph data and extract, interpret and use information presented in the graph
- Explore and determine best data collection procedures

**Subjects Covered**
Science, Math

**Grades**
4 through 12

**Activity Time**
45 minutes - 1 hour

**Season**
Late spring, summer, early fall

**Materials**
For each group:1 hula hoop or four equal-length sticks (30 cm) to form quadrats, index card, tape, notebook, pencils, and two accessible ecosystems to compare—one natural or restored, and one cultivated, such as a lawn.

## Background

Biodiversity means the variety of all living organisms in an area—all species of plants, animals, and microorganisms. It can also be summarized as the "totality of genes, species, and ecosystems of a region," or simply "life on earth." Biodiversity is generally described in these ways:

- Species diversity—the different types of living organisms
- Genetic diversity—the variability of genetic information between individuals of a species
- Ecosystem diversity—the variety of habitats as well as the variety of ecological processes and interrelationships within the ecosystem

Species diversity, together with the interrelationships between species, is important because it enhances the stability and resilience of an ecosystem. Genetic diversity is important not only for the healthy reproduction of each species, but for its survival and adaptability when the environment changes. The more diverse the gene pool, the more likely it will contain traits that allow the species to adapt. Ecosystem diversity provides the life support system for us all. It provides us with "ecosystem services" such as fresh air, clean water, soil fertility, flood and drought control, and climate regulation. It supplies us with food, medicine, and natural resources. It gives us economic benefits and natural beauty, improving our quality of life. Finally, it allows us to find a personal connection to nature.

Currently, the rate of biodiversity loss and species extinction is one of the highest the earth has ever experienced, and it is caused by human activity. E.O. Wilson uses the acronym HIPPO to describe the causes of biodiversity loss: Habitat destruction, Invasive species, Pollution, OverPopulation, and Overharvesting.

### A Prairie Example

The prairie is so rich in wildflowers that, on average, a new plant species comes into flower almost every day during the summer. Nearly 300 prairie plants have evolved living closely together; more plant species are found per acre of prairie than in almost any other ecosystem acre. In contrast, our lawns have only a few species—often northern European plants such as clover and plantain—and some have only one plant in them: Kentucky bluegrass. Any small area of prairie or lawn may have only a few different kinds of plants. However, several acres of prairie will have dozens and even hundreds of different kinds of plants. Several acres of lawn usually have only the same five or six species.

The presence of enough plant biodiversity ensures that some can withstand whatever stress nature provides, be it fire, flood, drought, disease, or insects. Diverse fields are more likely to include plants that can tolerate the stress. For example, the more diverse the plant community, the less productivity declines when rainfall is below normal, and the faster it recovers. Research indicates that after a dry spell, land with many species regains productivity within a year, while areas with five or fewer species can take over four years to recover. In a biodiverse field, the stress-tolerant plants use nutrients freed


© Earth Partnership • University of Wisconsin-Madison

up by the loss of less fit species, and this helps to maintain the overall productivity of the ecosystem.

## Taking an Inventory

This activity provides students with an opportunity to sample and compare the plant biodiversity of different sites. For this exercise, plant biodiversity is defined as the number of different plant species on a site. Sites that would provide interesting comparisons include a lawn, an old field, a one-year restoration, an older restoration or a remnant. The activity could also easily be adapted for woodland or other environments.

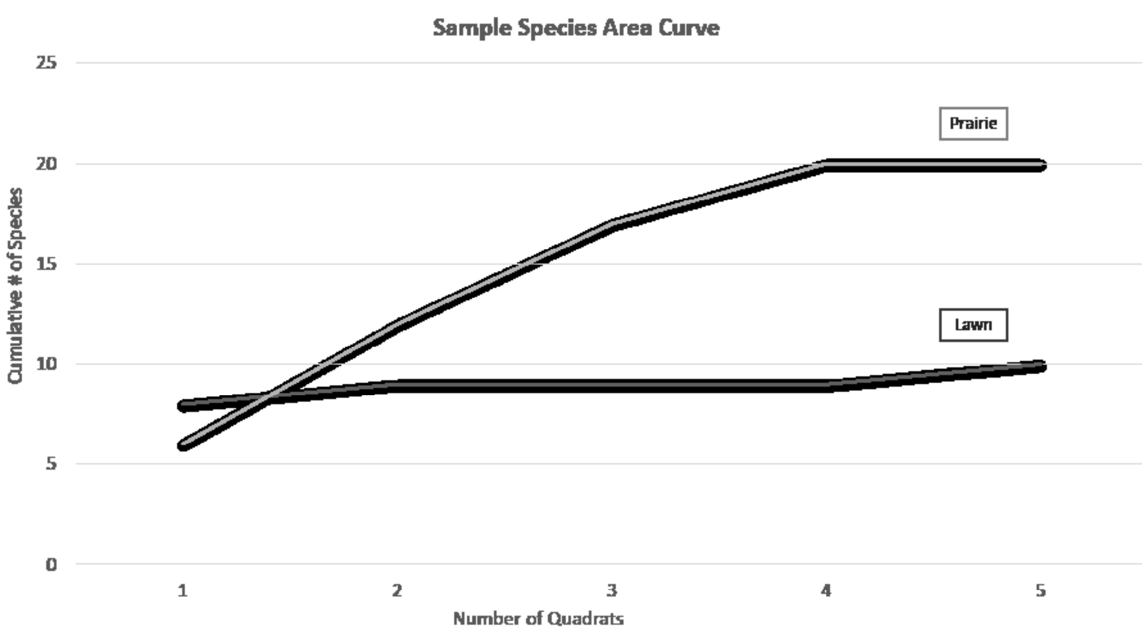
The most direct way to inventory the number of different plant species on a site is to count them. However, one usually cannot count all species in an ecosystem; instead, scientists sample a small portion of the area and use this sample to estimate the diversity of the whole area under investigation. These sampling areas, or “quadrats,” can be of any known size or shape and are often randomly distributed and sufficiently numerous so that the number of species found within the quadrats is representative of the entire population.

In many cases, a single prairie quadrat will have fewer species than will a quadrat taken from a lawn. However, this is not due to lower biodiversity. Prairie species tend to clump together, whereas lawn species are distributed in a more heterogeneous pattern. Therefore, a single quadrat may “capture” most of the lawn species but only a few of the prairie species. Subsequent lawn quadrats will reveal few new species, while subsequent prairie quadrats will contain numerous new species.

## The Species Area Curve

The Species Area Curve helps reveal this distribution pattern. The sample Species Area Curve below compares the cumulative number of species encountered versus the number of quadrats sampled for a lawn compared to a prairie. The graph levels off when sampling additional quadrats encounter no new species. Note that after several quadrat samples, the total number of species found in the prairie exceeds that of the lawn.

In addition to comparing ecosystems, the Species Area Curve is a useful tool in determining whether students have sampled enough quadrats to assess the diversity of the area. The number of sampling quadrats needed depends in part on the nature of the diversity and spatial distribution of the vegetation being sampled. As long as the graph continues to rise, students are still finding new species, and more quadrats are needed to inventory the ecosystem completely. At the point when the Species Area Curve levels off, a sufficient number of quadrats likely will have been sampled to accurately assess the species diversity.



## Activity Description

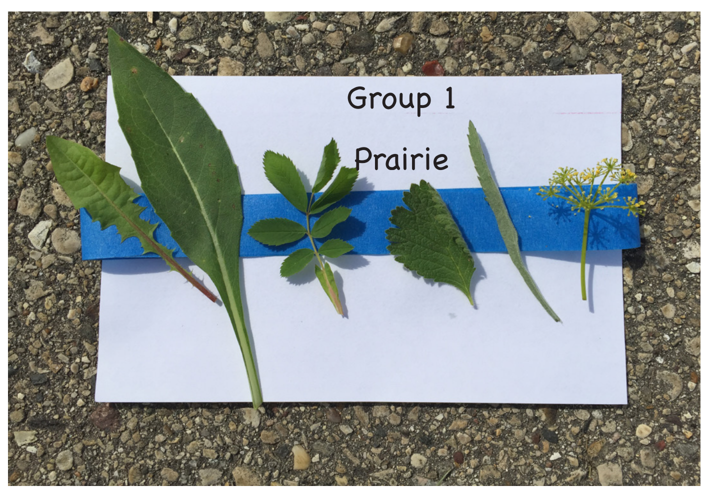
*Note: These instructions are written for a comparison between a prairie and a lawn; they can easily be adapted for woodland or other ecosystems. Make sure students are aware of poisonous or dangerous plants in the area.*

Divide into research teams. Each team should take an index card with a large loop of masking tape on it, a notebook and pencils, and either a hula hoop (for a round quadrat) or four sticks of equal length (for a square quadrat). Randomly choose a spot in the prairie for the first quadrat by throwing the hoop or a stick over your shoulder. If you are doing an annual survey of your restoration, you may have permanent sampling plots set up.

Count the number of different species of plants in your quadrat. If the plants are very small, place a small leaf of each species on the tape (generally appropriate for spring studies). If the plants are large, sketch the leaf on the index card or in your notebook and note any other identifying traits, as pictured. Identification of the plants is not necessary, only differentiation by leaf type or other characteristic. Repeat the process in a lawn.

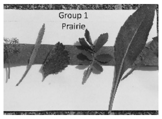
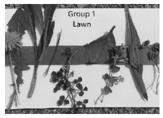
Rejoin the class and examine the cards and sketches. As a class, plot the number of species found in one group's quadrat on a Species Area Curve. A second group should then examine their data to see if they found additional species that the previous group did not mention. Plot the second data point by taking the number of species found by the previous group and adding to it the number of additional species found by the second group (i.e., plot the new cumulative total number of species).


On the following page is an example of how the class findings can be collectively organized before the graphing portion of this activity. Here, Group One found six species on the prairie. Group Two found eight species that Group One did not find, bringing the cumulative number of prairie species to 12. Similarly, Group One's lawn card indicates they found eight species. The card for Group Two indicates they found one additional plant in their quadrat, bringing the total lawn species to nine. Continue to complete the cumulative totals until all group cards are compiled. Based on the totals for each group, students can graph these data points and create a Species Area Curve. Plot the new cumulative total of species for each group, continuing through all the groups. Create separate curves for each ecosystem sampled. Determine the average number of species per plot and the total number of species found by the class.





© Earth Partnership • University of Wisconsin-Madison

| Prairie: Cards | Lawn: Cards | Prairie: # of NEW species found | Prairie: # of CUMULATIVE species found | Lawn: # of NEW species found | Lawn: # of CUMULATIVE species found |
|---|---|---|---|---|---|
|  |  | 6 | 6 | 8 | 8 |
| Group 2 Prairie Card | Group 2 Lawn Card | 6 | 12 | 1 | 9 |
| Group 3 Prairie Card | Group 3 Lawn Card | 5 | 17 | 0 | 9 |
| Group 4 Prairie Card | Group 4 Lawn Card | 3 | 20 | 0 | 9 |
| Group 5 Prairie Card | Group 5 Lawn Card | 0 | 20 | 1 | 10 |

## Extensions

- Record the number of insects, spiders and larger animals in each quadrat. Become a sleuth and find as many traces of animals as possible. Traces of animals can include decayed leaf matter, a litter layer in the soil, a gnawed leaf, a spotted or slightly diseased leaf, a spider's web, and so on.
- Repeat this study each year in your restoration to monitor the change in the restoration as it matures.
- Instead of randomly selecting the quadrat spot, sample a spot that you consider to be representative of the prairie. How does this change the results?
- For older students: Identify the plants in your plot. Identification of plants prior to blooming is very difficult, but a good key should allow identification of all blooming plants.

## Assessments

- Write a short essay explaining sampling methods, results, and related Species Area Curves for the restoration and lawn sampling areas.
- Create visual displays (e.g., graphs, tables) of results and Species Area Curves. Make oral presentations of findings and conduct peer reviews of these reports.
- Explain the various species distributions in the quadrats. Propose and implement additional research to determine possible impacts of the species distribution between lawn and restoration site.

# Ecosystem Observations

### Activity Overview
Students visit an ecosystem with a set of observation cards to familiarize themselves with that ecosystem at different times of year.

### Objectives
Students will:

- Experience a natural setting through firsthand contact
- Practice observation skills at different times of year
- Observe adaptations in life forms
- Develop a vocabulary to communicate impressions and observations
- Draw observed subjects

### Subjects Covered
Science, Math, Language Arts, and Visual Art

### Grades
K through 8

### Activity Time
1-2 hours, depending on time spent observing, distinguishing, and identifying plants and animal life

### Season
Any

### Materials
Observation cards, writing utensils, clipboards, measuring sticks

## Background
An important first step in studying or restoring an area is to get to know the model ecosystem. Students, as well as adults, may have had little firsthand experience with the ecosystem in question. While background material is important, students must have an opportunity for themselves to experience the natural model that they are going to restore.

Our first encounter with an ecosystem should include observing, exploring, and interacting with the area. It is fine for identification to come later. Too often we can get bogged down in identification and fail to open our eyes to other things going on.

Providing some direction and focus will help students make observations and personalize their experience. There are many ways to provide this direction. Following this page are masters of observation cards. These cards offer a set of possible observations. These cards can be modified and customized to fit the needs and interests of students, the curriculum, ecosystem, season, available time, etc. You could also make reproducible cards that challenge students to consider other things, such as pattern, texture, food webs, water dynamics and/or cultural considerations.

## Activity Description
In this activity, you will visit the riparian zone of the water-body we have chosen to study. Before beginning, discuss the boundaries within this ecosystem where the class will make your observations. Staying within these boundaries is important for the students' own safety and for the safety of any wildlife that may be in the area. Encourage the group to move slowly and carefully so as not to damage the plant life in the study area or create an erosion problem.

Each student will have a set of observation cards. They can work in pairs or individually to complete the observation cards outdoors.

Back in the classroom, everyone will share their observation cards with the class, and then compile the results as a group. What surprises, if any, did they find in the observation area? What plants and animals did they see or hear? How might this area differ from another area like a woods, schoolyard, prairie, or other ecosystem? What might they expect to observe during another season of the year?

## Extensions
- Use the words generated on the "What's Happening" card as the basis for a creative writing or poetry exercise.
- Assemble the appropriate cards to make a classroom book of your observations.
- Create a guidebook for others who might visit your site.
- Create a mobile or diorama of the things you observed in this habitat.
- Graph findings from the "Take a Look" tallies. Compile data from the "Take a Look" cards for a biodiversity study. See EP activity "What's Green and Grows All Over?"


© Earth Partnership • University of Wisconsin-Madison

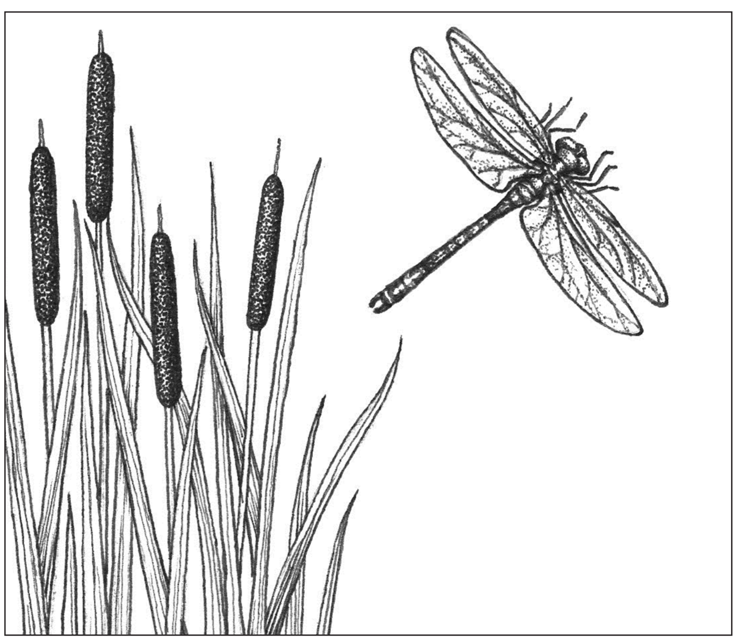
# Ecosystem Observations (cont.)

- Develop a computer database to file information collected for comparisons over time.
- Imagine that you are a small creature, such as a frog, dragonfly, or common yellowthroat living in this wetland (pond creek, lake, etc.). What makes this place a good place for you to live? What makes it not so good?
- Create a phenology wheel that describes your observations throughout the year. See EP activity "Phenology Wheels: Enhancing a Sense of Place".

## Assessments

- The quality of work in the booklet can be used for assessment.
- Compare and explain the similarities and differences of your observations from different times of the year.
- Describe the food web in this habitat, using text and/or visuals.
- Describe some of the adaptations you observed in the aquatic plants and animals.

# Ecosystem Observations



Name: ________________________________ Date: __________________________



© Earth Partnership • University of Wisconsin-Madison

# What's the Weather?


Air
Temperature

**Air Feels: (circle one)**
HOT WARM COOL
COLD

**Wind:**
CALM BREEZY WINDY
GALE

**Precipitation:**
NONE RAIN SNOW

**Light:**
SUNNY CLOUDY
PARTLY CLOUDY

---

# Show Me

Draw the smallest thing you see

Draw your favorite thing

Draw the biggest thing you see

© Earth Partnership • University of Wisconsin-Madison

# What's Happening?

| Listen | Look | Touch | Smell |
| --- | --- | --- | --- |
| Write 3 words that describe what you **hear** | Write 3 words that describe what you **see** | Write 3 words that describe what you **feel** | Write 3 words that describes what you **smell** |
| ________________ | ________________ | ________________ | ________________ |
| ________________ | ________________ | ________________ | ________________ |
| ________________ | ________________ | ________________ | ________________ |

# Insect Observations

Find an insect and observe what it is doing. Draw or describe what you see.

| Insect on the ground | Insect in the air |
| --- | --- |
| | |



© Earth Partnership • University of Wisconsin-Madison

Seeds Seeds

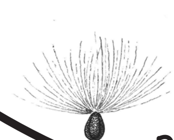
**Hitchhikers**

Find seeds that will stick to your clothing.

**Animal Express**

Find a berry or a nut.

Find seeds that are carried by the wind.



**Parachutes**

Find a very small seed.

**Micro-seeds**

Find an example of each seed type. Draw or tape your seed to your booklet.

# Leaf Size Measurements

Draw a **smaller** plant leaf here.

Name_______________________________

Leaf Length (from base to leaf tip):

_______________________________

Leaf Width (at widest point):

_______________________________

Surface Area (width x length):

_______________________________

Draw a larger plant leaf here.

Name_______________________________

Leaf Length (from base to leaf tip):

_______________________________

Leaf Width (at widest point):

_______________________________

Surface Area (width x length):

_______________________________

© Earth Partnership • University of Wisconsin-Madison

# Take A Look in Spring

| | | | |
|---|---|---|---|
| Different Colors | Plants that reach the top of your shoes | Plants that reach your knees | Signs of Animals |
| Birds or Bird Calls | Flowers / Seeds, Nuts and Berries | Butterflies / Other Insects | Spiders |

Tally how many you find (like this ~~IIII~~ )

# Take A Look in Summer

| | | | |
|---|---|---|---|
| Different Colors | Plants that reach over your head | Leaves bigger than your hand | Signs of Animals |
| Birds or Bird Calls | Flowers / Seeds, Nuts and Berries | Butterflies / Other Insects | Spiders |

Tally how many you find (like this ~~IIII~~ )


© Earth Partnership • University of Wisconsin-Madison

# Take A Look in Fall

| | | | |
|---|---|---|---|
| Different Colors | Plants that reach over your head | Leaves bigger than your hand | Signs of Animals |
| Birds or Bird Calls | Flowers / Seeds, Nuts and Berries | Butterflies / Other Insects | Spiders |

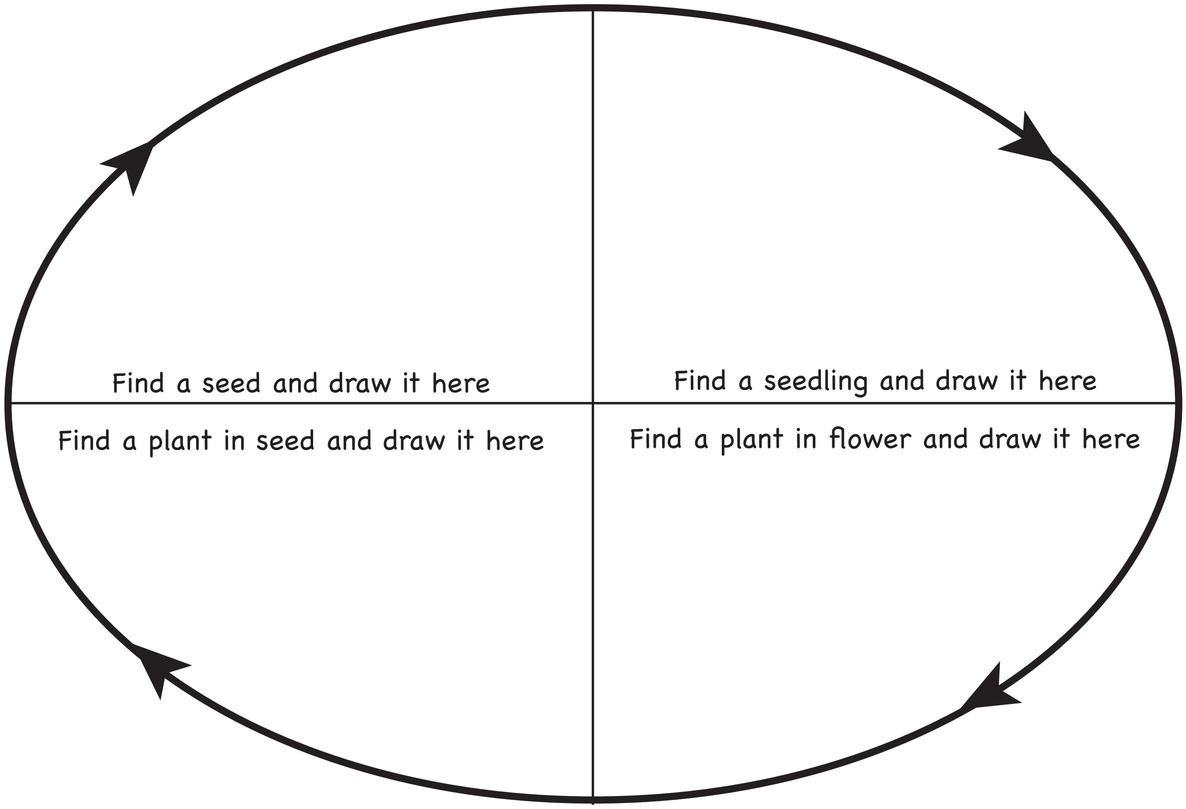
Tally how many you find (like this ~~IIII~~ )

# Take A Look in Winter

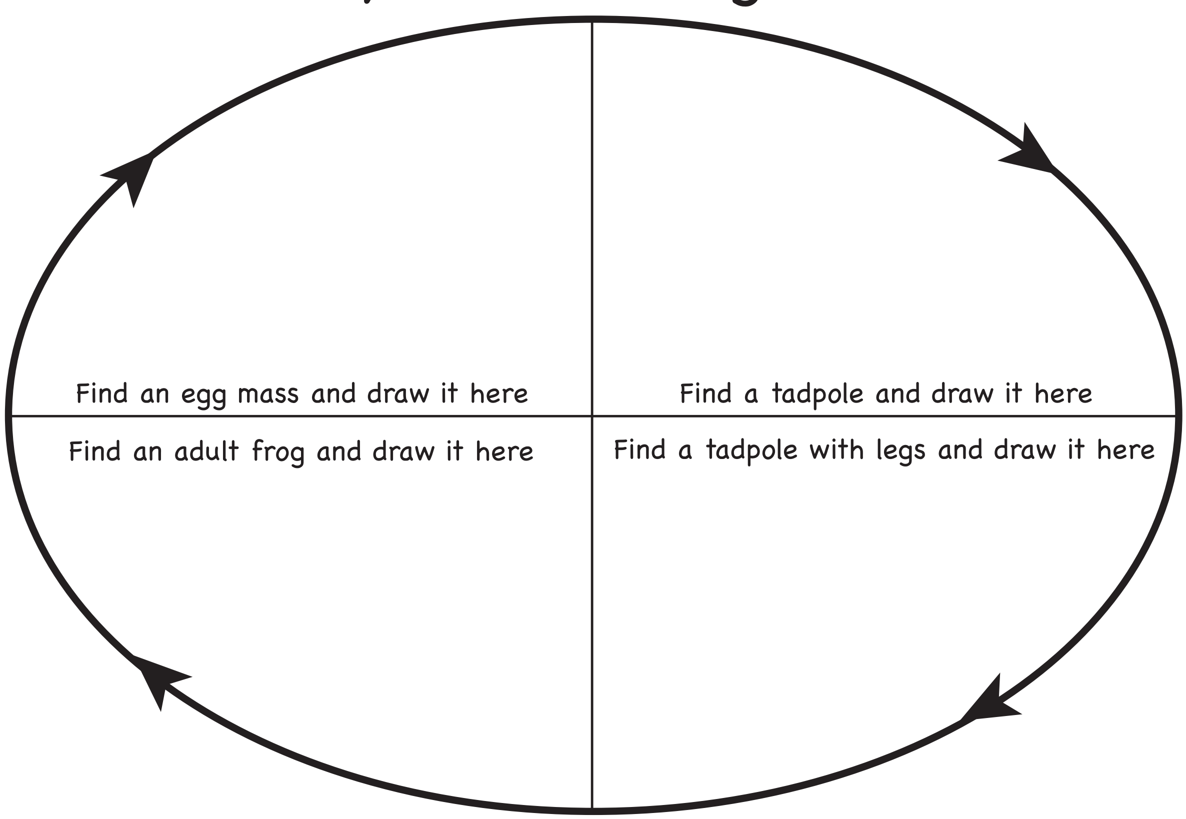
| | | | |
|---|---|---|---|
| Different Colors | Plants that reach over your head | Green Plants (hint: look under the snow) | Animal Tracks |
| Birds or Bird Calls | Seeds, Nuts and Berries | Bird, Insect, or Animal Shelters | Types of People Tracks |

Tally how many you find (like this ~~IIII~~ )

# Life Cycle of a Plant




# Life Cycle of a Frog or Toad





© Earth Partnership • University of Wisconsin-Madison

# Ecosystem Comparisons

**Activity Overview**
Students collect data to compare similarities and differences between two ecosystems and plant adaptation strategies for survival in each.

**Objectives**
Students will:
- Develop explanations for the connections between biological and physical things in two environments
- Observe the differences and similarities between two communities
- Discover and understand how plants adapt to environmental conditions
- Collect and compare data

**Subjects Covered**
Science and Math

**Grades**
3 through 12

**Activity Time**
1.5 hours, which can be divided into 2 sessions

**Season**
Fall or Spring

**Materials**
One 2-meter transect line (made of 2 tent stakes, 2+ meters of brightly colored rope, with each end of rope tied to one stake, distance between each stake exactly 2 meters) OR quadrat sticks (made of conduit pipe cut into four 1/2-meter lengths, spray-painted orange; when used, the sticks will be laid out on the ground in a square frame).

1 thermometer, 1+ soil thermometers, field sheets, clipboards, pencils, jar of bubbles

ALSO, for Version A: Upham Woods Digital Observation Technology Skills (DOTS) kit

**Source**
DOTS Kits connections provided by UW-Extension/Upham Woords Outdoor Learning Center

## Background

As students begin a restoration project, they need to understand the ecology and habitat requirements of the community they are restoring. As they study and compare two ecosystem models, students develop a clear understanding of how plants adapt to their environment and what conditions they need to survive. This knowledge will help them to select suitable plants for their site.

A study area will need to be defined. Two common methods for laying out an area are to use *quadrats* or *transect*s. When using a quadrat, a physical frame is laid on the ground in a random location, marking the boundaries of the study area. When using a transect, two stakes connected by a straight line are inserted into the ground, and the study area is bounded by a measured distance on either side of the line. For this activity, it's recommended that you use either a 1/2-meter quadrat frame, or a 2-meter transect line (measuring a quarter-meter on either side of the line). Ideas for how to make quadrats and transects are included in the **Materials** section of this activity.

The following descriptions are typical examples of how groundlayer plants adapt to light availability, wind, and moisture in woodland, prairie, and wetland ecosystems. See EP activities “Prairie Scavenger Hunt: Studying Plant Adaptations” and “Woodland Scavenger Hunt: Studying Plant Adaptations” for more information.

### Woodland (woods and forests)

- Phenology: 1/2 of the groundlayer plants bloom in the spring before the canopy leaves are fully extended. Spring ephemerals appear, bloom, set seed, then die back before the canopy is full.
- Leaf shapes of groundlayer: Leaves tend to be wide, umbrella-shaped (to capture light), with arching habits and are often three-parted.
- Tree biomass: 2/3 above ground; 1/3 below ground. The biomass accumulates in long-lived, above ground parts.

### Prairie (grasslands and meadows)

- Phenology: 1/4 of the plants bloom in spring; 1/2 in summer, of which 1/2 bloom in late summer; and 1/4 bloom in the fall.
- Leaf shapes: Leaves tend to be narrow to reduce water evaporation.
- Plant biomass: 1/3 above ground; 2/3 below ground. Vegetation dies back above ground each year.

### Wetland (marshes, wet meadows, wet prairies, sedge meadows, and fens)

- Phenology: fewer than 1/4 of the plants bloom in spring, primarily in June; over 1/2 in summer; and 1/4 bloom in the fall. Flowering in the spring is delayed because water in the soil from floods slows the warming of the ground.
- Leaf shapes: Leaves may be wide or narrow. Some woodland groundlayer species will grow in a wetland. The moist soil compensates for evaporation from the direct sunlight.

- Plant biomass: 1/3 above ground; 2/3 below ground. Vegetation dies back above ground each year.

The activity includes two activity levels for comparing ecosystems. In version A, students use Digital Observation Technology Skills (DOTS) kits developed by the Upham Woods Outdoor Learning Center in the Wisconsin Dells. Students look at location, air and soil temperatures, soil moisture, surface litter, wind speed, humidity, the visible sky, temperature gradients, different kinds of plants, evidence of animals, water quality, what they notice and wonder, and how they feel in the ecosystem.

Version B includes air and soil temperature, soil moisture, signs of animals, and soil color and contents. They also investigate surface litter, estimate wind speed and plant heights, determine percent of sunlight reaching the ground and percent cover in a square meter and consider aesthetics and how they feel in the ecosystem.

## Activity Description

Prairies, wetlands, and woodlands are natural communities that have different sets of plants, insects, animals, soils, and microenvironments. But there are also similarities—each community has a basic set of requirements to survive as a healthy, balanced ecosystem. Plants in each community need sun, water, and space, and the component parts of each ecosystem must share a myriad of interrelationships in order to succeed.

In this activity you will examine, record, and compare the biological and physical factors that are part of two communities. You will investigate the soils, surface litter, air and soil temperatures, wind speeds, light availability, plants and animals. You will also assess your perceptions and feelings in each community.

The objective is to observe the differences and similarities between the two communities, then to analyze and infer how the plants and animals have adapted to their particular habitats.

*Make sure students are aware of poisonous or dangerous plants in the area.*

### **Version A** (using DOTS Kits)

1. Divide into teams of 7-9. Assign roles to each team member: Recorder, Navigator, Thermal Imager, Thermal Investigator, Meterologist, Media Specialist, Water Monitor, and two Microbiologists.
2. Insert soil thermometers to one-inch and three-inch depths.
3. Lay out a quadrat or transect line to define an area to study.
4. Using your field sheet, collect data in the first ecosystem for 30 minutes.
    - Location: Use the GPS unit to determine latitude, longitude, and altitude
    - Soil moisture: Place your hand directly on the soil to feel how damp or dry the soil feels.
    - Surface litter: Examine the dead material (leaves, stems, etc.) on the surface of the soil. List what you see.
    - Soil temperature: Record the temperatures on the soil thermometers.
    - Weather: take measurements with the Kestrel weather station device
    - Wind speed scale: Estimate the wind speed on a scale of zero (no wind) to ten (strong wind), using a jar of bubbles. Bubbles will drop immediately in little or no wind; bubbles will stay up in the air and move quickly in a strong wind.
    - Canopy: Look straight up. Estimate on a scale of zero to one hundred how much of your visible field is obscured by tree cover, and by cloud cover. Next use the lux meter to determine brightness.
    - Heat: use the infrared thermometers to determine which are the hottest and coldest objects in your area, and what their respective temperatures are.
    - Plants: How many different kinds do you see in each category? It is not necessary to identify the plants. Count the number of kinds of plants having three different leaf widths—grasslike (very thin), thin (less than four fingers

wide), and broad (wider than four fingers). Count the different kinds of plants with fuzzy or waxy leaves, blooming, or in seed. Plants may be counted in more than one category. What is the purpose of these adaptations?

- Evidence of animals: Look along your transect and list the number of insects and spiders. Search for evidence of animals such as animal tracks, chewed leaves, and animal droppings.
- Microbiology: use the digital microscope and mini iPad to examine an object of interest.
- Water quality: take measurements with the Oakton multi-parameter tester.
- Media: take photos and video that capture something interesting about the site and that show your team in action using the tools.
- Finally, use the guiding questions on the sheet to explore your experiences of the site.

5. Repeat in the second ecosystem.
6. Return to the classroom to discuss your findings.
7. Questions for discussion:
    - In what ways are the two communities alike? How are they different?
    - What causes the similarities and differences between the two ecosystems?
    - Did you observe connections between biological and physical things in each environment?
    - What characteristics such as leaf size, leaf shape, and blooming time did plants exhibit to adjust to their environment?
    - How can different plants affect each other?
    - In what ways are plants and animals interdependent? Consider at least three examples.
    - How would this study change at a different time of year?

### Version B

1. Divide into teams.
2. Hang or place the air thermometer in the first ecosystem to be studied. Then insert soil thermometers to one-inch and three-inch depths.
3. Lay out a quadrat or transect line to define an area to study.
4. Using your field sheet, collect data in the first ecosystem for 30 minutes.
    - Soil moisture: Place your hand directly on the soil to feel how damp or dry the soil is.
    - Soil color and contents: Take a soil sample with a soil probe and record your observations.
    - Surface litter: Examine the dead material (leaves, stems, etc.) on the surface of the soil. Estimate the depth of litter and list what you see.
    - Air movement: Observe leaf movement to estimate air movement at canopy (if in the woodland), shoulder and ankle heights. Estimate air movement on a scale of 0 (no wind) to 10 (strong wind). Leaves are motionless in little or no wind; tree branches move in a strong wind. Use a jar of bubbles, if desired. See wind speed scale in elementary/middle school level instructions.
    - Percent sunlight: Estimate how much sunlight reaches your shoulders and the ground.
    - Percent cover: Examine your study area and estimate the percent cover of grasses, forbs or wildflowers, mosses and lichens, fungi, and bare ground or surface litter.

- Characteristics of plants: Describe representative plant forms, leaf sizes and shapes, flowers or fruits.
- Average height: Estimate the heights of the herbaceous, shrub and tree layers.
- Evidence of animals: Look in your study area and list the number of insects and spiders Search for evidence of animals such as animal tracks, chewed leaves, and animal droppings.
- Aesthetics: Describe patterns, textures, colors and contrasts in the ecosystem.

5. Repeat activity in the second ecosystem.
6. Return to the classroom to discuss your findings.
7. Questions for discussion:
   - What methods did you use to estimate plant heights, percent cover, and percent sunlight?
   - In what ways are the two communities alike? Different?
   - What causes the similarities and differences between the two ecosystems?
   - What connections did you observe between living and nonliving things in each environment?
   - What characteristics such as leaf size, leaf shape, and blooming time did plants exhibit to adjust to their environment?
   - Will the information you collected help you design your ecological restoration?
   - How can different plants affect each other?
   - In what ways (consider at least three) are plants and animals interdependent?

## Extensions

- Compare other communities such as savanna, wetlands, old fields, and woodlands in different stages of succession.
- Organize and display your findings using graphs, tables, charts, and diagrams.
- Develop your own questions and collect related data to better understand dynamics within an ecosystem.
- Collect this information over time and through different seasons of the year to create a phenological history of the site.
- Create artwork and poetry based on the aesthetic information you observed about patterns, textures, colors, and contrasts in the various ecosystems.
- Use this activity in conjunction with EP activity "Winter Ecology Observations in Your Watershed."

## Assessments

- Provide examples of differences among biological and physical things within the ecosystems, and provide possible reasons for those differences.  Think about adaptations.
- Create poems or a creative writing piece about experiences in the ecosystems studied.
- Explain the various measurements taken in the ecosystems studied. Explain how the results of the measurements were similar and different.
- Create visual displays (e.g., graphs, tables) of findings and observations.• What characteristics such as leaf size, leaf shape, and blooming time did plants exhibit to adjust to their environment?
  - Will the information you collected help you design your ecological restoration?
  - How can different plants affect each other?
  - In what ways (consider at least three) are plants and animals interdependent?


© Earth Partnership • University of Wisconsin-Madison

# **Ecosystem Comparisons: Field Sheet A** (for use with DOTS Kits)

*Items with a * can be measured with tools from DOTS (Digital Observation Technology Skills) Kits, developed by Upham Woods Outdoor Learning Center/UW-Extension*

**Name(s)**: ______________________________ **Today's date**: ________

**Ecosystem**: ______________________________

***Location** (*use GPS unit*):

____________ Latitude

____________ Longitude

____________ Altitude (ft)

**Soil Moisture** (check one):

_____ Wet _____ Moist _____ Dry

**Surface Litter** (describe):

____ **Air Temperature** (°F) ____ **Soil Temperature** (°F)

***Weather** (*use Kestrel Weather Station*):

_____ Wind Speed (mph)

_____ Wind Direction

_____ Humidity (%)

**Wind Speed** (use bubble wand):

| 0 | 5 | 10 |
|---|---|---|
| No wind (bubbles float straight down) | | Strong winds (bubbles blow far) |

**Canopy**:

_____ *Lux/Brightness (lx) (*use Lux Meter*)

_____ Estimated Canopy Cover (%)

_____ Estimated Cloud Cover (%)

***Heat**
(*use Fluke Infrared Visual Thermometer*):

Hottest Object:

Coldest Object:

(*use Kintrex Infrared Thermometer*):

____ Hottest Object Temperature (°F)

____ Coldest Object Tempareture (°F)

**Ecosystem**: ______________________________

***Location** (*use GPS unit*):

____________ Latitude

____________ Longitude

____________ Altitude (ft)

**Soil Moisture** (check one):

_____ Wet _____ Moist _____ Dry

**Surface Litter** (describe):

____ **Air Temperature** (°F) ____ **Soil Temperature** (°F)

***Weather** (*use Kestrel Weather Station*):

_____ Wind Speed (mph)

_____ Wind Direction

_____ Humidity (%)

**Wind Speed** (use bubble wand):

| 0 | 5 | 10 |
|---|---|---|
| No wind (bubbles float straight down) | | Strong winds (bubbles blow far) |

**Canopy**:

_____ *Lux/Brightness (lx) (*use Lux Meter*)

_____ Estimated Canopy Cover (%)

_____ Estimated Cloud Cover (%)

***Heat**
(*use Fluke Infrared Visual Thermometer*):

Hottest Object:

Coldest Object:

(*use Kintrex Infrared Thermometer*):

____ Hottest Object Temperature (°F)

____ Coldest Object Tempareture (°F)

# **Ecosystem Comparisons: Field Sheet A** (for use with DOTS Kits)

**Plants:** How many different kinds do you see?

_________ Grasslike
_________ With broad leaves (wider than 4 fingers)
_________ With thin leaves (narrower than 4 fingers)
_________ With fuzzy, waxy, or rough leaves
_________ With flowers
_________ With seeds

**Evidence of Animals**:

***Microbiology** (*use Digital Microscope*):

Description of Object:

***Water Quality** (*use Oakton Meter*):

_________ Water Temperature (°F)

_________ pH

_________ Conductivity (µS)

_________ Total Dissolved Solids (ppm)

_________ Salinity (ppm)

***Media** (*use Camera*):
Description of photo:

Description of video:

**What did you notice about this site?**

**What did you wonder more about when you were at this site?**

**What did this site remind you of?**

**Plants:** How many different kinds do you see?

_________ Grasslike
_________ With broad leaves (wider than 4 fingers)
_________ With thin leaves (narrower than 4 fingers)
_________ With fuzzy, waxy, or rough leaves
_________ With flowers
_________ With seeds

**Evidence of Animals**:

***Microbiology** (*use Digital Microscope*):

Description of Object:

***Water Quality** (*use Oakton Meter*):

_________ Water Temperature (°F)

_________ pH

_________ Conductivity (µS)

_________ Total Dissolved Solids (ppm)

_________ Salinity (ppm)

***Media** (*use Camera*):
Description of photo:

Description of video:

**What did you notice about this site?**

**What did you wonder more about when you were at this site?**

**What did this site remind you of?**


© Earth Partnership • University of Wisconsin-Madison

# Ecosystem Comparisons: Field Sheet B

Name: ________________________ Date: __________ Time: __________ Weather: ____________________

| Questions | Ecosystem: | Ecosystem: |
|---|---|---|
| Air Temperature | | |
| Soil Temperature 1" deep | | |
| Soil Temperature 3" deep | | |
| Soil Moisture (wet, moist, dry) | | |
| Soil Color (light or dark, gray, brown, black or red, etc.) | | |
| Soil Contents | | |
| Litter Depth and Contents | | |
| Air Movement: Scale 0 - 10<br>0 5 10<br>No wind Strong wind | | |
| Percent Sunlight | | |
| Percent Cover: Grass | | |
| Percent Cover: Flowering Plants | | |
| Percent C.: Mosses & Lichens | | |
| Percent Cover: Fungi | | |
| Percent C: Bare ground/litter | | |
| Characteristics of Flowering Plants and Grasses | | |
| Average Height: Tree Layer | | |
| Average Height: Shrub Layer | | |
| Average Height: Groundlayer | | |
| Signs of Animals (include insects and worms) | | |
| Aesthetics: Patterns | | |
| Textures | | |
| Colors | | |
| Contrasts | | |
| | | |

# Plant Families

### Activity Overview
Students learn the science of taxonomy while studying plant families represented in their schoolyards, in an ecological restoration or in their region.

### Objectives
Students will:

- Observe and identify flower, fruit and leaf structures of plants
- Identify and recognize patterns and characteristics that group plants into families
- Understand the science of taxonomy in classifying and naming organisms

### Subjects Covered
Science

### Grades
6 through 12

### Activity Time
25 minutes per plant family

### Season
Summer and fall

### Materials
Plant specimens in flower or seed, hand lens, observation sheets and pencils

## Background
Why study plant families as part of the restoration process?

- Learning characteristics common to a family helps with plant identification in the field.
- Studying plant families helps students understand plant composition in a natural community.
- Students will be able to develop a realistic species mix based on plant family composition in natural communities.
- Questions relating to plant families may develop into research projects.

The eight common plant families described in the activity are (choose five):

1. Daisy family: *Asteraceae*
2. Rose family: *Roseaceae*
3. Mint family: *Labiatae*
4. Bean families: *Fabaceae, Caesalpiniaceae, Mimosaceae* (previously *Leguminosae*)
5. Grass family: *Poaceae*
6. Milkweed family: *Asclepiadaceae*
7. Buttercup family: *Ranunculaceae*
8. Sedge family: *Cyperaceae*

## Pre-Activity Preparation
Obtain plant specimens on the day before or the day of the activity. Potential species are listed at the end of each family description page. Plants appropriate for dissection are weedy or common, found along roadsides or in gardens. (Be aware that garden plants are often hybrids and may have more flower parts than plants growing in the wild.) Flowers may also be available from florists. Never collect plants from natural areas. If plants are no longer blooming, students can investigate seeds, seed heads, and seed dispersal mechanisms.

Keep specimens cool and moist. Lay short-stalked flowers between moist sheets of paper toweling; put long-stemmed plants in a vase.

Set up stations with representative species of each plant family. Give each station a number. It may help to have handouts from EP Activity "Taxonomy and Field Guide Warm-up" available available for terminology.

## Activity Description
1. Divide the class into groups to evenly distribute students around the stations. Have students examine related specimens to determine distinguishing characteristics for each family. Instruct students to draw or write descriptions in the circle on your observation sheet that matches the station number.


© Earth Partnership • University of Wisconsin-Madison

# Plant Families (cont.)

2. Rotate with your group through all stations. You will have five to ten minutes at each station.
3. Share as a large group what characteristics seem to identify each family.
4. Confirm the identity of each family and discuss some key traits using the Plant Family Descriptions sheets.
5. Discuss plant classification. See the background section of EP activity "Botany Bouquet" for more information.

## Extensions

- Create a Venn diagram that displays similar and dissimilar characteristics of the different species observed in each plant family. From this, create a dichotomous key of the families.
- Examine one specimen at a time. Use an overhead of plant diagrams to discuss characteristics of the family.
- Create a classroom set of drawings depicting common plants within various plant families.
- Find plants native to your region in each family.
- See EP activity "Taxonomy & Field Guide Warm-Up" for more in-depth coverage of plant parts.

## Assessments

- Identify an unknown sample as belonging to each plant family.
- List one characteristic of each family that makes that particular family unique.
- Identify one feature per family that potentially may improve its member species' ability to survive and reproduce successfully. Discuss why.

# Plant Family Descriptions

## Daisy Family: Asteraceae (as-ter-AY-see-ee)

The daisy family is the largest family of flowering plants with more than 20,000 species. Some say a prairie should be called daisyland rather than grassland because 25% of the species are daisies while only about 10% are grasses. However, what the grasses lack in number of species, they more than make up for in number of individuals.

Plants in the daisy family tend to be aggressive and aggregate through reproduction of short rhizomes; examples include sunflowers and common goldenrod. Some species, such as thistle, produce antibiotic chemicals that repress the growth of other species within their colonies.

### Flowers

- What looks like a single flower is really a cluster of many tiny flowers called florets. There may be just a few florets or many hundred in a cluster.
- Florets grow on top of a head or receptacle. The head is backed by a group of leaves that look like green sepals.

*Ox-eye Sunflower, Heliopsis helianthoides*

### Florets

- Disk floret is located in the center of the receptacle.
- Petals of disk florets: five petals fuse to form a tube around the stamens and pistil.
- Stamens: five stamens fuse into a tube.
- Pistil: one pistil sticks out above the stamens.
- Stigma: the stigma splits into two branches that resemble golden arches.
- Ray florets form a ring that surrounds the disk florets.
- Petals of ray florets: five petals form a tube at the base then flatten out to form a long tongue. Ray florets may or may not have male and female parts.
- Flowers with only disk florets include thistles, white snakeroot, Joe-Pye-weed, and blazing-stars.
- Flowers with only ray florets include dandelion, wild lettuce, lion's-foot, and rattlesnake root.
- Flowers with both disk and ray florets include yellow coneflower, coreopsis, woodland sunflower, and asters.

### Fruit

- The fruit is a small, hard seed. One per floret.
- Often a pappus is attached to the top of the fruit. The pappus helps disperse seed away from the parent plant.
- Bristles are a type of pappus that hook onto fur or clothing. Examples include burdock and beggar-ticks.
- A parachute-like pappus disperses seed in the wind. Examples are dandelion, blazing-stars, goldenrods, and thistles.

### Leaves

- Leaves are alternate, occasionally opposite, usually toothed, lobed or divided.

### Typical Examples

- Plants native to North America:  Purple coneflower, pale purple coneflower, black-eyed Susan, wild quinine, ragweed, yarrow, prairie dock, Joe-pye-weed, blazing-stars, goldenrods, and asters.
- Non-native plants:  Common yarrow, giant ragweed, mayweed, spotted knapweed, Russian knapweed, yellow star


© Earth Partnership • University of Wisconsin-Madison

thistle, ox-eye daisy, chicory, Canada thistle, bull thistle, small flower galinsoga, prickly lettuce, tansy, ragwort, sow thistle, dandelion, and cocklebur.

- Cultivated plants: Edible sunflowers, lettuce, garden asters, daisies, and zinnias.
- Common and garden plants to use for dissection: Garden daisies, dandelion, ox-eye daisy, chamomile, black-eyed Susan, coreopsis, and sunflowers.

## Rose Family: Rosaceae (row-ZAY-see-ee)

Flowers in the rose family are very similar; however, fruits vary considerably, depending on where the flower parts are arranged on a floral cup. Both humans and animals relish the great variety of fruits in the rose family, from apples to strawberries, raspberries and cherries.

### Flowers

- Most flower parts are in groups of five— five sepals, five petals, and many stamens in rings of five. There may be one pistil or many.

### Floral Cup

- Most rose plants have a floral cup that grows beneath the flower.
- The floral cup may be a shallow saucer, a deep bowl, or a tube.

### Fruit

- The types of fruits include achenes, pomes, drupes, capsules, and follicles.
- The shape of the floral cup and how the flower is fertilized determine fruit type.

### Types of Fruit

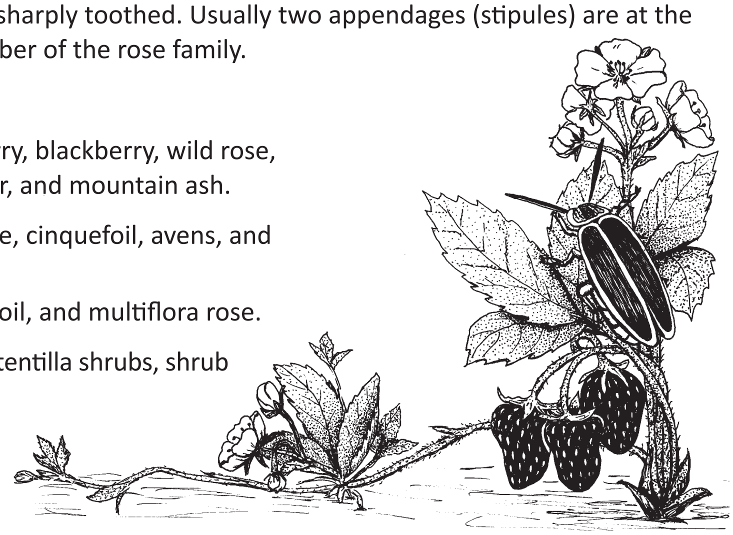
- Rose hip: A rose hip is a deep floral cup that encloses many small dry fruits.
- The juicy parts of apples, peaches, cherries, and pears are floral cups. The seeds in the core are the real fruits.
- Some floral cups remain small and do not grow around the fruits. An example is cinquefoil, which has a cluster of dry fruits.

### Leaves

- Leaves are alternate, simple, divided or lobed, and sharply toothed. Usually two appendages (stipules) are at the base of the leaf stalk. Stipules often identify a member of the rose family.

### Typical Examples

- Trees and shrubs native to North America: Raspberry, blackberry, wild rose, potentilla, hawthorn, plum, crab apple, amelanchier, and mountain ash.
- Native herbaceous plants: Strawberry, prairie-smoke, cinquefoil, avens, and Indian physic.
- Non-native plants: Rough cinquefoil, sulfur cinquefoil, and multiflora rose.
- Common and garden plants to use for dissection: Potentilla shrubs, shrub roses, crab apples, and cinquefoil.



*Wild Strawberry, Fragaria virginiana*

## Mint Family: Labiatae (lay-bee-AY-tee)

Labiatae comes from the word lip, which describes the shape of the flower. Mints are aromatic. The odor comes from oil produced in many small glands on the surface of the leaves and stems. Botanists believe aromatic oils deter animals and insects from feeding on the foliage. For humans, the pungent fragrance and flavor is used for making tea, candies, and gum, flavoring for food, and air fresheners.

*Beebalm, Monarda fistulosa*

### Flowers

- Five petals join together at the base to form a tube.
- The tube splits into two parts—two upper petals form the upper lip, three lower petals form the lower lip.
- The flowers are small—numerous flowers grow in clusters.
- Some flowers are found on the top of the plant; others form a wreath where the leaves attach to the stem.
- The number of stamens will vary.

### Fruit

- A single flower produces four little nutlets.

### Stem

- A square stem identifies the mint family. Feel the ridges by rolling the stem between your fingers.
- "All mints have square stems but not all square stems are mints." Cup-plant, a member of the daisy family, also has a square stem.

### Leaves

- Leaves are opposite, and may be toothed or lobed, but not divided.

### Typical Examples

- Plants native to North America: Dragonhead, dotted mint, mountain mint, bergamot, spearmint, hyssop, hedge nettle, and lopseed.
- Non-native plants: Creeping-Charlie, hemp nettle, henbit, motherwort, heal-all, bugleweed, and catnip.
- Culinary plants: Basil, thyme, marjoram, peppermint, and oregano.
- Common and garden plants to use for dissection: Bugleweed, henbit, grassleaf pennyroyal, bergamot, and garden mints.


© Earth Partnership • University of Wisconsin-Madison

## Bean Families: previously Leguminosae (le-gyu-men-NO-see)

### now divided into:
### Bean Family: Fabaceae (fa-BAY-see-ee), Senna Family: Caesalpiniaceae (se-sal-pi-NAY-see-ee, and Mimosa Family: Mimosaceae (mi-mo-SAY-see-ee)

Botanists recently divided the bean family into three new families, based on different kinds of flowers. Originally the family name, Leguminosae, described the typical fruit of the family—a legume. A legume is a pod with two or more seeds. Legumes (the term is also used to describe the plants themselves) fix nitrogen in the soil on account of a symbiotic relationship they have with bacteria. The bacteria, Rhizobium, attach to nodules on the roots of the plants, acquire food from the plants, and in return produce nitrogen, which plants need to grow. This relationship benefits the entire ecosystem. For example, while the biomass of a typical prairie is 4,000 pounds per acre, a prairie with a high percentage of legumes will weigh in at 8,000 pounds per acre. That's double the weight! Fixing nitrogen is an important function of bean family plants.

### Flowers (Fabaceae family)
- The unusual flowers identify members of this bean family.


*White Wild Indigo, Baptisia alba*

### Petals
- Flowers have five petals; some petals are fused.
- Two lower petals, called the keel, are fused except at the tips.
- Two petals, called wings, surround the keel.
- The fifth petal is on top and is called the top petal.

### Stamens
- Ten stamens are tucked inside the keel.
- Some flowers have ten stamens that form a tube; others will have nine stamens joined and one single stamen.
- The flower is structurally designed with spring-set stamens for cross-pollination by bees. The visiting bee lands on the keel (fused lower petals), which triggers the stamen cluster to snap up, showering the bee's hairy body with pollen dust.

### Pistil
- A single pistil is tucked inside the two lower petals.

### Fruit
- The fruit is a pod.
- Often when the fruit dries, it splits along two edges of the pod. Some pods do not break open at all; others break apart at the joints between each seed.

### Leaves
- Leaves are alternate, and compound in groups of three or several divided leaflets. Two appendages, called stipules, are located at the base of the leaf stalk.

### Typical Examples

- Trees and shrubs native to North America: Black locust, honey locust, redbud, Kentucky coffee tree, mesquite, sensitive brier, and wisteria.
- Native herbaceous plants: Wild indigo, lupine, tick-trefoil, white and purple prairie-clovers, milk-vetch, ground nut, Texas bluebonnet, and bush clover.
- Non-native plants: Black medick, kudzu vine, narrowleaf vetch, Scotch broom, Spanish broom, yellow and white sweet-clover, bird's-foot trefoil, and red clover.
- Agricultural and garden plants: Peas, beans, soybeans, peanuts, lentils, lima beans, alfalfa, and clovers.
- Common and garden plants to use for dissection: Bird's-foot trefoil, red clover, garden lupine, beans, peas, and sweet peas.

*White Wild Indigo, Baptisia alba*

## Grass Family: Poaceae (po-AY-see-ee)

Grasses are one of the most important plant families for people and animals. Grasses are directly or indirectly the chief source of our food. Grasses provide all grains and cereals—corn, wheat, rice, oats, rye, barley, and others. Wheat has been cultivated for more than 7,000 years. Rice is a main staple for more people than any other plant in the world. Sugar cane has long been used for sugar. Forage grasses such as brome grass and timothy feed livestock. Grass is a valuable wildlife food. Grasses are used in lawns, golf courses, and ornamental gardens. Visually, native grasses dominate the prairie. Grasses spread by rhizomes and stolons and grow in bunches or as dense masses that form sod.

### Flowers

- The florets are small, reduced in size, and borne on dense spikes or open clusters.
- Spikes or clusters are composed of units called spikelets. Spikelets may have one or more florets. Two empty bracts called glumes are at the base of the spikelet.

### Bracts

- Instead of sepals or petals, a grass floret is surrounded by a second pair of bracts. Bracts are small, modified leaves that grow just below the flower. The lemma bract is on the outside; the palea bract is tucked inside.

### Stamens

- Three stamens are hidden inside the bracts until the florets are ready to bloom.

### Pistil

- A single pistil is hidden inside the bracts until the florets bloom.
- The stigma is usually split into two feathery branches.
- Grasses are typically pollinated by the wind, but interestingly, you will see insects on the flowers when they are blooming. Take note of this when you see grasses bloom.

### Fruit

- The fruit of the floret is a single grain.


© Earth Partnership • University of Wisconsin-Madison

## Plant Family Descriptions (cont.)

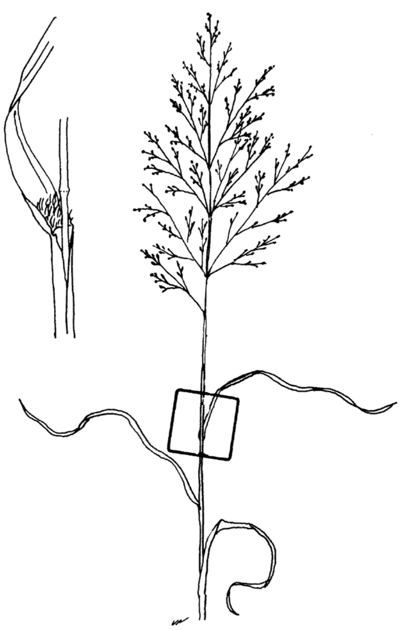
### Stem and Leaves

- The leaves are usually long and narrow. The base of the leaf, called the sheath, wraps around the stem.
- A small membranous part called a ligule is located where the leaf attaches to the stem. Ligule type often identifies species.
- The stem is frequently hollow between the nodes. The node is the place where the leaf attaches to the stem.

Bottlebrush Grass, *Hystrix patula*

### Identifying Features of Some Grasses When Not in Bloom or Seed

- Big bluestem: The lower leaves are covered with silky hair. Young shoots are somewhat flattened. Lower leaves curl when dry. Nodes tend to be bluish. Stems are solid, not hollow. Leaves are 1/4 to 1/2 inch wide and up to two feet long.
- Little bluestem: Little bluestem grows in clumps. Basal shoots are flattened and bluish-green in color. The leaves are usually folded, and usually not hairy. Leaf blades are 1/4 inch wide and four to eight inches long.
- Switch grass: A prominent nest of hairs is located where the leaf blade attaches to the sheaf.
- Indian grass: Indian grass has a sharp, claw-like ligule.



Switch Grass, *Panicum virginiatum*

### Typical Examples

- Plants native to North America: Dropseed, bottlebrush grass, wild rice, side oats, buffalo grass, Canada wild-rye, and grasses listed above.
- Non-native plants: Timothy, Kentucky bluegrass, reed canary grass, quack-grass, wild oat, cheat grass, Bermuda grass, crabgrass, barnyard grass, foxtail, and common reed.
- Grasses to use for dissection: Any.

## Milkweed Family: Asclepiadaceae (a-skle-pe-a-DAY-see-ee)

The milkweed family is very large and consists of perennial herbs and climbing shrubs. Members of the family are largely tropical, with Africa having the greatest concentration. Simple leaves and a milky juice in the stems and leaves identify milkweeds. This white-colored substance is a bitter-tasting, toxic compound that protects the plants from being eaten by most insects. Monarch larvae are unaffected by the compounds and actually prefer eating the tissues of these plants. A buildup of the toxic compounds in their bodies protects monarchs from predation as larvae and adults.

*Common Milkweed, Asclepias syriaca*

### Flowers
- Flowers are small, numerous and clustered in an umbel.
- Flower parts are in groups of five.

### Sepals
- Five sepals are partially joined.

### Petals
- Five downturned petals are partly joined.

### Nectarhoods
- Nectarhoods are complicated structures which involve the petals, stamens, and stigma.
- Nectaries in the nectarhoods secrete nectar that feeds insects.
- Five upright nectarhoods are attached to the petals.

### Stamens
- Five stamens are united at the base. Two pollen bags are united with a thin, sticky thread. These “saddlebags” adhere to the heads and legs of insect visitors.

### Pistil
- A single pistil has a large, five-lobed stigma.

### Fruit
- The fruit is a pair of follicles; usually only one matures. A follicle is a dry fruit that splits along one side.
- The seeds are flattened and crowned with tufts of long silky hairs.

