earth partnership

Pollinator Habitat Guide

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

Pollinator Habitat Guide

A Publication of

earth partnership

University of Wisconsin-Madison

2018

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UNIVERSITY OF WISCONSIN–MADISON

Based on the original Earth Partnership curriculum

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Technical advising also provided by:
Taylor Creek Restoration Nurseries, Inc. and Pheasants Forever

Sponsors:

Development of the original 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

Earth Partnership Mission

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

Earth Partnership 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 (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.

The original Earth Partnership curriculum follows a 10-step process (see diagram on following 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.

This guide is a companion guide that focuses on pollinator habitat restoration; other companion guides and activities focus on woodland restoration, water stewardship, rain gardens, 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: go.wisc.edu/b02p69

Visit Us at: www.earthpartnership.wisc.edu earth partnership

10 Restoration Education Steps

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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

Contents

Pollinators: An Ecological Partner in Peril

A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community.
It is wrong when it tends otherwise.

~ Aldo Leopold, "The Land Ethic" (1949)

A bee in search of food approaches a plant, lured by the bright colors of its blossoms and tantalizing aroma. The bee lands on a flower, and as it consumes the plant's nectar, its hairy body becomes coated in pollen from the plant's stamens (male reproductive part). Momentarily satisfied, the bee departs the plant but is soon in search of food again. When the bee finds another plant to feed on, the pollen that is stuck to this flying feeder rubs against the stigma (female reproductive part) of the flower. This contact makes fertilization between plants possible, and the opportunity for the flower to become a seed-bearing fruit is born.

Bees are just one example of pollinators. Butterflies, hummingbirds, flies, bats, and spiders are just some of the many animals that help aid plant fertilization. Some native plants - or plants "in the wild" - depend on animal pollination, as do many of our food crops. In fact, over seventy-five percent of all flowering plants are pollinated by animals (wind is the other main mechanism for pollination). Without animal pollinators, there would be a drastic loss of food for humans and wildlife alike. From almonds to blueberries, to alfalfa to sunflowers, many of our food crops would suffer or even disappear without pollinators. And for wildlife that consumes fruits, seeds, and the pollinators themselves, the loss of these animals would be a staggering ecological blow.

Pollinators face a variety of threats, ranging from climate change to disease to pesticides, and native pollinators are particularly vulnerable to the loss of suitable habitat. Pollinators, like all animals, need shelter, water, and food sources to survive. Native pollinators often require certain habitat conditions such as deadwood or undisturbed ground for nesting, host plants for laying eggs, and a diversity of wildflowers to provide meals of nectar and pollen.

Healthy habitat is critical to support healthy populations of pollinators. Some examples of threats to diversity include:

- Urbanization and habitat fragmentation
- Reduced crop diversity and fewer habitat areas on agricultural lands
- Loss of native plants and increase of hybridized and invasive species

In order to help pollinators rebound and thrive, we must create and maintain niches of ecological diversity in urban, suburban, and rural settings.

Native Plants: A Natural Fit for Pollinators

There are many different approaches to habitat restoration, and you'll see different ones outlined in this guide. The common element between all these approaches is emphasizing the use of native plants. By definition, native plants have grown in an area for a long time, and they have adapted to the particular conditions of their ecosystem. That long period of adaptation also means that the plants have co-evolved with other organisms. In the case of pollinators, that means that while plants have adapted to reproduce via animal pollination, pollinators have also adapted to gain sustenance and shelter from those plants. Thousands of years of growing and changing alongside one another has resulted in a mutually beneficial ecological relationship for both plant and pollinator. For example, the long bills of hummingbirds are adapted for feeding in the tubular flowers of columbine, and bees' preference for bilateral symmetry and blues and yellows leads them to a plant such as lupine.

The pollinator habitat restoration detailed in this guide is intentionally designed to support native pollinators. Currently, there is a great deal of attention on the decline of European honeybees, which poses a big threat to many of our food crops. Honeybees (who live in wax hives) are important pollinators, but they mainly pollinate agricultural crops, not native plants. Native bees pollinate native plants as well as agricultural crops. When blossoms are scarce, honeybees can actually compete with native bees for food. This is one of the reasons why it is so important to have landscapes covered with a wide variety of flowering plants, including native blooms. Rather than pitting pollinators against one another in a fight for survival, we can create abundant habitat for all varieties, so that humans and wildlife have enough food and can thrive in diverse, healthy ecosystems.

Who Can Help?

There is no single solution to the threats facing pollinators, but there is a silver lining to the complexity of the issue, which is that people of all ages, communities, and professions can help! Small actions, if taken by enough people, can have a meaningful impact. Dr. Karen Oberhauser, former director of the Monarch Lab at the University of Minnesota and current director of the UW-Madison Arboretum, has called for an "all hands on deck" approach to conservation. In the case of the monarch butterfly, she estimates that in order to sustain the population, every person in the U.S. would need to plant three milkweed plants (the host plant for the monarch caterpillar). The current deficit of milkweed is very serious, but if the planting is spread over many people and places, it seems like a much more manageable challenge.

Schools

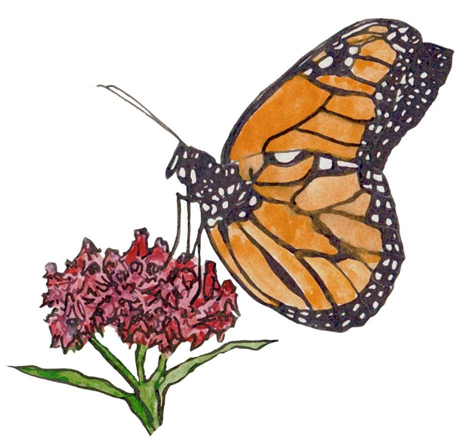
Making people aware of the opportunities to help is very important, and schools are a place for children, their families, and the entire community to learn about environmental issues and take action together. From population monitoring to creating outreach materials to planting native plants, studying and aiding pollinators provides important learning opportunities across grade levels and discipline. And whether in urban, suburban, and rural settings, there is a way for schools to support pollinator habitat.

Schools with large enough schoolyards can support native pollinators by planting native plant gardens or restoration sites that also serve as outdoor classrooms and community gathering areas. Schools with little or no outdoor grounds can grow native seedlings in the classroom to be grown in demonstration planters or distributed among families or community members. Rural schools may have special capacity for connecting with area farmers for knowledge exchange about pollinators and farming, and a chance for students to experience pollinator-friendly agricultural practices firsthand.

Connecting to the Community

What educators and students learn about pollinator habitat in school is relevant for the larger community. Stakeholders who are in a position to help pollinators include homeowners, businesses, municipalities, faith groups, public officials, and farmers. Farmers are a particularly important partner in the fight to save pollinators. Pollinators are essential to crop production, and native pollinators in particular can provide important services when (as is often the case nowadays) honeybees and other introduced pollinators become scarce. Many farmers are also interested in supporting ecological conservation on their farms, and some are eligible for financial incentives provided by public and private sources for managing wildlife habitat.

The habitat restoration strategies outlined in this guide can be used by anyone, as it involves a coherent learning process through restoration that includes studying your site, planning a design, growing and planting native plants, and saving seed for future plantings. Farmers can help support native pollinators by diversifying crops and practicing integrated pest management, in addition to restoring habitat in non-cropped areas. Students can learn about and do restoration as well as explore additional practices with farmers, natural resource professionals, and other stakeholders. This cooperative approach should be mutually beneficial to all involved - students have more hands-on learning experiences, farmers have increased potential for crop yields and ecological health on their farms, and multiple individuals in the school-family-community relationship develop a greater awareness of pollinators and how to protect them.



Pollinator Botany Bouquet

Activity Overview
A warm-up activity which introduces various plant species that support native pollinators 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 with pollinator associations that grow (or will grow) on your school ground and nearby natural areas

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 and indigenous languages such as 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.

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.

NECTAR NOTES

According to Robin Wall Kimmerer, a botanist, author, and enrolled member of the Citizen Potawatomi Nation:

Latin names we give [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.

from Gathering Moss: A Natural and Cultural History of Mosses (2003). OSU Press.

Consider Kimmerer's quote and discuss what you think is important about giving plants names. Do you feel differently towards plants when you have a name for them?

For example, 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 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."

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.

The following activity will help students understand different naming processes and familiarize them with the diversity, unique attributes and relationships of species they plant in pollinator-friendly 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. It also is a good primer for considering plant morphology and pollinator associations.

Pre-Activity Preparation

Prepare a bouquet of plant species that are pollinated by native pollinators. You will need multiple samples of plants from a handful of different species. The number of samples of each species should equal approximately a third to a quarter of the total number of students in your group. 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 your plant in hand, find other students who have the same plant and form a small group. If you don't know the other students, introduce yourselves to one another.
4. In your small group, come up with a creative description of your plant based on your close observations. Try to describe it in a way that would help others identify the plant. Use your observations of touch and smell in addition to sight. What pollinator(s) do you think might be attracted to this plant?
5. Considering all the observations that you have made, come up with a creative name for your plant.
6. At this point, have representative(s) from each group present their plant's creative name and description. Can you or someone in your group 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 (including pollinator associations) of each plant.

Educators examining plants during Botany Bouquet at a Latino Earth Partnership institute in Madison, WI.

Extensions

- Visit the library to further research the plants used in this activity, their habitat preferences, the pollinators they attract, 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.
- 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), and the root words of the plant's scientific name.

Assessment Ideas

- 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.
- Explain Carl Linnaeus's naming system to describe a given species. What are the advantages of this system? How does it compare to other ways of naming species?
- Based on your observations of plants, how do they differ structurally from one another? What are the advantages for these differences?

Taxonomy and Field Guide Warm-Up

Activity Overview
Students learn about plant parts in preparation for using 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

Subjects Covered
Science

Grades
2 through 12

Activity Time
50 minutes per part

Season
Any (plants collected during growing season)

Materials
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 understand the cultural needs of plants and 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, gain familiarity with vocabulary used in plant identification, and begin to understand how plant structures are involved in pollination.

Pre-Activity Preparation

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.

Some educators have made reusable specimen cards by covering leaves/plant parts with packing tape on index cards. Instead of collecting and saving plants, others do guided/directed drawing of plant parts.

Activity Description

Learning about plant parts

1. As a class, review plant parts, leaves, and flowers using samples 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.

Taxonomy and Field Guide Warm-Up (cont.)

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

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.

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" (K-12 Guide) 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.

Assessment Ideas

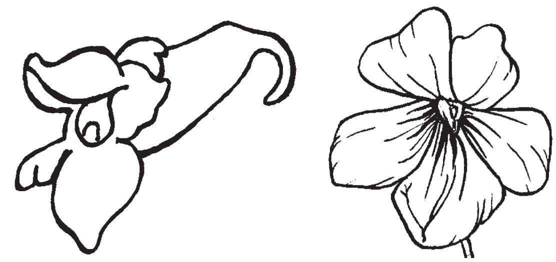
- Describe a plant using botanical terms.
- Using a plant specimen, describe how pollination occurs in that plant, employing specific vocabulary.
- Identify three specimens using a field guide.

