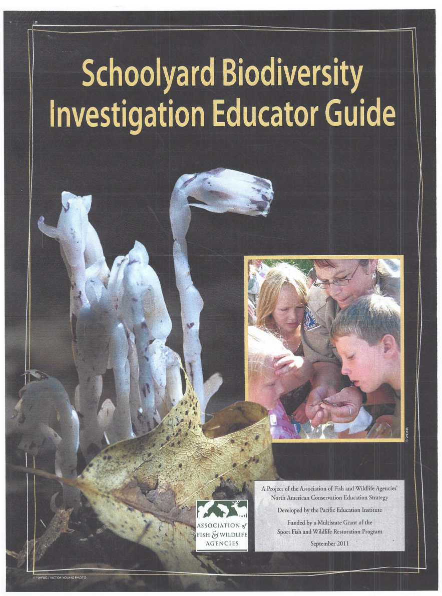
KANSAS SCHOOLYARD BIODIVERSITY INVESTIGATION EDUCATOR GUIDE

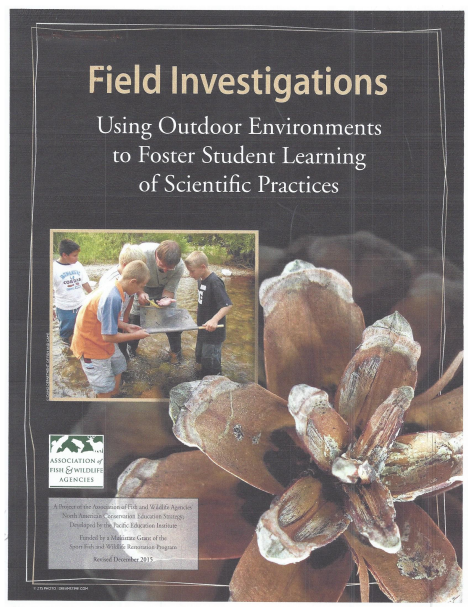
Kansas Department of Wildlife, Parks and Tourism

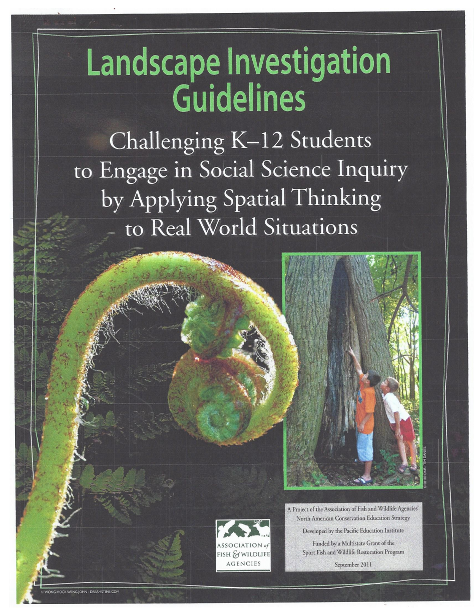
Kansas Schoolyard Biodiversity Investigation Educator Guide

2nd Draft - July 2018

Adapted from Materials Developed by the Association of Fish & Wildlife Agencies







with additional activities from Project WILD and Project Learning Tree

Kansas
Department of Wildlife, Parks and Tourism

Table of Contents

INTRODUCING BIODIVERSITY

from Schoolyard Biodiversity Investigation Educator Guide

Section 1
Introducing Biodiversity

What is Biodiversity?

Biodiversity can be defined on a variety of levels. Ecosystem biodiversity refers to the variety of habitats within a particular area or region. The Schoolyard Biodiversity Investigation focuses on species biodiversity, or the variety of plants and animals in a particular habitat. On a more complex level, genetic biodiversity looks at the variety of characteristics within a particular species.

The opposite of species diversity is monoculture. The term monoculture refers to a situation in which only one species occupies a particular area or region. Examples of man-made monocultures include lawns and farms (such as wheat fields or pumpkin patches).

This section includes several activities that can help students develop their own definitions of biodiversity and look deeper to understand the importance of species biodiversity.

Sentence Strip Definitions

1. Begin by asking, "Who has heard the word biodiversity?" and then ask "What do you think of when you hear the word biodiversity?" (option – write responses on the board)
2. Have students work with a classmate or small team to develop an initial definition of biodiversity. Remind the students to look at the parts of the word and break it down (bio and diversity). Initial definitions can be written on a scrap paper or in student journals.
3. Provide students with a variety of definitions of biodiversity (easily accessed by typing define: biodiversity in Google) or have students research the term with their partners/teams.
4. Once students have conducted further research, they can revise their definitions as needed.
5. Students write final definitions on sentence strips to be posted on the board.
6. Post and share sentence strips. Look at similarities and differences between the definitions, circling and/or highlighting key words in all definitions.

Why is Biodiversity Important?

Habitats that have a greater variety of different species of plants and animals have a greater biodiversity. These habitats are also healthier and more stable. One reason diverse communities have greater levels of health is that organisms of the same species tend to be more spread out. This reduces the ability of a disease to spread throughout a habitat. Additionally, if a certain type of species of tree or plant does become infected, the other species will remain and continue to provide the habitat components for the organisms in that area.

In an area consisting of monoculture, an area with only one type of plant species growing, the plants are more susceptible to disease and other stresses because they are all the same and less spread out (no other types of plants between them). As a result, [the entire habitat can be dramatically altered when impacted by disease or other stresses]. Human-made monocultures (crops, etc.) are created to make harvesting easier. However, they typically require larger amounts of pesticides and herbicides (to prevent diseases and/or "weeds") and larger amounts of energy and labor to maintain before harvesting.

Biological Diversity – Preventing Complete Loss of Habitat Due to Disease

This is simple activity demonstrates the impacts disease has on both a monoculture stand of trees and a biologically diverse community of trees. Students become trees and see very quickly that in a monoculture, disease spreads easily and it can eliminate an entire habitat. However, in a more diverse community, disease does not spread as much, resulting in a more intact habitat.

For more details and instructions, see Appendix A.

Appendix A

Biological Diversity – Preventing Complete Loss of Habitat Due to Disease

From How It Stops Disease From Spreading written by Kathy Paris

(http://www.accessexcellence.com/AE/ATG/data/released/0534-KathyParis/index.php)

Modified from original activity by Erica Baker

In this simulation, one set of cards represents the monoculture (the opposite of diversity) of a developed area. In this case, Douglas-fir trees were planted in a “green-belt” (open area where buildings are not built) of a constructed neighborhood in which all of the original trees and plants were cut down before construction. A disease hits one of the Douglas-fir trees and because of the proximity of the other Douglas-fir trees, disease spreads quickly. The other set of cards represents a biological diverse community – a neighborhood in which a builder planted a mixture of native trees (including Douglas-fir, Sitka Spruce, and Western Hemlock, Western Red Cedar) in the “green belt.” In this scenario, the Douglas-fir gets a disease, but the other native trees do not die. As a result, the majority of the habitat still exists. (Note: for North-Eastern Washington, the native trees would be Douglas-fir, Western Larch, Ponderosa Pine, and Lodgepole Pine.)

* Printable cards (with photos and general information) are available from the Washington Native Plant Society’s website: http://www.wnps.org/education/resources/plantid_cn.html

* To preserve cards, laminate them and give each student a sticky note (or ½ a sticky note) to put on the back of the card, or have the students use erasable markers.

Simulation 1: The First Set of Cards:

1. Give each student a Douglas-fir card – face down so that they do not know they all have the same tree species.
2. Pass out sticky notes and ask each student to place one sticky note on the back of the card. (If it is a larger sticky note, the students can draw a line to divide it in half – using the 1st half for the 1st simulation and the 2nd half for the 2nd simulation.)
3. Each person is to find 4 (or appropriate number based on class size) other people who have the same tree and have them write their names on the sticky note on the back of card.
4. All are to return to their seats and remain standing after they get 4 signatures

5. The teacher introduces the term "monoculture" and explains that this forest/habitat is a monoculture – a region with only one type of plant variety/species.
6. The teacher symbolizes the disease and touches one of the students. Ask that person to sit down (they have been infected and are now dead) and then read names on his/her card. As the names are read, those students sit too since they have been "infected."
7. Then ask another one of those sitting (dead) to read the names on his/her card- continue until all (or almost all) are sitting.
8. Ask them to explain why the disease spread so fast (they are so alike genetically; lack of diversity).

Simulation 2: The Second Set of Cards:

1. Collect the monoculture Douglas-fir forest cards and then pass out a mix of other cards (have students keep sticky notes, if needed) – again face down.

   For Western Washington Forests you can use Maple (vine or big-leaf), Sitka Spruce, Western Hemlock, Western Red Cedar and ALSO some Douglas-fir cards. For Eastern Washington (intermountain region), the native trees would be Maple (Douglas maple), Western Larch, Ponderosa Pine, Lodgepole Pine, and ALSO some Douglas-fir cards.
2. Pass out sticky notes and ask each student to place one sticky note on the back of the card or to transfer the sticky note from simulation 1 to the back of the second card.
3. Explain that in some forests (and even neighborhoods) there are a variety of trees. These habitats have a greater biodiversity.
4. Repeat steps 2-6 above. This time only those students that are the same variety as the diseased tree (Douglas-fir) that touched them will sit. Different variety trees don't sit (don't die) even if they are sitting near the diseased tree.
5. Many of the students will remain standing (didn't die).
6. Ask students to explain why the disease didn't spread and damage/destroy the entire forest this time (genetic or biological diversity)

Follow-Up Questions

For discussion or journal entries/discussion after the second simulation.

1. What does biological diversity mean?
2. What is a monoculture?
3. Why didn't all the different trees get the disease? (hint - genetics)
4. In which forest would you need to use more chemicals to control disease: the Douglas fir forest or the more varied forest? Why?
5. Which forest would have more diversity of wildlife? Why?
6. If you cut down a forest that has a variety of trees and replanted with one type of tree:
   a. What will happen to much of the wildlife that was adapted to that prior forest? (Hint: they can always just move elsewhere. If other habitats are good, they will probably be near carrying capacity already. In other words, the surrounding areas may already have good-sized populations growing in them.)

   b. Will this happen to all the wildlife? Explain.
7. Growing one plant, as is the case of growing only Douglas-fir, is called monoculture. Besides in neighborhoods, where else might we find monocultures?

KANSAS NATIVE PLANTS

Kansas Native Plants • Plant Guide

Guide to Plants of Kansas, native & alien

Google Custom Search Search

Kansas Trees

Plant Search

Name

Common Scientific Common Family Any

Characteristics

Origin Kansas Native Water Any Sun Any

Flower Characteristics

Color Any Bloom Month Any

Growth Characteristics

Growth Habit Tree Life Span Any Height between 0 and 999 feet

Reproduction Any

Search Reset

Plant Search Results (Records 50)

Scientific Name	Common Name	Common Family	Plant Type	Plant Height	Flower Color	Plant Origin	Image
Acer negundo	Box Elder	Maple	Tree	60.0 feet	Green/	Kansas Native	6
Acer saccharinum	Silver Maple	Maple	Tree	60.0 feet	Red/	Kansas Native	3
Acer saccharum	Sugar Maple	Maple	Tree	60.0 feet	Red/	Kansas Native	5
Aesculus glabra	Western Buckeye	Horse Chestnut	Tree	12.0 feet	Yellow/	Kansas Native	7
Amelanchier arborea	Downy Serviceberry	Rose	Tree	25.0 feet	White/	Kansas Native	5
Asimina triloba	Paw Paw	Custard Apple	Tree	15.0 feet	Red/	Kansas Native	5
Carya cordiformis	Bitternut Hickory	Walnut	Tree	60.0 feet	Green/	Kansas Native	7
Carya illinoinensis	Pecan	Walnut	Tree	60.0 feet	Green/	Kansas Native	9
Carya laciniosa	Shellbark Hickory	Walnut	Tree	60.0 feet	Green/	Kansas Native	7
Carya ovata	Shagbark Hickory	Walnut	Tree	60.0 feet	Green/	Kansas Native	7
Carya tomentosa	Mockernut Hickory	Walnut	Tree	60.0 feet	Green/	Kansas Native	8
Celtis occidentalis	Hackberry	Elm	Tree	45.0 feet	White/	Kansas Native	3
Cercis canadensis	Redbud	Bean	Tree	15.0 feet	Red/	Kansas Native	8
Crataegus crus-galli	Cockspur Hawthorn	Rose	Tree	12.0 feet	White/	Kansas Native	6
Crataegus mollis	Downy Hawthorn	Rose	Tree	21.0 feet	White/	Kansas Native	7
Diospyros virginiana	Persimmon	Persimmon	Tree	20.0 feet	Green/	Kansas Native	9
Fraxinus americana	White Ash	Olive	Tree	42.0 feet	Red/	Kansas Native	6
Fraxinus pennsylvanica	Green Ash	Olive	Tree	60.0 feet	Yellow/	Kansas Native	10
Gleditsia triacanthos	Honey Locust	Bean	Tree	45.0 feet	White/	Kansas Native	7
Gymnocladus dioica	Kentucky Coffee Tree	Bean	Tree	70.0 feet	White/	Kansas Native	2
Juglans nigra	Black Walnut	Walnut	Tree	90.0 feet	Green/	Kansas Native	6
Juniperus virginiana	Red Cedar	Juniper	Tree	36.0 feet	Green/	Kansas Native	4
Malus ioensis	Prairie Crabapple	Rose	Tree	18.0 feet	White/Pink	Kansas Native	12
Morus rubra	Red Mulberry	Mulberry	Tree	24.0 feet	Green/	Kansas Native	5
Ostrya virginiana	Hop Hornbeam	Birch	Tree	18.0 feet	Green/	Kansas Native	5
Platanus occidentalis	Common Sycamore	Sycamore	Tree	90.0 feet	Green/	Kansas Native	14
Populus deltoides	Eastern Cottonwood	Willow	Tree	60.0 feet	Green/	Kansas Native	4
Prunus hortulana	Hortulan Plum	Rose	Tree	12.0 feet	White/	Kansas Native	6
Prunus mexicana	Mexican Plum	Rose	Tree	12.0 feet	White/	Kansas Native	3
Prunus serotina	Black Cherry	Rose	Tree	45.0 feet	White/	Kansas Native	5
Quercus alba	White Oak	Oak	Tree	75.0 feet	Green/	Kansas Native	13
Quercus bicolor	Swamp White Oak	Oak	Tree	80.0 feet	Green/	Kansas Native	5
Quercus borealis	Red Oak	Oak	Tree	75.0 feet	Green/	Kansas Native	6
Quercus imbricaria	Shingle Oak	Oak	Tree	60.0 feet	Green/	Kansas Native	7
Quercus macrocarpa	Bur Oak	Oak	Tree	90.0 feet	Green/	Kansas Native	8
Quercus marilandica	Black Jack Oak	Oak	Tree	25.0 feet	Green/	Kansas Native	9

Scientific Name	Common Name	Common Family	Plant Type	Plant Height	Flower Color	Plant Origin	Image
Quercus muehlenbergii	Chinquapin Oak	Oak	Tree	60.0 feet	Green/	Kansas Native	8
Quercus palustris	Pin Oak	Oak	Tree	45.0 feet	Green/	Kansas Native	0
Quercus prinoides	Dwarf Chinquapin Oak	Oak	Tree	12.0 feet	Green/	Kansas Native	6
Quercus shumardii	Shummard's Oak	Oak	Tree	75.0 feet	Green/	Kansas Native	3
Quercus stellata	Post Oak	Oak	Tree	30.0 feet	Green/	Kansas Native	12
Quercus velutina	Black Oak	Oak	Tree	45.0 feet	Green/	Kansas Native	6
Salix amygdaloides	Peach Leaved Willow	Willow	Tree	60.0 feet	Green/	Kansas Native	6
Salix exigua	Sandbar Willow	Willow	Tree	15.0 feet	Green/	Kansas Native	10
Salix humilis	Prairie Willow	Willow	Tree	3.0 feet	Green/	Kansas Native	4
Salix nigra	Black Willow	Willow	Tree	60.0 feet	Green/	Kansas Native	8
Sapindus saponaria	Western Soapberry	Soapberry	Tree	20.0 feet	Green/	Kansas Native	2
Tilia americana	American Basswood	Linden	Tree	60.0 feet	White/	Kansas Native	7
Ulmus americana	American Elm	Elm	Tree	75.0 feet	Red/	Kansas Native	6
Ulmus rubra	Red Elm	Elm	Tree	60.0 feet	Red/	Kansas Native	2

KANSAS NATIVE PLANTS

Kansas Native Plants • Plant Guide

Guide to Plants of Kansas, native & alien

Google Custom Search | Search

Kansas Perennials

Plant Search

Name

Common | Scientific | Common Family Any

Characteristics

Origin Kansas Native | Water Any | Sun Any

Flower Characteristics

Color Any | Bloom Month Any

Growth Characteristics

Growth Habit Herb | Life Span Perennial | Height between 0 and 999 feet

Reproduction Any

Search | Reset

Plant Search Results (Records 296)

Scientific Name	Common Name	Common Family	Plant Type	Plant Height	Flower Color	Plant Origin	Image
Achillea millefolium	Western Yarrow	Aster	Herb	2.0 feet	White/	Kansas Native	5
Agastache nepetoides	Yellow Giant Hyssop	Mint	Herb	6.0 feet	Yellow/Cream	Kansas Native	4
Ageratina altissima	White Snakeroot	Aster	Herb	3.0 feet	White/	Kansas Native	8
Agrimonia parviflora	Smallflower Agrimony	Rose	Herb	3.0 feet	Yellow/	Kansas Native	3
Agrimonia pubescens	Downy Agrimony	Rose	Herb	2.0 feet	White/	Kansas Native	3
Agrimonia rostellata	Woodland Agrimony	Rose	Herb	2.0 feet	Yellow/	Kansas Native	6
Allium canadense	Canada Onion	Lily	Herb	0.8 feet	White/	Kansas Native	2
Ambrosia psilostachya	Western Ragweed	Aster	Herb	2.0 feet	Green/	Kansas Native	7
Amphicarpaea bracteata	Hog Peanut	Bean	Herb	3.0 feet	Violet/	Kansas Native	3
Anemone canadensis	Canada Anemone	Buttercup	Herb	0.5 feet	White/	Kansas Native	11
Anemone caroliniana	Carolina Anemone	Buttercup	Herb	0.5 feet	Violet/	Kansas Native	6
Anemone virginiana	Tall Anemone	Buttercup	Herb	3.0 feet	White/	Kansas Native	4
Antennaria neglecta	Field Pussytoes	Aster	Herb	0.8 feet	White/	Kansas Native	6
Antennaria plantaginifolia	Plantain-leaf pussytoes	Aster	Herb	1.0 feet	White/	Kansas Native	7
Aplectrum hyemale	puttyroot	Orchid	Herb	1.0 feet	Pink/Brown	Kansas Native	4
Apocynum cannabinum	Hemp Dogbane	Dogbane	Herb	3.5 feet	White/	Kansas Native	4
Aquilegia canadensis	Red Columbine	Buttercup	Herb	2.0 feet	Red/Pink	Kansas Native	7
Arisaema dracontium	Green Dragon	Arum	Herb	2.0 feet	Green/	Kansas Native	5
Arisaema triphyllum	Jack in the Pulpit	Arum	Herb	2.0 feet	Green/	Kansas Native	4
Arnoglossum atriplicifolium	Pale Indian Plantain	Aster	Herb	3.0 feet	White/	Kansas Native	4
Arnoglossum plantagineum	Tuberous Indian Plantain	Aster	Herb	3.0 feet	White/	Kansas Native	6
Artemisia ludoviciana	White Sage	Aster	Herb	3.0 feet	White/	Kansas Native	6
Asarum canadense	Canada Wild Ginger	Birthwort	Herb	0.5 feet	Violet/Brown	Kansas Native	5
Asclepias amplexicaulis	Bluntleaf Milkweed	Milkweed	Herb	3.0 feet	White/	Kansas Native	6
Asclepias hirtella	Tall Green Milkweed	Milkweed	Herb	3.0 feet	White/	Kansas Native	8
Asclepias incarnata	Swamp Milkweed	Milkweed	Herb	5.0 feet	Red/Pink	Kansas Native	5
Asclepias lanuginosa	Woolly Milkweed	Milkweed	Herb	0.5 feet	White/Green	Kansas Native	15
Asclepias meadii	Mead's Milkweed	Milkweed	Herb	3.0 feet	White/	Kansas Native	3
Asclepias purpurascens	Purple Milkweed	Milkweed	Herb	3.0 feet	Violet/	Kansas Native	10
Asclepias stenophylla	Narrowleaf Milkweed	Milkweed	Herb	2.0 feet	White/	Kansas Native	6
Asclepias sullivantii	Smooth Milkweed	Milkweed	Herb	3.0 feet	Red/Pink	Kansas Native	9
Asclepias syriaca	Common Milkweed	Milkweed	Herb	4.0 feet	Lavender/Pink	Kansas Native	9
Asclepias tuberosa	Butterfly Milkweed	Milkweed	Herb	2.5 feet	Orange/Red	Kansas Native	9
Asclepias verticillata	Whorled Milkweed	Milkweed	Herb	2.5 feet	White/	Kansas Native	8