### Leaves and Stem
- Leaves are usually opposite or whorled, simple and generally entire.
- The stem and leaves usually have a milky juice.

### Typical Examples
- Plants native to North America: Butterfly-weed, common milkweed, marsh milkweed, and blunt milkweed.
- Common plants to use for dissection: Common milkweed and scarlet milkweed (non-native).


© Earth Partnership • University of Wisconsin-Madison

## Buttercup Family: Ranunculaceae (ra-nun-kew-LAY-see-ee)

*Canada Anemone, Anemone canadensis*

The family name, Ranunculaceae, means "little frogs" because buttercups often grow in frog habitats. Members of this family are prevalent on every continent except Antarctica. Field characteristics for many species include a cone-shaped receptacle with numerous pistils and stamens. Often petals are missing and colorful sepals take their place. Members of the family are mostly herbaceous; some are aquatic and a few are woody shrubs and climbers.

### Flowers

- The family shows a wide variety of flower types and pollination methods. Most plants are insect-pollinated, such as columbine; some are wind-pollinated, such as meadow-rue. The annual plants are self-pollinated.

### Petals and Sepals

- Usually flowers have five sepals and petals. Some species have three to fifteen sepals with 23 petals or none at all. If no petals are present, as in marsh marigold, the sepals are bright-colored and petal-like. Some flowers, such as columbine, have a long, narrow spur at the back.

### Stamens

- The stamens are numerous; 20 to 50 stamens form rings around the pistils.

### Pistils

- One to one hundred pistils are arranged in circles on a cone-like structure.

### Fruit

- The fruit may form a cluster of small, dry fruits, called achenes, or a fleshy berry or a many-seeded follicle.
- Seeds may be dispersed in the wind with long, feathery structures, or with hooked spines that attach to passing animals, or with an oil secretion that attracts ants.

### Leaves

- Leaves are alternate, usually deeply divided, toothed or lobed. Leaf bases slightly wrap around the stem.

### Typical Examples

- Plants native to North America: Pasqueflower, marsh-marigold, goldseal, clematis, columbine, hepatica, doll's eyes, meadow-rue, larkspur, anemone, buttercups, and water-crowfoot.
- Non-native plants: Tall buttercup and creeping buttercup.
- Common and garden plants to use for dissection: Garden columbine, creeping buttercup, clematis, and delphinium.

## Sedge Family: Cyperaceae (cy-per-AY-see-ee)

Plants in the sedge family look very similar to grasses. You can distinguish sedges from grasses by looking at the stem. Grasses have round, usually hollow stems; sedges have triangular stems with a spongy pith. Sedges are numerous throughout the world and are usually found in damp places or at water edges. These herbaceous plants grow in tufted clumps and spread with creeping rhizomes and hairy, fibrous roots. The fruits furnish food for waterfowl.

Sedges are easy to identify by family because of their three-sided stems. It is very difficult to identify individual species with more than 4,000 species.

A type of paper called papyrus comes from a sedge that grew in marshes along the Nile River in Egypt during ancient times. This species is now extinct.

### Flowers

- The flowers are very small and grouped in spikelets on a spike or panicle.
- Sometimes male and female flowers are on different parts of the spike.

### Bracts

- Instead of sepals or petals, a sedge floret is surrounded by bracts. Bracts are small, modified leaves that grow just below the flower.

### Stamens

- Usually there are three stamens, rarely one or six.

### Pistil

- A single pistil with one style terminates in two or three stigmas.
- The ovary is surrounded by a persistent sac-like bract called a perigynium, which looks like a tiny seed. The mature perigynium is often topped by a beak.

### Fruit

- The fruit of the floret is a nutlet.

### Stem and Leaves

- The leaves are usually arranged in three vertical rows along a stem and closed.
- The stems are three-sided and triangular in cross-section. You can feel the edges with your fingers if you twirl a stem.
- The stem is frequently solid between the nodes. (The node is the place where the leaf attaches to the stem.)

### Typical Examples

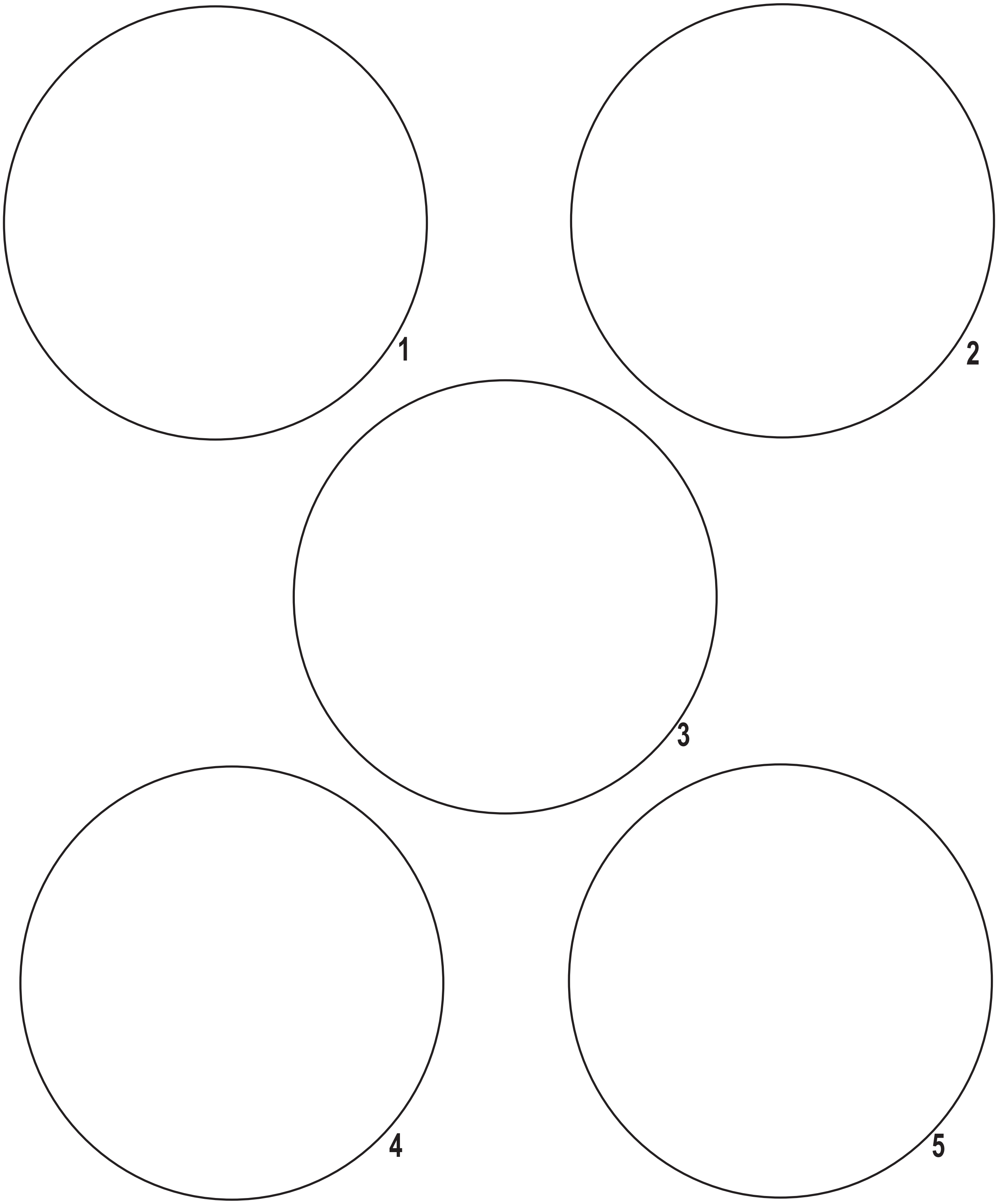
- Plants native to North America: Bottlebrush sedge, porcupine sedge, prairie sedge, Pennsylvania sedge, fox sedge, woodland sedge, tussock sedge, dark green bulrush, great bulrush, and hard-stem bulrush.
- Non-native plants: Purple nut sedge, papyrus, umbrella flat sedge, European lake sedge, rip gut sedge, bull sedge, and sugar grass sedge.
- Sedges to use for dissection: Any.

*Troublesome Sedge, Carex molesta*



© Earth Partnership • University of Wisconsin-Madison

# Plant Families: Field Sheet



# Taxonomy and Field Guide Warm-Up

**Activity Overview**
Students learn about plant parts and begin learning how to use a wildflower field guide.

**Objectives**
Students will:

- Develop a botanical vocabulary for describing plant, leaf, and flower types
- Distinguish differences between plants by their morphology or appearance
- Identify wildflowers using a dichotomous key

**Subjects Covered**
Science

**Grades**
Part 1: 2 through 12
Part 2: 6 through 12

**Activity Time**
50 minutes per part

**Season**
Any (plants collected during growing season)

**Materials**
Field guide with dichotomous key, reference and field sheets, plant specimens, pencils, clipboards, and hand lens

## Background

Botanists have developed a special vocabulary and set of criteria to identify plants based on morphology, or the appearance of plant parts. They have also developed a tool called a dichotomous key, specific to plants, to determine particular plant species. A dichotomous key is a series of paired descriptions. You choose the best description from each set of choices as you move down sets of options. Each choice becomes increasingly more specific until you arrive at an identity. This is called "keying" or "keying out" plants.

Depending on the kind of field guide used, the criteria can be difficult or relatively simple to understand. While there may be some initial frustration as you learn the technique, with hands-on practice it becomes easier and very satisfying. Learning to identify plants using a field guide is fun and can become an enriching life-long learning experience.  It is also an essential skill when developing and maintaining a schoolyard planting, allowing you to identify desired and undesired plants on the school grounds or natural area.

The following activity gives students the opportunity to learn and identify plant parts and to learn how they are integrated into a field guide as a means to identify unknown plants. The guide used here is Newcomb's Wildflower Guide by Lawrence Newcomb. The benefits of this guide include a fairly simple key and botanical terms, clear and detailed illustrations, and the identification of the family and origin of the plant. Many other guides are available and require slight modifications to navigate the key.

## Pre-Activity Preparation

For Part 1, collect specimens that represent each type of plant characteristic. Include plants with opposite, alternate, basal, and whorled leaf arrangements, leaves that are entire, toothed, lobed, and divided, and examples of regular and irregular flowers. See illustrations and definitions in the activity.

For Part 2, collect four or five specimens of a flowering plant species for classroom practice. Try keying out the plant to locate any potential "wrong turns" ahead of time.

## Activity Description

### Part 1: Learning about plant parts

1. As a class, review plant parts, leaves, and flowers using samples on an overhead projector and the reference sheets included with this activity.
2. Next, venture outside for hands-on experience. Take a clipboard, pencil, and the Taxonomy Treasure Hunt field sheets. Search your restoration site or nearby natural area to find examples of different kinds of leaves and flowers. Draw examples of what you find. Fill in plant names if you know them or wait until later.

The following definitions are helpful for talking about plant parts and for using field guides:


© Earth Partnership • University of Wisconsin-Madison

# Taxonomy and Field Guide Warm-Up (cont.)

## Leaves

### Leaf parts

- *Petiole*—The stalk of a leaf that attaches the leaf to the stem.
- *Blade*—The broad part of the leaf.
- *Apex*—The tip of the leaf; it may be narrow or broad.
- *Base*—The part of the leaf that connects to the petiole.
- *Margin*—The edge of the leaf; it may be entire (smooth), toothed (serrated), or lobed.
- *Leaflet*—One of the blades of a compound leaf.
- *Stipule*—An appendage at the base of a leaf.

### Leaf arrangement

Leaves and buds are attached to the stem at a node. How the leaves are grouped at a node determines leaf arrangement. Leaves are arranged the following ways:

- *Alternate*—Leaves are spaced singly along the length of a stem like steps. Only one leaf is attached to each node.
- *Opposite*—Two leaves are attached to a node directly across from each other like arms on a body.
- *Whorled*—Three or more leaves are attached to each node.
- *Basal*—Leaves are located at the base of the stem.

### Leaf type

- *Simple*—A simple leaf has only one part and is not divided.
- *Compound or divided*—A leaf is divided into smaller leaflets.
- *Pinnately compound*—Leaflets are arranged along the length of a central stalk.
- *Palmately compound*—Leaflets radiate from a single point like fingers radiating from the palm of a hand.
- *Bipinnately compound*—Leaflets are arranged along a branched stalk.

### Leaf margins

- *Entire (smooth)*—A smooth leaf margin.
- *Toothed (serrated)*—A margin with teeth.
- *Lobed*—Rounded divisions along the margin.

## Flowers

### Flower parts

- *Sepals*—A leaf-like structure that surrounds and protects the flower bud, collectively called the calyx.
- *Petals*—Leaf-like, often colorful structures that surround the reproductive parts of the flower and serve to attract pollinators.
- *Stamens*—The male or pollen-producing organ of the flower composed of the anther and filament.
- *Anther*—Produces pollen.
- *Filament*—Supports the anther.
- *Pistil*—The female part of the flower composed of an ovary, style and stigma.
- *Ovary*—The lower, usually enlarged part of the pistil, which contains the egg cells and where the seeds are produced. The ovary becomes the fruit.

- *Style*—The stalk-like portion of a pistil connecting the stigma and ovary. Pollen travels through the style to get to the ovary.
- *Stigma*—The terminal part of the pistil that traps pollen.
- *Pedicel*—The stalk of a single flower.

**Flower types (as described by Lawrence Newcomb in *Newcomb's Wildflower Guide*)**

- *Regular*—Flowers are radially symmetrical. All petals or petal-like parts are a similar size, shape, and color. Petals may be fused or united into a bell shape and will all still be similar. Daisy-like flowers will have petals, rays arranged like spokes on a wheel. Sometimes a hand lens is needed to see small flowers grouped together on a spike. Typical examples include sunflower, rose, harebell, and lily.
- *Irregular*—The flower is not radially symmetrical nor are the petals the same size, shape, or color. Some flowers may have a distinct upper and lower part called lips. Typical examples include beans, peas, violets, and irises.
- *Indistinguishable*—Flowers that have no visible flower parts or that are too small to count and determine petal arrangement. Examples include plantains, thistles, and Joe-Pye-weeds.

## Part 2: Using a field guide

During this part of the activity, you will use the Newcomb technique for identifying plants and flowers.

1. Distribute four to five specimens of a flowering plant to teams of students. Each student should have access to a plant specimen to be able to observe it closely.
2. Identify the unknown plant together as a class to become familiar with the wildflower guide. Newcomb asks a total of three classification questions concerning flower type, plant type, and leaf type. Fill out the Wildflower Field Guide Warm-up sheets to answer each classification question. After answering the three questions, the class will have a three-digit group number. Use the dichotomous Locator Key (pages 1-14 in the guide) to begin identifying the plant. The key will eventually take the class to the pages where the plant will be identified. You may need to retrace your steps if the description and illustration don't match your plant specimen. Expect this to happen sometimes!
3. Practice as a class with more specimens, if needed. Once everyone is fairly comfortable with using the wildflower field guide in group practice, either go outside to identify plants in the field or use additional specimens in the classroom.

## Extensions

- As a class, create your own field guide for the plants that exist in your restoration site. Each student can create a field sheet for one species in the guide. Include the common and scientific names, an accurate colored drawing, physical observations (size, shape, texture, etc.), additional field guide information (bloom time, height, etc.), habitat (prairie, wetland, woodland, etc.), unique facts (medicinal uses, Native American uses, etc.), and the date of your personal encounter with the plant in its natural habitat. Remember to cite all sources. Then gather all your field sheets into one field guide binder and create an index and key for a formal field guide look. (Source: Mark Lee.) See EP activities "Up Close and Personal" and "Construct a Key" for useful materials and information.
- Learn how to use different field guides. Compare the guides for usability, accuracy of illustrations, etc.
- Dissect flowers to learn about flower parts and their functions.
- Research how the parts of the plant function for the plant's survival, for example, how the parts of the flower promote pollination and fertilization.

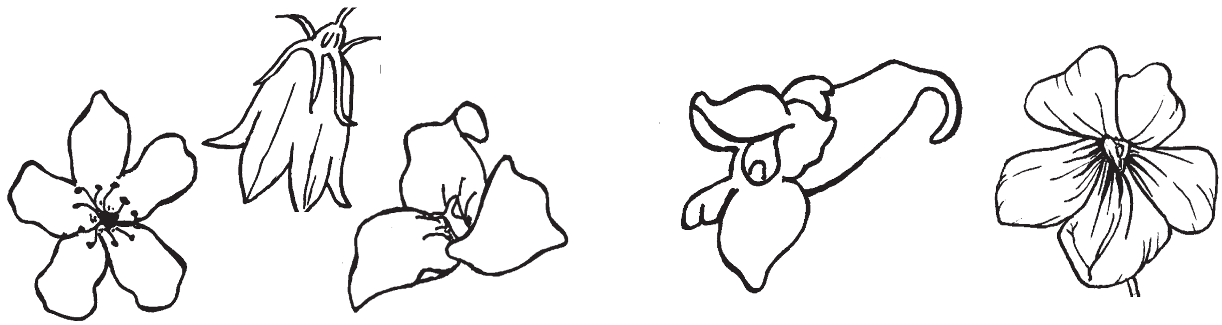
 © Earth Partnership • University of Wisconsin-Madison

## Assessments

- Without looking at a picture of the plant, use the field guide going backwards and construct a drawing of what the plant looks like. Then compare your drawing to the illustration for accuracy.
- Describe a plant using botanical terms.
- Identify three specimens using a field guide.

# Taxonomy and Field Guide Warm-up

1. Flower Type



**Regular Flowers**

Petals are arranged around the center and are similar in size.

**Irregular Flowers**

Petals are not arranged around the center and are not similar in size.

Flower Structure

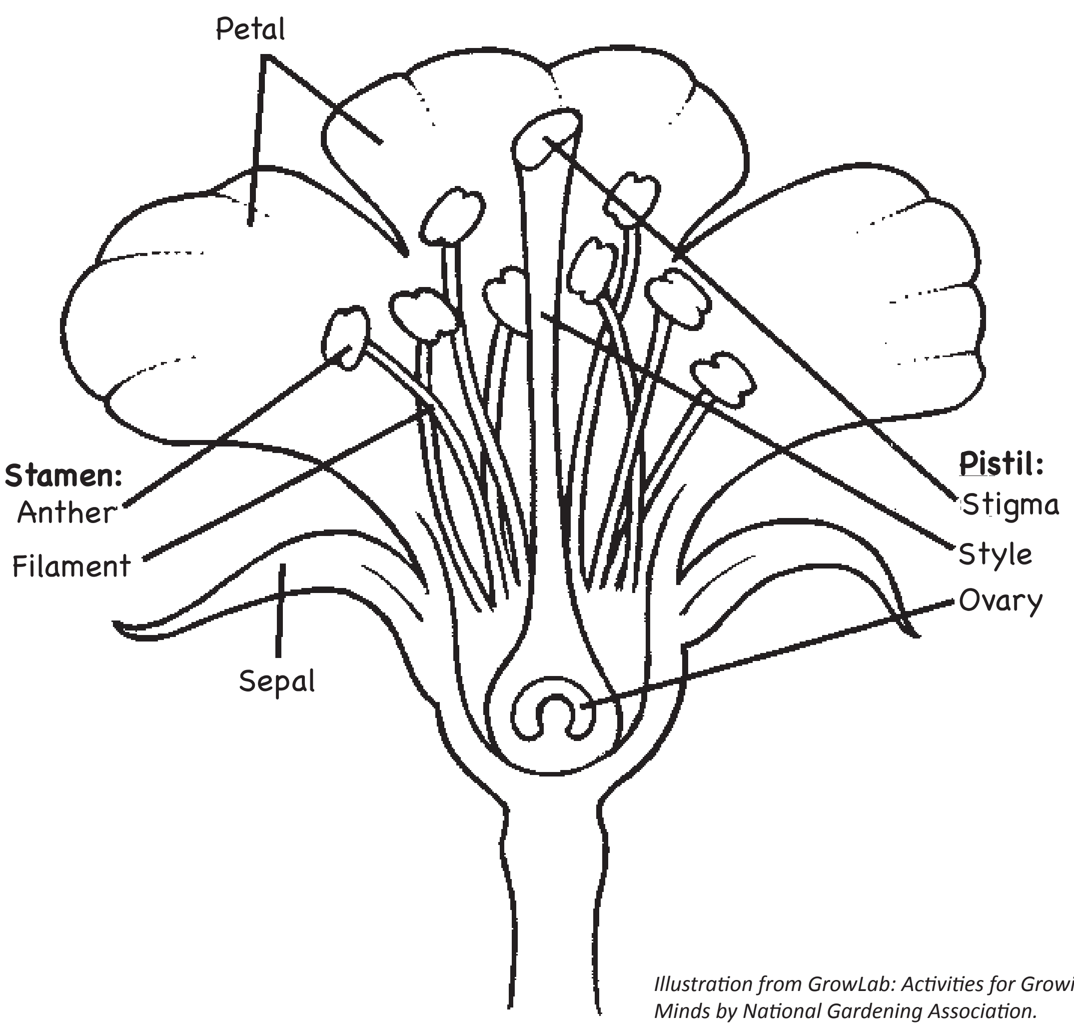


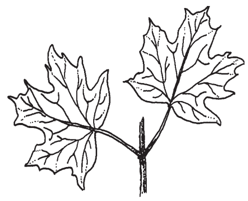

*Illustration from GrowLab: Activities for Growing Minds by National Gardening Association.*


© Earth Partnership • University of Wisconsin-Madison

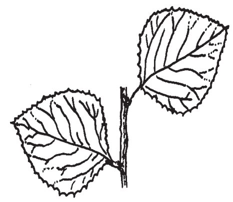
# Taxonomy and Field Guide Warm-up

## 2. Plant Type (Leaf Arrangement)

Basal



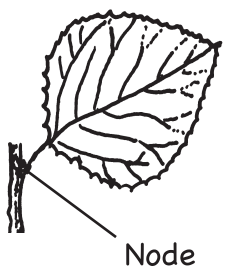
Opposite



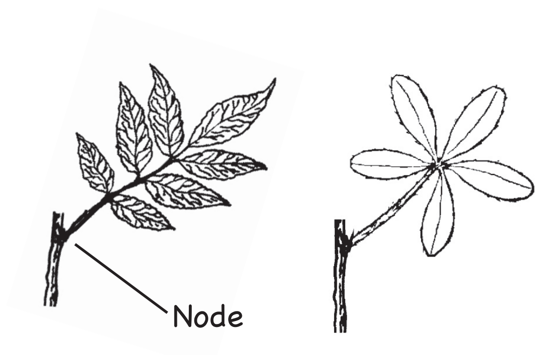
Alternate

Whorled

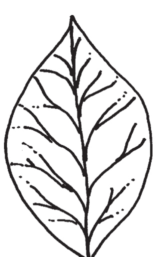
## 3. Leaf Type



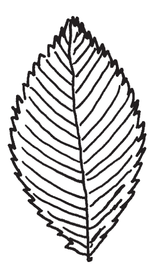

Simple



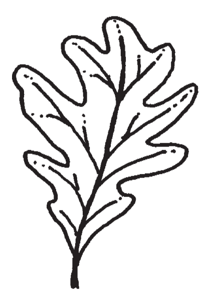

Divided



Entire
(smooth)



Toothed
(serrated)



Lobed

# Taxonomy Treasure Hunt

Find a plant in bloom.
Draw the flower. Is the flower regular or irregular?

Common name______________________

Scientific name_____________________

Find a divided leaf.
Draw the leaf.

Common name______________________

Scientific name_____________________

Find a plant with alternate leaves.
Draw the leaves.

Common name______________________

Scientific name_____________________

Find a sedge or grass with flowers or seeds.

Draw the inflorescence (the entire flower cluster).

Common name______________________

Scientific name_____________________

Find a member of the **Asteraceae** family.

What color is the flower?

_________________________________

What is the leaf arrangement?

_________________________________

How tall is the plant? (estimate)

_________________________________

Common name______________________

Scientific name_____________________

Wild Card!
Draw a plant of your choice. Label its parts using taxonomic names.

Common name______________________

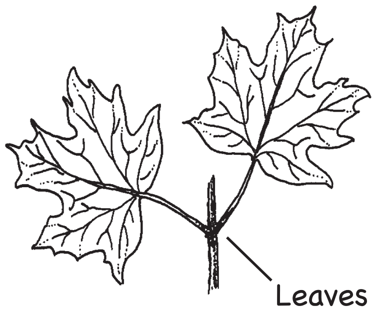
Scientific name_____________________



© Earth Partnership • University of Wisconsin-Madison

# Taxonomy Treasure Hunt

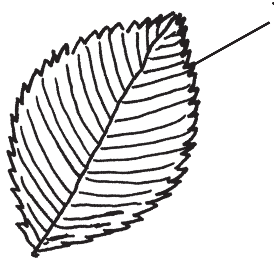
Find a plant with two leaves that meet at the stem.




These are **opposite** leaves.

Draw a plant with opposite leaves here.

Find a plant that has leaves with teeth along the edge.

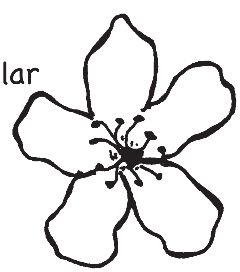



This leaf is **toothed or serrated**.

Draw a plant with toothed leaves here.

Find a plant with flowers.

Regular



Irregular

Draw and describe a flower.

# Waterdrop Journeys in the Water Cycle

**Activity Overview**
Students play a game of chance and movement to gain an understanding of the complexities of the water cycle.

**Objectives**
Students will:

- Learn how and where water moves as it travels through the water cycle.
- Experience the movement of the water cycle
- Experience an approximation of the time involved in the various destinations of the water cycle
- Learn water cycle vocabulary and concepts

**Subjects Covered**
Science and Language Arts

**Grades -** K through 8

**Activity Time**
Part 1: about a half hour for a classroom group of about 20 students; Part 2: 1 hour (or more) to write the story

**Materials**
Nine special dice with movement instructions, 9 (illustrated) station signs, 9 shallow trays, 9 sets of labeled paper strips ("trackers" on colored paper (blue: ocean*, lakes, rivers; white: clouds,* glaciers/icecaps;* green: plants; tan: animals, soil, groundwater.* Make more copies of *ones); 12 staplers (one each at the lakes, rivers, clouds, plants, animals, and soil stations and 2 each at the ocean, groundwater, and glaciers/icecaps stations), pencils, and 1 set of paper strips (1 per student) of a distinctly different color than the tracker strips.

*Note: This activity is an adaptation of the NOAA activity, "The Water Cycle," and gratefully used here with permission.*

## Background

Water circulates continuously throughout Earth's biosphere in what is called the hydrologic or water cycle. The water cycle is more complex than we can actually conceptualize. As the water moves it takes many paths, changing form (liquid, gas, solid) frequently, recycling again and again, but never lost.

The water cycle includes short loops and long travels: from the one inch journey up the stem of a violet, to the journey it next makes after photosynthesis occurs and the water molecule is transpired and swept up into the vast system of the atmosphere, which sweeps it across hundreds of miles before the water vapor condenses into clouds and falls as precipitation.

Some water loops last an instant: imagine the sip of a dragonfly from a one-drop puddle on a water lily leaf in a marsh. Some cycles last decades or centuries: Lake Superior, the largest of the Great Lakes, completes one water change every 191 years. Groundwater and glaciers hold onto their water for very long times.

Because the water cycle is so complex, with many small and large interconnected loops, we may need to simplify these cycles so that students can "see" the big picture more clearly and understand it better.

One big central cycle begins with water evaporating from the surface of a pond, lake, stream, river or the ocean, and up into the atmosphere as water vapor. The water vapor eventually condenses into water droplets, forming clouds. As more droplets connect, they eventually become heavy enough to precipitate and fall as rain, sleet, snow or hail.

Some of that water will infiltrate the soil where it falls. If it infiltrates deeply enough, it becomes groundwater in deep aquifers made of porous rock. Groundwater often discharges into springs, ponds, lakes, streams and rivers, replenishing them. From there, it may flow to the ocean, or evaporate into the atmosphere again.

Water in the soil can cycle up through a plant and be used in the process of photosynthesis. Transpiration through the leaf will move it out into the atmosphere once again. Of all the living things on earth, plants circulate the most water. Animals move water, too, first by drinking it, and then by passing it along through respiration (breathing) and excretion.

## Pre-Activity Preparation

**Note:** Careful set-up helps this activity work smoothly. Materials (dice templates, signs, etc.) can be found on the EP Curriculum Dropbox.

Set up a station for each of the nine dice and their tracker strips. Shallow trays work well to contain each station's materials. A stapler or two (fully loaded) should be at each station.

Since certain stations (oceans, glaciers/icecaps and groundwater) can be difficult to "escape" from, and thus tend to accumulate students, arrange the stations so that the slow-moving stations are not close to each other. If possible, use a room where the tables (or desks) can be moved towards the walls, creating a large space within which the students can move freely.


© Earth Partnership • University of Wisconsin-Madison

# Waterdrop Journeys in the Water Cycle (cont.)

The following describes what happens to a waterdrop, depending on the roll of the dice at each of the nine stations.

## Clouds

**Soil**: Water condenses and falls on soil.

**Glacier**: Water condenses and falls as snow onto a glacier.

**Lake**: Water condenses and falls into a lake.

**Ocean**: Water condenses and falls into the ocean.

**Stay**: Water remains as a water droplet clinging to a dust particle in the cloud.

## Ocean

**Clouds**: Heat energy is added to the water, so the water evaporates and goes to the clouds.

**Stay**: Water remains in the ocean.

## River

**Lake**: Water flows into a lake.

**Ground water**: Water is pulled by gravity; it filters into the soil.

**Ocean:** Water flows into the ocean.

**Animal**: An animal drinks water.

**Clouds**: Heat energy is added to the water, so the water evaporates and goes back to the clouds.

**Stay**: Water remains in the current of the river.

## Animal

**Soil**: Water is excreted through feces and urine.

**Clouds**: Water is respired or evaporated from the body.

**Stay**: Water is incorporated into the body.

## Glacier

**Ground water**: Snow melts and water percolates down through soil and rock to ground water.

**Clouds**: Snow melts and water evaporates to the clouds.

**River**: Snow melts and water flows into a river.

**Stay**: Snow stays frozen in the mountains.

## Plant

**Clouds**: Water leaves plant through the process of transpiration.

**Stay**: Water is used by the plant and stays in the cells.

## Soil

**Plant**: Water is absorbed by plant roots.

**River**: The soil is saturated, so water runs off into a river.

**Ground water**: Water is pulled by gravity; it filters into the soil.

**Clouds**: Heat energy is added to the water, so the water evaporates and goes into the clouds.

**Stay**: Water remains on the surface (perhaps in a puddle or adhering to a soil particle).

### Ground Water

**River**: Water filters into a river.

**Lake**: Water filters into a lake.

**Stay**: Water stays underground.

### Lake

**Ground water**: Water is pulled by gravity; it filters into the soil.

**Animal**: An animal drinks water.

**River**: Water flows into a river.

**Clouds**: Heat energy is added to the water, so the water evaporates and goes to the clouds.

**Stay**: Water remains within the lake or estuary.

## Activity Description

### Part 1

Arrange yourselves evenly among the stations. Only one person at a time will be rolling the die at each station, so make short lines.

Each of you will be taking a different journey through the water cycle. You will be keeping track of your own itineraries by adding a tracker slip to your paper chain at each destination. Some may find themselves "stuck" at one destination for several turns - if that happens, add a tracker slip for each turn at that station.

When you reach a destination station, first attach a tracker slip to your previous loop, then roll the die. Read the directions at each station, to understand both how and where you are journeying to next.

Be careful to add each new tracker slip to the preceding one; the order of your journey must make sense, just as water moves according to rules based on its special properties.

Practice a trial run. Have the first lake person roll the die and tell how a waterdrop might move from a lake and where it would go.

Remember that this water cycle is not a race. There is no end to the water cycle. There is no final destination. So enjoy the journey! When you have twelve trackers on your paper chains, you can sit while others complete their journeys.

### Wrap-up Discussion

- Before leaving the water cycle, share questions or ideas that you have.
- Did your journey make sense to you?
- Did you encounter any surprises?
- How might the movement of water in our area change in winter?
- Thinking back to instructions on each die, which water journey mode would winter shut down the most?
- Do students think it would be possible to develop an activity like this one that would add more of the complexity of the real world water cycle, yet still be playable?

### Part 2

Write an essay or a creative, yet factually correct, adventure about their waterdrop's journey in the water cycle. Include appropriate water cycle vocabulary.


© Earth Partnership • University of Wisconsin-Madison

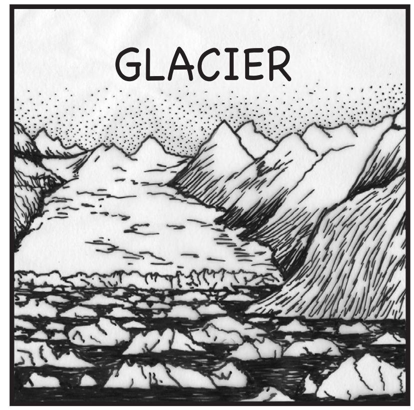
## Extensions

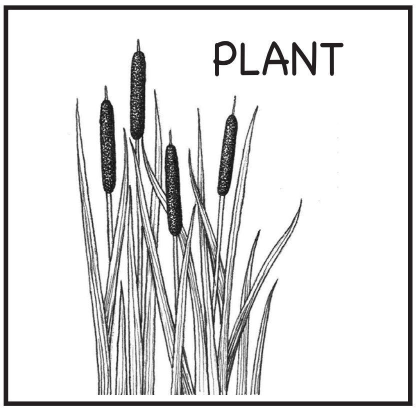
- Examine the tracker slips and note how many times the waterdrop had to change its state (liquid, gas, or solid) during its 12 mini-journeys.
- Read Aldo Leopold's Odyssey in A Sand County Almanac. This adventure of an atom in the biosphere will inspire students to write a more complex waterdrop adventure.

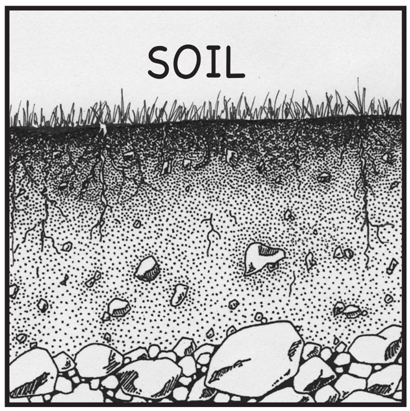
## Assessments

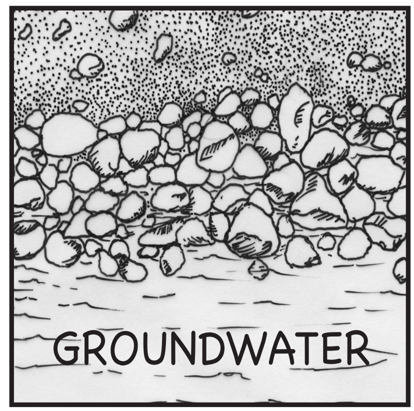
- Using the tracker chain, briefly describe and explain a waterdrop's journey in the water cycle, using appropriate vocabulary.
- Make a flowchart diagram of the waterdrop's journey in the water cycle.
- Create a diagram of the whole water cycle, labeling with appropriate vocabulary and concepts.



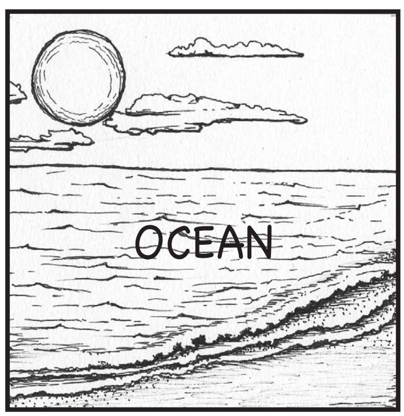


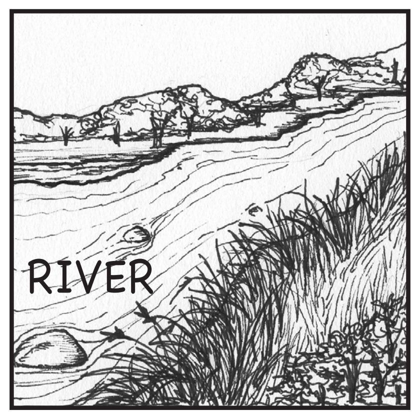







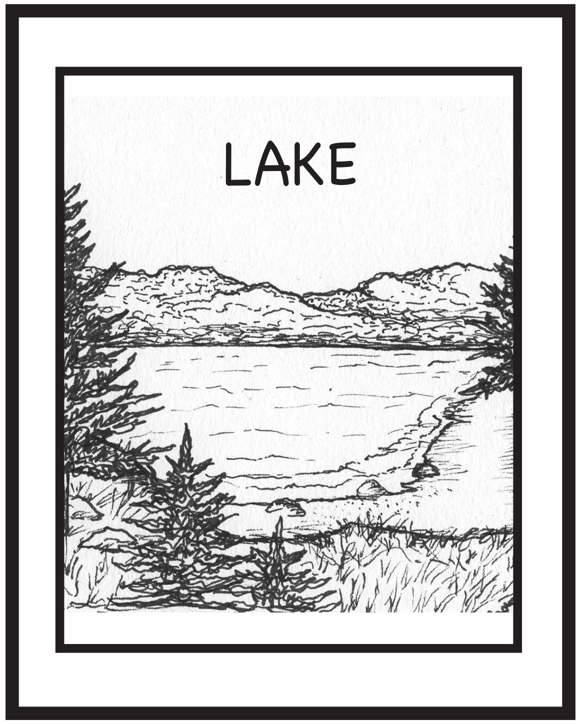





*These are samples... a complete set of reproduceable artwork for the cubes and cards is available in the EP Dropbox The cubes and cards are available in Spanish and English.


© Earth Partnership • University of Wisconsin-Madison

Sample of a large card for the "Lake" station. A PDF copy of a card for each station can be found on the accompanying CD.




**Ground water**
Water is pulled by gravity; it filters into the soil.

**Animal**
An animal drinks water.

**River**
Water flows into a river.

**Clouds**
Heat energy is added to the water, so the water evaporates and goes to the clouds.

**Stay**
Water remains within the lake or estuary.

# Waterdrop Journeys in the Water Cycle: Writing Activity

Name_________________________________________ Date_________________________________________

We recently participated in the water cycle activity. Your drop of water traveled from the following locations: lakes, ponds, rivers, creeks, ocean, glaciers, groundwater, soil, plants, animals, and clouds. Please list in order the twelve chains you added to your drop.

1.____________________ 2.____________________ 3.____________________ 4.____________________

5.____________________ 6.____________________ 7.____________________ 8.____________________

9.___________________ 10.___________________ 11.____________________ 12.___________________

The following are the processes that moved your drop of water from one place to the next:

Evaporation

Precipitation

Infiltration

Transpiration (from plants)

Respiration (animals)

Condensation (dew, frost)

Run-off, storm sewers

Ocean currents

Gravity

Freezing, thawing

Use the space below and on the back of the paper to tell the story of your drop of water. Explain where it traveled and include the processes that were involved. Be creative.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________



© Earth Partnership • University of Wisconsin-Madison

# Water in the Watershed

**Activity Overview**
Students participate and learn about watersheds, storm water runoff and pollution by creating a watershed model.

**Objectives**
Students will

- learn that a watershed (or drainage basin) is the area of land that contributes water to a stream or pond
- realize the flow of runoff and seepage in a watershed is directed by ridges – high points that separate adjacent watersheds
- know everyone lives in a watershed
- understand that land use activities in a watershed can affect water quality and quantity

**Subjects Covered**
Science and Social Studies

**Grades -** 4 through 8

**Activity Time -** 45 minutes

**Season -** Any

**Materials**
Shallow basin or tub; several sheets of newspaper; aluminum foil, plastic wrap or wax paper; spray bottle; food coloring; and 1 piece of paper towel OR substitute newspaper/foil/plastic wrap/wax paper with modeling clay or sand.

**Source**
Adapted from SWEAP: Small Watershed Ecology Assessment Project, Ana Ruesink, Institute of Ecosystem Studies, PO Box R, Millbrook, NY 12545
http://www.ecostudies.org/images/education/sweap/SWEAP.pdf
http://www.ecostudies.org/images/education/sweap/.%5CMODULE_1.pdf

## Background

Many students, and adults, do not have a concrete understanding of what a watershed is. The purpose of this activity is to provide an opportunity for students to learn the definition of "watershed", create a watershed model, and discover how the characteristics of a watershed determine how and where water and pollutants flow and accumulate. After experimenting with a watershed model, students will have the opportunity to research their own watershed. The act of finding out the name of the watershed one lives in, and viewing its map, creates a sense of place and personal connection to a watershed.

There are many similar activities to this one found online and in various watershed curriculum guides. Based on the amount of time and resources/materials you have available, you may find that another variation of this lesson may better meet your needs.

See EP Resources Watershed 101 and Stormwater 101 for information about watersheds and how land use activities in a watershed affect water quality and quantity.

## Activity Description

### Step 1: Watershed Basics

1. In groups of 3-4 students, create a simple watershed model by crumpling up several pieces of newspaper and placing them in the bottom of the basin.
2. Cover the newspaper with foil, plastic wrap or wax paper: this is the land surface. (OR use modeling clay or sand to create hills and valleys) The uneven distribution of the paper should create a raised relief map with hills and valleys.
3. What will happen to rain falling on the land surface. Where will it go? Where will it end up? Write your predictions on the Data Collection sheet (one per student, or per group).
4. Spray water on the plastic to test predictions. (The water will be easier to observe if you add a little blue food coloring.) The water will flow from the high points to low points in rivulets that represent streams and rivers and will collect in pools that represent lakes or an ocean. (Give groups ~10 minutes to spray water and make observations.)
5. Write your observations on the data collection sheet.
6. A representative from each group will report the group's observation to the class.
7. Class Discussion: The area draining into each stream, river, or lake is called a watershed. Notice that every location on the plastic is part of a watershed.

### Step 2: Where does pollution go?

1. Make a list of possible pollution sources.
2. Use a tiny piece of paper towel soaked in food coloring to represent a source of contamination like motor oil or lawn fertilizer or a leaky septic

system. (If you used blue coloring for the water and you use yellow coloring for the pollution, you will observe green "polluted" water, which can represent imbalanced algae levels.)

3. Predict what will happen to the contamination when it rains - write predictions on Data Collection sheet.
4. Place the dyed piece of paper towel on the plastic watershed model and spray to make it rain.
5. Record observations on the Data Collection Sheet.
6. Class Discussion: Again, a student from each group will share observations. Recognize that the "pollutant" flows into a stream and then into a nearby lake or ocean. Also, notice that only one "watershed" is polluted unless the pollutant is on a divide.

### Step 3: What watershed do we live in?

1. Go to the EPA's "Surf Your Watershed" website: http://cfpub.epa.gov/surf/locate/index.cfm
2. Enter the zip code for your school. More than one watershed may appear for your zip code, so you will need to look at each map to determine which one your school is located in.
3. Record the name of your watershed and print a copy of the watershed you are located in.
4. Look through the other information for your watershed that is provided for your watershed. Are there Citizen-based groups already at work in your watershed? What water use information is available? Can you find information about pollution concerns or water quality issues for your watershed?

### Extensions

- Students learn what local watershed they live in and continue to identify watersheds they are in until they identify the largest watershed that feeds into an ocean.
- Students research land use activities in their watershed and present findings.
- Students build a model of their own watershed.
- Students build models of the same watershed but with different land uses and amounts of impervious and pervious surfaces, and compare change in water quality and quantity.
- Follow this lesson with EP activity "Follow the Drop."

### Additional Resources

- After the Storm: A video co-produced by EPA and the Weather Channel. US Environmental Protection Agency. Washington, D.C. Publication # EPA 840-V-04-001
- Higgins, S., Kesselheim, A., Robinson, G. (1995). *Project wet: Curriculum and activity guide.* Bozeman, MT: The Watercourse and Council for Environmental Education.

### Websites

- About WDNR's Hydrologic Areas. http://www.dnr.state.wi.us/org/gmu/sidebar/whatis.htm#gmus
- Surf Your Watershed, US Environmental Protection Agency. www.epa.gov/surf
- Watershed in a Box, Make Waves for Action, Wisconsin DNR and UW Extension Environmental Resources Center. http://clean-ater.uwex.edu/wav/otherwav/winbox.pdf
- Watershed Planning Game, Bell Museum of Natural History. http://www.bellmuseum.org/ecogames.html
- Construct a Watershed Model: Another watershed lesson plan, more in-depth. http://www.therez.ms/students/documents/watersheds_wetlandsmodel.pdf

## Assessment

- Define a watershed.
- Describe how the shape of land forms controls the movement of water.
- Crumple a piece of paper and lay it on your desk to make a simple watershed model. Take a marker and outline the ridges of this watershed. Identify each smaller watershed in this model.
- Explain how a pollutant might enter lakes and rivers in a watershed and what you would do to stop it.


© Earth Partnership • University of Wisconsin-Madison

# Water in the Watershed: Data Collection Sheet

Name____________________________________________ Date____________________________________________

| | Predictions | Observations |
|---|---|---|
| Watershed | | |
| Pollution | | |

## Conclusions:

1. What is a watershed?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

2. How did the water move through the watershed?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

3. How did the land formations impact the flow of the rain through the watershed?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

4. What happens to a pollutant in a watershed when it rains?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

5. How could this be avoided?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

# Follow the Drop

**Activity Overview**
Students observe and collect information about water runoff on their school property.

**Objectives**
Students will:

- Practice observation and investigative skills
- Survey and collect information about their school site
- Learn about the nature of water in the landscape
- Calculate the volume of rain water falling and forming runoff on their school grounds
- Use critical thinking skills to develop ideas for storm water management on their school yard

**Subjects Covered**
Science, Math

**Grades**
4 through 12

**Activity Time**
2 hours: 1 hour on the school grounds, 1 hour in the classroom

**Season**
Any, preferably spring or fall

**Materials**
Clipboards, pencils (or colored pencils), "Follow the Drop" handout, map of schoolyard showing property lines and building locations (and/or graph paper), average annual rainfall data obtained from the weather bureau, local newspapers or TV weather newscaster, etc.

## Background

The purpose of this activity is to give students the tools they need to practice watershed citizenship by developing water friendly stormwater management plans for their schoolyard.

Everyone is a citizen of a watershed. Everyone has a watershed address. And everyone can practice good water citizenship at home, in the neighborhood, and in the schoolyard.

A watershed is the land area surrounding and draining into a specific body of water (stream, river, pond, lake). Water must flow downhill; bodies of water always lie in a low place in the land.

Before development, rain soaked into the land where it fell, because soil is permeable (absorbent). With development, more and more land was covered by structures and surfaces designed to shed water, not absorb it. These impermeable surfaces (such as roofs, sidewalks, driveways, roads and parking lots) create substantial areas that can shed substantial amounts of water. This water is called runoff or stormwater. In urban areas today, stormwater is considered the equivalent of trash: something to get rid of as fast as possible, instead of the precious resource it really is.

Water moving over the landscape in a large city, a medium-sized subdivision or single school yard after a rain will flow basically the same. Only the scales are different: a larger volume of water moves across the landscape in a large city compared to a small schoolyard. Nevertheless, in either case, water may flow in a sheet-like way, collect in channels, drain into pipes, accumulate in puddles, or soak into the ground during a rain storm. Rain water will eventually drain to a river, a lake or to groundwater. To have clean water in a life sustaining, healthy watershed, each site – whether large or small — requires thoughtful stormwater management. One of the best ways to ensure clean water is to control runoff near its source where precipitation first comes in contact with the land. Keeping water out of storm sewer systems lessens erosion and sediment carried into lakes and rivers, reduces pollutants carried by moving water, and decreases chances of flooding. See EP resource Storm Water 101 for more information.

## Pre-Activity Preparation

- Make a copy of an existing school map showing the location of buildings, driveways, and property lines. Locate north, and indicate a scale on the map.
- If desired, divide the map into sections. Assign a section to each student team. The team will locate and record all features described below that are inside their section. Each section can be reassembled to form a composite map.
- Another option is to give each team a complete map and assign the team only one feature to locate such as downspouts on school buildings.
- Obtain the average rainfall data from the weather bureau, local newspapers, etc. This data is used for calculating runoff on school grounds.


© Earth Partnership • University of Wisconsin-Madison

## Activity Description

This activity involves three steps. First, you will survey the school grounds, identify how water moves over the land, and mark this information on a map. Second, you will measure designated areas, and calculate the amount of runoff produced from those areas. Third, you will begin to identify locations for infiltrating water on the school grounds. These three steps are described below in more detail.

### Step 1: Identify Water Patterns

Form teams and go outside to identify the patterns of water movement. Locate the following features on your maps.

- Locate high and low points.
- Locate impervious (hard) surfaces such as parking lots and sidewalks, where water runs off.
- Locate porous (pervious/absorbent) surfaces such as garden beds or grassy areas where water may soak in or infiltrate the ground.
- Identify patterns in water movement such as where water might flow sheet-like, in gullies, or channels. Draw arrows to show direction of water movement.
- Locate places where water puddles. Hint: areas that puddle may have different plants than the surrounding area; the soil is often wet or it may become hard and cracked when dry.
- Locate downspouts on the school building or where water falls off roofs.
- Locate storm drains on school property.
- Locate where water enters the school grounds from hillsides, streets or other locations.
- Identify spots where water exits the school ground such as through ditches or off school parking lots.
- Identify where water spills from one surface to another such as where water is moving from a hard, impervious surface like a sidewalk to a pervious, vegetated area or vice versa.

### Step 2: Measure Areas for Rain and Runoff Calculations

Select an area and measure its size -- then calculate the amount of runoff it generates. Possible areas to measure include the school roof, parking lots, and playing fields or play areas. You may also consider measuring pervious areas compared to impervious areas. If your base map is drawn to scale, these measurements may be made in the class-room using rulers or a grid system. Use measuring tapes or paces to make on-the-ground measurements outdoors.

**Calculations:**

1. Calculate the area of your selected site (roof, parking lot, play area, etc.) by multiplying length by width to obtain a square foot measurement.

    **Example**: Calculate Area 30 feet x 50 feet = 1,500 square feet area

2. Multiply the area by the average annual rainfall to determine the volume of rainfall falling on your site. In this example, the average annual rainfall is 30 inches per year.

    a) First, convert average annual rainfall data from inches to feet.

    **Example**: Convert annual rainfall from inches to feet 30 in. ÷ 12 in. = 2.5 feet

    b) Next, multiply average annual rainfall data by area to get the volume of rainfall falling on your site.

    **Example**: Determine volume of rainfall 2.5 ft. x 1,500 sq. ft. = 3750 cu.

3. Calculate how much of the rain becomes surface runoff. The amount of surface runoff depends upon the surface type. The harder the surface – the more runoff generated. See the following examples:

If rain is falling on hard surfaces such as a parking lot, 100% becomes runoff.

**Example**: Calculate surface runoff from a parking lot 3750 cu. ft. x 1 = 3750 cu. ft.

If rain is falling on a lawn, approximately 60% becomes runoff. (Runoff from lawns can be a variable, depending upon soil type, condition of the lawn, and topography.)

**Example**: Calculate surface runoff from a lawn 3750 cu. ft. x .60 = 2250 cu. ft.

If water runs into a rain garden, which collects and infiltrates rain water, 0% becomes runoff.

**Example**: Calculate surface runoff from a rain garden 3750 cu. ft.. x .00 = 0 cu.

4. To help students understand these large volume numbers, have them convert cubic feet to gallons. 1 cubic foot of runoff produces 7.2827 gallons of water.

**Example**: Convert cubic feet to gallons 3750 cu.. ft.. x 7.2827 gallons = 27,410.125 gallons

### Step 3: Discuss Observations, Results, and Possibilities.

As a class, share your findings based on observations and data generated. Discuss the big picture of water movement by identifying characteristics observed, possible problem areas, etc. Talk about ways the school can reduce runoff on school grounds. Identify likely areas to create rain gardens to collect and infiltrate water.

## Extensions

- Go outside when it is raining, and observe storm water runoff in action. (See Rainy-Day Hike activity in Project Wet: Curriculum and Activity Guide. Bozeman, MT: The Watercourse and Council for Environmental Education. Pages 186 – 190.)
- Observe what the rain water runoff is picking up along its route – sediment, trash, oil, gas, etc.
- Calculate, using the activity formulas, the amount of water falling on the school grounds after a single rain event. Use a rain gauge to obtain rainfall quantity.
- Calculate the number of showers that can be taken with the rainwater runoff. A five-minute shower uses 25 gallons of water, and one cubic foot of runoff produces 7.2827 gallons of water.

  Example: Convert cubic feet to gallons 3750 cu..ft.. x 7.2827 gallons = 27,410.125 gallons
- Calculate possible number of showers 27410.125 gallons ÷ 25 gallons = 1093 showers

## Additional Resources


- Cochrane, Jennifer. (1987). *Water ecology.* New York: The Bookwright Press.
- Higgins, S., Kesselheim, A., Robinson, G. (1995). *Project wet: Curriculum and activity guide*. Bozeman, MT: The Watercourse and Council for Environmental Education.
- Hooper, Meredith. (1998). *The drop in my drink*. New York: Penguin Putnam Inc.
- Leopold, Aldo. (1966). *A sand county almanac*. UK: Oxford University Press.
- Leopold, Luna B. (1974). *Water: A primer.* San Francisco, CA: W.H. Freeman & Co.



© Earth Partnership • University of Wisconsin-Madison

- Nadeau, Isaac. (2003). *The water cycle: Water in plants and animals*. New York: Rosen Publishing Group, Inc.
- Nadeau, Isaac. (2003). *The water cycle: Water in the atmosphere.* New York: Rosen Publishing Group, Inc.
- Project Wild. (1999). *Where does water runoff after school? Project WILD.* Bethesda, MD: Western Regional Environmental Education Council.


## Assessments

- Describe the topography of your schoolyard and how it affects the flow of water during a heavy rainfall.
- Tell a story about a rain drop falling on the school ground. Describe its journey as it moves on the school property. (See “Odyssey” in Aldo Leopold’s *A Sand County Almanac)*
- List positive water-friendly landscape features and things that could change on the school ground to prevent runoff from leaving the schoolyard.
- Give an oral report on your findings along with follow-up suggestions for increasing infiltration and reducing surface runoff.

# Follow the Drop: Calculation Sheet

Name(s)____________________________________________ Date:______________________________

How much of the rain that falls on a school stays on the property? How much infiltrates into the ground? How much exits the site as runoff? As part of this investigation you will determine the answers to these questions. To do so, fill in the tables below in order.

First, explain the following key concepts in your own words, then complete steps 1 through 4:

- Precipitation
- Infiltration
- Runoff
- Permeable
- Impermeable
- Cubic feet
- Gallon

1. Calculate areas: Use the grid to determine the area covered in each of these types of cover.

| **Cover Type** | **Width (feet)** | **x** | **Length (feet)** | **=** | **Total Area (square feet)** |
|---|---|---|---|---|---|
| Roof (downspouts) | | x | | = | |
| Parking lot | | x | | = | |
| Lawn | | x | | = | |
| Native planting | | x | | = | |
| Rain garden | | x | | = | |
| Other | | x | | = | |

2. Convert average yearly precipitation or rainfall from inches to feet.

   Annual rainfall: ________ inches per year

   Rainfall in inches ________÷ 12 inches = _______feet

3. Determine the amount of rain that falls on each cover type every year.

| **Cover Type** | **Area from #1 (square feet)** | **x** | **Annual Rainfall (#2) (feet)** | **=** | **Total Rainfall per area (cubic feet)** |
|---|---|---|---|---|---|
| Roof (downspouts) | | x | | = | |
| Parking lot | | x | | = | |
| Lawn | | x | | = | |
| Native planting | | x | | = | |
| Rain garden | | x | | = | |
| Edible garden | | x | | = | |


© Earth Partnership • University of Wisconsin-Madison

# Follow the Drop: Calculation Sheet

*4. How much of the rain is runoff? Use the runoff calculator for each cover type.*

| **Cover Type** | **Total Rainfall (#3) (cubic feet)** | **x** | **% Runoff Calculator** | **=** | **Surface Runoff (cubic feet)** |
|---|---|---|---|---|---|
| Roof (downspouts) | | x | 1 | = | |
| Parking lot | | x | 1 | = | |
| Lawn | | x | .6 | = | |
| Native planting | | x | .4 | = | |
| Rain garden | | x | 0 | = | |
| Other | | x | .4 | = | |
| Total runoff | --------------------- | --- | ------------------ | | |

Information:

1. One cubic foot = 7.48 gallons
2. On average, an American uses 100 gallons of water per day.
3. On average, Americans as a whole use 400,000,000,000 gallons of water per day.
4. A family of four typically uses 100,000 gallons of water per year.
5. An average American uses 15 to 25 gallons of water per shower.

How many gallons of water from a nearby parking lot or roof could a rain garden save from running off into storm sewers? ________________________________

# Visual Assessment: A Landscape Through an Artist's Eye

**Activity Overview**
Students will draw a natural area from two different views as they look at it aesthetically, artistically, and historically.

**Objectives**
Students will:

- Practice observation skills
- Illustrate their observations with drawings
- Interpret and compare contrasting views
- Analyze and assess their feelings based on what they see

**Subjects Covered**
Language Arts and Art

**Grades**
K through 12

**Activity Time**
1 hour

**Season**
Any

**Materials**
2 pieces of plain white drawing paper, pencil, and clipboard per student, colored pencils optional

## Background

There are two approaches to aesthetically assess a landscape—vista and close-up views. A vista or panaromic view looks over a distance. A close-up view focuses on a part nearest the viewer. Each approach can invoke a different set of feelings and perceptions, along with contrasting artistic renderings.

Visit a natural area that could serve as a model for your school's restoration. Examine the close-up and vista views to determine what elements to include in your restoration. When planting a small space use the visual elements from a close-up view and for large spaces consider visual characteristics of the vista view. Incorporating these impressions into the school restoration project will help you create a landscape with the sense of beauty at the proper scale.

### Prairie Example: Vista View

**A historical account:**

> *The view . . . beggars all description. An ocean of prairie surrounds the spectator whose vision is not limited to less than 30 or 40 miles. This great sea of verdure is interspersed with delightfully varying undulations like vast waves of the ocean. Here and there sinking in the hollows or cresting the swells appear spots of trees as if planted by hand for the purpose of ornamenting this naturally splendid scene.*
>
> From an 1837 journal describing the beauty of a prairie.

**An artistic interpretation:**

Expansive, open, flowing movement, energy, and sweeping forms describe a vista view of a prairie. The line of the prairie is low, flat, or horizontal. Drifts of colors and forms create free-flowing patterns that weave in and out of the prairie. The movement is wave-like.

The ubiquitous grasses provide unity throughout the prairie. The grasses are the common linking elements through the entire scene. Colorful forbs accent the prairie scene. They add vividness and memorable focus points. "Drifts" of forbs gradually emerge and concentrate, then blend into the background again. Environmental factors such as soil type, microclimate, and individual plant characteristics create these drifts.

### Prairie Example: Close-up View

**A writer's account:**

> *. . .Look closely among the grasses around your feet. Blossoms of orange and pink and white are scattered all through the tangle of grasses, blazes of color against the cool green. Stretching out your arms, you can almost touch a dozen different kinds of bright flowers. Some of them stand alone—a single flower or two, different from all those surrounding it. Others blossom among a whole crowd of their own kind in a cheerful cluster. It is not an orderly flower bed, but it is a rich one.*

From <u>Seasons of the Tallgrass Prairie</u> by Carol Lerner.


© Earth Partnership • University of Wisconsin-Madison

**An artistic interpretation:**

Contrasts, texture, color, variety, and depth describe a close-up view of a prairie. The line is vertical and erect; a horizontal line is loosely introduced through the various heights of the plants. Distinct layers as in a forest are evident. The variety of species and individuals results in contrasts of colors, shapes, and textures. Texture plays an important visual role—fine-textured grasses contrast with broad-leaved plants. Different leaf shapes further diversify the texture. The emphasis of the close-up view is on the individual plants rather than the mass.

## Activity Description

Go out to a natural area and select a spot from which to view the entire landscape. Discuss the artistic characteristics of a vista view. Read or listen to a quote on how impressive the original landscape was when viewed as far as the eye could see. Imagine how it must have looked as you listen to the recounting.

Spread out and draw a vista view of the landscape. Draw for twenty minutes. Regroup, share your drawings, and describe what you noticed. How did the vista approach make you feel?

Now select a spot to observe a close-up view. Discuss the characteristics of a close-up view and read a quote about looking closely into a small space. Draw a detailed view for twenty minutes. Regroup, share your drawings, and describe what you noticed. How did the close-up approach make you feel?