Taxonomy Treasure Hunt

1. Flower Types

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

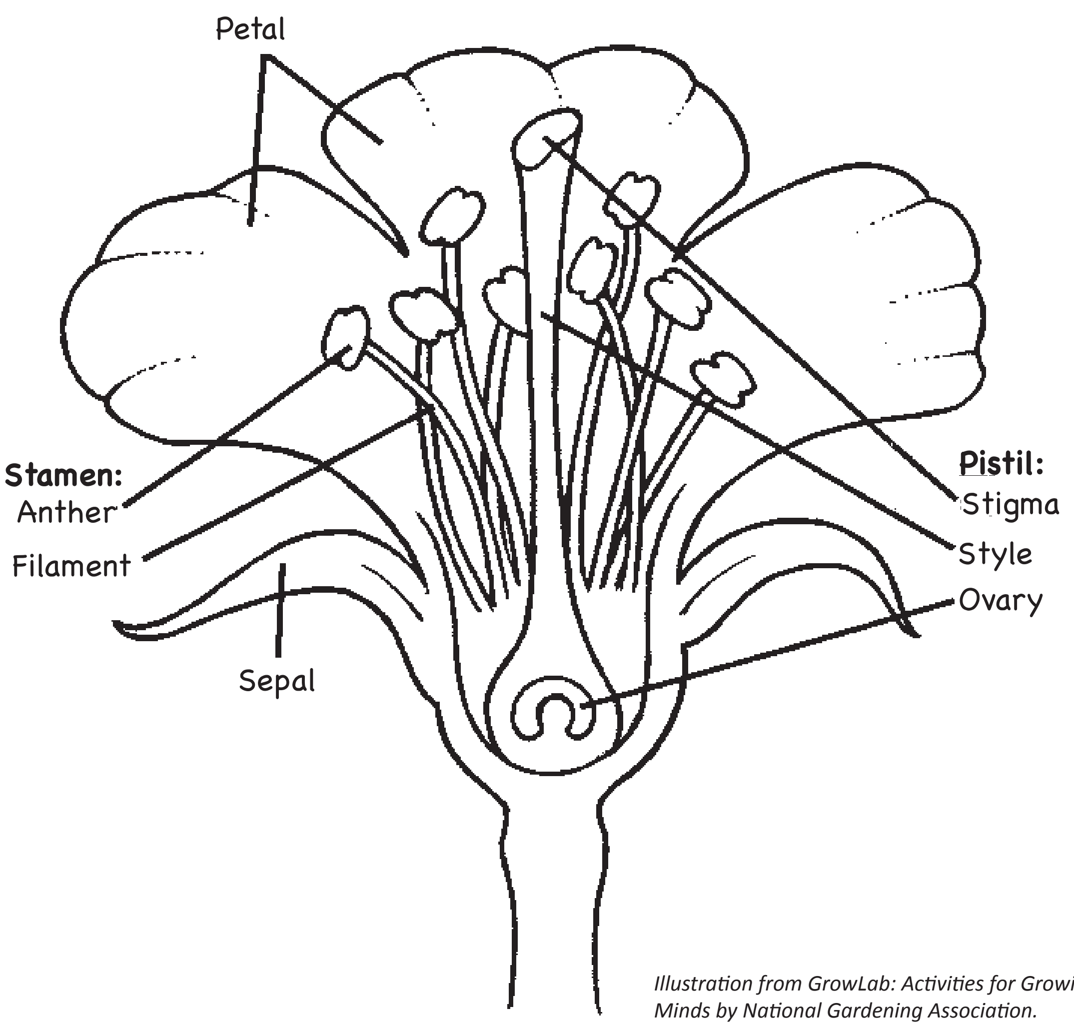
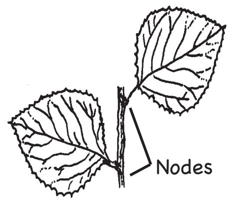


Illustration from GrowLab: Activities for Growing Minds by National Gardening Association.

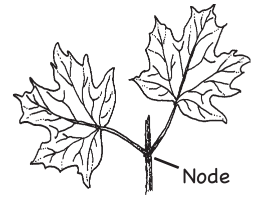
Taxonomy Treasure Hunt

2. Plant Types (Leaf Arrangement)

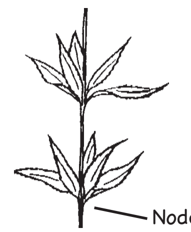
Basal



Alternate
(one leaf at each node)

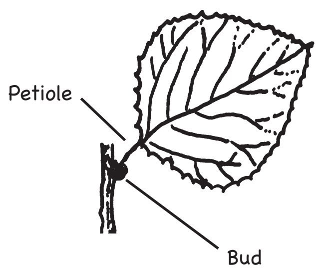


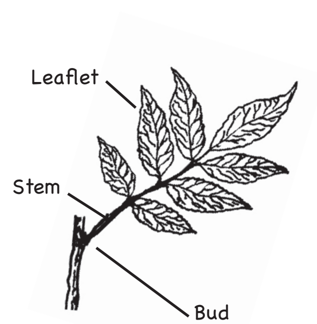
Opposite
(two leaves at each node)



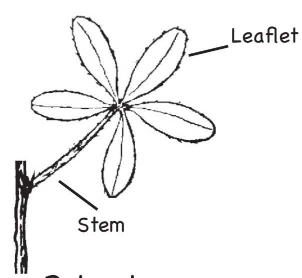
Whorled
(more than two leaves at each node)

3. Leaf Types





Pinnate

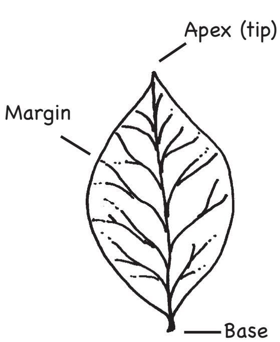


Palmate

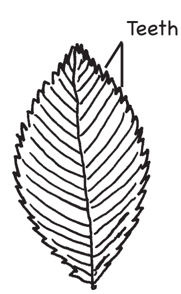
Simple

Divided or Compound

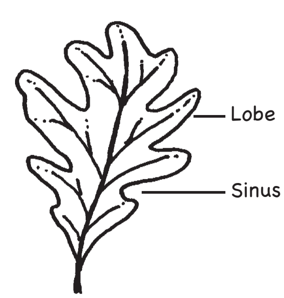
4. Leaf Margins



Entire
(smooth)



Toothed
(serrated)



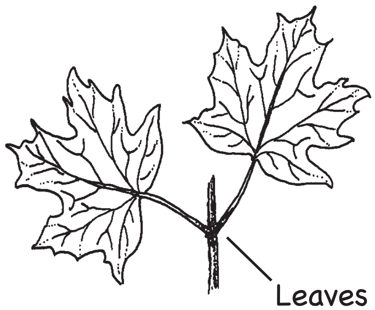
Lobed

Taxonomy Treasure Hunt

Find a plant in flower. 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). OR Find a leaf with lobes. Draw and label. Common name______________________ Scientific name_____________________
Find a plant in flower. What color is the flower? _________________________________ What is the leaf arrangement? _________________________________ How tall is the plant? (estimate) _________________________________ Common name______________________ Scientific name_____________________	Draw and label the plant using taxonomic names.

Taxonomy Treasure Hunt

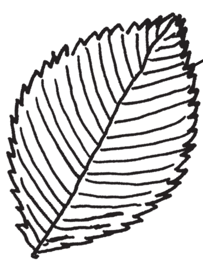
Find a plant with two leaves that meet at the stem.



These are **opposite** leaves.

Draw a plant with opposite leaves here.

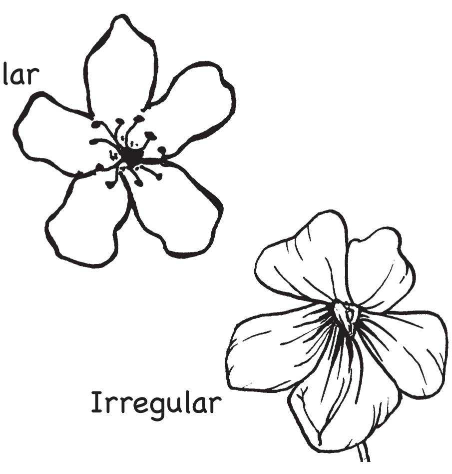
Find a plant that has leaves with teeth along the edge.



This leaf is **toothed or serrated**.

Draw a plant with toothed leaves here.

Find a plant with flowers.



Draw and describe a flower.

More or Less: Impacts of Habitat Restoration

Activity Overview
Students explore the wide range of benefits possible with pollinator habitat restoration

Objectives
- Understand ecological, agricultural, and cultural impacts from restoration action
- Understand that small pro-environmental actions can have ripple effects throughout the ecosystem and community
- Create cause-and-effect arguments

Subjects Covered
Language Arts

Grades
MS and HS

Activity Time
45 mins

Season - Any

Materials
"More or Less - Pollinator" printed cards

Source
Used with the permission of Community+Climate+Action. Based on Visualizing Changes, an activity in the Great Lakes Curriculum developed by Ohio State Sea Grant.

The original activity is a great complement to this one; find it at http://changingclimate.osu.edu/topics/education/

Background

Ecological issues, such as biodiversity loss, water quality impacts, climate change, and loss of pollinator habitat can be difficult to recognize in our daily lives. Considering threats to pollinators, we don't notice things like the decrease in population of the rusty patched bumblebee; we notice things like fewer fruits to pick when it comes time to harvest.

This activity helps people to see the ripple effects of stewardship actions, such as planting and maintaining native plant restorations. It's easy to see that planting adds flowers to a school, community, or farm site - but it's not always so obvious that it provides food for hummingbirds, or creates a place for a grandmother and grandson to share a handful of ripe berries, or a haven for butterflies to lay their eggs.

Use this activity to discover what you might see more of and what you might see less of when you plant native plants to support pollinators.

Pre-Activity Preparation

Before you begin, print the "More or Less - Pollinator" activity card sets according to the following instructions (these cards can be found on the Earth Partnership website). Make one set for each team of 4-5 students. For each set, you will need:

- One copy of the center card that says "Planting and Maintaining Pollinator Habitat"
- At least 4 copies of the pages with arrows that says "which leads to more" and "which leads to less." Print these double-sided, with "more" on one side and "less" on the other, preferably on colored paper. Cut along the lines to create four arrow-shaped cards from each sheet.
- One copy of each of the impact cards, each sheet cut into four pieces along the dashed lines.

Activity Description

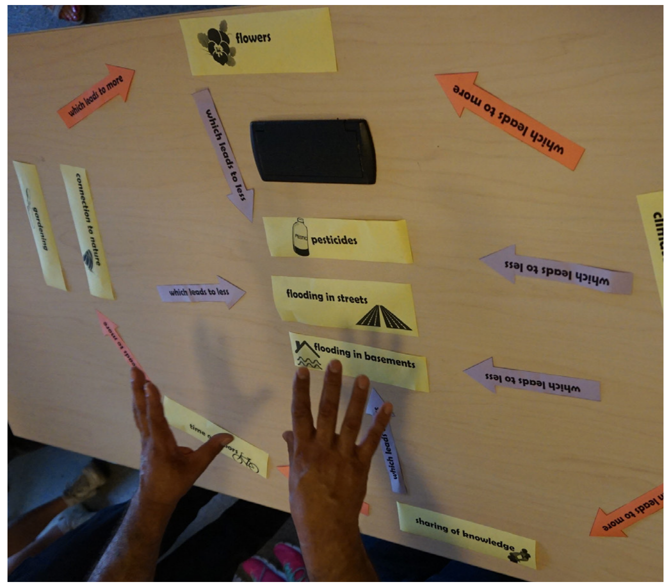
Divide into teams of 4-5 students. Begin by placing the sheet that says "Planting and Maintaining Pollinator Habitat" in the center of the area where you will work—this can be a big table, a bulletin board or the floor. Gather students around this sheet.

Place the "more" and "less" cards in a pile that everyone can reach. Spread out the impact cards so they are easy to see. Invite people, one at a time, to select an impact card that is a direct result of a card that is already in place. Ask them to connect the impacts with the "more" or "less" card that best describes the connection between these two impacts. Ask them to explain the connection. For example, someone might say that "planting & maintaining pollinator habitat / leads to more / time outdoors" because they would care for the planting themselves. Someone might follow up on that by adding "more / sharing of knowledge" because they would maintain the planting with students and parents at their school who would learn from each other.

Continue to add cards until you have one or more logical sequences of connected impacts.

Discuss the ripple effects that have been described. Consider asking:

- Is there an impact that you would especially like to see in your community?
- Is there an impact that you want to avoid in your community?
- Are there other impacts that you have thought of, that could be added to the model?



Institute participants lay out and discuss "More or Less" cards at Urban Ecology Center - Menomonee Valley in Milwaukee, WI.