Scientific Name	Common Name	Common Family	Plant Type	Plant Height	Flower Color	Plant Origin	Image
Asclepias viridiflora	Green Milkweed	Milkweed	Herb	2.0 feet	Green/	Kansas Native	9
Asclepias viridis	Green Antelopehorn	Milkweed	Herb	2.0 feet	Green/Violet	Kansas Native	12
Asplenium platyneuron	Ebony Spleenwort	Spleenwort	Herb	1.0 feet	Green/	Kansas Native	0
Aster drummondii	Drummond's Aster	Aster	Herb	3.0 feet	Lavender/Pink	Kansas Native	4
Aster ericoides	Heath Aster	Aster	Herb	2.0 feet	White/	Kansas Native	2
Aster laevis	Smooth blue aster	Aster	Herb	4.0 feet	Blue/Lavender	Kansas Native	10
Aster lanceolatus	Lanceleaf Aster	Aster	Herb	3.0 feet	White/	Kansas Native	6
Aster novae-angliae	New England Aster	Aster	Herb	4.0 feet	Blue/Violet	Kansas Native	4
Aster oblongifolius	Aromatic Aster	Aster	Herb	0.8 feet	Violet/Lavender	Kansas Native	3
Aster oolentangiensis	Sky Blue Aster	Aster	Herb	3.0 feet	Blue/Lavender	Kansas Native	4
Aster pilosus	Hairy Aster	Aster	Herb	3.0 feet	White/	Kansas Native	3
Aster praealtus	Willowleaf Aster	Aster	Herb	4.0 feet	Blue/	Kansas Native	3
Aster sericeus	Silky Aster	Aster	Herb	1.0 feet	Violet/Lavender	Kansas Native	3
Astragalus canadensis	Canada Milkvetch	Bean	Herb	4.0 feet	Yellow/Cream	Kansas Native	8
Astragalus crassicarpus	Ground Plum Milkvetch	Bean	Herb	0.5 feet	Violet/	Kansas Native	9
Bacopa rotundifolia	Disk Leaf Water Hyssop	Plantain	Herb	0.1 feet	White/Yellow	Kansas Native	7
Baptisia alba	White Wild Indigo	Bean	Herb	5.0 feet	White/	Kansas Native	9
Baptisia australis	Blue Wild Indigo	Bean	Herb	3.0 feet	Blue/	Kansas Native	5
Baptisia bracteata	Cream Wild Indigo	Bean	Herb	2.5 feet	Yellow/	Kansas Native	5
Berula erecta	Cut Leaf Water Parsnip	Parsley	Herb	1.0 feet	White/	Kansas Native	0
Boehmeria cylindrica	Bog Hemp	Nettle	Herb	3.0 feet	Green/	Kansas Native	6
Botrychium dissectum	Dissected Grape Fern	Adder's Tongue	Herb	1.0 feet	Green/	Kansas Native	4
Botrychium virginianum	Rattlesnake Fern	Adder's Tongue	Herb	1.0 feet	Green/	Kansas Native	8
Callirhoe alcaeoides	Pink Poppy Mallow	Mallow	Herb	2.0 feet	White/	Kansas Native	4
Callirhoe involucrata	Purple Poppy Mallow	Mallow	Herb	0.5 feet	Violet/	Kansas Native	6
Calylophus serrulatus	Toothed Evening Primrose	Evening Primrose	Herb	2.0 feet	Yellow/	Kansas Native	6
Calystegia macounii	Macoun's Hedge Bindweed	Morning Glory	Herb	5.0 feet	White/	Kansas Native	8
Camassia angusta	Wild Hyacinth	Lily	Herb	1.5 feet	Blue/	Kansas Native	9
Camassia scilloides	Wild Hyacinth	Lily	Herb	1.5 feet	Blue/	Kansas Native	3
Cardamine bulbosa	Bulbous Bittercress	Mustard	Herb	1.0 feet	White/	Kansas Native	1
Cardamine concatenata	Cutleaf Toothwort	Mustard	Herb	1.0 feet	White/	Kansas Native	5
Cassia marilandica	Maryland Senna	Bean	Herb	5.0 feet	Yellow/	Kansas Native	10
Circaea lutetiana	Enchanter's Nightshade	Evening Primrose	Herb	2.0 feet	Yellow/	Kansas Native	0
Claytonia virginica	Spring Beauty	Purslane	Herb	0.5 feet	White/Lavender	Kansas Native	8
Comandra umbellata	Bastard Toadflax	Sandalwood	Herb	1.0 feet	White/	Kansas Native	5
Conoclinium coelestinum	Blue Mistflower	Aster	Herb	2.0 feet	Blue/	Kansas Native	2
Corallorhiza odontorhiza	Fall Coralroot Orchid	Orchid	Herb	1.0 feet	Green/	Kansas Native	0
Coreopsis grandiflora	Big Flower Coreopsis	Aster	Herb	3.0 feet	Yellow/	Kansas Native	3
Coreopsis palmata	Finger Coreopsis	Aster	Herb	2.5 feet	Yellow/	Kansas Native	4
Coreopsis tripteris	Tall Coreopsis	Aster	Herb	5.0 feet	Yellow/	Kansas Native	3
Cryptotaenia canadensis	Canadian Honewort	Parsley	Herb	3.0 feet	White/	Kansas Native	9
Cypripedium pubescens	Yellow Lady's Slipper	Orchid	Herb	1.0 feet	Yellow/	Kansas Native	16
Cystopteris protrusa	Southern Bladder Fern	Wood Fern	Herb	1.0 feet	Green/	Kansas Native	2
Dalea candida	white prairie clover	Bean	Herb	3.0 feet	White/	Kansas Native	11
Dalea multiflora	Roundhead Prairie Clover	Bean	Herb	1.5 feet	White/	Kansas Native	10
Dalea purpurea	Purple Prairie Clover	Bean	Herb	1.5 feet	Violet/	Kansas Native	5
Delphinium tricorne	Rock Larkspur	Buttercup	Herb	2.0 feet	Blue/	Kansas Native	5
Delphinium virescens	Plains Larkspur	Buttercup	Herb	3.0 feet	White/Lavender	Kansas Native	7
Desmanthus illinoensis	Illinois Bundle Flower	Bean	Herb	5.0 feet	White/	Kansas Native	6
Desmodium canadense	Showy Ticktrefoil	Bean	Herb	3.0 feet	Violet/	Kansas Native	3
Desmodium canescens	Hoary Ticktrefoil	Bean	Herb	3.0 feet	Violet/	Kansas Native	2
Desmodium cuspidatum	Largebract Ticktrefoil	Bean	Herb	5.0 feet	Violet/	Kansas Native	5
Desmodium glutinosum	Pointed-leaf Ticktrefoil	Bean	Herb	5.0 feet	Violet/	Kansas Native	1
Desmodium illinoense	Illinois Ticktrefoil	Bean	Herb	5.0 feet	White/	Kansas Native	5
Desmodium paniculatum	Panicled Ticktrefoil	Bean	Herb	5.0 feet	Violet/	Kansas Native	1
Desmodium sessilifolium	Sessile-leaved Ticktrefoil	Bean	Herb	5.0 feet	Violet/	Kansas Native	3
Dicentra cucullaria	Dutchman's Breeches	Fumitory	Herb	1.0 feet	Violet/	Kansas Native	17
Dryopteris marginalis	marginal wood fern	Wood Fern	Herb	1.0 feet	Green/	Kansas Native	1
Echinacea angustifolia	Blacksamson Coneflower	Aster	Herb	2.0 feet	Red/	Kansas Native	5
Echinacea atrorubens	Topeka Coneflower	Aster	Herb	3.0 feet	Red/Pink	Kansas Native	3
Echinacea pallida	Pale Coneflower	Aster	Herb	3.0 feet	Violet/Pink	Kansas Native	11
Epilobium coloratum	Purpleleaf Willowherb	Evening Primrose	Herb	3.0 feet	White/	Kansas Native	0
Equisetum arvense	field horsetail	Horsetail	Herb	1.0 feet	Green/	Kansas Native	1
Equisetum hyemale	common scouring-rush	Horsetail	Herb	2.0 feet	Green/	Kansas Native	4
Equisetum laevigatum	smooth scouring-rush	Horsetail	Herb	2.0 feet	Green/	Kansas Native	0

Scientific Name	Common Name	Common Family	Plant Type	Plant Height	Flower Color	Plant Origin	Image
Erigeron philadelphicus	Philadelphia Fleabane	Aster	Herb	2.0 feet	White/	Kansas Native	6
Eryngium yuccifolium	Rattlesnake Master	Parsley	Herb	4.0 feet	White/Green	Kansas Native	9
Erythronium albidum	White Fawn Lily	Lily	Herb	0.5 feet	White/	Kansas Native	7
Erythronium mesochoreum	Midland Fawn Lily	Lily	Herb	0.5 feet	White/	Kansas Native	5
Eupatorium altissimum	Tall Boneset	Aster	Herb	5.0 feet	White/	Kansas Native	4
Eupatorium maculatum	Spotted Joe-Pye Weed	Aster	Herb	7.0 feet	Violet/Pink	Kansas Native	2
Eupatorium perfoliatum	Common Boneset	Aster	Herb	3.0 feet	White/	Kansas Native	3
Eupatorium purpureum	Sweet Joe-Pye	Aster	Herb	5.0 feet	Violet/Pink	Kansas Native	5
Euphorbia corollata	Flowering Spurge	Spurge	Herb	3.5 feet	White/	Kansas Native	3
Euthamia gymnospermoides	Grass Leaved Goldenrod	Aster	Herb	3.0 feet	Yellow/	Kansas Native	3
Evolvulus nuttallianus	silver wild morningglory	Morning Glory	Herb	0.5 feet	Pink/Violet	Kansas Native	6
Filipendula rubra	Queen of the prairie	Rose	Herb	3.0 feet	Pink/	Kansas Native	3
Fragaria virginiana	Wild Strawberry	Rose	Herb	0.5 feet	White/	Kansas Native	8
Galium circaezans	Forest Bedstraw	Coffee	Herb	0.6 feet	White/	Kansas Native	7
Galium concinnum	Shining Bedstraw	Coffee	Herb	2.0 feet	White/	Kansas Native	0
Galium obtusum	Bluntleaf Bedstraw	Coffee	Herb	2.0 feet	Green/	Kansas Native	5
Galium triflorum	Fragrant Bedstraw	Coffee	Herb	2.0 feet	White/	Kansas Native	5
Gentiana alba	White Gentian	Gentian	Herb	1.5 feet	White/	Kansas Native	4
Gentiana puberulenta	Downy Gentian	Gentian	Herb	1.5 feet	Violet/	Kansas Native	4
Geranium maculatum	Spotted Geranium	Geranium	Herb	1.0 feet	Red/	Kansas Native	3
Geum canadense	White Avens	Rose	Herb	3.0 feet	White/	Kansas Native	5
Geum vernum	Spring Avens	Rose	Herb	3.0 feet	White/	Kansas Native	0
Glandularia bipinnatifida	Dakota Verbena	Vervain	Herb	0.5 feet	Violet/Lavender	Kansas Native	9
Glandularia canadensis	Rose Verbena	Vervain	Herb	0.5 feet	Violet/Lavender	Kansas Native	6
Glycyrrhiza lepidota	Wild Licorice	Bean	Herb	3.0 feet	Green/	Kansas Native	0
Hedyotis nigricans	Narrowleaf Bluets	Coffee	Herb	1.0 feet	White/	Kansas Native	8
Helenium autumnale	Sneezeweed	Aster	Herb	3.5 feet	Yellow/	Kansas Native	7
Helianthus grosseserratus	Sawtooth Sunflower	Aster	Herb	8.0 feet	Yellow/	Kansas Native	5
Helianthus hirsutus	Hairy Sunflower	Aster	Herb	4.0 feet	Yellow/	Kansas Native	7
Helianthus maximilianii	Maximilian Sunflower	Aster	Herb	7.0 feet	Yellow/	Kansas Native	4
Helianthus mollis	Ashy Sunflower	Aster	Herb	5.0 feet	Yellow/	Kansas Native	6
Helianthus rigidus	Stiff Sunflower	Aster	Herb	5.0 feet	Yellow/	Kansas Native	4
Helianthus salicifolius	Willow Leaf Sunflower	Aster	Herb	7.0 feet	Yellow/	Kansas Native	5
Helianthus tuberosus	Jerusalem artichoke	Aster	Herb	8.0 feet	Yellow/	Kansas Native	5
Heliopsis helianthoides	False Sunflower	Aster	Herb	4.0 feet	Yellow/	Kansas Native	4
Heuchera richardsonii	Alumroot	Saxifrage	Herb	3.0 feet	White/	Kansas Native	0
Hibiscus laevis	Halberdleaf Rosemallow	Mallow	Herb	1.0 feet	Red/	Kansas Native	2
Hibiscus moscheutos	Crimsoneyed Rosemallow	Mallow	Herb	1.0 feet	Red/	Kansas Native	5
Hieracium longipilum	Long-bearded Hawkweed	Aster	Herb	4.0 feet	Yellow/	Kansas Native	4
Hybanthus verticillatus	Nodding Green Violet	Violet	Herb	0.5 feet	White/Violet	Kansas Native	10
Hydrocotyle ranunculoides	Floating Pennyroyal	Parsley	Herb	0.1 feet	White/	Kansas Native	8
Hydrophyllum virginianum	Virginia Waterleaf	Waterleaf	Herb	1.0 feet	Lavender/White	Kansas Native	7
Hypericum punctatum	Spotted St. John's-wort	St. Johns	Herb	1.5 feet	Yellow/	Kansas Native	3
Hypericum sphaerocarpum	Roundfruit St. John's-wort	St. Johns	Herb	1.5 feet	Yellow/	Kansas Native	0
Hypoxis hirsuta	Yellow Stargrass	Amaryllis	Herb	0.6 feet	Yellow/	Kansas Native	8
Iris virginica	Viriginia iris	Iris	Herb	4.0 feet	Blue/Violet	Kansas Native	2
Isopyrum biternatum	False Rue Anemone	Buttercup	Herb	1.0 feet	White/	Kansas Native	3
Justicia americana	American Water Willow	Acanthus	Herb	4.0 feet	White/Pink	Kansas Native	0
Kuhnia eupatorioides	False Boneset	Aster	Herb	3.0 feet	White/	Kansas Native	6
Laportea canadensis	Canada Wood Nettle	Nettle	Herb	4.0 feet	Green/	Kansas Native	6
Lespedeza capitata	Round-headed Bush Clover	Bean	Herb	4.0 feet	White/Green	Kansas Native	4
Lespedeza violacea	Violet Lespedeza	Bean	Herb	1.0 feet	Violet/	Kansas Native	3
Lespedeza virginica	Slender Bush Clover	Bean	Herb	3.0 feet	Violet/	Kansas Native	0
Liatris aspera	Button Gayfeather	Aster	Herb	3.0 feet	Violet/Lavender	Kansas Native	4
Liatris mucronata	Eastern Dotted Gayfeather	Aster	Herb	2.0 feet	Violet/Lavender	Kansas Native	3
Liatris punctata	Dotted Gayfeather	Aster	Herb	2.0 feet	Violet/	Kansas Native	4
Liatris pycnostachya	Thickspike Gayfeather	Aster	Herb	4.0 feet	Violet/Lavender	Kansas Native	7
Liatris squarrosa	Scaly Gayfeather	Aster	Herb	1.0 feet	Violet/	Kansas Native	2
Lilium michiganense	Michigan Lily	Lily	Herb	3.0 feet	Orange/Red	Kansas Native	11
Liparis loeselii	Loesel's twayblade	Orchid	Herb	1.0 feet	White/	Kansas Native	19
Lithospermum canescens	Hoary Puccoon	Borage	Herb	1.0 feet	Yellow/	Kansas Native	8
Lithospermum incisum	Fringed Puccoon	Borage	Herb	0.8 feet	Yellow/	Kansas Native	9
Lithospermum latifolium	American Stoneseed	Borage	Herb	1.0 feet	White/	Kansas Native	2

Scientific Name	Common Name	Common Family	Plant Type	Plant Height	Flower Color	Plant Origin	Image
Lobelia cardinalis	Cardinal Flower	Bellflower	Herb	3.0 feet	Red/	Kansas Native	11
Lobelia siphilitica	Great Blue Lobelia	Bellflower	Herb	3.0 feet	Blue/	Kansas Native	5
Lobelia spicata	Pale Spike Lobelia	Bellflower	Herb	2.0 feet	Blue/	Kansas Native	3
Lomatium foeniculaceum	Desert Biscuitroot	Parsley	Herb	0.5 feet	Yellow/	Kansas Native	6
Ludwigia alternifolia	Seedbox	Evening Primrose	Herb	2.0 feet	Yellow/	Kansas Native	6
Ludwigia peploides	Water Primrose	Evening Primrose	Herb	1.0 feet	Yellow/	Kansas Native	8
Lycopus americanus	American Bugleweed	Mint	Herb	2.0 feet	Violet/	Kansas Native	6
Lysimachia ciliata	Fringed Loosestrife	Primrose	Herb	3.0 feet	Yellow/	Kansas Native	4
Lythrum alatum	Winged Loosestrife	Loosestrife	Herb	3.0 feet	Violet/	Kansas Native	2
Melanthium virginicum	Virginia Bunchflower	Lily	Herb	6.0 feet	White/	Kansas Native	6
Mentha arvensis	Field Mint	Mint	Herb	4.0 feet	White/	Kansas Native	8
Mertensia virginica	Virginia bluebells	Borage	Herb	2.0 feet	Blue/	Kansas Native	5
Microseris cuspidata	False Dandelion	Aster	Herb	0.5 feet	Yellow/	Kansas Native	3
Mimulus alatus	Winged Monkeyflower	Figwort	Herb	3.0 feet	Blue/Violet	Kansas Native	16
Mimulus glabratus	Roundleaf Monkeyflower	Figwort	Herb	1.0 feet	White/	Kansas Native	8
Mimulus ringens	Alleghany Monkeyflower	Figwort	Herb	3.0 feet	Blue/Violet	Kansas Native	7
Mirabilis albida	White Four-O'clock	Four-o'clock	Herb	3.0 feet	White/	Kansas Native	10
Mirabilis hirsuta	Hairy Four O'clock	Four-o'clock	Herb	3.0 feet	White/	Kansas Native	0
Mirabilis nyctaginea	Wild Four-O'clock	Four-o'clock	Herb	3.0 feet	Violet/	Kansas Native	2
Monarda fistulosa	Mint-leaf Beebalm	Mint	Herb	3.0 feet	Violet/Lavender	Kansas Native	10
Nelumbo lutea	American Lotus	Indian Lotus	Herb	3.0 feet	Yellow/	Kansas Native	13
Nothoscordum bivalve	False Garlic	Lily	Herb	0.8 feet	White/	Kansas Native	5
Oenothera macrocarpa	Missouri evening primrose	Evening Primrose	Herb	0.8 feet	Yellow/	Kansas Native	6
Oenothera speciosa	Showy Evening Primrose	Evening Primrose	Herb	2.0 feet	White/	Kansas Native	7
Onosmodium molle	Western Marbleseed	Borage	Herb	2.0 feet	Green/White	Kansas Native	6
Ophioglossum engelmannii	Adders Tongue Fern	Adder's Tongue	Herb	0.3 feet	Green/	Kansas Native	5
Opuntia macrorhiza	Prickly Pear	Cactus	Herb	0.5 feet	White/	Kansas Native	3
Osmorhiza longistylis	Anise Root	Parsley	Herb	3.0 feet	White/	Kansas Native	5
Oxalis dillenii	Gray-green Wood Sorrel	Wood Sorrel	Herb	0.5 feet	Yellow/	Kansas Native	8
Oxalis stricta	Upright Yellow Wood Sorrel	Wood Sorrel	Herb	0.5 feet	Yellow/	Kansas Native	0
Oxalis violacea	Violet Wood Sorrel	Wood Sorrel	Herb	0.5 feet	Red/	Kansas Native	4
Packera obovata	round-leaf ragwort	Aster	Herb	2.0 feet	Yellow/	Kansas Native	3
Packera plattensis	Prairie Ragwort	Aster	Herb	1.0 feet	Yellow/	Kansas Native	9
Parthenium hispidum	Wild Quinine	Aster	Herb	2.0 feet	White/	Kansas Native	0
Pedicularis canadensis	Common Lousewort	Figwort	Herb	0.5 feet	Yellow/	Kansas Native	4
Penstemon buckleyi	Buckley Beardtongue	Figwort	Herb	3.0 feet	Pink/	Kansas Native	3
Penstemon cobaea	Showy Beardtongue	Figwort	Herb	2.0 feet	White/Pink	Kansas Native	8
Penstemon digitalis	Foxglove Beardtongue	Figwort	Herb	2.0 feet	White/	Kansas Native	5
Penstemon grandiflorus	Large-flower beardtongue	Figwort	Herb	3.0 feet	Pink/Violet	Kansas Native	9
Penstemon tubiflorus	Tube Beardtongue	Figwort	Herb	3.0 feet	White/	Kansas Native	8
Penthorum sedoides	Ditch Stonecrop	Penthorum	Herb	2.5 feet	White/	Kansas Native	9
Persicaria amphibia	Swamp Smartweed	Buckwheat	Herb	4.0 feet	Green/	Kansas Native	5
Persicaria punctata	Dotted Smartweed	Buckwheat	Herb	3.0 feet	Green/	Kansas Native	5
Phlox divaricata	Blue Phlox	Phlox	Herb	2.0 feet	Blue/Lavender	Kansas Native	6
Phlox pilosa	Prairie Phlox	Phlox	Herb	1.5 feet	Red/	Kansas Native	6
Phryma leptostachya	American Lopseed	Vervain	Herb	3.0 feet	Violet/	Kansas Native	9
Phyla lanceolata	Lanceleaf Fogfruit	Vervain	Herb	1.0 feet	White/	Kansas Native	7
Physalis heterophylla	Clammy Ground Cherry	Nightshade	Herb	1.0 feet	Yellow/	Kansas Native	1
Physalis longifolia	Long Leaf Ground Cherry	Nightshade	Herb	1.0 feet	Yellow/	Kansas Native	7
Physalis pumila	Prairie Ground Cherry	Nightshade	Herb	2.0 feet	Violet/	Kansas Native	5
Physalis virginiana	Virginia Ground Cherry	Nightshade	Herb	1.0 feet	Yellow/	Kansas Native	0
Physostegia virginiana	Obedient Plant	Mint	Herb	4.0 feet	Violet/Pink	Kansas Native	3
Phytolacca americana	Pokeberry	Pokeweed	Herb	3.0 feet	Green/	Kansas Native	3
Plantago rugelii	Blackseed Plantain	Plantain	Herb	1.0 feet	Green/	Kansas Native	3
Platanthera praeclara	Prairie Fringed Orchid	Orchid	Herb	2.5 feet	Yellow/	Kansas Native	4
Podophyllum peltatum	May Apple	Barberry	Herb	2.0 feet	White/	Kansas Native	8
Polygonatum biflorum	Solomon's Seal	Lily	Herb	4.0 feet	White/	Kansas Native	4
Polygonum hydropiperoides	Mild Water Pepper Smartweed	Buckwheat	Herb	3.0 feet	Green/	Kansas Native	4
Polygonum scandens	Climbing False Buckwheat	Buckwheat	Herb	3.0 feet	Green/	Kansas Native	0
Polygonum virginianum	Virginia Knotweed	Buckwheat	Herb	3.0 feet	White/	Kansas Native	6
Polytaenia nuttallii	Prairie Parsley	Parsley	Herb	3.0 feet	Yellow/	Kansas Native	3
Potentilla arguta	Tall Cinquefoil	Rose	Herb	3.0 feet	Yellow/	Kansas Native	3
Potentilla simplex	Common Cinquefoil	Rose	Herb	3.0 feet	Yellow/	Kansas Native	3
Prenanthes aspera	Rough Rattlesnake Root	Aster	Herb	4.0 feet	Yellow/	Kansas Native	4