## Extensions

- Repeat this exercise each season. Repetition allows you to observe change through time, to expand awareness, and to gain a sense of discovery and connection with the natural world.
- Visit a wetland or woodland to use as a model for your school's restoration. Examine the close-up and vista views to determine what elements you might want to include.
- Write an article for the local newspaper about the artistic splendor of your natural region.

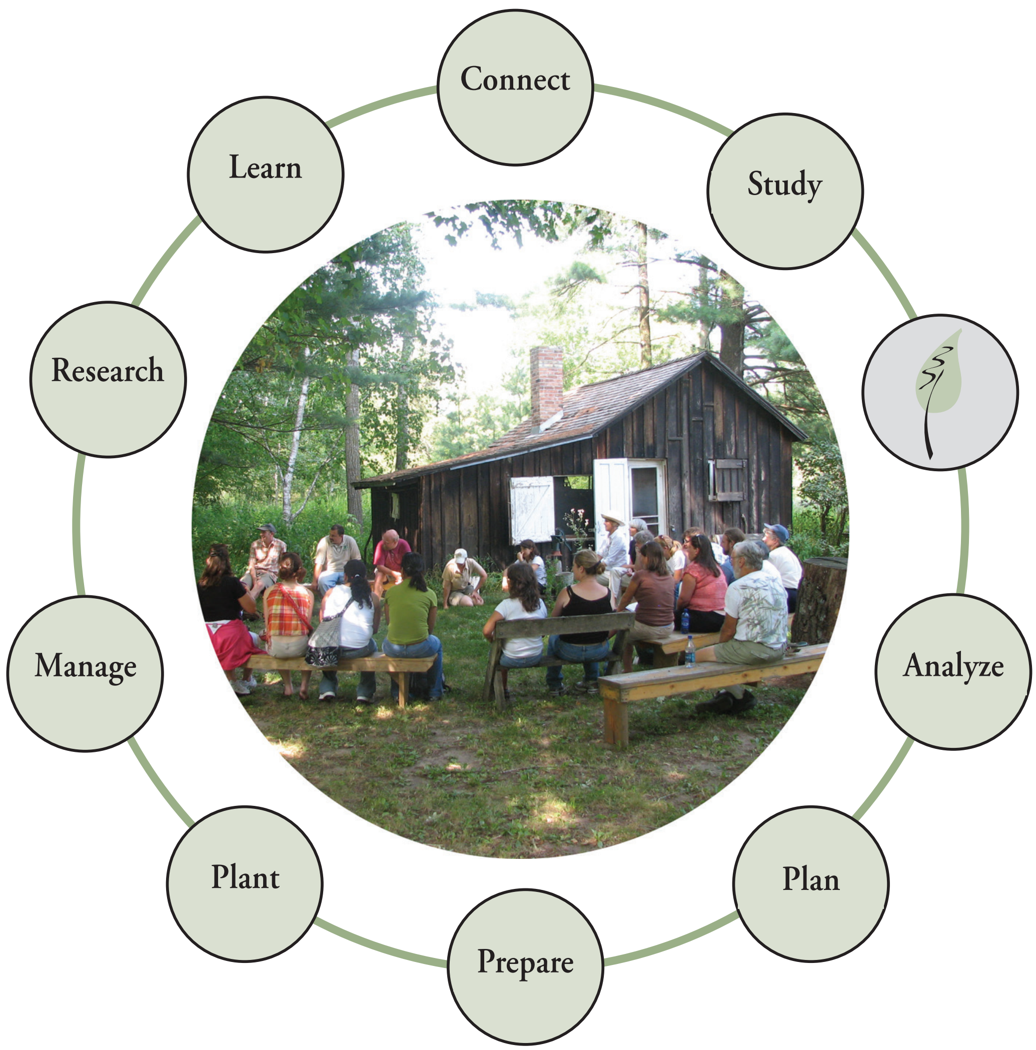
## Assessments

- Summarize the class discussion. Write the summary in a news article format.
- Compare and contrast the two views. Describe three design lessons you observed that you could incorporate into your school site restoration.

earth partnership

# Investigate

written and oral site history and
landscape patterns, past and present



# Section Introduction: INVESTIGATE

Understanding the history of a site is crucial to developing a restoration project that honors the ecological and cultural integrity of a place. The ways in which history informs restoration have evolved, but it still is a very important step in the learning process.

For a long time in the United States, restoration involved consulting records from when European immigrants first came to a region, and attempting to return the land to those seemingly pristine conditions. But the history of a landscape does not start with contact with Western civilization. For thousands of years, Native peoples had been interacting with and influencing their surroundings, and before then, ecological conditions were (and always have been) in flux due to climate changes, growth of and competition between plant and animal species, and disturbances in the environment like storms, floods, and erosion.

While European immigrants did not necessarily understand much of what they saw upon their arrival to new places, in many cases they left detailed records that can contribute to understanding a place. Also, subsequent land records in the form of surveyor's notes, maps, and photos can provide interesting snapshots of what was happening on the landscape in different points of time ("Land History: Primary Sources"). Information about the landscape and its influence on people can also be seen in many forms of expression from different cultures; important types to study include written stories ("Land History: Literature") and stories that are passed down from person to person ("Land History: Oral Histories").

Using multiple sources of information to investigate the history of a site can involve a balancing act between different accounts of what was happening and what happened in a given place. No one source represents the "true" version, but it is part of the restoration process to seek out and consider different kinds of information about land history. It is also part of the process to decide how what you learn about the historical conditions, patterns, and stories of your place influence what you do to care for the land now and into the future.


© Earth Partnership • University of Wisconsin-Madison

# Land History: Primary Sources

**Activity Overview**
Students interpret the past and gain a deeper understanding of our relationship to the land using a variety of primary sources.

**Objectives**
Students will:

- Read and discuss accounts from Native Americans, pioneers, settlers, and former local residents to understand human experience and relation to land
- Identify and examine various sources of information to construct an understanding of the past
- Explain different points of view about the same historical event

**Subjects Covered**
Language Arts and Social Studies

**Grades**
3 through 12

**Activity Time**
Depends on nature of research

**Season**
Any

**Materials**
Primary sources such as diaries, journals, biographies, census records, community newspapers, letters, artifacts, photos and scrapbooks from historical societies, libraries, universities or residents in the community

## Background

Learning about the history of the land through primary sources broadens student understanding of how Native Americans, explorers, traders, surveyors, settlers, and former local residents lived on the native landscape. Researching materials and oral traditions from their own community or geographical region can spark students' interest, connecting them to the specific natural and cultural significance of their school restoration.

Local libraries, historical societies, universities, and people in the community are good resources for primary source materials. Available materials might include family stories, diaries, journals, biographies, census records, community newspapers, letters, artifacts, photos and scrapbooks.

## Activity Description

Read a variety of primary sources. Then choose one of the following suggestions to interpret the information:

- Describe how a cultural group lived on the land. Explain their relationship with the land and ways of interacting with the native ecosystems.
- Describe the changes on the native landscape after European settlement.
- Detail how the land's resources influenced lifestyles and attitudes toward the landscape. You may compare and contrast different geographic areas or time periods.
- Read different accounts about local history and then create a timeline of significant events. Have each class member complete at least one index card describing a significant event. You can hang the events on a visual timeline using string and clothespins, and then review the events as a group.
- Read accounts from a variety of sources about a single theme such as land use, local foods and diet, styles of dress, professions, lifestyles, or quotes describing the area. Then create a timeline to illustrate change through time.
- Construct historical trees of community members in the area.
- Describe land uses, local economy, religion, politics, schools, changes in transportation, natural resources in the area, etc., based on information from primary sources.
- Explain different points of view about the same historical event, such as the Native American vs. the pioneer perspective, a woman's view compared to a man's, or viewpoints about conflicting use of land.

## Extensions

- As a class project design a display, write a skit, or compile quotes based on research of primary sources for a spring planting or a fall harvest celebration day.
- Invite elders to share their memories of the area when they were young or stories they heard from their parents and grandparents.

# Land History: Primary Sources (cont.)

## Assessments

- Describe the attitudes concerning land from three different inhabitants who lived in your region in the past.
- Describe the same event in history from two different perspectives.
- Create a historically authentic short narrative using what you learned through readings,oral history interviews and storytelling and research.



© Earth Partnership • University of Wisconsin-Madison

# Land History: Literature

### Activity Overview
Students read and discuss historical fiction and nonfiction that explores the human experience in relation to land.

### Objectives
Students will:

- Read and discuss literary and non-literary texts to understand human experience in relation to the land
- Draw on a broad base of knowledge and insights found in literature
- Explore the difference between fiction and nonfiction

### Subjects Covered
Language Arts, Science, and Social Studies

### Grades
K through 12

### Activity Time
Varies

### Season
Any

### Materials
Historical literature that deals with Native American, explorer, and pioneer experiences with the land. A bibliography follows the activity

## Background
Learning about the history of the land through literature deepens students' understanding of how indigenous peoples, explorers, and pioneers lived and related to native landscapes. Students will begin to see their school's restored native landscape not just as an assemblage of plants, but as a piece of an ecosystem with "deep roots"! By reading fictional or historical accounts of indigenous people, settlers, and immigrants, students will discover the challenges, hardships, joys, and insights of living on the land.

*Please note:* There is debate whether one should use Native American or American Indian when referring to indigenous people. "First Nations" and "Indigenous" are becoming more acceptable terms. Dr. Lisa Poupart, Professor in First Nations Studies at UW-Green Bay, observes First Nations is becoming the preferred term because it directly refers to the political sovereign status of First Nations in the U.S. Each Nation is a sovereign government with a direct relationship with the U.S. Federal Government. She explains, "Today there are 560 federally recognized First Nations tribes and bands in the U.S. In addition, there are many First Nations that are not federally recognized. Each Nation has a unique culture, language, and history. Each Nation also has its own name. As sovereign entities, each Nation should be referred to by its name. For example, I am a member of the Lac Du Flambeau Band of Lake Superior Chippewa. Traditionally we call ourselves Anishinaabeg. The term Ojibwe is also used to refer to my Nation."

## Activity Description
Read a work of historical fiction or nonfiction that explores the characters' relationship with the land. Consider the following questions when reading your book:

- How did the people care for and use the land?
- What were their beliefs and customs in respect to the land?
- Describe the land.
- How did the main character(s) or writer(s) feel about the land and why? Consider their viewpoints based on their previous experiences, goals, and relation to the land.
- What plants and animals lived on the land, and which ones were used for food or medicine?
- Are any of the plants described in the book growing in your restoration or could they be added?
- How is your restoration different from the land described in the book?
- Who is the author and what is his/her background or point of view? Describe his or her bias.
- Is this a work of fiction or non-fiction? How does that affect how we interpret the events in this book?

## Extensions

- After reading impressions, accounts and journals of early European settlers, write a fictional journal of a settler's experience on the land.
- Write a letter from a new settler to someone "back home" describing the new land.
- Read a book from a Native author, write about the Native perspective of land and relationships with the plants and animals.
- Write a new chapter based on the book you've read.
- After finishing your book, rewrite the book from a different perspective (maybe from your school or community.); write a sequel or prequel.
- As a class project design a display, write a skit, or compile quotes from your readings for a spring planting or fall harvest celebration day.
- Visit the local library or historical society to investigate the existence of diaries written by residents who lived in former times. Explore the difference between fiction and nonfiction.


© Earth Partnership • University of Wisconsin-Madison

# Land History: Oral History

**Activity Overview**
Students interview elders about the area's history.

**Objectives**
Students will:

- Learn about their place through oral history
- Prepare and conduct an interview
- Communicate and compare insights and perspectives gathered from the interviews

**Subjects Covered**
Language Arts and Social Studies

**Grades**
3 through 12; K-2 (see Extensions)

**Activity Time**
1 hour minimum for interviews plus time to analyze

**Season**
Any

**Materials**
Tape recorder (for the interview, if desired), stationery and postage stamps

## Background

Interviews with people who have lived in the area for a long time are a valuable resource for researching land history. When students talk to and listen to older members of the community, they learn what their community looked like long before fast food restaurants and shopping malls, and how young people related to the landscape before digital technology. There are many oral stories that have not been recorded or made available to the public, and they may be lost forever. By collecting and preserving these interesting stories for the future, students can perform a meaningful community service.

## Activity Description

Interview an elder living in your community. Here is a summary of useful ideas to help you prepare and conduct an interview:

1. Select a person to interview. To find someone with historical knowledge or personal experiences, contact your local newspaper, historical society, library, senior citizen center, tribal offices or publications and organizations such as the VFW, American Legion, service clubs or organizations.
2. Write questions you will ask during the interview. Possible interview questions include:
    - What changes in land use and land ownership did you witness?
    - How did the roads and transportation change?
    - What significant events took place in the area?
    - What stories did you hear as a child from your parents, grandparents, or others?
    - What activities did you do after school or in the summer?
    - Did you have a favorite place to visit? If so, where was it and what is there now?
    - What was located where the school is now?
    - Where did you go to school? What do you remember about your education?
    - What did you eat for meals? How much of your food did your family grow or raise? Did your family collect wild foods such as fruits or nuts and have favorite locations to collect food seasonally?
3. Rehearse the interview and discuss good etiquette for interacting with your subject. If you are interviewing in teams, assign roles (interviewer, notetaker, photographer) and practice those roles.
4. Make an appointment convenient for the person you are interviewing. Explain what your project is about and what topics you would like to cover.
5. Take a digital device and writing materials to the interview.
6. Before the interview, introduce yourself; thank the person for granting the interview and ask if they mind audio recording and picture taking.

6. Ask questions and listen attentively. Keep eye contact and show you are actively interested in the topic.
7. At the end of your interview, review your notes and ask follow-up questions or clarify unclear points. Thank your interviewee and offer to show him or her a copy of your finished work.
8. After the interview, write a thank you letter.
9. As soon as possible, write a summary of your interview.
10. Present and share interesting insights learned from the interviews. Discuss the different perspectives and experiences elders of the community remember of the area's history.

## Extensions

- The information collected through these interviews is a valuable contribution to the community. Create a booklet for the historical society or library. If possible add photographs and show family trees or Native American clans diagrams to embellish the booklet. Be aware of privacy concerns, however when sharing information.
- Compare the perspectives and experiences of the elders with those of today's children in the community.
- As a class project design a display, write a skit, or compile quotes to convey the findings during a prairie or season celebration day.
- Visit the local library or historical society to search for diaries written by residents in the past.
- Invite an elder to a classroom of K-2 students for a group interview.

## Assessments

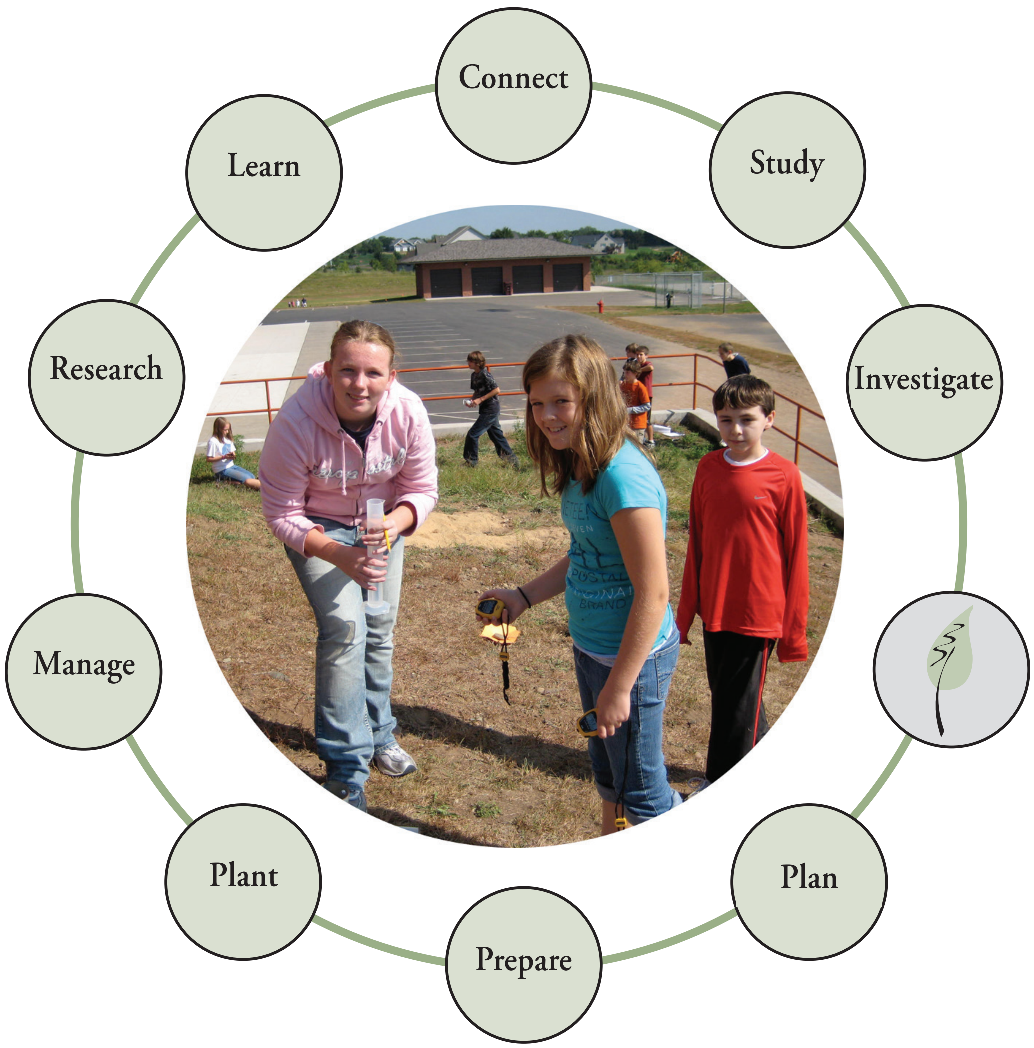
- Based on your experience at the interview, write what you learned about conducting an interview, what went well, and what you might change.
- Develop a five-minute presentation on what you learned about local history through the interview.
- Compare your personal experiences in your local community with your interviewee's experiences. What seems the same and what seems different and why?


© Earth Partnership • University of Wisconsin-Madison

earth partnership

# Analyze

soil, water, slope, sun/shade, vegetation,
physical and aesthetic qualities



# Section Introduction: ANALYZE

Site analysis is a crucial step in planning a successful restoration, and it is also a great way to involve learners in the project. Analysis can be done using simple techniques that use only basic materials, and it can be performed almost anywhere. All of the site analysis activities that you do can be represented on a final site analysis map.

Native vegetation grows along a continuum of moisture, soil and light conditions.  No two woodlands, marshes or wetlands are exactly alike, but rather respond to circumstances of soil, slope, location, temperature and seed sources that create the unique conditions for that particular site. This variation is why analysis of your particular site is so important. Analyzing the restoration site will help you determine which part of the native plant continuum may have existed on the site before development, which species could be on the site now, and other design considerations necessary for a successful restoration.

First, outline the physical area of the site (“Mapping Your Schoolyard”). Many schools and organizations already have site plans showing measurements of property boundaries and buildings. If you don’t have such a plan, you have an excellent opportunity to measure and present a site map. Google Maps and other online mapping/satellite imagery can be very helpful in representing the site. In addition to mapping current conditions, collect maps of historical usage, which can include public land surveys and plat books.

Next, begin collecting site-specific information.  The site analysis data gathered will include information about soils, water flow, physical objects such as buildings and hard surfaces, existing vegetation, slopes, aspect of slopes, traffic patterns, patterns of shade, views and other characteristics such as predominating wind patterns, underground utilities, noise and needs for supervision (“Noting Notable Features”).

Existing Vegetation: Map all the existing vegetation on site, starting with trees and shrubs.  Measure both the circumference of the trees and the extent of the branches ("Activity Suite: Tree Investigations").  Once you have identified the existing vegetation you will have guidelines for the potential species to introduce or to remove from the site. ("What's Possible?"),

Plants capture, absorb and hold water on their leaves, branches and roots. Vegetation can significantly reduce the amount of water running on the surface of the ground. Locate areas where plants are contributing to evapotranspiration and infiltration. Plants provide shade to cool the air, land surfaces and water flowing through the site. Heated storm water can potentially affect wildlife living in the receiving waters. Locate areas that contribute significant heat to the air and ground surfaces where new plantings would reduce these “heat island” effects and cool storm water. ("Activity Suite: Tree Investigations").

Slope: Slope affects human uses of the land. The erosion potential of the slope is determined by the types of soil present, and the nature of the slope (long, gradual, steep, short). When a slope erodes due to heavy or inappropriate use, drainage patterns are interrupted, topsoil erodes and sedimentation increases downstream. Protecting and restoring eroded slopes can be an important restoration action. Additionally, the steepness of the slope and the direction (aspect) of the slope influence plant growth by affecting water holding capacity in the soil and sunlight available to plants. Plants that are adapted to hot dry conditions grow on steep south-facing slopes, whereas plants adapted to cool moist conditions would go on most steep north-facing slopes (“Measuring Slope”).

Soils: Soil is a living community, composed of biotic organisms, organic material, weathered rock materials, air, and water. The biological parts of the soil include animals, plants, fungi, and microorganisms, and the organic materials are their decayed remains. The physical components of the soil include water, air (atmospheric gases), rocks, and rock particles. You can also find maps of soils that have been done on a county-wide level. These maps describe the general outline where soils occur and the characteristics of the soils. To fine-tune this information, you can collect soil samples and investigate them (“Identifying Your Soil,” “Infiltration Tests,” and “Soil Explorations”). Soils can also be sent to professional labs for more detailed analysis.

Other important factors in site analysis include:

Sun/Shade: Plants are adapted to different light conditions. Shade from buildings is different than shade from vegetation because it is solid and year-round. Shade from deciduous trees is usually dappled and nonexistent from fall to late spring. Some woodland plants that grow in dense woodlands would not do well in the shade of buildings because


© Earth Partnership • University of Wisconsin-Madison

there is no sunlight available in the spring.

Existing Wildlife: The existing wildlife habitat value of the site can be assessed by inventorying sources for food and water, locations for possible shelter, and places to raise young. Some of these habitat elements may be next to or near the site and accessible to wildlife from the site.

Topography and Water Flow: Keeping rain water close to where it falls and encouraging as many on-site processes in the water cycle as possible protects water quality and reduces large quantities of water surging into local rivers and lakes. Locating potential places to increase infiltration and evapotranspiration and to slow and filter rainwater is a goal for any water-friendly landscape. Identify places where water flows off hard surfaces such as roofs and pavement; places where water collects as puddles or flows through ditches; detention ponds, streams and natural water bodies; steep slopes where water could be slowed down and soil held by native species; or places where water collects and soaks into the ground.

Once you have analyzed site conditions and created a map synthesizing your findings, you can integrate your findings with other design educational and aesthetic design considerations to help guide your restoration plan.

*Educators at the 2015 Kickapoo Valley institute discuss their site analysis findings. Kickapoo Valley Reserve, LaFarge, WI. Photo: Claire Shaller Bjork.*

# Mapping Your Schoolyard

**Activity Overview**
Students use compasses and measuring tapes to create a map of their schoolyard.

**Objectives**
Students will:

- Measure their schoolyard using measurement tools
- Understand the relationship between a map and terrain
- Transpose observations on the ground to a scaled drawing
- Understand how the school map will inform their restoration project

**Subjects Covered**
Math and Social Studies

**Grades**
3 through 12

**Activity Time**
1 hour units; number of units depends on the size of your schoolyard

**Season**
Any

**Materials**
Existing maps of your school grounds (if possible), a classroom set of compasses, at least two 100- to 200-foot measuring tapes, grid paper, surveyor's flags, clipboards, pencils, a ruler, masking tape, table for setting up outside

## Background

A map of the schoolyard is essential for developing a restoration plan for several reasons. The map of the school site helps you envision and effectively develop a landscape design plan that meets student learning objectives while restoring a natural landscape. Educationally, the mapping process offers hands-on, cooperative skill-building experiences where students can employ math skills and visualize spatial relationships.

The first step in the map-making process is to locate existing maps of the school property such as construction blueprints, topographic maps from the U.S. Geological Survey, online maps, and city and community maps. These maps will save steps and time by providing a base map of your site. Additionally, you can use these maps to look at your school's position in relation to its surroundings, such as its geographical location, its position in the watershed, and its neighboring landowners. The maps may enable you to predict future land uses and future development that may affect your project. You can also identify natural areas with similar topography, soil, and hydrology that you can use as models for planning your restoration. All of this information will help you to understand your school's connections and relationships to the local environment.

Many schools have site maps showing the building locations and property perimeter. If your school does not, you will need to begin mapping by measuring the perimeter of the schoolyard and then adding distinguishing features. Your completed map will show locations of all permanent features such as buildings, drives, sidewalks, fences, walls, and other permanent structures; utilities above and below ground; playgrounds and athletic fields; existing vegetation; and open water.

Ultimately, this map will become a tool to help you determine what plant communities to plant on your site and where to plant them. The exact form a restoration takes can be determined by design considerations and restraints as well as your project goals and objectives. You may decide to include outdoor classroom seating areas, benches for quiet contemplation or socializing, pathways, rain gardens, butterfly and wildlife plantings, etc. There are many different ways to map your schoolyard. The following activity describes one way to create a map. Students may want to figure out their own way to map their grounds; for instance, students could use grid paper to estimate the location of objects and to create a relational scale among those objects. Regardless of approach, your final site map must include the following basic information:

1. direction and scale of the map
2. the physical outline of the site
3. location of human-built features such as buildings, utilities, play areas, and fences
4. slopes, low areas and high spots
5. soils
6. existing vegetation


© Earth Partnership • University of Wisconsin-Madison

7. light availability
8. traffic patterns
9. other uses

## Pre-Activity Preparation

### Indoors:

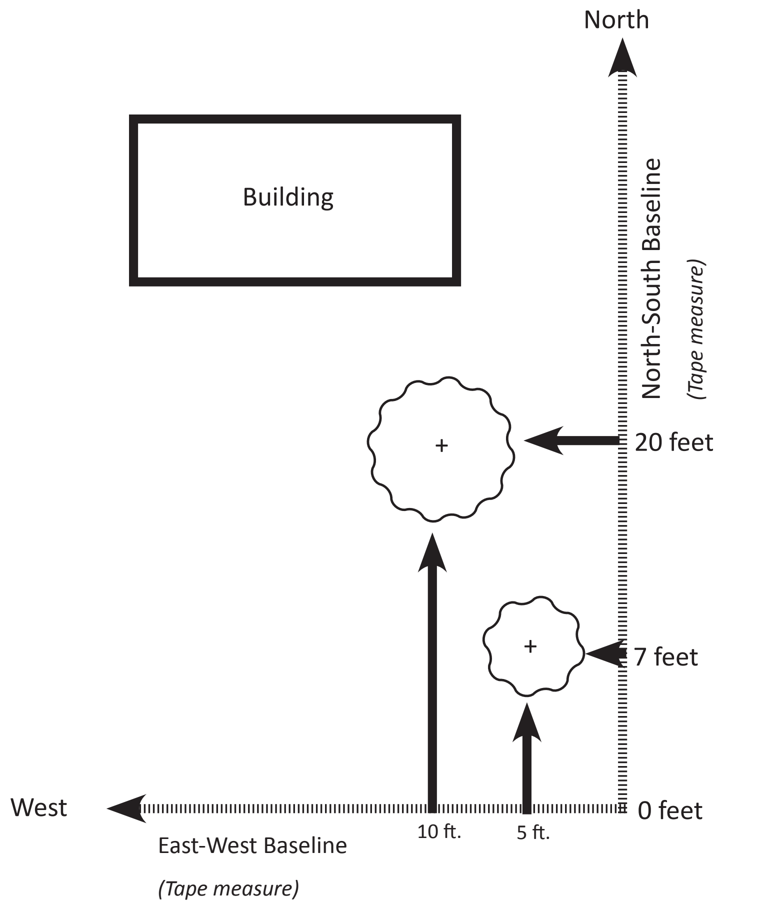
1. Divide the schoolyard into “mapping sections” to accommodate length of measuring tapes, time available, and class size (i.e., classroom management).
2. Determine the scale of your map based on the size of your schoolyard or mapping sections. The ultimate scale should allow you to view the whole site with adequate detail. Depending upon the size of your site, a scale ranging from 10 to 40 feet per inch seems to provide satisfactory information. Fitting a map on 11 by 17 grid paper is practical for making multiple copies and for student usability. Mapping sections can be pieced together to view the entire school property. One way to determine the scale of the map is to measure the perimeter of the school property or selected area and determine a ground to map ratio that will fit the size of paper. For example, if the area measures 320 feet by 200 feet and the paper is 17 by 11 inches, you may calculate a scale of 1 inch = 20 feet through simple division (320 ÷ 17, 200 ÷ 11). The site will measure 16 by 10 inches on the paper. This step takes some trial and error calculations. You can purchase grid paper to fit your scale or you can make a grid on the computer.
3. Familiarize students with compass operation using EP activity “Compass Basics.” Students will need to be able to sight objects using cardinal directions N, S, E, and W. Students can also map their classroom as a warm-up exercise.
4. Assemble measuring equipment: see Materials list.

### Outdoors:

1. Extend the measuring tapes on the ground to use as baselines for plotting the location of objects. First, lay out a baseline measuring tape on the north-south axis. Use a directional compass (set compass bearing N or S depending on walking direction) and one measuring tape. Walk in a north or south line using a compass while laying the tape on the ground. Place surveyor’s flags at twenty-foot intervals to help mark the baseline. Use additional tape measures to lengthen the baseline, if desired.
2. Next, lay out a baseline on the east-west axis. Begin on the 0 mark of the north-south line and lay out the second baseline perpendicular to the first. Again use a directional compass (set compass bearing E or W depending upon walking direction) and one measuring tape. Walk in an east-west line using a compass while laying the tape on the ground. Place surveyor’s flags at twenty-foot intervals to help mark the baseline.
3. Transpose the baseline onto the grid paper map. Use a ruler to draw the baselines on the map. Tape the map on a card table or other flat surface in the mapping area.

## Activity Description

1. Before going outside, review the mapping procedure on an overhead projector or chalkboard.

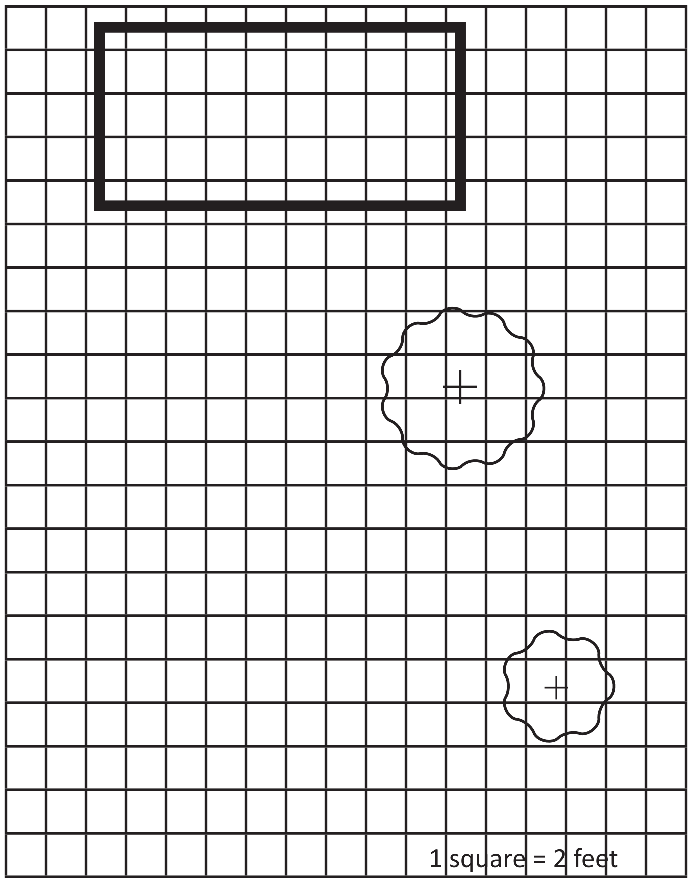



*Tape measures laid out as baselines to locate trees.*

2. Form teams of two. Go outside and practice locating objects using the compass. First, line up on the north-south baseline. One partner takes ten to twenty steps away from the north-south baseline while his/her partner stands opposite on the baseline. The partners should be facing each other. The person on the baseline sets his/her compass bearing to E and moves along the baseline until the partner is sighted exactly east on the compass. Look down and read the measurement on the baseline. This is the distance your partner is from 0 on the north-south baseline. Now trade places. Repeat.
3. Next, go to the east-west baseline and repeat this practice exercise, except set the compass bearing to N or S. When locating real objects, you must sight each object from the north-south baseline and the east-west baseline.
4. Now you are ready to locate trees, benches, and other objects within the designated area. You will do this by sighting objects from each baseline so that you take two measurements for each sighted feature. After you sight an object, place a flag next to it so others know it has already been located for the map.


© Earth Partnership • University of Wisconsin-Madison

5. Once you have taken the measurements, go to the map and mark the object on the map.
6. Once all objects have been sighted, create a final map.




*Map on grid paper showing location of trees and a building.*

7. As a group, discuss how the information you collected will inform your project.

Please note that this activity is written with two baselines joining at the 0 marks. Another option is to have the baselines intersect in the middle. The second option creates four quadrats. Each schoolyard is unique; try to lay out your baselines to minimize the number of baselines needed to map your site.

## Extensions

- Digitize the schoolyard map.
- Create a 3-D model of the school grounds.
- Use tracing paper to make map overlays of soils, sun and shade patterns, and hydrology. See EP activity "Noting Notable Features."
- Identify and examine characteristics of existing plants on the school grounds. Activities may include designing a key for identification, measuring the diameter and canopy, and measuring the shade patterns cast by the plants at different times of the day (See EP Activity Suite "Tree Investigations").

## Assessments

- Provide sighting measurements for trees, benches, signs, etc., and then locate these features on a map.
- Explain to another student how to set up a baseline.
- After experiencing this mapping method, describe alternate ways you might map a schoolyard.
- Describe the challenges you encountered mapping and how you might problem-solve solutions.
- Present your completed map to classmates and explain why the map is important to the restoration project.


© Earth Partnership • University of Wisconsin-Madison

# Noting Notable Features

**Activity Overview**
Students survey their schoolyard to learn about the physical, biological and human-related characteristics of the school property to inform native restoration projects focused on water-friendly landscapes.

**Objectives**
Students will:
- Describe biotic and a-biotic interactions at their school site
- Describe physical interactions (water patterns) at their school site
- Present scientific investigations using multi-media
- Survey and collect physical, biological and cultural information about their school site to use for decision-making
- Develop skills to collect and analyze data in a real world project
- Develop skills necessary to create maps such as: scale, measurement, relative position, orientation and direction

**Subjects Covered**
Science, Information Technology, Language Arts and Math

**Grades -** K through 12

**Season -** Any

**Materials**
Clipboards, map of schoolyard, student field sheets, pencils or colored pencils, compasses, soil and air thermometers (for 1 team), digital cameras (if possible), classroom discussion: Overhead projector or document camera/scanner, computer and LCD projector.

## Background

Before making decisions about where to locate your restorations or native plantings and what to plant at that site, students should have a good sense of the current characteristics of the land on which they will work. Site analysis is a great way to involve students from the very beginning of the project. You can use these investigative activities almost anywhere. All of the site analysis activities can be represented on a final site analysis map. This map becomes a tool to help determine what types of native plantings, restorations and wildlife habitats to restore or plant on your site and the ideal places to locate them.

## Pre-Activity Preparation

Make a copy of an existing map showing the location of buildings, paved areas, and property lines. Provide a place on the map for a compass rose (to indicate North), the scale and space for students to write their investigation focus. If desired, divide the schoolyard map into sections and investigate one section at a time. Make enough copies of the map for each student or group of students. For follow-up discussions create a transparency of the schoolyard map for an overhead projector or use a document camera with a Smart Board/LCD Projector or scan completed maps to display digitally.

Many schools have site plans showing measurements of property boundaries and buildings. If you don't have such a plan, you have an excellent opportunity for students to measure and develop a site map. See EP activity "Mapping Your Schoolyard" to learn how to map your site and draw your measurements to scale on graph paper. In addition to mapping current conditions, collect maps of historical usage, which can include original surveys and plat books to learn what was once exited on the site. If building a map from scratch is overwhelming to you, Google Earth is one resource that may help you with this.

Posting a large map in your classroom will help your students with the next activities.

## Activity Description

This activity will help you to get acquainted with your schoolyard. Before you can make any decisions about developing native plantings to protect water quality, planting wildlife habitat or restoring native ecosystems, you need to understand the characteristics of your schoolyard. Walk the school grounds to identify and locate physical, biological, and human-related features unique to the school.

By dividing into research teams, students will become "experts" in one important factor that will influence decisions made about the restoration. Each team will collect a different type of data (physical, biological or cultural), to create a fuller picture of the entire area. By giving each group a different focus, their research becomes more important and authentic. There are six teams:

# Noting Notable Features (cont.)

## Physical Features

**Topography and Water Flow Team** – This team will identify the lay of the land to locate high spots and determine the highest spot; to locate low spots, and determine the lowest spot and locate steep slopes, swales (ditches), and flat areas. Diagram the direction and flow of water and areas where water is standing for a period of time after a rain and areas that dry out more quickly than others. Locate downspouts and storm drains. Locate where water might exit the school property. Also add to the map which areas are hard surfaces (impervious) and which are porous (pervious).

**Microclimate Team** – This team will map and identify sun/shade patterns using a rating system, measure air and soil temperatures and determine prevailing wind directions.

## Biological Features

**Vegetation Team** – This team will identify and locate existing vegetation, starting with trees and shrubs. Locate different ground covers such as lawn grass, flower beds, unmowed areas (or old fields), prairie (meadow), woodland ground covers, and vegetable gardens, etc. Identify species, if possible, or use categories on the field sheet.

**Wildlife Team** – This team will identify wildlife or signs of wildlife in the schoolyard. Look for trees, shrubs, and plants that provide food (berries, nuts, or seeds) and cover for wildlife, locate sources of water and possible places to raise young.

## Cultural Features

**Traffic Patterns Team** – This team will identify traffic patterns for cars, bicycles and people in and around the school. Determine and indicate on the map where people walk that is not a designated sidewalk. Describe views as seen from drives, walkways, and classrooms.

**Land Use Team** – This team will identify human site use features such as play areas, athletic fields, and play equipment; structures including bike racks, signs, benches, picnic tables, and fences; and utility features above or below ground. Identify areas of high use and low use based on your observations.

## Part 1: Noting Notable Features: Site Inventory

1. Begin by reviewing your school-based map that the students created. List what information the map provides about the habitat and brainstorm what it does not provide. This brainstorm provides the impetus for further data collection on the site.
2. You will be on one research team that is responsible for very important information about the site. You will be responsible for reporting back to the whole group and, therefore your information needs to be thorough and accurate as it will influence decisions made about the restoration. There are 6 teams. Each team is responsible for completing instructions on their assigned field sheet and identifying those features on the schoolyard map using symbols. Knowing the focus of each research team, discuss how the student-generated list from step one connects with the focus of each team.
3. In your team, review your roles as described on your data collection sheet together prior to going outside. Report out to the class what information you will be collecting so everyone knows all of the pieces that are being considered. (An alternative to using pre-made data collection sheets would be to have students use the brainsorm from step 1 to create their own set of questions and data collection ideas for each team focus and share with the class to make sure all topics are covered.)
4. Collect tools your group feels are necessary to complete your assigned task. Each group will receive a copy of the class map. Use your map along with your data sheet to record your information where appropriate. It is recommended that you take digital pictures as evidence for the data that your group is reporting. It will also help to have these visuals when you do their presentations for the class.
5. Head out to the site and collect your data.


© Earth Partnership • University of Wisconsin-Madison

6. Come inside and review your map and all of the information you collected to make sure it is complete. Prepare a presentation for your classmates (This can be formal or informal, but encourage students to use the map and photos where relevant to explain their findings. They may need to scan and project their maps for better viewing.)

### Part 2: Analyze and Present your Investigations with your Team

1. Present your results to the class. Think about how the information that you collected helps make decisions about what you will do at your site.
2. Think about and discuss the interactions observed among biological and physical things on the school grounds. How might you be able to increase interactions for a healthy landscape? What is thriving and what is simply surviving here? Do we have enough biodiversity? How are we helping people interact with this site in a positive way? How could we improve this?

   For example, you observe a lone monarch butterfly hovering around a plant. You could research what kinds of plants monarchs and other butterflies need to survive and decide to plant caterpillar host and nectar plants to increase the population of butterflies. Or perhaps you observe the soil is compacted and plants are not able to grow. You could loosen the soil; add organic matter and plant vegetation tolerant to compaction. Soon soil organisms will begin decomposition, more plants can be added and new insects and other wildlife will appear increasing the number of interactions. Or take note of where erosion is occurring, and identify if the landscape needs re-grading or planted with native seeds and plants to halt erosion.
3. Based on your investigations, identify possible spaces for restoration projects, wildlife areas, rain gardens, bioswales, outdoor classrooms, and other site improvements.

## Extensions

- Discuss the following questions: How do you feel when you are on school grounds? Do you feel comfortable, welcome/unwelcome, inspired/uninspired, protected/exposed, free/restricted? Where are your favorite/least favorite areas, and why? What would you like to change about your school grounds? What would you like to stay the same? How do you envision your school looking in five years or ten years?
- Conduct a site analysis of your school's neighborhood to identify where water is allowed to infiltrate, detained or moving. Determine how your school is connected to these sites.
- Record and monitor the trees growing on the school grounds and determine how much water each tree is intercepts. See EP activity "Interception" (Water Stewardship Guide).

## Assessments

- Students should be assessed individually or in teams by writing their own plan for the school grounds including a map. They should support their ideas with data and explain how this improves the property.

# Noting Notable Features: Field Sheet

## Topography and Water Flow Team

**Directions:** Use a map of your school site to note the following physical features. Create a key and designate symbols to mark the various features on your map.

**Identify the topographical and water features on your site. Answer questions and take notes where indicated.**

- **Topography**
  Identify hills, valleys, slopes, and flat areas
  Find high spots. Determine the highest spot
  Find low spots. Determine the lowest spot
  Locate steep slopes
- **Water:**
  Designate drainage or waterways and show the direction water flows
  Show which surfaces are impermeable (water runs off and cannot pass through) and which are permeable
  Show where water flows off the site, if possible
  Locate spots where water collects that seem to have wet soil now or at some time of the year
  Locate storm drains
  Locate downspouts (indicate where the downspout drains onto, i.e., lawn, pavement, etc.)
  Find spots that seem especially dry, where water may run off quickly
  Locate ponds, streams, ditches, swales or springs

| |
|---|
| Describe the general lay of the land and any features that are unique or interesting. |
| How do you think topography influences the movement of water? |
| If downspouts are draining directly onto pavement, can the water be redirected to a lawn area, other porous surface or rain garden? If so, how? |
| How do the think the topography influences the plants and animals and how do you think the plants and animals influence topography? |
| Based on your observations, what is important to consider when developing a plan? |



© Earth Partnership • University of Wisconsin-Madison

# Noting Notable Features: Field Sheet

## Micro-Climate Team – Wind and Sun/Shade Conditions

**Directions:** Use a map of your school site to note the following physical features. Create a key and designate symbols to mark the various features on your map. Choose some representative sites on the property for making measurements.

**Analyze the wind and sun/shade conditions on your site. If possible, make observations at different times of the day and of the year.**

**Wind**

Determine prevailing wind direction and how the wind blows across your site. Consider if this may change seasonally.

**Sun/Shade and Temperature**

1. Light conditions and temperatures near and around vegetation.

Estimate the light conditions on a scale from one (the sky is not visible due to interference from tree canopy, etc.) to five (you see the entire sky from horizon to horizon). Look straight up. Do not count the clouds as a visual barrier of the sky. Measure air and soil temperatures. Indicate results on your map.

Location: _________________________________ No View 1 2 3 4 5 Full View

Time of day: ________ Air temperature: __________ Soil Temperature: __________

Location: _________________________________ No View 1 2 3 4 5 Full View

Time of day: _______ Air temperature: ___________ Soil Temperature: __________

Location: _________________________________ No View 1 2 3 4 5 Full View

Time of day: _______ Air temperature: ___________ Soil Temperature: __________

2. Estimate light conditions (shaded or sunny) and temperatures near buildings.

Location: _________________________________ Shaded or Sunny

Time of day: _______ Air temperature: ___________ Soil Temperature: __________

Location: _________________________________ Shaded or Sunny

Time of day: _______ Air temperature: ___________ Soil Temperature: __________

| What recommendations do you have for the school plan based on your observations? |
| --- |
| |

# Noting Notable Features: Field Sheet

## Vegetation Team

**Directions:** Use a map of your school site to note the following biological features. Create a key and designate symbols to mark the various features on your map.

**Identify trees, shrubs and groundlayer types or species on your site. Answer questions and take notes where indicated.**

**Trees and Shrubs**
Identify trees and shrubs and approximate locations if they not already identified on your map.
You may identify the exact species using field guides. Example: red oak
You may identify by type. Examples: deciduous, evergreen
You may identify groups. Example: aspens, birches, pines, large trees, small trees
Identify food types (berries, nuts, seeds) and cover for wildlife

**Groundlayer**
Locate different groundcovers such as lawn grass, flower beds, unmowed areas (or old fields), prairie (meadow), woodland ground covers, vegetable gardens, etc.
Identify food and cover for wildlife.

**Invasive Species**
Identify weedy areas or where invasive species are growing.

| |
|---|
| Identify plantings that are pleasant to be around. Why do these places feel good to you? |
| Identify areas where the plantings need improvement. Explain why. |
| Identify plantings that seem like they are for intercepting (capturing, catching) rain water. Why did you choose these sites? |
| What recommendations do you have for the school plan based on your observations? |


© Earth Partnership • University of Wisconsin-Madison

# Noting Notable Features: Field Sheet

## Wildlife Team

**Directions:** Use a map of your school site to note the following biological features. Create a key and designate symbols to mark the various features on your map.

**Identify wildlife and wildlife habitat on your site.**

**Wildlife**

Identify wildlife or signs of wildlife (pawprints, chewed leaves, nests, scat, dens, insect life).
Show their location on the map and record below. You will use the data collected as a baseline for monitoring change after a restoration project is implemented.

| Species | How Many? | What is it doing? | Where do you see it? |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**Wildlife Habitat**

Inventory sources for food, water, locations for possible shelter, and places to raise young. Some of these habitat elements may be next to or near the school site and accessible to wildlife from the school property.

| Location | Describe how this could help wildlife (food, water, possible shelter, etc.) |
|---|---|
| | |
| | |
| | |

What recommendations do you have for the school plan based on your observations?

# Noting Notable Features: Field Sheet

## Traffic Patterns Team

**Directions:** Use a map of your school site to note the following human-related features. Create a key and designate symbols to mark the various features on your map.

**General Traffic Patterns for vehicles, bicycles and people**
Identify driveways and parking areas with direction of traffic flow
Identify sidewalks
Identify pathways (watch where people walk and/or look for signs of pathways such as well-worn trails and shortcuts)
Identify where people enter or exit the school grounds

| |
|---|
| Describe anything of interest or concerns as you analyze the traffic patterns on your site. |
| Do you notice any erosion caused by trails or foot traffic? If so, where? |
| How well are the needs for walking, using wheelchairs or riding bikes being met on the school grounds? What do you recommend? |
| How would you change traffic patterns for reasons of safety or to improve movement in and around the school grounds? |
| What unique features do you observe? Do the trails or walkways lead you to these interesting features or not? |

**Views**
Analyze views within the space and from drives, walkways, and classrooms. Look for views you would rather not see or views that are pleasant to see.


© Earth Partnership • University of Wisconsin-Madison

# Noting Notable Features: Field Sheet

## Land Use Team

**Directions:** Use a map of your school site to note the following human-related features. Create a key and designate symbols to mark the various features on your map.

**Determine the different land uses and features on your site. Write notes and show locations on your map.**

Play areas and athletic fields: Identify site use features such as play areas and athletic fields

Seating Spaces: Identify existing seating areas such as outdoor classrooms or places for groups to gather.

Structures: Locate and identify structures including bike racks, signs, benches, picnic tables, shelters, bathrooms, and fences.

Utility Lines: Locate utility features above or below ground.

| |
|---|
| Use of Spaces: Identify areas of high use and low use based on your observations. What activities are happening in those areas? |
| Uses adjacent to your site: Indicate the uses near your site. How might they affect your restoration project? |
| Are the current uses of your site compatible with a restoration project? Why or why not? |
| What recommendations do you have for the school plan based on your observations? |

# What's Possible? Analyzing Existing Vegetation

**Activity Overview**
Students identify plants on the school grounds and decide what significance, if any, these plants will have for the school's ecological restoration project.

**Objectives**
Students will:

- Identify plants using field guides
- Analyze the suitability of existing plants for the ecological restoration
- Apply the information learned to make restoration decisions

**Subjects Covered**
Science

**Grades**
3 through 12

**Activity Time**
1-4 hours depending upon depth of research

**Season**
Spring or Fall

**Materials**
Field guides, landscape restoration books, local resource materials, and a school site map

## Background

Analyzing the existing vegetation on your school grounds helps you to make sound ecological decisions about what type of ecosystems to restore and which methods of site preparation and management are needed. Your educational and site goals, soil, slope, etc. also are taken into account when planning an ecological restoration. The following types of existing vegetation influence the direction of a restoration project:

1. Native plants—Existing native species may form the basis for the type of community to restore. Large, open-grown trees such as oaks may be ideal for a savanna, or areas planted in trees including maple, ash or linden could form a framework for a woodland planting. Sedges growing in a wet area indicate possibilities for a sedge meadow or wet prairie. Native fruiting shrubs may inspire the creation of a woodland edge planting for wildlife habitat.
2. Exotic plants—Most likely, many of the landscape plants in the schoolyard will be exotic plants from other places in the world. Some of these plants may adversely affect the restoration and cause management headaches. Identifying and perhaps eliminating those species will save time, expense, physical toil, and frustration. Honeysuckle, buckthorn, and oriental bitter-sweet are a few landscape plants that have spread out of control in natural areas. If these plants are on neighboring property you may or may not be able to control their presence, but you will be able to watch for it in your restoration and manage it through pulling or fire management. Your state's DNR resource person or county extension agent can provide information about invasive non-native species and management strategies.

   Some native species may also be undesirable in your restoration. For example, sumac, gray dogwood, and trembling aspen are invasive in a prairie restoration.
3. Groundcover plants—Herbaceous species growing as lawn, old field or in unmowed areas may include weedy annuals such as ragweed or crabgrass, troublesome biennials such as Queen Anne's-lace or wild parsnip, persistent, weedy perennials such as red clover or quackgrass and desirable native species such as New England aster and black-eyed Susan. Identifying the groundlayer species growing on the school site will help you determine suitable site preparation and management techniques.

## Activity Description

Identifying what is growing at your site will help you to know how to proceed with your restoration project. Based on the species present, you can determine potential communities to restore, site preparation techniques, and follow-up management strategies. First, you will identify the species on the school grounds, and then you will analyze how these existing plants will affect the restoration. Follow these directions:

1. Identify trees, shrubs, and groundcover species on your site using field guides.
2. Answer the following questions about the existing vegetation using field


© Earth Partnership • University of Wisconsin-Madison

guides, landscape books, plant community species lists, and state and county publications.

• Which plants are exotic or native?

• Are there species that may become weedy pests on-site or ajacent to the site?

• Are there existing native species that may be incorporated into the restoration or may help to determine the type of ecosystem to restore?

• What is the composition of the lawn or herbaceous ground cover? Which plants are annuals, biennials, and perennials and of those which are potentially troublesome, neutral, or desirable?

3. Label existing plants on a vegetation overlay map or base map. Indicate on the vegetation overlay map which species are insignificant to the restoration, which species need to be managed or eliminated, and which species could be incorporated into the restoration.

4. Identify potential ecosystems to restore. Use books listed under Additional Resources and/or consult with local resource persons.

## Extensions

- Research ethnobotany of the plants growing on the school grounds.
- For more information about exotic plants, see EP activity "A Seed's Journey."
- Conduct a Soil Seed Bank Study to learn what plant species are dormant in the soil as seeds.

## Assessments

- Name and describe four plants on the school grounds. Identify if each plant is native or non-native and how it may influence the restoration.
- Based on the existing native plants growing on the school grounds, are there any potential communities that can be restored? Explain why or why not.
- Which plant communities may be appropriate to plant or restore on your school grounds? Explain why.

# Activity Suite: Tree Investigations

### Activity Overview
Students will identify, measure, and track trees growing on the school grounds and calculate the ecosystem services provided by the tree

### Objectives
Students will:

- Identify the type of tree
- Measure and calculate tree dimensions:
- Tree height
- Tree circumference/diameter
- Canopy size
- Compile and maintain tree records
- Calculate ecosystem services of trees

### Subjects Covered
Math and Science

### Grades
K through 12

### Activity Time
Variable based on activity choice

### Season
Any

### Materials
Varies by activity. Includes: measuring tapes or d.b.h. tapes (diameter/logger's tape), compasses, surveyor's flags or stakes, calculators, pencils, paper, field sheets, clipboards, clinometer, and tree identification guides

## Background

Ecologists, foresters, and botanists collect and record data about trees to learn about the trees' health, growth patterns, monetary value, their influence on an ecosystem, etc. In these activities, students will use some of the same tools and calculations as professionals to learn about the trees on their school grounds.

Measuring the height and canopy spread of trees, buildings and other tall objects is an important part of site analysis. You should know the location, size, and height of any object on your proposed restoration site. The object may affect the plants that are growing and can grow there, the animals that will inhabit and live in the area, the temperature, the sunlight, and the soil conditions. Knowledge of how the object casts a shadow through the day and through the seasons should be considered in your planting design.

This unit is a collection of different investigations into the ways to identify trees on your property, and then measure their size and value. Many activity options are given and teachers can pick and choose the approach or combination of approaches best suited to their circumstances (student age, time restrictions, math knowledge, etc). Procedures are included for Tree Identification, Measuring Tree Height, measuring tree circumference/diameter, canopy size, carbon sequestration and other ecosystem services. You may choose to collect all data on one day, or return to the same tree multiple times to record additional information.

All options presented could be used as part of a long-term, multi-year analysis of tree growth and change over time. We are presenting ways for one time recording, but we encourage teachers to consider ways to track data over time through spreadsheets and journals. Documenting changes over time may influence decision making and restoration planning. Over time students may compare, contrast, and analyze growth rates and sizes of the trees (See EP Activity "Inquiry-Based Field Research", and "Inquiry Learning: Students as Ecological Researchers"). They may also recognize problems developing in a tree through long-term observations. If you conduct long-term monitoring, be sure to tag and number the trees and/or map them so you can track the changes accurately. A suggestion for creating laminated tags is in "Tree Identification" extensions.


© Earth Partnership • University of Wisconsin-Madison

# Tree Identification

**Activity Overview**
Students will identify their tree

**Objectives**
Students will:
- Familiarize themselves with common characteristics of trees.
- Use a dichotomous key to identify a tree

**Subjects Covered**
Science

**Grades**
2 through 12

**Activity Time**
20 minutes introduction; at least 5-10 minutes in the field to identify one tree

**Season**
This key is for leaf-on seasons. There are also twig identification guides for leaf-off tree seasons.

**Materials**
Field sheet, Cuttings from a variety of trees that represent the terms to be identified. Tree Identification Terms, Tree Identification Guide (all available at the end of this unit) LEAF tree identification guides available online as well (search online for: UWSP LEAF tree identification card) , Field Sheets, Clipboards, Pencils

## Background

Tree identification is a valuable skill to begin research into the vegetation already growing on your property. This first activity is necessary for all of the remaining tree investigations, unless you already know the types of trees you have. We are providing a guide to identify trees when leaves are present, but other guides are available for twig identification (See EP Activity "Twigs are for Kids"). The identification guide referenced in this activity is courtesy of UWSP LEAF program (search online for: UWSP LEAF tree identification card). Many other tree guides exist and you can experiment with ones that work best for you.

Students will need help learning to identify key characteristics of leaves and patterns of tree branching to complete this activity, so we recommend you spend some time familiarizing them with those characteristics. Many will also need assistance using a dichotomous key for the first time. You may want to consider laminating your copies of the tree identification terms and keys to take out into the field (also see EP Activity "Taxonomy and Field Guide Warm Up").

## Activity Description

### Step 1. Learning Tree Characteristics

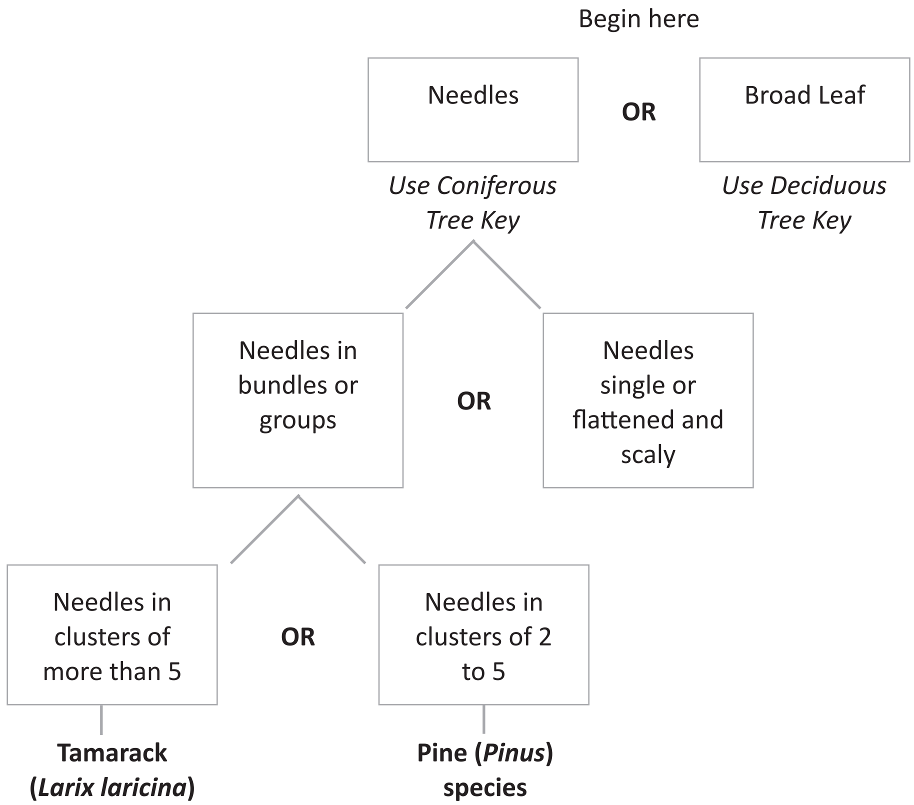
Provide each student or pairs of students with a copy of the Tree Identification Terms. Show or give them samples of tree cuttings to help them distinguish between major characteristics. For example, help students compare the stair stepping alternate branching with the symmetrical opposite branching pattern. Show them how to find the petiole to determine whether they see a simple or compound leaf. Count the bundles in different pine cuttings. Describe the different leaf margins they may encounter. Once they have some familiarity with these features, move on to the Key.

### Step 2. How to Use a Dichotomous Key

Dichotomous keys use a series of either/or questions to direct you through characteristics to identify your tree. The first characteristic to determine is whether your tree has needles or broad leaves. If it has needles, use the coniferous key. If it has broad leaves, use the deciduous tree key.

Most levels of the key have two options represented by the same number. Decide which one is correct and then go to the next choice, indicated in parentheses. For example, in the Coniferous Tree key you have two options labeled with the number 1: needles are in bundles or groups **OR** needles are single or flattened and scaly. If the tree has needles in bundles or groups, go to option (2), as indicated at the end of that line. There are two options given for choice (2) for number of needles to determine if you have a Tamarack or a Pine. Continue until you identify your species.

Another way to think about a dichotomous tree is thinking of the options like a path through a flow chart. *Example*:




**Step 3. Name that tree!**

Go outside and practice using the dichotomous key together as a class outside on one tree, then assign student teams to start identifying specific trees on the property. Fill in the tree name(s) on the field sheet.

## Extensions

- Ask students to tag the trees with identifying numbers as described below. This will help you to return to the same tree day after day or year after year for ongoing studies.
- Create a map of the location of the trees you identify.
- Tree Tag Preparation: Create a clear system to identify the trees in your study for accurate data collection. In a schoolyard with few trees, a schematic map is probably adequate to track locations. In a woodland, it will probably be necessary to tag trees. Tags can simply include the species and a number (Oak1 , Oak 2, Oak 3...) or they can contain more details using a code such as Oak 12 WLD (West woods, Large tree, Dry upland).
  You can make durable waterproof tags. Start with 3 x 5 cards and quarter them. Write the information with a permanent marker, then double- or triple-laminate the card. Trim, leaving a good inch of laminate all around the card. Add cloth tape at one corner and punch the hole there. Tie the tag to the tree with twine and check annually to see if twine should be replaced or lengthened as the tree grows.