Extensions

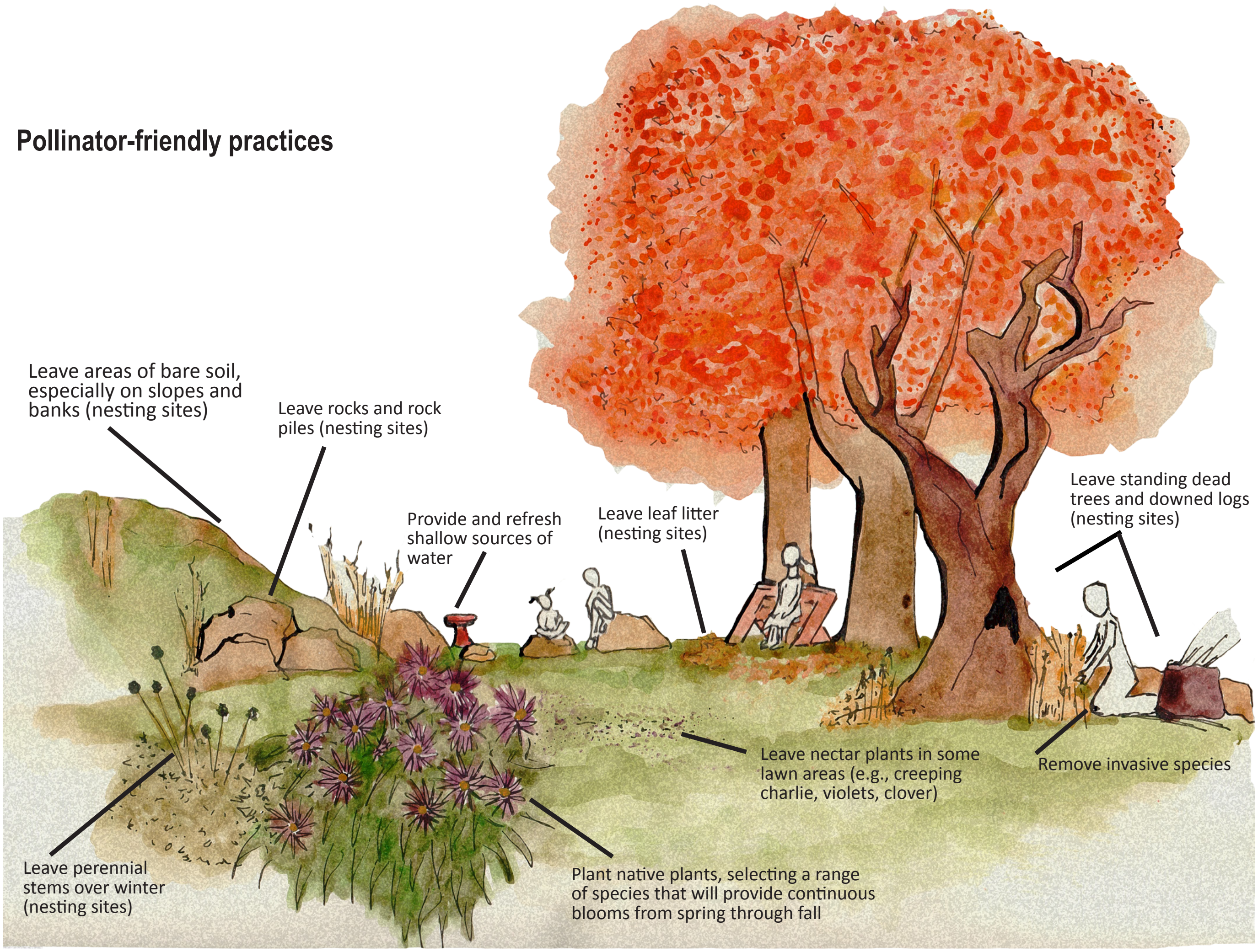
- Using blank cards write-in impacts that you think of on your own.
- Create different impact sequences, using various environmental actions that are happening in your school or community, such as energy conservation, recycling or sustainable agriculture. You can make a set of cards, or simply write down the ripple effects on a big piece of paper or white board.

Assessment Idea

- Create a cause-and-effect argument by choosing at least three causes/effects to encourage a principal, farmer, parent, teacher, business owner, or another person to develop a pollinator garden.

More or Less: Impacts of Habitat Restoration (cont.)

Pollinator-friendly practices



Practices that are unfriendly to pollinators

Tilling, compacting, or scraping soil

Cutting down dead trees, removing branches, leaf litter, and downed logs

Increasing lawn area

Cutting back plant material in the fall

Planting hybrids/cultivated plants that are bred for colors or blooms that give little or no benefit to pollinators

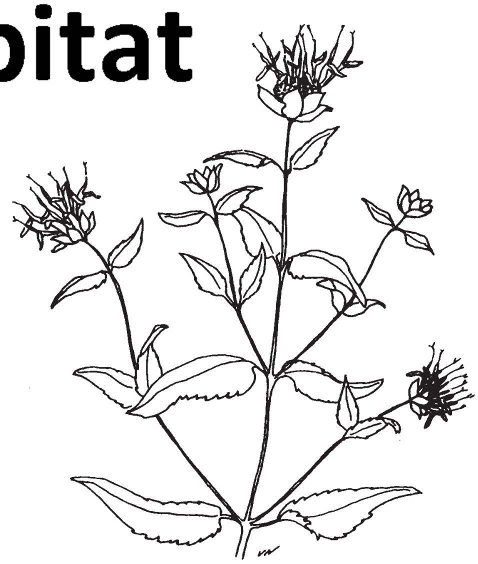
Planting only annual plants

Spraying plants that pollinators use for food or nesting, including “weedy” plants such as creeping charlie or clover

Using insecticides, fungicides or herbicides in areas with nesting or feeding sites, or rodent poison in burrows

List adapted from Holm, H. (2014). Pollinators of native plants. Pollination Press, LLC: Minnetonka, MN.

planting a pollinator habitat



which leads to more

which leads to more

which leads to more

which leads to more

which leads to less

which leads to less

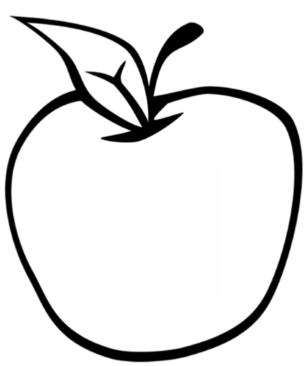
which leads to less

which leads to less

sources of nectar

pollinator host plants

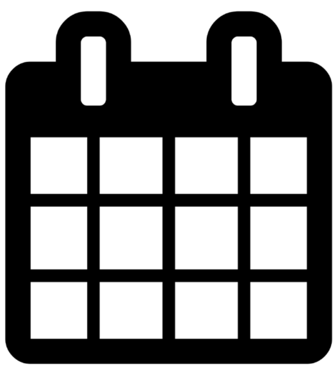
runoff



fruits

crop production

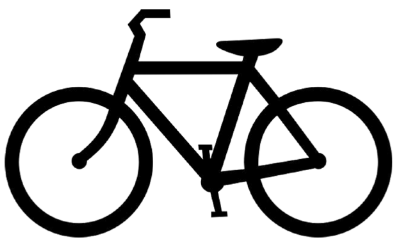
food for insectivores



blooms throughout growing season

good nutrition

screen time

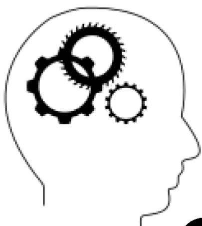


time outdoors

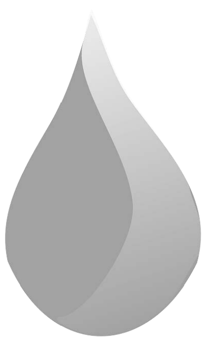
sharing of knowledge

low impact exercise

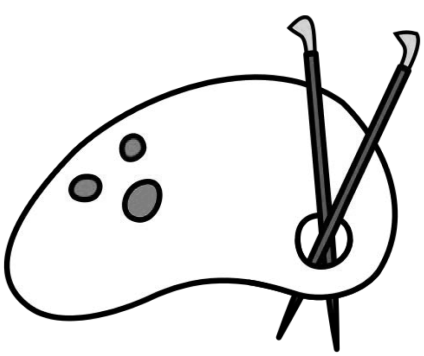
lawn



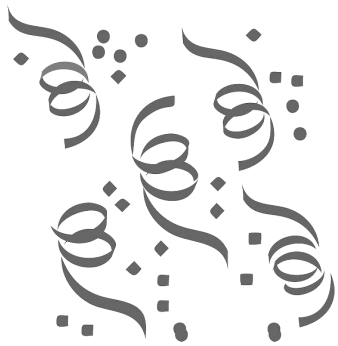
opportunity to learn



clean water



color

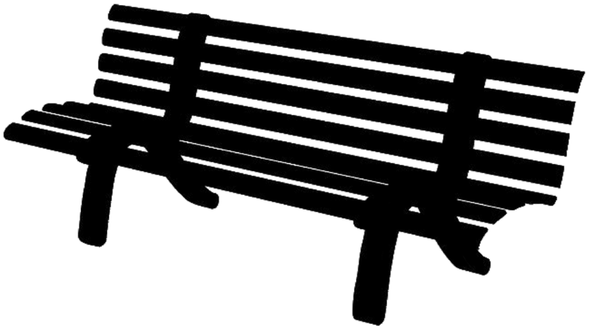


variety

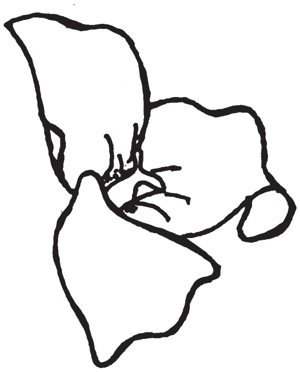
maintenance

water pollution

biodiversity

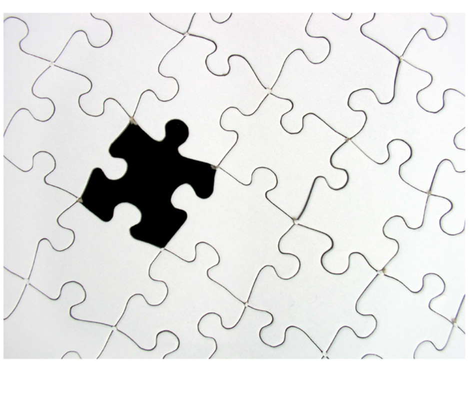


green space

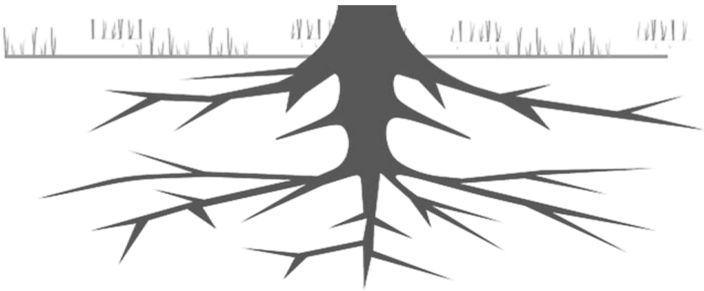


beauty

flooding



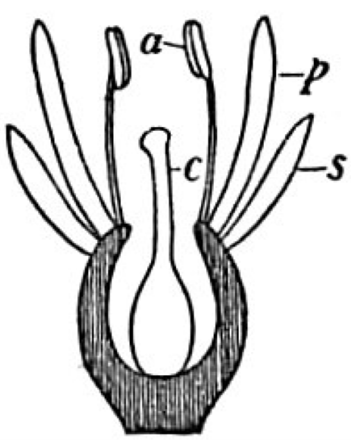
habitat fragmentation



replenished groundwater

curb appeal

connection to nature

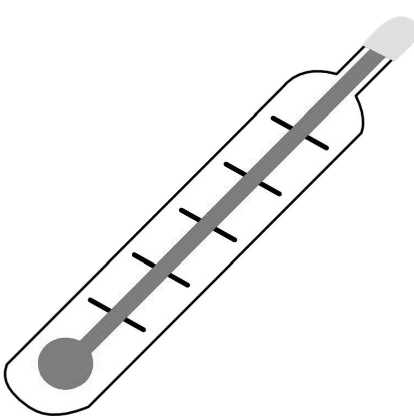


plant fertilization

passing down traditions

muddy walkways

pesticides



climate resilience

Observations from a Single Spot

Activity Overview

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

2) Students reflect at their single spot over time about their observations and expereinces developing a pollinator garden.

Objectives

Students will:

- Practice observation skills
- Create expressive writing in response to direct observation
- Perceive seasonal and/or phenological changes in a natural setting
- Reflect on restoration expereinces systmatically over time to deepen undestandings about self, others, and stewardship

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

Reflecting on your observations and experiences as you develop a pollinator habitat at your school or on private or public lands offers keen personal insights about your perspective and position on stewardship. You can use your single spot as a special place to record your feelings, discoveries, and insights over time. Reflecting on alliances you form with farmers and other community members and the skills you develop restoring pollinator habitat helps you to identify your innate skills and abilities. As you learn about and interact with the native plants, insects and wildlife you build a relationship with these non-human communities and recognize what they need to survive and thrive. Reflecting on the process of restoration at your single spot can be a powerful way to understand how this journey transforms not only the environment but the people who are involved in the process.

Activity Description

Go out to a natural area and select a spot. You will need to identify 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, 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.

Observations from a Single Spot (cont.)

As you begin to embark on a pollinator habitat project, return to you spot and consider the following:

- Why are you developing a pollinator habitat?
- Why is this important or not?
- How is this experience changing your perspective about your role and responsibility as a human member of the land community?
- What are you learning about yourself and others?
- What surprises you? What questions come to mind?
- How will these experiences influence your decisions or actions in the future?
- Do your answers change over time and, if so, in what ways?

NECTAR NOTES

The goal of journaling should be to capture one exceptional moment each day.
-Artist and naturalist Clare Walker Leslie

How does making observations from a single spot helps you to recognize exceptional moments? Observe both the large and small details of an area as you take the time, space and effort to enjoy a special place. 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 is a springboard for personal reflection.

Extensions

- 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.

Assessment Ideas

Develop a rubric to measure change over time in discussions and writings by evaluating complexity of observations, perception of phenological changes, depth of expressive writing, and understanding about self and others related to stewardship action. Students may:

- Create a short story based on single spot observations or reflections.
- Keep a nature journal or portfolio of observations over time.
- Make oral presentations to peers of observations/reflections and related writings.

Conducting a Community Assessment

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.

Assessment Ideas

- 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.

Getting the Word Out

Activity Overview
Students write and develop outreach materials such as a brochure, flyer, door hanger, article or poster that informs the community about their pollinator habitat restoration.