Scientific Name	Common Name	Common Family	Plant Type	Plant Height	Flower Color	Plant Origin	Image
Prunella vulgaris	Common Selfheal	Mint	Herb	1.0 feet	Violet/	Kansas Native	5
Psoralea argophylla	Silverleaf Scurfpea	Bean	Herb	2.0 feet	Violet/	Kansas Native	3
Psoralea esculenta	Prairie Turnip	Bean	Herb	1.0 feet	Violet/	Kansas Native	7
Psoralea tenuiflora	Slim Flower Scufpea	Bean	Herb	2.0 feet	Violet/	Kansas Native	2
Pycnanthemum tenuifolium	Slender Mountain Mint	Mint	Herb	2.0 feet	White/	Kansas Native	5
Pycnanthemum verticillatum	hairy mountain mint	Mint	Herb	2.5 feet	White/	Kansas Native	1
Pycnanthemum virginianum	Virginia mountain mint	Mint	Herb	3.0 feet	White/	Kansas Native	4
Ratibida columnifera	Prairie Coneflower	Aster	Herb	3.0 feet	Yellow/	Kansas Native	4
Ratibida pinnata	Gray-headed Coneflower	Aster	Herb	4.0 feet	Yellow/	Kansas Native	5
Rudbeckia laciniata	Cutleaf Coneflower	Aster	Herb	5.0 feet	Yellow/	Kansas Native	10
Rudbeckia subtomentosa	Sweet Coneflower	Aster	Herb	4.0 feet	Yellow/	Kansas Native	3
Rudbeckia triloba	Brown-eyed Susan	Aster	Herb	3.0 feet	Yellow/	Kansas Native	4
Ruellia humilis	Prairie Petunia	Acanthus	Herb	0.8 feet	Violet/Lavender	Kansas Native	10
Ruellia strepens	Woodland Petunia	Acanthus	Herb	3.0 feet	Violet/	Kansas Native	5
Rumex altissimus	Pale Dock	Buckwheat	Herb	3.0 feet	Green/	Kansas Native	2
Sagittaria brevirostra	Short Beak Arrowhead	Water Plantain	Herb	3.0 feet	White/	Kansas Native	9
Sagittaria latifolia	Broad Leaf Arrowhead	Water Plantain	Herb	3.0 feet	White/	Kansas Native	2
Salvia azureus	Blue Sage	Mint	Herb	4.0 feet	Blue/	Kansas Native	2
Sanguinaria canadensis	Bloodroot	Poppy	Herb	0.5 feet	White/	Kansas Native	9
Sanicula odorata	Fragrant Sanicle	Parsley	Herb	3.0 feet	Yellow/	Kansas Native	7
Schrankia nuttalli	Sensitive Briar	Bean	Herb	1.0 feet	Red/	Kansas Native	7
Scrophularia marilandica	Maryland Figwort	Figwort	Herb	7.0 feet	Yellow/	Kansas Native	8
Scutellaria lateriflora	side-flower skullcap	Mint	Herb	4.0 feet	Blue/	Kansas Native	5
Scutellaria parvula	Small Skullcap	Mint	Herb	1.0 feet	Violet/	Kansas Native	5
Senecio pseudaureus	Falsegold Groundsel	Aster	Herb	2.0 feet	Yellow/	Kansas Native	0
Silene stellata	Starry Campion	Pink	Herb	3.0 feet	White/	Kansas Native	3
Silphium integrifolium	Wholeleaf Rosinweed	Aster	Herb	5.0 feet	Yellow/	Kansas Native	8
Silphium laciniatum	Compass Plant	Aster	Herb	8.0 feet	Yellow/	Kansas Native	10
Silphium perfoliatum	Cup Plant	Aster	Herb	8.0 feet	Yellow/	Kansas Native	6
Sisyrinchium campestre	White-eyed Grass	Iris	Herb	1.0 feet	White/	Kansas Native	8
Smilacina racemosa	False Solomons Seal	Lily	Herb	2.0 feet	White/	Kansas Native	3
Solanum carolinense	Carolina Horse Nettle	Nightshade	Herb	2.0 feet	White/	Kansas Native	9
Solidago canadensis	Canada Goldenrod	Aster	Herb	6.0 feet	Yellow/	Kansas Native	8
Solidago gigantea	Giant Goldenrod	Aster	Herb	6.0 feet	Yellow/	Kansas Native	7
Solidago missouriensis	Missouri Goldenrod	Aster	Herb	2.5 feet	Yellow/	Kansas Native	2
Solidago nemoralis	Gray Goldenrod	Aster	Herb	2.5 feet	Yellow/	Kansas Native	6
Solidago petiolaris	Downy Goldenrod	Aster	Herb	3.0 feet	Yellow/	Kansas Native	3
Solidago rigida	Stiff Goldenrod	Aster	Herb	4.0 feet	Yellow/	Kansas Native	9
Solidago speciosa	Showywand Goldenrod	Aster	Herb	3.0 feet	Yellow/	Kansas Native	4
Solidago ulmifolia	Elmleaf Goldenrod	Aster	Herb	3.0 feet	Yellow/	Kansas Native	7
Spiranthes cernua	Nodding Lady's Tresses	Orchid	Herb	2.0 feet	White/	Kansas Native	4
Spiranthes lacera	Slender Lady's Tresses	Orchid	Herb	2.0 feet	White/	Kansas Native	0
Spiranthes magnicamporum	Great Plains Lady's Tresses	Orchid	Herb	2.0 feet	White/	Kansas Native	9
Spiranthes vernalis	Spring Lady's Tresses	Orchid	Herb	2.0 feet	White/	Kansas Native	8
Stachys tenuifolia	Slenderleaf Betony	Mint	Herb	3.0 feet	White/	Kansas Native	8
Teucrium canadense	Germander	Mint	Herb	3.0 feet	Violet/	Kansas Native	4
Thalictrum dasycarpum	Purple Meadowrue	Buttercup	Herb	2.0 feet	Violet/	Kansas Native	3
Tradescantia bracteata	Bracted Spiderwort	Spiderwort	Herb	1.5 feet	Blue/	Kansas Native	17
Tradescantia ohiensis	Ohio Spiderwort	Spiderwort	Herb	3.0 feet	Blue/Violet	Kansas Native	10
Tradescantia tharpii	Tharp's Spiderwort	Spiderwort	Herb	1.0 feet	Blue/Violet	Kansas Native	6
Tragia betonicifolia	Betony Noseburn	Spurge	Herb	1.0 feet	Green/	Kansas Native	0
Tragia ramosa	Catnip Noseburn	Spurge	Herb	1.0 feet	Green/	Kansas Native	6
Triosteum perfoliatum	Horse Gentian	Honeysuckle	Herb	3.0 feet	Green/	Kansas Native	2
Urtica dioica	Stinging Nettle	Nettle	Herb	3.0 feet	Green/	Kansas Native	4
Uvularia grandiflora	Large Flower Bellwort	Lily	Herb	1.0 feet	Yellow/	Kansas Native	1
Verbena hastata	Blue Verbena	Vervain	Herb	5.0 feet	Blue/Violet	Kansas Native	12
Verbena simplex	Narrowleaf Verbena	Vervain	Herb	1.0 feet	White/Lavender	Kansas Native	4
Verbena stricta	Woolly Verbena	Vervain	Herb	3.0 feet	Violet/Lavender	Kansas Native	5
Verbena urticifolia	White Verbena	Vervain	Herb	3.0 feet	White/	Kansas Native	7
Verbesina alternifolia	Wingstem	Aster	Herb	6.0 feet	Yellow/	Kansas Native	10
Vernonia baldwinii	Baldwin Ironweed	Aster	Herb	4.0 feet	Violet/	Kansas Native	3

Scientific Name	Common Name	Common Family	Plant Type	Plant Height	Flower Color	Plant Origin	Image
Vernonia fasciculata	Western Ironweed	Aster	Herb	5.0 feet	Violet/	Kansas Native	0
Veronicastrum virginicum	Culver's Root	Figwort	Herb	4.0 feet	White/	Kansas Native	5
Vicia americana	American Vetch	Bean	Herb	1.0 feet	Blue/Violet	Kansas Native	4
Viola pedatifida	Prairie Violet	Violet	Herb	0.5 feet	Violet/	Kansas Native	3
Viola pubescens	Yellow Violet	Violet	Herb	0.6 feet	Yellow/	Kansas Native	1
Viola sororia	Common Blue Violet	Violet	Herb	0.5 feet	Blue/	Kansas Native	7
Yucca filamentosa	Yucca	Agave	Herb	6.0 feet	White/	Kansas Native	2
Zigadenus nuttallii	Nuttall's Death Cama	Lily	Herb	2.0 feet	White/	Kansas Native	2
Zizia aurea	Golden Alexanders	Parsley	Herb	3.0 feet	Yellow/	Kansas Native	9

Native Plant Landscaping Fact Sheet

Kansas Native Plant Society

Why grow native plants?

- Native plants are better-adapted to regional climates than most typical nursery plants.
- Most native plants require less water than typical garden plants.
- Once established, native plants are low maintenance because many of them are perennials.
- Native plants are simply beautiful and unusual.
- Regional native plants attract interesting species of native birds.

How do I know what native plants to use?

- Establish plants from your nearest regional native seed/plant source.
- Do not buy inexpensive cans of wildflower seeds from discount stores, catalogs, or greenhouses. These seeds may contain weedy species, filler, and plants that are not from the area where you live.
- Collect seeds from native plant prairies near your home.
- Visit a reputable native plant nursery close to home.
- Ask the greenhouse owner where the native plants originated.

Could I dig plants from the wild?

- In many states this practice is illegal.
- Most mature plants do not survive the transplanting.
- The conditions in the wild probably do not match the conditions in your backyard garden.
- It is better to leave the plants where all can enjoy them.
- Buy or collect seeds to get the best value for your landscaping.

How do I use native plants in my landscaping?

- Native plants can be used as a small "wildflower meadow". Buy good quality mixed wildflower and grasses seed for this type of landscaping.
- A border or grouping of "specimen" plants can be effective in a landscaping plan.
- Mix native plants with other types of exotic, non-invasive perennials for an attractive and low maintenance garden.
- Mix native perennials with shrubs or trees.

What are suggestions for sun-loving native plants in my backyard?

In eastern Kansas try plants noted with the letter E.
In western Kansas try plants noted with the letter W.

Ashy Goldenrod - *Solidago mollis* **EW**
Ashy Sunflower - *Helianthus mollis* **E**
Big-flower Coreopsis - *Coreopsis grandiflora* **E**
Black-eyed Susan - *Rudbeckia hirta* **EW**
Blanket Flower - *Gaillardia pulchella* **W**
Blue Grama - *Bouteloua gracilis* **W**
Blue Sage - *Salvia azurea* **E**
Blue Wild Indigo - *Baptisia australis* **E**
Buffalo Grass - *Buchloe dactyloides* **W**
Butterflyweed - *Asclepias tuberosa* **E**
Canada Wild-rye - *Elymus canadensis* **EW**
Dakota Vervain - *Verbena bipinnatifida* **EW**
Eastern Gamma Grass - *Tripsacum dactyloides* **E**
Gray-headed Coneflower - *Ratibida pinnata* **EW**
Hairy Grama - *Bouteloua hirsuta* **W**
Indian Grass - *Sorghastrum nutans* **EW**
June Grass - *Koeleria macrantha* **EW**
Large-flower Butterfly-weed - *Gaura longiflora* **EW**
Little Bluestem - *Schizachyrium scoparium* **EW**
Louisiana Sagewort - *Artemisia ludoviciana* **W**
Missouri Goldenrod - *Solidago missouriensis* **EW**
Narrow-leaf Purple-coneflower - *Echinacea angustifolia* **W**
New England Aster - *Aster novae-angliae* **E**
Pale Purple-coneflower - *Echinacea pallida* **E**
Prairie Dropseed - *Sporobolus heterolepis* **E**
Purple Poppy Mallow - *Callirhoe involucrata* **EW**
Rocky Mountain Zinnia - *Zinnia grandiflora* **W**
Rose Vervain - *Verbena canadensis* **E**
Rough Gayfeather - *Liatris aspera* **EW**
Serrate-leaf Evening-primrose - *Calylophus serrulatus* **W**
Shell-leaf Beardtongue - *Penstemon grandiflorus* **E**
Side-oats Grama - *Bouteloua curtipendula* **EW**
Stiff Goldenrod - *Solidago rigida* **EW**
Switch Grass - *Panicum virgatum* **EW**
Western Wheat Grass - *Agropyron smithii* **EW**
White Beardtongue - *Penstemon albidus* **W**

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What native woodland plants are recommended for shady areas in eastern Kansas?

America Columbine - *Aquilegia canadensis*
Canadian Brome - *Bromus pubescens*
Drummond's Aster - *Aster drummondii*
Elm-leaf Goldenrod - *Solidago ulmifolia*
Golden Ragwort - *Packera obovata*
River Oats - *Chasmanthium latifolium*
Solomon's Seal - *Polygonum biflorum*
Wild Bergamot - *Monarda fistulosa*
Wild Ginger - *Asarum canadense*
Wild Sweet William - *Phlox divaricata*

How do I get started?

- Check your city ordinances. There may be restrictions on height of plants in your front yard.
- Get ideas from the references listed below.
- Start small.
- Encourage your neighbors to join you in native plant landscaping.

How should I prepare my yard for Native Plants?

The best preparation for native plants is to duplicate, as much as possible, the natural conditions where the plant grows. However, the soils, moisture, and micro-organisms in the garden will likely not be the same as a woodland or prairie. So, adjustments may be necessary to simulate a native plant's acceptable growing conditions.

Where do I learn more about growing native plants?

Books (Many of these may be available at your public library.)

- 100 Easy-to-Grow Native Plants: For American Gardens in Temperate Zones by Lorraine Johnson, Firefly Books, 1999.
- Butterfly Gardening: Creating Summer Magic in Your Garden by Xerces Society, Smithsonian Institution, Sierra Club Books; 2nd edition, 1998.
- Gardening with Prairie Plants by S. Wasowski, The Univ. MN Press, 2002.
- Growing and Propagating Wild Flowers by H. R. Phillips, The Univ. NC Press, 1985.
- Growing Native Wildflowers by Dwight R. Platt and Lorna Habegger Harder, Kansas Native Plant Society, 1997. For more information or to order, visit [www.kansasnativeplantsociety.org] or contact Dyck Arboretum at (620) 327-8124.
- Native Trees, Shrubs, and Vines: A Guide to Using, Growing, and Propagating North American Woody Plants by William Cullina, Houghton Mifflin Company, 2002.
- Natural Landscaping: Designing with Native Plant Communities by John Diekelmann, Robert M. Schuster, Renee Graef (Illustrator), University of Wisconsin Press; 2nd edition, 2003.
- The New England Wild Flower Society Guide to Growing and Propagating Wildflowers of the United States and Canada by William Cullina, Houghton Mifflin, 2000.
- A Practical Guide to Prairie Reconstruction by Carl Kurtz, The Univ. of Iowa Press, 2001.
- The Prairie Garden by J. R. Smith with B. S. Smith, The Univ. WI Press, 1987.
- Restoring the Tallgrass Prairie by Shirley Shirley, The Univ. of Iowa Press, 1994.
- The Tallgrass restoration handbook for prairies, savannas, and woodlands by S. Packard and C.F. Mutel, Island Press, 1997.

Websites

- Dyck Arboretum of the Plains www.dyckarboretum.org
- Gardening with Native Plants of Kansas www.kansasnativeplants.com
- Grow Native www.grownative.org
- Iowa Prairie Network - Prairie Management & Reconstruction www.iowaprairienetwork.org/mgmt/management.htm
- Kansas Native Plant Society www.kansasnativeplantsociety.org
- Lady Bird Johnson Wildflower Center www.wildflower.org
- Plant Native www.plantnative.org
- Prairies Forever www.prairies.org

MAPPING YOUR SCHOOL GROUNDS

from Landscape Investigation Guidelines and Schoolyard Biodiversity Investigation Educator Guide

Overview

The Landscape Investigation process requires students to read maps, analyze artifacts and images, distinguish patterns and determine relationships between the physical and human components within a location. To be successful, students must have a general understanding of maps, as well as the physical and human components depicted through maps, images and artifacts.

Through the two-step *Building Spatial Skills* process, students develop the basic skills to read and interpret maps, images and artifacts as they gain a spatial understanding of the physical and human components of a familiar location: the school campus.

Students first create maps of their school campus while identifying spatial features such as distances, directions, patterns and arrangement. Then, through deeper analysis and the interpretation of maps, images and artifacts, students build their understanding of the physical and human components that make a campus a *place.*

The skills and geographic spatial thinking developed during this process will be used and enhanced throughout the three phases of the Landscape Investigation.

Process

Step 1	**Understand Space** Students develop mapping skills and understand the geographic meaning of *space* as they research, experience, measure and document the locations, distances, directions, patterns, shapes and arrangements while creating maps of the school campus.
Step 2	**Define Place** Students read and interpret various information sources, ranging from historical maps to aerial photographs, as they explore the relationships between physical and human components of the campus.

Prior Knowledge: Reading and Interpreting Maps

As classrooms prepare for social science geographic inquiry, the more prior experience students have reading and interpreting maps, the better. However, if this is students' first exposure to maps, or if they have had few opportunities to read and use maps in the classroom, it can be helpful to spend some time orienting students to the key components of different maps and how to read them.

Students should be able to look at a map and describe:

1. Orientation: What is located north, south, east, and west of a particular point on the map?
2. Legend: What are the symbols, lines, circles, and other shapes that represent what you will find in that place (human and natural features)?
3. Scale: What is the unit of measurement on the map that equals a distance on the land? What is the distance from Point A to Point B?

Step 1: Understand *Space*

Objectives

Students will:

- Define the term space.
- Create a basic map of the school campus, including labels, orientation (compass rose or North arrow), legend, and scale.

Materials

- Large paper for creating maps
- Pencils (standard and color) and drawing tools
- Rulers and/or tape measures
- Computers with Internet access (optional)
- Printed maps and satellite images/aerial photographs of the school campus

Time Needed

One to two 50 minute periods

Background

A quick search on the Internet or in a dictionary reveals that *space* is frequently defined as an area void of objects, an expanse, an interval of time or simply a distance between two objects. The National Geography Standards (NCGE 1994), however, define *space* in the following way:

> "...space in the world is identified in terms of location, distance, direction, pattern, shape and arrangement." (page 31)

In *Step 1: Understand Space*, students develop their own definitions of *space* as it relates to geography by creating a basic map of their school campus. Students explore the campus, using existing maps and aerial images as reference, and considering the components of geographic space (location, distance, direction, pattern, shape and arrangement). This information is used to draw line maps documenting the major campus features.

Through this process, students develop enhanced mapping skills and understand the meaning of *space* as they experience, measure and document the locations, distances, directions, patterns, shapes and arrangements of the school campus.

Process

1. Work with students to create a class definition of the components of *space* according to *geographers* – location, distance, direction, pattern, shape and arrangement. Place the definition somewhere visible in the classroom.

   For example:

   Space is:

   Where things are located (latitude and longitude)
   How far apart or close together they are (miles, feet, meters)
   Where they are compared to other things (north, south, east, west)
   and
   How they are arranged or distributed (including patterns and shapes)

2. Discuss with students that they will individually create and label maps that communicate the ***space*** of the school grounds.
3. Guide students as they orient themselves to the school campus by first using **paper maps** (such as the ones provided to substitute teachers, fire evacuation maps, etc.). Then provide students with **digital images** (satellite or aerial images from Google Maps, Google Earth, etc.).
4. As students look at these resources, briefly discuss student observations of the school campus structures and features.

5. Upon completion of the discussion, provide students with rulers/tape measures, note paper and pencils to utilize as they **physically** walk around the outside the school. During this time, students can create scratch maps while taking measurements, writing notes, etc.
6. Once back in the classroom, students then create their own campus maps that depict the *space* of the school campus: locations, distances, directions, patterns, shape and arrangement (including buildings, etc.). Labels, orientation (such as a compass rose or North arrow), scale and legends should be discussed and included as desired (See Figure 1).

   Note: If needed, students can use existing maps and images to assist with the creation of their maps. Students should also have the opportunity to return to areas of the campus for further measurements, notes, etc.

7. Upon completion of the maps, facilitate students as they share and discuss in terms of spatial features:

   What structures or features are on the campus?