## Assessments

- Tag trees without names and ask students to use the dichotomous key to identify them as a final assessment.


© Earth Partnership • University of Wisconsin-Madison

# Measuring Tree Height

### Activity Overview
Students will estimate tree height in a variety of ways.

### Objectives
Students will:
- Determine a measurement indirectly using estimation, ratio, proportion
- Measure length, height, and angle directly
- Use similar triangles (and possibly trigonometry) to determine height

### Subjects Covered
Science and Math

### Grades
K through 12

### Activity Time
15 minutes introduction; 45 minutes in field; 15 minutes calculation/discussion in classroom

### Season
Any

### Materials
Methods 1, 2, and 3: meter stick or tape measure, calculator. Method 4: sighting stick (to make, cut a 3-4 cm wide strip of wood to exactly 30 cm; at exactly 3 cm drill a hole 5-10 mm in diameter), meter stick or tape measure, calculator. Method 5: large protractor or clinometer, tape measure (or meter stick), scientific calculator

## Background
Measuring the height of trees, buildings and other tall objects is an important part of site analysis. You should know the location, size, and height of any tall object on your proposed restoration site. The object may affect the plants that are growing and can grow there, the animals that will inhabit and live in the area, the temperature, the sunlight, and the soil conditions. Knowledge of how the object casts a shadow through the day and through the seasons should be considered in your planting design.

There are many ways to estimate height. Below are five methods, starting with the simplest. Most techniques use estimation, ratios or similar triangles to find measurements. We recommend letting students "devise" some of these methods using what they learned in math class, but they are presented here as "how to" techniques.

## Activity Description
Estimate tree height by one of the methods described below (or let your students use their math skills to create their own) and record your results in the boxes marked "Enter Your Data" in the activity description. After you finish your estimations, record the height on a class data sheet. Compare estimates and methods. Which methods do you think are the most accurate? Why?

### 1. Rough estimate
Work in groups of two. Measure the height of one person and record. That person should then stand straight against the tree. The second person stands at a distance and estimates how many "heights" of that person make up the tree height. Walk farther back and repeat. Make this estimate four times and find the average. Multiply that estimate by the person's measured height to get the tree height.

*Example:*

Carla is 4'4" tall. Her partner estimates that the tree is 4.5 "Carla-heights" tall.

4'4" = 52", 52" x 4.5 = 234", the tree height estimate is 234" = 19'6

**Enter Your Data: Rough Estimate**

| height of person | X | number of "heights" (use average) | = | tree height |
|---|---|---|---|---|
| ______________ | | __________________ | | __________ |

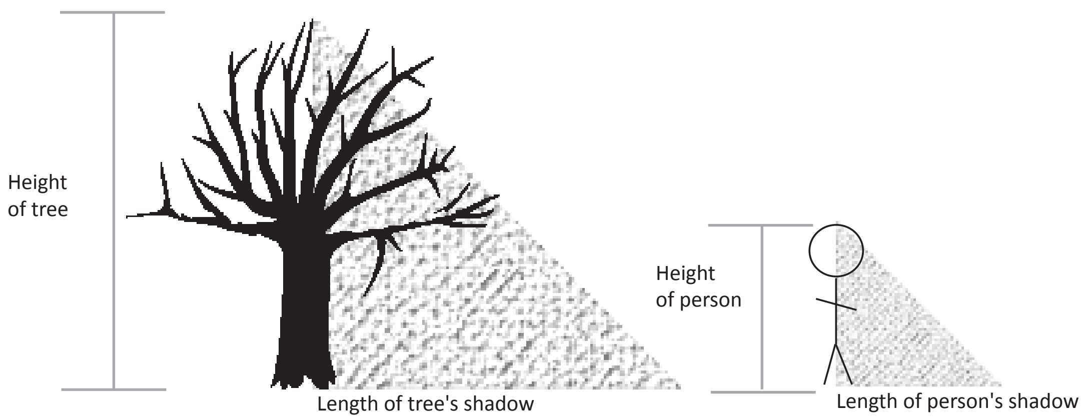
### 2. Logger's estimate
Work in groups of two. One person stands at a distance from the tree and extends an arm to full arm's length. Bracket the tree height between the thumb and forefinger. If the tree is too big, walk farther away from the tree. Without changing the distance between the fingers, rotate the hand so the thumb is on the base of the tree and the forefinger marks a spot along the ground some distance out from the tree base.

The second person then locates the spot on the ground identified by the first person's forefinger. The distance from that spot to the base of the tree equals the height of the tree. (Note: It is important that the first person keep their arm fully extended throughout this exercise; don't bend your arm to make the tree "fit" between your thumb and forefinger. If the tree does not fit, walk farther away or closer to the tree.)

**Enter Your Data: Logger's Estimate** ______________________________

### 3. Shadows (ratios or similar triangles)

Work in groups of two. Measure the height of one person and then measure their shadow and record. Immediately measure the length of the tree's shadow and record. Make sure you consistently use inches or feet for measurements.




The tree height can be calculated by the following proportion:

$$\frac{\text{height of tree}}{\text{length of tree's shadow}} = \frac{\text{height of person}}{\text{length of person's shadow}}$$

*Example:*

Willy is 5'1" (61") tall and his shadow measures 3'10" (46"). The tree shadow measures 21'7" (259"). The following ratio can be written:

$$\frac{X''}{259''} = \frac{61''}{46''}$$

The tree height (X) equals 343" or 28'7"

**Enter Your Data: Shadows**

height of person X length of tree's shadow / length of person's shadow = tree height

______________ ___________________ _____________________ _________

### 4. Sighting Stick

Work in groups of two. Using the sighting stick, move a distance from the tree so that, when held at arm's length, the base of the stick is at the base of the tree and the stick just covers the height of the tree. In this position, sight through the hole to the tree. The second person should mark the spot on the tree that is visible through the hole.


© Earth Partnership • University of Wisconsin-Madison

## Measuring Tree Height (cont.)

Because the stick is 30 cm long and the hole is drilled at 3 cm, tree height can be calculated using the following proportion:

$$\frac{3\text{cm}}{30\text{cm}} = \frac{\text{height of marked spot on tree}}{\text{height of tree}}$$

**Enter Your Data: Sighting Stick**

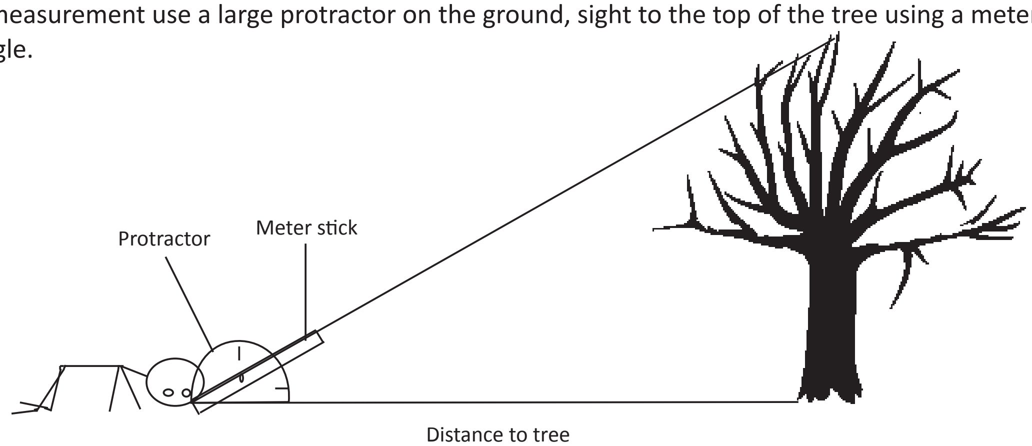
30 cm X height of the marked spot on the tree / 3 cm = tree height

______________________________ ________

### 5. Angle measurement (similar triangles or trigonometry options)

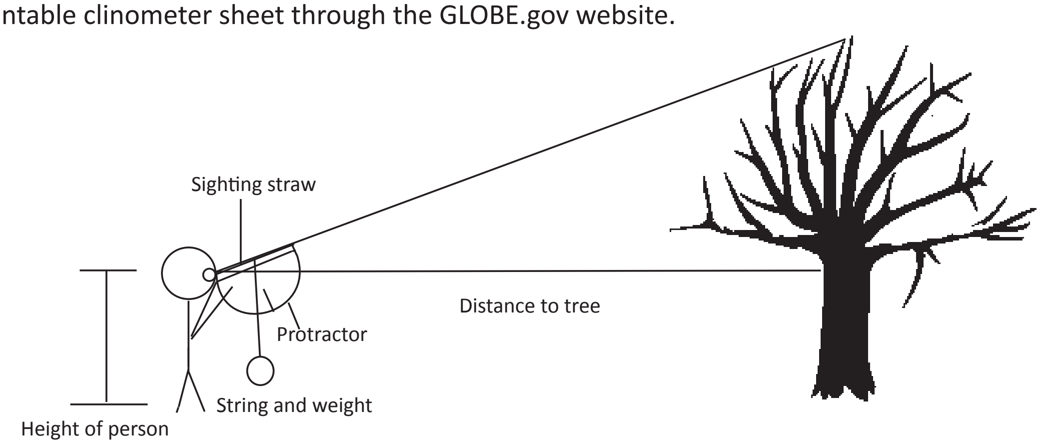
**From the ground**

Work in pairs. Pick a spot at some distance from the tree. Measure and record the distance from the base of the tree to that spot. Measure the angle necessary to sight to the top of the tree from that spot on the ground. To have a more accurate measurement use a large protractor on the ground, sight to the top of the tree using a meter stick and read off the angle.




**From standing position**

Alternatively, you may sight from a standing position. To do this with more accuracy, devise a crude clinometer. You can do this by attaching a straw lengthwise on the flat side of a protractor and then taping a string with a weight on the end to the middle of the straw. The weight should swing freely. By sighting to the tree top along the base of the protractor (through the straw), you can then read the correct angle from the string. You can find a free printable clinometer sheet through the GLOBE.gov website.



## Measuring Tree Height (cont.)

After calculating the tree height, *add to that figure your height up to your eye*.

Tree height can be calculated using the following equation:

$$\text{tangent of an angle} = \frac{\text{length of opposite side/height of tree}}{\text{length of adjacent side/distance to tree}} = \frac{\text{height of tree}}{\text{distance to tree}}$$

*Example:*

Let's say the angle measured to the top of the tree is sixty degrees and you are standing twenty-five feet from the tree when you measure. The variable X will represent the unknown height of the tree.

tangent(60) x 25 feet = 43.3 feet

The tree height (X) will equal 43 feet and four inches tall.

Note: You can avoid using trigonometry by using the clinometer to find tree height with just one very simple calculation. If you move yourself back from the tree until the weight is showing an angle of 45 degrees, the height of the tree will be the distance between you and the base of the tree plus your height.

| Enter Your Data: Angle Measurement | | | | |
|---|---|---|---|---|
| Tan of angle | X | distance to tree | = | tree height |
| __________ | | _____________ | | _________ |

## Extensions

- Have different groups measure the height of the same tree and compare results. Are differences caused by the chosen method or student technique/error? What if all groups use the same method, do we get the same answer? Why or why not?
- Estimate where shadows would fall on the property during the year based on the changing position of the sun.
- Measure shadows at different times of the day or year and record and map measurements. Trace the change in shadows and relate to the sun's position in the sky.
- Invite a forester into the classroom to learn about modern tree measurement techniques and how this information is used in forestry.

## Assessments

- Based on the data collected, which tree height measurements seem the most accurate and why? *(Note for teachers: Foresters use angle measurement most often. However, they should be aware if they site from the standing position that they need to account for their own height in their calculations. Students should always think about the accuracy of their instrument reading techniques.)*
- Based on the data collected, which tree height measurement is the least accurate and why? *(Note for teachers: the first two estimation methods are likely the least accurate due to lack of experience in estimating height and inaccuracy of holding fingers in place to measure distance)*
- Determine the range, median, and mode for the tree height data collected.


© Earth Partnership • University of Wisconsin-Madison

# Measuring Tree Circumference/Diameter

**Activity Overview**
Students will identify, measure, and track trees growing on the school grounds.

**Objectives**
Students will:

- Measure and calculate tree dimensions
- Compile and maintain tree records

**Subjects Covered**
Math and Science

**Grades**
4 through 12

**Activity Time**
Variable based on activity choice

**Season**
Any

**Materials**
Varies by activity. Includes: Measuring tapes or d.b.h. tapes (diameter/logger's tape), calculators, pencils, paper, field sheets, clipboards, field sheet, and internet access.

## Background

Ecologists, foresters, and botanists collect and record data about trees to learn about the trees' health, growth patterns, monetary value, their influence on an ecosystem, etc. In this activity, students will use some of the same tools and calculations as these professionals to calculate the canopy cover of trees on their school grounds.   These measurements can be used consider the approximate the age of and carbon sequestered by a tree, as well as various other ecosystem services.

## Activity Description

A d.b.h. tape (or diameter/logger's tape) is calibrated to measure the circumference and diameter of a tree. D.b.h. stands for "diameter at breast height" and measures the tree at 4.5 feet above ground level. If a d.b.h. tape is not available, students may measure the circumference with a flexible measuring tape and then calculate the diameter.  We recommend demonstrating the technique for all students if possible.

Directions for measuring circumference/diameter

1. Using a d.b.h. tape, measure the distance around the tree 4.5 feet above the ground. Enter the diameter and circumference on the field sheet. If the tree is on a slope, measure from the ground at the mid-point of the tree base. If a branch or growth is on the trunk at the 4.5-foot level, measure just below and record the measuring height. Measure the largest trunk with multiple-trunk trees.
2. Using a measuring tape, measure the distance around the tree at 4.5 feet above the ground. Calculate the diameter by dividing the circumference by (3.14). Enter the diameter and circumference on the field sheet.

## Extensions

- Record the data in a spreadsheet to monitor growth and change over time. Return to the same tree once/year.
- Construct a d.b.h. tape by relating circumference and diameter.
- Invite a forester into the classroom to learn about modern tree measurement techniques and how this information is used in forestry.
- Estimate tree age. It is fairly easy to estimate a tree's age by multiplying the tree diameter by it's growth factor. Growth factor refers to the rate at which a tree species grows every year. It is an average, based on specific soil and climate conditions. Smaller numbers indicate fast growers; larger numbers indicate slow growers. *Caution*: site conditions can vary greatly, and thus affect growth. Therefore age calculations are only rough estimates and should not be taken for absolutes.  We use them as instructional when we cannot take tree cores to count the rings.

# Measuring Tree Circumference/Diameter (cont.)

**Growth factors of common trees**

| | | |
|---|---|---|
| American Elm - 4 | Box Elder - 2 | Red Pine - 4 |
| Aspen - 2 | Cottonwood - 2 | River Birch - 3 |
| Basswood - 3 | Green Ash - 3 | Shagbark Hickory - 7.5 |
| Black Cherry - 5 | Ironwood - 21 | Sugar Maple - 5 |
| Black Oak - 5 | Red Maple - 4 | White Ash - 4 |
| Black Walnut - 4 | Red Oak - 5 | White Birch - 5 |

## Assessments

- Assign multiple groups to measure the same tree and compare results.  Discuss discrepancies and challenges to make an accurate measurement. Re-measure if needed.


© Earth Partnership • University of Wisconsin-Madison

# Measuring Canopy Size

**Activity Overview**
Students will identify, measure, and track trees growing on the school grounds.

**Objectives**
Students will:

- Measure and calculate tree dimensions
- Compile and maintain tree records

**Subjects Covered**
Math and Science

**Grades**
4 through 12

**Activity Time**
15 min/tree

**Season**
Any

**Materials**
Varies by activity. Includes: measuring tapes, compasses, surveyor's flags or stakes, calculators, pencils, paper, field sheets, and clipboards

## Background

Ecologists, foresters, and botanists collect and record data about trees to learn about the trees' health, growth patterns, monetary value, their influence on an ecosystem, etc. In this activity, students will use some of the same tools and calculations as these professionals to calculate canopy size of trees on their school grounds.   This information is useful when considering the influence of shading on ground vegetation for restorations.

Canopy and crown spread are measured with measuring tapes and compasses. A tree's canopy extends from the trunk to the tip of the branches, called the drip line. Crown spread is the average spread of the canopy. Students measure the canopy first, then calculate the crown spread.

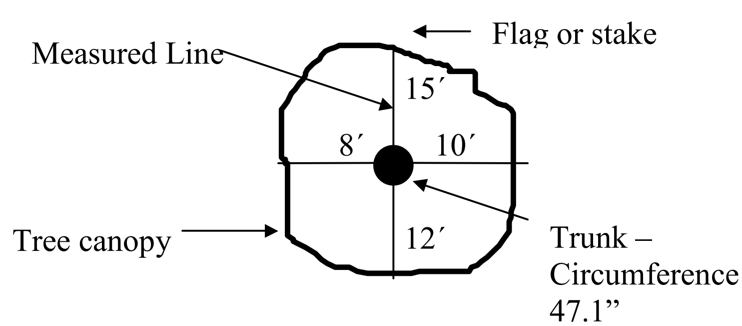
## Activity Description

### Measuring canopy and crown spread

Use a compass to mark lines running N, S, E, and W from the trunk of the tree.

1. Use a compass to mark lines running N, S, E, and W from the trunk of the tree.
2. Find the edge of the canopy (drip line) along these compass lines and place a surveyor's flag or stake at those four points as shown in the drawing .
3. Measure the distance from the trunk to each flag. Record the four measurements and draw a diagram on the field sheet.
4. Connect the lines to draw a circle around the tree to indicate the canopy. If the tree is particularly asymmetrical you may need to take extra measurements from the trunk to the drip line.
5. To calculate the average crown spread, add the four numbers together and divide by two.

*Example:* crown spread = (8' + 15' + 10' + 12') ÷ 2 = 17.5'



## Extensions

- Estimate the square area covered by the tree canopy. (Square area of canopy cover = (15' + 12') X (8' +10') = 286 sq. ft.)
- Examine shade effects on vegetation growing under and around the tree. Notice where the ground vegetation changes and estimate the size of the area (length x width) below the tree where shade appears to cause this change. Use the information to consider the following questions: Does the effect of shading on vegetation extend beyond the tree canopy? How far beyond? Is the shading effect symmetrical (extends the same direction in all directions from the tree)? In which direction does the shading extend the farthest? How will this change over the growing season?
- Make a map of the area surrounding the tree. Go outside at several different times of the day and mark shaded areas with flags. Locate the shade patterns on the map. Determine the area shaded during most of the day and the area shaded half of the day. Use the information for plant species selection.
- Do you have a champion tree? The total size of a tree can be ranked with a point system using the sum of circumference, tree height, and crown size. The American Forest System point value equals circumference in inches + height in feet + one-fourth of crown size in feet. You can use the calculations entered on your field sheet, but you will first need to make one final calculation to adjust crown spread. For example if the crown spread was calculated as 17.5', you must divide 17.5 by 4 (or x .25), which is 4.4, to enter into the formula.

.25 x _______ (average crown spread) = _______ (1/4 crown spread)

Use this formula to calculate total tree size:

______ circumference (in) + _______ tree height (ft) + ______ 1/4 crown spread (ft)) = __________ points

Tree size = 47.1 + 86 + 4.4 = 137.5

- Now you can rank the trees on the schoolyard from largest to smallest.
- Compare your tree to the American Forests Champion Trees or Wisconsin champion trees from the DNR

## Assessments

- Assign multiple groups to measure the same tree and compare results. Discuss discrepancies and re-measure if needed.


© Earth Partnership • University of Wisconsin-Madison

# Trees as Carbon Sinks

**Activity Overview**
Students investigate the ecosystem services performed by trees.

**Objectives**
Students will:
- Use a website to learn more about the tree's ecosystem services: carbon sequestration, water interception, energy conservation, air quality improvement
- Write a brief report about the tree

**Subjects Covered**
Science, Math

**Grades**
4 through 12

**Activity Time**
10-15 minutes for internet; 10 to 30 minutes for report writing

**Season**
Any

**Materials**
Tree measurements, computer with internet access

## Background

Students are often introduced to the idea of woodland values in terms of the products that come from trees cut for lumber, or the value of living trees for wildlife, erosion and storm water control, clean air and oxygen, as well as their aesthetic value in recreation areas.

Trees benefit wildlife—most importantly as providers of food (seeds, nuts or berries) and shelter. For example, birds feed on insect grubs harboring in the bark of trees and on caterpillars feeding on the leaves of trees.

- Trees provide erosion control in several ways. Tree canopies diminish the impact of intense precipitation on soil. Tree roots hold soil securely, preventing erosion and reducing sediment flow to surface waters.
- Tree roots absorb significant amounts of rainfall, reducing flooding and at the same time increasing on-site infiltration of rain which recharges the groundwater supply. Less widely known, perhaps, is that the hydraulic activity of tree roots helps maintain the water table where it is useful to other native plants, agricultural crops and wells.
- Trees improve air quality by absorbing pollutants out of the air, as well as adding oxygen as a by-product of photosynthesis.

Those services that trees provide us that don't always have a monetary value are called ecosystem services. When scientists and the public discuss climate change, they discuss another ecosystem service: living trees' ability to sequester atmospheric carbon. When a tree undergoes photosynthesis, it takes carbon dioxide out of the atmosphere and converts it into sugars, leaves, wood and bark. The carbon that becomes part of the wood of the tree stays put for decades or centuries until the tree dies and decays. Carbon sequestration by trees is considered such an important way of decreasing atmospheric carbon dioxide that forests are being planted as carbon sinks. Initially, many carbon-offset/carbon-sink forests were planted in the tropics; recent studies show temperate zone forests to be equally good at carbon sequestration.

How much carbon can one tree sequester? This activity will help us find out.

## Activity Description

1. Fill in the top part of the Trees as Carbon Sinks worksheet using data collected in the field. You will need the tree species and diameter measurements, as well as the general location.
2. Discuss the Land use type question on the worksheet with students in advance if they do not understand the categories. This information is required to make the calculation.
3. Go to the National Tree Benefit Calculator found at http://treebenefits.com/calculator/. Enter the local zip code, species, and tree diameter to learn how many pounds of carbon the tree is sequestering as well as pounds of other air pollutants, gallons of flood prevention, etc.
4. Record the information.
5. As a class, compile and analyze the data.

## Extensions

- If time allows, encourage students to play with their land-use type to see how the values change. Try to determine why this might occur.
- Where do these numbers come from? Examine the model behind this website.

## Assessments

- Which trees are most valuable and for what ecosystem services?
- What is the total "value" of our trees?


© Earth Partnership • University of Wisconsin-Madison

# Trees as Carbon Sinks: Worksheet

Name(s) ____________________________________________________

Tree name __________________________________________________

Other Common Name(s) ______________________________________

Scientific Name __________________________________

Location ____________________________________

Land use type nearest to tree (check one):

____ Single Family Residential

____ Multi-Family Residential (e.g., apartment building)

____ Small Commercial Business

____ Industrial or Large Commercial Business (school)

____ Park or other vacant land

Circumference (inches): ________ Diameter of trunk at 4.5 (dbh): ______ inches (diameter = circumference/3.14)

## Your Tree's Eco-Services

Visit the National Tree Benefit Calculator Site (tree.benefits.com/calculator/) to calculate the ecosystem services your tree provides, such as reducing carbon, intercepting storm water, improving air quality, and reducing energy use. To calculate the ecosystem services that your tree provides, you will need to enter your local zip code, tree species, tree diameter, and land use type data that you've collected.

Carbon sequestered per year: _______________________

Storm water intercepted per year: ___________________________

Energy conserved per year: ________________________________

Air quality improved by absorbing pollutants: ________________

What other benefits does your tree offer that are not included in the Tree Benefit Calculator?

____________________________________________________________________________________________________

____________________________________________________________________________________________________

____________________________________________________________________________________________________

____________________________________________________________________________________________________

____________________________________________________________________________________________________

What is our relationship with this tree?

____________________________________________________________________________________________________

____________________________________________________________________________________________________

____________________________________________________________________________________________________

____________________________________________________________________________________________________

____________________________________________________________________________________________________

# Measuring Slope

**Activity Overview**
Students measure the slope and calculate percent slope for their planting project.

**Objectives**
Students will:

- Measure and calculate degree of slope using simple tools
- Use math concepts in problem-solving a real-world situation
- Understand how the percent slope, i.e., steepness of a slope, affects the construction of a restoration

**Subjects Covered**
Science and Math

**Grades**
3 through 12

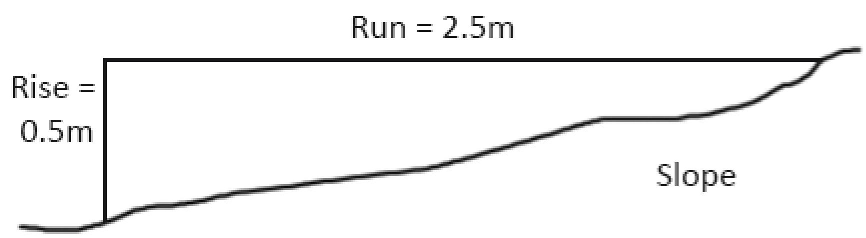
**Activity Time**
1-2 hours

**Season**
Any

**Materials**
For each team of 4 students - 1 Line level*, 5m or longer measuring tape or string, (2 wooden stakes,) meter stick, clipboard and field sheet

## Background

In restorations, it is important to determine the slope of the land in order to estimate the erosion potential of the site and to select the most appropriate planting techniques. The degree of slope also affects soil moisture and therefore influences species selection. The slope of a land area is expressed as the percent height the land rises or falls over a given distance. Slopes of 15 to 20% may be erosion-prone, as may be shallower slopes that have recently been graded or de-vegetated and slopes with clay soil. Usually, steep upper slopes are drier than lower or gentle slopes.




The easiest way to determine the percent slope of an area is to measure the change in height (elevation over a measured distance), then calculate the percentage of slope. Use the following formula to determine slope:

Rise ÷ Run x 100 = Slope %

OR

(Change in elevation [rise] ÷ horizontal distance [run] x 100 = slope %)

0.5” ÷ 2.5” x 100 = 20%

## Pre-Activity Preparation

For each team:

- This activity can be done in any measurement unit, but we encourage metric. Get a 5 m or longer measuring tape or create a 5 m string marked off in 10 cm increments. Two students can hold either end of the tape/string or you can use a stake to hold one end in the ground.
- Assemble a measuring tool packet with measuring tape or string, line level, meter stick or second shorter measuring tape, clipboard, field sheet and a pencil.

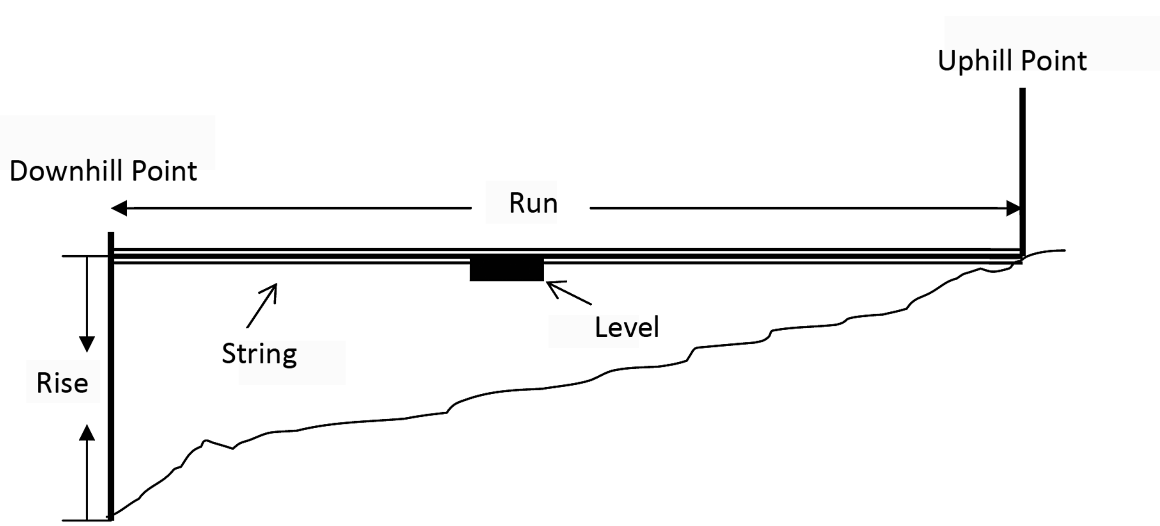

© Earth Partnership • University of Wisconsin-Madison

## Activity Description

1. Form teams of 5 students each, and hand out measuring tool packets. Each student has a different role. Two students are in charge of the 5 m measuring tape or string, one student works the level, another measures vertical distance. The fifth student records data.
2. Practice measuring slope in the classroom following the instructions below before going outside.
3. Select measuring sites in and around the proposed restoration. Not all students will be able to measure the slope in the restoration. Locate other sites for comparison, especially if different slopes are evident. Another option is to have all students practice in different spots, then measure the restoration as a group, in which students take turns doing and describing each step. If your hill is particularly long or has an uneven slope, this will provide opportunities for multiple students to make authentic measurements. Discuss the variation of the slope of the site and the implication for restoration.
4. Record measurements on the field sheets.

### Directions for measuring the slope

1. Hold one end of the measuring tape or string at the uphill end of the measuring site.
2. Find the downhill end of the site. This may or may not be the bottom of the full hill depending upon the length of the slope. Choose a representative slope if it is a long one. The student holding the downhill end of the tape should move it until the student with the level lets them know the tape is level.
3. Measure the rise from the ground to the height of the downhill end of the measuring tape.
4. Measure the run as the distance between the two students holding the level, horizontal measuring tape.
5. Record these numbers and calculate the slope.



## Extensions

- Measure a slope at three places along a line, and plot the results on a graph.
- Another technique for measuring slope uses just two meter sticks, which can be less cumbersome for younger students. Position one stick vertically on the lower side of the slope. The other stick, which has a level affixed in the middle, is placed horizontally against this stick to determine horizontal run. Adjust the "run" stick until the level indicates that the stick is flat, and read the height that has been indicated on the "rise" stick. Since meter sticks use a base ten system, there is no need for calculation - the rise will be the same as the percent slope.

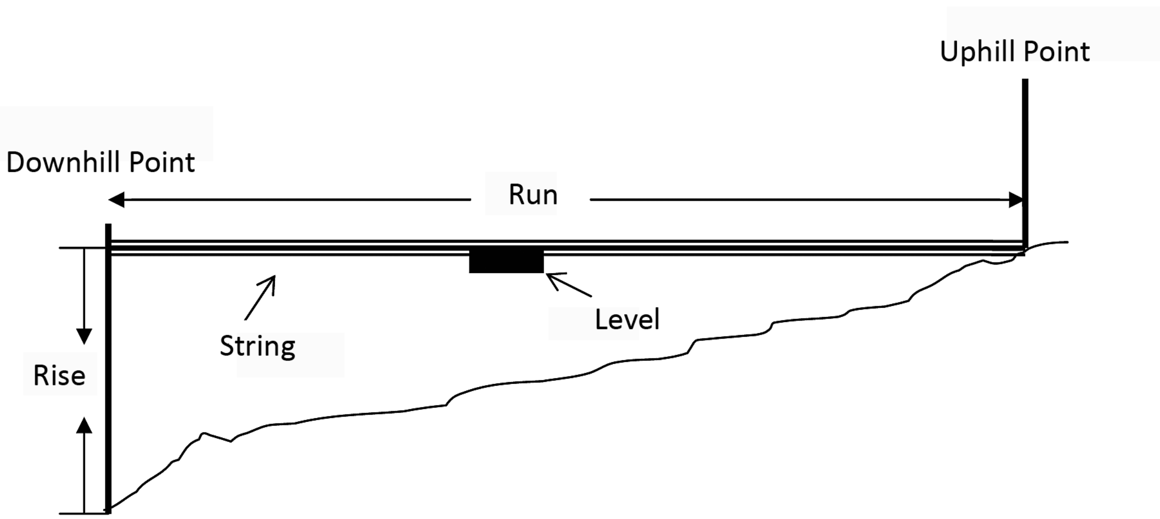
  Also, since this technique measures a smaller area, you will need to calculate the slope at several different places and then take the average of your findings. Use the Measuring Slope Field Sheet to note your measurements.
- Discuss how percent of slope affects human uses of the land. To learn about land use in relation to slope for the soils in your area, contact the Soil Conservation Service (U.S. Department of Agriculture). The combination of soil type and steepness of slope affects how an area may be used. Environmental problems created by inappropriate land use include interruption of drainage patterns which causes increased runoff, erosion, downstram sedimentation and flooding; loss of topsoil; loss of vegetation; destruction of uinique landscapes and sensitive habitats; and natural disasters such as slides, slippage and floods. As soil becomes soaked it gains weight and eventually gravity pulls it downslope. Sandy soils will stand on steeper slopes better than clay soils because they drain faster.
- Compare the slopes on your site with the recommended grading standards and crticial grades for North America:
  - Maximum grade for trails
    - Easy: 10% for a maximum distance of 50 feet
    - Moderate: 14% for a maximum distance of 50 feet
    - Difficult: 20% for a maximum distance of 50 feet
  - Grade for playing fields
    - Maximum: 3 to 5% (allowable)
    - Minimum: 2%
  - Grades for streets and drives
    - Maximum: 5 to 11% (allowable)
    - Minimum: 1%
    - Mowed banks with grass: 3%
    - Unmowed banks: 5%

## Assessments

- Describe the steps to accurately measure the slope on your schoolyard.
- Discuss why we must be concerned with slope when doing a restoration.


© Earth Partnership • University of Wisconsin-Madison

# Measuring Slope: Field Sheet




**Slope Formula**

Rise (change in elevation) ÷ Run (horizontal distance) x 100 = slope %

| Location | Rise | Run | % Slope |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| Average Slope: | | | |

# Identifying Your Soil

**Activity Overview**
Students identify soil type at their proposed planting location(s) using a soil texture feel test key.

**Objectives**
Students will:

- Manipulate and feel soil to classify soils by texture using a key
- Understand the relationship between soil particle size and water movement through soils
- Compare the composition of soil types

**Subjects Covered**
Science

**Grades**
K through 12

**Activity Time**
1 hour

**Season**
Any

**Materials**
Soil samples, spray bottles of water, paper toweling, Key to Soil Texture by Feel

## Background

Soil is made up of three particle sizes—sand, silt, and clay. Sand is the largest particle (0.05 to 2 mm diameter); silt is intermediate (0.05 to 0.002 mm); and clay is the smallest (less than 0.002 mm). Soils have different textures depending upon the proportions of sand, silt, or clay particles in the soil. A soil texture is graded into 14 texture classes or types such as sand, sandy loam, silty clay loam, loam, sandy clay, or clay. Sandy soil is any mix with over 90% sand; sandy loam is 70% sand, 15% silt, and 15% clay; clay soil is 50% clay, 25% silt, and 25 % sand; heavy clay is any mix with over 60% clay particles.

The texture of the soil influences the moisture holding capacity of soil, the drainage rate, and the soil's ability to hold nutrients. Coarse, sandy soils drain water quickly, are poor storehouses of nutrients, and create droughty conditions for plants. In clay soils water drains slowly; as a result, soil remains wet for long periods and often hinders root development. Plants growing in clay must be able to tolerate long periods of excessive moisture with low oxygen conditions, or endure dry, hard soil. The medium texture of silt-sized particles creates a loamy soil that is well drained and holds nutrients. It is ideal for most plant growth.

Soils can be classified into texture classes or types by the way they feel and respond to handling. Sand feels gritty, and the grains do not stick together when squeezed. Silt feels velvety or flour-like when dry and forms a weak ribbon when wet. Pulverized dry clay feels smooth; aggregates and clods are very hard and difficult to crush by hand. Wet clay feels sticky or very smooth and satin-like when rubbed and forms a long, flexible ribbon.

### Where does organic matter fit into the soil mix?

Organic matter is the biological components of the soil. Organic matter is either decomposed material or material in the process of decomposition; or fresh organic material; or living organisms. Organic material plays vital roles in the soil. It acts like a sponge, being able to absorb six times its weight in water. It holds onto nutrients that would otherwise wash away. Organic matter loosens heavy clay soil by creating spaces for air and water movement. Also, it adds nutrients such as nitrogen, phosphorus, potassium, and carbon.

## Activity Description

Collect soil samples from proposed restoration locations on the school grounds. Collect one and one-half cups of soil per sample for your classroom. Place about two teaspoons of soil in your hand. Spray water from a spray bottle to moisten the soil enough to form a ball. Next, use the soil texture feel test key to determine soil type. The step-by-step directions on the key will guide you through the process of soil identification. As a warm-up exercise, practice determining soil type with samples that are clearly comprised of sand, silt, or clay.  Record your observations.

## Extensions

- Soil textures vary from one horizon (soil layer) to the next; therefore, try to determine the texture in each of the A, B, and C horizons. Learning the soil


© Earth Partnership • University of Wisconsin-Madison

texture of each horizon will help you assess the soil's permeability at different levels. In some soils, the water drains quickly in the topsoil but drains poorly in subsoil. See EP activity "Soil Investigations" for more information about soil horizons.

- Take soil samples in the schoolyard, and send samples to a soil testing lab for professional testing and analysis.
- Determine soil type using a soil texture triangle to determine percentages of sand, silt and clay in a soil sample.
- Classify and compare soil texture at different locations on a slope or in eroded areas. Which particles collect at the base of the slope or remain on top? Which particles erode first? Is the pattern similar to particle movement on a slope? Can you predict which soils are more susceptible to erosion?
- Predict infiltration rates for each soil type in the yard based on your observations and identification. Then run the infiltration test.

## Assessments

- Explain how soil is classified, and describe two to three properties of each soil textural type.
- Explain the relationship between soil particle size, plant growth, and water movement through the soil.
- Determine the soil texture of three soil samples.

# Key to Soil Texture by Feel

Begin at the place marked "start" and follow the flow chart by answering the questions until you identify the soil sample. Please note that soils having a high organic matter content may feel smoother (siltier) than they actually are.

**Start** →

Place approximately 2 teaspoons of soil in your palm. Add water by drops and knead soil until it is moldable and feels like moist putty.

Does soil remain in a ball when squeezed?

**Yes** ↓ **No** → **Sand**

Place ball of soil between thumb and forefinger. Gently push the soil with thumb, squeezing it upward into a ribbon. Form a ribbon of uniform thickness and width. Allow the ribbon to emerge and extend over forefinger until it breaks from its own weight. Does soil form a ribbon?

**No** → **Loamy Sand**

**Yes** ↓

Does soil make a weak ribbon <1" long before it breaks?

**Yes** ↓

Does soil feel very gritty?

**Yes** → **Sandy Loam**

**No** → **Loam or Silt Loam**

Does soil make a weak ribbon 1" – 2" long before it breaks?

**Yes** ↓

Does soil feel very gritty?

**Yes** → **Sandy Clay Loam**

**No** → **Clay Loam or Silty Clay Loam**

Does soil make a weak ribbon <2" long before it breaks?

**Yes** ↓

Does soil feel very gritty?

**Yes** → **Sandy Clay**

**No** → **Clay**

*Source: Adapted from WOW!: The Wonders of Wetlands, Environmental Concern Inc.*



© Earth Partnership • University of Wisconsin-Madison

# Infiltration Tests: Exploring the Flow of Water Through Soils

**Activity Overview**
Students measure water flow into and through soils.

**Objectives**
Students will:

- Compare water movement through soil at different test sites and over time
- Collect data
- Interpret results to inform decision-making about school ground plantings
- Increase understanding of water-soil dynamics
- Understand human impact on the landscape

**Subjects Covered**
Science and Math

**Grades**
4 through 12

**Activity Time**
45 minutes; 2 hours wait time

**Season**
Spring or Fall

**Materials**
Option 1, Cut-Can Infiltrometer: metal cylinders (approximately 15 cm in diameter and 13-20 cm in length), hammer, scrap wood board, stopwatch or watch which reads in seconds, and measuring cup with capacity for half a liter or 1 pint.

Option 2, Water Absorption Test: shovel, ruler, stopwatch, 2-3 gallons of water

## Background

How water flows into and through a soil has great implications for the diversity of plants that can be supported by that soil. Different species of plants will be favored by a slow- versus a fast-draining soil. Accordingly, the choice of plant species for a native planting or for ecological restoration is determined in a large part by the dynamics of soil and water. Water flow through soil also plays a significant role in how large to build a rain garden. Infiltration rate measurements determine how quickly water soaks into the soil.

There are a number of factors which can influence how wet or dry a particular soil is and how water infiltrates the soil. The physical structure and texture of the topsoil is a key characteristic affecting water flow. A sandy soil has larger pore spaces than a clay soil. Pore spaces are the air spaces between particles. This allows water to percolate or infiltrate the soil more quickly. Clay soil is made up of smaller particles and pore spaces slowing water's ability to infiltrate.

Subsoil characteristics can also play a major role in water movement. A heavy (clay) subsoil layer can act as a seal underneath the topsoil. If there is enough rain, the topsoil will become saturated and there will be no place for the water to go regardless of the characteristics of the topsoil.

Soil compaction can lead to destruction of soil structure (the arrangement of soil particles and pore spaces), and thus reduce water flow. The pore spaces and natural cracks are squeezed out in a compacted soil, creating a cement-like consistency. Heavy construction vehicles, poor farming practices, and even walking on wet soil destroys soil structure and impedes water flow.

The amount of water being held by a soil at the time of testing can also greatly affect how water soaks into the ground. A saturated soil (where all pore spaces are full of water) will usually have a different flow rate than the same soil in an unsaturated state (like a dry sponge with many holes that can be filled with water). This is due to the presence of soil-water matrix forces in unsaturated conditions. These matrix forces are complex and result from a combination of adhesion forces (the attraction between soil surfaces and water) and cohesion forces (the attraction of molecules of water to each other). In saturated conditions gravitational forces alone are responsible for water movement in soils.

The first infiltration test described below is used to quantify the ability of water to move into and through a soil. Due to the great number of factors affecting the flow of water through soils, using this test on a relative basis is best. This means that a number of tests could either be run at the same time at different sites or at the same site at different times. The results from that particular set of tests are then only directly compared to each other. This technique is suitable to long-term soil infiltration testing. Usually as native plants mature and their roots spread, infiltration improves. This procedure can be used to track change over time. "Tilth" is a way to describe how tillable the soil is and how easily seedlings or roots can push through the soil. "Permeability" refers to how easily water (or other substances) pass through the soil. Compact soils are generally less permeable with slower infiltration rates and concrete is generally impermeable to water.

The second infiltration test is often used when planning a rain garden. The rate at which the water soaks into the ground indicates if the soil is sandy, silty, or clayey. Learning the soil type is a critical factor in determining how big to build a rain garden (see EP activity "Sizing a Rain Garden"). Learning soil type will also inform plant selection. Matching plants to soil type helps in choosing plants that will survive your proposed planting.

## Activity Description

### Option 1: Cut-Can Infiltrometer (best for comparative studies)

Carefully choose and prepare a test site. A level location will yield the best results by allowing the water to infiltrate evenly into the soil. A site with gravel will most likely be difficult or impossible because of difficulties in sinking the cylinder into the soil. A heavy lawn sod will create similar difficulties because of the dense mat of roots. Work around living plants, and expose bare soil by removing any leaf litter. Disturb the soil surface as little as possible.

Sink the cylinder into the soil approximately five to seven centimeters (two to three inches) to create a tight seal between the bottom of the cylinder and the soil. You will most likely need to use a hammer to do so. It is best to place a wood board on top of the cylinder when hammering to keep from denting its top. Hammer in circles around the top to keep the cylinder perpendicular with the soil surface. During the test, if water leaks out the bottom and sides of the cylinder, your results will be skewed. You will need to repeat the test with the cylinder either farther in the soil or sunk more carefully so the soil is less disturbed along the cutting edge of the cylinder.

*Middle school students run infiltrometer test at Edgewood College campus, Madison, WI. Photo: Cheryl Bauer-Armstrong.*

Have your watch ready and add the water to the cylinder. Time how long it takes for all of the water to move into the soil with complete elimination of all puddles.

#### Additional considerations

Some soils have very slow infiltration rates, which can lead to unnecessarily long run times. If you suspect you might have this problem, you can use an alternative procedure which is a bit more complicated but also more efficient. Graduate your cylinder by making one-centimeter (or one-half-inch) marks up its inside. To calibrate your gradations, measure how deep a given amount of water will fill an uncut can and extrapolate to your scale.

As a related math activity, this measurement can be achieved by calculating the volume corresponding to your gradations. Measure the diameter of your cylinder and calculate its cross-sectional area. (Remember the area of a circle = $\pi$ r2.) Multiply this number by the length of your gradation to determine the corresponding volume. Your calculations will be greatly simplified if you use metric units (one cubic centimeter = one milliliter).

 © Earth Partnership • University of Wisconsin-Madison

# Infiltration Tests: Exploring the Flow of Water Through Soils (cont.)

### Option 2: Water Absorption Test (best for rain garden planning)

Perform the following infiltration test at each location selected for a potential rain garden.

1. Dig a hole six inches deep by six inches in diameter.
2. Fill hole with water and let stand for one hour.
3. Refill hole with water. Measure depth of water with a ruler.
4. Let stand one hour. Then measure the depth again.
5. Use the following chart to determine soil types based on the rate at which water soaks into the soil.

| Soil type | Sand | Silt | Clay |
|---|---|---|---|
| Rate | 2 1/2 inches/hour or 4 hours total | 1/2 inch/hour or 12 hours total | 1/3 inch/hour or 18 hours total |

6. Record soil characteristics on data sheets.
7. Use data collected in EP activities “Designing a Rain Garden” and “Sizing a Rain Garden.”

## Extensions

- Before going into the field, conduct tests of infiltration rates for known soil components like sand, gravel, or clay in clear plastic bottles. This allows students to see water moving through particles in the soil.
- Compare infiltration rates through saturated versus unsaturated soils. Does the rate of infiltration vary with different soils? How does a recent rain event change infiltration rate?
- Investigate infiltration through subsoil. Carefully dig off the topsoil and place the infiltrometer into the subsoil layer.
- Compare infiltration rates between compacted soil and uncompacted soil. Observe and identify visual characteristics of compacted soil on the site. Think of other comparisons you could make on your property.
- Research what you can do to improve soil infiltration.

## Assessments

- Using the results of the infiltration tests, describe how different soil types and/or soil compaction influences water flow through soil.
- Based on the results of the infiltration tests, where would you locate a rain garden for best infiltration?
- Describe the factors that influence infiltration rates.

# Infiltration Tests Field Sheet

## Cut-Can Infiltrometer Data - Test 1

**Vegetation Type**
Prairie, woodland, savanna, garden, other_______________________________________________________

**Soil Characteristics**
Type: sand, loam, clay, other ____________________________________________________________

Tilth: compacted, intermediate, fluffy, other ____________________________________________________

Moisture level before test: select a number from 1-5 where 1 is bone dry and 5 is saturated __________

**Infiltration Rate** __________________ **minutes/250 ml**
(Note: If a different volume was measured, give the rate as minutes per 250 ml)

## Cut-Can Infiltrometer Data - Test 2

**Vegetation Type**
Prairie, woodland, savanna, garden, other_______________________________________________________

**Soil Characteristics**
Type: sand, loam, clay, other ____________________________________________________________

Tilth: compacted, intermediate, fluffy, other ____________________________________________________

Moisture level before test: select a number from 1-5 where 1 is bone dry and 5 is saturated __________

**Infiltration Rate** __________________ **minutes/250 ml**
(Note: If a different volume was measured, give the rate as minutes per 250 ml)

## Cut-Can Infiltrometer Data - Test 3

**Vegetation Type**
Prairie, woodland, savanna, garden, other_______________________________________________________

**Soil Characteristics**
Type: sand, loam, clay, other ____________________________________________________________

Tilth: compacted, intermediate, fluffy, other ____________________________________________________

Moisture level before test: select a number from 1-5 where 1 is bone dry and 5 is saturated __________

**Infiltration Rate** __________________ **minutes/250 ml**
(Note: If a different volume was measured, give the rate as minutes per 250 ml)


© Earth Partnership • University of Wisconsin-Madison

# Infiltration Tests Field Sheet

| Soil type | Sand | Silt | Clay |
|---|---|---|---|
| Rate | 2 1/2 inches/hour<br>or 4 hours total | 1/2 inch/hour<br>or 12 hours total | 1/3 inch/hour<br>or 18 hours total |

## Water Absorption Data - Test 1

**Vegetation Type**
Lawn, garden, field other ____________________________________________

**Soil Characteristics**
Tilth: compacted, intermediate, fluffy, other ______________________________

**Infiltration Rate** ___________ **inches/hour**

**Soil Type**____________________________________________________

## Water Absorption Data - Test 2

**Vegetation Type**
Lawn, garden, field other ____________________________________________

**Soil Characteristics**
Tilth: compacted, intermediate, fluffy, other ______________________________

**Infiltration Rate** ___________ **inches/hour**

**Soil Type**____________________________________________________

## Water Absorption Data - Test 3

**Vegetation Type**
Lawn, garden, field other ____________________________________________

**Soil Characteristics**
Tilth: compacted, intermediate, fluffy, other ______________________________

**Infiltration Rate** ___________ **inches/hour**

**Soil Type**____________________________________________________

# Soil Explorations

**Activity Overview**
Students identify the components of soil to understand through direct observation and experience that each ecosystem builds soil by recycling matter and nutrients.

**Objectives**
Students will:

- Practice observation and identification skills
- Develop investigative and comparative skills
- Practice accurate data-recording skills
- Observe adaptations in soil-dwelling organisms
- Understand the role of biological and physical matter in soil
- Gain an understanding of how ecosystems recycle matter and nutrients

**Subjects Covered**
Science, Language Arts

**Grades**
4 through 12

**Activity Time**
30 minutes to 1 hour

**Season:**
Spring or Fall

**Materials**
Soil samples (about one quart of soil per team of students), trays for soil samples, Soil Explorations field sheets, pencils, clipboards, bug boxes, hand lenses (if desired), shovel or trowel.

## Background

Soil is a living community, composed of biological organisms, organic material, weathered rock materials, air, and water. Parts of the soil include animals, plants, fungi, and microorganisms, and the organic materials of their decayed remains. The physical components of the soil include water, air (atmospheric gases), rocks, and rock particles. UW-Madison soil scientist Dr. Francis Hole used to describe soil as "the root domain of lively darkness and silence." Largely unseen by human eyes, these active underground parts form a vibrant complex system which supports life and all activities happening above ground. Knowing the components of the soil on your site and understanding the soil-building process are essential for developing a successful restoration project.

Billions of organisms live in the soil. Some are microscopic, such as fungi, bacteria and tiny animals; some could fit on a head of a pin, including mites, nematodes, and springtails; and some are easily seen, like ants, beetles, and earthworms. There are so many organisms in the soil that there is more biomass or weight below the ground than above it. The biomass of soil organisms in one acre equals the weight of twelve horses. These organisms decompose matter, aerate the soil, and improve its structure, while creating dynamic micro food webs in the spaces (pores) between soil components.

Plants are also part of the soil. Under the soil surface is a dense network of thin fibrous roots and thick deep taproots. A single acre may contain millions of miles of roots. The roots hold water and open channels for air and water to move through the soil. Each year 50 to 80 percent of the roots slough off, adding organic matter to the soil. Roots feed small mammals, insects, and microorganisms living or burrowing underground. Decaying plant parts provide organic matter and nutrients to those components of the soil. The organic matter provides stability to soil structure, increases water holding capacity, and aerates the soil.

Physical matter includes rocks, stones, sand, etc. These inert materials are the backbone of the soil and provide support, density, and structure to the soil unit, while supplying essential minerals for growing plants as well as habitat for other creatures.

Soil is formed using materials at hand. Thus, each ecosystem builds soil by recycling itself. A woodland soil will contain decomposed wood, tree leaves, bark and twigs. Soils of meadows and prairies may contain more decomposed stems and grass leaves. Soils near a pond or wetlands will often hold aquatic macroinvertebrates and large quantities of partially decomposed plant matter. Hydric soils, built under wet conditions, display the slow process of anaerobic decomposition, where plant debris retains its form for years.

## Activity Description

Students will explore a soil sample to investigate its components. You will need a soil sample (about one quart) for every four to six students. Samples could come from one location, but more interesting comparisons are possible if each sample comes from a different part of your site. To compare ecosystems, collect soil samples from a woodland, prairie, wetland, vegetable garden, schoolyard lawn, etc. Place each sample in its own tray and label carefully so that samples can be returned to the exact spot they came from: returning the microscopic soil inhabitants to where they were collected is the important last action of this activity.

1. Group students into teams of four to six. Each team should have a designated recorder who will need a field sheet, pencil, and a clipboard. Everyone else will need a magnifying glass.
2. Teams should examine each sample thoroughly, using fingers to gently stir the soil, and using magnifying glasses to examine tiny matter and organisms.
3. Using the Soil Explorations Field Sheets, describe the soil type, color, and moisture—then observe and record everything you find, such as tiny pieces of leaves, tiny roots, small stones, sand, and creatures like ants, earthworms, sowbugs, centipedes, beetle grubs, etc.
4. Come together and compare notes.

    Did the soil contents make sense based on where the sample came from?

    What surprises did you find?

5. Return the soil samples to their original spots.

## Extensions

- Compare soil samples from different ecosystems or areas.
- Graph the contents of the soil.
- Examine the soil using a microscope and describe your findings.

## Assessments

- Explain how the contents of your soil sample confirm that each ecosystem builds soil out of its own materials.
- Create a model that demonstrates the cycle of living matter (plant or animal) into organic soil and then back to living matter.

# Soil Explorations: Field Sheet

Names_______________________________________________________________ Date_________________

Location _____________________________________________

Soil Type __________________________________________ Soil Color ____________________________________________

Soil Moisture _______________________________________ Infiltration Rate_______________________ minutes/250 ml

What we found (write description)

_______________________________________________________________________________________________

_______________________________________________________________________________________________

_______________________________________________________________________________________________

What we found (draw)

Location _____________________________________________

Soil Type __________________________________________ Soil Color ____________________________________________

Soil Moisture _______________________________________ Infiltration Rate_______________________ minutes/250 ml

What we found (write description)

_______________________________________________________________________________________________

_______________________________________________________________________________________________

_______________________________________________________________________________________________

What we found (draw)


© Earth Partnership • University of Wisconsin-Madison

# Soil Profile Investigations

**Activity Overview**
Students learn about the process of soil development through examination of soil profiles.

**Objectives**
Students will:

- Describe the characteristics of soil horizons from samples taken on their school grounds
- Understand the processes of soil and horizon development

**Subjects Covered**
Science

**Grades**
3 through 12

**Activity Time**
1 hour

**Season:**
Spring or Fall

**Materials**
16" soil auger (may be available for loan through county extension office), crayons or colored pencils, water, clipboards, pencils, field sheets, and the Soil Texture Feel Test.

## Background

Soil is created when various physical, chemical, and biological processes change a parent material (usually rock) into soil. As soil forms, different horizons or layers develop. Each horizon has its own characteristics due to the soil-forming processes. The character, depth, and arrangement of the horizons determines the nature and classification of soil. A rich carpet of soils blankets the earth as a result of the diversity of parent materials, climates, floras, faunas, and topography.

### Major horizons

**A horizon**

The top layer of soil is the A horizon. This topsoil contains organic matter and minerals. It is darker in color than the lower horizons due to humus and other organic matter. Prairie soil has an organically rich, dark-colored A horizon. Tama silt loam, a Wisconsin prairie soil, is 33 inches deep. Fayette silt loam, a lighter-colored forest soil, has an A horizon that measures 14 inches. Wetland soils may be comprised of peat, muck, or dark minerals. The wetland A horizon may be 1 to 40 feet deep because of the buildup of decomposed and undecomposed organic content. Rainforest and desert soils have a thin A layer or no top layer at all due to the high rainfall and leaching of organic material or lack of rainfall and vegetation. A 16" soil probe will generally only reveal the A horizon, but it will still reveal interesting differences in layers.

**B horizon**

The B horizon, or subsoil, has a high mineral content. It is lighter in color than the topsoil; the compounds leached from above influence its color. Clay often accumulates in this layer.

**C horizon**

The C horizon consists of rocks and other parent material from which the soil is derived. The rocks are of different sizes and stages of weathering; they are beginning to form the soil particles. This zone is outside the zone of biological activity.

## Activity Description

You will examine soil profiles from different areas on your schoolyard. A soil profile is a vertical column of soil that is extracted with a soil auger or probe.

1. Select areas of study and take a sixteen-inch soil profile in each area. To take a profile, insert the soil probe perpendicular to the soil surface. Obtain deeper soil profiles by using an extension on the probe. If the soil is too hard to yield a sample, pour a bucket of water on the ground and allow the water to seep into the soil.
2. Examine your profile and identify the depth of the A and B horizons, soil color, structure, contents, and organisms. Diagram your samples to scale using colored pencils or crayons on the field sheets.
3. At each sample site, determine the soil texture (sand, silt, and clay) of each horizon using the soil texture feel test. See EP activity "Identifying Your

Soil" for instructions.

4. Back in the classroom, describe and compare soil color, texture, and contents among the samples.
5. If compiling a site map (see EP activity "Noting Notable Features), add this information.

## Extensions

- Contact your local county extension agent for a soil survey map that identifies soil types on and around the school grounds. Determine if the existing soils on your school site match the soil map. Often the recent soil profiles will not match the classification on the soil surveys due to the alteration of soil during construction and grading. What are the differences?
- Compare soil characteristics, profile, infiltration rate and soil life present in a restoration, lawn, and/or construction site.

## Assessments

- Describe the characteristics of each soil horizon.
- Describe the physical, chemical and biological processes of soil development and give an example of each process.


© Earth Partnership • University of Wisconsin-Madison

# Soil Profile Investigations Field Sheet

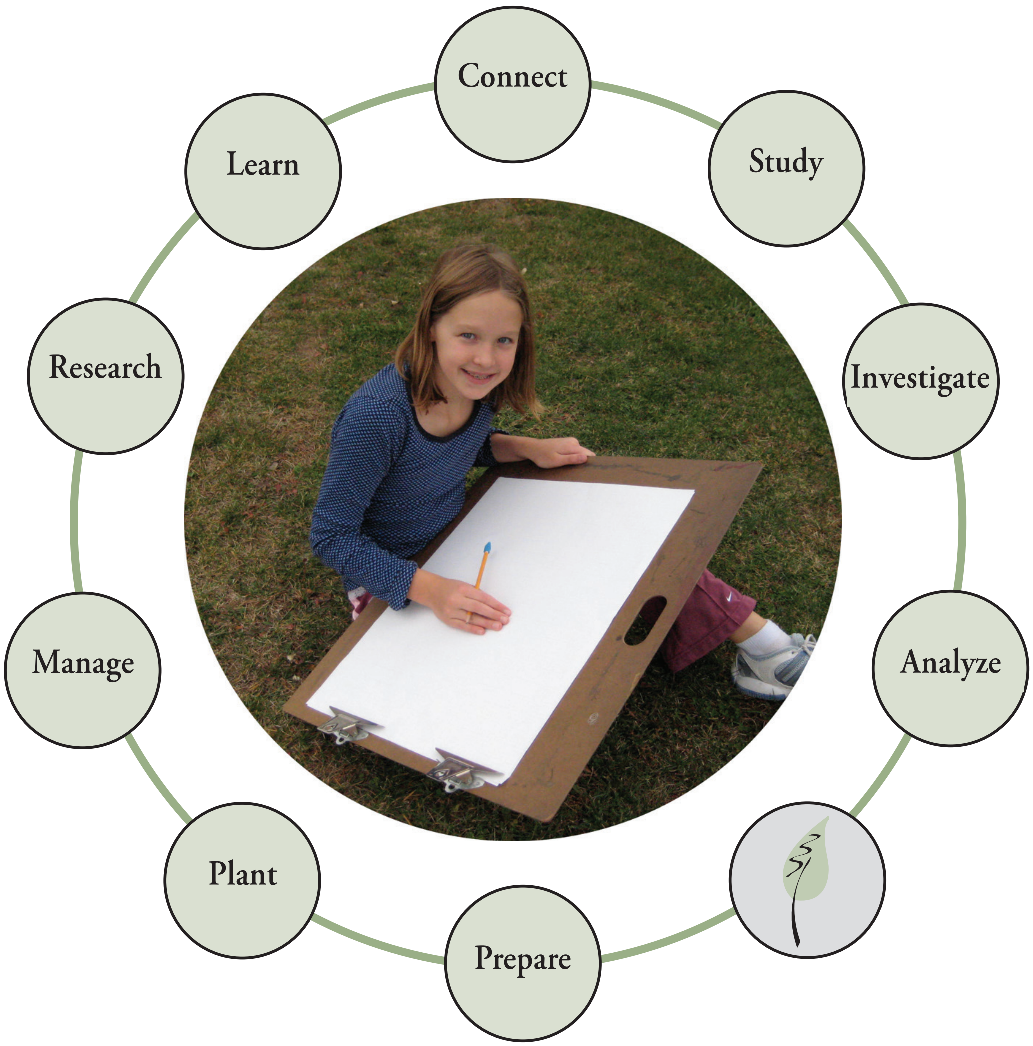
Names_______________________________________________________________ Date_________________

| Sample #1 | Sample #2 |
| --- | --- |
| Location of profiles: ____________________________ | Location of profiles: ____________________________ |
| ______________________________________________ | ______________________________________________ |
| Infilitration rate: ________________________________ | Infilitration rate: ________________________________ |
| Soil type: ____________________________________ | Soil type: ____________________________________ |
| Describe and list contents of each layer: | Describe and list contents of each layer: |

earth partnership

# Plan

a butterfly garden, rain garden, grassland,
woodland, or wetland restoration



# Section Introduction: PLAN

While there is no reason to be intimidated by planning the restoration, careful attention to this stage of the process goes a long way in laying the foundation of a successful and enjoyable restoration experience for you and your students and/or community. Planning and design open up unique creative opportunities as well for people of all ages to share their vision for the site.