Objectives
Students will:

- Explain the purpose of pollinator habtat restoration
- Learn how to develop outreach materials
- Participate in a service-learning project

Subjects Covered
Language arts, Science, Environmental Science, and Social studies

Grades
4 through 12

Activity Time
In class: 10 minutes introduction, ~50 minutes for student presentations

Season
Any

Materials
Access to information about the plight of pollinators and how to support them (see resource lists in "Resources and Vocabulary"), card stock, poster board, a computer and printer (option-al), markers, pens and pencils, clip art, pictures, scrap booking materials, and other design materials, etc.

Background
An important component of restoring pollinator habitat on the school ground is making the connections with surrounding community members and sharing the story of the project. Getting the word out can be as simple as writing invitations to celebrate the planting to developing colorful brochures explaining what a native pollinator is and why they need their habitat restored.

The development of informational brochures or articles can bring about awareness, understanding, and citizen action. Student-developed outreach materials are a powerful way to inform and advise local citizens about local issues.

Activity Description
Your assignment is to create an attractive and inviting outreach product that you will use to inform the community about your pollinator habitat restoration and/or related topics. Follow the three steps below to develop your outreach product.

1. Form teams.
2. Decide on the purpose, content, and format for your outreach product. Other things to consider when deciding on an outreach approach include your time frame, the audience(s) you want to reach, the message you intend to send, and financial resources available (if any).

There are several types of outreach materials to choose from including:

- brochure or informational pamphlet
- poster
- door hanger
- invitation
- article for a school or community newspaper or newsletter
- Web page on the school Web site
- radio or television news broadcast
- P.S.A. (Public Service Announcement)
- video

Many topics, stories and messages are possible. Consider the following suggestions, or brainstorm other ideas with your teammates:

- invite the public to your restoration planting and celebration
- develop a sequence of posters announcing the coming new restoration
- write advertisements for help with short and long-term maintenance
- organize an open house featuring the new restoration

- put together a PowerPoint presentation to show at a PTO/PTA or school board meeting
- design a T-shirt introducing the restoration (You may consider selling T-shirts as a fundraiser.)
- compose a song dedicated to the restoration
- write a persuasive article to motivate community members to build restorations on their properties
- offer information on how to support pollinators, and where to find funding, native plants, and planting advice
- design a permanent sign and other signage

3. Present and distribute outreach materials.

After your outreach materials are developed, present your project to the class for constructive feedback. Disseminate your materials.

Extensions

- Develop a documentary of the restoration project.
- Invite public relations professionals to share how they develop new products and materials.
- Compile materials and photographs to keep as a record for the restoration project.

Assessments Idea

- Use the following rubric for presentations:

	Not so hot	Getting warmer	Hot
Audience	It is not clear who my/our audience is or what they are asked to do.	My/our audience is identified; but the information is not useful to my/our audience.	My/our audience is identified and the information applies directly to their situation.
User-friendly	My/our materials are messy and difficult to read.	My/our materials help explain the issue and solution but include too many points.	My/our materials are eye-catching and help make my issue and solution clear to the audience.
Message	The message is long, wordy and confusing.	The message is clear but not written in an active voice.	The message is clear and direct.
Grammar and Punctuation	Words are misspelled, and punctuation is sloppy.	A few careless mistakes and typos are missed.	Grammar and punctuation is correct.

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 an ecological level, one way of thinking of restoration is restoring healthy ecological function to a site. This includes increasing 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 cre-at-ing 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 res-to-ration 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?

Who is your audience? Who do you think will be consuming what you create? Think about where your product will be viewed, and who might come look at it. What age group(s) are you communicating to? What does your audience care about? Knowing that will help you ask the following question...

What is the story that you want to tell? There are many stories that can be told about one restoration, depending on the "angle" that you take. You could focus on the ecological impacts of the restoration, the types of pollinator that you hope to support, the different people that were involved, or what you learned through the process. Your story could include one or all of these elements, or something else entirely.

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.

NECTAR NOTES

A designer knows he has achieved perfection not when there is nothing left to add, but when there is nothing left to take away.
- Antoine de Saint-Exupéry

Today, many people carry smartphones that are capable of storing thousands of photos, and there are hundreds of websites or apps that make storing and sharing photos very easy. You don't need to be a professional to create and share a photo essay - but what often sets a great photo essay apart from a good one is editing, the careful selection of what goes in (and what stays out) of your story. You want your narrative to be complete, but too much information could distract or diminish the impact.

One approach to editing your product is to try removing up to half of your photos, to see if your story is as strong with fewer photos. What is most important to keep in? Consult with teammates and, once you have a draft, get feedback from people who don't know about your restoration project. Do they have the right amount of information to understand your story?

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 webpages for the school website. The site could be regularly updated to involve other students to include photographs, be interactive or could incorporate extensive links to other resources.

Assessment Ideas

- 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.

Noting Notable Features

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

Objectives
Students will:
- Describe biotic and a-biotic interactions at their 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 habitat restorations suitable for monarchs, butterflies, and other insect pollinators, 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 these site analysis activities can be represented on a final site analysis map. This map will help you and your students determine where to locate pollinator habitat and types of habitat suitable for your site. The exact form the habitat areas will take can be determined by design and other considerations and needs as well.

The site analysis data gathered will include information about physical objects such as buildings and other structures, topography, water movement, land use, existing vegetation, habitat suitability, slopes, traffic patterns, patterns of sun and shade, views, predominating wind patterns, wildlife and utilities. Students learn about soil in more depth through experiencing EP activity “Identifying Soil for Growing Pollinator Habitat”.

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.

Most properties 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 existed on the site. If building a map from scratch is overwhelming to you, Google Earth is one resource that may help you with this.

Activity Description

This activity will help you to get acquainted with your schoolyard, urban or rural properties. Before you can make any decisions about developing native plantings, you need to understand the characteristics of your site. To understand the existing features of your landscape and how they will influence your ideas and plans, you will conduct what is called a site analysis. To do this, you walk the grounds with a map to identify and locate physical, biological, and human-related features unique to your school or landscape.

First divide into research teams, each team will become “experts” in one important factor that will influence decisions made about your pollinator-friendly habitat restoration. Each team will collect a different type of data (physical, biological or cultural), to create a fuller picture of the entire area. 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 presentations for the class. There are six teams:

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.

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 and areas sheltered by the wind.

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, agricultural areas, and vegetable gardens, etc. Identify species, if possible, or use categories.

Wildlife Team – This team will identify wildlife or signs of wildlife in the schoolyard. With pollinators in mind, look for clues to support their habitat needs such as trees, shrubs, and plants that provide larval food (host plants) and provide pollen and nectar sources throughout the season. Look for potential nesting sites – hollow or pith-filled plant stubble, cavities in wood or rocks, loose sandy or loamy soil, leaf piles and downed logs. Places that provide shelter such as windbreaks.

Cultural Features

Traffic Patterns Team – This team will identify traffic patterns for cars, bicycles and people in and around the school or property. 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. On agricultural landscapes, identify how the land is being used. Look for idle portions or marginal areas for crop production such as farm field edges, grassed waterways, ditches, slopes too steep for growing crops, soils easily erodible if disturbed, fencerows, and areas surrounding electrical power infrastructure. These are all good candidates for developing pollinator habitat.

Part 1: Noting Notable Features: Site Inventory

1. Go outside and begin by reviewing your map and orienting its features to what is visible on the ground.
2. In your teams, complete instructions for your investigation and identify features on your map using symbols.
3. Come inside and review your map and the information you collected to make sure it is complete. Prepare a presentation for your classmates This can be formal or informal, use the map and photos where relevant to explain your findings

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?
3. Based on your investigations, identify possible spaces for developing pollinator habitats and other eco-friendly projects such as wildlife areas, rain gardens, outdoor classrooms, and other site improvements.

Noting Notable Features (cont.)

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 neighborhood to identify pollinator habitat or potential for habitat. Determine how your school is connected to these sites.
- Using a map of your city, town or county, identify public green spaces, parks, bike trails, rivers, streams, and greenways. Determine how these areas could be connected to form green corridors to increase mobility of pollinators.

Assessment Ideas

- Students should be assessed individually or in teams by writing their own plan for the school grounds including a map based on their investigations. They should support their ideas with data and explain how this improves the property for supporting native pollinators or other improvements such as protecting water quality, conserving resources or outdoor learning.

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 the directions water flows.
- Show where water flows off the site, if possible.
- Show which surfaces are impermeable (water runs off and cannot pass through) and which are permeable.
- Locate drainage ditches or swales.
- Locate spots where water collects that seem to have wet soil now or at some time of the year.
- Find spots that seem especially dry, where water may run off quickly.
- Locate storm drains.
- Locate downspouts (indicate where the downspout drains onto, i.e., lawn, pavement, etc.).
- Locate ponds, streams, or springs.

Describe the general lay of the land and any features that are unique or interesting.

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 winter wind direction and how the wind blows across your site. Winter winds are from the northwest.
- Determine prevailing summer wind direction and how the wind blows across your site. Summer winds are from the southwest.
- Locate areas sheltered by the wind.

Sun/Shade and Temperature

- Designate areas that receive the most sun.
- Designate areas that receive the most shade from trees or buildings.
- Designate areas that receive partial sun (half sun half shade during the day).

At up to five locations, 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 in these areas. Indicate results on your map. Include the date and time.

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.

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).

Groundlayer

- Locate different groundcovers such as lawn grass, flower beds, unmowed areas (or old fields), prairie (meadow), woodland ground covers, vegetable gardens, etc.
- Locate areas where vegetation is not growing and the soil is exposed.

Invasive Species

- Identify weedy areas or where invasive species are growing.

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.
- If you observe wildlife, record how different species and what they/he/she are doing.
- 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.

Pollinators

- Identify larval foods (host plants for caterpillars).
- Identify plants that provide pollen and nectar. Hint: Plants with fruits and seeds may be clues, too.
- Look for potential nesting sites – hollow or pith-filled plant stubble, cavities in wood or rocks, loose sandy or loamy soil, leaf piles and downed logs.
- Places that provide shelter such as windbreaks.
- Places with water.

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 or bike lanes.
- Identify pathways (watch where people walk and/or look for signs of pathways such as well-worn trails and short-cuts).
- Identify where people enter or exit the school grounds or site.
- Determine how well the needs for walking, using wheelchairs, or riding bikes are being met on the school grounds.

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.

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.
- Identify the land uses adjacent to your site.

Noting Notable Features: Field Sheet

Land Use Team - Farm Land

Directions: Use a map of your site to note the following 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.

Look for idle portions or marginal areas for crop production such as:

- Farm field edges
- Grassed waterways
- Ditches
- Slopes too steep for growing crops
- Soils easily erodible if disturbed
- Fencerows
- Areas surrounding electrical power infrastructure

What's Possible? Analyzing Existing Vegetation

Activity Overview
Students identify plants and decide what significance, if any, these plants will have for the native pollinator habitat project.

Objectives
Students will:

- Identify plants using field guides
- Analyze the suitability of existing plants for the pollinator habitat project
- Apply the information learned to make planting 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, pollinator plant guides, local resource materials, and a site map

Background

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

1. Native plants— Existing native species can form the basis for the type of community to restore. A community or association of native plants are adapted to the local environment and have co-evolved with native pollinators forming complex, balanced and sustainable ecosystems. To support pollinator populations, you must nurture a diversity of native species that offers a continuous succession of blooms, edible foliage and a network of interactions. Identify the native species present then determine what local plant community the plants ares typically found growing in to provide a framework for selecting additional species. These plants may also provide a clue for the type of soil and the amount of moisture available. If possible, determine if your site is a planted restoration or if your site is a remnant plant community. Remnants are original, native ecological communities that existed before European settlement. This information adds to your understanding of the history of the site and can be used for making management decisions.
2. Invasive plants—Most likely, many nursery grown landscape plants growing on your site are exotic or non-native plants from other places in the world. Some of these plants escaped cultivation and may adversely affect the restoration and cause long-term management headaches. Identifying and perhaps eliminating those species will save time, expense, physical toil, and frustration. Honeysuckle, buckthorn, and oriental bittersweet are a few landscape plants that have spread out of control in natural areas. Other non-native, invasive plants that were brought to North America for food or unintentionally should also be identified. For example, wild parsnip, dandelion, and reed canary grass. If invasive species 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 plants may be native and invasive, too. These native species may also be undesirable in your restoration. For example, sumac, gray dogwood, and trembling aspen can be invasive in a prairie restoration.
3. Herbaceous 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 site will help you determine suitable site preparation and management techniques.

What's Possible? (cont.)

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 growing on your site, and then you will analyze how these existing plants will affect the restoration. Invite community partners knowledgeable with plant identification to assist with your assessment. Follow these directions:

1. Identify trees, shrubs, and herbaceous species on your site using field guides.
2. Answer the following questions about the existing vegetation using field guides, landscape books, plant community species lists, and state and county publications.
   - Which plants are exotic (non-native) or native?
   - Are there species that may become weedy or invasive on-site or adjacent 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.