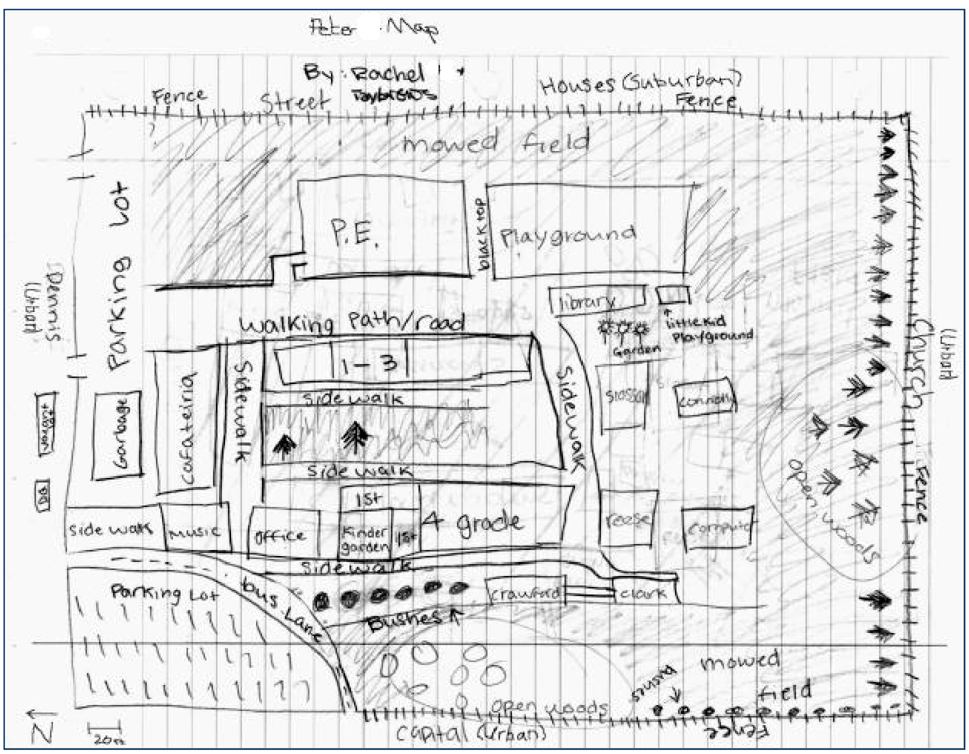
   Where are the structures? [location]

   Are the features/structures grouped or located in particular locations? [arrangement, pattern, shape, direction]

   Do you see any patterns related to how the features or structures are arranged or grouped? [arrangement, pattern, shape, direction]

   What do you notice about the distances between different features or structures or groups of features or structures? [distance]

FIGURE 1. Student Campus Map (6th Grade Student , Peter G. Schmidt Elementary)



Step 2: Define *Place*

Objectives

Students will:

- Define the term *place.*
- Determine the physical/natural and human/cultural components of a place – the school campus.
- Determine the relationships between the physical/natural and human/cultural components on the school campus.

Materials

- Large student-created maps (Step 1)
- Pencils (standard and color), rulers, and drawing tools
- Computers with Internet access (optional)
- Materials about the school campus: Printed maps, satellite images/aerial photographs, photos, pamphlets brochures or websites, and other materials from local museums or experts. (For more information related to types and access, see Table 4*)*

Time Needed

One to two 50 minute periods

Background

A school campus is more than just buildings and features. It is a collection of human and physical components that are continually interacting. In fact, a school campus is a *place.*

According to the National Geography Standards (NCGE 1994) "Place is identified in terms of the relationships between physical environmental characteristics, such as climate, topography, and vegetation, and, such human characteristics as economic activity, settlement, and land use... Place, in fact, is space endowed with physical and human meaning" (NCGE, p. 31-32).

In *Step 2: Define Place,* students explore the physical/natural and human/cultural characteristics of their school campus. They read and interpret various sources including maps and aerial photographs, adding to their personal maps and enhancing their geographic skills. During this process the students consider the relationships between the human and physical features on the campus and the impacts of those relationships. The students discover what makes the school campus a place.

Process

1. Revisit the definition of *space* created during Step 1, discussing how looking at the spatial features of a location can help someone develop a very general understanding of that location. However, really understand what a site is like (such as the school campus), one must look at it as a *place.*
2. Share the National Geography Standards definition of place (NCGE 1994):

   "Place is identified in terms of the relationships between physical environmental characteristics, such as climate, topography, and vegetation, and, such human characteristics as economic activity, settlement, and land use... ***Place, in fact, is space endowed with physical and human meaning"*** (NCGE, p. 31-32).
3. Discuss the fact that defining *place* requires students to have an understanding of physical/natural and human/cultural characteristics of a space. Work with students to define *physical/natural characteristics* and *human/cultural characteristics*, and give examples of these types of characteristics (Table 3).

   If you were asked to describe the ***physical or natural characteristics*** *of a place, what features of that place would you need to describe?*

   What would you need to describe if you were asked about the ***human or cultural characteristics*** *of a place?*

TABLE 3. Physical and Human Characteristics of a Place

Physical and Human Characteristics of a Place	
Examples of Physical (Natural) Characteristics	**Examples of Human (Cultural) Characteristics**
landforms soil types water features economy biomes climate natural vegetation topography	population land use economy religion built components political systems settlement

4. Revisit the maps created of the school grounds during Step 1. Explain that the students will now add **features and labels** to their maps that further communicate the **current physical and human characteristics of the school grounds**, including land use, traffic/movement, types of vegetation/plants, topography, weather, etc.

   Discuss potential resources for finding the necessary information about physical and human characteristics of a place with students. Where might they look? How many sources should they use? How do they know the information is accurate? Share available materials with students (Table 4).

   Note: Sometimes it can be helpful to have students divide up research so that different teams or students can look more in-depth at particular components. However, during this initial activity, all students should be given the opportunity to practice looking at different maps and resources to determine the physical and human characteristics of a place.

5. Students add details, draw arrows, or even create symbols to depict the physical and human characteristics of the school campus to the line map, using resources you provide (maps, images and additional materials, see Table 4). All details should be labeled and a legend for all features and symbols should be placed on the map or a supplementary piece of paper.

   Note: The purpose of this activity is to provide students with an opportunity to utilize a variety of resources while gathering and mapping information related to physical and human components. It is not intended to be too in-depth (or to require an extensive amount of time), as the students will later conduct a more thorough study of a less-familiar location.

TABLE 4. Sources of Information and Maps for Documenting Features of a Place.

Sources of Information and Maps for Documenting Features of a Place
Printed maps. (planimetric maps with line drawings). These maps typically show streets, buildings and some local features. Hard copy county and city maps are usually provided free of charge by local government offices.
Satellite images and/or aerial photographs. These images can be obtained free of charge from online GIS programs or desktop software such as Google Maps, ArcGIS Explorer Online or Google Earth. In addition, the state departments of natural resources, fish and wildlife agencies, local museums or public libraries may have both historical and current images. Be sure to note the date on the aerial photos.
Pictures and Images of people, places and things. Pictures and images can come from students' families, local museums, or even the public library. It is helpful if images are labeled with descriptions and dates.
Pamphlets, brochures or websites. Materials from local governments, organizations or groups can provide additional information related to both physical and cultural characteristics of an area.
Local museums and experts. Frequently cities and towns have local historical museums and volunteers eager to share their knowledge. Specific questions and/or requests can ensure that students receive the necessary information and materials.
Note: In addition to recent resources, historical maps, images, aerial photographs, etc. can be valuable tools for visualizing how areas have evolved – enabling students to have an increased awareness of patterns and movement. (Dates should always be written on maps and photos.)

6. Upon completion of the student maps, have students share the physical and human characteristics documented on their maps through small group and/or large group sharing sessions. Compile a list or master map that depicts the characteristics.
7. Discuss the fact that the physical and human characteristics of a location do not exist in isolation. Frequently, the features of a location interact and influence one another.
8. Brainstorm with the students about how different physical and human characteristics might affect or be affected by other characteristics of a location, such as the school campus. Create diagrams, images and/or lists as desired.
9. Reflection: Ask students to reflect upon their observations by responding to the following prompt:

   Choose one physical or human characteristic of the school campus. Thoroughly describe the characteristic and how it might affect or be affected by other characteristics of the school campus.

   For example, describe the school garden and how it might affect or be affected by student traffic (where kids walk), noise levels, weather and student learning/activities.

Section 2
Mapping the School Grounds

Materials

Pencils

Colored Pencils

Campus Maps

Plain paper for student-created maps

Large butcher paper and copy of school map for large, cut-up map

Schoolyard Biodiversity Data Sheets

(1 set for investigation, extra copies for practice, as needed)

Vegetation Survey Data Sheet

Wildlife Survey Data Sheet

Alien Planet Habitat and Key (1 set per pair of students)

Clipboards

Tape measures

Stopwatches/timers

Thermometers

School maps can be created by individual students, partners or small groups in a variety of ways:

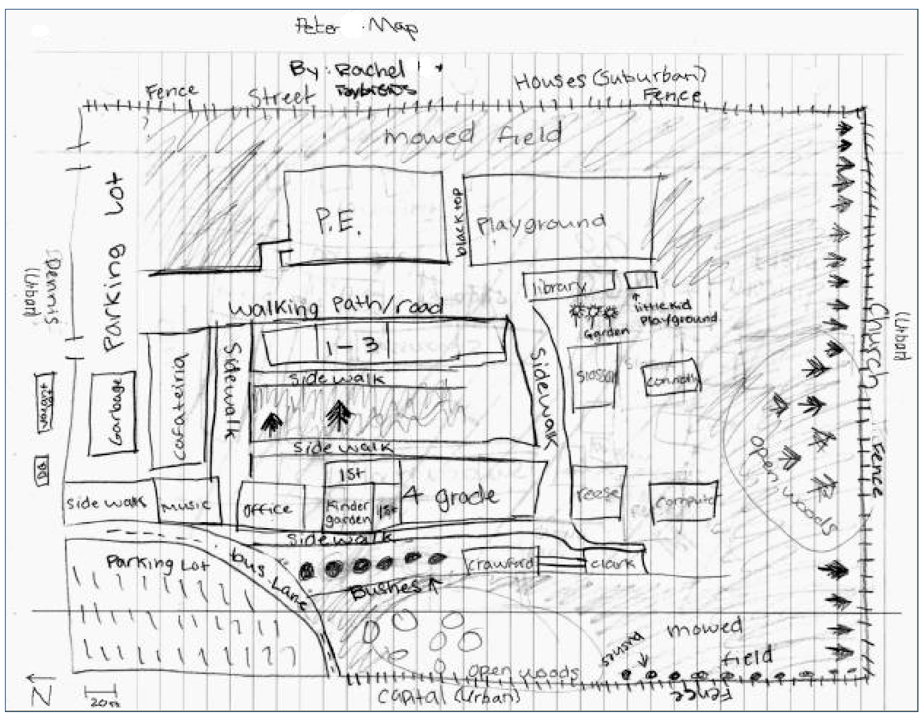
A. Student partners or teams can create maps of the entire school grounds, working first to draw the main structures, boundaries, etc. and then adding details/descriptions of the various habitat/land types using the Suggested Classification of Habitat/Land Types list.

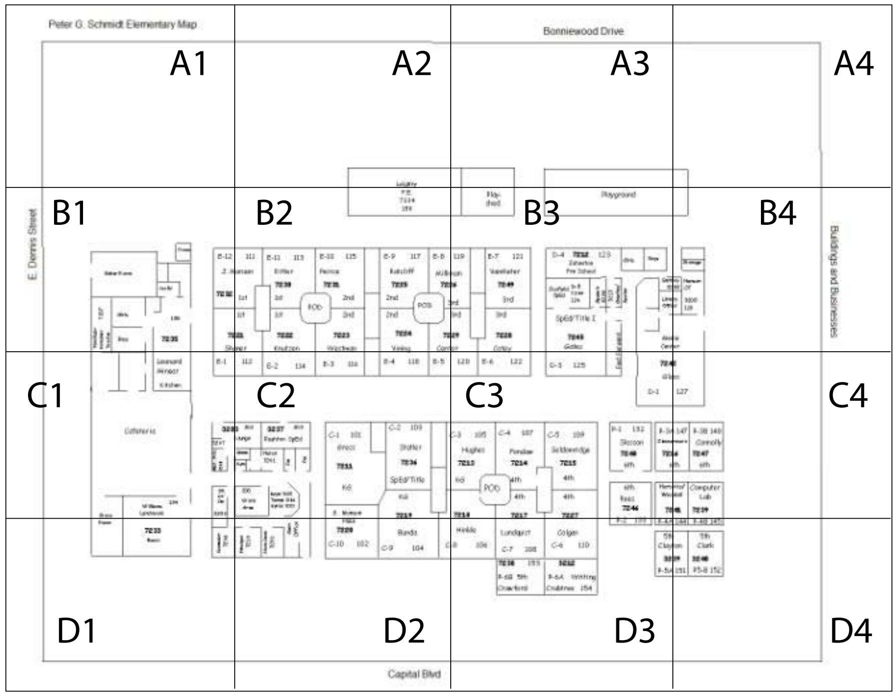
As students create or enhance their maps, be sure they draw and label both natural and man-made features, while also labeling the habitat/land types of each area, if desired. Also remind students to include a title, an approximate scale (if desired) and the North arrow (↑).

This can be an involved process, but can be connected with lessons related to understanding maps, legends, keys, etc. and will allow all students to explore the entire school site.

Once students have mapped the school campus, a master map (a large map drawn on butcher paper) can be created, incorporating information from all of the students.

Example of student-created map





Note: It can be helpful to label each section using numbers, codes or letters to ensure ease of re-assembly.

B. The school site can be divided into sections, with different student pairs/teams assigned to each section. Students can add and label features such as trees and bushes, fill in the habitat types, and add other details.

An easy way to create a large master map is to project a copy of the map typically given to substitute teachers by the school secretary onto a large piece of butcher paper or pieces of butcher paper taped together. If not using a school site, outline maps of areas can sometimes be located on the Internet.

Once the master map is created, lines can be drawn to divide it into sections, and it can be cut and distributed to each student team.

Example: Suggested Classification of Habitat/Land Types:

Grass/meadow – maintained (mowed)

Grass/meadow/shrub – not maintained ("wild")

Savannah/wooded grassland – mixed trees and grass

Forest – mostly coniferous (needles)

Forest – mostly deciduous (leaves)

Forest – even mix of both coniferous and deciduous

Wetland/marsh

Sand/beach

Agriculture/Farms

Developed – Suburban (houses, some green space)

Developed – Urban (in the city, little/no green space)

Water – large pond, lake or ocean

Other (be sure to describe)

FIELD INVESTIGATIONS

from Field Investigations: Using Outdoor Environments to Foster Student Learning of Scientific Practices and Project WILD

Chapter 1

Field Investigations and the Next Generation Science Standards

"Students...need experiences that help them recognize that the laboratory is not the sole domain for legitimate scientific inquiry and that, for many scientists (e.g., earth scientists, ethologists, ecologists), the "laboratory" is the natural world where experiments are conducted and data are collected in the field." (Schweingruber, 2012)

What are field investigations?

Field investigations of the environment involve the systematic collection of data for the purposes of scientific understanding. They are designed to answer a question through the collection of evidence and the communication of results; they contribute to scientific knowledge by describing natural systems, noting differences in habitats, and identifying environmental trends and issues.

Why conduct field investigations?

Field investigations help students become systems thinkers, provide opportunities to engage in science and engineering practices and understand that science does not only happen in a laboratory or classroom. Outdoor experiences in natural settings increase students' problem solving abilities and motivation to learn in social studies, science, language arts and math. Outdoor experiences also provide students with place-based connections and engage students in relevant learning experiences. Outdoor, placed-based learning, as an instructional strategy, encompasses a range of techniques and approaches that build on students' interests and backgrounds so as to engage them more meaningfully and support them in sustained learning. These strategies have been shown to promote educational equity in learning science and engineering.

The Three Dimensions of the Next Generation Science Standards (NGSS) (Next Generation Science Standards: For States, By States, 2013)

The Framework for K-12 Science Education and the Next Generation Science Standards are built on three integrated dimensions:

- Science and Engineering Practices
- Crosscutting Concepts
- Disciplinary Core Ideas

Field investigations can provide opportunities for students to engage in all three of the dimensions of the Next Generation Science Standards. The specific components of each of the three dimensions are outlined in the table below.

Science & Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
1. Ask questions (for science) and define problems (for engineering) 2. Develop and use models 3. Plan and carry out investigations 4. Analyze and interpret data 5. Use mathematics and computational thinking 6. Construct explanations (for science) and design solutions (for engineering) 7. Engage in argument from evidence 8. Obtain, evaluate, and communicate information	1. Patterns 2. Cause and effect 3. Scale, proportion, and quantity 4. Systems and system models 5. Energy and matter 6. Structure and function 7. Stability and change	**Physical sciences** • Matter • Force & Motion • Energy • Waves **Life sciences** • Structure & Processes • Ecosystems • Heredity • Evolution **Earth and space sciences** • Earth in the Universe • Earth Systems • Earth & Human Activity **Engineering, technology and applications of science**

Crosscutting Concepts

When planning and conducting field investigations, students and scientists grapple with the difficulties of working in a natural system while at the same time developing an understanding of its complexities and subsystems. In order to understand the system, students need to utilize the Crosscutting Concepts in concert with the associated Disciplinary Core Ideas.

The questions below provide some examples of how students and teachers might use the Crosscutting Concepts to make sense of their outdoor learning experiences.

Patterns: What patterns do we notice in the system? What patterns do we notice in our data?

Cause and Effect: What might be causing ________ to happen?

Scale, Proportion, and Quantity: How many ________ are in this area? Are some organisms larger in one area than another? What parts of the system might be very small or unseen?

Systems and Systems Models: What are the important parts of the system? How do the parts work together?

Energy and Matter: Where are energy and matter flowing through this system?

Structure and Function: How does the structure of ______ relate to its function?

Stability and Change: What parts of the system are changing over time? What parts seem to stay the same?

Science and Engineering Practices

The Next Generation Science Standards encourage instruction that focuses students on solving problems and explaining phenomena - activities which characterize the pursuits of scientists and engineers. In field investigations, students pose a question then plan and conduct an investigation to answer that question. Students use evidence to support explanations and build models, as well as to pose new questions about the environment. Students learn that the scientific method is not a simple linear process and, most importantly, experience the difficulty of answering essential questions such as:

- What defines my environment?
- What are all the parts and interrelationships in this ecosystem?
- What is a healthy environment?
- What is humans' relationship to the environment?
- How has human behavior influenced our environment?
- How can our community sustain our environment?
- What is my role in the use and preservation of environmental resources?

Science beyond the laboratory or classroom

Field investigations help students become informed citizen scientists and engineers, contributing knowledge to their community's understanding of natural resources in order to make issues of concern visible and share differing points of view about the preservation and use of those resources. The Next Generation Science Framework highlights how "all science learning can be understood as a cultural accomplishment." Research shows that a cultural perspective can transform learning experiences to make them more engaging and meaningful for learners. Informal learning environments can be particularly good at engaging youth from non-dominant communities in science learning and identification.

How are field investigations different from controlled laboratory experiments?

Classroom science often overemphasizes experimental investigation in which students actively manipulate variables and control conditions. Experiments begin with a hypothesis regarding links between variables in a system followed by identifying those variables of interest and designing a "fair test" where the variables are manipulated, controlled and measured to gather evidence to construct an explanation or solve a problem.

Investigations in the natural world where it is difficult to manipulate variables and maintain "control" and "experimental" groups scientists look for descriptive, comparative, or correlative trends in events. Many field investigations begin with gathering baseline data followed by measurements intentionally taken in various locations (e.g. urban and rural, or where some natural phenomenon has created different plot conditions) because of a prediction that differences will occur.

Are all field investigations the same?

No. For conceptual clarity, we have identified three types of field investigations—descriptive, comparative, and correlative.

Descriptive field investigations: Involve describing and/or quantifying parts of a natural system.	**Comparative field investigations:** Involve collecting data on different populations/organisms, or under different conditions (e.g. times of year, locations), to make a comparison.	**Correlative field investigations:** Involve measuring or observing two variables and searching for a relationship.

Each type of field investigation is guided by different types of investigative questions. Descriptive studies can lead to comparative studies, which can lead to correlative studies. The three types of field investigations are often used in combination to study the natural world.

A model for field investigation

The table below outlines the differences and similarities between the three types of field investigations and relates these to the essential features of inquiry. See Windschitl, M., Dvornich, K., Ryken, A. E., Tudor, M., & Koehler, G. (2007) A comparative model of field investigations: Aligning School Science Inquiry with the Practices of Contemporary Science, School Science and Mathematics 1 (107), 367-390 for a complete description of the field investigation model.

THREE TYPES OF FIELD INVESTIGATIONS			
Essential Questions	What defines my environment? What is a healthy environment? What is humans' relationship to the environment? How can our community sustain our environment? What is my role in the preservation and use of environmental resources?		
	Descriptive	**Comparative**	**Correlative**
Formulate Investigative Question	How many? How frequently? When did it happen?	Is there a difference between groups, conditions, times, or locations? Make a prediction or hypothesis about differences.	Is there a relationship between two variables? Make a hypothesis about the relationship.
Identify Setting within a System	Identify geographic scale of investigation (e.g., riparian corridor or Cedar River Watershed) Identify time frame of the investigation (e.g., season, hour, day, month, year)		
Identify Variables of Interest	Choose measurable or observable variables	Choose a measured variable in at least two different (manipulated variable) locations, times, organisms, or populations	Choose two variables to be measured together and tested for a relationship

<table>
<tr><th></th><th>Descriptive</th><th>Comparative</th><th>Correlative</th></tr>
<tr><td rowspan="2">Carry out Investigations</td><td colspan="3">Multiple measurements over time or location in order to improve system representation (model)
Individual measurement is repeated if necessary to improve data accuracy
Record and organize data into table(s) or other forms</td></tr>
<tr><td></td><td colspan="2">Describe how sampling, measurement, observations were consistent for the two or more locations, times or organisms (controlled variables) and was random and representative of the site.</td></tr>
<tr><td>Analyze and Interpret Data</td><td colspan="3">Means, medians, ranges, percentages, estimations calculated when appropriate.
Organize results in graphic and/or written forms and maps using statistics where appropriate
What patterns do we notice in the data?
Might there be any cause and effect relationships here?</td></tr>
<tr><td></td><td colspan="2">Typical representations of the data to build descriptive and comparative models
• Charts
• Line Plots
• Bar Graphs
• Maps</td><td>Typical representations of the data to demonstrate correlations upon which models are developed
• Scatter plots
• r-values</td></tr>
<tr><td rowspan="2">Construct an Evidence-Based Explanation or Argument</td><td colspan="3">Makes a claim that answers the investigative question.
Use evidence from observations collected to support the claim.</td></tr>
<tr><td colspan="3">Does the claim answer the question?
Does the evidence support the claim?
Does the reasoning connect the evidence to the claim?
Does the reasoning contain a science principle?</td></tr>
<tr><td>Discussion</td><td colspan="3">What questions do I have about the data we collected?
What questions do I have about the way we gathered the data?
What other data or information might we need to collect or find?
How does this data help us to understand the entire system?
Did we identify any problems that might need to be solved?</td></tr>
</table>

Documenting the Field Investigation Science Practice

Identify the Phenomenon to Be Investigated

The phenomenon (something puzzling that students are trying to explain) and purpose of the investigation is described. The essential question and investigation question are identified.