Planning is also an important part of the learning process, and it can be done in creative ways that engage different learning styles and skills. For instance, considering what plant species to select in the restoration may seem daunting, but if you begin with an interactive play about changing seasonal blooms ("A Growing Year"), you're well on your way to understanding what to consider when choosing what to plant.

Creating an actual design plan for the restoration is an opportunity to incorporate all the ecological, historical, cultural, and aesthetic information that you have collected into a cohesive vision for your site. Designing as a collaborative process yields more innovative ideas that meet different needs and goals, and it promotes investment in the restoration within your community ("Designing a Restoration"). Learners of all ages can get involved in taking the design on paper and moving it out onto the landscape, exercising their math reasoning and critical thinking skills ("What's a Square Foot Anyway?").

Once you have a design plan, you can use your enhanced knowledge of plants to select which varieties you will include in the restoration ("Species Selection"). You can also make the practical aspects of ordering plants an exercise in real-world math and logic applications ("How Much Seed Do I Need?" and "Balancing the Budget").


© Earth Partnership • University of Wisconsin-Madison

# A Growing Year

**Activity Overview**
Students take part in a play that illustrates the seasonal march of a prairie as plants bloom and set seed.

**Objectives**
Students will:

- Use a model to explain an event in the natural world
- Take part in a play to illustrate the sequences of events in natural ecosystems that are repeated each year
- Identify changes in plants at different times of the year
- Increase understanding of prairie plant adaptations

**Subjects Covered:**
Language Arts and Science

**Grades:**
3 - 8

**Activity Time:**
30 minutes

**Season:**
Any

**Materials:**
1 plant phenology card per student (1 set is 15 cards; see masters in Dropbox for making cards or have students create their own set), musical instruments if available

## Background

In order to avoid intense competition and to adapt to weather cycles, native plants have evolved different seasonal periods of growth, flowering, pollination, and seed dispersal. As a result, we can experience a changing vista of colors, scents, insects and textures throughout the growing year.

This activity provides a kinesthetic introduction to help with plant selection for schoolyard restorations. The concept of the phenology of different bloom times is applied to the restoration process; for example, one goal for developing an ecologically sound native planting is to have at least one species blooming at any given time during the growing period. See EP activity "Species Selection" for more information about choosing plants based on phenology.

The plant details shared here serve as an example for a prairie in the midwestern United States, but can be adapted to any region. Students can research their own backgrounds and write their own narratives telling about the native species that grow in their area.

In the prairie, one of the best-known and most dramatic sequences involves the plants blooming from mid-April through October, as one blooming plant wanes and another takes center stage. During the growing season approximately one new prairie plant blooms each day. This sequential, or phenological, change is dramatic, somewhat predictable and easily observable.

Varied growth patterns are one way prairie plants have adapted to their environment. Most prairie plants are long-lived perennials that are able to slow their growth rates to share water, light, and minerals with crowded neighbors, creating a complex and rich mixture of vegetation. Perennials are herbaceous plants that die back to the ground at the end of their growing season but survive underground by roots or a stem. Staggering the growth and flowering times is one way of decreasing competition for resources.

Many prairie grasses and forbs (i.e., wildflowers) have extensive root systems that allow them to survive fires, harsh winters, and droughts because they have buds at or below the soil surface and more root mass below the ground than biomass above the ground. The root systems of many prairie species reach depths of over six feet and some even extend as deep as twenty feet! By having extensive root systems, plus a variety of blooming times and different stem heights, prairie species have adapted to their environment and are able to coexist, filling every niche available in the prairie ecosystem.

Fifteen plants are used to illustrate the seasonal changes that occur in a prairie: bee balm, lupine, big bluestem, New England aster, black-eyed Susan, pasque flower, butterfly-weed, prairie dock, compass plant, purple coneflower, goldenrod (stiff), spiderwort, shooting star, yellow coneflower, and little bluestem.

## Activity Description

Everyone receives a card with a plant illustrated in its flowering stage on one side and in its seed stage on the other side. If musical instruments are available, have each student choose an instrument to represent their plant in bloom. The play begins in the winter. Crouch down as if you are dormant and underground. When you hear your plant is blooming, stand up and hold the card above your head with the picture of the flowering plant showing. Play your instrument until you hear your plant is setting seed. Then flip your card over to show a seeding plant and stop playing your instrument. When winter comes again and the aboveground portion of your plant dies, crouch down into the winter dormant state again. Double up students on cards as needed with larger class sizes, representing multiple individuals of the same species.

### Sample Play Narrative

*It is a cold winter season. The days are cold and short. Nights are long. To most humans, the prairie looks lifeless. All above-ground portions of the plants are brown and brittle. But underneath, the roots are quite alive.* (All students should be in a group and crouched down. They are the roots of their plants.) *You are our prairie; your roots are alive but you can imagine a blanket of snow over your heads. The covering of snow and soil keeps the roots protected.*

*Now the days start to get warmer and longer. The snow melts, the soil warms. Plants start to grow and leaves start to emerge from the ground.* (Students start to sit up a bit. As their plant blooms, they stand up and hold their card up.)

*Now it is* (insert month) *and the* (insert names of plants in bloom) *begin to bloom while the* (insert names of plants seeding) *stop blooming and begin to set seed.* (Continue through the months listed below.) *Now it is May....*

| | **BLOOMS** | **STOP BLOOMING, SET SEED** |
|---|---|---|
| **April** | Pasque Flower | |
| **May** | Lupine<br>Shooting Star | Pasque Flower |
| **June** | Butterflyweed<br>Yellow Coneflower<br>Spiderwort<br>Purple Coneflower<br>Black-Eyed Susan | Lupine<br>Shooting Star |
| **July** | Big Bluestem<br>Little Bluestem<br>Compass Plant<br>Bee Balm | Compass Plant<br>Butterflyweed<br>Spiderwort<br>Yellow Coneflower |
| **August** | Prairie Dock<br>Goldenrod | Big Bluestem<br>Little Bluestem<br>Black-Eyed Susan<br>Bee Balm |
| **September** | New England Aster | Prairie Dock<br>Goldenrod |
| **October** | | New England Aster<br>Purple Coneflower |


© Earth Partnership • University of Wisconsin-Madison

Narrative Continued:

*Now the temperatures are getting colder and the days shorter and nights longer. The above-ground portion of the plants dies and only the roots are alive.* (The students crouch back down.) *The winter is back and the prairie once again looks dead. But it is not dead; it is alive and waiting. Waiting for another year.*

## Discussion

Discuss how adaptations such as extensive root systems and different blooming times enable prairie plants to survive in their environment. What are some threats to these plants' survival? Emphasize that there is a wide variety of ways plants and animals adapt to the prairie and other ecosystems. Visit the library to research other plant and animal adaptations in the prairie. You can expand on this play to include different plant and animal adaptations throughout the year.

## Extensions

- Create your own cards. Draw the flowering plant form on one side and the seed form on the other. Use a field guide or other reference to draw and color the picture accordingly.
- Write a story that describes a plant and its seasonal adaptations.
- Keep a phenology journal and record plant changes during different times of year.
- Create other phenological sequences from either observations or research projects (see Earth Partnership for Schools activities 1-1 and 1-15, "Observations From a Single Spot" and "Ecosystem Observations."
- Write and direct a phenological play with younger students.
- Create a phenology book or calendar that describes observations throughout the year.
- Create a computer database to record seasonal observations.
- Read *A Sand County Almanac* (see especially chapters "April" and "July" for prairie perspectives).

## Assessments

- List and explain at least two ways prairie plants have adapted to their environment.
- Create a visual representation of the changes in prairie bloom and seed set from the play you acted out. This could be a graph, calendar, etc.
- Write a short story describing a prairie plant's adaptations and seasonal changes.
- Create a mobile with drawings illustrating the blooming and setting seed versions of different prairie plants and the time of year these changes occur.
- Research a prairie plant; describe its characteristics and seasonal adaptations. Make an oral report to the class and conduct peer reviews of these reports.
- Develop a web page on a specific plant(s) using photos, drawings, and life history information.

**Sample Prairie Year card with a plant in flower and in seed**

Black-eyed Susan
*Rudbeckia hirta*

| | |
|---|---|
| In bloom | July |
| Floreciendo | julio |

| | |
|---|---|
| In seed | August |
| Produciendo semillas | agosto |

Black-eyed Susan
*Rudbeckia hirta*


© Earth Partnership • University of Wisconsin-Madison

# Designing a Restoration

## Activity Overview
Students create a restoration landscape plan for their school grounds.

## Objectives
Students will:
- Create a design for the restoration project based on goals, use, function, aesthetics and the ecology of the site.
- Use critical thinking to explain why their design choices are appropriate.
- Explain the benefits of using native plants in a landscape design to improve water quality, soil processes and wildlife habitat.
- Apply understanding of how organisms interact in their environment by including design elements that meet wildlife needs.
- Develop positive communication, cooperation and shared decision-making skills to work as a team.
- Apply mathematical concepts (e.g., geometry, graphing, measurement, perimeter, area) to a real-life project.

## Subjects Covered
Science, Technology Education, Math, Language Arts and Art

**Grades -** 3 through 12

## Activity Time
1 hour preparation; 1 to 2 class periods planning; 1 class period for presentations

**Season -** Any

## Materials
Map of restoration site or school grounds, rulers, pencils, native plant information resources and post-it notes

## Background
Designing a schoolyard restoration project with native plants is a sequential process that meets the goals and needs of the people involved, fits existing site conditions, improves habitat for wildlife, addresses environmental concerns and creates a special place to experience the natural world.

In a native landscape, plants take on their natural forms and change through the seasons and from year to year. Native plants assembled in natural communities ecologically belong together and enhance the beauty of the landscape.

The first step in preparing a design involves measuring and mapping your space. See EP activity "Mapping Your Schoolyard" to learn how to map your site and draw your measurements to scale on graph paper. The second step involves conducting a site analysis to help you understand the existing conditions of your site such as soils, slopes, location of underground wires, views to screen or highlight, etc. The data collected from the site analysis will give you the information needed to make informed landscape design decisions. (See EP activity, "Conducting a Site Analysis.")

After you create a map and compile the site information, you can begin the design process. To start, generate design criteria such as the goals and objectives for your site. Possible ideas and considerations include:

- Restoring ecological representations of plant communities native to the local region
- Attracting wildlife such as butterflies, songbirds, and amphibians
- Keeping rainwater on school property by adding rain gardens and swales to naturally infiltrate water into the soil to improve water quality and recharge groundwater
- Providing access for all children with a system of trails that includes trails wide enough for a wheelchair
- Providing seating areas for students to assemble as a large group for discussions or small spaces for solitary reflection
- Increasing biodiversity on the school grounds
- Providing for educational opportunities in a natural area
- Including a diversity of plants for student learning
- Creating a school entrance that welcomes students and visitors
- Establishing an interpretive trail or signage
- Providing seasonal interest and change with a variety of flowers, fruits, vegetation colors and textures
- Strategizing how the area will look from different perspectives such as from inside the school
- Planting native species in areas that are difficult to maintain such as a steep slope or low area that is intermittently wet

- Replacing hard, impervious surfaces with porous, pervious surfaces; for example, replacing little-used paved areas with porous pavement or loosening compacted soil and planting with vegetation
- Locating a restoration area that is convenient to visit so students may experience it on their own outside of the formal classroom
- Designing theme gardens such as ethno-botanical gardens, sensory gardens, butterfly or bird gardens, shady (woodland) or prairie gardens

Next, draw your design ideas and possible landscape arrangements either on transparent paper overlaying your base map or directly on a map. Feel free to try out ideas—there are many options for a landscape plan and there is no perfect design. Do give each area a definite shape with boundaries. These boundary lines define your landscape. Try different arrangements using the design principles below.

**Space.** A landscape design creates space in the form of outdoor rooms. The ceiling can be either open or closed by a tree canopy or nearby structure. Forests provide canopied spaces, savannas offer semi-canopies, and prairies present an open ceiling or no canopy. Tree trunks, shrubs, tall herbaceous plants, or vines on a fence define walls. The floor is formed by the groundlayer such as low-growing herbs, vines, moss, or leaf litter. The character of the space will vary depending upon the time of year—leaf on, leaf off—and the seasonal heights of plants.

**Composition.** Arrange the elements of your design so that each area fits together to create an ordered whole.

**Proportion or scale.** Design the size of planting beds and select plant species that are in proportion with the size of the space and the heights of surrounding landscape features. Small-sized plants fit in small spaces whereas large-sized plantings fit in big spaces. Conversely, small plants in a large area look dwarfed and out of place and plants too big for an area crowd the space.

**Balance.** Balance may be symmetrical, creating a more formal landscape in which one side of an area mirrors the other, or asymmetrical, achieving an informal or natural look. An informal look might balance a group of shrubs on one side of an area with a single tree on the other side.

**Repetition.** Arrange similar elements through a space by repeating forms, textures or curves. Repetition unifies your design.

**Contrast.** Contrast creates variety in the landscape. To create contrasts, place plants with big leaves next to fine textures or one bright color next to another.

**Sequence.** Sequence is the arrangement of elements that leads you in to a certain direction.

Choosing structures and plants is the final step in the plan. See EP activity "Species Selection" to learn how to select species appropriate for your site.

Note: This activity is set up for students to work in teams to create a landscape design. This collaborative approach is one of several options. Students may also work independently on a design plan. Often it is a challenge to choose one plan that meets the design criteria for the site. Many schools have successfully taken ideas generated from several student design plans and combined these ideas into one final plan. An advantage to this approach is that all students involved feel ownership in the design process.

## Activity Description

1. Go out to the area designated for the landscape design. Walk the area to get a feel for the space and review the site analysis data.
2. Go back to the classroom and discuss what was observed or seen as unique.
3. Divide into teams of two or three. Brainstorm design criteria for the site.
4. Draw your design plan for the site. See Background section for sample criteria.


© Earth Partnership • University of Wisconsin-Madison

# Designing a Restoration (cont.)

5. Write a document that supports your design ideas.
6. Present your plans to the class.
7. As a group, decide what parts you like in each plan.
8. Choose a committee who will take these ideas and create a composite design plan.

## Extensions

- Design a planting for a local park or an abandoned lot.
- Find a landscape that you like in your neighborhood.  Explain what design elements you think are successful and why.
- Go to a natural area and look for three natural examples of design elements. Describe what you see.

## Assessments

- List three design considerations and why they are important for a successful landscape plan.
- Explain the benefits of using native plants in a landscape design.
- Conduct peer review of design plan presentations.

# What's a Square Foot Anyway? Laying out the Design Plan

**Activity Overview**
Teams of students lay out a restoration design plan on the school ground using a scale drawing and square foot templates.

**Objectives**
Students will:

- Transfer points on graph paper to physical points on the ground
- Apply mathematical concepts (e.g., geometry, graphing, measurement, perimeter, area, etc.) to a real-life design project
- Demonstrate techniques of measurement using scale drawings
- Generate a model for a real-world project

**Subjects Covered**
Math

**Grades**
K through 12

**Activity Time**
60 minutes

**Season**
Any

**Materials**
A design plan drawn on graph paper, 2 "square foot" cardboard pieces and string per student (see illustration at the end of activity), surveyor flags, one 100 foot measuring tape, spray paint

## Background

After students design their restoration, they need to transfer the plan from paper to the school landscape. In this activity, students are able make that transition from a concept on paper to an actual location on the school ground. This step not only lays out the restoration plot but also offers students a chance to see how a concept can materialize into a reality.

The following list of warm-up activities may help students not familiar with these mapping concepts:

- In the classroom, draw out sample designs or have students draw a design on graph paper. Have the students determine the area in square feet. One square on the graph represents one square foot.
- Practice using the cardboard square foot templates to create different shapes and visualize various square foot areas.
- Measure spaces such as a classroom or library using the square foot templates.

## Activity Description

In this activity, students will lay out your restoration design plan on the school ground. Follow each step and when they are finished, the schematic drawing will be physically marked on the ground ready for site preparation and planting.

First, measure, and cut out two, one square foot cardboard pieces. Attach a string to each cardboard piece to tie the cardboard to your feet. Students will wear the cardboard-like shoes to layout the restoration plot.

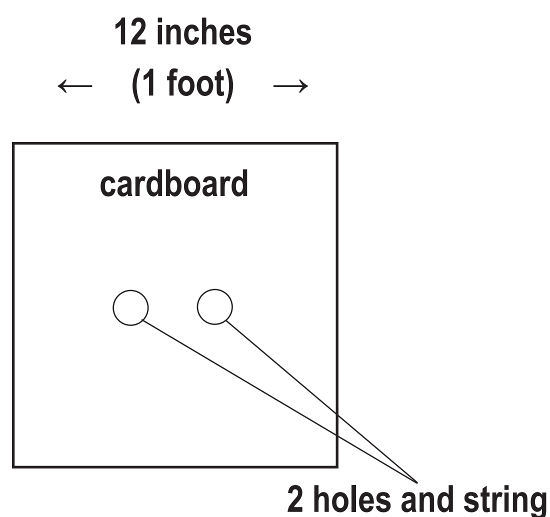



*illustration showing one "square foot"*

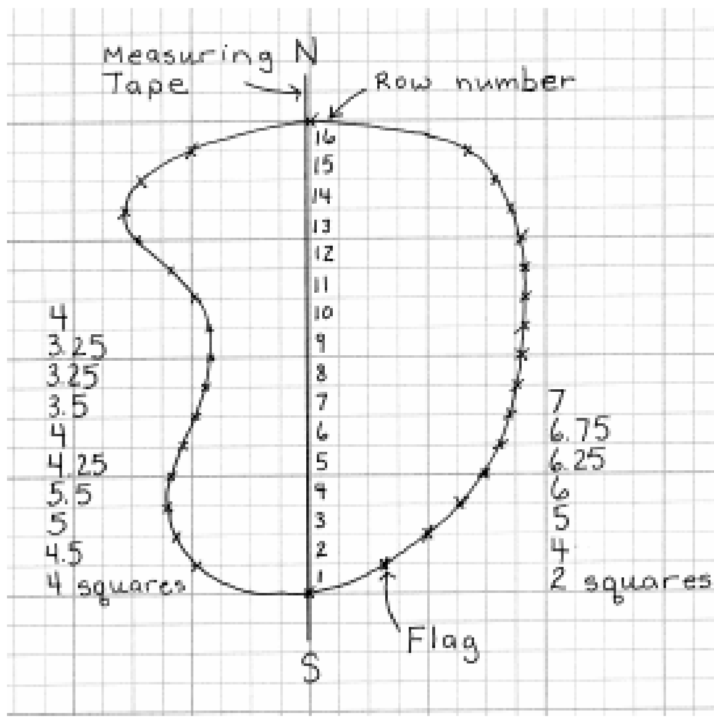
1. Assign roles. Two students will call out the design ("callers") and two students will place flags ("flaggers"). The remaining students will wear the square feet cardboard pieces on their feet and step out the design ("line people").

2. Divide into two teams. Each team will have one "caller", one "flagger" and


© Earth Partnership • University of Wisconsin-Madison

several "line people."

3. Before you go outside, project the design for the whole class to see. Draw a line through the middle of your design in a north/south or east/ west direction (using cardinal points is preferable). Number each row. Count the number of squares to the right of the line. Record this number on the row. Count the number of squares to the left of the line. Record this number on the row. (See illustration.)
4. Go outside and lay out the measuring tape in a north/south or east/west direction at the site of the restoration. The measuring tape represents the line on the design plan.
5. Divide into your two teams. Begin at one end of the garden. One team will lay out the design to the left of the line and the other team will lay out the design to the right of the line.




6. To begin the mapping process, the "callers" call out the number of squares in the first row. The "line people" then line up shoulder to shoulder wearing the cardboard templates on their feet. For instance on the example below, in the first row, there are 2 squares (or 2 square feet) to the right of the line and 4 squares (or 4 square feet) to the left of the line. One student with cardboard squares tied to his/her feet stands to the right of the line to measure out two square feet. To the left of the line, two students will stand side-by-side to measure out 4 square feet.
7. Once the "line people" are standing in position the "flaggers" place a flag at either end of the row.
8. Repeat this process for each row in the design.
9. After each flag is placed on the ground you will see the perimeter of your design laid out with flags. Walk the perimeter of the rain garden.
10. Use landscape spray paint to mark the perimeter of the garden.

## Extensions

- Practice different layouts using a set number of square feet, e.g. 4, 6, 10, etc. Measure the perimeters of the different layouts. Which layouts create the largest perimeters? What effect would perimeter have on a garden plot?
- Measure the square feet of different existing features on the school ground. Compare and rank the areas in terms of size. What is the ratio of built areas to natural areas?
- Create a map of an area using cardboard pieces.

## Assessment

- Calculate square footage of shapes and designs drawn on graph paper.
- Draw a rain garden design and calculate square footage.
- Explain the relationship between perimeter and shape.

*EP institute participants using their square feet to lay out a rain garden. Photo: Libby McCann.*

 © Earth Partnership • University of Wisconsin-Madison

# Species Selection

### Activity Overview
Students create a list of native species for their restoration site as determined by environmental, ecological, aesthetic and educational criteria.

### Objectives
Students will:

- Identify and communicate criteria for selecting native species that will grow in their restoration
- Choose species based on functional, ecological and aesthetic considerations
- Work cooperatively as a team
- Learn about native plants and identify species that can deliver ecosystem services

### Subjects Covered
Science and Math

**Grades -** 3 through 12

### Activity Time
Two 50 minute blocks (10 minutes introduction, 10 minutes to develop criteria, 30 minutes to select species, 50 minutes to compile species selections and determine quantities desired for each species)

**Season -** Any

### Materials
Species selection form, wildflower and grass field guides, native plant nursery catalogs/websites

## Background

Selecting the right species for your restoration site helps ensure survival of your plants. Important considerations for selecting species for successful plant survival include light availability and soil type. Plant height, attracting wildlife and aesthetics such as flower color, leaf textures and fruits can also play a role in plant selection.

This activity can be used for grassland, meadow, prairie, savanna, sunny or shady gardens. If you are planting a rain garden, refer to EP Activity "Rain Garden Species Selection" for directions on selecting bimodal species that can tolerate the wet *and* dry conditions that a rain garden will experience.

To begin the process of species selection, identify your site features (sun shade, soil type, etc). Then determine what plant characteristics will fit your site and needs. Review the following criteria and identify the criteria that fit your site characteristics and goals for your project. There are several resources available to help you choose appropriate plants. For instance, use nursery catalogs, plant field guides or regional web-based, native plant finders to select species. List those potential species on the species selection form.

Two main categories of plants to consider are *herbaceous* (lacking a persistent woody stem above ground) and *woody* (trees, shrubs and some vines) species.

Native herbaceous species can be *perennial* (they come back year after year), *biennial* (has a two-year life cycle) or *annual* (life cycle is completed in one year). Most native plant seedlings will be perennials, and some seed mixes will contain biannuals or annuals. When planning how many plants to plant, consider that herbaceous species should be planted one foot apart. In addition to flowers, a restoration also needs to have a mix of grasses and sedges, and other plants such as rushes, ferns and mosses should be considered, depending on the site.

Woody species are perennials, and they will have some above-ground parts that show throughout the entire year. They should be spaced according to their ultimate size (see below for more information about spacing).

You may need to adjust the number of species in your mix depending upon your budget, availability, and size of your restoration. As a general rule, try to have a new flower come into bloom every week during the growing season.

### Species Selection Criteria:

**1. General Composition- Herbaceous (Grasslands and Rain Gardens)**

- **Grass-to-forb ratio.** A reasonable mix of grass and forb species that mimics the natural structure and character of a grassland or rain garden can contain anywhere from 30 to 80% grass. Aesthetically, grass species (including sedges and other grass-like species) define the visual character or essence of the prairie. Ecologically, grasses provide structural support for forbs (flowering plants), hold the soil with their fibrous root systems and provide food and cover for wildlife. Forbs provide visual interest, food for wildlife on a continual basis and enhanced diversity. A lower proportion of grasses (30%) will result in a more striking floral display, but it will also cost more.

## Species Selection (cont.)

When determining a ratio of grasses to forbs, consider cost, ecology and aesthetics of the site.

- **Pioneer Species.** A planting mix should include some fast-maturing pioneer species such as bee balm, black-eyed Susan, yellow coneflower and blue or hairy vervain. These forbs will hold the soil and provide early interest. Additionally, you may include Canada wild-rye, a pioneer grass, as a cover crop to help reduce the spread of weeds.
- **Plants to Avoid.** Some plants can be overly aggressive either through vegetative reproduction or seed. These species, such as sunflowers, switch grass, common goldenrod, and cupplant often form large masses. Species with this type of growth habit are appropriate for large sites but may become too overpowering in smaller plantings.

**2. General Composition - Woodland Restorations**

- **Woodland Structure:** Choose species for each vertical layer: canopy (upper and lower canopy trees), understory (large to small shrubs) and groundlayer. Within each layer include dominant and associate species. The ratio of grass/sedge to wildflowers in a woodland restoration tends towards less grass-like species and more wildflowers with some ferns.

  Make sure to consider mature size when selecting woodland plants. Plants should be scaled to their surroundings. For example, a small courtyard will need small-sized trees. Where utility lines are present, plant a tree that will not grow into the lines.
- **Pioneer Species.** Choose pioneer species to function as a nurse crop for the shade-tolerant, longer-lived canopy and groundlayer species, and to create a closed canopy quickly. Pioneer woodland species include white birch, white pine, pin cherry, black cherry and the poplars (trembling aspen, bigtooth aspen, balsam poplar and cottonwood).
- **Edge Species.** Woodland edge communities form a boundary between a shady forest and sunny field or prairie, and typically contain a mix of species from each community. This edge functions as a buffer zone to lessen the harmful effects of drying winds and hot sun. The diversity of bird species attracted to the woodland edge habitat is an added benefit. Some possible edge species to consider are hazelnut, sumac, hawthorn, prairie crab apple, elderberry, serviceberry and the dogwoods and viburnums.

**3. Additional Criteria for all Plantings**

- **Plant sources and native species:** Choose plants native to your specific region. Native plants are well adapted to your specific climate and soils and do not require winter protection or fertilizer. They also work more effectively infiltrating water on account of their long root systems.
- **Sunlight availability.** The amount of sunlight an area receives determines the types of plants that will survive those light conditions so that they will flower and set seed. Plants that need full sun need at least 6 to 8 hours of direct sun during the growing season; plants that require shade cannot tolerate more that 3 hours of direct sun. The hours and angle of sunlight change with the seasons, too. Some areas shaded most of the day at one time of the year may be in full sun other times of the year, or areas sunny in the spring may be shady in summer.

  Common guides for choosing plants based on the amount of sun or shade available are:

  > ***Sun*** – Areas receive a minimum of 6 to 8 hours of sun per day during the growing season. Prairie and wetland species including sedge meadow species grow well under these conditions.
  >
  > ***Partial shade*** – Partially shaded areas receive 3 to 6 hours of sun per day. Savanna and some prairie and woodland species grow well in partial shade.
  >
  > ***Shade*** – Areas of shade receive less then 3 hours of direct sun. Woodland groundlayer species grow in this environment.

  Trees and shrub species follow the same guidelines. Most species lists will identify a plant's sun/shade requirements.


© Earth Partnership • University of Wisconsin-Madison

- **Phenology.** One of the best known and most dramatic sequences in a grassland restoration or rain garden involves flowers blooming from mid-April through October. During the growing season approximately one new plant blooms each week. This sequential or phenological change is striking and attractive to pollinating insects such as butterflies. In shady areas, blooming peaks in the spring with a few species blooming during summer and fall. When choosing species, particularly in sunny areas, select plants for a continuous bloom.
- **Habitat for Wildlife.** Planting a diversity of native wildflowers and grasses, along with shrubs and trees nearby (or in the garden), provides maximum habitat and opportunity to attract a variety of butterflies and birds. Wildlife in the schoolyard adds life, beauty, discovery and educational opportunities. Planning and proper plant selection will increase the number and variety of butterflies and birds attracted to a planting. A diversity of flying and crawling insects are attracted to flowers. Grazing insects such as grasshoppers, leafhoppers, and butterfly larvae feed primarily on the leaves of grasses and forbs. These insects form the base of the food web, especially for birds. Birds also feed on highly nutritious seeds produced by native plants. Tall and short grasses and trees and shrubs provide cover and nesting. Woody plants provide wind protection for butterflies and hummingbirds that seek nectar on prairie flowers.
- **Height.** When selecting species, be aware of each plant's ultimate height and spread at maturity. Plant height should be in proportion with the size of your planting. Typically, small restorations are planted with short species. Large plants in a small area tend to overwhelm the site and appear unkempt. Large areas can be planted with a mix of short and tall prairie species. Short species are less than four feet; tall species are greater than four feet.
- **Color and Texture.** Flower color is an aesthetic consideration. Look for color combinations and contrasts within each blooming interval. Combining plants of complimentary colors (yellow/purple, red/green, orange/blue) tends to intensify the colors. Plant texture varies as well, from fine, delicate leaves and tiny flowers to thick leaves and lush blooms. Combine plants of varying textures to highlight these differences in flower and leaf form. Finer textures and smaller, more abundant blooms can also make a small planting site look larger.
- **Species desired for lessons, activities and research.** A restoration offers many hands-on learning activities and inquiry-based opportunities. You may select plants used for food and medicine or that illustrate plant adaptations. Consider species that have a variety of seed types to learn about seed dispersal mechanisms or to test seed germination methods. Also pick plants that awaken your senses and curiosity with fragrances, textures, shapes and sounds.
- **Species blooming during the school year.** Many species bloom during the summer months when students are on vacation. To make sure students experience plants in bloom during the school year, increase the number of species that bloom in the spring and fall months.

## Activity Description

### Select Species

1. As a group, review the restoration site characteristics and identify criteria that fit your restoration site and goals for your project. Fill out the species selection criteria worksheet.
2. Divide into teams. Each team may be responsible for choosing species within a bloom period such as April/May, June, July, August, September/October and a team to select grasses and other grass-like species or trees and shrubs, if desired. You will find that some species choices will overlap.
3. Next have each team select 4 to 5 potential species using nursery catalogs, plant field guides and web-based regional native plant lists and finders.
4. Re-group; go into the round and share out as teams the species chosen and why.
5. Compile all species selected on a master species selection form.

# Species Selection (cont.)

### Complete the Master Species List

1. Review master species list and make adjustments, if needed.
2. Begin to determine quantities for each species. First divide the grasses/sedges from the wildflowers. Use the criteria for your grass/sedge to wildflower ratio to calculate how many plants you need for each group. The total number of herbaceous plants needed equals the number of square feet of the site. It is possible to space the plants wider to about 1.5 square feet per plant. If you are adding trees and shrubs, use the following spacing guidelines to determine quantities:
    a. Trees: 10 to 20 feet apart.
    b. Large to medium shrubs: 6 to 8 feet apart.
    c. Small shrubs: 3 to 5 feet apart.
3. Assign quantities to each species. For design purposes, order wildflowers in groups of three, five, or more. Order shrubs in quantities of one, three or more. Avoid ordering plants in twos; planting in pairs causes the eyes to jump back and forth between the two plants. Order enough grass-like species to fill the required number needed.
4. The next step is determining the budget for the species selected. See EP activity “Balancing the Budget.”

## Extensions

- Help students visualize the spatial arrangement by using scaled symbols on graph paper to determine the number of species that will fit on your site.
- Research plants selected using the EP activities “Plant Power” and/or “Up Close and Personal.”
- Make posters of plants selected.
- Create your own version of EP activity “A Prairie Year” or “A Rain Garden Year,” using the species selected.

## Assessments

- Explain why it is important to match species to the site conditions.
- Choose three criteria and explain why you think they are important for selecting plant species for your restoration.
- Outline reasons why the species selected are appropriate for your restoration.

# Species Selection Criteria: Worksheet

Location: __________________________________________________ Size:_____________________ (sq. ft.)

**Environmental Conditions:**

Circle the site characteristics that describe your site:

**Soil Type:** Sand Silt/Loam Clay

**Percent Slope:** less than 4% 5% - 7% 8% - 12%

**Light:** Full sun Partial shade Shade

**Species Characteristics**

Necessary Criteria: Determine your specifications for criteria based on site conditions.

Number of small plants (1 plant/square foot) _______

Number of trees (10-20 feet apart) _______

Number of large to medium shrubs (6-8 feet apart) _______

Number of small shrubs(3-5 feet apart) _______

**Plant types: (circle all that apply)**

Grasses Sedges Wildflowers Ferns Shrubs Trees Other ____________

Height: Minimum height: ____________ Maximum height: ____________

**Phenology (time of bloom):**

_____% Spring (April – May), _____% Early Summer (June), _____% Summer (July),

_____% Late Summer (August), ____ % Fall (September – October)

**Additional Criteria:** Identify criteria that fit your project goals such as flower color, textures, fragrance, wildlife value, and plants for pollinators, cultural significance, and inquiry-based learning, etc.

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

## GRASSLAND/RAIN GARDEN SPECIES SELECTION WORKSHEET

| Plant Name | Height | Sun | Flower Color | Wildlife | AP | MY | JU | JL | AU | SE | OC | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grasses and Sedges | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Forbs | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |


© Earth Partnership • University of Wisconsin-Madison

## WOODLAND SPECIES SELECTION WORKSHEET

| Plant Name | Height | Sun | Flower Color | Wildlife | AP | MY | JU | JL | AU | SE | OC | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trees | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Shrubs and Vines | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Groundlayer | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

# How Much Seed Do I Need?

**Activity Overview**
Students measure and calculate the restoration site's area and calculate the quantity of seed needed.

**Objectives**
Students will:

- Add, subtract and multiply whole and decimal numbers to solve a real-world problem
- Measure length, perimeter and calculate area
- Construct an accurate map from direct measurement

**Subjects Covered**
Math

**Grades**
3 through 12

**Activity Time**
2 hours to measure and calculate restoration site's area; 30-60 minutes for seed calculations

**Season**
Any

**Materials**
Tape measure and graph paper to calculate restoration site's area, calculator for seed calculations

## Background

By this point in the restoration process, students have already performed a site analysis to determine what ecosystem to restore, and have decided which species to include (see EP activity, "Species Selection: Herbaceous Plants"). The next step is to calculate how much total seed is needed. This activity focuses on this step.

Prairie restorations can be planted with seeds, transplants or a combination of both. If you are planting with seedlings or transplants, figure one plant per square foot. There need not be exactly one plant in each square foot, but use your total area to figure the number of plants you need. If planting with seeds, target a seeding rate of 40-60 seeds per square foot. This is roughly equivalent to twenty pounds of seed per acre or .0073 ounces of seed per square foot. (Somewhat lower rates are sometimes used to make the planting more economical; however, we feel that twenty pounds per acre is ideal.)

If using a combination of transplants and seeds, you need to first determine how many transplants you wish to include. Seed quantity is then calculated based on the original square footage minus the square footage covered by transplants that you intend to use. For example, if you plan to plant 400 transplants into a 1,000-square-foot prairie, the transplants account for 400 square feet (at a rate of one plant per square foot). Hence, seed should be calculated based on a 600-square-foot plot.

Try to plant 50% grass seed and 50% forb seed, by weight. Include at least 3-5 grass species and 20-40 forb species. Remember that all these numbers are only guidelines. Individual plantings will vary.

After considering how much total seed is needed, students will need to decide how much seed of each species to order in EP activity, "Balancing the Budget."

## Activity Description

In order to calculate how much seed is needed for your prairie restoration, you need to know the area of the proposed planting. If you do not know this, grab a tape measure and measure the site. If it is not a regular shape, you may need to be creative to calculate the area. Divide the area into smaller triangles, squares or rectangles, calculate the area in each shape and add them together. Alternatively, the perimeter can be precisely mapped on a piece of graph paper using a simple scale such as one square equals one foot. After mapping the perimeter carefully, count the squares in the interior. Calculate the area in a square and multiply the number of squares by the area of each square.

The other piece of information you need to know is how many transplants, if any, are going to be planted into the restoration. After that you are ready to calculate the total seed needed for your restoration. How Much Seed Do I Need? Data Sheet will walk you through the process. The calculations are based on a guideline of 40-60 seeds per square foot and twenty pounds of seed per acre (or .0073 ounces of seed per square foot).


© Earth Partnership • University of Wisconsin-Madison

## Extensions

- Determine the amount of seed needed to restore alternative sites on the school grounds.
- Using maps, determine the amount of seed needed to restore part of a local park or some other area.
- If you have permission, collect some seed from a natural or restored area. Determine the percentage, by weight, of seed collected to total material collected. Conduct tests to determine the percentage of seeds that germinate (see EP activity "Germination Determination"). Multiply these two percentages together to determine the percent of pure live seed in your sample. See the Web site below for additional calculations.

## Assessments

- Show how you determined the area to be selected and the calculations you used to determine the amount of seed to purchase.

# Balancing the Budget

**Activity Overview**
Students balance their desired species list and seed quantity needs with the budget they have for the planting. They create a final seed order that is biologically, culturally, and ecologically sound and fiscally realistic.

**Objectives**
Students will:

- Analyze and solve problems by calculation and estimation
- Learn to balance multiple variables in a non-linear problem
- Compare and consider ecological and fiscal trade-offs, make final decision
- Use reasoning abilities to justify strategies
- Create a balanced budget

**Subjects Covered**
Math

**Grades**
3 through 12

**Activity Time**
1-3 hours, depending on student level

**Season**
Any

**Materials**
Species list for restoration, seed quantity calculations, prairie seed price list

## Background

Once you know which species you wish to plant (see EP activity, "Species Selection: Herbaceous Plants") and you have determined how much seed you need (see EP activity, "How Much Seed Do I Need?"), it is time to put a budget together. As most projects do not have an unlimited budget, the final step is to balance desires (species selection) and needs (how much seed is needed) with how much money you have available. In other words, it is time to consider what you can afford.

Students will create a seed order based on needs and desires for their restoration plot and then calculate the total price. If the price tag exceeds the money available, they'll need to consider how to make it cheaper. They can plant fewer seeds per foot, increase the grass to forb ratio (generally grasses are cheaper than forbs), or change the quantities of individual species chosen (some species are far more expensive than others). They can calculate their seed count to see if, while staying within the guidelines of .0073 ounces per square foot, they have exceeded the suggested count of 40-60 seeds per square foot. (Using small, light seeds could result in this imbalance.) Students will have to decide how to meet their budget based on what they consider to be the best trade-offs.

If, after calculating their seed order, they find that they have money left over, they still have decisions to make. Do they want to enhance their planting, and if so, how? Do they want to add more transplants, more seeds, different seeds or consider restoring a larger area?

While, in the purest sense, an ecological restoration should be undertaken with only the ecology in mind and without consideration of costs, in the real world other factors must be considered. Learning to critically think through the goals, desires and trade-offs in order to make the best choices possible will give the students real-world experience that extends beyond ecological restoration.

## Activity Description

You now have a list of all the species you wish to include in your restoration. You have also determined how many ounces of grass seed and forb seed you need. Now it is time to put it together into a master seed order. But one more factor needs to be considered—money. In this activity you will put together an order that balances what you want to have in the restoration (the species list) and the amount of seed you need (ounces of grass and forb seed) with what you can afford.

Based on your species selection list and grass and forb weight targets, fill out the order columns on the Practice Seed Order Form. When determining quantities for each individual species, you might want to check the number of seeds per ounce, as one ounce can contain as few as 400 or as many as 800,000 seeds. Keep in mind that you want to maintain a balance of different heights, flowering times and flower colors for the forbs. Referring to your seed price list, fill out the Cost column. Compare your total to the money you have available. If you have extra money available, consider if you want to enhance your planting, and if so, how? Do you want to add more transplants,


© Earth Partnership • University of Wisconsin-Madison

change the quantities of certain species, add more seeds or add different species?

If the price tag of your draft order exceeds the money available, consider how to make it cheaper. Do you change the quantities of individual species chosen (some species are far more expensive than others) or do you have another idea?  You might wish to calculate how many seeds you are proposing to plant. Sometimes, while staying within the guidelines of .0073 ounces per square foot, you can exceed the suggested count of 40-60 seeds per square foot. For instance, if you used many small, light seeds you could be within the weight recommendations but planting far more seeds per square foot than is necessary.

Rewrite your order and recalculate the costs so that the order matches the money you have available. On a separate sheet, briefly describe how you balanced the budget and then justify the decisions you made.

## Extensions

- Create a planting mix comprised entirely of transplants. A practice order form is included.
- Calculate how much your seed mix would cost if you were planting a large-scale restoration such as a one-acre site.

## Assessments

- Create a seed mix and assess if the mix is ecologically sound (fits pre-determined criteria) and is within budget.
- Calculate the difference in costs to work with these seeds to adequately plant a defined area.

## Balancing the Budget: Practice Order Form for Seeding

| Common Name | Quantity | Size | Cost/Unit | Final Cost |
|---|---|---|---|---|
| Grasses and Sedges | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| Forbs or Wildflowers | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| TOTAL | | | | |


© Earth Partnership • University of Wisconsin-Madison

# Balancing the Budget: Practice Order Form for Planting

| Common Name | Quantity | Size | Root* | Cost/Unit | Final Cost |
|---|---|---|---|---|---|
| Shrubs and Trees | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| Herbaceous Plants (e.g., wildlfowers, grasses, sedges, and ferns) | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| TOTAL | | | | | |

*Options for root types: C = Container; BR = Bare-root; B&B = Balled and Burlapped

earth partnership

# Prepare

the site: remove existing vegetation, lay out the design

# Site Preparation Techniques

## Background

Good site preparation is the single most important factor for the success of habitat restoration once you have matched the appropriate habitat to the site. If site analysis has identified unwanted vegetation, removing it is a crucial first step. Methods to remove vegetation include pulling, cutting, girdling, cultivating, treating with herbicide, burning (no till), smothering or mulching, removing sod, and planting a cover crop. You can determine which method or combination of methods will work best for the site by considering existing vegetation, soil conditions, topography, time, and cost.

Note: Site preparation can tie into other study projects. Students can do a seed bank study to see what seeds are in the soil and predict potential weed problems. The types of weeds will indicate further site preparation that is needed. In addition, many non-native weeds were brought to this country for food or medicinal uses, so they can be studied as part of an ethnobotany activity.

## Trees and Shrubs

Remove species that do not fit with the habitat you are restoring. This includes any non-native species. It may also include native species that are not appropriate for the conditions you want to create. For instance, poplars, sumac, prickly ash, and other native species may be too aggressive if you are trying to restore an open grassland or savanna community. Techniques to remove undesired woody species include weed wrenches, tug-a-suckle, a combination of cutting plus herbicide, and girdling.

### Weed wrenches or tug-a-suckle

Pull shrubs using these techniques. Weed wrenches use leverage. Tug-a-suckle uses half-inch diameter ropes twenty feet long with carabiners attached at one end and knots tied onto the rope for the tuggers to hold onto. Groups of students can pull the shrubs from the ground with either technique.

**Disadvantage:**

- Soil is disturbed and needs to be smoothed out and planted.

### Cutting plus herbicide

Cut down trees and shrubs and treat the stumps of re-sprouting species with herbicide. Follow the manufacturer's label precisely. *Note: students should not handle herbicide.*

**Disadvantage:**

- This technique does not work at all times of year, for example, when sap is rising.

### Girdling

Girdle trees to kill them without herbicide. Remove the new living layer (phloem) in a band at least a half-inch wide all the way around the trunk. This method can be used from spring to early summer by inserting a broad flat blade just under the phloem layer and "popping" off the bark.

## Groundlayer

Techniques to remove groundlayer vegetation and to prepare the planting bed include cultivating, treating with herbicide, burning (no till), smothering or mulching, removing sod, and planting a cover crop.

### Cultivation: plowing, tilling, rototilling or scarifying

These techniques kill weeds and their germinating seeds. They also break up the soil to get a good seed-to-soil contact. Plowing is good for deeper cultivation and for a larger area where you can maneuver machinery. Rototilling can be done in a smaller area. Scarifying involves lightly breaking up or loosening the soil close to the surface.


© Earth Partnership • University of Wisconsin-Madison

Cultivation Steps:

1. Rototill or plow to a depth of six to eight inches.
2. Wait two weeks. Till again to a depth of four inches to turn over the new growth.
3. Wait another two weeks. Till shallowly, to a depth of one to two inches, to turn over existing plants and to prepare a smooth seed bed.
4. Plant.

OR

1. Rototill.
2. Wait two to four weeks.
3. Spray with an herbicide and wait two more weeks (see herbicide section for more information), or as an alternative to spraying at this point, cover the area with mulch.
4. Plant seeds and lightly rake into contact with the soil, or place plants.

   If there are rhizomatous, perennial weeds such as quackgrass, till for one entire growing season. Keep tilling at intervals of two to three weeks. Quackgrass will increase in density if given more time between cultivations.

**Disadvantages**:

- If weeds are a significant problem, four to six tillings may be required.
- Multiple tillage may ruin the soil structure. It destroys air pockets and tilth (the state of aggregation of a soil), can create a plow pan in soils with clay content, can cause erosion, and brings up weed seed.
- Tillage is not recommended for erosion-prone sites.
- Existing native plants on the site will be destroyed.
- Tilling is not useful in savanna or woodland sites because of potential damage to woody plant roots.

### Herbicide Treatment

If an herbicide treatment is chosen, use a low-toxicity, non-persistent herbicide such as Roundup, Kleenup, or Ranger; for wet areas use Rodeo. Check your school's regulations on herbicide use, and follow manufacturer's instructions carefully. *Note: students should not handle herbicide.*

Steps for old fields:

1. Burn or mow to remove heavy duff and/or last year's growth. This will encourage new growth. Herbicide is most effective when sprayed on green, growing vegetation.
2. Spray herbicide when the vegetation is six to eight inches tall.
3. Wait two weeks. Spray herbicide again if there are still green plants.
4. Wait two weeks. If the vegetation is still green, spray a third time, then wait two more weeks.
5. Plant seed or plants. If seed is planted, rake it shallowly into contact with the soil.

Steps for lawn areas:

1. Spray with herbicide when the grass is green and actively growing.
2. Wait two weeks. Use herbicide again if needed. Spot-spray green areas if needed, then wait before planting.
3. If the lawn is completely brown, scarify the soil and plant.

**Advantages:**

- Herbicides are effective at weed removal.
- Herbicides can be used for erosion-prone sites or areas difficult to get equipment into because of wet soils, steep slopes, or other obstacles.

**Disadvantages:**

- Herbicides may kill soil microbes or cause other environmental problems.
- School districts may restrict the use of herbicides.
- A licensed applicator may be required to spray the site.

## No-Till:

This method was once considered incorrect for site preparation, but many savanna restorations are now prepared this way. It prevents damage to woody plant roots as well as soil structure.

No-till Steps:

1. Burn off existing groundlayer, then plant desired species.

**Disadvantages:**

- Burning doesn't destroy all the weeds.
- Burning doesn't always work on wet soils.
- Burning is ineffective on aggressive perennial weeds such as quackgrass.

## Smothering or Mulching

Various materials can be used, including:

- Newspapers (six to twelve sheets thick) and wood chips. Newspaper breaks down quickly in high moisture.
- Black plastic. The plastic conducts heat and bakes everything, so it does a good job of destroying perennial weeds. Water doesn't filter through, so soil microbes can be affected. It does break down and is unsightly. For a nicer appearance, you can cover it with wood chips.
- Clear plastic. It stimulates growth, then bakes the plants. This requires extra plastic to expand as the weeds grow before they are killed by the intensity of the sunlight.
- Permeable landscape cloth. The fabric doesn't alter water drainage. The vegetation decays underneath, creating a friable soil. Landscape cloth is reusable and will last about five years. It can be covered with wood chips. It can be expensive, especially for a large area.
- Discarded woven-back carpeting placed upside down.

Smothering/Mulching Steps:

1. Lay mulching material over restoration site.
2. Keep site covered for one growing year.
3. Till shallowly to prepare a smooth seed bed. Plant.

**Advantages:**

- Works well on steep slopes.
- Site preparation is a one-time labor event that involves students.
- The wood chips can be used for trails.


© Earth Partnership • University of Wisconsin-Madison

# Site Preparation Scenarios

### Activity Overview

Part 1: Students read, discuss, make judgments, and present the pros and cons about different scenarios related to site preparation for a restoration.

Part 2: Students research, develop, and present recommendations for site preparation of their school restoration.

### Objectives

Students will:

- Examine and evaluate possible site preparation actions they might take that have an impact on the environment
- Gain an understanding of the pros and cons of various methods of site preparation
- Make decisions between various site preparation options under certain circumstances and present their decisions orally and/or in writing

### Subjects Covered

Language Arts, Science, and Social Studies

### Grades

9 through 12

### Activity Time

Part 1: 1 hour to introduce site preparation; 45-60 minutes to discuss hypothetical scenarios. Part 2: 1 hour to research school site; 1-2 hours to discuss options and determine method of site preparation for school restoration

### Season

Any

### Materials

Scenario cards, background information on site preparation

## Background

Site preparation can affect the growth of both the desirable species you plant and preexisting weed species. Any restoration effort will have weeds in the first years. The weeds can be annuals, herbaceous perennials, or woody perennials. There are a number of possible methods for removing existing vegetation and preparing the site, including pulling, cultivating (tilling), treating with herbicide, burning (no till), smothering or mulching (plastic or organic), removing sod, and using a cover crop. The advantages and disadvantages of these methods vary widely. When deciding which option to use, you will need to consider such factors as safety, price, effectiveness, convenience, opportunity for student involvement, length of treatment, and possible environmental side effects, as well as details of the site itself such as existing vegetation, soil conditions, and topography. Refer to EP activity "Site Preparation Techniques" for more detailed information.

This activity is designed to give students the opportunity to examine their own values and beliefs as they relate to the environment and restoration process. It is not the intent of the activity to prescribe a "right" and "wrong" answer, but rather to provide a forum for students to discuss both the scientific and personal factors involved in choosing any particular site preparation technique. In some cases, students may perceive what would be the most ethical solution to a given problem while admitting that they realistically might not choose that option for scientific or other reasons. In the activity, six scenarios are presented, each of which has to do with issues of site preparation. The action choices are preceded by "would you" rather than "should you," to encourage students to think about what they would do in each given situation.

## Pre-Activity Preparation

Become familiar with the six scenarios. Depending on the time available, you can use these scenarios in different ways. If a short time is available, each group can work with a different scenario, and toward the end, each group can share its reactions to its own scenario with the other groups. This way you can cover a number of the scenarios in one activity, requiring less total time. If a longer time is available, each group can work with the same scenario. Later, the groups can compare their reactions. This way everyone will be involved with the same scenario, allowing for wider comparisons. You can then go on to try the remaining scenarios in turn, but you will need much more time.

## Activity Description

**Part 1**

1. Review as a class the basic information on site preparation described in EP activity, "Site Preparation Techniques."
2. Divide into groups of four or five. Each group receives a scenario which raises a set of problems associated with site preparation. Read through your scenario and become familiar with it. Your job is to think about how you would react if this situation were really happening to you, weigh the options, and make a personal decision about what you would do.

3. First, take about ten minutes for group members to think individually about the scenario. How would you deal with this situation? Consider what you would do and take notes on your choices.
4. Next, take about five minutes for each person to share his or her ideas with the group. Students should listen to everyone's ideas, but not discuss them at this stage.
5. When all group members have offered their ideas on possible reactions, take about ten minutes minimum to discuss all the ideas as a group. Consider the ideas in some depth, and try to reach a consensus view.
6. Come back together as a class. Each group presents their ideas. You can ask questions, but debate is not necessarily needed at this point. What's important is that you listen and capture all the consensus views that have been agreed upon. It may be helpful to list these views on a wall board or flip chart for all to see.
7. Finally, hold an open discussion about the issues and the problems that have surfaced. Take enough time to reflect as a group on what has been learned from the activity.

**Part 2**

1. Visit the proposed restoration site on your school grounds.
2. In groups, determine which site preparation option(s) is best suited for your restoration and why. Come up with a plan that includes recommendations for removal of aggressive species, if any are present on the site, as well as a discussion of the advantages of your plan, justification for your choices, and a timeline. Consider factors such as safety, price, effectiveness, convenience, opportunity for student involvement, length of treatment, and possible environmental side effects.
3. Each group presents their recommendations. As an entire class, decide how best to prepare your site.

## Extensions

- Choose a scenario and write a short paragraph on the positive and negative effects of all the possible site preparation options. Indicate what, if any, additional information is needed in order to make a responsible and informed decision. Identify what seems, in your judgment, to be the most responsible decision, and explain your reasoning.
- Invite guest speakers from the Department of Natural Resources, local parks, etc. to discuss how they address issues of site preparation and exotic species.
- Come up with your own site preparation scenarios and discuss them with the class.
- Design and implement research projects related to site preparation issues. Collect data, present your investigative results, and explain the implications of the results as they relate to site preparation.

## Assessments

- Describe why site preparation is important in the restoration process.
- Provide at least one pro and one con to each site preparation option.
- Recognize at least three to five considerations when preparing a restoration site.

**Scenario #1:**

You and your friends have raised a lot of money to support the native planting on your school grounds and you want begin the first planting this spring. The site you have chosen is fairly large (5,000 square feet) and has been maintained as a lawn for the past five years. You have been told that your options are to plant a cover crop or mulch the site, which means that you would not be able to actually plant for another year. What are the advantages to these approaches? What are the disadvantages? What other option(s) would allow you to plant this spring? How would you convince your friends (and school) to go ahead and plant in the spring?

 © Earth Partnership • University of Wisconsin-Madison

## Site Preparation Scenarios (cont.)

**Scenario #2:**

You want to restore a prairie on your school site in an area with a very steep slope that is prone to erosion. There are a few native plants growing on the slope such as bee balm and black-eyed Susan. A local community member has volunteered to till the site. Is this the best option for this situation? Why or why not? What approach would you suggest? Are there other options and/or information you need to formulate another proposal?

**Scenario #3:**

Last year, you chose to use a glyphosphate herbicide on a 1,000-square-foot restoration site that had been established in an old abandoned field in the local park. You are concerned that persistent weeds and other undesirables will invade your prairie restoration. While you were able to plant the first restoration site rather quickly, there was a backlash among some community members who did not like the use of herbicides in the park. Your group wants to plant another 1,000 square feet this spring, but you are concerned about using herbicides again. What are your options and what would you do to address further community concerns? Are there other options and/or information you need to formulate another proposal?

**Scenario #4:**

The site for your prairie restoration is on a steep slope with sandy soils. The community and the administration want the site planted quickly. They suggest hiring a landscape contractor to prepare the site and to plant the prairie seed and cover crop with a tractor. While this may lead to quicker growth, you are concerned that if you and the rest of the students don't get to help in the planting, students won't care about the restoration and may not treat it well. What discussion points would you make to get the community and administration to consider alternatives to hiring a contractor? Are there compromises that would accommodate different views? What are the limitations of each?

**Scenario #5:**

Your woodland site is being threatened by garlic mustard, which can smother out the groundlayer where you want to plant additional wildflowers. Garlic mustard (Alliaria petiolata) is a biennial exotic which has in the last few years become a major threat to woodlands. It invades along edges of woodlands and spreads along trails and streams, growing in dense stands that choke out all other plants. Water flow, animals, and human activities further disperse garlic mustard. You could choose to use herbicide treatments, but are concerned about health hazards, cost, the need to employ a licensed applicator, and community concerns that might be raised. You could also hand-weed, particularly in areas where the infestation is only scattered and desirable woodland plants can be saved, but you are concerned these efforts will not be enough to stop the invasion. What would you do?

**Scenario #6:**

A special place was selected at a local park for students to restore an ecological restoration for at least four years of summer classes. Each year 2000 square feet of area will be prepared for planting the following year. The space is at the main entrance of the park and for that reason the restoration site must look well designed and presentable at all times of the year. Given that students will be involved in the site preparation and that the area must be aesthetically pleasing, what method(s) of site preparation would you suggest?

earth partnership

# Plant

sow seeds, transplant seedlings, and celebrate!

# Section Introduction: PLANT

After all the study and preparations that have led up to it, planting is an exciting step in the restoration process. You may get ready to plant by collecting seeds from your site or another area and sowing them directly as seeds or starting them indoors to grow seedlings (“Seeds to Seedlings” activities). You can also order seeds or plants from a nursery. If you plant from seed, you’ll need to understand how to spread the seed effectively (“Mixing the Seed” and “A Time to Sow”). If you plant plants, there are some techniques to follow to help ensure a healthy start to the plants in their new home (“Planting Native Plants”).

Whether you choose seeds or plants, whether your site is acres large or a tiny patch, it is important to recognize that planting is a momentous occasion in the life of the restoration. Encourage students, families, and community members to view this time as a celebration. You can incorporate music, dancing, and food into your festivities – and if you spread seed, dancing the conga across the site can be a fun and functional way to get those seeds settled into the ground!

Making planting a celebratory experience honors the work that everyone has put into the restoration so far, and it also encourages investment in the sustainable well being of the restoration. If people approach planting as a time to connect to the site and to one another, then they will be more likely to view the restoration as a positive force in the school and/or community that is important to take care of in the future.


© Earth Partnership • University of Wisconsin-Madison

# Seeds to Seedlings: Seed Collection

### Activity Overview
Students collect seeds for their restoration and discover the potential of seeds by observing the relationship of plants and seeds to their surroundings.

### Objectives
Students will:

- Explore the phenology of plant flowering times and seed maturation
- Use observation skills and plant identification skills
- Discover the many types of seeds and investigate seed ripeness and dispersal patterns
- Collect seed for use in future activities

### Subjects Covered
Science and Math

### Grades
K through 12

### Activity Time
30 minutes in the field; 30 minutes classroom discussion

### Season
Late Spring, Summer, Fall, and early Winter

### Materials
Paper bags, marking pens, gloves, notebook

## Background
Restoring the land requires a source for seed and plant material. Seed from a local source can provide the following benefits: local plants are adapted to your local growing conditions, pollinators exist, and costs to restore an area are reduced. States and regions are divided into "Ecotype Regions," zones that are differentiated by microclimate and population barriers such as water, mountains, streams, etc. Your natural area may also have different microclimates where the same species exist under different conditions. The optimal collection site for seeds and plants is as close as possible to your receiving site, the area you hope to restore.

There are specific guidelines for collecting seeds so that enough seed remains on the plants for wildlife and future plant populations. These guidelines are a part of a seed collecting code of ethics. The following guidelines ensure continued survival of species and established biosystems.

- Collect only 10% of the harvestable seed of those species which are uncommon or depend solely on seed for reproduction (annuals and biennials).
- Most species may be harvested at a 25% rate and a few widespread and common species may be collected at 50% of the harvestable seed. Never collect above the 50% rate.
- Walk lightly to avoid trampling plants during the growing season.
- If collecting from gardens or restorations, check the source of plant material.
- Realize when collecting seed you are disrupting interactions between plants and animals.
- Avoid collecting protected species. Leave that to the experts to ensure proper collection, storage and propagation.
- State and federally listed species can only be collected with a permit.

The goal is to collect seed at full maturity, and therefore to ensure the greatest percentage of viability. There are two stages of seed development: the soft dough stage and the hard dough stage. The seed is in the soft dough stage if, when squeezed between the thumb and forefinger, the seed interior is ejected as a doughy substance. Seeds often are green or light-colored. Soft dough seed tends not to be viable. Seeds in the hard dough stage are brown or dark-colored and easily shatter. The hard dough stage can be determined by a bite test. Simply put, if the seed is too hard to bite, it may be considered mature and has, in all probability, achieved dormancy. Dormancy is a condition of the seed in which germination is prevented by internal mechanisms. These mechanisms may be either physical or chemical in nature and help protect the future seedling from germinating at a time which may be detrimental to its survival, such as late in the fall. Generally, seeds mature approximately one month after flowering. Lists with possible seed collection dates are often available through the Department of Natural Resources, nature centers and universities.