Assessment Ideas

- 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 site, are there 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.

Soil Explorations: 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

For a successful native planting, you need to know the types of soil and related soil moisture in your proposed planting areas. Soil types will very on sites by topography, soil disturbance, and moisture levels, therefore it is important to test your soil in different locations. Soil moisture relates to soil type and where the soil is located on the land. One of the most important reasons to identify soil type and moisture is for plant selection. Plants are adapted to growing conditions influenced by the soil, along with light conditions. Some plants will thrive in sandy soils and others in clay. Selecting plants that match the soil type gives you a better chance for plant survival. This activity will give students the ability to determine soil type leading to informed plant selections and improved plant survival.

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. These sandy soils are frequently considered dry soils. 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. Some clay soils may be considered moist if they do not dry out or wet if located in low areas on the land. 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. The moisture levels of loamy soil are often classified as medium, neither too wet or too dry. Like the diversity of plants, soils are very diverse when considering combinations of soil type and moisture levels. In other words, it is not always true sandy soils will be dry and clay soils will be wet. Observations of where the soil is located on the land and how it interacts with water, i.e., flooding, surface runoff and absorption (infiltration), will help you make a fairly sound determination.

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 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 infiltration tests using the EP activity "Infiltration Tests: Exploring the Flow of Water Through Soils".

Assessment Ideas

- 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.

Soil Explorations: Infiltration Tests

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.

Infilitration rate measurements determine how quickly water soaks into the soil. There are a number of factors which can influence this rate. 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 will usually have a different flow rate than the same soil in an unsaturated state. 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 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 changes. This procedure can be used to track change over time.

Activity Description

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.

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

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.

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 While the water is soaking into the soil, determine and record the vegetation type and soil characteristics (you can also use the soil texture feel test from "Identifying Your Soil") at your site on the field sheet. Record the infiltration rate. As a class, show our findings and compare soil characteristics and results across sites.

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 = π 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).

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 you to see water moving through particles in the soil.
- Compare infiltration rates through saturated versus unsaturated soils. Does the rate of infiltration vary depending on soil type? Compacted versus uncompacted soil? How does a recent rain event change infiltration rate?
- Investigate infiltration through subsoil. Carefully dig off the topsoil before placing infiltrometer into the ground.
- Make an argument about the impact of native plants on infiltration.

Assessments

- Using the results of the infiltration tests, describe how different soil types and/or soil compaction influences water flow through soil.
- Make an argument about the impact of native plants on infiltration. Based on the soil types and infiltration at the test sites, describe the characteristics that plants will need in order to thrive in these soils.
- Describe the factors that influence soil permeability.

Soil Explorations Data Sheet

Names: ____ Date: ________________

Location: ____

Vegetation Type (prairie, woodland, savanna, garden, other): ____

Soil Characteristics

Type (sand, loam, clay, other): ___________________________

Color: __________________________

Moisture level before test (use a scale 1-5, where 1 is bone dry and 5 is saturated): _________________

Infiltration Rate: _________________ (minutes/250 ml)

What we found (write description):

____

____

____

____

____

____

What we found (draw):

Designing a Habitat Restoration

Activity Overview
Students create a restoration landscape plan providing multiple benefits based on identified goals

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 support pollinators, improve water quality, soil processes and 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 restoration project with native plants is a sequential process should meet the goals and needs of the people involved, fit existing site conditions, improve ecological integrity and function, and create 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. They are the foundation for sustaining complex interactions with insects and other wildlife sustaining a diverse and healthy 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:

Environmental - (Physical features)

- 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
- 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
- Build a green infrastructure to reduce energy use for heating and cooling buildings and reduce heat island effects by installing green roofs, planting trees to shade pavement and buildings
- Planting native species in areas that are difficult to maintain such as a steep slope or low area that is intermittently wet or to protect soil from erosion

Ecological (Biological features)

- Restoring ecological representations of plant communities native to the local region
- Increasing biodiversity on the school grounds
- Attracting wildlife such as butterflies, songbirds, and amphibians

Human-related (Cultural features)

- Providing access for all children with a system of trails that includes trails wide enough for a wheelchair

Designing a Habitat Restoration (cont.)

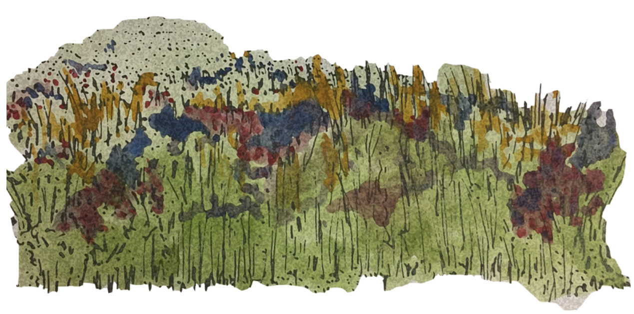
- Providing seating areas for students to assemble as a large group for discussions or small spaces for solitary reflection
- Providing for educational opportunities in a natural area
- Including a diversity of plants for student learning
- Creating a school entrance that welcomes students and visitors
- 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
- 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

Design elements especially important when restoring pollinator habitat:

- Choose sunny or mostly sunny sites for planting. Plants typically need long windows of sunlight during the day in order to produce enough energy to make flowers.
- Select plant species that will provide blooms throughout the growing season to provide pollen and nectar throughout the growing season. Most native plants bloom only for several days, and picking a range of plants will keep your restoration appealing to pollinators from late spring through early fall. Human visitors will appreciate this, too!
- Plant in clumps of the same species (also known as “drifts”), in order to encourage pollinators to visit - and fertilize - multiple plants.
- Plant butterfly and moth host plants to provide larval food when they are caterpillars.
- Add sites for nesting. Native bees, many of whom create wood tunnel nests, can find good habitat in old logs or dead tree limbs left on the site (called “snags”), plants with hollow stems, or piles of brush or rock.

Pollinator habitat restorations are valuable at any size - what is important is to select the kind of planting that can provide the most benefit to pollinators while also fitting the constraints and opportunities of your site.

Prairie Restoration

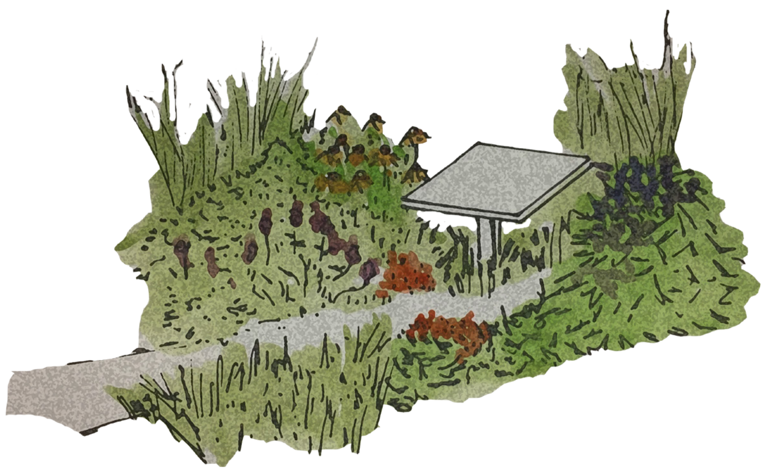


A traditional restoration is often done on a larger scale, with less control of plant placement and forms, and more effort to replicate natural mechanisms of seeding and plant succession. Restoration of any ecological community can be done, but the prairie offers a diverse sequence of blooms throughout the year that can provide excellent support to a wide range of pollinators. Consider a restoration option in swales, gullies, under utility lines, and along waterways.

Fencerow Planting

A fencerow planting can be especially appropriate and beneficial for pollinator support on farm sites. By populating the margins between fields with native plants, farmers can provide important nesting and food opportunities for native pollinators - and the pollinators in turn can provide enhanced fertilization of agricultural crops.

Native Plant Garden



A native plant garden is more intentionally designed than a traditional restoration, and can be done on small, medium, or large scales. Since a native plant gardener selects where and what to plant, the garden can be constructed to fit a broad range of human as well as ecological uses; a native plant garden can also be a place of refuge or gathering, an outdoor classroom, a trail system, and an artistic expression on the landscape.

Developing a Design Plan

After you determined your design criteria, 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. Brainstorm design criteria for the site. See Background section for sample criteria.
3. Divide into teams of two to four.
4. Draw your design plan for the site.
5. Write a document that supports your design ideas.
6. Present your plans to the class.
7. In teams, decide what parts you like in each plan. Use post-it notes to post your favorite parts of each design.
8. Choose a committee who will take these ideas and create a composite design plan.

Extensions

- Conduct peer review of design plan presentations.
- Find a landscape that you like in your neighborhood. Explain the 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.

Assessment Ideas

- 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.

What's a Square Foot Anyway? Laying out the Design Plan

Activity Overview
Teams of students lay out a native pollinator garden 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 pollinator garden, they need to transfer the plan from paper to the landscape. In this activity, students are able make that transition from a concept on paper to an actual location on the ground. This step not only lays out the native garden plot but also offers students a chance to see how a concept can materialize into a reality. THis activity is designed for small-scale plantings.

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, you will lay out your native pollinator garden design plan on the ground. Follow each step and when you 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. You will wear the cardboard-like shoes to layout the native garden plot.

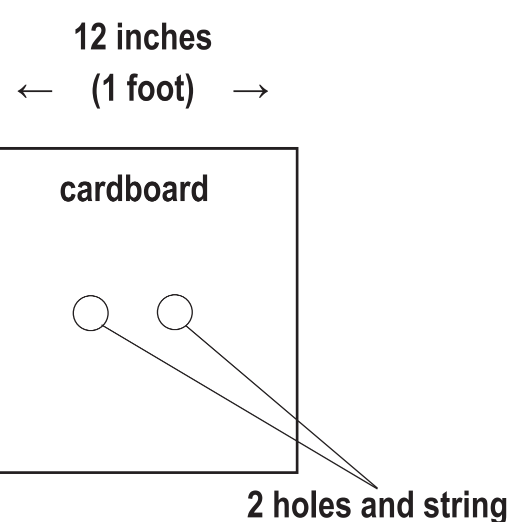


illustration showing one "square foot"

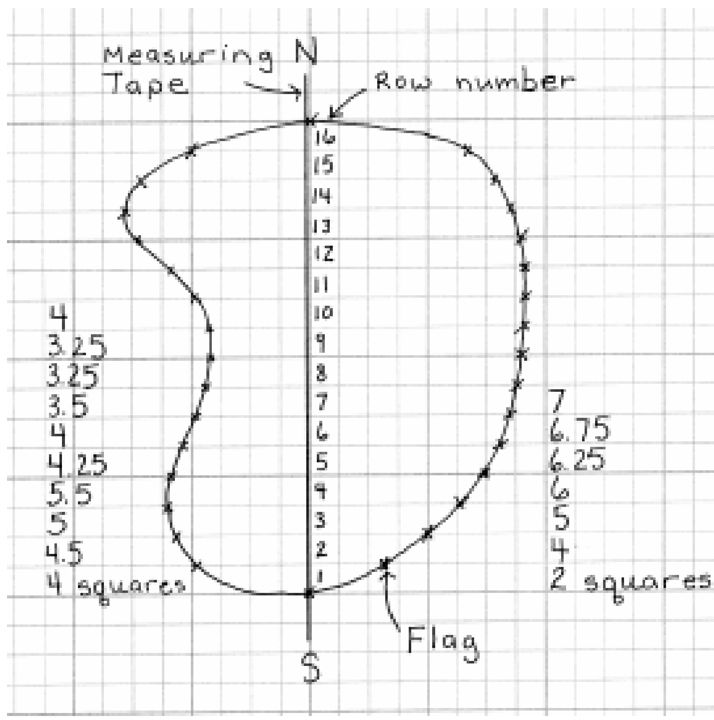
1. Assign roles. Two people will call out the design ("callers") and two people will place flags ("flaggers"). Everyone else will wear the square feet cardboard pieces on their feet and step out the design ("line people").
2. Divide into two teams. Each team will have one "caller", one "flagger" and

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 Ideas

- Calculate square footage of shapes and designs drawn on graph paper.
- Draw a native pollinator 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.

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. Supporting pollinators throughout the growing season is key, as are other elements such as plant height, sun requirements, soil type, and aesthetic considerations such as color, texture, and shape. Keep in mind natural communities are dynamic and complex. A community planted by human hands will not attain the same diversity and complexity as a natural ecosystem that has taken thousands of years to evolve. Through time and natural processes, the restored community will flourish in its own direction.

To begin the process of species selection, identify your site features (sun shade, soil type, etc) and which pollinator(s) you are trying to support. Review the following information 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.

Native herbaceous wildflower species or forbs 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 plants are perennials, although there are some native annuals and biannuals. When planning how many plants to plant, consider that herbaceous species should be planted one foot apart on average. In addition to forbs, 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. If you are planting on a small site that has high visibility, you may want to limit the number of species in order to maintain an aesthetically cohesive appearance. Multiple small beds with several species in each can be ecologically beneficial and also appear well-kept.