Essential Question is the big picture question that cannot be answered with one investigation.

Investigation Question is the researchable question that can be answered with qualitative or quantitative observations or measurements.

Make a Prediction (Initial Claim)

Predictions are not typically made for descriptive studies. For comparative studies, students predict what will happen to the responding (measured) variable when one of the changes occurs. For correlative studies predict the relationship. Secondary students should also give a reason for their prediction.

Decide on Materials

The materials needed to perform the investigation are listed.

Plan the Field Investigation

The investigation plan includes:

- Logical steps to do the investigation; steps written clearly so someone else could follow procedure.
- What variables are under study? What is changed (manipulated/independent)? What is measured (responding/dependent)?
- How, when and/or where will observations/measurements be taken? How will samples or measurements be repeated?
- How is sampling/measurement method consistent (controlled variables) or systematic? Secondary students should describe how sampling is random and representative of the site.

Carry out the Investigation (Collect the Data)

Data/observations/measurements are recorded systematically on a data collection sheet. Location, date, time of day and a description of study site (including weather) are recorded.

Analyze and Interpret Data

Organize Data

Results are organized into categories in tables, charts, graphs, maps, and/or other written forms making appropriate calculations (e.g. total growth, distances, total number observed).

Populations are estimated; means, modes, medians, t-values and r-values are calculated; graphs, tables, or maps are generated.

Identify Relationships

Patterns and trends in the data are observed and described.

Interpret Data

Relationships are identified in the data and how these patterns identified in the data provide evidence for a conclusion or claim is described.

Construct an Argument/Explanation

An argument/explanation is constructed that answers the original question being investigated based on the evidence collected and analyzed. This argument/explanation includes:

- **A claim**

  A one sentence answer to the question.
- **Evidence**

  Supports the claim above with sufficient and appropriate evidence collected in the investigation.
- **Supportive reasoning (justification)**

  Connects the evidence to the claim using justification and scientific principles.

Extend the Investigation

Investigations are extended to allow for students and the class to make sense of the investigation in a broader context than just the specific field investigation that was conducted. The following are ideas:

- Compare data to other similar systems models.
- Identify factors in the field that may have affected the outcomes of the investigation.
- Describe how the procedures might have been more systematic.
- Compare scientific arguments by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail. Provide and receive critiques on arguments.
- Provide new questions about the system or model.
- Recommend future actions and explain why.
- Add to the model of the current system under study.

Chapter 2

Preparing Students to Conduct Field Investigations

The three lessons presented in this section are designed to give you and your students structured experiences with field investigations. Students will learn about the kinds of questions that guide field investigations, conduct a descriptive field investigation and conduct a comparative field investigation of surface temperature at different locations on the school grounds. These experiences are designed to help students gain the skills necessary to conduct field investigations, such as posing an investigation question; planning and carrying out investigations; analyzing and interpreting data; and constructing explanations. (NGSS-Science and Engineering Practices)

These experiences give students a framework and understanding of field investigations so they can later plan their own field investigations based on their own questions, as described in Chapter 3 and 4 of this guide.

Lessons in this section include:

1. What Questions Can I Investigate?
2. Descriptive Field Investigation: What Plants and Animals use the Schoolyard Habitat?
3. Comparative Field Investigation: How Does Surface Temperature Vary With Location?

Chapter 2: Preparing Students to Conduct Field Investigations

Lesson 1: What Questions Can I Investigate?

Objectives

Students will:

1) distinguish between three different types of investigative questions;
2) suggest questions that can be asked about the natural world.

Student Outcomes

I can categorize investigative questions into whether they are descriptive, comparative, or correlative questions and come up with questions about the natural world.

Thinking Skills

Comparing/Contrasting, Classifying

Learning Experience

Students sort investigative questions into three categories (descriptive questions, comparative questions, and correlative questions).

Materials

- Sets of Investigative Questions (one set per three students). Copy questions onto card stock and cut into sentence strips; place in an envelope.
- Handout. Three types of field investigation questions.
- Question on Board: Given the categories descriptive, comparative, and correlative, how would you categorize the set of questions in your envelope?

Next Generation Science Standards (NGSS)

Dimension from the Framework	Connections to the 3 Dimensions of NGSS
Disciplinary core idea: none	This is a rare lesson where there is no connection to a disciplinary core idea. This is a mini-lesson on the Science and Engineering Practice #1 Asking Questions.
Crosscutting concepts: • Patterns • Cause and effect	• Students observe patterns to classify types of questions. • Students see some questions indicate cause and effect.
Science and engineering practice: • Asking questions	Students sort questions to analyze many types of questions that lead to descriptions and explanations of how the natural world works.
Common Core State Standards	**Connections to Common Core State Standards (CCSS)**
Common Core ELA - Anchor Standards – College and Career Readiness – Anchor Standards for Writing -7	CCSS.ELA-LITERACY.CCRA.W.7 Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

Background

This lesson provides a focus on the NGSS Science and Engineering practice of asking questions. Scientific questions differ from other types of questions in that they can be answered by explanation based on empirical evidence. Field investigations provide students with an opportunity to ask questions that differ from the traditional controlled experiments in the classroom. Field investigations work well to contribute information (evidence) about essential questions about natural resources such as:

- What defines my environment?
- What is a healthy environment?
- What is humans' relationship to the environment?
- How can our community sustain our environment?
- What is my role in the preservation and use of environmental resources?

These essential questions about the relationships between humans and the environment are complex and cannot be answered with one field investigation.

Asking a testable question is central to scientific practices. The following lesson is geared to help students think about the ways questions are asked and the types of questions field investigators research. There are three types of field investigations - descriptive, comparative, and correlative.

Descriptive field investigations involve describing parts of a natural system. Scientists might try to answer descriptive questions such as, "Where do cougars go when their habitat becomes a new housing development?" or "What areas do cougars select for den locations?"

In comparative field investigations, data is collected on different populations, or under different conditions (e.g., times of year, locations), to make a comparison. A researcher might ask a comparative question such as, "Is there a difference in lichen growth in areas of high pollution and areas of low pollution?"

Correlative field investigations involve measuring or observing two variables and searching for a pattern. These types of investigations are typically not explored until high school. Correlative questions focus on two variables to be measured together and tested for a relationship: "Do animal tracks increase with greater forest canopy cover?" "Does the salmon population go down when dissolved oxygen concentrations go down?"

Lesson 1: What Questions Can I Investigate?

ENGAGE

1. Review the essential questions. These big picture questions are why we conduct field investigations. What defines my environment? What is a healthy environment? What is humans' relationship to the environment? How can our community sustain our environment? What is my role in the preservation and use of environmental resources?

2. Asking questions is an important part of scientific investigations. While these essential questions are important questions, they are too big to investigate. Scientists work by investigating smaller, testable questions. Ask the students to brainstorm questions them might have about their schoolyard.

3. Have students share their questions with a partner or make a class list of questions.

EXPLORE

1. Give groups of students the cards with examples of questions. Advise them that there are different kinds of questions. Ask them to sort the cards without any leading directions and ask they share what categories they used to sort them and what patterns did they notice in each type of question.

2. Introduce the three categories scientists use. Distribute the handout and discuss the three types of field investigation questions. You may want to give them broad examples of each type: Descriptive - Lewis and Clark, Going to Mars; Comparative-Darwin comparing finches; and Correlative - CO2 levels and temperature across the globe or predator/prey relationships. If needed ask students questions to help them identify differences in the questions.

   a. What patterns do you notice in each type of question?

   b. What words are important to look for when identifying each type of question?

3. Ask the students to now sort the questions into three categories - descriptive, comparative, and correlative.

EXPLAIN

1. Give the groups time to think about each question and agree on the categories.

2. When they have their questions categorized, facilitate a discussion by asking the questions below or have the groups discuss before sharing with the class.

    a. Did you all agree to this category? Explain how you came to this decision.

    b. Can each one of you come up with a justification as to why these questions fall into the categories they do?

    c. Do you have an "uncertain pile" if so, why? What more do you need to know?

    d. What questions do you have about your categories?

    e. Think of your own examples of each type of question?

3. Using a chart identifying the different question categories, have students, from the groups place a question in the category they selected and have them say why they chose that category.

ELABORATE

1. Discuss why scientists need to think about the questions they pose before working in the field.
2. Have student come up with a descriptive, comparative, and correlative question about an area of interest in the natural world.

EVALUATE

As students categorize the questions ask them to justify how they classified each question, and ask them to identify the patterns they notice in each type of question (e.g., descriptive questions often begin with "how many," "when," or "where").

Some questions may fit more than one category; what is important is that students can justify their thinking for each category. For example, students may identify the question, "What is the air temperature at your school throughout the year?" as descriptive, because they would be documenting the temperature of a specific location. Other students may call it a comparative question, because they could use the collected temperature data to compare two different times of year.

Student page - Three Types of Field Investigation Questions

Descriptive Questions

Descriptive field investigations involve describing parts of a natural system. Descriptive questions focus on measurable or observable variables that can be represented spatially in maps or as written descriptions, estimations, averages, medians, or ranges.

- How many _____ are there in a given area?
- How frequently does _____ happen in a given period?
- What is the [temperature, speed, height, mass, density, force, distance, pH, dissolved oxygen, light density, depth, etc.] of ______?
- When does _____ happen during the year? (flowering, pollination)
- Where does_____ travel over time? (What is an animal's range?)

Comparative Questions

In comparative field investigations data is collected on different groups to make a comparison. Comparative questions focus on one measured variable (Dependent variable) in at least two different (Independent variable) locations, times, organisms, or populations.

- Is there a difference in ______ between group (or condition) A and group B?
- Is there a difference in ______ between (or among) different locations?
- Is there a difference in ______ between two different times?

Correlative Questions

Correlative field investigations involve measuring or observing two variables and searching for a pattern. Correlative questions focus on two variables to be measured and tested for a relationship.

- What is the relationship between variable #1 and variable #2?
- Does _____ go up when _____ goes down?
- How does _____ change as _____ changes?

Investigative Questions for sorting (copy and cut into strips for group use)

Are more insects found in the schoolyard in September, October, or November?

Is wind speed greater near the building or out on the school grounds in March?

Where do you find the most pillbugs (isopods): under a log, under a pot, or under bushes?

Are soil temperatures coolest at a depth of 5 cm, 10 cm, or 15 cm?

In April, which twigs grow faster, those on maple trees or those on sweet gum trees?

Are traffic sounds louder in front of the school or behind the school?

How many Pileated Woodpeckers live on the school grounds?

How many deer live on the school grounds?

How often do butterflies lay eggs in a season in northeast Kansas?

What is the air temperature of the school throughout the school year?

What types of birds use the school habitat during the school year?

When do robins in Kansas nest?

Do tree species, tree density, tree diameter, or tree height differ between north- and south-facing slopes on the school grounds?

Do birds sing more from 8:30-9 a.m. or from 3-3:30 p.m.?

What is the relationship between number of days above 60F in the spring and germination of seeds (or time of flowering)?

Chapter 2: Preparing Students to Conduct Field Investigations

Lesson 2: Descriptive Field Investigation:
What Plants and Animals Use the Schoolyard Habitat?

Objectives

Students will:
1) observe an outdoor area;
2) represent their observations using pictures, numbers, words, labeled diagrams;
3) pose descriptive and comparative questions based on their observations.

Student Outcomes

Lesson 2*- I can carry out a descriptive field investigation in my schoolyard and record my observations using pictures, numbers, words, and labeled diagrams. I can come up with a descriptive and comparative question based on my observations.*

Thinking Skills

Observing, Finding Evidence

Learning Experience

Students will conduct a descriptive investigation by observing a particular outdoor area.

Materials

Per Class
- Field Guides

Per Pair of Students
- Hula Hoops
- Yard or Meter sticks
- Tape Measures
- Colored Pencils
- Paint Chips (to help name as many different forms of the "same" color, e.g. green)

Per Student

Clipboards
Ruler
Hand Lenses

Next Generation Science Standards (NGSS)

Dimension from the Framework	Connections to the 3 Dimensions of NGSS
Disciplinary core idea: • LS4.D Biodiversity and Humans	Students observe living things in a specific habitat. This is a foundational activity for understanding in this Disciplinary Core Idea and can connect to multiple NGSS Performance Expectations such as: • 2-LS4-1 Make observations of plants and animals to compare the diversity of life in different habitats. • 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.
Crosscutting concepts: • Patterns • Systems and Systems Models	• Students look for patterns in which living things live in the schoolyard. • Students clarify the schoolyard ecosystem as a system by identifying the living parts of the system.
Science and engineering practice: • Planning and carrying out investigations • Analyzing and interpreting data • Obtaining, evaluating, and communicating information	• Students plan and conduct observations of the schoolyard. • Students analyze and interpret the data to answer the question, "What lives in the schoolyard?" • Students communicate their findings from the investigation.

Common Core State Standards	Connections to Common Core State Standards (CCSS)
Common Core ELA –Anchor Standards – College and Career Readiness Anchor Standards for Writing – 2	**CCSS.ELA-LITERACY.CCRA.W.2** Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.
Common Core ELA - Anchor Standards – College and Career Readiness – Anchor Standards for Writing -7	**CCSS.ELA-LITERACY.CCRA.W.7** Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

Background

In descriptive field investigations, researchers describe parts of a natural system. This lesson helps students learn how to conduct a descriptive field investigation of a specific site. Although it is not a long-term study focused on identification of organisms, students observe a large area and a small study area. Allowing students to make observations multiple times helps them notice detail and ask investigative questions based on their own observations of a habitat. By extending this into a longer term study and collecting data over time at the same site, students can begin to see patterns and notice cause and effect relationships.

Breaking a large area into parts can help students consider different aspects of a larger ecosystem. Students need multiple observation sessions outdoors in order to pose meaningful questions. Students could spend multiple sessions observing a large study area, noting their overall observations, and then focusing on looking up, looking down, and looking in the middle. Finally, students can select a much smaller study area for their focused observation.

Lesson 2: Descriptive Field Investigation:

What Plants and Animals Use the Schoolyard Habitat?

ENGAGE

1. Ask students, "What do you think when you hear the word habitat?" Have students do a think-pair-share[1] and then come up with a class definition or have students define their own habitat.

   Teacher note: Project WILD, a wildlife-focused conservation education program for K-12 educators and their students, has an activity that compliments this lesson titled "Oh Deer!"

2. Write the investigative question on the board: "What plants and animals use the schoolyard habitat?" Discuss strategies for observing - using four of the five senses (sight, hearing, touch, smell) and recording observations (drawing, using numbers, labeled diagrams writing). Using an object (e.g., pinecone, leaf, twig, rock) ask students to describe its physical properties and characteristics. To prompt student thinking model drawing and/or writing observations.
   - What does it look like? (e.g., size, shape, color)
   - What does it feel like? (e.g., texture, temperature)
   - What does it smell like?
   - What does it sound like?

Large Study Area

EXPLORE

1. Divide the class into pairs before going outside. Students should have multiple opportunities to create observation journals and record data, e.g., measurements. As an extension, paint chips may provide students an understanding that there are multiple shades and names of a color (e.g., green) and can expand their color vocabulary. Below are sentence starters that will help students generate questions about the system they are drawing (Fulwiler, 2007).
   - I am curious about…
   - It surprised me that…
   - I wonder how this part affects another part in the system…
   - Questions I could investigate are…

Day 1: Overall Observations. Students record general observations and questions.
Day 2: Looking Up. Students look up (above eye level) and record observations and questions. What do we see in the sky? What is in the trees? What is flying?
Day 3: Looking Down. Students look down (to the ground) and record observations and questions. What is in the bushes? What is in the ground/soil? What is under the rocks, bark, etc.?
Day 4: Looking in the Middle. Students look at eye level and record observations and questions. What is in our normal field of vision? What might we be missing?

[1]**Think-pair-share** (TPS) is a collaborative learning strategy in which students work together to solve a problem or answer a question about an assigned reading. This technique requires students to (1) think individually about a topic or answer to a question; and (2) share ideas with classmates.

EXPLAIN

1. After each observation session ask students to share their findings and questions. Ask: What plants did they observe? What animals and evidence of animals did they see? What other organisms were in the schoolyard? What questions did you have? Make a class list of their findings and questions.
2. Optional: Have students categorize the types of organisms they found in the schoolyard habitat and summarize their findings.
3. As a class categorize the questions students posed (descriptive, comparative, correlative, essential questions, why questions, questions we can look up).

Type of Question	Examples
Book/Internet Research	What is the name of this insect? What is the normal range of this animal? What are the habitat needs of a rabbit?
Essential-Life Pondering, Always Wonder	How do trees alter climate? Is this area healthy?
Descriptive	What kinds of birds do we see in the local park? What plants live in this area? What is the average temperature in the forest?
Comparative	Which type of tree is the most common? Do wet areas or dry areas have more moss? Do fallen logs or leaf litter have more invertebrates? Are there more birds on the lake in summer or winter?
Correlative	How is fall leaf color related to the number of sunny days in fall? How is when butterflies first appear in spring related to temperature?
Why Questions	Why is this forest a good habitat for plants and animals?

Special Study Area

EXPLORE

1. Divide the class into pairs and give each pair a hula hoop and a yard stick.
2. Students select a study area and place the yard stick in the middle of the hula hoop to create a transect[2] line and two observation quadrats[3]. Model this set up in the classroom before going outside; show students how to record locations of plants and animals by noting the nearest inch on the yard stick (e.g. there are three acorns, one at 4 inches, one at 15 inches and one at 22 inches).
3. Students record observations using written words/phrases, drawings, labeled diagrams, and numbers to describe the area within the hula hoop, to contrast the two observation quadrats, or to note items along the transect line.
4. Students use field guides to identify plants and animals.

EXPLAIN

1. Students discuss the relationship they have noticed between the large study area and smaller special study area. Ask students, what similarities and differences did you notice?
2. Students formulate two descriptive questions and two comparative questions about the special study site based upon their observations.
3. Ask students to answer the investigative question by writing or discussing, "What plants and animals use the schoolyard habitat?"
4. Create a map of the school grounds, identifying organisms in each study area.

ELABORATE

1. Have students categorize the organisms they observed and share what they observed in the special study area. Have students write an explanation/argument using Claim, Evidence, Reasoning (See Claim, Evidence, Reasoning Rubric Appendix B for description) to answer one of the following questions:
    - What types of organisms use the schoolyard?
    - Does the schoolyard provide habitat for a diversity of organisms?
    - How many organisms use the smaller study area in the schoolyard as habitat?
2. Using student maps of the school grounds, students look for patterns and come up with questions about those patterns.
3. As an extension, students could carry out an investigation of one of the questions they came up with during the lesson.

[2]A transect is a straight line or narrow section through an object or natural feature or across the earth's surface, along which observations are made or measurements taken.

[3]A quadrat is a plot used in ecology and geography to isolate a standard unit of area for study of the distribution of an item over a large area. Quadrats can be rectangular, circular, irregular, etc.

EVALUATE

1. Review how students' are representing their observations including numbers, words, labeled diagrams, and drawings. Descriptions might include size, shape, color texture, or smell. As you review student work you can look for:

    a. drawings that fill the notebook page

    b. small objects/organisms are enlarged

    c. drawings are detailed

    d. parts of an organism/object are labeled

    e. color is added as appropriate

    f. drawings have captions or titles and note the date and place recorded

2. During student observations, assess their insights and what they reflect about the quality of the observations.
3. Assess their descriptive and comparative questions to check understanding of those categories.
4. Assess the accuracy of their maps for displaying their observational data.
5. Use Claim, Evidence, Reasoning Rubric to evaluate how they communicate about their observations. – see Appendix B.

Examples of Student Questions

5th grade students at Arlington Elementary School in Tacoma, Washington recorded numbers of the animals in Oak Tree Park and generated questions based on their observations:

What is the most occurring plant at Oak Tree Park?

What are the life styles of the birds at Oak Tree Park?

What is the lifecycle of each species?

What are the eatable plants?

What mammals (not birds) do we see at Oak Tree Park in the spring?

How big is Oak Tree Park?

How many different kinds of trees are there?

What the most common trees?

What part of the forest do most birds live in during the spring time?

Why is Oak Tree Park a good habitat for plants and animals?

What kind of bird is not commonly seen in Oak Tree Park?

Is there water at the park during spring?

How many different animals live in the forest?

What is the most common plant you see at Oak Tree Park?

How many different types of birds are in Oak Tree Park?

How many different types of ants are there in Oak Tree Park?

What is the least common bird you see at Oak Tree Park?

How many total square miles is Oak Tree Park?

What kind of bird do we see in Oak Tree Park?

How many different species of plants are in Oak Tree Park?