## Activity Description

Go out in the natural or restored area and locate both flowering plants and plants with seeds. Collect when humidity is low and no rain or dew is present. Students can pair up with a paper bag, pen and notebook; each group should choose different species.

**STEPS:**

1. Make a list of plant attributes and/or draw plant in notebook.
2. Identify plant using a key or identification book.
3. Write plant name, date, location, and student names on the paper bag.
4. Compare ripe to unripe seeds.
5. Hold seed stalk (panicle) over paper bag and drag hand over panicle or stalk to allow seeds to drop into bag. You can also collect them in your hand and place them into the bag. Remember: any seeds that drop on the ground are good for the natural area.
6. Compare different types of seeds, for example, those with "wings" and with those that are sticky. Discuss how different seeds types are dispersed.
7. Tape or glue a sample of each seed type into notebook.
8. Weigh seeds and write amounts onto the paper bags.
9. Place bags in cool, dry area in order to dry.

### Questions for discussion

When collecting seed, what would happen if we removed all the seed of a particular species? What would happen if we left seed behind and did not collect it?

How we choose to collect influences the natural area we take seed from. Why would it be important to let seed remain on each plant?

How is diversity influenced if we leave half of the seed on each plant in the natural area?

## Extensions

- Chart flowering and seed maturity times of specific plants for comparisons (grasses, forbs, legumes).
- Count out 100 seeds of each species you collected and then weigh them to compare weight differences among species.
- Keep a nature journal that includes drawings and phenology records.
- Explore many ecotype regions and note the differences between ecotypes and genotypes.
- Investigate genetic diversity and population genetics.

## Assessments

- From your experience, describe how you can identify if a seed is ripe and ready for collecting.
- Describe different seed dispersal methods you observed while collecting seed. What are the advantages to the different types of dispersal mechanisms?
- What would happen if all seed was collected from a site?
- What are the benefits of collecting seed from a local seed source?


© Earth Partnership • University of Wisconsin-Madison

# Seeds to Seedlings: Seed Cleaning and Storage

### Activity Overview
Students clean seed they collected in the field.

### Objectives
Students will:

- Differentiate the seed from the chaff
- Discover methods for removing chaff from the seed
- Compare the seed coats of different species
- Explore the seed "timeline"
- Use observation skills and plant identification skills

### Subjects Covered
Science and Math

### Grades
K through 12

### Activity Time
30 minutes in the classroom

### Season
Any

### Materials
Trays, gloves, rolling pin, sandpaper, ziplock bags, plastic containers with lids

## Background
Seeds have adapted to their environment in different ways in order to survive and eventually germinate. There are short-lived, recalcitrant seeds that must remain moist in order to survive. Many short-lived seeds ripen in the spring and are often aquatic or nut species. Medium-lived seeds, called orthodox, can remain viable for up to two to three years in the wild. In storage, orthodox seeds such as conifers, fruit trees and grasses can remain viable for up to fifteen years. Seeds with hard seed coats that are impermeable to water are long-lived. One of the world's longest-running experiments was initiated by Professor William James Beal in 1879 to investigate how long seeds can remain dormant and still germinate. After 126 years, seeds were still viable.

Once seed has been dried, it is ready for processing. Processing includes two basic steps: threshing, which breaks the actual seed from its protective coating (often referred to as "chaff"), and cleaning, which "seperates the wheat from the chaff," so to speak.

### Threshing
There are many techniques for threshing; it takes only a little imagination. One of the simplest ways is to rub the harvested material against a coarse screen with a gloved hand. Try rubbing the plant between two ping-pong paddles. Or, alternatively, you could cut open an inner tube, tie off one end, place the material to be threshed inside, and then roll the tube underfoot on the floor. For removal of seeds from pods, a rolling pin and a wooden tray may be effective. Or gently rub the pods between two bricks. Mechanical threshing may be accompanied by employing a hammer mill. This method works particularly well on the hulled seeds of tick trefoil, bush clover, beebalm and black-eyed Susan.

### Cleaning
The ideal is to get seed completely clean. While this ideal is not 100% attainable, don't worry; the seed will grow. Still, strive for the 100% clean because it will reduce the volume of material to be stored, it will make sowing of the seed easier, and it will increase the likelihood of planting viable seed. Cleaning is accomplished by shaking the threshed material through progressively tighter meshed screens. Naturally, not all undesirable material will be sifted out, but there are various methods for removal of the dirt and smaller pieces of plant material that remain. Since the desirable seed is denser than the leftover material it is a simple process to blow that material away. With this process, a little experimentation is in order. Place a fan (or perhaps a hair dryer) on a table, and winnow the chaff from the seed. The trick is to discover at what distance to place the wind source so the chaff but not the seed itself will blow away. Start at a greater distance and move closer as the seed gets cleaner—an ounce of caution is worth a pound of cure! Commercial seed producers use a fanning mill in the final stages of seed cleaning. Note: This process may be dusty so participants may want dust masks.

### Storage

Storing seeds in the right conditions can be very important for maintaining their viability. For medium- and long-lived seeds, removing the chaff and other plant parts can assist in drying the seeds and increase the success of storage. Dry seeds still need 3-8% moisture to remain viable. Store in sealed containers, such as ice cream pails or yogurt containers, in a refrigerator set at 41 degrees Fahrenheit.

## Activity Description

Take seed you have collected (see EP activity, "Seeds to Seedlings: Seed Collection") and place different species on different trays.

### STEPS:

1. Break the seed out of its seed heads. Experiment with different threshing techniques to find the best method.
2. Remove chaff and plant parts from seeds. Use sandpaper or a gloved hand to pop the seed from the chaff and/or try other techniques to best clean the seed.
3. Observe the different plant parts to determine which is the seed. Use a microscope if available.
4. Compare different species and note the different types of seeds (recalcitrant, orthodox, and long-lived).
5. Weigh cleaned seed and note the differences in seed weight.
6. Place cleaned seed into sealed containers.
7. Store in refrigerator.
8. Note: Recalcitrant seeds need to remain moist; therefore, place in sealed container with moist sand or peat moss. Moisture level should be like a damp sponge.

## Extensions

- Weigh seeds over the course of the school year. How might these seeds change? What accounts for any changes you may find? Which types of seeds change the most?
- Explore different habitats and compare the types of seeds (recalcitrant, orthodox and long-lived) within each habitat.
- Discuss how short-lived seeds take advantage of their surroundings.
- Find out why a seed would need to be impermeable to water and to wait to germinate.
- Research the progress of Professor Beal's ongoing research. More Information on "Rip Van Winkle Plants". http://earthsky.com/2002/esmi021218.html

## Assessments

- Describe the different threshing techniques, which ones work the best for them, and why.
- Write out detailed directions to another student on how to do this activity step by step.


© Earth Partnership • University of Wisconsin-Madison

# Seeds to Seedlings: Propagating Seeds in the Classroom

### Activity Overview
Students explore methods of propagation and investigate dormancy in seeds while relating those methods to natural processes.

### Objectives
Students will:

- Investigate seed dormancy
- Explore seed dispersal mechanisms and animal interactions
- Explore the phenology of seedling germination, cotyledon stage, first true leaves
- Use observation skills and plant identification skills

### Subjects Covered
Science and Math

### Grades
K through 12

### Activity Time
15-30 minutes for Part 1, one month before planting activity; 30-45 minutes for Part 2

### Season
Late Winter to late Spring

### Materials
Seeds, water, sandpaper, ziplock bags, inert material (sterilized sand, vermiculite or peat), planting containers or trays (egg cartons and paper tubes work well), potting soil, refrigerator

## Background
For good germination, seeds generally require warmth, moisture, and eventually light. Moisture tends to be the limiting factor, but other factors also play a role in how well seeds germinate, or if they germinate at all. A seed contains an embryo, an endosperm, and a seed coat. Water must penetrate the seed coat for the seed to imbibe water, swell, and germinate. Although some spring-blooming species have seeds that germinate the same year they fall, other seed use "dormancy" to postpone germination until later—for example, seeds might drop in the fall, stay dormant through the winter, and germinate in the spring. Dormancy provides a safety net so the seed will not germinate until habitat conditions are favorable to the survival of seedlings. A seed must break dormancy to allow enough water to saturate the seed coat and trigger germination.

Seed treatment for breaking dormancy is used when propagating seeds. Seed treatments mimic natural processes, so it is important to think of what ecosystem the seeds came from when considering what type of treatment is required. There are four general treatments (and many variations) for breaking dormancy and eliminating the barriers to germination: dry-cold stratification; moist-cold stratification; scarification; and other treatments such as chemical (inhibitor), morphological, physiological, and embryonic (deep). Some seeds have double dormancy and require combinations of treatments.

### Dry-cold stratification
Dry-cold stratification is exactly what it sounds like. The seed is stored in a dry condition while being exposed to native habitat temperature conditions—commonly called winter.

Dry-cold stratification requires only cool temperatures of 32 degrees Fahrenheit for one to two months. Most commercial seed has undergone this treatment already. Plants like lavender hyssop, lead plant, aster, and blazing-star require dry-cold stratification.

### Moist-cold stratification
Moist-cold stratification requires cool temperatures of 32 degrees Fahrenheit, plus a moist, inert material such as sand, peat, or vermiculite. The moisture level should be like a moist sponge. The potential for seed rot can be reduced by first sterilizing the inert material in a 400-degree oven for one hour prior to wetting. Many species need a 30-day period of moist-cold stratification, although some may need as few as ten and others as many as 90 days. Lupine is a species that needs only ten days while wild quinine and bottle gentian need 30 days.

### Scarification
Scarification is the act of breaking through the seed coat by rubbing sandpaper across it, by treating it with acid, or by pouring hot water onto the seeds. 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 between two pieces of sandpaper. Acid scarification is used for seeds with tough, thick seed coats. Many of

these larger seeds are food sources for birds and other animals. The acid scarification mimics 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.

### Other treatments

Other treatments include heat, harvesting immature fruits, and an application of plant hormones (regulators). Complete information on these methods can be found in the book *Plant Propagation: Principles and Practices*. If seed is planted in the field in the fall, the physical and biological processes encountered in the soil will naturally break dormancy to allow the germination process the following spring. Some seed may take two to three years in the field to break dormancy.

## Activity Description

### Part 1: Seed Treatment

1. Verify seed treatment method. Proceed with following steps unless different techniques are recommended for your seeds. Seeds that do not need pretreatment can be planted right away.
2. Scarify seeds lightly with sandpaper or hot water.
3. For moist-cold stratified seed:
    - Fill ziplock bag with sterilized sand, vermiculite or peat and moisten.
    - Place moist seeds that need moist-cold stratification in ziplock bag.

    For dry-cold stratified seed:
    - Place dry seeds in ziplock bag.
4. Label bags.
5. Refrigerate bags for at least 30 days.
6. Compare how moist-cold seeds look after 30 days with those in dry-cold stratification. Plant seed using directions below.
7. Consider these questions as a class:
    - What natural process are we imitating by using an abrasive or acid to penetrate the seed coat?
    - How does stratification relate to the food web?
    - Which seeds require moist-cold stratification and which do not? What is the shortest length of time required and what is the longest? How long can you keep seeds in moist-cold storage?
    - Why might a particular species need hot, moist conditions to germinate?

### Part 2: Seed Planting

1. Fill containers with soil and moisten very well; let sit to absorb water.
2. Remove seeds from refrigeration (see Part 1 above).
3. Plant seeds as deep as the seed is large; tiny seed can remain on the surface.
4. Water seeds well.
5. Place seeds in a south-facing window and under fluorescent lights for best results. Fluorescent lights need to remain on 24 hours per day unless you have very large windows; if you do, turn fluorescent lights off during the day and back on for the evening.


© Earth Partnership • University of Wisconsin-Madison

6. Continue to water daily as needed. Look for signs of germination. You will first observe the hypocotyl or stem of the seedling below the cotyledons. The cotyledons appear next: they are the leaves of the embryo and source of food for the young plant. Next the true leaves appear.
7. Once the seedlings have germinated and have grown their first true leaves, transplant them into growing trays or pots. If interested, see Additional Resources for a source for deep groove tube trays.
8. Consider these questions as a class:
   - Compare the germination of species that do and do not require treatment.
   - How densely can you plant seeds before they are negatively influenced by their seedling neighbors?
   - Which species germinate the fastest? Some species, called pioneers, are the first to colonize a disturbed area. Do any of your species seem to be pioneers?

## Extensions

- Chart the growth of your plants and monitor the phenology: when do they germinate, get their first true leaves, flower, and go to seed?
- Explore germination rates by counting out a specific amount of seed for each species. How many germinated? X number of seeds germinated out of 100 seeds will give you the percent germination. What trends do you see? Do some germinate faster than others?

## Assessments

- Look at different seeds and identify stratification techniques based on characteristics and/or species name.
- Describe the processes of plant growth from a dormant seed to a mature plant. Include drawings of each stage.
- Tell a story about a seed using terminology learned in this activity such as dormancy, stratification, seed coat, germination, cotyledons, and true leaves.

# Planting Native Plants

**Activity Overview**
Students plant native transplants in their school's natural area.

**Objectives**
Students will:

- Learn how to properly plant transplants
- Understand that plants need space, soil, water, and sunlight to grow
- Participate in a project to improve the environment

**Subjects Covered**
Science

**Grades**
K through 12

**Activity Time**
1 hour

**Season**
Local planting season

**Materials**
Plants, trowels, source for water, watering containers, and mulch (if desired)

## Background

Planting a native garden is a very special event in a school year and an important contribution to the environment. Therefore, consider including the entire school community by integrating some form of a ceremony or dedication into the planting project. Because of curriculum requirements, this may be the only opportunity some students will have to participate in the planning and implementation of a native garden.

Whether you are planting shrubs, trees, or herbaceous plants, there are a few tips for successful planting. First, dig a hole that is considerably wider and as deep as or just slightly deeper than the container or root system of the plant. It is not necessary to modify the soil, so use the soil you dig out to fill the hole back in once you have placed the plant. If you modify the soil within the hole too much, you might discourage the plant from extending its roots away from the hole.

If you purchase plants in pots, it is possible that the plants have not been growing in the pots for very long; therefore, much of the soil will fall off when you remove the plant from the pot. That is okay. The pots are a way for the plant to be held until you get it into the ground. On the other hand, if the plants have been in the pot for too long, the roots can coil around the pot, becoming "pot-bound." If that happens, and you do not loosen and straighten the roots when you remove them from the pot, the roots will continue to grow in this pot form and eventually strangle the plant. In either case, when placing the plant in the hole, straighten the roots out. Do not coil the roots to fit them into too small a hole because they will continue growing in the direction you place them and could once again strangle the plant. If you cannot dig a large enough hole, it is better to cut the root than to coil it.

A common error when planting woody plants is to plant them too deep. Woody plants have a root collar that should be level with or slightly above the grade of the soil when you are finished filling in the hole. The same is true when you are planting "plugs" or other herbaceous plants. Try to place them at the same soil height as they were originally growing. This might take some close inspection but is usually obvious. Plugs can seem root-bound, but if the roots are not coiled you can just spread them out.

Generally, plants are spaced about one foot apart when planted in the ground. After planting, water the soil well and make provisions for continued watering the first summer. After a planting, new transplants need to be watered once each week for four weeks. Skip a week if there is a one-inch rainfall during that particular week. You can mulch with composted leaves or with wood chips to help hold in moisture. Create a slight lip with soil around the planting hole to help when watering. The lip helps the water stay there long enough to soak in. You may find it helpful to mark the plants with tall markers to help you find them in mid to late summer or to identify them when weeding. What is readily apparent in May can be very hard to find in July or August.


© Earth Partnership • University of Wisconsin-Madison

## Activity Description

**Preparation for planting day**

Arrange for volunteers to assist students with planting. Develop and distribute a planting schedule. Many options are possible when planting with students. Pairing older with younger students has proved very successful. Having students planting in pairs works well, too. Give each class/group about 30 minutes of planting time on the schedule. Contact the media and have a student team prepared to write articles and take photographs. Plan a celebration and invite the school community.

**On planting day**

Set up plants, trowels, water, and watering containers near the planting site. If desired, place plant markers where transplants will be located or mark planting zones according to plant height on the ground.

**Planting day**

Once a class is at the planting site, begin by giving a planting lesson or demonstration. Describe what a plant needs to grow and thrive and give step-by-step planting instructions. Instructions can include locating a planting spot, digging a hole, removing the plant from the pot, separating roots (if needed), planting at the proper level, refilling the hole with soil, placing a marker, watering, and perhaps adding mulch.

Have students begin at the center of the garden and work out to avoid trampling the new transplants. After all the plants are in the ground, spread the remaining mulch between plants.

Step back and enjoy the work done and the future promise of a healthy landscape.

## Extensions

- Look for opportunities to plant in parks and other public areas.
- Follow the growth of your transplant by taking photographs and measurements, making drawings, and recording when the plant first blooms.
- Write a song or poem about your planting experience.

## Assessments

- Draw and describe how to plant a transplant as a cartoon feature.
- Draw correct and incorrect versions of planting. Explain how to fix the incorrect drawing.

# Mixing the Seed

## Activity Overview
Students mix the seeds and filler, noting each species that is being added.

## Objectives
Students will:

- Become familiar with plant species names, scientific and common
- Observe a variety of seed shapes and sizes
- Understand that an ecosystem must have a wide diversity of plants

## Subjects Covered
Math, Science and Language Arts

## Grades
K through 8

## Activity Time
15-30 minutes

## Season
Spring or Fall, when the seeds are going to be planted

## Materials
Seed mix, filler (sawdust, vermiculite or sand), 2 large tubs (5-gallon buckets or 30-gallon trash cans)

## Background
You have the seed in hand, the site is prepared and the planting celebration date is set. What do you do with that seed? While you could quickly prepare the seed mix by yourself, this is a great opportunity to involve students of almost any age. It is an opportunity to get younger and older students working together and can be done as part of the celebration with the entire school or earlier in the day with a smaller core of students.

The seed needs to be thoroughly mixed and, if you are planning to hand broadcast, an inert medium must be added to the mix. The inert medium or "filler" can be sawdust (make sure the dust is only from untreated lumber), vermiculite (available from most garden stores), or sand. It should be slightly dampened so that the seed will stick to it.

While you need to mix in at least an equivalent volume of seed and inert material, there are no problems and several benefits to adding far more filler. The filler serves several functions. It transforms a small volume of seed into a large volume of seed mix, enabling the mix to be spread more evenly over the site. It also allows more students to be involved by planting a larger volume of mix. Why have each student plant a small cupfull of mix when they could plant two or three large cupfuls? Furthermore, if the seed mix is more "dilute," accidental spills or uneven distribution by individual students are less problematic. The filler also makes it easy to see where the mix has been spread, which is especially helpful when many students are planting on a single site.

Depending on the total volume, the seed and filler can be mixed in a white 5-gallon bucket (available from most supermarket deli counters), or for larger volumes, in a 30-gallon trash can. After the filler has been thoroughly mixed in, divide the mixture in half and put into two containers.

If you are planting any legume seeds, legume innoculant must be mixed into the seed mix. Innoculant can be purchased at garden stores or from prairie seed distributors.

## Activity Description
Distribute the packages of prairie seeds among yourselves. Take turns as each person with a package of seeds comes up to the front and says the name of their species. Other things about the species can be said such as what the plant looks like, when it blooms or another interesting fact. If you wish, the name can be written on a piece of tagboard that will then contain the names of all species in the mix.

While saying the plant's name, pour the seed into the bucket that will contain the mix. Continue until all seeds have been added. Mix the seeds carefully by hand until they look well-mixed. Add the filler and mix again, being careful to get the smaller seeds from the bottom well-distributed. Carefully divide the mixture into two equal portions. The seed mix is now ready! The next step is to sow the seed, which can be done with as many students as possible and in the context of a school planting celebration.


© Earth Partnership • University of Wisconsin-Madison

## Extensions

- When creating the mix, it is a good time to consider how the plant looks when it is flowering. Photographs from prairie seed catalogs (back issues of which are often donated to schools if requested) or coloring sheets from wildflower coloring books could be mounted on a prairie poster or mural.
- When creating a seed mix, a few seeds can be set aside to germinate so the students can observe the appearance of seedlings of each species. This will help in identification of seedlings in the spring. A seedling identification guide could be created. For more information on seed germination procedures, see EP activity "What Does a Seed Need?"

## Assessments

- Students can write up an evaluation of what they learned or liked most about the activity.

# A Time to Sow

### Activity Overview
A group of students, teachers, parents and community members will plant the restoration and dance in the seeds.

### Objectives
Students will:

- Understand how seeds are planted
- Experience a sense of pride, ownership and completion in an important and complicated task

### Subjects Covered
Language Arts and Physical Education

### Grades
K through 12

### Activity Time
30 minutes

### Season
Spring or Fall, when the restoration is planted

### Materials
Seed mix, well-marked and prepared site, enthusiastic participants

## Background
One of the beauties of hand-sowing a prairie restoration site is the potential for many students, teachers, parents, and community members to become involved. As few as one and as many as 500 people can participate in the actual planting—possibly even more, depending on the size of the site. If involving many people, the planting can be done in one large group or in several small groups. In either case, make sure the boundaries of the group's planting area are well-marked and clearly understood. Regardless of group size, we recommend organizing the sowing of seed in the way described below. While sowing needs to be done carefully and everyone needs to clearly understand what to do, this can be a joyous and fun celebration.

## Activity Description
It is important that all areas end up covered with seed and that no areas get dumped with too much seed. All of the "sowers" should line up along one edge or side of the planting area. Spread out the line so you are evenly spaced and the line stretches from one end to the other. If your planting is an irregular shape, you will have to spread out so that each person will be covering approximately the same area.

Each sower gets a container or cup. One person, the "seed distributor," should take half of the total seed mix for that area and walk down the line allowing each sower to take a small, equivalent portion (perhaps one or one-half cupful or one handful). If there is seed left, the seed distributor goes down the line again letting each person take another equal portion. The idea is to have each sower plant the same amount of seed. When everyone is ready, walk across the planting, spreading your seed as you go. Plant up to where your neighbor is planting so no areas get missed. Try to make your quantity of seed last until you get to the far edge. If you have seed left over, turn around and walk back, planting the rest of the seed.

After all of that seed has been planted, line up as you did before, but this time along an adjacent side of the planting. This time your planting paths will cross at right angles to the paths you planted before. Divide up the second half of the seed among all sowers and plant as before.

After sowing the seeds, it is important to make sure that the seeds have good contact with the soil. The seeds can be raked in (which is a lot of work) or danced in (which is a lot of fun). This is an essential step to get the seeds ready to germinate. Dance all you want, but make sure that all areas are danced in. Bring music or create your own.

## Extensions
- Create invitations for the community, school officials, parents, etc.
- Monitor the planting to look for emerging seedlings.
- Describe the science involved in sowing seed to maximize germination.

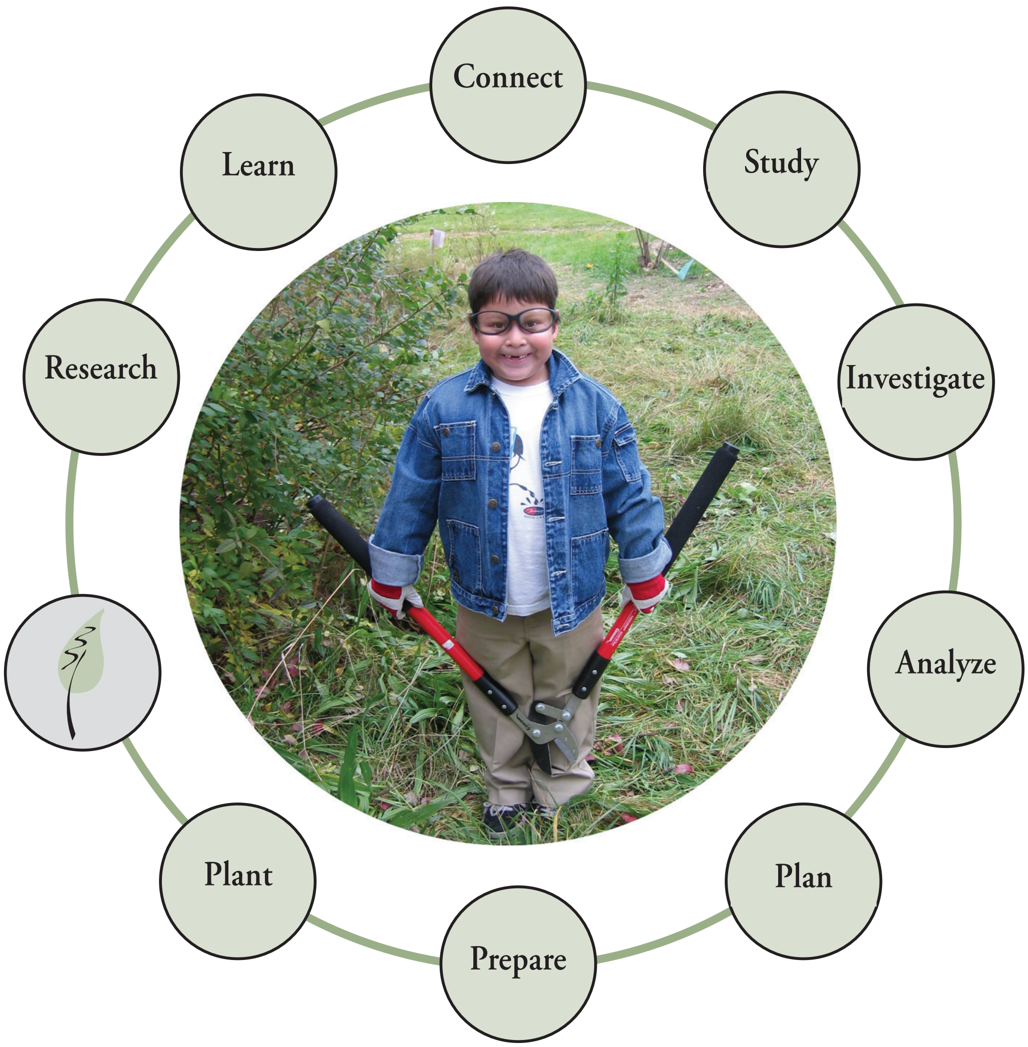
## Assessments
- Write a paragraph about your experience sowing seed and how it relates to practicing land stewardship.


© Earth Partnership • University of Wisconsin-Madison

earth partnership

# Manage

remove invasive species;
create signage



# Managing Your Restoration

**Activity Overview**
Students learn about plant and garden care while managing a new restoration.

**Objectives**
Students will:

- Understand plant needs for growth and survival
- Learn basic land care principles
- Participate in a service learning project

**Subjects Covered**
Science and Physical Education

**Grades**
3 through 12

**Activity Time**
1 hour

**Season**
Spring, Summer, Fall

**Materials**
Gardening gloves, trowels, water source, recycled milk jugs or equivalent. Optional: buckets, wheelbarrow, or plastic garbage bags

## Background

An ecological restoration planting will regularly need some maintenance to remove weeds and dead plant material. Native plant restorations do not need fertilizers, winter protection, or irrigation. Native plants are adapted to the climate and soils and can tolerate excessive heat, bitter cold, drought, and flooding.

The first several years require the most care while the plants are establishing themselves in the garden. As they are maturing the first year, they need regular watering to encourage good root development. Make sure that the water soaks deeply into the ground. A short sprinkle of water encourages the roots to grow along the surface, which makes them less hardy during droughts and freezing temperatures.

Pull weeds to reduce competition for space, soil nutrients, light, and water. Most weeds are pioneer species, which means they grow very quickly. They fill in the open spaces and often can crowd out new plants. Spreading a three-inch layer of wood chips or leaf mulch around the new plantings helps control some of these weeds.

Instead of burning the site, which may be very difficult to do in an urban setting or if the site is close to buildings, you can mow the site to cut back the weeds and stimulate growth of the native plants. Mow the site in early spring when the weedy plants are taller than the natives. Another option is to mow the site in the fall, when the native plants have gone dormant and the weeds, like buckthorn, honeysuckle, garlic mustard and dame's rocket, are still green. You can mow at these times for the first several years or as long as it takes until the native plants dominate over the weeds.

Much of the maintenance occurs during the summer months. Therefore, before summer vacation, enlist volunteers to monitor, water, weed, and possibly mow the site during summer vacation. Local garden clubs, summer school students, scout groups, families, Wild Ones members, and Master Gardeners may be willing to volunteer during the summer.

The basic elements of a management plan are:

- *Where to work*—This could be along edges or paths, or the whole site.
- *When to work and what to do*—Take note of when specific weeds appear and when they flower, so you can remove them before they set seed and spread.
- *Other activities*—These might include watering, spreading mulch, mowing the site, or collecting seeds.
- *How to work*—For most weeds, pulling the plant is enough. In general, control recommendations are:

  Cultural: monitor plants before they become a problem; make sure your mulch doesn't contain weed seeds.

  Biological: sometimes land care managers introduce a plant's natural enemies, such as specific insects or bacteria, to control a weed species.


© Earth Partnership • University of Wisconsin-Madison

## Managing Your Restoration (cont.)

Mechanical: prescribed burning, mowing, cutting, girdling, and pulling are ways to physically remove a plant. These methods imitate natural processes, so they are preferred. Because of soil disturbance, sometimes it is helpful to replant or reseed areas of bare soil so that weed seeds don't regrow. Another option is to mulch bare patches of soil after it is weeded.

Chemical: on particularly persistent invasive plants, sometimes herbicides are used, such as Round-up, Klee-nup, Ranger, and Rodeo (for wet areas). Follow the manufacturer's instructions carefully. Be sure to check school policy for using herbicides.

Below is an example of a management plan chart. This chart can be modified to be more general or detailed so that it includes specific dates when activities occurred.

| **Restoration Management Plan for Year 1** | | | | |
|---|---|---|---|---|
| Management Activity | Spring | Summer | Fall | Winter |
| Planting and Seeds | Plant native plants, mulch around plants. | | Collect seeds. | Watch for birds on seed heads. |
| Watering | Water site once a week for first 3 weeks. | Water site every 3-4 weeks, if needed. | Only water if in drought. | |
| Weed control | Pull garlic mustard, dame's rocket, etc. Girdle aspen trees. | Pull bindweed, burdock, thistle, clover, spurge, wild parsnip, ragweed, etc. | Cut down or remove honeysuckle and buckthorn before they set fruit. Dig up oriental bittersweet. | |
| Mowing | Cut back old growth. Mow weeds when they are taller than native plants; use a clipper or string trimmer so new plants don't get smothered. | Clip every 6 weeks. First clip to a height of 4 inches, then 6 inches, then 8 inches. | Mow site when native plants are dormant and invasive species are still green. | |
| Trail maintenance | Chip paths with wood chips, etc. | Weed along paths. Cut back plants that have fallen over path. | | |
| Compost | Start compost pile. | Turn compost pile. | | Cover compost pile for winter. |

© Earth Partnership • University of Wisconsin-Madison 

| Restoration Management Plan for Year 2 | | | | |
|---|---|---|---|---|
| Management Activity | Spring | Summer | Fall | Winter |
| Planting and Seeds | Mulch around plants. Reseed and plant bare patches. | Collect seeds. Reseed areas if there are bare patches of soil after weeding. | | Watch for birds on seed heads. |
| Watering | Water new plants or newly seeded areas. | Only water if in drought. | Only water if in drought. | |
| Weed control | Pull garlic mustard, dame's rocket, etc. Girdle aspen trees. | Pull bindweed, burdock, thistle, clover, spurge, wild parsnip, ragweed, etc. | Cut down or remove honeysuckle & buckthorn before they set fruit. | Dig up oriental bittersweet. |
| Mowing | Cut back old growth. Mow weeds when taller than native plants. | | Mow site when native plants are dormant and invasive species are still green. | |
| Prescribed burn | | | | |
| Trail maintenance | Pick up trash. Re-chip paths with wood chips, etc. | Weed along paths. Cut back plants that have fallen over path. | | |
| Compost | Turn compost pile. | Turn compost pile. | Turn compost pile. | Cover compost pile for winter. |

## Activity Description

### Year 1

**Watering**

For the first three weeks after planting, water the restoration once per week. It is not necessary to water during a given week if one inch of rain accumulates. Water the garden during periods of drought in midsummer, if needed.

**Weeding**

1. Identify if the plant is a weed or a native plant. Once weeds are identified, assign a specific weed for each student or group of students to hand-pull. This ensures that only the weeds are removed. Have students look closely at the weed to become familiar with the leaf shape and arrangement, flower structure, height, and other noteworthy features.
2. Remove the plants carefully in order not to disturb the native species. Pull from the base of the plant. It is easier to pull the plants when the weeds are young and small or on the day after a rainfall.
3. Keep track of how many different weeds are pulled and how many of each kind. Take notes in a journal that records the date, weeds, and how many are pulled.


© Earth Partnership • University of Wisconsin-Madison

4. Take the pulled weeds to a compost pile. Note: some weed species, like garlic mustard, need to be bagged and put in the trash so seeds do not have a chance to germinate.
5. Return to the classroom, and make a chart of the weeds pulled. Save the charts to compare with future weeding sessions. Take note of how amounts and kinds of weeds change over time. This will also help track which weeds to look for at what time next year.
6. Check status of weeds and pull them, if necessary, once every three weeks during the summer. A layer of mulch helps to reduce weed growth and therefore weeding time.
7. Keep stems and seed heads on during winter for visual interest, wildlife cover, food for birds, and winter lessons.

### Year 2

**General Maintenance**

In spring when new growth begins, cut off dead plant material and compost it.

**Watering**

Only water if in a drought.

**Weeding**

Continue weeding as needed. Native plants will fill in the spaces and form a dense root mass, which will significantly reduce weeding over time.

Continue to weed the garden every three weeks or so during the summer.

### Beyond Year 2

**General maintenance**

Each spring when new growth appears, cut back dead plant material and compost it.

**Burning**

If permitted in your community, burn the restoration in the spring. Write a prescribed burn plan and prepare the site for a burn. Check with your fire department about burning regulations, and obtain a burn permit before you conduct a prescribed burn.

## Extensions

- Modify the Management Plan chart based on Year 1 and Year 2 data that was collected.
- Create a map of the restoration and mark where the invasive plants grew and when they were weeded. Also, mark trail maintenance or replanting activities on the map.
- Create a field guide of the native plants and weeds in your restoration.
- Identify and research the native and weed species. Find out if the weeds are native or non-native. Learn about their history and life cycles.

## Assessments

- Develop a poster describing the importance of weeding.
- Identify one weed in your restoration project, and describe techniques for removing it. Recommend a preferred option for your site and why.
- Write a persuasive speech to convince your friends to care for the restoration plot.
- Describe three actions needed to implement a management plan.

# Weed Cards

### Activity Overview
Students will identify non-native and/or invasive plants in their restoration site and create a set of labeled identification cards to be used by anyone weeding the garden.

### Objectives
Students will:
- Identify non-native and/or invasive species
- Learn how to press and label plants
- Learn how to create a useful resource for others to use

### Subjects Covered
Science

### Grades
4 through 12

### Activity Time
45 minutes to collect and press samples; 45 minutes to identify plants and make cards

### Season
Spring, Summer

### Materials
Materials: Newspapers, cardboard, heavy books or phone books, pressed weed samples, digital camera or scanner and color printer (optional), cardstock paper, black markers, plant field guides such as *Newcomb's Wildflower Guide* or the *Golden Guide to Weeds* (multiple copies), clear contact paper or laminating machine

## Background
Being able to properly identify non-native and invasive species (also called weeds) is an important step in managing a restoration. Weeds can out-compete native plants, depriving them of space, food, water, or sun in order to thrive. Weeds can be prolific reproducers and can change the soil chemistry and microorganisms in order to gain their competitive edge. It's important to be able to identify weeds and remove them, especially over the summer months before they flower and set seeds.

## Activity Description
1. Take small samples of suspected weeds (or other undesirable plants) from the restoration; it is easiest to identify a plant when it is flowering. Identify the plants in the classroom by using field guides or books. Determine their common and scientific names, and if they are non-native plants or invasive native plants.
2. If you are pressing plants, place the sample between the folds of a section of newspaper and write the name of the sample, date and location found on the outside. Carefully arrange the plant between the folds so you can see leaf arrangement and flower shape. Stack the samples and weigh the stack down with a heavy book or other object for at least a week to dry. Alternatively, use a camera or color scanner to capture the plant and then print high quality images of each sample (include an object for scale in each image).
3. Cut cardstock paper to fit the size of the plant sample or image. Write the common and scientific name at the top, and at the bottom write "Remove from garden."
6. Place clear contact paper over the to preserve it, or put it through a laminator. If you're using dried plants, avoid glue because this can damage the samples.
7. Cards can be used by anyone weeding the garden. Hand a card to each person weeding the garden, and ask them to remove all of that kind of plant. If there are more weeders than cards, then just give them a live plant sample from the garden. Cards can be kept with the garden supplies and be used by all teachers, even those who don't know what plants are in the garden.

## Extensions
- Go outside and weed your restoration plot with the new cards.
- Write an instruction booklet for how to use the weed cards.
- Collect samples of native plants and make "Native Plant" cards.
- Construct a plant key using the cards. See EP activity "Construct a Key."
- Visit an herbarium and learn how plant samples are used for studying plant distribution and other research.

## Assessments
- Describe what clues you use to identify a plant.


© Earth Partnership • University of Wisconsin-Madison

# Young Restoration Checkup

**Activity Overview**
Students inventory and determine the health of the restoration based on the presence of prairie and weed species.

**Objectives**
Students will:

- Determine species present in the restoration
- Collect data and evaluate existing condition of the restoration
- Make predictions of the future health of the restoration

**Subjects Covered**
Science

**Grades**
3 through 12

**Activity Time**
1-3 hours, depending on student level

**Season**
Fall

**Materials**
Species list for restoration and plant field guides

## Background

During the first years after a planting of a restoration, weeds often dominate the site while the native plants hide underneath. Seeds germinate in the first year, but put most of their growth into their root systems. In fact, 60% to 90% of the plant's biomass is formed underground during the first year. Therefore, weeds are visually more obvious than the forbs and grasses. Finding annuals growing in the restoration is usually not a problem, but they should not be allowed to go to seed.

During the second year, native biennial species will begin blooming. Non-native biennials are often evident as well; biennials that are a concern in an early midwestern prairie planting include thistles, Queen Anne's-lace, sweet-clovers, mustards, and wild parsnip. Other plants that may be of concern in your young prairie include persistent perennial invaders like quackgrass, red clover, bindweed, reed canary grass, and dandelion. Action to control persistent invasive weeds is necessary. Often by the third year, a restoration begins to look more "presentable" with many native species beginning to bloom.

## Activity Description

1. Take a pulse: Inventory the internal pulse of the restoration as measured by biodiversity. Determine species present. Create a checklist of native and non-native species. Native seedlings and invasive weeds may be identified using a pictorial key. Indicate if a species is flowering. Check off the lifestyle (annual, biennial or perennial) of each species.
2. Diagnosis: Analyze the results to see if the species present have a positive (intentional native species) or negative (unintentional invasive species) or neutral (unintentional, but not a problem) impact on the future health of the restoration, given the lifestyle of each species. What symptoms help to determine the health of the restoration?
3. Prescription: What action(s) can be taken to improve the quality of this restoration? If possible, include a timetable for action.
4. Prognosis: How does the future look for this restoration? Use features to support your prediction(s).

## Extensions

- Use the resources below to research management alternatives.
- Carry out management actions (species removal, mowing, etc.).
- Repeat the checkup at regular intervals.

## Assessments

- What is a native plant? Name three native plants growing in your restoration.
- What is a non-native plant? Name three non-native plants growing in your restoration.
- Identify one non-native plant growing in your restoration and explain why it is or isn't a concern based on its lifestyle and other factors.

# Young Restoration Checkup Field Sheet

Restoration Name ________________________________________ Planting Date __________ Today's Date __________

| Plant Name | Native Species | Non-Native Species | Invasive | *Lifestyle |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

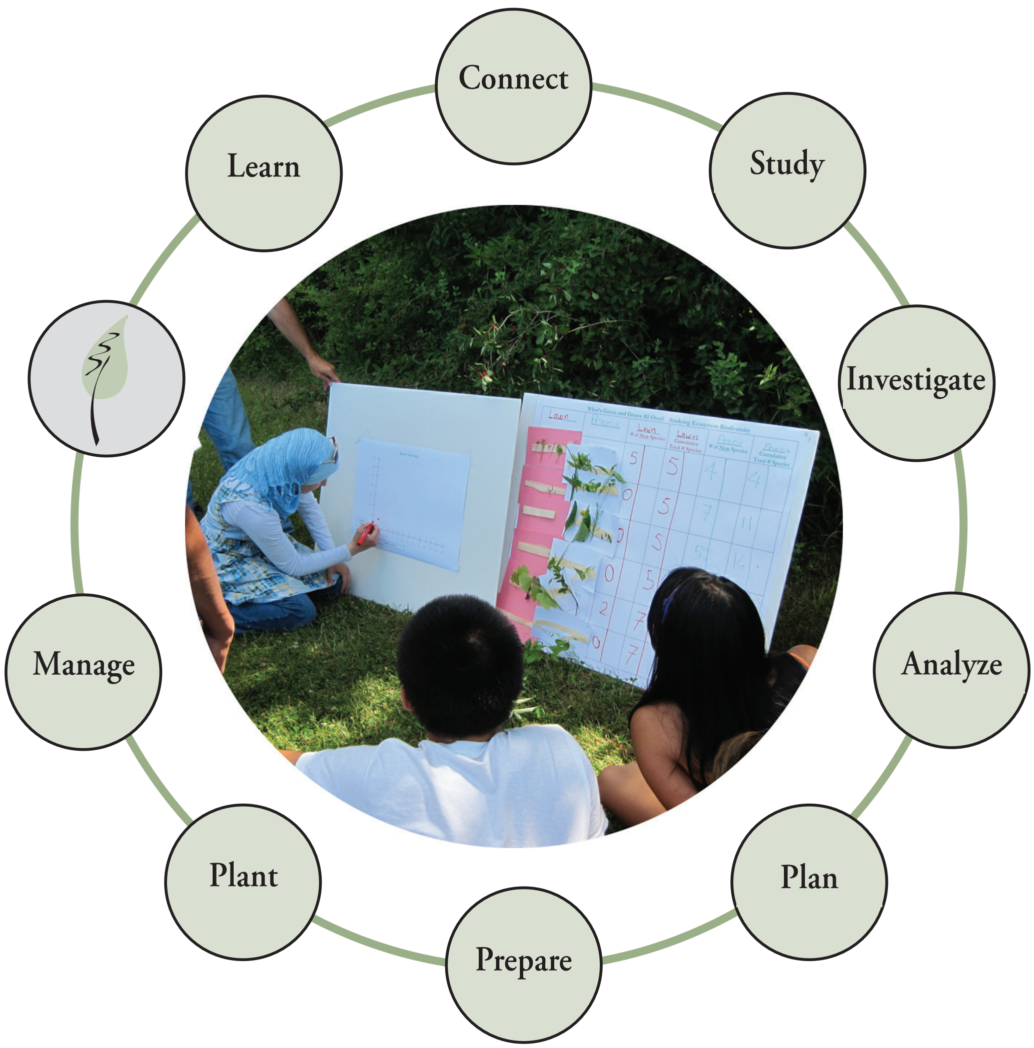
*A=Annual; B=Biennial; P=Perennial


© Earth Partnership • University of Wisconsin-Madison

earth partnership

# Research

make observations, ask questions,
and use evidence to answer



# Section Introduction: RESEARCH

Restoration of an area is an ongoing process, providing endless opportunities for students to develop short and long term investigations. Every site is unique, local climate and weather, human activity and other factors will influence what works best for your location. School site restoration provides authentic opportunities for students to become knowledgeable individuals about their site and to discover the best way to plant and manage their property. This section suggests ways to engage students in original scientific inquiry: developing their own questions, designing the method of investigation, conducting a study, collecting and analyzing data, drawing conclusions, and applying their findings to decision-making about the site.

As in any school-based project, you as the educator will use your discretion to decide how teacher- or student-directed the project will be (“Inquiry Learning,” “Inquiry-Based Field Problems”). Time and resource constraints, safety, age-appropriateness and other factors always play into limiting how far a study can go. Educators are encouraged to include students as much as possible in brainstorming questions, or developing methods of investigation, but we also provide different options for scaffolding those processes to make it possible for anyone to participate.

Topics for research could include investigating seed viability and the best germination techniques for your seeds stock (“Germination Determination,” “What Does a Seed Need?”), analyzing insect populations on the site (“Sweeping Discoveries,” “Pollination Observations”), and experimenting with different methods of weed control. Encourage students to follow their curiosity--investigations might not have any obvious immediate application on site, but rather help students more deeply understand the diversity and nature of your site and how it changes over time.  Multi-year projects, managed by the teacher, could help document tree growth, species density and diversity changes, flowering dates, or changing climate conditions (“Phenology: Climate Change in Your Schoolyard”). Collecting baseline phenological data about a property may prove beneficial for an applied problem later in time.

The process of doing scientific investigation is often messy and unpredictable. Those who dive into authentic inquiry will encounter obstacles and must learn to problem-solve around unexpected events or findings.  Students should be reassured that they will not be penalized if they have to change their methods, or cannot collect as much data as anticipated due to unforeseen events, or overly ambitious agendas. This is a learning process for good design and adjustments on the fly. If students are on task and adapting to the project needs, they should receive a positive assessment even if their results are inconclusive. Although we would like to get the “correct answer” the first time, that rarely happens-even for professionals. Nature adapts and so will we.


© Earth Partnership • University of Wisconsin-Madison

# Inquiry Learning: Students As Ecological Researchers

**Activity Overview**
Students identify a research question about their schoolyard restoration or another local issue. They design and conduct research and present their results orally and with other media.

**Objectives**
Students will:

- Identify an environmental issue
- Develop a plan to organize research data
- Collect data and conduct research
- Analyze/interpret research data

Communicate findings

**Subjects Covered**
Language Arts, Science, and Environmental Education

**Grades**
6 through 12

**Activity Time**
Varies for research; 10-15 minutes for presentation

**Season**
Any

**Materials**
Varies depending on research; also see Additional Resources

## Background

Restoration ecology is a young field in which research of all kinds can be pursued and shared with a broader audience. With more questions than answers, students can share in the excitement of investigating the unknown.

First, students need to identify an issue to investigate in their restoration and find out how that fits into the larger world of ecological research. What do we need to know about ecological restoration? What are both the large and small questions which would help us learn from our schoolyard restoration? By completing an ecological research project and presenting it to others, students will have an opportunity to ask questions that are meaningful to them and that may contribute to the field of restoration ecology.

## Activity Description

The following tips and ideas can help you develop an exciting research project:

**Research tips**

- Select a topic you're interested in studying
- Keep the scope of your research specific
- Use a variety of credible sources
- Follow the scientific method of research: Problem Statement, Hypothesis, Observation, Evaluation and Conclusion
- Develop a consistent system for collecting data
- Keep a bibliography so that you can quote or give credit to a source

**Questions to address in your presentation**

- Why is this subject important or interesting?
- What did you investigate?
- What were your predictions?
- How did you collect your data?
- What did you find out?
- Were your findings consistent with your prediction?
- What problems did you encounter?
- Did any factors influence your results?
- Have any other studies been done related to your topic?
- What impact could your study have on your community?
- How could you improve the study?
- Knowing what you know now, what would be an interesting question to research?

**Suggestions for presentations**

- Make sure you have a full understanding of your topic
- Select words carefully to present the most accurate picture possible
- Include an introduction that catches the attention of your audience and gives a preview of your research
- Focus the body of your speech on the research project
- Transition smoothly from point to point
- Identify connections between your research and your environment
- Include all major points
- Leave the audience with a final thought
- Practice your presentation while focusing on body language
- Be creative and use visual aids effectively
- Share your findings with your school and community

## Extensions

- Visit other classrooms or schools and present your research project.
- Repeat the process with new questions or variations.

## Assessments

- Evaluate your presentation using the Rubric for an Ecological Research Presentation.


© Earth Partnership • University of Wisconsin-Madison

# Inquiry Learning (cont.)

| | Not so hot | Getting warmer | Hot! |
|---|---|---|---|
| **Introduction** | People may be unclear about what I researched because my introduction is weak. | My introduction is to the point, but it doesn't flow into the rest of the presentation. | My introduction grabs the audience's attention and gives a good idea of what I will talk about. |
| **Research** | My research question is vague and my methods are unclear. I still don't understand the topic. | I show a good understanding of the topic, but some steps in the study are incomplete. | I obviously followed research methods and have a full understanding of the topic. |
| **Relevance** | I present my data, but I don't explain why it should matter to anyone. | I make a connection between my research and the real world. | It is obvious to others why my research matters. |
| **Organization** | My presentation lacks a natural flow. It's unclear how I went about conducting my research. | My work has a beginning, middle, and an end. The investigative work is included, but a bit unorganized. | My presentation has an interesting opening, an informative middle, and a convincing conclusion. |
| **Word Choice** | I use some of the same words over and over. Some words may be too confusing for others. | The words I use are bland or sound as if I am trying too hard to impress. I have a few noticeable pauses. | The words that I use are natural, yet distinct. I use similes or metaphors to describe my work. |
| **Voice/Tone** | My presentation is too formal or informal. I use a monotone voice, like I don't like the topic. | My tone is okay, but my presentation doesn't sound like me. I need to include personal thoughts. | I sound excited about my research. I tell how I think and feel about it. I project my personality. |
| **Visual Aid** | My visuals are difficult to read and aren't related to my research. I'm reading directly from the visual. | My visuals help explain my research, but I include too many points. I need to be less flashy. | My visuals help make my research clear to the audience. I maintain eye contact with the listeners. |
| **Conclusion** | Listeners weren't sure when I was done. I didn't give a summary statement. | It was clear that I was ending the presentation. The general statement I use ties it all together. | The summary I use is unique and pulls all the parts together. I leave the audience with a final thought. |

# Inquiry-Based Field Problems

**Activity Overview**
Students ask questions and design experiments on their schoolyard restoration site.

**Objectives**
Students will:

- Collaborate with peers to plan and implement a research project
- Collect and analyze data
- Present scientific results in writing

**Subjects Covered**
Science, Math, and Language Arts

**Grades**
6 through 12

**Activity Time**
Varies; see individual field problems

**Season**
Any

**Materials**
Varies; see individual field problems

## Background

A schoolyard restoration can provide a much-needed unifying framework for inquiry-based learning across grade levels and subjects. Students involved in building and studying their school site are motivated to engage in the scientific process. Since ecological restoration is a young field with more questions than answers, students can share in the excitement of investigating the unknown.

The following inquiry projects reflect current topics in the field of restoration ecology that you can investigate and present in small teams. "Field problems" are inquiries into the plant and animal life of prairies, savannas, woodlands and wetlands.

## Activity Description

To get started on your inquiry project, form small groups of three to four students. Meet with your group members to determine the direction of the inquiry. The field problem explorations and presentations may need to be adapted to fit available time, needs, and interests. Use group cooperation skills to ensure that all members have input.

There are five steps to the project: writing a scientific question of interest, designing research methods, collecting and analyzing your results, discussing your findings as a team, and writing a scientific article to share your findings.

### Question of Interest

As a group, you are welcome to use the sample inquiry questions provided with each field problem, modify them, or come up with your own research question related to the topic. It is also useful to reword your question as a prediction. For example, if you are wondering whether there is a greater diversity of plant species in the shade or in the sun, you might predict that diversity is greater in one area or the other, given what you know already. Explain what knowledge you already have that helps you make that prediction. Draw a model of what you think will happen and why, or write and explain your hypothesis.

### Methods

Determine how you will go about answering your question. Your group will need to devise a data sheet to keep track of your findings. If your investigation involves daily data collection, your team may need to plan for that additional time outside the classroom. Remember: "You can do almost anything you want to do, but you certainly can't do everything you want to do." Photos of your project (your study area, equipment, etc.) are very helpful for giving presentations and writing articles. Be aware of your time constraints as you design and also consider whether or not anyone has allergies or if there are poisonous plants to avoid.

If possible, duplicate your experiment one or more times (these are called replicates) so that you don't mistakenly attribute your results to one factor when, in fact, they were due to something abnormal. An example of this could be that you think the plant diversity in sunny areas is ten times higher


© Earth Partnership • University of Wisconsin-Madison

than in the shade, but the only shady spot you examined was under a walnut tree that, unknown to you, gives off chemicals from its leaves, roots, and fruit to inhibit the growth of other species.

If you are looking at the influence of a particular factor, keep all other things the same as best you can. For example, if you are researching whether there are more birds nesting in a managed woods or in one overgrown with invasive non-native shrubs, you should look at areas of similar size, spend the same amount of time looking in both areas, use or don't use binoculars in both areas, etc.

### Results

Explain what happened. Think about making tables, graphs, or charts to illustrate your findings.

### Discussion

Return to the model you drew or prediction you wrote when you started this project. Were your findings consistent with your predictions? How can you revise or add additional details to your original model based on the data you collected? Your observations either strengthen your original argument or contradict what you thought would happen. What did you learn from your study?

What would you do differently in the future to improve the study?

Based on your experience, what would be an interesting and worthwhile follow-up study?

### Scientific article

Prepare a concise written version of your inquiry process and results. (This can also function as a written version of a presentation; see Extensions.) Use the following template for a scientific article:

1. Title of research project
2. Names of researchers
3. Grade level
4. Name of school, city, state, zip code
5. Introduction: Describe what your research is about, including any specific question. Why is this interesting or important to study? Include your predictions.
6. Methods: Describe your methods for conducting the research and organizing the data, including locations, size of study plots, equipment, and date. Include photos, if appropriate.
7. Results: Share your findings. Include any graphs or tables, if appropriate.
8. Discussion: Were your findings consistent with your predictions? Describe the significance of the results. How do your results compare with similar studies? Mention any factors that may have led to errors in the data and any related future studies that occurred to you during this project.
9. Acknowledgments: Make a brief statement that may include funding information, people that provided technical assistance, etc.
10. References, if any were used: Use the Internet or the library to look up the APA Formatting and Style Guide to learn how to cite texts in a scientific article, which is different from citing in a literary paper.

## Extensions

- Research what other students and restoration ecologists already know about this topic and what they found in similar investigations. Do your results agree with those findings? Why or why not?
- Plan and implement a five- to ten- minute presentation on your research project. See EP activity "Inquiry Learning: Students as Ecological Researchers."

- Present research projects at a student conference.
- Publish findings in a newsletter or journal.

## Assessments

- Conduct a peer evaluation for group members.
- Use a rubric for presentations. Remember that the scientific process is messy and unpredictable. If students had to change course along the way, but adapted well, their overall grade should not be affected.

### Field Problem #1: Biodiversity and Invasive Species

An invasive plant is one that can spread rapidly, usually changing the environment by crowding or shading out other plants. Invasive plants can be native or non-native (e.g., originally from somewhere else such as Europe or Asia). Non-natives were often brought intentionally by settlers for food or medicinal uses, ornamental reminders of home, and a variety of other purposes. Invasive plants often grow rapidly, mature quickly, produce many seeds or vegetative shoots, and lack predators, parasites and diseases to control their numbers. Invasives often form single species stands ("monocultures") that decrease native plant and animal diversity. In contrast, a diversity of native plants provides food and cover for a variety of animals. Private, local, state and federal groups have begun to monitor and control the spread of a number of invasive plants.

**Approach**

Decide as a group if you want to explore one of the following questions, or some other question related to invasive plants that you can measure during the time you have available:

1. Is there an invasive plant problem anywhere in your area?
2. Can you document the presence of an aggressive invasive in your area?
3. Can you determine any factors that have led to the spread of this invasive throughout your area?

**Materials**

Specimens of invasive plants, magnifying glass, compass, weed identification guide, data sheet, map of the area, quadrat sticks or hula hoops, and blank paper.

### Field Problem #2: Species Competition

One explanation for species diversity is that different species reduce direct competition with one another by living in different areas, eating different foods, etc. For example, cliff swallows nest on cliffs and eat insects in the air, while hairy woodpeckers nest in holes in trees and eat insects found under tree bark. But scientists don't entirely understand how so many plant species can coexist in some areas. Many theories are related to the way different species avoid growing in the same place and avoid flowering at the same time. Still, more research is needed.

**Approach**

Consider what adaptations certain plants have that make them successful in one habitat vs another. Your group might want to collect evidence to support your ideas. For example, are some plant species are more abundant in the shade than in full sun? Are there other species that are more abundant in full sun? If so, what adaptations do they have? Could you measure those differences?

Suggestion: You don't need to identify every species, as long as you can distinguish them from one another. Make up fun names for ones that you distinguish, but can't identify. You can take pictures and e-mail them to experts for species identification.

**Materials**

Map of area, tape measure, quadrat sticks or hula hoop, field guide, data sheet, compass, magnifying glass, and flagging

 © Earth Partnership • University of Wisconsin-Madison

### Field Problem #3: Insect Communities

Did you know that there are more species of insects than all other animals combined? Insects are important because they play a number of vital roles in nature. Some, such as bees, pollinate flowers. Others, such as dragonflies, control the numbers of other insects by eating them. Most insects serve as prey (food) for other animals including fish, frogs, birds, and bats, among others. Many insects are herbivores (plant-eaters) that are specialized to eat certain plants, while other insects are specialized to hunt in a certain way (e.g., ambush bugs hide in flowers that they resemble and wait to snatch bees, wasps, and butterflies with their huge front legs). Consequently, the plants in an area largely determine the insect community found there. Usually, a more diverse plant community will harbor a more diverse insect community.

**Approach**

What question does your group have regarding insect diversity? For instance, your team could compare different kinds of insects found in an area that has a high diversity of plants with an area that has low plant diversity. How will you collect data and analyze it to answer your question? As a group, decide on your question and then an approach to collecting and analyzing your data that helps answer the question. Consider ways to safely catch insects.

**Materials**

Sweep nets, white sheets, pitfall traps and trowels, bug boxes, plastic bags, insect guides, map of area, and data sheets

### Field Problem #4: Bird Populations

Birds live virtually everywhere and play important roles in nature. Each species has requirements for nesting sites, food, water, and shelter. Birds control the populations of other animals, especially insects, but also disperse the seeds of numerous plant species. No doubt, there are birds feeding, if not nesting, somewhere on your school grounds. Finding a nest can lead to other exciting discoveries.

**Approach**

As a group, decide what question you will ask regarding birds in relation to the area you have chosen to look at. Some examples: Are there more bird nests in the prairie than the lawn? or Where do adults find food for their young? As a starting point, your group can search for a bird nest or nests somewhere in your area. Observe the nest. Find out as much as you can about the bird that built it. Are there eggs or young in the nest? How often do the adults feed the young? If you wonder about anything else related to the bird, observe or explore in a way that can help you answer that question. Have fun, but please don't harass the birds.

Suggestion: One way to find a nest is to spot an adult carrying food, then follow the bird to its nest. An agitated adult is a clue that you are near its nest. If you listen carefully, you can often hear nestlings or fledglings (young birds that have left the nest) begging their parents for food.

**Materials**

Binoculars, bird guides, map of area, stop watch, data sheet, and blank paper

### Field Problem #5: Mammal Populations

Small mammals, including mice, voles, moles, and shrews, are quite abundant in fields, prairies, and woods, but how many have you seen? Occasionally, we may see a burrow, but which animal made it? Mice and voles are herbivores (plant-eaters) and eat enormous quantities of vegetation. The meadow vole, for example, eats almost its own weight each day in leaves, flowers, seeds, roots, and tubers! By their tunneling, moles aerate the soil and reduce erosion by allowing rain to penetrate the soil. Shrews are voracious predators (animal-eaters), sometimes consuming more than their own weight each day in invertebrates (animals without backbones such as insects and spiders), young mice and fungi.

**Approach**

Earth Partnership would like to discover an easy and inexpensive, yet effective and humane way that students can record animal tracks on school grounds to determine which species are present. We've tried various techniques (track tubes with homemade ink and store-bought inkpads, sprinkling wet sand and dry flour), but are still not satisfied. Can you hone one of these methods or come up with a whole new method and provide evidence that your method works? If you can determine an effective method, what question does your group have regarding mammals in your chosen area? For instance, are there more mammals of a particular species in one area than another or a greater diversity of species in one area than another? As a group, decide on your question and an approach to collecting and analyzing your data that helps answer the question. Are there any factors that you didn't plan on that might have caused the results you found?


© Earth Partnership • University of Wisconsin-Madison

# Germination Determination: What Does a Seed Need?

### Activity Overview
Students select one species and design an experiment to determine a stratification regime that will result in the highest germination percentage.