Species Selection Criteria:

- **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. When determining a ratio of grasses to forbs, consider cost, ecology and aesthetics of the site.

- **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.

  - **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 spe-cies, such as switch grass, common goldenrod, cup plant, and some sunflowers, often form large masses. Species with this type of growth habit are appropriate for large sites but may become too overpowering in smaller plantings.
  - **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.

- **Food Sources and Nesting Sites for Pollinators:** As desribed throughout this guide, there are many specific pollinator-plant associations. Some pollinators require a specific species for nesting, others can feed and lay eggs on a variety of plants with certain characteristics. 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. 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. Nursery catalogs and a wealth of online resources provide specific information about specific plants for pollinator habitat.

- **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.

- **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.

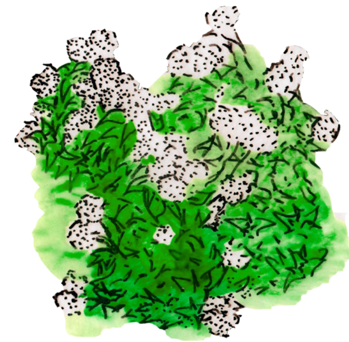
  Common guides for choosing plants based on the amount of sun or shade available are:

  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.



- **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.
- **Species that should be added later or planted as transplants.** Some species do not germinate and survive well in a new planting, such as prairie dropseed, shooting-star, alum root, gentians, and lilies. In most situations, plants that are difficult to germinate in the field can be added as seed after a prescribed burn a year or more after the original seed mix is planted. An alternative would be to add them as transplants. Note these species on your plant list, and designate areas for them on your planting map.

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.

Complete the Master Species List

Review master species list and make adjustments, if needed.

For projects using plants or transplants, begin to determine quantities for each species. First divide the grasses/sedges from the forbs. Use the criteria for your grass/sedge to forb ratio to calculate how many plants you need for each group. If planting one plant per square foot, the total number of herbaceous plants needed equals the number of square feet of the site. The one-foot spacing is a general guideline; keep in mind that taller species can be spaced wider than smaller species (consider a spacing rule of approximately 1/4 or 1/2 of the plant's mature height). 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.

Species Selection (cont.)

For projects using seed, go to EP activity "How Much Seed do I Need?"

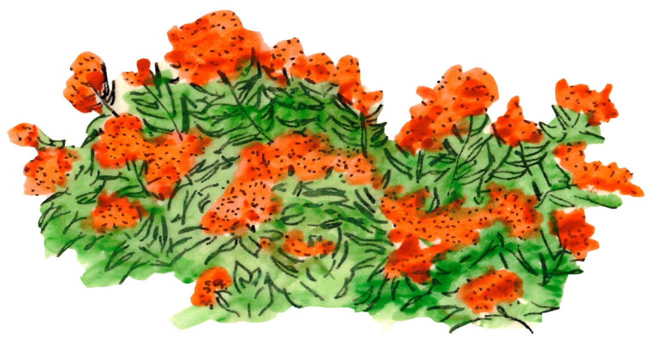
The next step is determining the budget for the species selected. See EP activity "Balancing the Budget."

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.
- Make posters of plants selected. Consider using a phenology wheel of the months to depict the bloom times, colors, and textures that will be exhibited throughout the year.

Assessment Ideas

- 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 CharacteristicsPlant types: (circle all that apply)

Grasses Sedges Wildflowers Ferns Shrubs Trees Other ____________

Plant (Mature) height range _________ to ______________ Plant Spacing (average spacing or range) ___________

Phenology (time of bloom):

_____% Spring (April – May), _____% Early Summer (June), _____% Summer (July),

_____% Late Summer (August), ____ % Fall (September – October)

Specific Plant-Insect Interactions:

____ High diversity of plants with different flower structures and floral resources (pollen and nectar)

____ Host plants for butterfly and moth larvae (caterpillars)

____ Continuous succession of blooms throughout the growing season

Additional Criteria: Identify criteria that fit your project goals such as flower color, textures, fragrance, sensory, wildlife value, cultural significance, and inquiry-based learning, etc.

SPECIES SELECTION WORKSHEET **Location:** **Date:**

Plant Name	Height	Sun	Flower Color	Wildlife*	AP	MY	JU	JL	AU	SE	OC	Comments
Grasses and Sedges												
Forbs												

Wildlife* - identify kinds of insects or other wildlife and/or host plant or nectar source for pollinators

How Much Seed Do I Need?

Activity Overview
Students measure and calculate the area for the pollinator habitat restoration 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
1 hour to measure and calculate the planting area for the pollinator habitat; 30-60 minutes for seed calculations

Season
Any

Materials
Tape measure and graph paper to calculate the site's area, calculator for seed calculations

Background

By this point in the pollinator habitat restoration process, students have performed a site analysis to locate where to restore habitat spaces and what species to include in these places.(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.

Pollinator habitat 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 ten pounds of seed per acre or .0037 ounces of seed per square foot. (Somewhat lower rates are sometimes used to make the planting more economical; however, we feel that ten 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 4-5 grass species and 30-40 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 pollinator habitat 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 ten pounds of seed per acre (or .0037 ounces of seed per square foot).

Extensions

- Determine the amount of seed needed to restore alternative sites on the school grounds.
- Using a map of your entire site, calculate the size of different areas based on land use and compare how the land is used based on percents of the total whole.
- 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.

Assessment Idea

- 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 and you have determined how much seed you 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.

Learning to critically think through the goals, desires and trade-offs to make the best choices possible gives 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, 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 to increase the foraging resources for pollinators. 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, change the quantities of species, 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 or do you have another idea? You might calculate how many seeds you are proposing to plant. Sometimes, while staying within the guidelines of .0037 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 more seeds than 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.

Assessment Idea

- Explain how to balance cost concerns and ecological considerations.

Balancing the Budget: Practice Order Form for Seeding

Common Name	Quantity	# seeds	Cost/Unit	Final Cost
TOTAL				

Site Preparation Techniques

Background

Good site preparation is the single most important factor for the success of a pollinator habitat restoration once you have matched the appropriate plants to the site conditions. 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.

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 woody species that do not fit within your plan. 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 or affect the flowering potential of the pollinator plants. 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.

Site Preparation Techniques (cont.)

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.

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.

Learning about and problem-solving which techniques to implement in these scenarios provides students with information about different site conditions they may encounter in the field. They can apply this process when determining site preparation options for their restoration projects and for projects with collaborating local farmers and landowners.

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 or in your community.
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.

Assessment Ideas

- 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 to 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?

Scenario #2:

A local farmer is concerned about the loss of habitat for monarchs and wants to partner with your class to increase monarch breeding habitat. The farmer has identified an area not planted in crops. It has 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. What approaches would you suggest to prepare the area for a planting? Which option would you consider the best choice and why. 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 habitat 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:

A site was identified for developing a pollinator habitat on your school grounds, as part of your community's decision to increase eco-friendly landscapes at schools and in neighborhoods. 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:

A special place was selected at a local park for students to restore a pollinator garden 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?

Seeds to Seedlings: Seed Collection

Activity Overview
Students collect seeds for their habitat 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. A 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 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 restoration sites, check the source of plant material.
- Realize when collecting seed you are disrupting interactions between plants and animals.
- Avoid collecting protected species. Leave the protected species for 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 thumbnail test. Simply put, if the seed is too hard to scratch with a thumbnail, 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 fall. Generally, seeds mature approximately one month after flowering. Lists with seed collection dates are often available through the Department of Natural Resources, nature centers and universities.

Seeds to Seedlings: Seed Collection (cont.)

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. Work in pairs or individually, using a paper bag, pen and notebook.

STEPS:

1. Compare ripe to unripe seeds.
2. Compare different types of seeds, for example, those with "wings" and those that are sticky. Discuss how different seeds types are dispersed.
3. Identify plants that have seeds ready for collection using a key or identification book.
4. Make a list of plant attributes and/or draw plant in notebook.
5. Tape or glue a sample of each seed type into notebook.
6. Write plant name, date, location, and your names on the paper bag.
7. Begin collecting the seed. You can practice different ways to collect seed to determine what method works the best. The following tips can get you started:

- Grass seeds (example - Indian Grass) or seeds growing on a long stalk (Blazing Star) - Hold seed stalk (panicle) over paper bag and drag your hand over panicle or stalk to allow seeds to drop into the 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.
- Seeds in a tight seed head (Pale Purple Coneflower) or a loose panicle (New England Aster) – Use pruners or scissors to clip the seed head.
- Seeds inside pods (milkweed, wild indigo) – pick or clip the entire pod and place it in your paper bag.

8. Place bags in cool, dry area in order to dry.

Questions for discussion

When collecting seed, what would happen if we removed all the seeds 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).
- 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.

Assessment Ideas

- 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?

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

Cleaning seed 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.

Separating seed from the seed head by hand using gloves and screens with different sizes.

Activity Description

Place the different seeds you have collected (see EP activity, "Seeds to Seedlings: Seed Collection") 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 and store in a refrigerator.

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. Moisture-treated seeds can become moldy, so it is best to plant within two weeks of treatment completion.

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) in 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 take time to germinate.

Assessment Ideas

- Describe the different threshing techniques, which ones work the best for different types of seeds and why.
- Write out detailed directions to another student on how to do this activity step by step.

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 while propagating seeds.

Objectives
Students will:

- Investigate seed dormancy
- Explore the phenology of seedling germination, cotyledon stage, first true leaves
- Use observation skills and plant identification skills
- Experience how to grow native plants

Subjects Covered
Science and Math

Grades
K through 12

Activity Time
15-30 minutes for Part 1: Seed Treatment, one month before planting activity; 30-45 minutes for Part 2: Seed Planting

Season
Late Winter to late Spring

Materials
Seeds, water, sandpaper, ziplock bags, inert material (sterilized sand, vermiculite or peat), germination flat, planting containers or trays (egg cartons and paper tubes work well), potting soil, bacterial inoculants (for legume species), heat and light source, and a 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. Some seeds need a certain treatment in order for them to be able to take up water and break dormancy.

Seed treatment for breaking dormancy 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 a combination 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 the 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 seeds that need moist-cold stratification in ziplock bag.

   For dry-cold stratified seed:
   - Place dry seeds in ziplock bag.
4. Label bags.
5. Place bags in a refrigerator kept at 35-40° F. for at least 30 days.
6. Compare how moist-cold seeds look after 30 days with those in

*Lightly scarify with sandpaper to thin the seed coat.**

*In preparation for moist-cold stratification, mix sterile sand, water, and seed in a zip lock bag and place in a refrigerator.**

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 to penetrate the seed coat?
    - How does stratification relate to a 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 or germination flats with a potting mix 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. Lightly cover seed with vermiculite.
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.
6. Seeds need high humidity to encourage germination. Continue to water daily as needed to ensure seeds are kept moist and do not dry out. Look for signs of germination, usually within 10 to 20 days. 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 the seedlings from the germination tray into individual pots or deep grove tube trays.

    - Carefully lift out about a one square inch of soil and seedlings from the germination trays and gently separate the seedlings.
    - Plant each seedling to individual pots or deep grove tube trays. Have trays ready and filled with potting soil. Use your finger or a dibble (a wooden stick) to make a hole in the soil large enough to accommodate the root. Tuck the new transplant into the soil for good soil root contact. The seedling should be at the same depth as in the sprouting medium. Repeat this process until one tray is full of new transplants. Then slowly water the seedlings by not pouring water directly on the seedling. Make sure the soil is fully moistened.
    - Move trays to a location that provides light, heat and air movement. Keep the soil moist but not wet.
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 grow in an area after disturbance. Do any of your species seem to be pioneers?

*Clockwise from top: the sequence of transplanting seedlings.**

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?

Assessment Ideas

- 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.

Thank you to Taylor Creek Restoration Nurseries for the photos used in this activity.

*Seedlings are now planted in their pots. Within-2-3 months they will be ready to plant in the field.**

Sowing Seed for a Pollinator Habitat

Activity Overview
A group of students, teachers, parents and community members will sow seeds for a pollinator habitat restoration.

Objectives
Students will:

- Understand the process of how seeds are planted
- Experience a sense of pride, ownership and completion in an important and complicated task

Subjects Covered
Math, Science, Language Arts, and Physical Education

Grades
K through 12

Activity Time
30 to 60 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), small cups, well-marked and prepared site, enthusiastic participants

Background
One of the beauties of hand-sowing a native 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.

Seed can be sown from March to June or beginning early September up until the soil is partially frozen. There are advantages and disadvantages for spring or fall plantings. Advantages for seeding in the spring are better seed germination of warm season grasses, more time for good soil preparation and weed control before planting, and the best option for sandy soils. Disadvantages include increase chance of heat and drought effecting seedling survival, difficulty of seeding on clay soils too wet in the spring. Advantages of a fall planting include seeds break dormancy over winder naturally, seedlings do not need watering because they germinate at their natural time, and increased germination of forbs. Disadvantages of a fall planting include lost seeds by herbivores, reduced germination of warm season grasses, and no opportunity for weed control in the spring.