Nature Observation Form

Location: Oak Tree Park

Date	Animal Observed	How many	Comments
5/1/07	American Crow	1	hopping on branches
	Stellar's Jay	1	looking for food
	Chikadee	2	hiding or looking for things
	Squirrel	3	climbing on a tree
	Anna's Hummingbird	1	flying
	Barn's Swallow	5	making noises and flying
	Ants	many infinity	in anthill
	Red Breast Nuthatch	2	flying. Long-beaked
	American Robin		
	Gall		

Nature Observation Form

Location: ~~Oak~~ ~~Oak~~ ~~Oak~~ Oak Tree Park

Date	Animal Observed	How many	Comments
5/11	Chickadee	3	I could tell by the white
5/11	Anna's Hummingbird	1	saw pink on it. Micro
5/11	Baby Gary Oak tree	1	leaves are shiny
5/11	Ant hill	unknown	
5/11	Branch of oregon grape	1	berries are brown
5/11	hazel nut tree	1	soft leafs
5/11	daisy	1 clump	
5/11	blue bell flower	1 huge clump	
5/11	lilac bush	1	
5/11	Cedar	1	
5/11	indian plum	1	
5/11	crow	1	black

indian plum

Educator Insights

Below are insights and comments shared by pre-service teachers who conducted the special study area investigation.

"We measured the circumference of this tree and discovered the circumference is equal to our height. We were really surprised; it looks so different in a circle."

Quantitative observations were used; numbers describe the physical characteristics of a tree and demonstrate understanding of comparative measurement by comparing human height to tree circumference.

"We've seen the effects of time in our space; things fly in and out of our space and the amount of shade in our space has decreased."

This observation demonstrated awareness that places are not static, but instead are constantly changing by citing two pieces of evidence ("things fly in and out" and amount of shade) to support a claim that time effects what is observed.

"What is this—pollen or a seed? What is this tree that is dropping berries on us?"

By posing questions, pre-service teachers demonstrated a desire to identify the objects they observed. By making detailed observations they could later conduct research to identify the object.

"Look at all the different green colors on this fern. We can't just call them all green."

This careful observation demonstrated attention to nuanced color differences, rather than just labeling an entire plant as green. They recognized a need for a larger color vocabulary to make accurate descriptions.

Pre-service teacher recorded descriptive and comparative questions in her lab book after observing a special study area

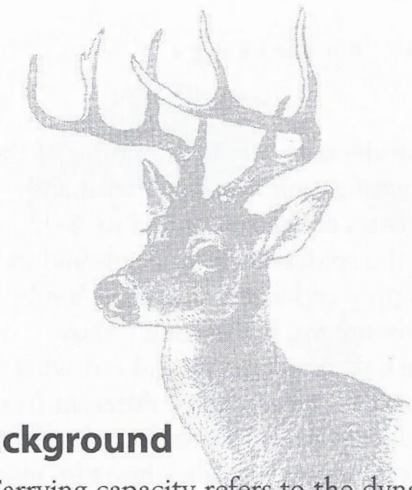
Descriptive ?'s

1. how many evergreen trees do you see when facing the music building?
2. what color(s) is in the tree bark?
3. how often does the sun shine in a certain spot (time for ten minutes)?
4. how many bird chirps do you hear in 30 seconds?
5. use 3 adjectives to describe how the stump feels
6. How does this area smell?

Comparison ?'s

1. how do the circumferences differ on two trees?
2. Is there a difference between the shape & color of the stump rings, based on location?
3. Compare the ground → some places more moist than others?
4. compare the volume of sounds, a half hour apart?

Oh Deer!



Objectives

Students will: 1) identify and describe food, water and shelter as three essential components of habitat; 2) describe factors that influence carrying capacity; 3) define "limiting factors" and give examples; and 4) recognize that some fluctuations in wildlife populations are natural as ecological systems undergo constant change.

Method

Students portray deer and habitat components in a physical activity.

Materials

An area—either indoors or outdoors—large enough for students to run (e.g., playing field); chalkboard or flip chart; writing materials

Grade Level: 5-8

Subject Areas: Science, Environmental Education, Math, Expressive Arts

Duration: one 30- to 45-minute session

Group Size: 15 and larger recommended

Setting: indoors or outdoors; large area for running needed

Conceptual Framework Topic Reference: WPIIA, WPIIA2, WPIIA2a, WPIIA2a1), WPIIA2a2)b), WPIIA2a2)c)i, WPIIA2a2)c)ii

Key Terms: habitat, limiting factors, predator, prey, population, balance of nature, ecosystem

Appendices: Simulations, Ecosystem, Early Childhood

Background

Carrying capacity refers to the dynamic balance between the availability of habitat components and the number of animals the habitat can support. A variety of factors related to carrying capacity affect the ability of wildlife to successfully reproduce and to maintain their populations over time. The most fundamental of life's necessities for any animal are food, water, shelter and space in a suitable arrangement. Without these essential components, animals cannot survive.

However, some naturally caused and culturally induced limiting factors serve to prevent wildlife populations from reproducing in numbers greater than their habitat can support. Disease, predator/prey relationships, varying impacts of weather conditions from season to season (e.g., early freezing, heavy snows, flooding, drought), accidents, environmental pollution and habitat destruction and degradation are among these factors. An excess of such limiting factors leads to threatening, endangering and eliminating whole species of animals.

This activity illustrates that:

- good habitat is the key to wildlife survival;
- a population will continue to increase in size until some limiting factors are imposed;
- limiting factors contribute to fluctuations in wildlife populations; and
- nature is never in "balance," but constantly is changing.

Wildlife populations are not static. They continuously fluctuate in response to a variety of stimulating and limiting factors. We tend to speak of limiting factors as applying to a single species, although one factor may affect many species.

Carrying capacity limitations can result in competition between and among domestic animals, wildlife and humans.

Natural limiting factors, or those modeled after factors in natural systems, tend to maintain populations of species at levels within predictable ranges. This kind of "balance in nature" is not static but is more like a teeter-totter than a balance. Some species fluctuate or cycle annually. Quail, for example, may start with a population of 100 pairs in early spring, grow to a population of 1,200 birds by late spring and decline slowly to a winter population of 100 pairs again. This cycle appears to be almost totally controlled by the habitat components of food, water, shelter and space, which are also limiting factors. Habitat components are the most fundamental and the most critical of limiting factors in most natural settings.

This activity is a simple but powerful way for students to grasp some basic concepts: first, that everything in natural systems is interrelated; second, that populations of organisms are continuously affected by elements of their environment; and third that populations of animals continually are changing in a process of maintaining dynamic equilibrium in natural systems.

Procedure

1. Tell students they will be participating in an activity that emphasizes the most essential things animals need in order to survive. Review the essential components of habitat with the students: food, water, shelter and space in a suitable arrangement. This activity emphasizes three of those habitat components—food, water and shelter—but the students should not forget the importance of the animals having sufficient space in which to live, and that all the components must be in a suitable arrangement for wildlife populations to reach their maximun size.
2. Ask the students to count off in fours. Have all the ones go to one area; all twos, threes and fours go together to another area. Mark two parallel lines on the ground or floor 10 to 20 yards apart. Have the ones line up behind one line; the rest of the students line up behind the other line, facing the ones.
3. The ones become "deer." All deer need good habitat in order to survive. Again ask the students what the essential components of habitat are: food, water, shelter and space in a suitable arrangement. For the purposes of this activity, assume that the deer have enough space in which to live. The deer (the ones) need to find food, water and shelter in order to survive. When a deer is looking for food, it should clamp its "hooves" over its stomach. When it is looking for water, it puts its "hooves" over its mouth. When it is looking for shelter, it holds its "hooves" together over its head. A deer can choose to look for any one of its needs during each round or segment of the activity; the deer cannot, however, change what it is looking for (e.g., when it sees what is available during that round). It can change what it is looking for in the next round, if it survives.
4. The twos, threes and fours are food, water and shelter—components of habitat. Each student is allowed to choose at the beginning of each round which component he or she will be during that round. The students depict which component they are in the same way the deer show what they are looking for; that is, hands on stomach for food, etc.
5. The activity starts with all players lined up behind their respective lines (deer on one side, habitat components on the other side)—and with their backs facing the students along the other line.
6. Begin the first round by asking all of the students to make their signs—each deer deciding what it is looking for, each habitat component deciding what it is. Give the students a few moments to put their hands in place—over stomachs, mouths or over their heads. (The two lines of students normally will display a lot of variety—with some students portraying water, some food and some shelter. As the activity proceeds, sometimes the students confer with each other and all

continued

make the same sign. That's okay, although don't encourage it. For example, all the students in habitat might decide to be shelter. That could represent a drought year with no available food or water.)

NOTE: Switching symbols in the middle of a round can be avoided by having stacks of three different tokens, or pieces of colored paper, to represent food, water and shelter at both the habitat and deer ends of the field. At the start of each round, players choose one of the symbols before turning around to face the other group.

7. When the students are ready, say: "Oh Deer!" Each deer and each habitat component turn to face the opposite group, continuing to hold their signs clearly.

8. When deer see the habitat component they need, they are to run to it. Each deer must hold the sign of what it is looking for until getting to the habitat component student with the same sign. Each deer that reaches its necessary habitat component takes the "food," "water" or "shelter" back to the deer side of the line. "Capturing" a component represents the deer successfully meeting its needs and successfully reproducing as a result. Any deer that fails to find its food, water or shelter dies and becomes part of the habitat. That is, any deer that died will be a habitat component in the next round and so is available as food, water or shelter to the deer that are still alive.

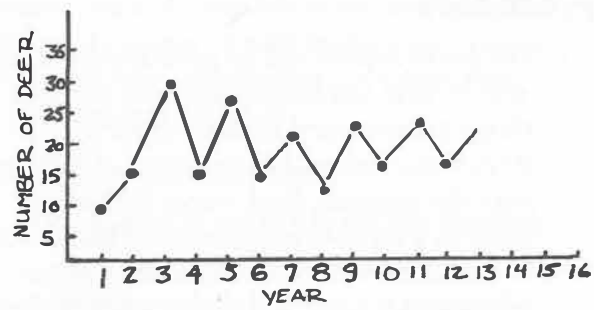
NOTE: When more than one deer reaches a habitat component, the student who arrives there first survives. Habitat components stay in place until a deer chooses them. If no deer needs a particular habitat component during a round, the habitat component just stays where it is in the habitat. The habitat component can, however, change which component it is from round to round.

9. Record the number of deer at the beginning of the activity and at the end of each round. Continue the activity for approximately 15 rounds.

10. At the end of the 15 rounds, gather the students together to discuss the activity. Encourage them to talk about what they experienced and saw. For example, they saw a small herd of deer (seven students in a class size of 28) begin by finding more than enough of its habitat needs. However, because the population of deer expanded over two to three rounds of the activity until it exceeded the carrying capacity of the habitat, there was not sufficient food, water and shelter for all the members of the herd. At that point, deer starved or died of thirst or lack of shelter, and they returned as part of the habitat. Such things happen in nature also.

NOTE: In real life, large mammal populations might also experience higher infant mortality and lower reproductive rates.

11. Using an overhead projector, a flip chart pad or an available chalkboard, post the data recorded during the activity. The number of deer at the beginning of the activity and at the end of each round represents the number of deer in a series of years. That is, the beginning of the activity is year one; each round is an additional year. Deer can be posted by fives for convenience. For example:



The students will see this visual reminder of what they experienced during the activity: the deer population fluctuated over a period of years. This process is natural as long as the factors that limit the population do not become excessive, to the point where the animals cannot successfully reproduce. The wildlife populations will tend to peak, decline and rebuild; peak, decline and rebuild—as long as there is good habitat and sufficient numbers of animals to reproduce successfully.

12. What is realistic and unrealistic about this simulation? (Deer that don't survive **do** become recycled as nutrients but it is not instantaneous. Deer need **all** habitat components to survive. Poor habitat usually results in a weakened individual that sussumbs to disease, etc., not instant death.)
13. In discussion, ask the students to summarize some of the things they learned from this activity. What do animals need to survive? How do these components influence carrying capacity? What are some "limiting factors" that affect the survival of animals? How do factors limiting carrying capacity affect the health, numbers and distribution of animals? How do these factors affect competition within a species? Why is good habitat important for animals? Are wildlife populations static, or do they tend to fluctuate as part of an overall "balance" of nature? Is nature ever really in "balance" or are ecological systems involved in a process of constant change?

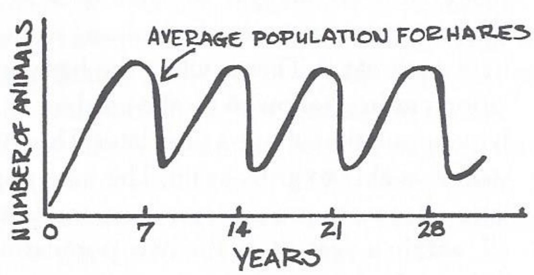
Variations

1. After the students have played several rounds of "Oh Deer!," introduce a predator such as a mountain lion or wolf into the simulation. The predator starts in a designated "predator den" area off to the side. The predator has to skip or hop. This impediment reduces the possibility of violent collisions between deer and predators. The predators can tag deer only when they are going towards the habitat and are between the habitat and deer lines. Once a deer is tagged, the predator escorts the deer back to the predator den. The time it takes to escort the deer simulates the time it takes to eat. The "eaten" deer is now a predator. Predators that fail to tag someone die and become habitat. That is, in the next round the predators that died join the habitat line. They will become available to surviving deer as food, water or shelter. During each round, keep track of the number of predators as well as the number of deer. Incorporate these data into the graphs.
2. Instead of drawing the line graph for students as described in Step 11, have the students create their own graphs. Provide them with the years and numbers of deer.

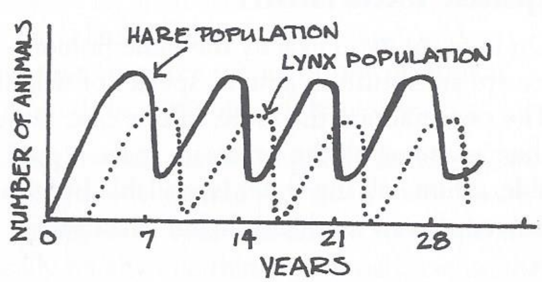
Extensions

1. When the students have finished tabulating and discussing the graph data, ask them if they have ever heard of the Hudson Bay trappers in American history. Tell them briefly who they were.

   There are a hundred years or more of records of the activities of these trappers. In those records are some interesting data. These data refer to pelts shipped from America to Europe, particularly the pelts of snowshoe hares and lynx. Researchers have found that snowshoe hare populations seem to peak about every seven to nine years and then crash, repeating the process over each comparable time period. A snowshoe hare population graph would look like this:



   It also has been discovered that lynx populations do the same thing—except that they do it one year behind the hare populations. The combined graph would look like this:



continued

Plot both sets of data on a graph, adding first the hares and then the lynx. Ask the students:

- Which animal is the predator? Which prey?
- Are predators controlling the prey, or are prey controlling the predators? (The number of prey animals available is an indicator of how many predators can live in the area.)
- How is this graph similar to the one created in the deer habitat activity? Who controls the population fluctuations? (Sometimes the habitat—when the deer population is not too large; sometimes the deer—when the deer population destroys the vegetative food and cover.)

2. Some recent research has added a new dimension to the story of the snowshoe hares and the lynx.

   It has been found that a major winter food of the hare is a small willow. As the hare population grows, the use of the willow plants grows too. However, when the willow plant has been "hedged" or eaten back so far, the plant generates a toxin (poison) so the hare can't eat it. That is when the hare population crashes, followed by the crash of the lynx population about a year later. Then the willow is able to grow again. The hare population begins to grow in response, and last of all, within a year or so, the lynx population follows. And the cycle has begun again—over and over—every seven to nine years.

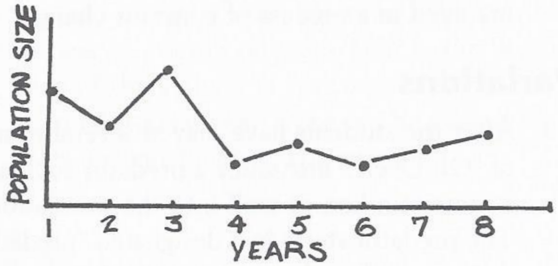
3. Discuss the "balance" of nature. Is it ever in "balance?"

Aquatic Extension

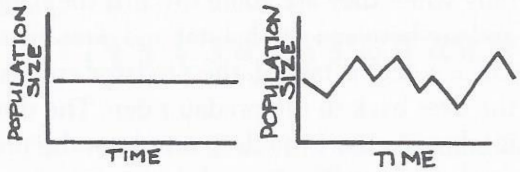
Do the activity in exactly the same fashion, except substitute an aquatic species of wildlife. The essentials are the same. In this case, rather than assuming all the necessary space is available, assume all the water is available but space is needed, as is food and shelter. Hands on stomach is food, hands together over head is shelter—and arms out to the side is space. Otherwise, conduct the activity in the same fashion. The objective remains the same, except that now food, shelter and space are the three essential components of habitat. Examples of possible aquatic species: manatee, salmon, frog.

Evaluation

1. Identify three essential components of habitat.
2. Define "limiting factors." Identify three examples.
3. Examine the graph below. What factors may have caused the following population changes:
   a. between years 1 and 2?
   b. between years 3 and 4?
   c. between years 5 and 6?
   d. between years 7 and 8?



4. Which of the following graphs represents the more typically balanced population?



Appendix B- Claim, Evidence, Reasoning Rubric

Adapted from *Middle school students' use of appropriate and inappropriate evidence in writing scientific explanations.* (McNeill, 2007)

Important Attributes for Argument/Explanation

Note: Not all attributes will be in every explanation

Claim:

- Limits claim to place, date, and time of study-unique to field studies
- Directly and clearly responds to the question.

Evidence:

Appropriate:

- Measurements and/or observations are relevant to the claim
- Averages and/or totals of what was measured/observed are given

Sufficient:

- Enough data is given to share the trends of data without giving all the data
- Enough data is given to share the range of data from different conditions, organisms, locations, or times

Reasoning

Stands-out: Does not repeat claim or evidence.

Link:

- Describes why there is enough evidence to support the claim.
- Describes how the investigation method with controlled variables and/or multiple trials helps validate the data

Science Concept:

- A science concept is given that connects the evidence (results) with the claim
- The science concept is clear
- The science concept is accurate

Chapter 2: Preparing Students to Conduct Field Investigations

Lesson 3: Comparative Field Investigation:
How Does Surface Temperature Vary with Location?

Objectives

Students will:

1) Plan and carry out an investigation on surface temperature in their schoolyard;
2) Analyze and interpret their data;
3) Write an argument/explanation using data as evidence.

Student Outcomes

Lesson 3- *I can work collaboratively to plan and carry out an investigation on surface temperature in my schoolyard. I can analyze the surface temperature data from my schoolyard to provide evidence in constructing an argument/explanation for why or why not differences occur.*

Thinking Skills

Observing, Finding Evidence, Inferring

Learning Experience

Students will conduct a comparative field investigation by measuring the surface temperature at three different locations on the school campus.

Materials

- Thermometers
- Stopwatches

Next Generation Science Standards and Common Core ELA and Math

Dimension from the Framework	Connections to the 3 Dimensions of NGSS
Disciplinary core idea: • 4-ESS2-1-Biogeology -Living Things can affect the physical characteristics of their regions. • MS-ESS3-3- Human Impacts on Earth Systems-Human activities have altered the biosphere, sometimes damaging it although changes to environments can have different impacts for differently living things. • MS-ESS2-2-The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.	4-ESS2-1 Students note abiotic and biotic parts of an urban ecosystem and relate temperature differences of various land surfaces to whether the surface has vegetation or not and/or what types of vegetation are influencing microclimates. MS-ESS3-3 Students compare surface temperatures on vegetative vs man-made surfaces to obtain evidence of how humans are changing environments and the cycle and flow of energy in urban ecosystems. MS-ESS2-2 Students investigate surface temperatures to gather evidence on how the planet's geosphere, atmosphere, and biosphere interact to effect surface temperatures in an urban ecosystem.

Dimension from the Framework	Connections to the 3 Dimensions of NGSS
Crosscutting concepts: • Patterns • Cause and Effect • Systems and system models • Energy and Matter: Flows, Cycles, and Conservation	• Students collect temperature measurements in an ecosystem to see how different types of land surfaces affect surface temperature. • Students look for patterns in their data and consider reasons for differences including the flow of energy in the system.
Science and engineering practice: • Planning and carrying out investigations • Analyzing and interpreting data • Constructing explanations • Engaging in argument from evidence • Engaging in Argument from Evidence • Obtaining, evaluating, and communicating information	• Students plan and carry out an investigation to answer the question, "Which surface—on the open grass, under the bushes, or on the black top—has the highest temperature?" • Students analyze and interpret their data. • Students use the Claim, Evidence, Reasoning framework to construct an evidence-based argument/explanation to answer the question, "Which surface - on the open grass, under the bushes, or on the black top - has the highest temperature?" • Students use their evaluation to communicate their findings to others.
Common Core State Standards	**Connections to Common Core State Standards (CCSS)**
Common Core ELA Connections	• 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. • Write informative/explanatory texts to examine a topic and convey ideas and information clearly. • Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience. • Write arguments to support claims with clear reasons and relevant evidence.
Common Core Math	• Reason abstractly and quantitatively. • Display numerical data in plots on a number line, including dot plots, histograms, and box plots. • Describe the nature of the attribute under investigation, including how it was measured and its units of measurement.

Background

Now that students have sorted investigative questions and conducted a descriptive field investigation of the schoolyard habitat, they are prepared to conduct a comparative field investigation by measuring one particular environmental parameter - temperature. See Fontaine, J.J., Stier, S.C., Maggio, M. L., and Decker, K. L. (2007) Schoolyard Microclimate, The Science Teacher, pg. 22-38, for additional background information about temperature.

In comparative field investigations, data is collected on different groups, at different times and locations or under different conditions, to make a comparison. These measurements are taken to provide evidence to answer the investigation question. In this investigation, students gather temperature data in different locations to answer the comparative question, "Which surface - open grass, under the bushes, or on the blacktop - has the highest temperature?"