### Objectives
Students will:

- Develop, design, and carry out a scienti• ic investigation
- Communicate the results of their investigations
- Explore dormancy mechanisms and germination phase of a plant life cycle

### Subjects Covered
Science and Math

### Grades
6 through 12

### Activity Time
Approximately 2 hours for designing the stratification experiments; 2-3 hours for setting up the experiments; 1 hour for setting up germination tests and 1-2 hours for recording and writing up the results. The experiments must run for at least three months.

### Season
Late Fall or early Winter for seeds collected the previous growing season

### Materials
Film cans or ziplock bags or 3-4 petri dishes or small plates per group, seeds, filter paper or heavy-duty paper towel, thermometer, and cold space such as a refrigerator. Equipment for various seed treatments might include peat moss, vermiculite, sawdust (from non-treated wood), sand, sandpaper, rolling pin or other materials depending on experimental design

## Background
Seeds need appropriate environmental conditions to germinate. These conditions include appropriate oxygen concentrations, temperature, moisture, and in some cases, light. Seeds from plants that bloom early in the growing season may germinate if the environmental conditions are suitable and they are planted immediately. However, most seeds will develop dormancy that prevents germination until certain environmental conditions are met. Biologically, this is a protection mechanism that prevents seeds from germinating when the conditions are not favorable for long-term growth. For instance, a seed that ripens in late fall may encounter a late, warm, wet spell ideal for germination but too late in the season for survival of the seedling. In this case the plant may only germinate if dormancy is "broken" with exposure to a prolonged cold spell delaying germination until after a cold "winter." This process of breaking dormancy by exposure to a cold spell is called cold stratification.

Working with seeds you collect yourself for restoration creates new puzzles in terms of seed viability and germination requirements. When planting from seed it is best not only to know how much seed you are planting, but also how much of that seed is viable and thus able to germinate. If seed is found to have very low germination rates, it may be necessary to either find a new source or over-plant by an appropriate amount. The older the seed source, the more important this is, for most seed viability decreases over time. This aging process can vary considerably from species to species. Storage conditions can also have a significant effect. If seed is purchased or acquired from a reputable source, it is reasonable to assume that the seed has been handled appropriately and has likely been recently tested. But, if the seed is older, or if you harvested and cleaned it yourself, it may be a good idea to determine the germination rate.

Most seeds will only germinate if moist-cold stratified, that is, exposed to cold, moist conditions. Moist-cold stratification is defined as a treatment where the seed is kept in a damp, cool (below 40 degrees Fahrenheit, but not freezing) condition for a period varying from 10 to 30 days. Other seeds require warm, moist stratification. Another dormancy-breaking mechanism, scarification, involves creating little cracks in the seed coat. In that case, germination is delayed until the seed coat has been broken.

Our current knowledge about what is necessary to break dormancy is based on practical experience in the field. However, myriad questions remain about the best treatments for individual species. For instance, if a seed demands cold stratification, what is the ideal temperature? How long should it stay at that temperature? Is longer better? Can germination percentages be increased by increasing the humidity? For moist stratification, how much water is ideal? What temperature? How long? What is the ideal cold stratification medium? For seeds that require scarification, what is the best way to scarify and how much scarification is ideal? The answers to each of these questions vary from species to species. There are many opportunities for student-led investigation leading to information that might be of practical significance in the field of ecological restoration.

Film canisters, petri dishes or ziplock bags are good for moist stratification. A refrigerator can provide cold temperatures. Slightly different temperatures are often found in different places in the refrigerator (the crisper, the butter shelf, etc.) so check in advance where you will place your experiment. Scarification can be done by rubbing the seed gently between two pieces of sandpaper, tumbling the seed in a canister of sand or rolling lightly with a rolling pin. Students may come up with other scarification techniques, but should bear in mind that the point is to create small fissures on the seed coat and to avoid breaking, crushing or otherwise damaging the seed.

## Activity Description

Pick a plant and find out what is known about treatment necessary to stratify its seed. The way those seeds are stratified will affect the number that germinate (the germination percentage). You are charged with conducting a research experiment to find more detailed information about how to stratify the seed of your species so that you maximize germination.

1. Some seeds, such as *Tradescantia ohiensis* (spiderwort), need to be physically abraded (scarified) before they will germinate. This can be achieved by lightly and briefly rubbing the seeds between two pieces of sandpaper. Too much abrasion will cause too much damage and lower germination rates, so be careful!
2. Some seeds, especially grasses, require only a cold (not moist) stratification. Purchased seed will usually come cold stratified.
3. Other seeds, such as *Eryngium yuccifolium* (rattlesnake-master), produce large enough quantities of a germination inhibitor that a standard test is not possible. If you find that you are getting very poor germination test results, it may be that you are dealing with such a species.
4. Determine if your seed needs a period of cold to germinate. In colder climates, most seeds need a period of moist-cold stratification to germinate. The standard method for moist-cold stratification germination is easily achieved by dampened seed in the refrigerator for 30 days. If possible, check the temperature of your refrigerator at several locations. The ideal temperature for moist-cold stratification is below 40 degrees Fahrenheit but not freezing. The crisper (or other lower compartment) is frequently the coolest and best location
5. Design an experiment to get more information about one part of the stratification requirements. Possible questions:
    - Does germination rate decrease as seeds get older?
    - If your seed needs wet stratification, how wet?
    - Is sawdust, sand, vermiculite, peat, or something else a better medium for the wet stratification?
    - What storage temperature is best?
    - What is the best length of time for storage?
    - If your seed requires only dry stratification, would wet stratification improve germination percentages?
    - What temperature is best for dry stratification?
    - What method of scarification?
6. In designing your experiment, clearly state your hypothesis. You should be testing only one variable while trying to keep all others constant. Keep a set of seeds untreated as a control, or compare two variations on a method (eg. two methods of scarification) side by side. Consider how many seeds you need to test for each treatment. Remember, you will want to calculate a germination percentage on your seeds at the end of the experiment, so you need enough treated seeds to be able to get an accurate percentage. Record as much information as possible about how you treated your seeds. Try to keep your experimental procedures simple.
7. After treating your seeds. try to germinate them using the technique below to see if the treatment affected the germination percentage. When testing prairie seed it is best to use 100 seeds, although as few as 50 seeds may be


© Earth Partnership • University of Wisconsin-Madison

adequate. A large number is necessary because there can be a great amount of variation in germination rates. (If it is necessary to decrease this number even farther, expect less accurate results.)

8. Record your data carefully and report your results in a written paper, oral presentation or scientific poster.

### Generic germination test procedure (after stratification experiment)

1. Lay down two pieces of filter paper in a petri dish, or zip-lock bag. Note: it may be possible to use a heavy-duty paper towel or cloth towel as a substitute for filter paper. The paper needs to be able to hold up to repeated handling when wet, and not contain any chemicals which would inhibit germination.
2. Place a sample of your seed on top of this paper. Try to spread out the seeds as much as possible. Some seeds contain germination inhibitors and closely spaced seeds may inhibit the germination of one another.
3. Lay down two more sheets of filter paper on top of the seeds.
4. Wet the sandwich of filter paper and seed with distilled water. Chlorine and other chemicals in city water may adversely affect germination. Bottled drinking water and clean well water may be acceptable alternatives. Use just enough water to soak the paper, but not enough to produce standing puddles. This is easily done by using a squirt/spray bottle, although flicking water with your fingers can work well also.
5. Place the petri dish in an area out of direct sunlight. Many seeds need light to germinate, but too much bright light (such as direct sunlight) can turn your petri dish into a greenhouse oven! Room temperature is good for germination of most prairie seed. Avoid hot spots such as radiators or heat ducts. Likewise, a cold drafty windowsill may be too cool to allow germination.
6. Keep the filter paper well-moistened. Initially it is a good idea to check the moisture level a couple of times a day until you know how quickly it is drying out and needs watering.
7. After several days begin to look for emergence of the seedling root (or radicle). It is this event which defines germination. Keep an eye on the increase in percentage of seed germinated. When it becomes clear that no more seeds are germinating, count the number of seeds that have germinated, and determine the overall germination percentage. The time that it takes to reach this point can be affected by the species itself, and the environmental conditions during the germination test. Have patience, and check your seed at least once a day!

## Extensions

- For younger students, simplify by using the generic germination test procedure after you know seeds have been properly stratified and determine a germination percentage.
- Create a class poster session for each student or group to display their scientific posters and report results at one time. Alternatively, a seminar of presentations or class database could serve the same purpose.
- Record your information in a database containing information from previous years. Look at previous years' data to help form your own questions.

## Assessments

- Describe dormancy mechanisms and the germination process of a plant life cycle.
- Develop a rubric for developing, designing and implementing a scientific investigation.
- Use a journal to keep track of germination. Include drawings and calculations.
- Compare the different germination rates and hypothesize what may have caused the variability.
- Report on what you learned and make recommendations for using this seed in the restoration based on the results.

# Sweeping Discoveries

**Activity Overview**
Students will conduct insect surveys in the interior, edge and outside of a prairie restoration and compare their results.

**Objectives**
Students will:

- Practice observation skills
- Perceive the relationship between insects and their environment
- Consider the impact of humans on the environment

**Subjects Covered**
Science

**Grades**
3 through 12

**Activity Time**
1-2 hours, depending on time spent observing, distinguishing and identifying insects

**Season**
Spring, summer or fall

**Materials**
For each team, one sweep net, white sheet or large white paper, bug box and/or magnifying glass

## Background

Scientists are learning about the plants that once grew on the North American prairies, but very little is known about the insect life associated with those native prairies and grasslands. While historical records often describe native plants, little is written about insects. However, we know insects play an extremely important role in any ecosystem as pollinators, decomposers and food sources.

In a natural area, the habitat at the edge of the area's boundary is very different ecologically from its interior. It can differ with respect to temperature, relative humidity, penetration of light and exposure to wind. The availability of pollinators and seed dispersers can also vary, along with the success of seed dispersal. Other differences between the edge and the interior of a prairie include competition from exotic species, the existence of suitable animal habitat and the populations of soil organisms.

If the majority of our remaining natural prairie is in small remnants, there will be more "edge" habitat and less "interior" habitat, and the proportions of various species will be modified. This activity looks at the insect life of a prairie by comparing insect populations at the edge, in the interior and on the exterior of the prairie.

If your students need help identifying insects, you may want to play EP Insect Charades before beginning this activity. The field sheet also helps with some basic classification.

## Activity Description

1. Divide into small teams and go out to your prairie restoration. Each team should start at a different spot along the restoration's edge.
2. Starting at the restoration's edge, pace off about twenty feet (seven meters) into the prairie, and then the same distance out of the prairie. This defines your three sampling areas: interior, edge, and exterior.
3. Sample the first area by sweeping the net six times in a single direction. Empty the contents into a two-gallon ziplock bag and examine what insects you have found. Record your findings on the field sheet. This is one "sweep."
4. Repeat this process in each of the other two areas and record the results.
5. Compile the class findings and discuss. Were any of the insect species present in one environment, but not the other? Did you find any species in both environments? Speculate on these findings.

## Extensions

- Keep tallies of the number of individuals of each type of insect. Create names to distinguish species, or use books to identify species by order (e.g., grasshopper, beetle), then create names to distinguish species within an order (e.g., green fly with long legs). Graph the results. In most ecosystems, there are a few abundant species and many uncommon ones. Discuss the concept of endangered species.

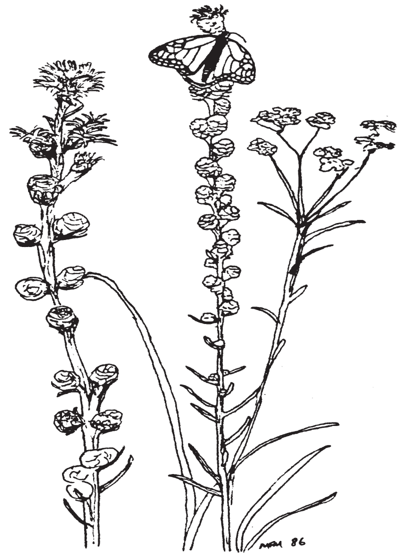

© Earth Partnership • University of Wisconsin-Madison

- Investigate the WI DNR's Rare Animal website for a list of threatened and endangered insects in Wisconsin.
- Repeat these same methods at a remnant prairie. Compare the insect communities in the restoration and the remnant. Design a research project to address your hypotheses.
- Repeat the same methods in a woodland. Compare the insect communities.
- Observe blooming plants. Are the same species of insects found on different plant species?

## Assessments

- Make oral presentations of your findings.
- Hypothesize about the reasons underlying the results you found.

# Sweeping Discoveries



Name: ___________________________________

Date: ____________________________________

## Sweeping Discoveries - Tally Page

Sampling Area: ____________________________________________________

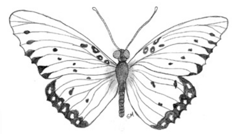
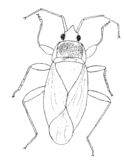
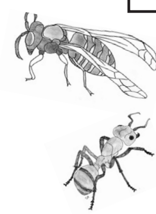
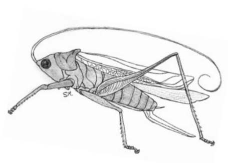
Record total # of insects in each category per team. Add the totals and record below.

| | Dragonflies & Damselflies | Butterflies & Moths | True Bugs | Wasps, Bees, Ants | Beetles | Grasshoppers & Crickets | Flies | Leafhoppers | Spiders (not insects) | Other |
|---|---|---|---|---|---|---|---|---|---|---|
| Team 1 | | | | | | | | | | |
| Team 2 | | | | | | | | | | |
| Team 3 | | | | | | | | | | |
| Team 4 | | | | | | | | | | |
| Team 5 | | | | | | | | | | |
| Total | | | | | | | | | | |


© Earth Partnership • University of Wisconsin-Madison

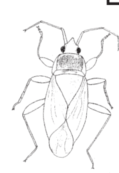
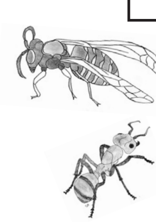
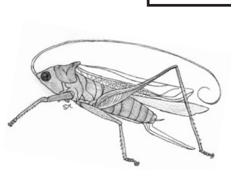
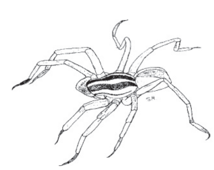
# Sweeping Discoveries Field Sheet

Sampling Area: ____________________________________________

| | | | | |
|---|---|---|---|---|
|  Dragonflies & Damselflies |  Butterflies & Moths |  True Bugs |  Wasps, Bees, Ants |  Beetles |
|  Grasshoppers & Crickets |  Flies |  Leafhoppers |  Spiders (not insects) | Other |


# Sweeping Discoveries Field Sheet

Sampling Area: ____________________________________________

| | | | | |
|---|---|---|---|---|
|  Dragonflies & Damselflies |  Butterflies & Moths |  True Bugs |  Wasps, Bees, Ants |  Beetles |
|  Grasshoppers & Crickets |  Flies |  Leafhoppers |  Spiders (not insects) | Other |

# Pollination Observations

### Activity Overview
Students conduct a timed observation of a flowering plant and tally its pollinators, then analyze and present findings in this introduction to field research.

### Objectives
Students will:
- Conduct simple research in the field
- Appreciate the relationship between plants and their pollinators
- Learn about native pollinators
- Understand that good research depends on accurate observations
- Discuss, analyze and present their research project

### Subjects Covered
Science, Math, (Art)

### Grades
3 through 12

### Activity Time
4–5 minutes for timed observation in the field, 30–60 minutes to discuss, analyze and present results (depending on grade level)

### Season
Early September for prairies, May for woodlands. Note: This activity is very dependent on the weather. Choose a warm day (preferably 70 degrees) when it is not rainy or very windy.

### Materials
Pollinator Tally Field Sheet, pencils, clipboards, insect field guides. Optional: line drawings of the plants included in the study.

## Background
Pollination is a reproductive strategy of flowering plants. It is the transfer of pollen from the stamens to the stigma of a flower in order to produce seeds. Some external action is usually necessary to move the pollen. Insects are our most important pollinators: 70 percent of all plants require an insect pollinator. Birds, especially hummingbirds, some bats, and wind are also important pollintators.

Plants needing insect pollinators have devised ways to attract them: conspicuous flower petals, fragrance, nectar, and sticky pollen. In contrast, flowers pollinated by the wind are usually small, without fragrance or nectar, and have light, dry pollen which can be carried on the breeze.

Students may begin this activity with several misunderstandings about pollinators such as:

- Students may assume that bees are our only pollinators. Actually, quite a few other insect groups are also pollinators: butterflies, moths, beetles, true bugs, and flies.
- Students may connect bees and flowers to honey, but they may not connect insect pollinators to the fruits and vegetables they eat.
- Students may assume that domesticated honeybees are our main pollinators, but native bees, especially bumble bees, pollinate the majority of our flowers and food crops. There are about 2000 species of native bees in North America alone.
- Students may have heard about colony collapse disorder and other problems threatening our domesticated honeybees. Native bees are also experiencing problems—mostly due to habitat loss and pesticides.

The best way to help native pollinators is to provide habitat where flowers grow from early spring until late fall. Backyard and schoolyard gardens can be a big help. Native wildflowers are best, but many flowers will provide nectar. Brushpiles create good nesting habitat for many insect pollinators, as are patches of bare ground for bees who nest underground. Another important way to protect pollinators is to avoid using pesticides whenever possible; bees are very sesitive to pesticide residues and most pesticides will kill beneficial insects as well as the problem ones. Consider becoming active in bee research projects, such as the Great Sunflower Project to track wild bee populations.

## Activity Description
This activity is designed as an introduction to field research and the careful observations on which it depends.

### Step 1: Outdoor Observation
Most native bees do not sting. If any students are afraid of bees, this fact may calm their anxiety. Caution: Before beginning this activity, be sure to know whether any students are allergic to bee stings and what they would require in the event of any emergency. If an Epipen is needed, be sure you know how to use it and take it with you outdoors.

 © Earth Partnership • University of Wisconsin-Madison

# Pollination Observations (cont.)

Good research begins with a question. "What insects pollinate this plant?" is a good question that truly needs answers. Much remains unknown about our pollinators—observation is the only way to answer this question. Thus, your students could make a valuable contribution to science with this research.

- Find a profusely blooming patch of flowers of one species.
- Predict who might be the pollinators.
- Name the insect groups on the tally sheets to become familiar with them.
- Observe the flowers for exactly four minutes; someone should time the group and say when to start and stop. Tally what you see during this time.
- Stand close enough to the flowering plants so you can see clearly. You may need to help identify insects—some flies and bees are look alikes! Now begin tallying insects.

### Step 2: Analyze, Discuss and Present Findings

Younger students will understand the process better if they create a personal document of their observations before making a composite document of the group's observations. Older students can begin with step 2.

Younger students can create a personal document of their observation. Give students a line drawing of the plant they observed—they can color this if they wish. Next, have students cut their tally sheets into rectangles so that each insect remains with its tally marks. Then, have the students glue the rectangles to their plant picture. Create a composite document of your group's observation. Consolidate everyone's tallies onto a clean line-drawing of the flower observed for each insect type.

**Discuss the composite document:**

- Did your observations support your prediction? Were there surprises?
- Is it clear that scientific knowledge is built from observations?
- Is it clear that the group's accuracy depends on personal accuracy?
- Is the composite statistically more valid than individual observations? Why?

**Discuss how to present their findings:**

- Does the line drawing with its tallies tell the story clearly?
- Would a graph tell the story better? (Stop here with the youngest students).
- Older students might benefit from thinking about other ways to present information.

## Extensions

- A similar observation could answer an equally engaging question, "What insects use or depend on this plant?" For example, grasshoppers might eat its leaves. Butterflies might lay eggs on its leaves so that their caterpillars could eat its leaves. Ants might herd aphids on its stems. A spider might construct its web there. Beetles and bees might drink its nectar.
- This observation could lead to a deeper understanding of the community of plants and their insects. See "Woodland Neighbors Make A Community" for another related activity.
- Observe the same growing area throughout growing seasons. What flowers attract bees? (April-October) What flowers attract other insect species?
- Plan and plant a "Pollinator Garden"! You will need a sunny spot but it needn't be large. For starters, see EP activity "Where Does Your Garden Grow? The Xerces Society website is also a great source of information: www.xerces.org

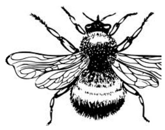
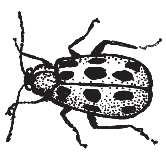
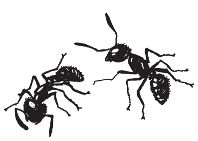
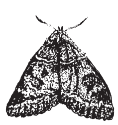
- Create a brochure to inform people in your school and community about the decline and importance of pollinators, and that also tells them what they can do to help provide habitat and protect them.

## Assessments

- Explain why multiple observations are statistically more valid than single observations
- Explain the importance of pollinators to flowering plants using words or by creating a cartoon or other visual.
- Describe an action you could take which would be beneficial to pollinators.
- Describe the relationship between a specific insect species and a specific flower species.
- Write a narrative which communicates the class data including procedure, analysis, and conclusions.


© Earth Partnership • University of Wisconsin-Madison

# Pollination Observations: Tally Sheet

| Type of Insect | Plant | Number of Insects |
|---|---|---|
| Bees  | | |
| Bumblebees  | | |
| Wasps  | | |
| Flies  | | |
| Beetles and Bugs  | | |
| Ants  | | |
| Butterflies  | | |
| Moths  | | |
| Other<br>(Wind, Hummingbird,etc.) | | |

# Phenology: Climate Change in Your Schoolyard

**Activity Overview**
Students learn about climate change and phenology

**Objectives**
Students will:

- Define and give examples of phenology (the timing of life cycles)
- Understand how changes in climate affect plant phenology
- Formulate ideas and questions about how changes in phenology may affect relationships among species

**Subjects Covered**
Science and Language Arts

**Grades**
5 through 8; modifiable for 3 through 12

**Activity Time**
50 minutes

**Season**
Any

**Materials**
*A Sand County Almanac*, journals for recording phenological observations, Internet access to phenology-related Web sites

**Source**
Sarah Wright from Center for Biology Education, University of Wisconsin-Madison

## Background

Aldo Leopold is a conservation hero, celebrated around the world for his work as an ecologist and his beautiful book, *A Sand County Almanac*. Aldo was an enthusiastic phenologist—someone who studies the timing of life cycles—and always carried a journal for recording events like the first bloom of flowers and the return of migrating birds. *A Sand County Almanac* can be read like a wonderfully written and very accurate phenology notebook. The book contains observations Aldo made from 1935-1945 near his family's cabin, affectionately known as "the Shack," in the Baraboo Hills of Wisconsin. The whole Leopold family practiced phenology for fun during their trips to the Shack. When Aldo's daughter, Nina Leopold Bradley, moved back to Baraboo in 1976, she started right where Aldo left off, observing and recording phenological events. She kept a clipboard hanging in her kitchen for making observations.

The Leopold family enjoyed observing phenology on the land they loved. Their data also turned out to be very useful for a reason no one would have imagined back in the 1930s: documenting climate change. Many plants and animals time their life cycles to temperature. If we focus on plants, there are a few main reasons why plants do the things they do (see EP Activity "Prairie Scavenger Hunt: Studying Plant Adaptations" for more information). One reason is having enough light; plants grow and bloom only when the days are long enough. We would expect that plants would keep the same schedule year to year if sunlight hours were the only factor, but plants also need water and nutrients. The availability of these things depends a lot on temperature. For example, early spring plants need days warm enough to melt snow. Prairie plants in summer hurry to bloom and set seed before it becomes too dry. Thus, most plants take their cues for when to do things like grow, bloom, and set seed based on temperature. Backyard phenologists who record first bloom dates each year can easily see how the seasons are changing: spring is arriving earlier, summer stays later. Comparing Aldo Leopold's plant phenology notes from 1935-1945 with Nina Leopold Bradley's data from 1997-2007 shows us how these changes are occurring on their land near Baraboo.

## Activity Description

The following table shows the first bloom phenology of most of the plants mentioned in the EP activity, "A Prairie Year." For each species, this table includes the average date Aldo Leopold saw it bloom between 1935 and 1945, followed by its Julian date, or the day of the year (e.g., January 1 would be 1, June 22 would be 174, and so on through 365). Then the same information is listed from Nina Leopold Bradley's observations. The Julian date makes it easier to compare Aldo's and Nina's observations with each other.


© Earth Partnership • University of Wisconsin-Madison

| Plant Species | Aldo 1st bloom | Aldo day of year | Nina 1st bloom | Nina day of year |
|---|---|---|---|---|
| Pasque flower | April 19 | 110 | April 7 | 98 |
| Lupine | May 20 | 141 | May 13 | 134 |
| Shooting star | May 22 | 143 | May 10 | 131 |
| Spiderwort | June 2 | 153 | May 25 | 146 |
| Black-eyed Susan | June 22 | 174 | June 13 | 165 |
| Butterfly weed | July 5 | 187 | June 21 | 173 |
| Bergamot | July 12 | 194 | July 3 | 185 |
| Yellow coneflower | July 14 | 196 | June 30 | 182 |
| Compass plant | July 15 | 197 | June 25 | 177 |
| Prairie dock | July 19 | 201 | July 15 | 197 |
| Big bluestem | July 30 | 212 | July 24 | 206 |
| New England Aster | August 21 | 234 | August 27 | 240 |
| Stiff goldenrod | August 27 | 240 | August 9 | 222 |

How many species bloom earlier now than when Aldo saw them? How many are later? Which ones have changed their schedules the most? Can you think of reasons for these differences? What might this mean for planning your prairie or other restoration?

You may notice that nearly all the plants bloom earlier now than they did when Aldo observed them. This is probably largely due to the warmer average temperature that plants experience. Even though the precise blooming dates change from year to year and are different for different species, the overall change we see across years and across species paints a strong picture that summer is coming earlier and staying later. You may also notice that New England aster actually blooms later now than it did in Aldo's time. This could be because it is an early fall species, and since fall arrives later, so does the onset of flowering for this species. Some of these species are on such a different schedule that Aldo would need to revise his Almanac. For example, the compass-plant appears in the "July" chapter, but would now need to be written into "June."

## Extensions

- Observe the phenology of plants on your site or the organisms with whom these plants have relationships, like pollinators such as bees and butterflies or even diseases like fungus or galls.
- Visit Paradise Lost? Climate Change in the North Woods Web site to see the entire Leopold phenology data set.
- Look at weather records to discern relationships between weather and phenology from one year to the next
- Keep a phenology journal about a question that interests you.
- Interview an older family member, tribal elder, community member, farmer, or scientist about how phenology has changed over time and present your findings.
- Create writing or art based on your findings and hold a phenological art show.
- Write a phenological "personal ad" for species whose relationships may be disrupted! Here's an example:

    *NO LONGER WAITING 4 U. All summer long I anticipated your vibrations. I bloomed showier than ever, with the most alluring UV stripes and sweetest nectar, just for you. So many lonely days in waiting...afraid I'd go unpollinated & finally gave my reward to another. Where were you?*

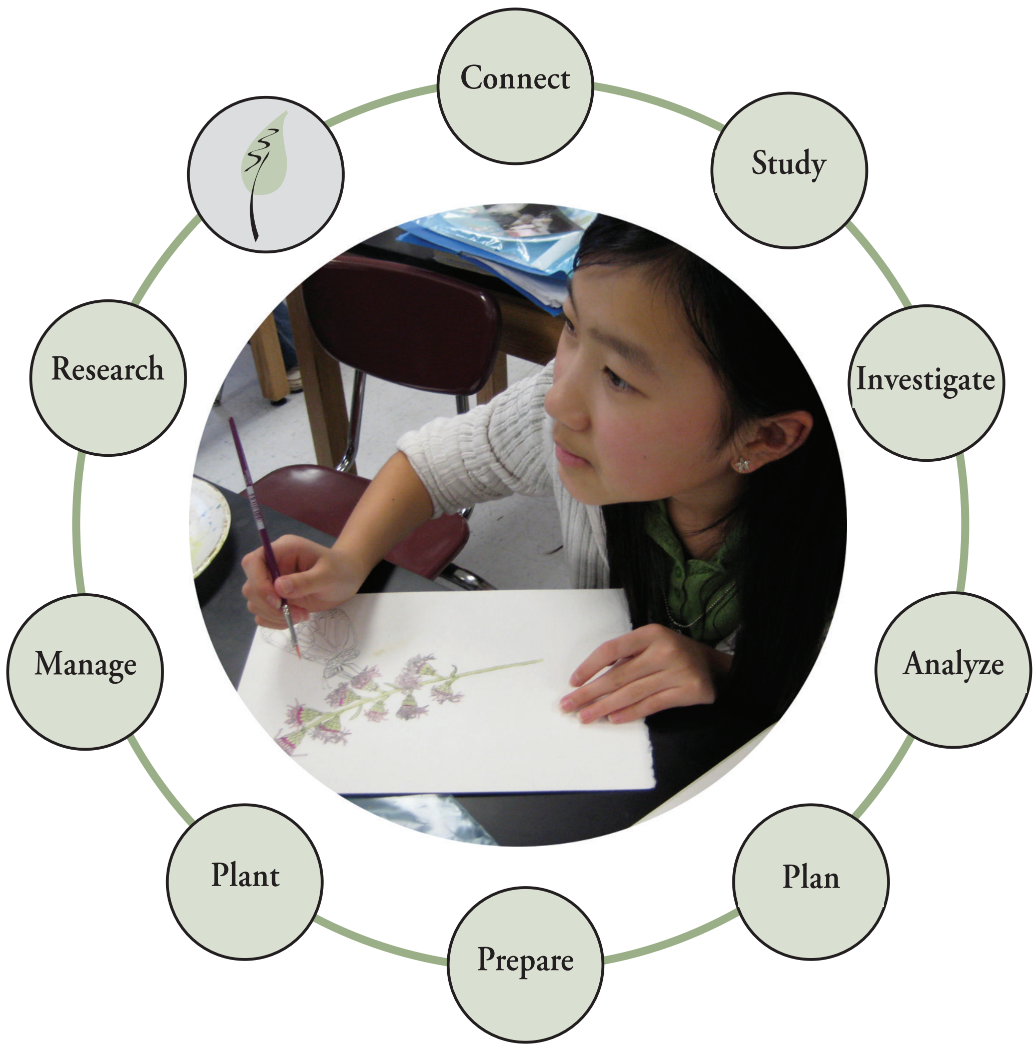
## Assessments

- Create a graph, chart, or picture which conveys how phenology has changed between Aldo's and Nina's periods of observation.

earth partnership

# Learn

language arts, science, math, social studies,
music, art, life skills, love of nature



# Section Introduction: LEARN

Although people learn tremendous amounts through the process of planning, implementing, and caring for a restoration, the learning opportunities created by these new spaces do not end when the last plant is placed in the ground. Your site is now a home for all students, educators and the community - even those who did not participate in the restoration - to utilize, learn from, and enjoy.

Restored areas serve as an outdoor classroom, available year round for work in language arts, math, art, science, and social studies. They provide inspiration for writing poetry, a context for studying geometric figures, and a new twist to learning world geography. The connections to art and literature can be explored as learners enhance their observation skills and relational understanding of their surroundings. Budding scientists can record, analyze, and communicate conditions and changes in an outdoor, living laboratory.

Natural areas are critical for helping people connect with their sense of place, and they contribute positively to child development. Outdoor play encourages the development of social skills, and access to nature improves concentration and attention, reduces stress and enhances emotional health. Many of these benefits manifest themselves in higher academic achievement.

Educators can find myriad opportunities to foster learning in outdoor spaces, connected to different curriculum elements and learning goals. This section provides a sampling of activities from diverse content areas: for early learners, noticing patterns in the outdoors (“Nature Shapes”); for science, an interactive, engaging way to identify insects on the site (“Insect Charades”); for literacy and civic engagement, communicating the impacts of the restoration experience and the importance of caring for it in the future (“Letter to a Relative”); for social studies, understanding important traditional uses for and origins of different plants (“Plant Power,” “A Seed’s Journey”); and for language arts, exploring the restoration experience and connections to the site through poetic and musical expression (“Schoolyard Poetry”). Learning opportunities change with the seasons, as students grow, and as the restoration progresses (“Phenological Nature Walks”). Other possibilities for learning extensions can be found in Earth Partnership companion curriculum, and of course through your own expertise and explorations as an educator!

Consider how these spaces can provide concrete contexts for meeting learning goals, and be creative in allowing learners to experience the benefits that the outdoors can provide. However you decide to structure learning experiences in these spaces, remember the importance of outdoor learning for all people, throughout their whole lives.


© Earth Partnership • University of Wisconsin-Madison

# Geometry in Nature

**Activity Overview**
Students find plants that represent geometrical shapes.

**Objectives**
Students will:

- Practice observation skills
- Learn geometrical shapes
- Identify shapes in nature

**Subjects Covered**
Science and Math

**Grades**
K through 5

**Activity Time**
30 minutes to find plants; 30 minutes to add pictures to the classroom shape book

**Season**
Late Spring, Summer, early Fall

**Materials**
Set of cards with labeled pictures of the common geometrical shapes (circle, square, triangle, rectangle, oval, pentagon, hexagon, octagon), a classroom shape book containing shapes found in other built and natural areas (optional), red string

## Background

Natural or garden areas on or near school grounds can provide students with a variety of opportunities to apply concepts learned in the classroom to the natural world. As students explore a natural setting, they reinforce their conceptual understanding of geometrical shapes such as circles, triangles and squares, and they combine the challenges of observation and identification with a meaningful outdoors experience.

## Activity Description

1. In this activity, you will be visiting a natural or garden area and looking for geometrical shapes. Before you begin, review as a group the geometrical shapes you will be recording in the field.
2. Each student receives a card with a geometrical shape. Go out to the natural area with your card and look around until you find a plant or plant part shaped like your shape.
3. Tie a red string around the plant. At the end, the group can gather to admire each person's discovery.
4. You can draw your plant shape on another card. These drawings can be added to a classroom shape book.
5. Have a class discussion about the group's observations and findings in the field. What was most interesting or surprising? What shapes did you find and where?

## Extensions

- Investigate the plant shapes you found in more detail using reference books. Could the geometrical shapes you discovered be of special importance to the survival of a plant? Why or why not? What additional information or research is needed to learn more?
- Create your own shape book and make observations throughout the year.
- Invite a local artist to speak about the use of form and function in natural artwork.

## Assessments

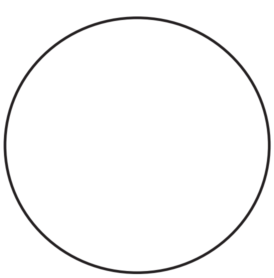
- Define at least four geometrical shapes.

# Nature Shapes

# Nature Shapes

Look for plants (flowers, leaves, stems or seeds) that have the shape of a

**Circle**



Draw a picture of your plant. Circle the shape in your drawing.

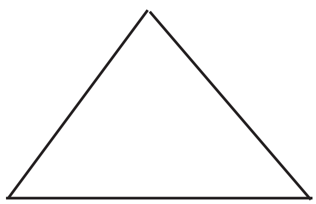


© Earth Partnership • University of Wisconsin-Madison

# Nature Shapes

Look for plants (flowers, leaves, stems or seeds) that have the shape of a

**Triangle**

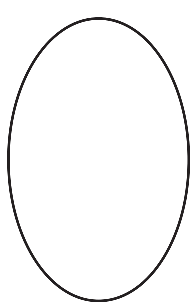


Draw a picture of your plant. Circle the shape in your drawing.

# Nature Shapes

Look for plants (flowers, leaves, stems or seeds) that have the shape of an

**Oval**

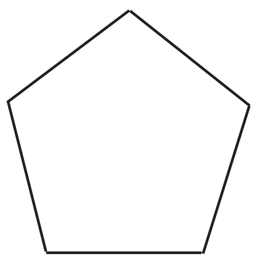


Draw a picture of your plant. Circle the shape in your drawing.

# Nature Shapes

Look for plants (flowers, leaves, stems or seeds) that have the shape of a

**Pentagon**

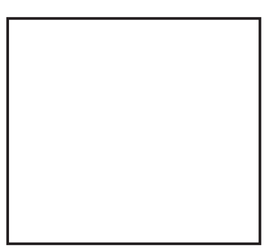


Draw a picture of your plant. Circle the shape in your drawing.

# Nature Shapes

Look for plants (flowers, leaves, stems or seeds) that have the shape of a

**Square**



Draw a picture of your plant. Circle the shape in your drawing.

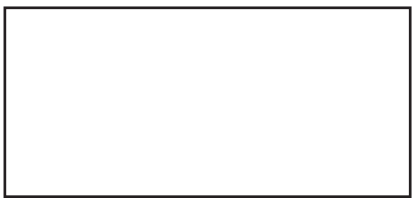


© Earth Partnership • University of Wisconsin-Madison

# Nature Shapes

Look for plants (flowers, leaves, stems or seeds) that have the shape of a

**Rectangle**

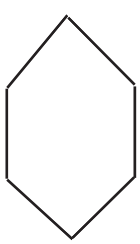


Draw a picture of your plant. Circle the shape in your drawing.

# Nature Shapes

Look for plants (flowers, leaves, stems or seeds) that have the shape of a

**Hexagon**



Draw a picture of your plant. Circle the shape in your drawing.

# Insect Charades

**Activity Overview**
Students play charades in small teams to learn more about the major categories of insects and to discuss unique characteristics of those eight orders.

**Objectives**
Students will:

- Learn how insects differ structurally from one another
- Identify major orders of insects
- Increase their understanding of insect structure

**Subjects Covered:**
Science and Language Arts

**Grades:**
K-8

**Activity Time:**
30-45 minutes

**Season:**
Any

**Materials:**
Stopwatch, 1 insect order identification card per student team (1 set is 8 cards)

## Background

Insects have been incredibly successful at surviving and have been around at least 350 million years, which is even before dinosaurs came into existence! Many insect species are beneficial because they eat harmful insects, recycle nutrients by breaking down plant matter and are a food source for other species. If you look closely, insects can be found nearly anywhere: you can find crickets under a rock, beetles in rotting plant materials, grasshoppers in an open field, mayflies and dragonflies along a lakeshore or skimming the water's surface, a walking stick on a tree stem, termites under bark and moth larvae in roots. A myriad of other insect habitats surrounds you. Knowing more about the structure of insects, how to identify them and where to look for them can be a key to understanding the diversity of your school's habitat restoration.

Insects are part of the Arthropodo phylum (grouping) in the kingdom of animals that also includes spiders, ticks, mites, crayfish, and millipedes. True insects are part of the Insecta class and have three major body characteristics:

- *Head*—This includes the mouth, eyes, and antennae.
- *Thorax*—Adults have three pairs of jointed legs; many insects have one or two pairs of wings full of large muscles. Wings are only present in the adult stage of some insect types. The Latin word for wing is "ptera," which is a useful word to know when learning the scientific Latin names for different insects.
- *Abdomen*—This includes the heart and the digestive and breathing organs.

Insects also have a hard covering on the outside of their bodies called an exoskeleton, which is made of a plastic-like material ("chitin"). This tough outer skeleton keeps insects from drying out and serves to protect them from surrounding environmental hazards. As they grow and the exoskeleton becomes more confining, insects have to molt. Once they become adults, insects stop molting and growing. On the inside, insects are very different from humans. They have no lungs, a primitive nervous system, and a poor circulatory system with no veins or arteries. Although their organ system works well for a small creature, these internal features generally prevent insects from getting larger than three to four inches long by two inches wide and two inches high.

Although some people consider spiders insects, they are not. Rather, spiders belong to the class Arachnida and have two body parts, four pairs of legs and no wings or antennae. Ticks and mites also differ from true insects and have four pairs of legs and only one major body division.

Insects change through their lives by way of a process called metamorphosis. Some insects go through a complete metamorphosis, which involves four stages of development: egg, larva (caterpillar), pupa (cocoon for moths and chrysalis for butterflies), and adult. Common orders of insects that experience complete metamorphosis include beetles, caddisflies, moths, butterflies, flies, fleas, wasps, bees, and lacewings. Other insects go through incomplete or gradual metamorphosis, which involves three stages of development: egg, nymph (resembles adult but lacks wings and is smaller), and adult. Common insect orders that go through gradual metamorphosis include aphids, grass-


© Earth Partnership • University of Wisconsin-Madison

hoppers, true bugs, dragonflies, cockroaches, and leafhoppers.

## Activity Description

This is a useful warm-up activity to become familiar with eight of the major orders of insects by playing charades. Charades is a game of pantomime where players have to "act out" a word of phrase without speaking, while the others try to guess what the word or phrase is. The objective is for the other players to guess the phrase as quickly as possible.

1. Divide into teams of three to four students. Each team receives one set of eight insect order identification cards.
2. Review as a larger group the eight major orders of insects. Write the eight insect orders on slips of paper and put them into a hat. Each team chooses one order from the hat, which you will then represent when playing charades.
3. Review these general rules: every team member must play a role in acting out their team's insect order; no talking while acting out your order; teams will be given one minute to perform their insect charade; and whichever team identifies the insect order first by voicing the correct identification receives one point.
4. Review acceptable gestures and hand signals and invent any others group members deem appropriate.
5. Adjourn with your team to a separate room (or separate area within the same room) to decide how you will physically represent the insect order you have chosen. Once you have decided how you want to represent your insect type, come back to the same room with all the other teams to play charades!

After the game, review as a class the eight major insect orders and how the teams were able to identify them through charades. Discuss what some threats to these insects' survival might be. There are a wide variety of ways that insects adapt to survive in different ecosystems. Visit the library to research insects that live in prairies, wetlands, woodlands, and other ecosystems. How have these insects adapted to survive in a particular habitat? You can expand on the charades to include different insect orders, plants, and/or other animals that might be found in the natural area you are restoring on your school grounds.

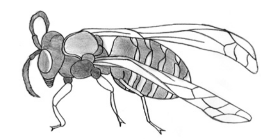
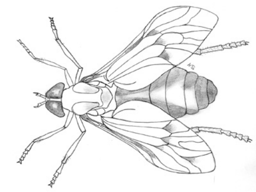
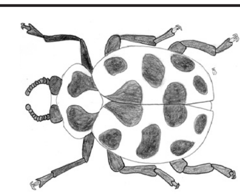
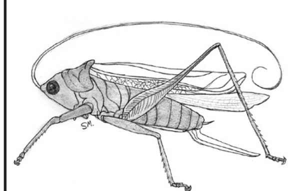
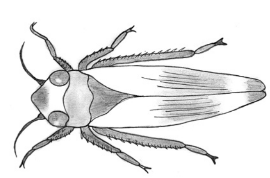
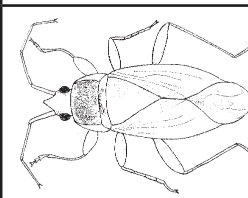
## Extensions

- Create your own cards for charades. Draw other insects, plants, and animals that are representative of the ecosystem being restored on your school site. Use a field guide or other reference to draw the organisms accurately. Then play another round of charades based on these new additions.
- Write a short story describing the eight major orders of insects.
- As a class, do insect sweeping (see EP activity "Sweeping Discoveries") or other types of insect collecting during different times of year on your school restoration site and record your findings.
- Create a computer database to record insect observations.
- Research an insect order, describe its characteristics, and describe the life history of at least one genus within that order.

## Assessments

- Name and describe at least two insect orders and/or the parts of a true insect.
- Compare a true insect to a spider.
- Create a mobile with drawings illustrating various insect orders and their unique physical characteristics.
- Make an oral report to the class about an insect order you researched and conduct peer reviews of these reports.
- Develop a Web page on a specific insect order using photos, drawings, and life history information.

# Insect Charades: The Big Eight

| | Order | Example Insects | Common Characteristics | Illustration |
|---|---|---|---|---|
| 1 | The Membrane Wings (Hymenoptera) | Ants<br>Bees<br>Wasps | • 2 pairs of clear, membranous wings<br>• Compound eyes<br>• Sponge-like, sucking or biting mouthparts<br>• Long legs<br>• Stinger |  |
| 2 | The Two Wings (Diptera) | Flies<br>Mosquitos<br>Gnats | • 1 pair of regular wings and 1 pair of very small wings<br>• Compound eyes<br>• Sponge-like or sucking mouthparts |  |
| 3 | The Scaly Wings (Lepidoptera) | Moths<br>Butterflies | • 2 pairs of scaly wings<br>• Antennae feathery, needle or pin-like<br>• Compound eyes<br>• Sucking mouthparts |  |
| 4 | The Sheath Wings (Coleoptera) | Beetles | • 1 pair of hard wings<br>• Wings cover top of body and meet in straight line down center of back<br>• Biting mouthparts |  |
| 5 | The Straight Wings Orthoptera) | Crickets<br>Grasshoppers<br>Locusts | • 1 pair of leathery wings in front (fold over bodywhen not in use)<br>• 1 pair fan-like wings in back<br>• Long legs/high hopper<br>• Make rhythmic sounds<br>• Chewing mouthparts |  |
| 6 | The Toothed Wings "Born to Teeth" (Odonata) | Dragonflies<br>Damselflies | • 2 pairs of wings<br>• Most have thin legs and short antennae<br>• Large compound eyes nearly cover small heads<br>• Biting mouthparts |  |
| 7 | The Same Wings (Homoptera) | Aphids<br>Cicadas<br>Treehoppers<br>Leafhoppers | • Both (2) pairs of wings are same from base to tip<br>• Wings held in tent-like position over body when resting<br>• Piercing or sucking mouthparts |  |
| 8 | The Half Wings (Hemiptera) | True Bugs<br>Back Swimmers<br>Water Striders | • 2 pairs of wings: thick and leathery near the body and thin at tip<br>• Wings fold back forming triangle behind the head<br>• Snout on head is used for piercing and sucking |  |


© Earth Partnership • University of Wisconsin-Madison

# Letter to a Relative

**Activity Overview**
Students will write a letter to a relative to reflect on why they are doing a native restoration on their school grounds.

**Objectives**
Students will:

- Write an expressive piece employing descriptive detail and a personal voice
- Compose a reflective writing piece that conveys knowledge, experience and insights about past, present and future

**Subjects Covered**
Language Arts

**Grades**
3 through 12

**Activity Time**
50 minutes

**Season**
Any

**Materials**
Clip boards, pens, pencils.

## Background

Why do you want to plant an ecological restoration or native plant garden? Perhaps you want to make your schoolgrounds a healthier place for wildlife and people. Maybe you are interested in the insects, birds, butterflies and other wildlife you find in a prairie, woodland or wetland and want to attract them to your site. What do you hope to accomplish for the environment, your school, your community, future generations, and yourself? Writing a letter to someone in the past or the future will help to focus one's thoughts.

## Activity Description

As your class considers creating a native planting, visit an existing restoration or remnant. Reflect on your vision for the future. Why do you want to do a restoration? Why is it important to you? To consider these questions, write a letter to your ancestor or descendant. Tell them what you are doing today to restore native ecosystems and why.

Find a quiet place to think and write. After 20 minutes or so, share some of your thoughts or read your letter to the class.

## Extensions

- Create a poster entitled, "Ecological Visions for the Future." Include past, present and future.
- Revise, compile and publish the class letters.
- Create a time-line. Have students research pivotal events, including lifespans of relatives. Imagine the changes in landscape in their lifetimes, into the future at chosen intervals.

## Assessments

- Use a rubric to assess the student's writing quality.
- Before learning about the native ecosystems, ask student to write a personal letter to a relative explaining why they are restoring an ecosystem. At the conclusion of the year, ask the students to write a second letter. Assess changes in their knowledge, insights and attitude.

# Plant Power

**Activity Overview**
Students research indigenous uses of plants and look for examples in their native plant garden (or do an indoor version). Students will identify, examine and draw plants they find using a field sheet.

**Objectives**
Students will:
- Learn about the uses of plants in indigenous cultures
- Conduct research using multiple sources of information
- Identify native plants in the field
- Make field observations of plants as part of plant usage research.

**Subjects Covered**
Language Arts, Science and Social Studies

**Grades**
3 through 12

**Activity Time**
1 hour in the field; 1 hour in the classroom

**Season**
Any (spring or fall are the best seasons for plant identification in the field)

**Materials**
Informational resources, field guides, clipboards, worksheets and writing utensils

## Background

Native plants have been used by people for medicine, food and other purposes throughout time. Indigenous people of many cultures have extensive knowledge of native plant uses, handed down from one generation to the next through oral traditions. For example, nearly 400 plant species have been identified as being used by the Anishinabe or Ojibwe people. About 123 species of prairie plants have been identified as food sources. Many of the same plants have been used for both medicine and food, although preparation techniques vary, and different parts of the plant may be used. Developing an understanding of plant uses can help us not only to appreciate plants and how they fit into different ecosystems, but also to value and respect the knowledge and experience of indigenous cultures.

Ethnobotany is the study of how plants have been used by various peoples and cultures around the world, both in the past and present. Such studies are particularly important in the field of medicine, where scientists are researching plants as potential sources for future medicines. Aspirin, cortisone and novocaine are all examples of medicines that came from native plants utilized for centuries by indigenous people for their curative properties. Aspirin originated in willow; indigenous people chewed willow bark or steeped willow stems in boiling water to make a pain-relieving tea. Since the late 1800s, salicin, a derivative of native willows, has been officially listed as a pharmaceutical product, and synthetic substitutes for salicin are manufactured today for pain relief. Unfortunately, much indigenous knowledge about plants has been lost over time, and indigenous names (which may have revealed known properties) have been replaced by English and Latin names. Nevertheless, there is a tremendous opportunity to preserve as much knowledge as possible, to gain a better understanding of the relationships between people and plants, and thus to increase awareness of the need to preserve biodiversity.

In this activity, students will research indigenous uses of plants and also make observations in a natural setting to consider and understand the different characteristics of plants. Students can feel the rough or smooth leaves of a native plant, see the variety of sizes and shapes, smell the strong scent of a plant from the mint family and hear insects buzzing around the plants.

## Activity Description

### Part 1: In the classroom

As a class, determine what resources to use for researching traditional plant uses.

Work in teams of two to investigate five native plants growing in your region. For each plant, furnish the following information: the Latin and common names, a plant description, a description of plant uses and references.

Compile information from all the teams to use as a resource in that native plant garden. You can also develop a computer database to file this information for later use.


© Earth Partnership • University of Wisconsin-Madison

## Part 2: In the field

Observation is a significant part of learning about the natural world in First Nation communities. Discuss how you use your senses in your daily life to be aware of the environment around you. Are you making the best use of your senses and observation skills? Explain why or why not.

In this activity, you will be using your senses of touch, sight, smell, and sound—but NOT your sense of taste! When investigating native plants in the field, it is essential that you do not pick or taste any plants unless proper precautions are taken. Also make sure that everyone can identify plants like poison-ivy and wild parsnip if they grow in your area. This will help everyone avoid an unpleasant or dangerous field experience.

In teams, search for examples of plants growing in your school garden that were traditionally used for food, beverages, or medicinal remedies for illness or injury. Once you locate a plant specimen, use your senses of smell, touch, hearing, and sight to examine the plant more closely. Notice if you smell, feel, or observe any characteristics such as a strong fragrance or a thick sap that may indicate how the plant was used. Is there anything unique about the plant that might indicate a use for medicinal or food purposes? Use the Plant Power field sheet to help record observations. For more information on plant terminology, see EP activity "Taxonomy Field Guide and Treasure Hunt."

## Modified Part 2: In the classroom

If you would like to explore indigenous plant uses, and you do not have easy access to living native plants, you can do a modified version of this activity as an indoor game. You and/or students can set up the game, and then play it as a group.

Select a list of native plants that are traditionally used for their medicinal or food value in your locale. If students are helping with the set-up, have each student or student team select just one plant to research and prepare. That way, everyone will be able to participate in the game without already knowing all the answers. For each plant, find an image or actual example of its use and an example of the source plant itself (photos, twigs, dried flowers, nuts, seed heads or leaves can all be stored and used throughout the year). Number the source plant examples and lay them out on a table.

Pass out examples of the plant products and let students examine them. Consider using some that can be sampled. Some easy examples require no cooking (e.g., maple syrup, fresh or dried berries), and some can be prepared before-hand as a special edible treat (e.g., wild rice, Jerusalem artichoke, cattail spikes). For student safety, use only printed images of medicines. Include a "clue" card with brief visual description of the source plant with the use examples, so that students have some hints as they try to match which products come from which sources. You can also include additional information about nutrition or health.

Example clue card and source plant:


## Extensions

- Biology students: Search out native prairie plants growing in your native garden that may have biologically active chemicals. Test plants to find which ones might inhibit bacterial growth in petri dishes.
- Prior to researching plant uses, go out to your native garden and hypothesize about various plant uses based on your observations.
- Create a menu for a balanced diet using plants and animals native to the region.
- Make natural dyes and dye your own cloth. See North American Dye Plants by Anne Bliss (1980).
- Read literature about Native American life and look for specific information about native plant uses. Create a list of plants and note how they have been used in the past and present.
- Prepare a list of native plants and their uses according to the time of year they can be used or harvested. Create a phenological calendar based on this information and related pictures or photographs of the plants.
- Use EP activity "A Seed's Journey" to learn about plants brought to North America for food and medicine by Europeans.
- Research modern-day medicines that originally came from native North American plants.

## Assessments

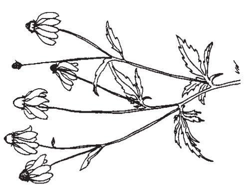
- Compare and contrast past and present uses of native plants.
- Research a native wild plant and describe its characteristics, history, and uses over time. Make an oral report to the class. Conduct peer reviews of these reports.
- Describe two important uses of native plants.
- Create a mobile that includes the plants you identified, their uses, and how the senses might help to identify the plant.


© Earth Partnership • University of Wisconsin-Madison

# Plant Power Field Sheet

**Latin name**

**Common name**



Height

Flower color

Time of bloom

Habitat

General description (Describe leaves, stem, roots, flower, seed, etc.)

Medicinal
and food uses...

Picture

Did you know...

# A Seed's Journey

### Activity Overview

Students identify non-native plants and research the introduction of these non-native plants to the New World.

### Objectives

Students will:

- Identify plant species using observation skills and key
- Conduct research, engage in inquiry and communicate findings
- Learn how historical events have changed the present day landscape

### Subjects Covered:

Science

### Grades:

3 through 12

### Activity Time:

45 minutes plant identification; 45 minutes research; 45 minutes to create/display findings

### Season:

Identification is best done in the fall; research can be done any time.

### Materials:

Resource books to identify non-native plants and to research their introduction into North America, blank world maps, graph paper, plant photos or drawings, poster board

## Background

Plant composition in the ecosystems of North America has changed since European settlement and the introduction of non-native plant species from other parts of the world. Once non-native plants are transplanted from their homeland and no longer constrained by naturally occurring disease and competition, they often spread aggressively, out-competing native plants. Consequently, the interrelationships in a naturally functioning ecosystem are thrown out of balance. Restorationists, land managers, and homeowners spend millions of hours and dollars removing many of these exotic plants. How and why did these plants come here in the first place?

Non-native weeds and seeds came to North America several different ways. Colonists brought seed from their homelands for their family garden plots. Puritan women brought plantain (*Plantago major*) to North America for treating bites, cuts, and other painful wounds. These plants escaped their well-tended gardens via birds, animals, or settlers' feet, and quickly spread throughout North America. Native Americans called the plantain "white man's foot" because it would grow along well traveled-trails.

Dandelion (*Taraxacum officinale*) originated in Asia Minor. It spread to Europe before written history. For centuries, its long taproot and leaves have been used for food and medicine. The leaves and flowers contain more vitamins C and A than most garden vegetables. Dutch, German, French, and English immigrants brought seed from the Old World. The parachuted dandelion seed spread west before settlers arrived to claim their homesteads. Apache Indians welcomed the new plant and sent groups in search of it for spring feasts.

Seeds or plants also reached North America in impure shipments of grain, as ornamental plants, or as a food for domestic animals. Crabgrass (*Digitaria sanguinalis*) was first brought over in 1849 by the U.S. Patent Office as forage food. Later, Eastern Europeans brought crabgrass for cereal and flour. Today, crabgrass has spread to every state in the nation and is considered the number one pest in lawns.

Honeysuckle (*Lonicera tartarica, L. morrowii, L. X bella*) was introduced as an ornamental in the colonies in 1752 and is still sold at garden centers today. It is a serious nuisance in natural areas around urban centers, eliminating native wildflowers and shrubs. The summer-ripening fruit is readily consumed by birds and dispersed in forests and fields.

So what is a weed anyway? Eleanor Roosevelt said, "A weed is an unloved flower." Often a weed is described as a plant that is unwanted and grows or spreads aggressively.

## Activity Description

1. Identify non-native plants in your restoration plot, in your schoolyard, or in an old field using field guides.
2. Research the origins of these non-native plants and how and why they were brought to North America.
3. Indicate on a world map where the exotic species originated, their route to


© Earth Partnership • University of Wisconsin-Madison

North America,  and the extent of their spread, with approximate dates.

4. Create a display of your findings. Include a world map, a description with a drawing or photograph of your plant, a summary of how your plant came to the new world, and its impact in natural ecosystems today.

## Extensions

- Compose a fictional essay about a seed's journey to the new world from its native home.
- Construct a timeline or graph that shows the number of plants introduced through history.  Determine historical events that may correlate with the introduction of non-native species.
- Discuss what the implications are for the modern world when plant-seed hitchhikers are carried all over the world.
- Research cases of exotic plant or animal introductions, both intentional, such as kudzu or water hyacinth in the southeast United States, or unintentional, such as sea lamprey in the Great Lakes. Consider the case history and biological results of these prolific pests.

## Assessments

- Create portfolios or flash cards of non-native plants with a few facts on their introduction.

# A Seed's Journey Field Sheet

**Plant name**

| General description | Where did it come from? |
|---|---|
| | Where is it found today? |
| What are its medicinal or food uses? | How can we control it? |

**Picture or Drawing**

**When and how did it come here?**

**Why did it come here?**



© Earth Partnership • University of Wisconsin-Madison

# Schoolyard Poetry

**Activity Overview**
Students write poetry to express their feelings and experiences in a natural system.

**Objectives**
Students will:

- Write expressive pieces in response to direct experience
- Develop writing that expresses creative and aesthetic content
- Practice observation skills
- Gain knowledge and practice writing different types of poetry
- Practice the use of poetic devices

**Subjects Covered**
Language Arts

**Grades**
K through 12

**Activity Time**
Varies; 30 minutes or more

**Season**
Any

**Materials**
Outdoor natural space, notebook, and pencil

## Background

Incorporating poetry writing into field experiences and other native garden project activities can provide students with a new perspective on the natural world. Poetry can be a way to enhance observation skills, make personal connections to a subject or understand the subject more clearly. Experimenting with verse can be a fun way for students to focus their ideas and become more clear about exactly what they wish to convey to their reading or listening audience.

## Activity Description

Find a comfortable spot in a natural area. To get inspired and get your thoughts rolling, try walking slowly, sitting still, or lying back so you can see the sky. Consider what you are seeing, feeling, hearing, smelling, thinking and observing. Pick one of the poetry styles and try to convey something about what you are experiencing.

### Haiku

*Example from Kathleen Morgen, Verona Middle School*

An ancient poetry form from Japan built on three lines using 17 syllables, usually in a 5-7-5 pattern.

**Indian Grass**

| | |
|---|---|
| Line 1: 5 syllables | Once upon a time |
| Line 2: 7 syllables | you brushed chins with buffalo. |
| Line 3: 5 syllables | Come, tickle mine now. |

### Cinquain

*Example from Sylvia Marek, UW-Madison Arboretum Naturalist*

| | |
|---|---|
| Line 1: title | Feathers |
| Line 2: description of title | Colorful, Light |
| Line 3: action of title | Flying, Preening, Fluffing |
| Line 4: statement or feeling | Wish I could fly |
| Line 5: repeated title, synonym, or rename | Bird |

### Noun verse

*Example from Joan Field, Mendota Elementary School*

| | |
|---|---|
| Line 1: noun | Lead-plant |
| Line 2: two adjectives | purple, spiky |
| Line 3: two verbs ending in “ing” | growing, stretching |
| Line 4: synonym | *Amorpha canescens* |

# Schoolyard Poetry (cont.)

## Diamante

| | |
|---|---|
| Line 1: first noun | Prairie |
| Line 2: two adjectives | Hot, multi-colored |
| Line 3: three verbs | Teeming, streaming, dreaming |
| Line 4: two words for first noun and two for second noun | Wild fired, stately crowned |
| Line 5: second noun (opposite the first) | Woodland |

## Quatrain

Four lines that rhyme, often part of a longer poem. The rhyme pattern of a quatrain will be aabb, abab, abcb, or abba. The letters that are the same represent which lines should rhyme with each other.