The first step in the process is mixing the 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 5-gallon bucket, or for larger volumes, in a 30-gallon trash can. After the seed and filler are thoroughly mixed in, divide the mixture in half and put into two containers.

Sowing Seed for a Pollinator Habitat (cont.)

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

First step - Mixing the Seed

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 what insect it attracts.

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 in the context of a planting celebration.

Second Step - Sowing the Seed

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

- 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?"
- 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.

Assessment Idea

- Write a paragraph about your experience sowing seed and how it relates to practicing land stewardship.

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 restoration 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 transplanting, or moving a fully germinated seedling into a permanent growing site. Seedlings are often transplanted from containers, although some plants (mostly trees and shrubs) can be temporarily stored with bare roots or with roots wrapped in burlap until transplating.

Seedlings that have been growing in a greenhouse have a significant transition moving from a controlled climate to the outdoors. This is especially true in northern climates, and in the springtime. In order to help delicate seedlings transition from the nursery environment to the raw elements, it's a good idea to "harden off" the plants before transplanting. For a period of one to two weeks, set seedlings outside for a couple of hours on fair weather days and then make sure to take them into shelter at night. Do not put the seedlings out in heavy rain, wind, or below-freezing temperatures during this transition period.

When you're ready to transplant, 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.

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.

NECTAR NOTES

Planting native species in our gardens and communities is increasingly important, because indigenous insects, birds and wildlife rely on them. Over thousands, and sometimes millions, of years they have co-evolved to live in local climate and soil conditions.
-David Suzuki, Geneticist and Environmental Activist

Discuss what you consider to be the importance of planting native plants. What do you hope will happen to these plants as they grow, and what impact(s) do you hope that they will have?

Extensions

- 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.

Assessment Ideas

- 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.

Managing Your Habitat 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

A habitat restoration 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. 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.

    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. Sometimes, it is easy to pull young weeds (particularly after a rain), but take caution when pulling weeds because many well-established weed species can be difficult to pull. Wear sturdy work gloves to protect your hands from distress related to pulling and possible irritants from poison ivy, wild parnsip, or other toxic weeds; wear long plants and safet glasses when appropriate.

Chemical: on particularly persistent invasive plants, sometimes herbicides are used, such as Roundup, Klee-nup, Ranger, and Rodeo (for wet areas). Follow the manufacturer's instructions carefully. Be sure to check school policy for using herbicides, and make sure the chemicals (even those that are common and can be freely purchased at home and garden stores) are handled only by adults who are allowed to apply chemicals (some areas and some chemicals may require an official certification in herbicide application).

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. Even after you have tailored a management plan to your restoration, you may need to adapt your plan to respond to environmental changes or other unexpected occurences. A monitoring plan (see EP activity "Monitoring Your Restoration") will help you keep apprised of what is happening in your restoration, which can in turn inform your management plan.

Restoration Management Plan for Year 1				
Management Activity	Spring	Summer	Fall	Winter
Planting and Seeds	Plant native plants, mulch around plants.	Collect seeds.	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.

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. Rechip 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.

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. Your burn crew should be led by a person experienced in prescribed burns; in some cases, it may be required that this person be certified.

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.

Assessment Ideas

- 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.

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
Summer - Fall

Materials
Species list for your 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 perennials like quackgrass, red clover, bindweed, reed canary grass, and Canada goldenrod (a native plant that can spread aggressively). 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

- Research management alternatives.
- Carry out management actions (species removal, mowing, etc.).
- Repeat the checkup at regular intervals.

Assessment Ideas

- 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

Monitoring Your Restoration

Activity Overview: Students monitor habitat restorations and organize data to track progress and change. Use data to inform management decisions and to contribute to citizen science databases.

Objectives
Students will:

- Increase observational skills
- Analyze data over time
- Understand how to look at information qualitatively, quantitatively, spatially, and seasonally
- Understand the process of turning raw data into meaningful information
- Know how to construct data on a variety of graphic organizers
- Interpret data to inform decision-making
- Develop positive communication, co-operation, and shared decision-making skills to work as a tea

Subjects Covered: Science, Information Technology, Math and Environmental Education

Grades: 3 through 12

Season: Depends upon type of data collected, ideally spread data collection throughout the school year

Materials: Clipboards, data collection field sheets, pencils, colored pencils, large phenology wheel of the year (including months), access to a computer lab

Background

Monitoring is an important tool to help analyze the development of a restoration and to make management decisions that will ensure a successful project. When restoring pollinator habitat, there is an excellent opportunity to track the presence and patterns of vital insects, birds, host plants, and also invasive species. This information can be used by students to answer research questions and help shape management plans. It can also be pooled with the observations of other restoration sites in schools, backyards, park land, or community centers. Data that is generated by many individuals towards a research goal is often referred to as "citizen science."

NECTAR NOTES

The Cornell Lab of Ornithology is a citizen science and ecological teaching resource. Their website notes that "citizen science" can refer to a wide range of concepts dealing with public engagement in and democratic approaches to science. Their definition is a simple one:

Projects in which volunteers partner with scientists to answer real-world questions.

Words are chosen very carefully in concise definitions. Discuss what it means to be a "volunteer" or a "scientist." What is a "real-world" question?

What do you think of this definition? Does this definition of citizen science fit with your habitat restoration goals? Why might it be important for a pollinator habitat restoration to contribute to larger scientific research?

Monitoring is a rewarding and informative experience. They record observable facts indicating that their efforts of planning, planting, and managing a native habitat is working along with their other ecological and environmental actions. Establishment of native plantings takes time and sometimes changes are not clearly evident. With monitoring, change is closely observed and quantified, so even the small changes become obvious.

- The data may indicate that a new management plan or strategy is needed if, for example, biodiversity has decreased on the site or invasive species have become more prevalent.
- Information about plant vigor as plants grow, bloom and set seed throughout the seasons.
- Data can show how the planting affects local fauna populations and diversity by providing increased food supplies, cover and places for raising young.

- How wildlife interacts with and affects plants; for example, an insect pollinates a flower, which increases seed production. The data may inform how plants and animals interact in an ecological community that is sustained by these interactions.
- Determine research questions early on in the restoration process. Having a well-articulated question or sets of questions is an important part of good scientific method, and it will help structure data collection as well as analysis.
- Observe important trends and make their own conclusions about ecological changes over time. Data collected can also make meaningful contributions to large-scale research projects. Students can research various citizen science data hubs online, many of which focus on specific pollinator types or individual species. Good citizen science programs will also have detailed data collection guidelines, which will be important to follow from the start of your monitoring project.

Key Questions

- What data can we collect about our site?
- How often do we anticipate collecting data (weekly, monthly, annually)?
- What changes do we anticipate observing? Why? What evidence will we look for?
- What are our data collection methods? Why is being specific about them important?
- How would we best represent our collected data (graph, written summary, photo comparisons, etc.)?
- What observations surprise you?
- Has the restoration solved any problem that was identified?
- Are there indicators in the data that show er are meeting our restoration goals? What are they?

Activity Description

The process for implementing a monitoring activity involves collecting data on the restoration project and transforming it into meaningful information to be used for making management decisions and tracking change. We are doing authentic scientific work by assessing our site and contributing to a larger body of knowledge. Collect data on field data sheets (use sheet provided or develop original) or another graphic organizer, such as a phenology wheel. Compile the scientific data collected and save it for future monitors to compare to previous data for longitduinal studies. If your class is contributing to a citizen science monitoring project, you can upload or send in data to the appropriate contact.

What Data to Collect?

Begin by posing the question, "what data can we collect at our site?" Consider what kinds of information will help determine if the goals of the restoration are being met (and which will also help inform your management of the restoration). Record your ideas on post-it notes.

Sort the post-it notes into categories. Examples of possible data to collect include the following:

- Pollinator species: species richness (number of species found) and relative abundance (how common a given species is in relation to the other species present in that location), change in populations over time
- Plant species: plant species present (may focus on pollinator host plants or food sources), size and height of plants, percent cover of species, what's in bloom or setting seed at what point in the season, number and types of invasive species
- Weather and climate data: temperature, precipitation, weather conditions, depth of snow, hours of day light, etc.
- Cultural practices/awareness: number of classes that go outside for lessons, number and type of lessons taught outside, levels of familiarity with importance of pollinators and threats to them

Monitoring Your Restoration (cont.)

- Aesthetics: colors, textures, and patterns on school grounds

Split into teams to investigate the various data collection categories. Not all data collected will be relevant for citizen science monitoring, so be clear about which questions pertain to your own specific research and site management versus citizen science projects.

Since you will be measuring change over time, you should first collect baseline data (ideally this occurs before the project begins). Some of the data collected may not be a result of restoration efforts, but may influence the data collected such as weather conditions.

Baseline Data

Decide on when and how to collect your data. Make data collecting plans. These plans should include protocols for data collection (how, when, where, why), what tools are needed to collect the data, and what type of data collection sheets.

Collect and represent baseline data as per your protocols. This step may involve counting and representing raw data. This step allows for deep discussions around how to use tallies, charts and graphs. Pose the question: What representation best fits the information that we are trying to convey? You may decide to revise data collection protocols after experiencing their first data collection.

Data Analysis

Analyze the data as the year continues and more data is collected. Consider developing a rubric for data presentations, which can be good tools for assessing student learning.

You will already have research questions in mind, but be open to new insights as you look through the data. Questions to consider:

- What is changing?
- Is the restoration helping to addres any problem(s) that were identified?
- Is the restoration space viewed differently by the school community, or the surrounding neighborhood?
- Are there indicators in your data that shows that you are meeting your restoration goals? What are they?

Use different kinds of data visualization or interpretation to detect trends and patterns about the progress of the habitat restoration. You must select a type of presentation that fits your data and questions:

Line graphs can be used to track changes over short or long periods of time (e.g., what is the frequency of monarch butterfly sightings on our restoration over the course of a school year?).

Pie charts can be used to show parts of a whole (e.g., what is the plant species composition in our restoration?).

Bar graphs can be used to compare between different groups (e.g., how do counts of bees differ between our restoration site and the schoolyard lawn?).

Photos can be used to make comparisons; be careful to specify what criteria you are looking for, and give consistent definitions for analyzing changes (e.g., how has vegetation density, in terms of percent cover, changed on our restoration site over the course of five years?).

As data accumulates over the years, begin to analyze and interpret change over time.

- What patterns seem to be emerging?
- How has your restoration improved your schoolyard habitat in terms of pollinator support and presence?
- What new questions have emerged based on this data?

Use this information to predict future changes and modify management strategies.

- Compare observed seasonal changes, bloom time and timing of seed setting, emergence of invasive species, etc. with the timeline outlined in your management plan.
- What's working: are there features (particular plant species, nesting materials, proximity to water, shelter from elements, etc.) that are associated with frequent pollinator sightings? If so, does your management plan adequately incorporate them?
- What's not working: are pollinator counts static, or is native plant species richness decreasing? What measures can be taken to address these challenges?

Next Steps

- Submit data to citizen science databases.
- Plan for continued data collection, maintenance, or expansion of your site. For management activities, refer to EP activities: "Managing Your Woodland Site," "Woodland Restoration Checkup," "Mobilizing Work Groups," "Managing Your Restoration," "Invasive Species," "Weed Cards," "Weed Lotto" and "Young Prairie Checkup."

Extensions

- Write a site management plan describing how the site has changed over time, areas for improvement, and steps towards improvement.
- Present the status of your habitat restoration project to the school board, PTO, local conservation groups, and other interested stakeholders.
- Determine and illustrate different ways to display data that accurately portray your findings.
- Use phenology wheels in art, writing and photography (see EP activity "Wheelscapes: Enhancing Sense of Place"). Scan your class phenology wheel to compare with other classes.

High school agriculture teachers gather at an Enel Green Power solar farm in Buffalo, MN to monitor pollinator habitat restoration on-site. Photo: Cheryl Bauer-Armstrong.

Insect Charades

Activity Overview
As a strategy to begin to learn how to identify insects for monitoring and inquiry activities, students play charades in small teams to learn 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-12

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, grasshoppers, true bugs, dragonflies, cockroaches, and leafhoppers.

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.

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. There are a wide variety of ways that insects adapt to survive in different ecosystems. How have these insects adapted to survive in a particular habitat? Discuss what some threats to these insects' survival might be. Some threats include habitat degradation, fragmentation, conversion of natural areas to development, loss of native plants, invasive plants, non-native plants that native insects won't eat, planting hybrids and cultivators bred for color and blooms but offer no nutrition or access to nectar, pesticides, insecticides, systemic insecticides, fungicides, monocultures of crops, and climate change. Discuss solutions to threats. Planting native landscapes, building green infrastructure, use alternative pest control, proper application of pesticides, removal of invasive species, connect fragmented landscapes by building corridors, replace lawn with native groundcovers, plant forage plants, plant a continuous succession of blooming plants.