This investigation involves collecting and organizing multiple trials of temperature data in a data table, analyzing the data by calculating average temperatures, graphing the averages, and writing an argument/explanation about the average surface temperature at different locations. Having each group repeat multiple measurements at each location helps students understand the importance of multiple trials in scientific studies. A sample data sheet is provided. Students can record data in a science notebook, tape the sample data sheet into a notebook, or simply use the data sheet to record observations.

"In field observations, planning involves deciding how to collect different samples of data under different conditions, even though not all conditions are under the direct control of the investigator". (NGSS Appendixes Volume 2, p. 54).Carrying out a comparative field investigations involves identifying the independent (what is to be compared), dependent (what is to be measured or observed) variables and controls. These elements provide for a "fair test".

> **Independent (Manipulated) Variable**: The factor of a system being investigated that is being compared (collecting different samples of data under different conditions). (NGSS Appendixes Volume 2, p. 55). In this investigation, the type of surface is the independent variable.
>
> **Dependent (Responding) Variable**: The factor of a system being investigated that changes in response to the manipulated variable and is measured or observed. In this investigation, the surface temperature is the dependent (measured) variable. It is important that students actually record multiple measurements at one location so they experience repeating trials.
>
> **Controlled Variables**: The conditions that are kept the same in a scientific investigation to provide for a fair test. In the case of field investigations not all conditions are under the control of the investigator. In this investigation, using the same type of thermometer, how thermometers are positioned, wait time, and light exposure are all controlled variables.

Lesson 3: Comparative Field Investigation:

How Does Surface Temperature Vary with Location?

ENGAGE

1. Have students thinking about the question "Is the temperature outside in the schoolyard the same in every place?" Have students turn and talk about their ideas.
2. Elicit responses from students by asking the question "Have you ever stood in the sunlight in a black shirt?" Have students turn and talk about their experience.
3. Review the investigation question, "Which surface - on the open grass, under the bushes, or on the black top - has the highest temperature?" Have students write the question in their notebooks or use data sheet provided.
4. Tell students that good investigation questions describe what we will manipulate (independent variable). Have students underline the manipulated (independent) variable in the question (surface).
5. Good comparative questions also describe what to measure (dependent variable). Have students double underline the responding (dependent) variable in the question (temperature).

Elicit responses

EXPLORE

1. Take students outside to visit the site where they are to carry out the investigation and to practice with the equipment (thermometers).
2. Students visit all the locations with the three surface types. Students leave a thermometer flat on the ground for a determined number of minutes, shade the thermometer from direct sunlight and record the temperature one time at one of the surface types. Now that students have practiced the measurement process, they are ready to write a complete procedure.
3. Students return to the classroom and write a prediction of which surface type will have the highest temperature.
4. Review the importance of recording the date, time, and weather including air temperature, and for describing the study site.
5. Review the importance of multiple trials and explain that every team will measure the temperature of all three surfaces and take three trials at each location.

Practices:
Questioning

Planning and carrying out investigations

Cross cutting concepts:
Patterns

6. Have students create a data table or provide data sheets. A sample data sheet is included at the end of this lesson. Be sure the data table includes:
    - Clear title for the table
    - Locations (manipulated variable) to the left side
    - Temperature (responding variable) labeled across the top with appropriate units
    - Multiple trials labeled
    - A place for averages

7. Ask students, "When we go outside and take the surface temperature, what do we need to do the same each time (controlled variables) to provide for a fair test?"
8. Have students do a "think-pair-share". List controls on the board and have students write them in their notebooks.
9. High school students should select sampling locations that are representative and random of the site (see map for an example).
10. Students work in groups to design and write their step-by-step procedure which needs to include: multiple trial indicators; where they take measurements (independent variable); what they will be measuring and recording (dependent variable); how they will take measurements (controls).
11. Optional-self assessment of procedure using key on example page 37.

Teacher Note: As students become more proficient at writing procedures they can write them prior to conducting the investigation.

12. Students carry out the surface temperature comparative investigation following their procedure. They:

- Record date, time, and place where investigation takes place (study site).
- Describe the weather and site of the investigation recording air temperature.
- Leave thermometer flat on the ground the determined number of minutes, shading the thermometer from direct sunlight, and record the temperature four times at each of the three locations (on the open grass, on the blacktop and under the bush).

EXPLAIN

1. Students calculate averages (mean, medians, or modes) for each location.
2. Students display data in graphic form or on maps. See page 41.
3. Optional-Students discuss which graphic representation is best and why.
4. Students review the procedure and make any changes to include what they actually did in the field.
5. Argumentation - in groups students discuss:
    - patterns in the data
    - the procedure
    - any factors that may have influenced their data
    - any inconsistent data
6. Students share in a whole class discussion and record.
7. Ask students, "Do we have evidence to answer our question, 'Which surface - on the open grass, under the bushes, or on the black top - has the highest temperature?" Have students discuss in groups.
8. Students construct an argument/explanation using data as evidence to answer the investigation question. Use the Claim, Evidence, Reasoning Template page 42. See example page 44.

ELABORATE

Here are some ideas for elaboration:

1. Have students discuss using some of these questions:
    - What are possible reasons the temperature was or was not different for different surfaces? (Cause and Effect)
    - What is the effect of plants (vegetation) on surface temperature?
    - What is the effect of human built hard surfaces on surface temperature?
    - What inputs to the system might cause the surface temperature to be higher in one location than another?
    - How do you think surface temperatures might be different if you measured them at different times of the day? Different times of the year?
    - What inputs or changes to the system might change the surface temperature data collected?
    - What inputs affect temperatures in a local ecosystem?
    - How do various land surfaces affect temperature of an area?

4-ESS2-1-Biogeology -Living Things can affect the physical characteristics of their regions.

MS-ESS3-3- Human Impacts on Earth Systems-Human activities have altered the biosphere, sometimes damaging it although changes to environments can have different impacts for differently living things.

MS-ESS2-2-The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.

- How does this information add to my understanding of the school-yard ecosystem?
- What does this information indicate for organisms that live in the schoolyard ecosystem?
- How might this information inform actions/decisions on campus or in their community?
- How do human caused changes in the biosphere effect changes in the atmosphere (temperatures)?

2. Have students continue their research and/or investigation to add to their argument/explanations, such as:
    - Read a non-fiction article about microclimates, light absorption, heat islands, etc. This will allow them to add more to their reasoning statements. Ask students to think about the absorption of solar energy by living things and man-made surfaces;
    - Communicate their investigation by creating posters/PowerPoint presentations, etc.;
    - Explanation of what different surface temperatures means for microclimates and/or heat islands;
    - Create new questions and investigations;
    - Repeat a temperature investigation at different times of year or under different weather conditions;
    - Conduct a simple controlled investigation with thermometers in colored envelopes/cans to provide more data for students to understand differences in color absorption of light;
    - Read articles describing the energy transfer/transformations from the sun to the thermometer.

3. Students should be given the opportunity to discuss findings and revise their Claims Evidence and Reasoning following this section.

EVALUATE

Procedure - Student Self Evaluation:

Have students self-evaluate their procedures using the key on page 37 to make sure they included:

1) What is being changed to make a comparison - indicates three different surfaces.
2) What is being measured – temperature.
3) What is being controlled - how measurements were taken. These may include:
    - Calibration and or wait time before any measurements;
    - Wait time once thermometer is placed on the surface;
    - How thermometer is held;
    - How the thermometer is shaded from direct sunlight.
4) Indication of multiple trials.

See Procedure Scoring Rubric page 36.

Data Collection-Student Self Evaluation:

Have students review their charts and graphs of data to see if they include:

1) Data recorded correctly and accurate averages.
2) Title and columns and/or axes labeled correctly.
3) Correct units.
4) An appropriate graph if they graphed the data.
5) Explanation of graphic display if applicable.

Two sets of sample data are given on pages 43 and 45 with scoring rubric annotation.

Argument/Explanation Evaluation:

Review students' constructed argument/explanation for elements of a good argument/explanation:

This rubric is given on page 38.

Claim

- Directly and clearly responds to the question.
- Limits claim to place, date, and time of study.

Evidence

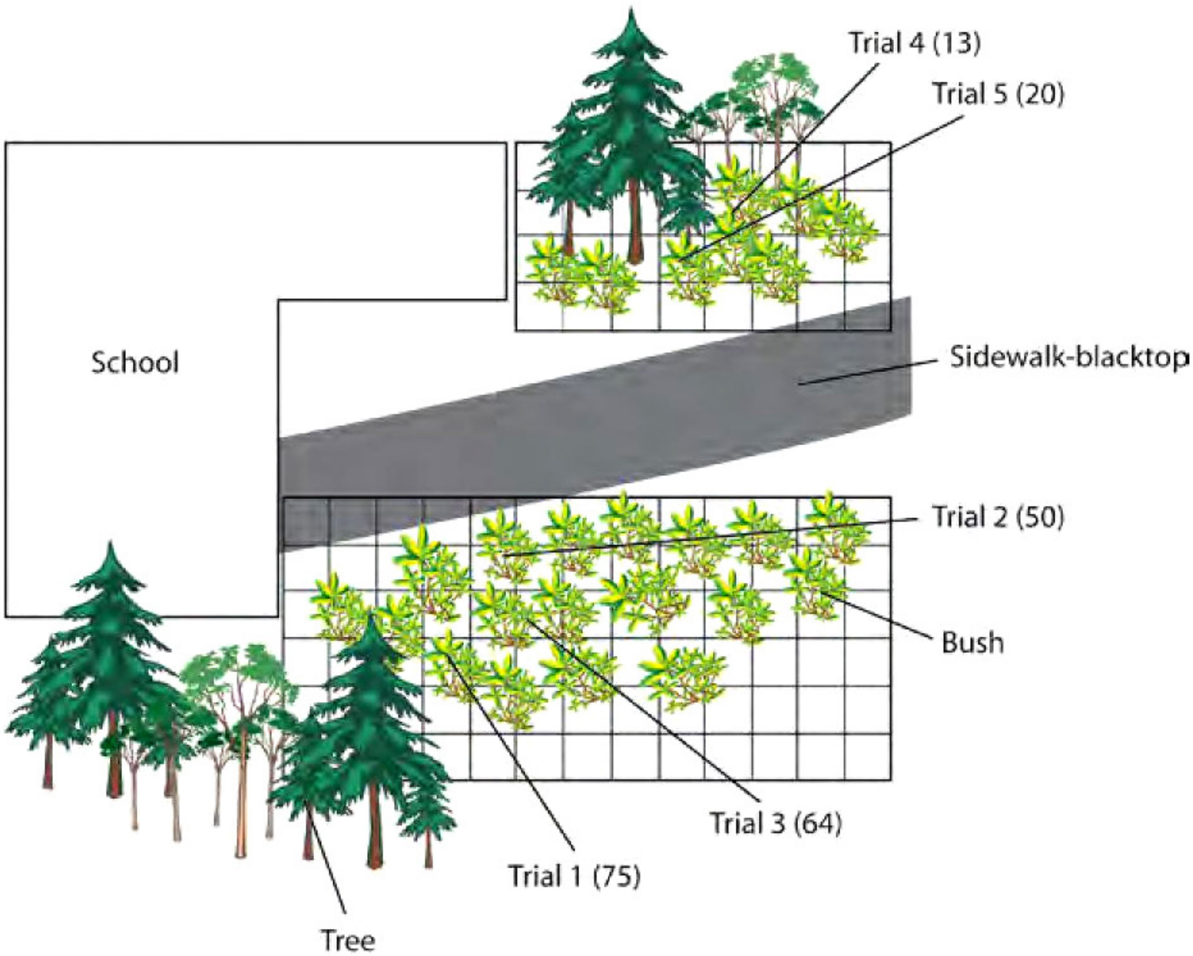
- **Appropriate** - gives average temperature data.
- **Sufficient** - gives average temperature data for the all three surfaces, but doesn't give all the data.

Reasoning

- **Stands-out** – does not repeat claim or evidence.
- **Link** - tells why there is enough evidence to support the claim.
- **Science Concept** - possible examples include:
    - o Darker colors absorb more sunlight making them warmer than other colored objects.
    - o Bushes can shade the surface from direct sunlight; therefore the surface will be cooler.
    - o Without direct sunlight (cloudy day) to be absorbed all the surface locations will be similar to the ground or the air because heat will be transferred to the surface from the ground or the air.

Map of Random Site Selection

Elementary students can select any site on the schoolyard to take temperature measurements. Secondary students should use a selection procedure that ensures that sample sites are selected randomly.



One way to provide for random sampling is to obtain or create a map of the school grounds and then place an acetate grid over the map. Begin by either using random numbers or every so many squares; take the surface temperature at those sample spots as the trials for the investigation. The example is given for taking the sur¬face temperature under five bushes using ten random numbers. The first five sample spots that occur under bushes on the grid will be used as the five trials. The numbers generated were: 13, 20, 32, 34, 50, 64, 71, 75, 82, and 97. Spots 13, 20, 50, 64, and 75 were used because there were bushes present.

Self - Evaluation: Procedure Rubric

Have students review their written procedures for the four important attributes of a procedure: 1) What is kept the same in the investigation-controlled variables, 2) What is being changed to make a comparison-independent variable, 3) What is being measured or observed-dependent variable and 4) logical steps in which trials are repeated.

Rubric for Procedure	
Controlled Variable (kept the same- how measurements were taken)	Student states at least one way that measuring and/or sampling are kept the same. • Wait time before taking temperatures so thermometer has time to reach temperature. • Temperature taken on top of ground each time. • Wait the same # of minutes each time before reading temperature. • Thermometer held the same way each time to measure surface of the ground. • Thermometer shaded from direct sun.
Independent Variable (manipulated variable-what is changed to make a comparison)	Student states what is changed. Secondary students should also state how the sites were chosen randomly at each location. For this investigation: • Surface type or location is implied or stated as the independent variable that is changed/manipulated in the investigation.
Dependent Variable (Responding variable-what is measured or observed)	Student states what is measured. For this investigation: • The temperature is implied or stated as the variable that is measured.
Logical Steps with Trials Repeated	The steps of the procedure are detailed enough to repeat the procedure effectively. Student indicates that data will be recorded or creates a data table that includes date, time, and weather conditions. Student notes that data will be measured more than once at each location. Data tables should be left blank when planning an investigation so that data can be collected.

Sample Procedure

1. Record date, time, and area where investigation takes place (study site).
2. Describe weather (cloudy, sunny) and site of investigation.
3. Leave thermometer outside for five minutes to make sure first readings are accurate.
4. Place thermometer flat on the ground in first location (black top) and wait two minutes.
5. Record the temperature in °C without picking up the thermometer (temperature can be recorded in Celsius or Fahrenheit depending on your thermometers).
6. Repeat the temperature measurement in this location two more times*.
7. Move to the second location (on the open grass) and take three* temperature measurements and record.
8. Move to the third location (under the bush) and take three* temperature measurements and record.

Key

Underlined ➡ Independent Variable (manipulated variable - what is changed to make a comparison)

Double underlined ➡ Dependent Variable (responding variable - what is measured or observed for data)

Circled ➡ Controlled Variables (what is kept the same in the investigation)

* ➡ Multiple trials

Important Attributes of an Argument/Explanation

See Appendix B for a generic rubric.

Claim: Directly and clearly responds to the question. Clearly describes which surface has the highest temperature or describes that there was no differences among the surface temperatures. Limits claim to location, date, and time where field study took place.
Evidence **Appropriate:** Gives average temperature data. **Sufficient:** Gives average temperature data for the all 3 surfaces, but doesn't give all the data.
Reasoning **Stands-out:** Does not repeat claim or evidence. **Link:** Tells why there is enough evidence to support the claim. **Science Concept:** Possible examples include: • Darker colors absorb more sunlight making them warmer than other objects. • Bushes/vegetation can shade the surface from direct sunlight and therefore the surface will be cooler. • Without direct sunlight (a cloudy day) to be absorbed all the surface locations will be similar to the ground or the air because heat will be transferred to the surface from the ground or the air.

Sample Data Sheet

How Does Temperature Vary With Surface?

Comparative Question: Which surface-on the open grass, under the bushes, or on the blacktop-has the highest temperature °C?

Prediction/Hypothesis:____

____

Date__________________________Time__________________________

Study site (location)____

Study site description____

____

____

Weather____

Type of Surface vs. Temperature °C

Type of Surface	Temperature °C			
	Trial 1	Trial 2	Trial 3	Average Temperature
Open Grass				
Under Bushes				
Blacktop				

Sample Argument/Explanation Student Page

Which surface-on the open grass, under the bushes, or on the blacktop-has the highest temperature?

Claim
Did I clearly answer the question?
Did I limit the claim to the date, time, and place of the field study?

Evidence
Did I use the right data?
Did I give enough data?

Reasoning
Did I tell why there is enough evidence to support the claim? OR
Did I use a science concept to explain why my evidence supports the claim?

EXAMPLE 1- Data with a difference

Sample Data:

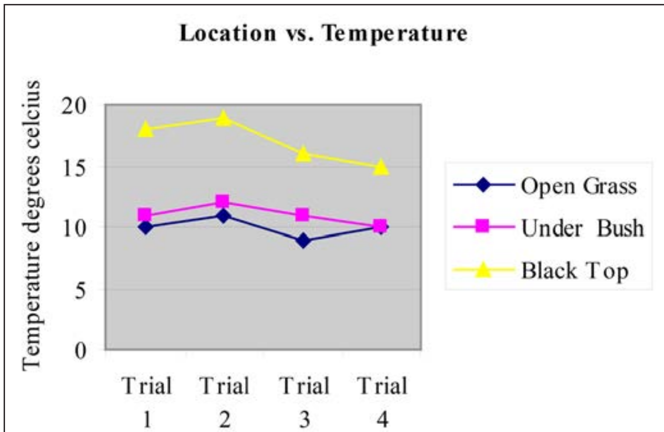
March 18, 2005, 2:30 pm
Dearborn Park Elementary, Seattle, Washington
Sunny afternoon

Location vs. Surface Temperature °C

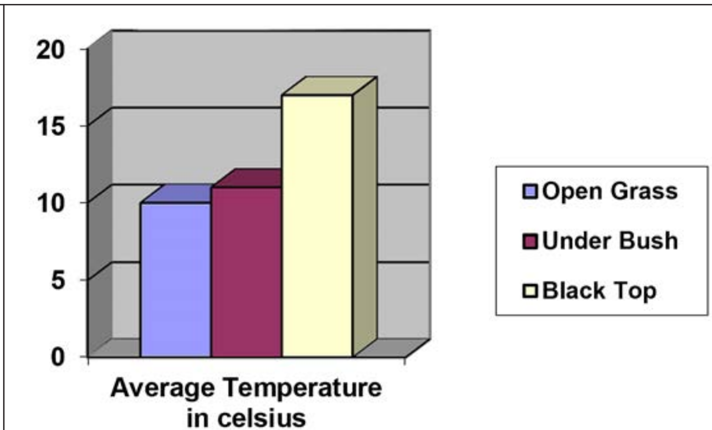
Location	Surface Temperature °C				
	Trial 1	Trial 2	Trial 3	Trial 4	Average
On the Open Grass	10	11	9	10	10
Under Bushes	11	12	11	10	11
On the Black Top	18	19	16	15	17

Data Analysis

Students can analyze temperature data by calculating the average surface temperature of each surface location and then graphing the data. Graphs help students see the comparisons of average surface temperatures visually. Seeing data displayed in more than one way and discussing the pros and cons of each, helps students understand that scientists make choices about how to best present collected data.



This graph displays all the data points and provides an opportunity to consider how averages are calculated from a set of points.



This graph displays only a summary of the average surface temperatures.

A numberline helps students see median and mode when comparing only two locations

Grass			X									
		X	X	X								
Black Top	8	9	10	11	12	13	14	15	16	17	18	19
								X	X		X	X

Example 1- Constructing Arguments/Explanations

Examine the Dearborn Park data and write a scientific explanation that answers the question:

Which surface - on the open grass, under the bushes, or on the blacktop - has the highest temperature °C?

Claim At Dearborn Park Elementary on March 18, 2005 at 2:30 pm the blacktop had the highest average surface temperature.
Evidence The blacktop surface temperature was 17°C. On the grass had the lowest average surface temperature of 10°C while under the bushes was an average of 11 °C.
Reasoning The blacktop was 7 °C warmer than on the open grass so this was enough of a difference even with our small sample size to indicate that the blacktop was the hottest surface. The blacktop had the highest temperature of any of the 3 surfaces on this sunny day because dark colors just like my black T-shirt absorb more sunlight and get warmer than other colors. Both on the grass and under the bushes had green plants covering the surface so they didn't absorb as much light and didn't get as warm.

Which surface - on the open grass, under the bushes, or on the blacktop - has the highest temperature?

Important Attributes of an Argument/Explanation

See Appendix B for a generic rubric.

Claim

Directly and clearly responds to the question.

Clearly describes which surface has the highest temperature or describes that there was no differences among the temperatures.

the black top had the highest average surface temperature

Limits explanation to place, date, and time of study.

Dearborn Park Elementary, March 18, 2005 at 2:30 pm

Evidence

Appropriate: Gives average temperature data.

Sufficient: Gives average temperature data for the all 3 surfaces, but doesn't give all the data.

The average blacktop surface temperature was 17°C. On the grass had the lowest average surface temperature of 10°C while under the bushes was an average of 11 °C.

Reasoning

Stands-out: Does not repeat claim or evidence.
Link: Tells why there is enough evidence to support the claim.
Science Concept: Possible examples include:

- Darker colors absorb more sunlight making them warmer than other colored objects.
- Bushes can shade the surface from direct sunlight and therefore the surface will be cooler.
- Without direct sunlight (cloudy day) to be absorbed all the surface locations will be similar to the ground or the air because heat energy will be transferred to the surface from the ground or the air.