## Couplet

Two lines that rhyme, often part of a longer poem. When using couplets, lines 1 and 2 rhyme and lines 3 and 4 can rhyme (aabb), but they do not all rhyme together. Create the same rhythm in both lines of your couplet when using them in a rap. Couplets can be long or short. To create the same rhythm in rhyming lines, make phrases with the same amount of syllables in each line or drag out some of the syllables in your shorter line to hold more beats than one.

## Rap

Raps are rhymes recited along with a beat or rhythm. The rhymes are commonly arranged in a couplet or quatrain poetry form.

To write a rap, first think of a story you would like to tell about your topic. Select a few key words you would like to use that are descriptive of the natural area and your experience. Brainstorm and come up with as many words that rhyme with your key words as you can.

Create short phrases with one to five words each, using the rhyming word last. Keep in mind different goals when creating your phrases. Use names of plants and animals found in the natural habitat. Think about their actions and functions or how other inhabitants of their environment use them. Use your senses to describe sounds, smells, sights and touch. Think about new understanding and overall feelings you have gained from your experience. New words that you would like to rhyme with may result from this step. Brainstorm more rhyming words to work with the ends of some of your new phrases.

Mix and match phrases until you find a combination of lyrics you like. When you have some lyrics, it is time to match them with a rhythm. Most raps are based on a 4/4 rhythm. The count would look like this: 1, 2, 3, 4. 1, 2, 3, 4. Each number gets one beat. Within your four count you can come up with many different rhythms. Here are examples of how to add beats to a four count. The numbers still fall on the beat and the symbols and letters will be between, so count slowly to start.

| | |
|---|---|
| 1…2…3…4 | (regular four count) |
| 1, and, 2, and, 3, and, 4 | ("and" is a half beat between the beats, called the off beat) |
| 1, eand, 2, eand, 3, eand, 4 | (1, eand, 1/4 rest, 2, rest so beat and the half stay in time) |
| 1, eanda, 2, eanda, 3, eanda, 4 | (tha "a" at the end of "eanda" replaces the rest in the previous rhythm) |

Mix up different combinations of beats to get different rhythms. Try tapping out the rhythms on your knee to see if you like the flow of your new rhythmic creation.

**Example:** (1 and 2 eanda 3, 4) ( 1 eand 2, 3 eanda 4)


© Earth Partnership • University of Wisconsin-Madison

Each syllable in your lyrics can represent a beat to create the flow of your lyrics. The back beat should be made of simple sounds and simple rhythm to keep the four count steady for the rapper.

**Example:** (1, 2, 3, 4 ) (mm, ba, mm, ba)

(1, 2, 3-and, 4) (mm, ba, chi-ba, mm)

(1-and, 2, 3-and, 4) (chi-ba, mm, chi-ba, mm)

Put all your work together and perform your own rap song.

### Shape poems

1. Decide the theme you will use for your poem.
2. Pick an image that is symbolic of your poem.
3. Decide whether you want your words to form the outline of the picture or to fill in the image.
4. Sketch the image in dark lines on the page. You will use this page as a guide to see where you need to place your words.
5. Write your poem on the page. If you want your words to follow the outline, turn the paper as you print.
6. There are no poetic rules for your poem; choose any rhyming or metrical form you wish.
7. Write enough words to fill the shape or alter the size of the shape to fit your words.

**Some poetic devices to try**

*Alliteration*—The repetition of initial consonant sounds.

*Allusion*—A reference to a well-known person, place, event, literary work, or work of art.

*Hyperbole*—Exaggeration for effect (I'm so hungry I could eat a horse).

*Imagery*—A word or phrase appealing to the sense of sight, sound, smell, taste, or touch.

*Metaphor*—A figure of speech in which something is described as though it were something else (a heart of stone, a copper sky).

*Meter*—The rhythmic pattern of a poem.

*Onomatopoeia*—The use of words that imitate sounds (hiss, crash, buzz, ring, jingle).

*Personification*—Figurative language giving human characteristics to a non-human subject (Father Time, Mother Earth).

*Repetition*—The use, more than once, of a sound, word, phrase, sentence, or pattern in poetry.

*Rhyme*—The repetition of sounds at the ends of words.

*Simile*—A figure of speech that compares two unlike things using "like" or "as" (her teeth were like pearls; the clouds were as pink as flamingos).

## Extensions

- Generate a list of nouns, adjectives and verbs that can be used to describe your native garden's plants and animals.
- Create a poetry journal for your writings.
- Establish a poetry reading circle at your school, or designate a section of your garden as a poetry garden with benches and tables for listening, reading and writing.
- Incorporate poetry writing into any future field trips or restoration projects.

- Learn how to count rhythms and have a music circle in class using instruments or voices. If there are no instruments, make your own.
- Have the music circle provide a back beat for student rap presentations, or use a back beat circle for show and tell or other speaking opportunities that give students a chance to free-style.
- Perform poems at a poetry slam.

## Assessments

- Describe two forms of poetry and provide an example of each.
- Write a poetry sample indoors before visiting a natural area and after visiting a natural area. Note differences in writing content and style.
- Keep a poetry journal or portfolio of your writing, and see how your abilities develop over time.


© Earth Partnership • University of Wisconsin-Madison

# Wheelscapes: Enhancing Sense of Place with Phenology Wheels

**Activity Overview**
Students will deepen their sense of place by regular visits to a specific place, by writing or creating artwork about that place and by assembling their work on a wheel of the year.

**Objectives**
Students will:

- Identify with a specific place by regular and frequent (at least seasonal) visits to that place
- Become familiar with that place in its changing seasons
- Increase knowledge of the phenology of that place
- Develop observation skills
- Use drawing, photography, and/or writing to deepen awareness of that place
- Understand what art, writing, and science have in common

**Subjects Covered**
Science, Art, Language Arts

**Grades -** 3 through 12

**Activity Time**
Variable (some visits could be brief walks, some could/should include time for sitting, reflection and artwork/writing)

**Season -** Any

**Materials**
Small writing/drawing notebooks, pencils, colored pencils, camera and wheels of the year*

**Source**
Georgia Gómez-Ibáñez, Cambridge Elementary School, WI

## Background

Gaining a deep sense of place is very rewarding, can be an enjoyable, lifelong activity and is arguably essential to human well-being. It is part of our human inheritance: throughout history we have lived intimately with our place. Only very recently have so many people become disassociated with, and consequently unappreciative of and ignorant about, the land (soils, waters, plants and animals) where they live.

In the recent past children naturally formed a relationship with the land by exploring, playing, and working in it. Most children nowadays are not allowed such unsupervised roaming. This activity seeks to re-establish the natural feelings children once had for the land around their home and community.

What sort of "place" will be conducive to this endeavor?

First of all it must be within walking distance, so that visits can be as regular and frequent as possible. The best places will be somewhat "wild," like a woods, a pond or a prairie. A schoolyard with lovely trees will suffice, or perhaps a courtyard garden or a butterfly garden. A less formal and groomed place will be better than "lawn," but lawn under a tree would do. Ideally this place will be visited not only in every season, but in every sort of weather. Rainy day or snowy day walks will evoke deep responses.

Each visit need not include an art or writing response, but some visits should include time to sit, slow down and quietly experience the place. Drawing and/or writing are useful devices to achieve focus and attention to details. Indeed, the observational skills so necessary for scientists are the same ones necessary for artists and writers.

Each student could have a personal wheel of the year (11" x 17" paper) on which to draw and/or write images or impressions of the place. A large classroom size wheel (24" x 24") could be used to display student work, month by month or seasonally, creating a collective evocation of the place.

Ongoing discussions will help students relate to this place: What makes this place special? If the place has no boundary features, how are they defining the space for the place? Might they want to set some goals on frequency of visits, or special phenomena they hope to observe, or weather they hope to experience?

## Activity Description

### Activity 1: Creating Classroom Wheelscapes

**Photo/Phenology Wheelscapes**

- A photo taken from a single spot once a month creates a remarkable and evocative photographic record of a place. The scene should be chosen with care so that the photos can tell the story of the year without words. The series of photos can express this story if set up linearly, but the flow of seasonal change is evoked more powerfully if the photos are arranged around a large wheel of the year.

- Every wheel has a center. For this activity, and the ones which follow, it will be important to decide upon an image for the center. What image will express something meaningful about this place? A photo of the students in their place? A single photo of the place (or a favorite spot within the place)?

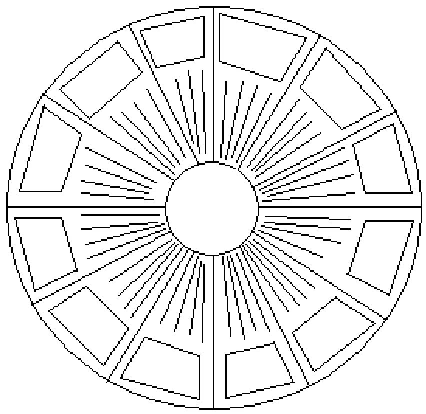


*Figure 1: Photo-phenology Wheel of the Year with phenological observations*

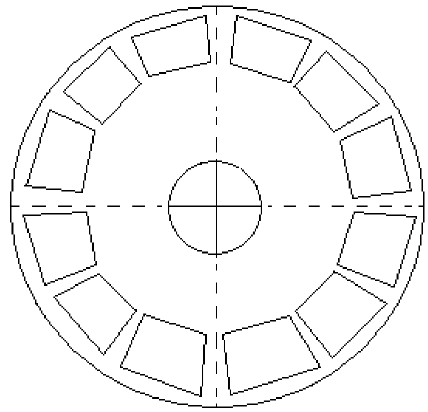


*Figure 2: Photo-phenology Wheel of the Year arranged by season*

- Figure 1 focuses on phenology of place. It could have monthly photos arranged around the edge, but much of the space will be occupied by specific phenological observations (e.g. leaf fall, trees bare of leaves, buds swelling, leaves open) and seasonal/weather observations (last rain, first snow, etc.). For younger children the teacher will decide what to look for, but older students could help come up with a list.
- Four seasonal photos, cropped to fit together as a centering circle could emphasize the seasonal theme of this wheel. See figure 2.
- If this large wheel has a permanent, prominent place on the classroom wall, it will provide an ongoing, growing body of knowledge about the class "place," a tangible presence of that place, as well as a handy seasonal "color palette" for class artists and writers to reference.

#### Reflective Wheelscapes

Ideally this large wheel of the year will have a permanent display place on a classroom wall. It will be blank as the year begins, but as the year progresses and the wheel fills up with student work, it will evoke the presence of that place daily.

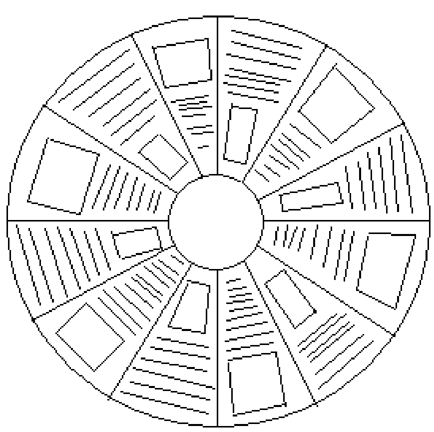


*Figure 3: Reflective Wheelscape, student work arranged by month.*

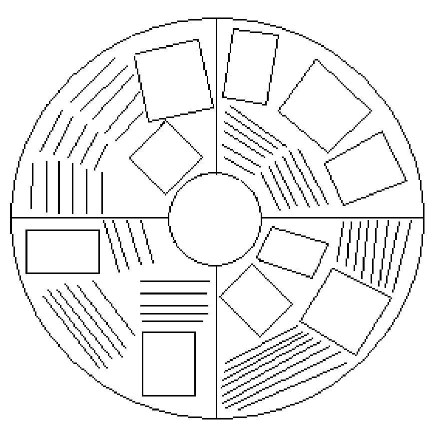


*Figure 4: Reflective Wheelscape, student work arranged by season.*


© Earth Partnership • University of Wisconsin-Madison

# Wheelscapes: Enhancing Sense of Place with Phenology Wheels (cont.)

- These wheels, figures 3 and 4, are meant to be filled with student work (artwork, poems, short written observations) all focused on the place, grouped by month or by season. Discuss how these student works individually evoke a sense a place. Do the combined works evoke a more complete essence of place? What aspects of the place did not show up in the student work? Why not?
- It is important for the wheel to have a center, but for a community wheel it might work well to wait until the students are familiar with the place before they choose what the center image should be.

### Activity 2: Personal Wheelscapes

#### Personal Impressions of a Place

- Personal wheels of the year help each student create a collection of personal reflections and observations about a specific place. The students fill their personal wheels with poems, short written observations, and/or drawings, monthly or seasonally. The place celebrated will usually be the same place that the whole class is visiting. Thus, sharing the personal wheels will enrich everyone's understanding and appreciation of that place, and may well inspire improved observational skills as well as drawing and writing efforts.
- Each student should choose what occupies the center of their own wheel. Possibilities include: a special moment or memory, a favorite spot, an interesting plant or animal, or an activity. Younger students respond well to having a photo of themselves, in their own personal favorite spot, at the center of their wheel.


*Sample personal wheel with photo of student and place in center.*

## Activity 3: 13 Ways of Seeing

- This variation asks students to consider different perspectives on the same place or object. For example they could consider a tree from the perspective of a bird, a raccoon, a cloud, etc. Thirteen ways of seeing reflects the thirteen annual cycles of the moon. The classroom activity does not necessarily require each student to create 13 perspectives, although pairs of students could each create one spoke of a larger class wheel.

### Extensions

- The large classroom wheelscape is targeted as a classroom activity. However, it could be an "advanced level" (grades 9 to 12) project for an interested student (or small team of students) in high school. In this case, the place chosen would not necessarily need to be near the school, because it might be a project worked on outside of school hours.
- A modification of the personal wheel for grades K through 2 could be the making of a 4 panel windsock, depicting 4 seasonal observations in the place. Younger children will easily see how their sequence of the seasons goes "round and round."
- An extension of the personal wheel for older students (grades 9 through 12) would be to have the personal wheels celebrate a personal favorite place. (This would be an outside of school activity.) Sharing these wheel-journals could spark good discussions about what makes a favorite place special. Are these common themes? Or are the reasons as varied as the students? These places could be compared to the class place. Are the phenologies the same? Or are there micro climate factors at work? What might they be?

## Assessments

- Develop a phenology wheel to share/summarize site observations with others.
- Student work for this activity can serve as an assessment.


*Student example of seasonal cycles and observations of one species.*


*Example of personal wheel documenting observations of changes in local trees and plants throughout the year.*


*Phenology wheel showing thirteen different ways of looking at a cattail plant.*


*The seasons of sugar bushing on a wood burned wheel. Photo by Gretchen Watkins.*



© Earth Partnership • University of Wisconsin-Madison

| Sample: 2008 "First and Lasts" Phenology Chart | | |
|---|---|---|
| FALL | | |
| WEATHER | First Day Cold enough for a sweatshirt | September 29 |
| | First morning cold enough to see your breath | October 4 |
| | First hard frost | October 4 |
| | First day cold enough for a coat, hat, mittens | November 9 |
| | First Snow | Nov. 24- 2 in. |
| | Last real rain | November 13 |
| | Pond beginning to freeze | November 30 |
| | Pond frozen solidly enough to walk on | December 12 |
| | Day equal to night | September 23 |
| | Sunrise later than 6 a.m. | October 5 |
| | Sunset earlier than 6 p.m. | September 19 |
| OBSERVATIONS | | |
| Birds | Notice not as much morning birdsong | August 24 |
| | First day to see migrators: | |
| | Sandhill Cranes | September 15 |
| | Canada Geese | October 2 |
| | Warblers | September 20 |
| | Last day to see hummingbirds | September 24 |
| | First day to see Juncos back from arctic (to spend winter here) | October 27 |
| | First day to see Robins gathering in great numbers in woods | October 8 |
| Plants and Trees | First tree leaves turning color | September 20 |
| | First day lots of leaves falling | October 11 |
| | Trees mostly bare of leaves | November 8 |
| | Hickory nuts begin falling | August 27 |
| | Acorns begin falling | August 27 |
| | Jack in the Pulpit berries turn red | August 24 |
| | First goldenrod blooming in prairie | August 28 |
| | First New England asters blooming in prairie | August 28 |
| | Last cup plant blooms in prairie | September 25 |
| | Last compass plant blooms in prairie | September 18 |
| | Last prairie dock blooms in prairie | September 8 |
| | Last New England aster blooms in prairie | October 26 |
| | Last goldenrod blooms in prairie | October 4 |
| | Last zigzag goldenrod blooms in woods | October 6 |

# Phenological Nature Walks

**Activity Overview**
Students observe and record seasonal changes on a self-guided walk in a natural area at different times of the year.

**Objectives**
Students will:

- Practice observation skills
- Perceive seasonal and/or phenological changes in a natural setting
- Collect data

**Subjects Covered**
Language Arts and Science

**Grades:**
K through 12

**Activity Time**
30 minutes, 4 times a year

**Season**
Any

**Materials**
Field sheets, pencils, clipboards, and field guides (optional)

**Source**
*My Nature Journal: Explorations of the Natural World Using Phenology* by Cheryl Bauer-Armstrong and Miguela Smith

**Please see appendices for:**
Common Core State Standards
Next Generation Science Standards

## Background

*If you want an adventure, take the same walk that you took yesterday, and do so again tomorrow.*
- John Burroughs

Phenology is defined as the study of natural events—such as bird migration or fall leaf color—that recur periodically in relation to climate and seasonal change. The word "phenology" comes from the Greek words "phainestai" (to appear) and "logos" (to study). A person who studies phenology is a phenologist. People have been practicing phenology since ancient times. 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. Today, people observe and record natural events to stay in tune with the seasons and keep time with the natural order.

The discovery of the first bloom of a plant was an event treasured and recorded by conservationist 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, p. 44). Leopold kept daily journals of observations wherever 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 their family walks, Leopold and his children would compare changes from year to year as they learned about the natural world.

It is not necessary to travel to distant natural areas to study phenological changes and the wonders of nature. Taking a walk along the same route will tune your senses into the discovery of nature's cycles and help you become more aware of seasonal change. A schoolyard, restored prairie, local park or empty lot all provide information for budding naturalists.

## Activity Description

Take a sensory nature hike once each season. Walk the same route. What changes do you see from hike to hike? Consider questions such as: "What is the weather like? What sounds do you hear? What do you smell? Feel? What is different about this walk compared to the others?" Use the Phenological Nature Walks Field Sheet to record what you see, hear, smell and touch. On a separate sheet of paper, summarize your observations and changes you observe throughout the year. Explain what influences these changes and how plants and animals adapt based on your observations.

## Extensions

- Draw a picture of something you find interesting on your nature hike.
- Create a poem inspired by your phenological discoveries. The poem could be a haiku, cinquain, diamante or other appropriate form.
- Create a phenology journal of your experiences.


© Earth Partnership • University of Wisconsin-Madison

- Take a walk in different ecosystems; compare the similarities and differences.
- Develop a Web page or computer database to record your observations over time.
- Design a phenology calendar and record observations throughout the year.

## Assessments

- Present your observations to peers.
- Create a phenology journal for a specific time frame.
- Write a short story that describes seasonal changes you observe.
- Define phenology and describe at least four seasonal changes.

# Phenological Nature Walks: Field Sheet

Name: ______________________________________ Date: ___________ Time: ___________

Where are you?

Who is walking with you?

What is the weather?

What evidence of animals, birds, or insects do you see or hear?

What is special about the plants that you see?

What do you smell?

What do you hear?


© Earth Partnership • University of Wisconsin-Madison

# APPENDIX A : National Education Standards

## *Next Generation Science Standards (NGSS) and Common Core State Standards (CCSS)*

# APPENDIX A : National Education Standards

# APPENDIX A : National Education Standards

## How to Read Standards Alignment

*The documents in this appendix are presented in the following format:*

## Activity Title(s)

*Some individual activities are aligned to standards, others progress from beginner to advanced learning activities that together align with the standards listed.*

**Purpose Statement (grade band):** *The purpose statement is a Common Core State Standard element, and underlined phrases indicate alignment to the three various dimensions of the Next Generation Science Standards. The online version is specifically color-coded to demonstrate alignment to each of the following: 1) Science and Engineering Practices, 2) Disciplinary Core Ideas, and 3) Crosscutting Concepts.*

### Disciplinary Component Ideas: *Next Generation Science Standards*

*Unit builds toward students meeting performance expectations: Next Generation Science Standards*

### Connections to Common Core State Standards:
**ELA/Literacy**

**Mathematics**

## Community Assets Mapping; Inquiry Learning: Students as Ecological Researchers; Telling the Restoration Story; Migration Stories; More or Less: Restoration Impacts; Sharing and Comparing Stewardship Projects

**Purpose Statement (3-5)**: We can obtain information from our surroundings to describe the interactions within our community that will help us to protect Earth's resources and environments.

**Purpose Statement (MS)**: We can study relationships in our community in order to design a process that will help us mitigate harmful human impacts on our ecosystem.

**Purpose Statement (HS):** We can use our community assets to design a cost-risk balanced solution to the problem of ecosystem degradation in our community.

### Disciplinary Component Ideas:
ESS3.C: Human Impacts on Earth Systems. How do humans change the planet?

*Unit builds toward students meeting performance expectations:*

5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

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

### Common Core State Standards Connections:
**ELA/Literacy**

W.3.8; W.4.8; W.5.8. Recall relevant information from experiences or gather relevant information from print and digital



© Earth Partnership • University of Wisconsin-Madison

sources

WHST.6-8.7. Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

WHST.6-8.8. Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

**Mathematics**

MP.2. Reason abstractly and quantitatively.

## Observations from a Single Spot; Ecosystem Observations; Inquiry-Based Field Problems; Winter Ecology Observations in your Watershed

**Purpose Statement (K-2):** We can make firsthand observations about the many different kinds of living things in our ecosystem, on land and in water, and how they change.

**Purpose Statement (3-5):** We can develop a model that describes the interactions of species in our ecosystem, from what organisms eat for survival to how matter cycles through the soil.

**Purpose Statement (MS):** We can examine patterns in our ecosystem to see how relationships are interdependent, crafting an explanation that will help predict relationships in our ecosystem.

### Disciplinary Component Ideas:

LS2.A: Interdependent Relationships in Ecosystems. How do organisms interact with the living and nonliving environments to obtain matter and energy?

LS4.D: Biodiversity and Humans. What is biodiversity, how do humans affect it, and how does it affect humans?

*Unit builds toward students meeting performance expectations:*

2-LS4-1. Make observations of plants and animals to compare the diversity of life in different habitats.

5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

### Common Core State Standards Connections:

**ELA/Literacy**

W.K.7; W.1.7; W.2.7. Participate in shared research and writing projects

W.2.8. Recall information from experiences or gather information from provided sources to answer a question.

SL.1.4; SL.2.4. Describe/tell a story or recount an experience

SL.K.5; SL.1.5; SL.2.5. Add drawings or other visual displays to descriptions as desired to provide additional detail/clarify ideas; (Grade 2 – create audio recordings).

SL.3.5; SL.4.5; SL.5.5. Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes.

RST.6-8.7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

SL.6.5; SL.7.5; SL.8.5. Include multimedia components/integrate multimedia and visual displays into presentations

SL.6.1; SL.7.1; SL.8.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6/7/8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

SL.6.4; SL.7.4; SL.8.4. Present claims and findings

RST.6-8.7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

**Mathematics**

2.MD.D.10. Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph.

MP.4. Model with mathematics.

MP.5. Use appropriate tools strategically.

## Wheelscapes: Enhancing Sense of Place with Phenology Wheels

**High school standards are found in CCSS connections.*

**Purpose Statement (3-5; MS):** We can create a phenology wheel that models what we've observed about the cyclical patterns of Earth in the solar system.

**Purpose Statement (3-5; MS):** We can create a phenology wheel that demonstrates what we've observed about seasonal changes in our special place throughout a given period of time, which can also serve as a model for thinking about how matter travels through our ecosystem.

**Purpose Statement (HS):** We can integrate phenology wheels in our communication as a multimedia way to enhance understanding of complex ideas about ecological phenomena, personal experiences, and seasonal changes.

### Disciplinary Component Ideas:

ESS1.B: Earth and the Solar System. What are the predictable patterns caused by Earth's movement in the solar system?

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems. How do matter and energy move through an ecosystem?

*Unit builds toward students meeting performance expectations:*

5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.

5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

### Common Core State Standards Connections:

# APPENDIX A : National Education Standards

**ELA/Literacy**

W.K.8; W.1.8; W.2.8; W.3.8; W.4.8; W.5.8. Recall relevant information from experiences or gather relevant information from print and digital sources

W.3.3; W.4.3; W.5.3. Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences.

W.9-10.2; W.10-11.2. Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.

SL.3.5; SL.4.5; SL.5.5. Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes.

SL. 9-10.5; SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

**Mathematics**

MP.2. Reason abstractly and quantitatively.

## Botany Bouquet

**Purpose Statement (K-2):** We can make observations about plant species to show that there are many different kinds of living things in our area.

**Purpose Statement (3-5):** We can observe and describe the components of a plant's external features, constructing a model of our plant observations throughout the year.

### Disciplinary Component Ideas:

LS1.A: Structure and Function. How do the structures of organisms enable life's functions?

LS4.D: Biodiversity and Humans. What is biodiversity, how do humans affect it, and how does it affect humans?

*Unit builds toward students meeting performance expectations:*

2-LS4-1. Make observations of plants and animals to compare the diversity of life in different habitats.

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

### Common Core State Standards Connections:

**ELA/Literacy**

W.K.8; W.1.8; W.2.8; W.3.8; W.4.8; W.5.8. Recall relevant information from experiences or gather relevant information from print and digital sources

## What's Green and Grows all Over? Studying Ecosystem Biodiversity

**Purpose Statement (MS):** We can evaluate the biodiversity of our schoolyard, assessing how changes to the landscape might promote or discourage the growth of different species.

# APPENDIX A : National Education Standards

**Purpose Statement (HS):** We can design, evaluate, and refine a restoration solution that promotes biodiversity, in order to understand that changes in species richness will lead to changes in ecosystem functioning.

## Disciplinary Component Ideas:

LS4.C: Adaptation. How does the environment influence populations of organisms over multiple generations?

LS4.D: Biodiversity and Humans. What is biodiversity, how do humans affect it, and how does it affect humans?

LS2.A: Interdependent Relationships in Ecosystems. How do organisms interact with the living and nonliving environments to obtain matter and energy?

*Unit builds toward students meeting performance expectations:*

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

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

environment and biodiversity.

HS-LS2-2. Use mathematical representations to support and revise explanations based on

evidence about factors affecting biodiversity and populations in ecosystems of different scales.

## Common Core State Standards Connections:

**ELA/Literacy**

WHST.6-8.1 Write arguments to support claims with clear reasons and relevant evidence.

WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

SL.8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

**Mathematics**

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics

6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.

6.SP.B.5 Summarize numerical data sets in relation to their context.


© Earth Partnership • University of Wisconsin-Madison

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSS-IC.A.1 Understand statistics as a process for making inferences about population parameters based on a random sample from that population.

HSS-IC.B.6 Evaluate reports based on data.

## Ecosystem Comparisons; Germination Determination: What a Seed Needs; Sweeping Discoveries

**Purpose Statement (3-5):** We can construct an argument about which environmental factors cause organisms to thrive, survive, or not survive at all, comparing within and between ecosystems.

**Purpose Statement (MS):** We can construct an explanation of community structure variability that we observe in ecosystems, based on patterns of interdependent relationships between species and interactions with the living and nonliving environment.

**Purpose Statement (HS):** We can evaluate explanations of differing community structure and function across ecosystems, understanding that adaptations can cause species to survive and reproduce (or not) and that there are complex interactions that affect the numbers and types of organisms in a given community.

### Disciplinary Component Ideas:

**LS4.C:** Adaptation. How does the environment influence populations of organisms over multiple generations?

LS2.A. Interdependent Relationships. How do organisms interact with the living and nonliving environments to obtain matter and energy?

*Unit builds toward students meeting performance expectations:*

3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can

survive well, some survive less well, and some cannot survive at all.

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across

multiple ecosystems.

HS-LS2-6 . Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems

maintain relatively consistent numbers and types of organisms in stable conditions, but changing

conditions may result in a new ecosystem.

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result

in: (1) increases in the number of individuals of some species, (2) the emergence of new species over

time, and (3) the extinction of other species.

### Common Core State Standards Connections:

**ELA/Literacy**

RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.

W.3.8 Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.

WHST.6-8.1 Write arguments to support claims with clear reasons and relevant evidence.

WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

SL.8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

SL.11-12.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

**Mathematics**

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

MP.5 Use appropriate tools strategically.

3.MD.B.3 Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in scaled bar graphs.

3.MD.B.4 Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters.

6.SP.B.5 Summarize numerical data sets in relation to their context.

HSS-IC.B.6 Evaluate reports based on data.

## Plant Families; Taxonomy and Field Guide Warm-up; Exploring your Site through Color, Pattern, and Texture; Geometry in Nature

**Purpose Statement (K-2):** We can use our observations about patterns in [plant]/[animal] forms to understand how different species fulfill their needs for [water and light]/[food], and how their structures can be inherited or due to the environment.


© Earth Partnership • University of Wisconsin-Madison

# APPENDIX A : National Education Standards

**Purpose Statement (3-5):** We can analyze different [plant]/[animal] forms to argue that many traits are inherited, and that species can be grouped into families based on patterns of how they're constructed to serve various essential functions.

**Purpose Statement (MS):** We can create an argument, based on our observations of morphology and scientific guides, about how certain [plant]/[animal] structures enable reproduction in a variety of ways.

**Purpose Statement (HS):** We can describe plant and animal structure as a way to model the idea that multicellular organisms have systems that build on each other and contribute to energy flow and growth.

## Disciplinary Component Ideas:

LS1.A: Structure and Function. How do the structures of organisms enable life's functions?

LS1.B: Growth and Development of Organisms. How do organisms grown and develop?

LS1.C: Organization for Matter and Energy Flow in Organisms. How do organisms obtain and use the matter and energy they need to live and grow?

LS3.A: Inheritance of Traits. How are the characteristics of one generation related to the previous generation?

LS3.B: Variation of Traits. Why do individuals of the same species vary in how they look, function, and behave ?

*Unit builds toward students meeting performance expectations:*

K-LS1-1. Use observations to describe patterns of what plants and animals (including humans) need to survive.

1-LS3-1. Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.

3-LS3-1. Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

## Common Core State Standards Connections:

**ELA/Literacy**

W.K.7 Participate in shared research and writing projects

W.1.7 Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions).

W.1.8 With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.

W.3.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

**Mathematics**

K.MD.A.2 Directly compare two objects with a measurable attribute in common, to see which object has “more of”/”-less of” the attribute, and describe the difference.

1.MD.A.1 Order three objects by length; compare the lengths of two objects indirectly by using a third object.

4.G.A.3 Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded across the line into matching parts. Identify line-symmetric figures and draw lines of symmetry.

## Creating an Underground Prairie

**Purpose Statement (3-5):** We can construct a model of a prairie root system to demonstrate that prairie roots are external structures adapted to meet the water and nutrients demands of the plant system.

**Purpose Statement (MS):** We can use our model of a root system to construct an explanation about how the environmental conditions of a prairie as well as evolution may influence a plant to grow a certain way.

### Disciplinary Component Ideas:

LS1.A: Structure and Function. How do the structures of organisms enable life’s functions?

LS1.B: Growth and Development of Organisms. How do organisms grow and develop?

*Unit builds toward students meeting performance expectations:*

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

### Common Core State Standards Connections:

**ELA/Literacy**

W.3.3; W.4.3; W.5.3; W.6.3; W.7.3; W.8.3. Write narratives to develop real or imagined experiences

## Waterdrop Journeys in the Water Cycle

**Purpose Statement (3-5):** We can develop a model that describes how water is present in oceans, glaciers, underground, surface bodies of water, and the atmosphere as a way of understanding the components and interactions in the water cycle.


© Earth Partnership • University of Wisconsin-Madison

# APPENDIX A : National Education Standards

**Purpose Statement (MS):** We can develop a model that describes how water cycles through Earth's major systems (including soil, water, air, and living organisms).

### Disciplinary Component Ideas:

ESS2.A: Earth Materials and Systems. How do Earth's major systems interact?

ESS2.C: The Roles of Water in Earth's Surface Processes. How do the properties and movements of water shape Earth's surface and affect its systems?

*Unit builds toward students meeting performance expectations:*

5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

### Common Core State Standards Connections:

**ELA/Literacy**

W.5.3. Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences.

SL.5.5. Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes.

SL.8.5. Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

WHST.6-8.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

## Water in the Watershed; Measuring Slope

**Purpose Statement (3-5):** We can measure the slope of our schoolyard to understand how that component will cause rainfall to move at a certain speed and affect the way water is filtered.

**Purpose Statement (MS - HS):** We can measure the slope of our restoration site, defining it as a design criterion since we understand the mechanical principles of water's movement, and we can use our findings to plan a layout for our restoration.

### Disciplinary Component Ideas:

ESS2.A: Earth Materials and Systems. How do Earth's major systems interact?

ETS1.A: Defining and Delimiting an Engineering Problem. What is a design for? What are the criteria and constraint of a successful solution?

ETS1.C: Optimizing the Design Solution. How can the various proposed design solutions be compared and improved?

*Unit builds toward students meeting performance expectations:*

4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

### Common Core State Standards Connections:

**ELA/Literacy**

RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

**Mathematics**

MP.2. Reason abstractly and quantitatively.

MP.4. Model with mathematics.

MP.5. Use appropriate tools strategically.

4.MD.A.1. Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table.

## Land History: Primary Sources, Literature, Oral History

**Purpose Statement (K-2):** We can ask questions and make observations about what a site used to be like, based on evidence gathered from texts and people from our community and elsewhere, to help us think about how a new design for the site could address environmental issues.

**Purpose Statement (3-5; MS):** We can identify criteria for and constraints on our restoration solution by researching what our site used to be like, and in the process, learning more about what environmental risks and societal needs can be addressed by the design.

**Purpose Statement (HS):** We can optimize a restoration design by generating questions about past ecosystems and land use on our restoration site, and by acquiring evidence from a variety of sources that will help formulate future design ideas.

### Disciplinary Component Ideas:

ETS1.A: Defining and Delimiting an Engineering Problem. What is a design for? What are the criteria and constraints of a successful solution?

ETS1.B: Developing Possible Solutions. What is the process for developing potential design solutions?

*Unit builds toward students meeting performance expectations:*

K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

 © Earth Partnership • University of Wisconsin-Madison

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

### Common Core State Standards Connections:

**ELA/Literacy**

RI.2.1. Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text.

RI.5.1. Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

RI.7 .1. Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.

RI.5.9. Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.

RST.6-8.1. Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.9. Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

W.2.6. With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers.

W.2.8. Recall information from experiences or gather information from provided sources to answer a question.

W.5.7. Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

W.5.8. Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

W.5.9. Draw evidence from literary or informational texts to support analysis, reflection, and research.

WHST.6-8.7. Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

WHST.6-8.8. Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

WHST.6-8.9. Draw evidence from informational texts to support analysis, reflection, and research.

SL.2.5. Create audio recordings of stories or poems; add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings.

## Follow the Drop

**Purpose Statement (3-5):** We can analyze stormwater runoff in our schoolyard by making observations about surface impermeability and how the flow of rainfall shapes our landscape – and vice versa. We can use this cause and effect information as we design a solution to slow down and filter storm water.

**Purpose Statement (MS):** We can study surface permeability and storm water runoff in our schoolyard, in order to understand how human developments such as lawns and pavement can cause erosion, pollution, and flooding. We can use this data as we begin to design a system for catching and filtering rainwater.

**Purpose Statement (HS):** We can investigate the mechanical properties of water by studying its ability to erode land surfaces and transport materials across our schoolyard, considering how we can apply our understanding of water's functionality to our design of a water catchment system.

### Disciplinary Component Ideas:

ESS2.A: Earth Materials and Systems. How do Earth's major systems interact?

ESS2.C: The Roles of Water in Earth's Surface Processes. How do the properties and movements of water shape Earth's surface and affect its systems?

ESS3.C: Human Impacts on Earth Systems. How do humans change the planet?

*Unit builds toward students meeting performance expectations:*

4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

### Common Core State Standards Connections:

**ELA/Literacy**

W.4.8; W.5.8. Recall relevant information from experiences or gather relevant information from print and digital sources

SL4.5; SL.5.5. Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes.

SL9-10.5; SL.11-12.5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

WHST.6-8.2. Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

WHST.6-8.7. Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

WHST.9-12.1. Write arguments focused on discipline-specific content.

WHST.9-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

**Mathematics**

MP.2. Reason abstractly and quantitatively.

MP.4. Model with mathematics.


© Earth Partnership • University of Wisconsin-Madison

4.MD.A.3. Apply the area and perimeter formulas for rectangles in real world and mathematical problems.

5.MD.C.5. Relate volume to the operations of multiplication and addition and solve real world and mathematical problems involving volume.

6.EE.B.6. Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.

7.EE.B.4. Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

HSN.Q.A.1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

HSN.Q.A.2. Define appropriate quantities for the purpose of descriptive modeling.

HSN.Q.A.3. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

## Water You Doing with Hydrology?

**See standards alignment for Follow the Drop*

### Additional Disciplinary Component Ideas addressed:

ETS1.A: Defining and Delimiting an Engineering Problem. What is a design for? What are the criteria and constraints of a successful solution?

ETS1.B: Developing Possible Solutions. What is the process for developing potential design solutions?

### Additional performance expectations built towards:

K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

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

## Noting Notable Features

**Purpose Statement (K-2):** We can look at the human impacts on our school grounds, assessing natural and human patterns, to construct an argument about where the best spots for a restoration would be.

**Purpose Statement (3-5):** We can make observations about the physical characteristics of our schoolyard and the elements that have caused them as we plan a restoration.

**Purpose Statement (MS):** We can assess how human activities and the use of technology, in addition to natural processes, have altered our schoolyard, applying scientific principles as we begin our restoration design.

# APPENDIX A : National Education Standards

**Purpose Statement (HS):** We can offer ideas for responsible management of our environment, presented through a model or simulation of current trends in our schoolyard (such as topography and how it affects the flow of water during a heavy rainfall).

### Disciplinary Component Ideas:

ESS2.E: Biogeology. How do living organisms alter Earth's processes and structures?

ESS3.C. Human Impacts on Earth Systems. How do humans change the planet?

*Unit builds toward students meeting performance expectations:*

K-ESS2-2. Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.

4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

### Common Core State Standards Connections:

**ELA/Literacy**

W.K.7; W.1.7; W.2.7. Participate in shared research and writing projects

W.K.8; W.1.8; W.2.8; W.3.8; W.4.8; W.5.8. Recall relevant information from experiences or gather relevant information from print and digital sources

**Mathematics**

MP.2. Reason abstractly and quantitatively.

MP.4 Model with mathematics.

MP.5. Use appropriate tools strategically.

K.MD.A.1. Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object.

K.MD.B.3. Classify objects into given categories; count the number of objects in each category and sort the categories by count.

## Soil Explorations; Identifying Your Soil

**Purpose Statement (K-2):** We can investigate soil patterns in our schoolyard, describing and classifying it into different types, suitable for different species of plants.

**Purpose Statement (3-5):** We can analyze a sample of our soil and describe its various components to show that matter is being cycled in our ecosystem.

**Purpose Statement (MS):** We can look at the patterns of nutrient cycling in our soil to predict the best strategy for planting and managing our area.

**Purpose Statement (HS):** We can use our analysis of soil as we design our restoration solution, selecting plants that will promote biodiversity and groundwater recharge and ameliorate harmful anthropogenic changes.


© Earth Partnership • University of Wisconsin-Madison

# APPENDIX A : National Education Standards

### Disciplinary Component Ideas:

PS1.A. Structures and Properties of Matter. How do particles combine to form the variety of matter one observes?

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems. How do matter and energy move through an ecosystem?

LS2.C: Ecosystem Dynamics, Functioning, and Resilience. What happens to ecosystems when the environment changes?

*Unit builds toward students meeting performance expectations:*

2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.

4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

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

### Common Core State Standards Connections:

**Mathematics**

4.MD.B. Represent and interpret data

5.MD.B. Represent and interpret data

6.SP.B.4. Summarize and describe distributions.

7.SP.A. Use random sampling to draw inferences about a population.

## Infiltration Tests: Exploring the Flow of Water through Soils

**Purpose Statement (3-5):** We can make observations about the rate of water absorption on our school grounds and use that as a basis for explaining how rainfall can cause harmful effects like flooding and erosion.

**Purpose Statement (MS-HS):** We can identify criteria, like soil type, that is important for developing successful restorations and ensure that our design takes into account our scientific findings.

### Disciplinary Component Ideas:

ESS2.A: Earth Materials and Systems. How do Earth's major systems interact?

ETS1.A: Defining and Delimiting an Engineering Problem. What is a design for? What are the criteria and constraints of a successful solution?

*Unit builds toward students meeting performance expectations:*

4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

HS-ETS1-1. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

### Common Core State Standards Connections:

**Mathematics**

MP.2. Reason abstractly and quantitatively.

MP.4. Model with mathematics.

MP.5. Use appropriate tools strategically.

5.MD.C.3. Recognize volume as an attribute of solid figures and understand concepts of volume measurement.

6.RP.A.3. Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.

7.G.B.4. Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle.

8.G.C.9. Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems.

## Designing a Habitat Restoration

**Purpose Statement (3-5; MS; HS):** We can use the results from our site testing to generate restoration designs, communicating with our peers to compile the best elements that will improve ecological conditions in our schoolyard.

### Disciplinary Component Ideas:

ETS1.B: Developing Possible Solutions. What is the process for developing potential design solutions?

ETS1.C: Optimizing the Design Solution. How can the various proposed design solutions be compared and improved?

*Unit builds toward students meeting performance expectations:*

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

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

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

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

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

### Common Core State Standards Connections:

**ELA/Literacy**


© Earth Partnership • University of Wisconsin-Madison

SL.3.1.; SL.4.1; SL.5.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 3/4/5 topics and texts, building on others' ideas and expressing their own clearly.

RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

**Mathematics**

MP.2. Reason abstractly and quantitatively.

MP.5. Use appropriate tools strategically.

HSN.Q.A.1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

## Species Selection

**Purpose Statement (3-5):** We can use our research about the needs of various plant species in order to determine which planting design will contribute to the healthiest ecological interactions in our schoolyard.

**Purpose Statement (MS; HS):** We can divide into teams to systematically select planting designs based on needs and ecological relationships, taking into account a wide range of ecological, aesthetic, and educational considerations.

### Disciplinary Component Ideas:

ETS1.B: Developing Possible Solutions. What is the process for developing potential design solutions?

LS2.A: Interdependent Relationships in Ecosystems. How do organisms interact with the living and nonliving environments to obtain matter and energy?

LS2.C: Ecosystem Dynamics, Functioning, and Resilience. What happens to ecosystems when the environment changes?

*Unit builds toward students meeting performance expectations:*

3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

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

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

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

# APPENDIX A : National Education Standards

### Common Core State Standards Connections:

**ELA/Literacy**

SL.3.1; SL.4.1; SL.5.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 3/4/5 topics and texts, building on others' ideas and expressing their own clearly.

SL.6.1; SL.7.1; SL.8.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6/7/8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

SL.9-10.1; SL.11-12.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9-10/11-12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.

SL.9-10.2. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, orally) evaluating the credibility and accuracy of each source.

## What's a Square Foot Anyway?

**Purpose Statement (3-5; MS; HS):** We can consider our soil type and slope criteria, as well as human and aesthetic interests, as we lay out our restoration design.

### Disciplinary Component Ideas:

ETS1.A: Defining and Delimiting an Engineering Problem. What is a design for? What are the criteria and constraints of a successful solution?

*Unit builds toward students meeting performance expectations:*

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

### Common Core State Standards Connections:

**Mathematics**

MP.2. Reason abstractly and quantitatively.

MP.4. Model with mathematics.

MP.5. Use appropriate tools strategically.

4.MD.A.1. Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table.

7.EE.3. Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

## Managing Your Restoration

**Purpose Statement (K-2; 3-5):** We can use our observations of plant structures and our knowledge of what plant systems need to survive as we make decisions about planting maintenance, including weeding, watering, mulching, and removing dead plant material.

**Purpose Statement (MS, HS):** We can apply scientific principles regarding plant needs and the ecosystem services that they provide as we make management decisions (regarding weeding, watering, mulching, etc.) about our restoration to reduce harmful impacts of human activity on the landscape.

### Disciplinary Component Ideas:

LS1.A: Structure and Function. How do the structures of organisms enable life's functions?

LS1.C: Organization for Matter and Energy Flow in Organisms. How do organisms obtain and use the matter and energy they need to live and grow?

ESS3.C: Human Impacts on Earth Systems. How do humans change the planet?

ETS1.C: Optimizing the Design Solution. How can the various proposed design solutions be compared and improved?

*Unit builds toward students meeting performance expectations:*

K-LS1-1. Use observations to describe patterns of what plants and animals (including humans) need to survive.

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

### Common Core State Standards Connections:

**ELA/Literacy**

W.3.8; W.4.8; W.5.8. Recall relevant information from experiences or gather relevant information from print and digital sources

WHST.6-8.1 Write arguments to support claims with clear reasons and relevant evidence.

W.9-10.2; W.11-12.2. Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.

**Mathematics**

MP.5. Use appropriate tools strategically.

4.MD.A.1. Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec.

## Planting a Restoration

**Purpose Statement (K-2; 3-5):** We can use our observations of plant structures and our knowledge of what plant systems need to survive as we make decisions about planting depth, sun exposure, and moisture level.

**Purpose Statement (MS, HS):** We can apply scientific principles regarding plant needs (such as soil depth for root growth, sunlight, and water) and the ecosystem services that they provide as we design and implement a restoration to reduce harmful impacts of human activity on the landscape.

### Disciplinary Component Ideas:

LS1.A: Structure and Function. How do the structures of organisms enable life's functions?

LS1.C: Organization for Matter and Energy Flow in Organisms. How do organisms obtain and use the matter and energy they need to live and grow?

ESS3.C: Human Impacts on Earth Systems. How do humans change the planet?

ETS1.C: Optimizing the Design Solution. How can the various proposed design solutions be compared and improved?

*Unit builds toward students meeting performance expectations:*

K-LS1-1. Use observations to describe patterns of what plants and animals (including humans) need to survive.

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

### Common Core State Standards Connections:

**ELA/Literacy**

W.3.8; W.4.8; W.5.8. Recall relevant information from experiences or gather relevant information from print and digital sources

WHST.6-8.1 Write arguments to support claims with clear reasons and relevant evidence.

W.9-10.2; W.11-12.2. Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.

**Mathematics**

MP.5. Use appropriate tools strategically.

4.MD.A.1. Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec.

## Weed Cards

**See standards alignment for Plant Families/Taxonomy*

### Additional Disciplinary Component Ideas addressed:

ETS1.A: Defining and Delimiting an Engineering Problem. What is a design for? What are the criteria and constraints of a successful solution?

ETS1.B: Developing Possible Solutions. What is the process for developing potential design solutions?



© Earth Partnership • University of Wisconsin-Madison

### Additional performance expectations built towards:

K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

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

## Insect Charades; Pollination Observations

**Purpose Statement (3-5; MS):** We can study interactions between pollinators and plants to determine how the two depend on each other for food and reproduction, constructing a model of pollination data to illustrate the different types of pollinator-plant relationships.

**Purpose Statement (HS):** We can disseminate information that we've learned about the importance of pollinators and actions that can be taken to protect them (for instance, designing a native garden or reducing the use of certain pesticides), taking into account diverse human and nonhuman considerations when considering how to frame our argument.

### Disciplinary Component Ideas:

LS1.B: Growth and Development of Organisms. How do organisms grow and develop?

LS2.A: Interdependent Relationships in Ecosystems. How do organisms interact with the living and nonliving environments to obtain matter and energy?

ETS1.B: Developing Possible Solutions. What is the process for developing potential design solutions?

*Unit builds toward students meeting performance expectations:*

5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.

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

### Common Core State Standards Connections:

**ELA/Literacy**

W.3.3; W.4.3; W.5.3. Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences.

W.9-10.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

RI.4.7. Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.

RI.5.7. Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.

SL.3.5; SL.4.5; SL.5.5. Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes.

WHST.6-8.2. Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

WHST.9-10.1; WHST.11-12.1 Write arguments focused on discipline-specific content.

RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

**Mathematics**

3.MD.B.3. Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in scaled bar graphs.

MP.4. Model with mathematics.


© Earth Partnership • University of Wisconsin-Madison

# APPENDIX B: Equitable Opportunities for English Language Learners

## *Introduction: Offering Equitable Opportunities for English Language Learners to Engage in Science*

**Author: Emily Miller**

***Earth Partnership Curriculum is responsive for all students and aligned to the NGSS***

**The units within the Earth Partnership curriculum are aligned to the NGSS.** Scientists and engineers explain and predict natural phenomena and solve problems in the natural and design world and the NGSS is modeled on their practices, ideas and world views. The NGSS advances the idea that all students can learn science by engaging with phenomena and participating in the science practices in an authentic way. Earth Partnership adopts this conceptual framework and engages students in meaningful learning experiences that mirrors real world application and prepares students for college, career and community.

*Earth Partnership curriculum leads students through the real world problem solving and science practices that landscape designers must employ. They learn to survey, plan, design and create a restoration to solve storm water issues. The lessons also walk students through the steps of community outreach and collaboration.*

**Earth Partnership is accessible to English Language Learners (ELLs), promotes equitable opportunities for students learning English and science simultaneously and is culturally and linguistically responsive.** Earth Partnership is a place-based curriculum which contextualizes all experiences in the local environment. It is place-based because it is interdisciplinary, draws on community resources and provides for the students to invest in their local ecology and for the community, in turn, to invest in the students. The curriculum draws on students' "Funds of Knowledge" and is culturally and linguistically responsive. One critical principle of culturally responsive pedagogy is socio-political action which is embedded within the Earth Partnership curriculum. This Earth Stewardship pedagogical stance is fundamental to the Earth Partnership program. The curriculum involves students in community-based problem solving through restoration projects, engineering projects (e.g., planning and creating a restoration) and actions that promote biodiversity, among others.

*The Earth Partnership Woodland Curriculum Sampler involves students in the community action of habitat restoration. While participating in caring for a community woodland, students build understanding of the steps that forest ecologists undertake while developing a restoration plan.*

The NGSS are more rigorous than Wisconsin Model Academic standards and require language intensive practices to engage in three dimensional learning – the blending of core ideas, science and engineering practices and crosscutting concepts.

**Earth Partnership integrates the three components of NGSS that are the most exciting for ELLs.** These are: The use of crosscutting concepts, engineering, and the science and engineering practice of modeling.

### Crosscutting concepts:

Scientists observe phenomena in the natural world through a specific (scientific) lens that can be taught to students through the use of crosscutting concepts. These are implicit ideas that scientists use across settings but have been invisible to students. Often these crosscutting ideas are acquired intuitively after many experiences in science, but they may never be without explicit teaching. Now with NGSS, the teacher may drive the lesson and/or unit with the crosscutting concept in mind. For example, when a child observes the ice caves of Wisconsin, they might say, "wow, that's amazing!" and observe the "magical" features of the caves, the dark stone, the ice tendrils fused together in caves formed in the bedrock. However, a scientist would approach the phenomenon differently, their lens inspiring different types of questions: "Where I have I seen something similar to the ices caves, and under what conditions are they formed (crosscutting concept - patterns)?" Or they might wonder, "What is it about the molecular structure of water that cause these to be formed this way (crosscutting concept structure and function)?" Another aspect a scientist might consider is the entire system involved - the weather changes and climate specifics that interacted with the earth and water to form the ice caves (crosscutting concept - systems and systems models).

*Crosscutting concepts and ELLs:*

Crosscutting concepts can be places explicitly in the driving question. They should form the framing of the experience of the phenomenon and the approach for the entire unit.

Crosscutting concepts provide a repeated structure of language support because they can occur repeatedly throughout the year, across science disciplines. The ELLs will be supported in understanding through employing the same language, discourse and vocabulary with which to approach making sense of science every time they recognize a familiar crosscutting concept. ELLs can be explained the continuity of the crosscutting concepts, even across the school day, and use tools – conceptual webs, picture dictionary, purposeful, guided lessons, to gain more access to the science content and participate in collaborative sense making.

## Modeling

Developing models is an active process that the student takes part in and progress in ability across the years. Models can be drawings, graphs, diagrams, objects, etc. that are student created and are "close read" and revised as new evidence comes to light. They must show relationships between variables, have a causal mechanism and not just show, but predict or explain phenomenon. The model serves as a student- centered, often conceptual or abstract explanation of their own understanding of the phenomenon. It can provide valuable insight for the teacher as to next steps and how to appropriately build learning and progress the lesson.

*Modeling and ELLs:*

The NGSS practice of developing and using models should be incorporated into every lesson that is designed with ELLs in mind.

For ELLs, the evolving model can serves as a language scaffold supporting the students' communication of ideas with peers, as well as their ability to comprehend the students' message. Not only is the student more determined to learn the vocabulary of the components in their model that they have deemed important to describe and predict the phenomenon, they also have a developing, often pictorial description of how they make sense of the science, which can enable receptive and productive language and thus aid in meaning making between students. The conceptual model can become the conduit for other science and engineering practices, the students can engage in argument about why they should revise their model in a certain way, or ensure that the patterns they observed in the data are represented in the model.

Modeling Provides For:

1) Authentic and meaningful discourse around complex science ideas

2) Student-centered language scaffold

3) Avenue for engagement with other science and engineering practices

4) Assessment opportunity for ELLs

## Developing explanations

Another NGSS practice that involves complex language, and offers more equitable learning opportunity for ELLs, is constructing explanations and designing solutions. The scientific explanation involves a claim about the phenomenon under study, evidence (reason for making the claim), and reasoning, the logical connection between the claim and the evidence. This complete explanation represents a structure of English language that needs to be taught to all students, and one that all students (ELLs and non-ELLs) struggle to produce. This is a practice that mirrors how engineers and scientists produce discourse, insisting with each other that claims are backed logically and make use of the evidence accurately. Developing solutions in engineering similarly relies on generating ideas as well as language and makes use of the evidence collected. To engage in this practice, the student needs to take all of the information that they have encountered about the natural problem and design the best solution, keeping in mind the constraints of the problem.

*Developing explanations and designing solutions and ELLs:*

 © Earth Partnership • University of Wisconsin-Madison

# APPENDIX B: Equitable Opportunities for English Language Learners

Developing explanations and designing solutions can leverage ELL discourse in an authentic context that involves engaging with the scientific phenomenon and making sense of the phenomenon.

This science and engineering practice makes use of general science understanding, creativity and language, and can be scaffolded so that is an arena where ELLs shine and genuinely contribute to the overall discussion. ELL students can be supported to develop explanations by having the template Claims-Evidence-Reasoning remain unchanged so that the ELL can expect the same structure and participate in high level thinking. One way to support students in developing explanations is through the use of an "Evidence Wall", with pictures and drawings to provide a way for students to locate and use the language they need for their C-E-R. In addition, the constant use of the student-created conceptual models can be leveraged to support meaning making and reliance on use of evidence. Non-ELLs do not have the corner on abstract thought and creative ideas, and with purposeful, "planfull" lesson design, ELLs have an arena to demonstrate their capacity in science.

## Engineering

Engineering, according to NGSS, is applied science. Students must use the core ideas that they learned in the unit to solve an engineering problem based on real-world problems in the natural or designed world. Engineering has specific practices that correspond, but are not the same as, the science practices in NGSS. Engineering can be used to set the context for science learning, or as an assessment of the students understanding of science ideas. For example, the teacher could set up a problem on the sand table that mimics a city being flooded and pose the problem of developing a solution that would keep the city safe. The students would then need to go about developing the required knowledge about the way water moves over the land to solve the problem. They would end the unit with the student developing and refining their solutions. The other way to introduce engineering is at the end of the unit. In the earlier example, the students would learn about water and how it travels over land. The teacher could assess their understanding by posing the problem of the city being flooded and then see if the students' solution showed comprehension of the disciplinary care ideas.

*Engineering and ELLs:*

Engineering provides a relevant context for ELLs to connect between their real- world knowledge and school science.

ELLs can demonstrate an understanding of ideas through their solutions and engineering, being extended more than one avenue to grapple with complex ideas and demonstrate science mastery. Also, engineering is another opportunity for students to use the discipline specific and general language involved in the disciplinary core ideas. This repeated experience of ideas through application generates flexible, creative thinking in a highly engaging setting, without a new barrage of required language. Finally, engineering is the perfect context for collaborative grouping and is an avenue for authentic discourse that involves academic language.

## Possible lesson template for ELL inclusion

An ideal lesson template for ELL inclusion incorporates many opportunities for ELLs to engage in all of the high leverage language and complex thinking tasks. Within each step, strategies for ELLs are incorporated appropriately to meet content and language objectives:

**1. Experience phenomenon** – Driving Question

Develop a Model – Literacy connection: *Explain relationships and causal mechanisms*

Investigate Phenomenon – New evidence

**2. Revise model** – Literacy Connection: Argue for revision

Investigate Phenomenon – Collaborative Research

**3. Revise model based on research**

**4. Engineering connection**

Assessment: *Model and Use evidence to Explain Optimal Design of Engineering*

Earth Partnership, aligned to the NGSS, offers opportunities for equitable learning opportunities for ELLs in science class and beyond. Earth Partnership presents research-based strategies for English Language Learners that provide access to the science learning and acquiring the language of science in English. These strategies are highlighted in Earth Partnership resources, to support teachers in meeting students' needs at all levels of acquisition.

## Sample: Strategies for English Language Learners in Science

### LITERACY STRATEGIES

Literacy strategies clarify and unpack the structure of texts, graphs and scientific genres of writing. With literacy strategies, ELLs are prompted and supported in accessing academic language.

EXAMPLES:

teaching the uses of graphic organizers; reading trade books or literature with scientific themes; language functions: describe, explain, predict, infer, conclude; concept map, word wall, Venn diagram; science journal; activating prior knowledge

### LANGUAGE SUPPORT STRATEGIES

Language support strategies are often referred to as ESOL strategies that support the development of language, structures and new vocabulary (academic and non-academic) in the science classroom.

EXAMPLES:

hands-on activities; realia (real objects or events); multiple modes of representation (gestural, oral, pictorial, graphic, textual); presentation of key science vocabulary in context – both general academic terms and discipline specific terms

### DISCOURSE STRATEGIES

Discourse strategies involve tools and protocols that enable student-to-student communication to promote authentic sense-making in academic contexts.

EXAMPLES:

expertise groups (jigsaw); purposeful turn and talk; monitoring tone and speed of speech; collaborative group protocols and roles

### HOME LANGUAGE SUPPORT

This strategy involves building on and making use of students' home language to support science learning in English. It includes teaching students how to create linguistic and cultural bridges between school science and the home to capitalize on emerging bilingualism.

EXAMPLES:

introduce key science terminology in both languages; making contrasts explicit (use of language as well as words and structures); highlight cognates as well as false cognates in both languages; allow code-switching opportunities for bilingual communication in the classroom

### HOME CULTURE CONNECTIONS

Students have historical, socio-cultural and community based "ways of knowing" and making sense of science. These


© Earth Partnership • University of Wisconsin-Madison

connections allow teachers to access and build on the assets which the students bring from their homes, communities and locally-based natural settings.

EXAMPLES:

students' cultural artifacts community resources (e.g., local scientist); place-based; socio-political action; funds of knowledge (a passed down family skill); conceptual web; allowing code-switching

**Sources: Miller, 2013, NGSS case studies for ELLs; Fathman & Crowther 2006; Lee & Buxton, 2013; Rosebery & Warren 2008*

## Example: Botany Bouquet

### LITERACY STRATEGIES

Observe a diagram of the plant in a field guide.

Determine in groups, or in large group, how you can use arrows and labels to help identify the parts of the plant, and the specialized structures that the plant has in common with others of the same species.

### LANGUAGE SUPPORT STRATEGIES

Photos of plants, and the actual plants (realia, or the actual object or event) embedded within the lesson provide language support. Practice saying the words out loud and quizzing each other in the names, or matching the written word with the photo. One student can describe one of the plants and the other has to guess which one they are describing.

### DISCOURSE STRATEGIES

Mix up students so that they are partnering with non-group members. Place the cards with photos in front of the students. Have them describe their plant to their partner to see if their partner can guess which one they are describing.

### HOME LANGUAGE SUPPORT

Analyze the Latin names for the species. Do they look like words in Spanish? What are some clues from Spanish you can use to identify which plant has which Latin name?

### HOME CULTURE CONNECTIONS

After investigating and getting to know the plant(s) well, ask a gardener in the community about the human uses for the plant. Are there different uses discovered when more gardeners are consulted?

E