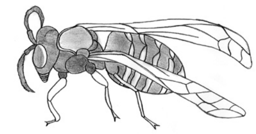
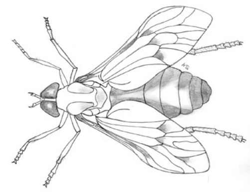
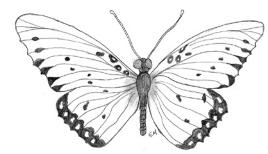
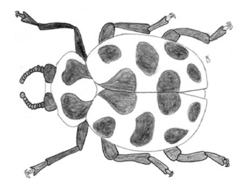
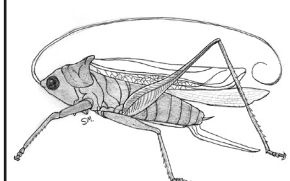
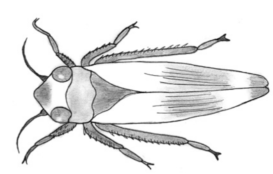
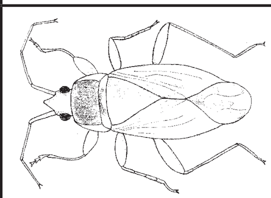
Extensions

- 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.
- 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.

Assessment Ideas

- Name and describe at least two insect orders and/or the parts of a true insect.
- Compare a true insect to a spider.
- 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 Bees Wasps	• 2 pairs of clear, membranous wings • Compound eyes • Sponge-like, sucking or biting mouthparts • Long legs • Stinger	
2	The Two Wings (Diptera)	Flies Mosquitos Gnats	• 1 pair of regular wings and 1 pair of very small wings • Compound eyes • Sponge-like or sucking mouthparts	
3	The Scaly Wings (Lepidoptera)	Moths Butterflies	• 2 pairs of scaly wings • Antennae feathery, needle or pin-like • Compound eyes • Sucking mouthparts	
4	The Sheath Wings (Coleoptera)	Beetles	• 1 pair of hard wings • Wings cover top of body and meet in straight line down center of back • Biting mouthparts	
5	The Straight Wings Orthoptera)	Crickets Grasshoppers Locusts	• 1 pair of leathery wings in front (fold over bodywhen not in use) • 1 pair fan-like wings in back • Long legs/high hopper • Make rhythmic sounds • Chewing mouthparts	
6	The Toothed Wings "Born to Teeth" (Odonata)	Dragonflies Damselflies	• 2 pairs of wings • Most have thin legs and short antennae • Large compound eyes nearly cover small heads • Biting mouthparts	
7	The Same Wings (Homoptera)	Aphids Cicadas Treehoppers Leafhoppers	• Both (2) pairs of wings are same from base to tip • Wings held in tent-like position over body when resting • Piercing or sucking mouthparts	
8	The Half Wings (Hemiptera)	True Bugs Back Swimmers Water Striders	• 2 pairs of wings: thick and leathery near the body and thin at tip • Wings fold back forming triangle behind the head • Snout on head is used for piercing and sucking	

Sweeping Discoveries

Activity Overview
Students will conduct insect surveys to analyze change over time in pollinator populations.

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 per data collection, including time spent observing and identifying insects and discussing findings

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

A healthy habitat restoration is abuzz with pollinators and other insects that aid in decomposition and provide food sources. Insect sweeping is a fun way for students to learn more about the insects that are supported by their habitat restoration, and to track the health and success of the restoration over time. If your students need help identifying insects, you may want to play EP activity "Insect Charades" before beginning this activity. The field sheet also helps with some basic classification.

Activity Description

1. Divide into small teams, hand out a sweep net to each team, and go out to your restoration.
2. Each team samples a random area in the restoration 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.
3. Compile the class findings and discuss insect species richness and relative abundance on your site. Make note of species that provide pollinator services.
4. Return to the site periodically over the course of the growing season, conducting the same sweeping collection. Keep a classroom graph of insect species richness, and add to it after each sampling day. Have students manage the graph and discuss trends.

Extensions

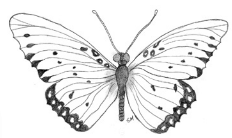
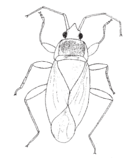
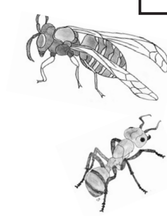
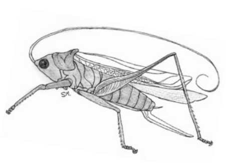
- Maintain a classroom insect sweeping dataset, and add to it annually. Have students compare findings from previous years with their current findings, and depict these changes using line graphs or bar charts.
- Discuss the concept of endangered species. Investigate state natural resources department or conservation organization websites for a list of threatened and endangered insects in your area.
- 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?

Assessment Ideas

- Make oral presentations of your findings.
- Hypothesize about the reasons underlying the results you found.

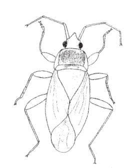
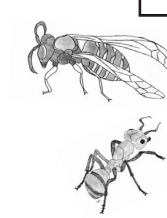
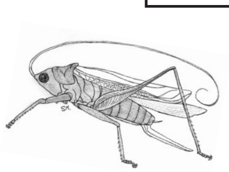
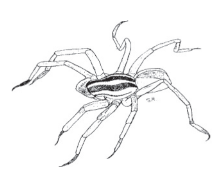
Sweeping Discoveries Field Sheet

Team Members: ______________________________ Sampling Date: _________

 Dragonflies & Damselflies	 Butterflies & Moths	 True Bugs	 Wasps, Bees, Ants	 Beetles
 Grasshoppers & Crickets	 Flies	 Leafhoppers	 Spiders (not insects)	Other

Sweeping Discoveries Field Sheet

Team Members: ______________________________ Sampling Date: _________

 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
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 you or people you are working with are afraid of bees, this fact may be reassuring. (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.)

Good research begins with a question. “Which 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.

Pollination Observations (cont.)

- Find a profusely blooming patch of flowers of one species (if you have a blooming habitat restoration, this is the perfect place to do this!).
- 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.

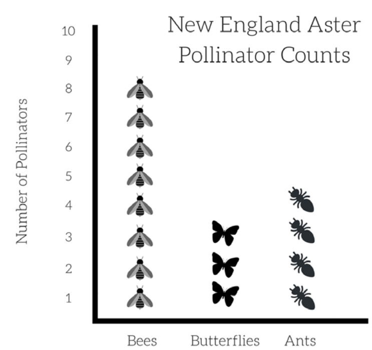
If you want to gather more ecologically meaningful data, you can return to your site periodically (once a month during the growing season is a very good benchmark) to see if there are any changes in pollinator counts over time. Try to keep as much consistency as possible in your observation methods across time intervals; you can brainstorm as a group what you think is most important to keep consistent, and why (e.g., time of day, avoiding monitoring sessions during inclement weather; length of observation period, etc.). If you would like help with setting guidelines for observation methods, the Xerces Society has online manuals for citizen scientists monitoring pollinators.

Step 2: Analyze, Discuss and Present Findings

Visualizing data can help better understand the research process, and it is also a very important step for scientists to analyze and communicate their findings. Different types of visualizations help with different kinds of analyses.

Picture Graph (Provides quick visual synopsis of findings; appropriate for younger learners)

Picture graphs are a good introduction to graphing, since they focus on counting, are easy to understand, and can be fun to make. As a group, make separate picture graphs for each plant observed. Pollinator types will be presented along the X-axis; numbers of pollinators observed will be presented along the Y-axis. Graph one plant at a time, using a large piece of paper. Indicate on the graph how many of each pollinator you saw on the specified plant. Represent your counts by drawing a simple symbol, using stickers, or gluing cut-outs onto the graph. Title the graph, draw the axes, and set the scale ahead of time.

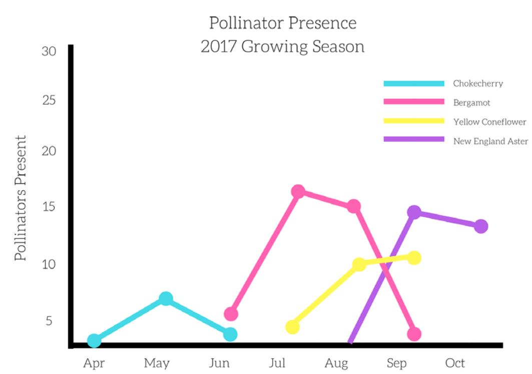


Once all the counts are added, display all the graphs at once and discuss the findings. Do you see any patterns? Did one plant have an especially high number of pollinators? Did one type of pollinator appear a lot on different plants? Were there any pollinator types that weren't found at all?

Line Graph (Good for depicting change over time; appropriate for more advanced learners)

If you have the opportunity to do pollination observations multiple times, over a period of time, you can create line graphs to analyze trends in the presence of different types of pollinators over the course of a month, a growing season, or even years.

Create your graphs using pen and paper or a computer program such as Microsoft Excel. The setup of the graph will depend on what question(s) you would like to ask. For example, if you are interested in tracking the overall presence of pollinators during a growing season, you can create a line graph with months represented along the X-axis and numbers of pollinators observed along the Y-axis. Multiple lines can be depicted on one graph, each representing a different pollinator group (i.e., How does the presence of various pollinator types vary throughout the growing season?), or each line can represent a different plant species (i.e., Which plants attract the most pollinators,



and for how long throughout the growing season?). Explain your graph: what question(s) did you have in mind when drawing them and what information do they depict about the data?

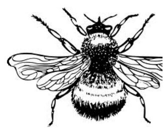
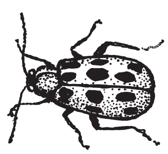
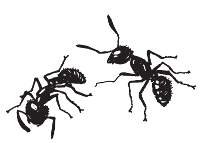
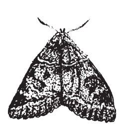
Extensions

- 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.
- Observe the same growing area throughout growing seasons. What flowers attract bees? (April-October) What flowers attract other insect species?
- 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.
- Describe an action you could take which would be beneficial to pollinators, and what your predictions would be about subsequent changes in the data that you collect.

Assessment Ideas

- 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 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.

Pollination Observations: Tally Sheet

Type of Insect	Plant	Number of Insects
Bees 		
Bumblebees 		
Wasps 		
Flies 		
Beetles and Bugs 		
Ants 		
Butterflies 		
Moths 		
Other (Wind, Hummingbird,etc.)		

Learn More about Pollinators

Websites/Organizations

Journey North: https://journeynorth.org

Monarch Joint Venture: https://monarchjointventure.org

Monarch Watch: https://monwarchwatch.org

University of Minnesota Monarch Lab: https://monarchlab.org

US Fish and Wildlife Service: https://www.fws.gov/pollinators/

Xerces Society for Invertebrate Conservation: https://xerces.org

Publications/Media

Burris, Judy and Richards, Wayne. The Life Cycles of Butterflies: From Egg to Maturity, a Visual Guide to 23 Common Garden Butterflies. North Adams, MA: Storey Publishing.

Disneynature (2013). Wings of Life. Learn more: https://nature.disney.com/wings-of-life

Holm, Heather (2014). Pollinators of Native Plants. Minnetonka, MN: Pollinator Press, LLC.

National Research Council (2007). Status of Pollinators in North America. Ebook available: https://www.nap.edu/catalog/11761/status-of-poolinators-in-north-america

Schwartzberg, Louie (2011). The Hidden Beauty of Pollination. TED Talk, available: https://www.ted.com/talks/louie_schwartzberg_the_hidden_beauty_of_pollination?language=en

Tallamy, Douglas (2007). Bringing Nature Home: How You Can Sustain Wildlife with Native Plants. Portland, OR: Timber Press.

Xerces Society (2011). Attracting Native Pollinators: The Xerces Society Guide to Conserving North American Bees and Butterflies and Their Habitat. North Adams, MA: Storey Publishing.

Xerces Society (2014). Farming with Native Beneficial Insects: Ecological Pest Control Solutions. North Adams, MA: Storey Publishing.

Xerces Society (2016). 100 Plants to Feed the Bees: Provide a Healthy Habitat to Help Pollinators Thrive. North Adams, MA: Storey Publishing.

APPENDIX: Educational Standards

(Next Generation Science Standards and Common Core Math and Literacy 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

Activity Index:

APPENDIX: Educational Standards

Telling the Restoration Story; More or Less: Restoration Impacts; Getting the Word Out

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 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.

APPENDIX: Educational Standards

Observations from a Single Spot

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.

Pollinator 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

Sweeping Discoveries; Monitoring Your Restoration; Young Restoration Check-up

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

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.9-12.7 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.8.1 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.

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.

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.

APPENDIX: Educational Standards

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.

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.

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?

APPENDIX: Educational Standards

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

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.

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:

APPENDIX: Educational Standards

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 Native Plants

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.

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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

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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.

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.