Link - *The blacktop was 7 °C warmer than on the open grass so this was enough of a difference even with our small sample size to indicate that the blacktop was the hottest surface.*

Science Concept: *The blacktop had the highest temperature of any of the 3 surfaces on this sunny day because dark colors just like my black T shirt absorb more sunlight and get warmer than other colors. Both on the grass and under the bushes had green plants covering the surface so they didn't absorb as much light and didn't get as warm.*

Example 2 - Data with no difference among surfaces

Sample Data:

December 7, 2005, 11:00am
Tumwater District Office, Tumwater, Washington
Cloudy, cold morning

Location vs. Surface Temperature °C

Location	Surface Temperature °C				
	Trial 1	Trial 2	Trial 3	Trial 4	Average °C
On the Open Grass	8	6	7	7	7
Under Bushes	6	8	7	8	7
On the Blacktop	8	7	7	7	7

Example 2 - Constructing Arguments/Explanations

Examine the Tumwater data above and write a scientific explanation that answers the question:

Which surface - on the open grass, under the bushes, or on the blacktop - has the highest temperature °C?

Claim

At the Tumwater District Office on December 7, 2005, all the surfaces -blacktop, open grass, and under bushes- had the same temperature so no surface had the "highest" temperature.

Evidence

All three surfaces had the same average temperature of 7 °C.

Reasoning

There were 4 trials at each location so I think this was enough evidence to make a claim about the surface temperatures at these locations.

The weather was cloudy and cold and surface temperatures were measured in the morning. The surfaces received no direct sunlight during the morning and probably for days. Thus, all the surfaces were the same since there was no direct sunlight to absorb to make darker surfaces warmer just like on a cloudy day a dark T-shirt doesn't make you warmer.

Which surface - on the open grass, under the bushes, or on the blacktop - has the highest temperature?

Important Attributes of an Argument/Explanation

See Appendix B for a weighted rubric.

Claim **Directly and clearly responds to the question.** Clearly describes which surface has the highest temperature or describes that there was no differences among the temperatures. *all the surfaces -blacktop, open grass, and under bushes- had the same temperature* **Limits explanation to place, date, and time of study.** *At the Tumwater District Office on December 7, 2005*
Evidence **Appropriate**: Gives average temperature data. **Sufficient**: Gives average temperature data for the all 3 surfaces, but doesn't give all the data. *All three surfaces had the same average temperature of 7 °C.*
Reasoning **Stands-out**: Does not repeat claim or evidence. **Link**: Tells why there is enough evidence to support the claim. **Science Concept**: Possible examples include: • Darker colors absorb more sunlight making them warmer than other colored objects. • Bushes can shade the surface from direct sunlight and therefore the surface will be cooler. • Without direct sunlight (cloudy day) to be absorbed all the surface locations will be similar to the ground or the air because heat energy will be transferred to the surface from the ground or the air. **Link** - *There were four trials so I think this was enough evidence to make a claim about the surface temperatures at this location.* **Science Concept**: *The surfaces received no direct sunlight during the morning and probably for days. All the surfaces were the same since there was no direct sunlight to be absorbed to make darker surfaces warmer.*

Calibrating Thermometers

For thermometers with no calibration ability:

1. Have thermometers numbered.
2. Have students either turn on and hold thermometers in the air or just hold in the air.
3. Students wait a set amount of time, then read and record air temperatures.
4. Optional: students could investigate different wait times to see what is optimal for their thermometers.
5. Optional: Student could go to pre-determined locations and record temperatures.
6. Students record their measurements on a class chart.
7. Students do not use any thermometers that have readings that vary greatly from other thermometers.
8. Students calculate the average (mean, median, or mode) rounding to the nearest whole number.
9. Students do not use any thermometers that are more than 3º C above or below the average.
10. Students whose thermometers are greater or less than the average will add or subtract that number from their measurements in the field. Example: The class average for the room is 21°C - if your thermometer was at 22 °C in the room, you would subtract 1 degree from your readings in the field.

For thermometers with calibration ability:

Many thermometers have procedures for calibrating them. Students can follow the directions on the thermometer or probe, or teachers can calibrate using the following generic instructions:

Calibration in Ice Water

1. Add crushed ice and distilled water to a clean container to form a watery slush.
2. Place thermometer probe into slush for at least one minute taking care not to let the probe contact the container.
3. If the thermometer does not read between 30° and 34° F adjust to 32° F (0°C). Non-adjustable thermometers should be removed from use until they have been professionally serviced.

Calibration in Boiling Water

1. Bring a clean container of distilled water to a rolling boil.
2. Place thermometer probe into boiling water for at least one minute taking care not to let the probe contact the container.
3. If the thermometer does not read between 210° and 214° F adjust to 212° F (100°C) Non-adjustable thermometers should be removed from use until they have been professionally serviced.

YouTube directions: https://www.youtube.com/watch?v=VpJULQICiGM

Example of Extension to support NGSS Disciplinary Core Ideas - Taking the Learning Deeper

Next Generation Science Standards

MS-ESS3-3 Performance Expectation:
Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).

Disciplinary Core Ideas:

- MS-ESS2-2 The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.
- MS-ESS2-6 Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
- MS-ESS3-3 Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.

Students investigating temperatures in their schoolyards is a perfect engagement lesson for students being able to "apply scientific principles to design a method for monitoring and minimizing human impact on the environment" (Performance expectation MS-ESS-3). After students have investigated surface temperatures on their school campuses, students could explore the phenomenon of heat islands formed in urban areas or microclimates in their own schoolyard.

Heat islands: Have middle school students explore the heat island effect and the role plants play in keeping regions cooler, students would be able to construct arguments/explanations of:

- How the planet's systems interact (sunlight and living and non-living things) to cause weather and climate changes in urban areas;
- How human activities have altered the biosphere.

By doing more investigations of temperature in their communities or their region, students can expand their data collection to monitoring temperature changes overtime. Further, using their understanding of sunlight, land surfaces, and vegetation, students could come up with possible solutions such as planting trees and green roofs to help minimize the urban heat island effect.

Microclimates in the schoolyard: Have students investigate temperatures on their entire campus and map temperatures finding out where microclimates occur. (Minimum-maximum thermometers would be very useful for these investigations). Students would be able to construct arguments/explanations of:

- How the planet's systems interact (sunlight and living things) to cause weather and climate changes in in their schoolyard;
- How human activities have altered the biosphere.

Using the new data, students could design plantings to improve their schoolyards.

Third grade students at Loyal Heights Elementary in Seattle, WA investigated the soil temperature on the north side and south side of the schoolyard to see which location would allow seeds to sprout earliest in the spring (focus question). They recorded soil temperature data and wrote an argument/explanation about which side of the schoolyard would be the best place to plant their seeds. Note, that although both students claim that the south side of the schoolyard is the best for planting because the soil temperatures are warmer, only the first student included the actual data points.

Focus Question: Which location would allow seeds to sprout earliest in the spring?

Question: Which location, the north side or the south side of the schoolyard, has the highest soil temperature 5 cm below the surface?

Soil Temperature Investigation

Soil Temperature Investigation Procedure:

1. Go to the first location north side in the schoolyard and write the name in the first box under the heading: location.
2. Record the date, your school name, and study site description.
3. Describe the weather.
4. Insert the soil thermometer into the soil to the 5cm mark.
5. Wait 1 minute.
6. When the teacher says OK, take the temperature and record in the Trial 1 box.
7. Take the temperature of the soil at 2 more sample sites in the first location as instructed by your teacher, and record as Trials 2 and 3.
8. Go to the second location __________ and write the name in the 2nd box under the heading: location, and follow steps 4 through 7.

Date 5/1/07

School Loyal Hight Elem

Study site description Some shade Some Sun a tree SS no tree

Weather Sunny partly cloudy, low 50s

Location vs. Soil temperature °F at 5 cm				
	Soil Temperature °F at 5 cm			
Location	Trial 1 °F	Trial 2 °F	Trial 3 °F	Middle Number °F
N.S.	52	62	62	62
S.S.	69	73	73	73

6

9

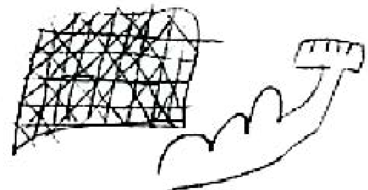
5/2/07

I think the South side would be the Best Place Because the Soil is warmor. And more people atend to the soil. Also the middle number was 69,7373 on the South side. The middle number Was 52,62,62,1. Look at the numbers the South side is warmar.

Focus Question: Which location would allow seeds to sprout earliest in the spring?

Question: Which location, the north side or the south side of the schoolyard, has the highest soil temperature 5 cm below the surface?

Soil Temperature Investigation



Soil Temperature Investigation Procedure:

1. Go to the first location Nor th side in the schoolyard and write the name in the first box under the heading: location.
2. Record the date, your school name, and study site description.
3. Describe the weather.
4. Insert the soil thermometer into the soil to the 5cm mark.
5. Wait 1 minute.
6. When the teacher says OK, take the temperature and record in the Trial 1 box.
7. Take the temperature of the soil at 2 more sample sites in the first location as instructed by your teacher, and record as Trials 2 and 3.
8. Go to the second location South side and write the name in the 2nd box under the heading: location, and follow steps 4 through 7.

Date 5-1-07

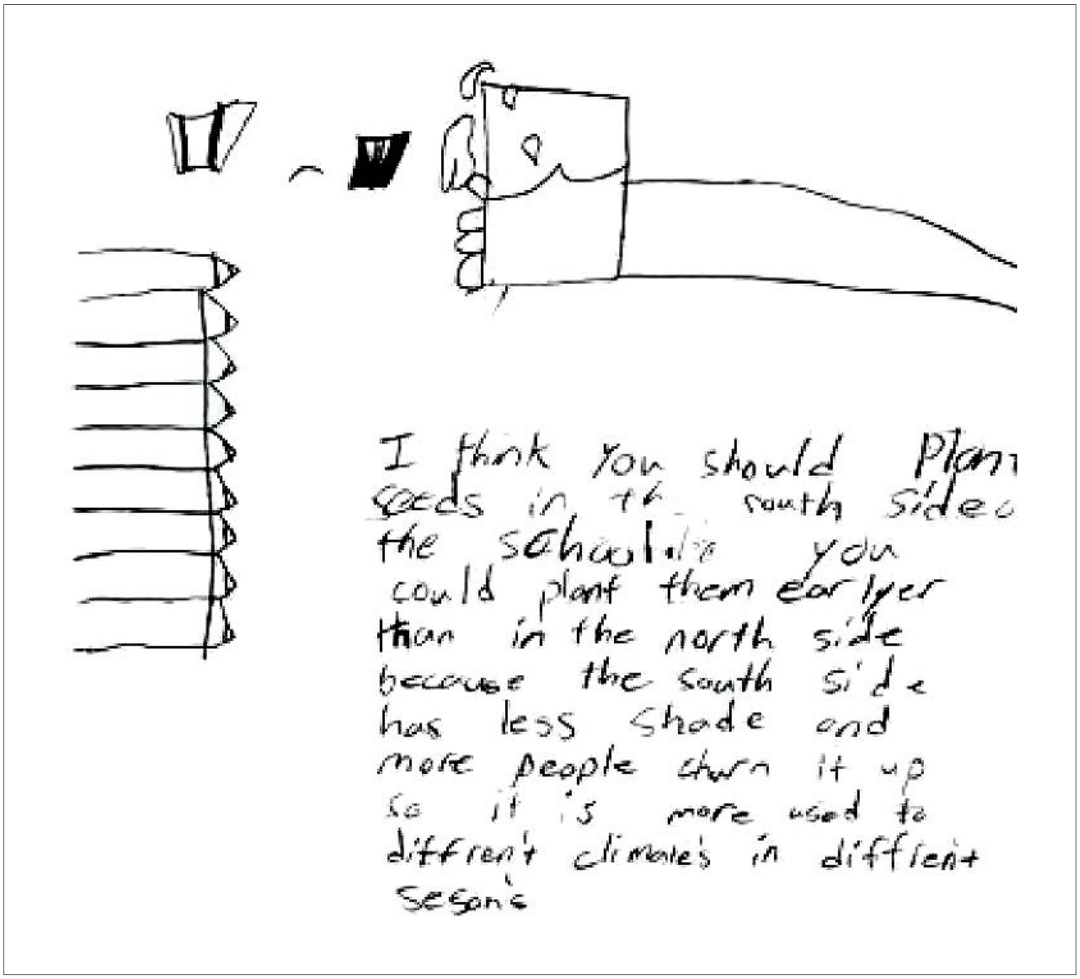
School loyal Heights

Study site description [illegible]

Weather Sun Cloud low 50s

55 [illegible]

Location vs. Soil temperature °F at 5 cm				
	Soil Temperature °F at 5 cm			
Location	Trial 1 °F	Trial 2 °F	Trial 3 °F	Middle Number °F
North	66°F	67°F	66°F	66°F
South	73°F	71°F	70°F	71°F


I think you should Plant
seeds in th south side o
the school so you
could plant them earlyer
than in the north side
because the south side
has less shade and
more people churn it up
so it is more used to
diffren't climate's in diffrent
seson's

Following are three argument/explanations written by 9th grade students who conducted the surface temperature field investigation. Though the students try to explain why there are differences, none limits their argument/explanation to the date, time, and place of the study as it was not required at the time.

Question: **How do different locations (on the open grass, under trees, or on the black top) affect the surface temperature of the ground on the school campus?** when the thermometer was placed on the open grass, the temp. did not get that high and ended up being the lowest temp. on the grid. Because it was placed on the open grass the sunlight did not heat up the thermometer due to the sunlight soaking into the field. The first trial for "on the open grass" was 10°C, the second got hotter & was 10.6°C, the third at 9.9°C and the last even cooler with an 8.9°C, leaving it with an average of 9.7°C. Under the trees was an average of 10.7°C and on the black to extremely hot at an average of 17°C. The black top made it even hotter because the number one color that soaks up the most sun is black. The different locations get/soak up different amounts of sun making the thermometer hot.

Student 1: This student does not make a clear claim statement that the blacktop location has the highest temperature probably because the question was asked using the word "how". The student does try to explain why the grass is the coolest, "due to sunlight soaking into the field" and even sites the range of trial data as evidence. The student gives appropriate and sufficient data. The explanation that "the number one color that soaks up the most sun is black" is a good explanation for their grade level.

Question: How do different locations (on the open grass, under trees, or on the black top) affect the surface temperature of the ground on the school campus? The hypothesis is, Under trees will have the lowest temperature because it's shaded all day. The hypothesis was wrong because the average temperature for under the trees was 10.7°C, when the temperature for in the grass was 9.7°C. Both lower than the 17.0°C the black top's temperature. I'm confident the different locations affected the surface temperature of the ground because some areas attrack more sun than others. The data supports my conclusion because the color black seems to attrack more sun light than an open field. Which is why the black top had the highest temperature. The reason the trees had a higher temperature than the field is because the trees are able to collect more sunlight for photosynthesis than grass.

Student 2: Again, this student does not have a clear separate claim statement probably because of the wording of the question using "how". The student does give data for all three locations as evidence. The student gives the reasoning "because the color black seems to attract more sunlight than an open field. Which is why the black top had the higher temperature" begins to acknowledge how black colors absorb more light than other colors.

Question: How do different locations (on the open grass, under trees, or on the black top) affect the surface temperature of the ground on the school campus? The temperature was the highest on the black top because there is nowhere for the heat to go but sit on the top. The grass and under the tree was about the same they had a difference of one 1°C when the black top was atleast 6°C hotter. The shade from the trees did not help at all because it was 1°C hotter than the open grass.

Student 3: This student does have a clear claim statement, "The temperature was the highest on the black top". The student supports the claim with evidence that the difference between the grass and under the tree was 1°C and the "black top was at least 6 °C hotter". The reasoning that "there is nowhere for the heat to go but sit on top" is an incorrect attempt.

DESCRIPTIVE FIELD INVESTIGATIONS

from Field Investigations: Using Outdoor Experiences to Foster Student Learning of Scientific Practices and Project Learning Tree

Chapter 3

Building Field Investigations from Student Questions

The three lessons presented in this section show how to create a field investigation from student generated questions. Students begin with a descriptive investigation of schoolyard trees and shrubs, and then conduct a comparative field investigation of twig growth. Students observe, draw and label the parts of a deciduous tree/shrub to answer a descriptive question. Then they observe, draw and label twigs in winter to answer a descriptive question about twigs. Finally, students plan and conduct a comparative investigation about twigs. As an option, students could do careful observations and submit their data to Project BudBurst[4] www.budburst.org

Lessons in this section include:

1. **Descriptive Field Investigation**: Trees/Shrubs

   What Does This Tree/Shrub Look Like?

   What are the Physical Characteristics of this Tree/Shrub?

2. **Descriptive Field Investigation**: Twigs

   What do Twigs Look Like Each Month?

   What are the Physical Characteristics of Twigs on this Tree in Winter?

3. **Comparative Field Investigations**: Twigs

   Is There More Twig Growth on the North or South Side of the Tree/Shrub?

   Do Buds on _______________Type of Tree/Shrub or ____________Type Tree/Shrub Burst Earliest in Spring?

[4]Project BudBurst is a project to get students and others outside taking a moment to observe how plants in their community change with the seasons. When students and others share their observations with Project BudBurst, they become part of an ecological record.

Chapter 3: Building Field Investigations from Student Questions

Lesson 1: Descriptive Field Investigation: Trees/Shrubs

What Does This Tree/Shrub Look Like? What are the Physical Characteristics of this Tree/Shrub?

Objectives

Students will:

1) draw and label the parts of a tree,
2) draw and label the parts of a twig, and
3) plan and conduct a comparative investigation on twigs.

Student Outcomes

Lessons 1, 2, and 3 - I can ask questions and carry out a descriptive field study of a tree and record detailed observations using words and labeled diagrams. I can carry out a descriptive study of a twig and record detailed observations using words and labeled diagrams. I can plan and carry out a comparative investigation and construct arguments/explanations using evidence.

Thinking Skills

Observing, Classifying, Finding Evidence, Inferring

Learning Experience

Students will observe, diagram and label a tree and then a twig, ask questions about deciduous twigs, and plan and conduct a comparative investigation about twigs.

Materials

- Journals
- Rulers
- Compass
- String

Additional Resources

Project Learning Tree - The Closer you Look, pg. 263

Project Learning Tree - Adopt a Tree, pg. 97

Project Learning Tree - Bursting Buds, pg. 277

Project BudBurst, www.budburst.org

Winter Twig Investigation lesson in NSTA Press Citizen Science: *15 Lessons That Bring Biology to Life, 6-12.*

Sky Tree by Thomas Locker

Next Generation Science Standards and Common Core

Dimension from the Framework	Connections to the 3 Dimensions of NGSS
Disciplinary core idea: **4-LS1-1: Structure and Function** • Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction (4-LS1-1) **MS-LS1-5 Growth and Development of Organisms** • Genetic factors as well as local conditions affect the growth of the adult plant	Students draw and label the parts of a tree/shrub (system drawing) and then describe the function of the parts of the tree/shrub. Students draw and label a twig and learn the structure and functions of the parts of a twig. Students examine and compare twig growth to understand both genetic factors (different trees grow differently) and local conditions.

<table>
<tr><th>Dimension from the Framework</th><th>Connections to the 3 Dimensions of NGSS</th></tr>
<tr><td>Crosscutting concepts:
• Patterns
• Systems and system models
• Structure and function</td><td>Students look at trees/shrubs and twigs as systems with parts that have functions. They observe patterns in the tree/shrubs and on twigs to describe the tree/shrub or twig and compare growth of twigs.</td></tr>
<tr><td>Science and engineering practice:
• Asking questions
• Planning and carrying out investigations
• Analyzing and interpreting data
• Constructing explanations
• Engaging in argument from evidence
• Engaging in Argument from Evidence
• Obtaining, evaluating, and communicating information</td><td>• Students plan and carry out an investigation to answer the questions about trees and then twigs.
• Students analyze and interpret their data.
• Students use the Claim, Evidence, Reasoning framework to construct an evidence-based argument to answer their questions on trees/shrubs and twigs.
• Students use their evaluation to communicate their findings to others.</td></tr>
<tr><th>Common Core State Standards</th><th>Connections to Common Core State Standards (CCSS)</th></tr>
<tr><td>Common Core ELA Connections</td><td>• 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.
• Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
• Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.</td></tr>
<tr><td>Common Core Math Connections</td><td>• Measurement including solving problems.
• Represent and interpret data-Display numerical data in plots on a number line, including dot plots, histograms, and box plots.
• Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.</td></tr>
</table>

Background

The more time students have in the natural environment to observe, the greater their ability to ask questions. Outdoor journaling or yearlong observations are helpful in increasing the effectiveness of these lessons: good questioning comes from good observation. For students to become inquirers and ask questions about the world around them, they must have multiple opportunities to observe their environment and learn to trust their own observations. Building investigations from students' questions typically involves observing a large system and then gradually narrowing the student's focus to one part of their environment by asking a researchable investigation question.

Each year we observe deciduous trees as their leaves turn color in autumn and fall to the ground, and new leaves burst forth again in the spring. During the growing season of spring and summer, twigs grow on trees from their tips and produce buds that have the beginnings of new leaves, stems, and sometimes flowers tightly contained in a water proof casing. By observing deciduous trees in winter, last year's growth can be measured from the twig tip to the last ring on the twig called a bud scale scar.

Lesson 1: Descriptive Field Investigation: Trees/Shrubs

What Does This Tree/Shrub Look Like?
What are the Physical Characteristics of this Tree/Shrub?

ENGAGE

1. Students write what they already know about trees/shrubs and draw and label a tree/shrub from memory. See student pages.

EXPLORE

1. Ask the question: What are the parts of the ___________ tree? Or ask: What are the physical characteristics of the ______________tree?
2. Students record the date, time, place, air temperature, and weather.
3. Students go outside to draw and label the parts of a deciduous tree in fall or winter. Measuring the tree and its parts helps students make drawings to scale.
4. Students write down questions they have about the tree.

Examples of Descriptive Questions about Trees and Shrub

EXPLAIN

- When does this tree lose its leaves?
- How long does it take for the tree to lose all of its leaves?
- When do the leaves turn color in the fall?
- What color do the leaves turn in the fall?
- What are the physical characteristics of this tree? (e.g., height, crown spread, shape of tree, shape of leaves, size of leaves)
- What plants live on this tree?
- What animals use this tree for their habitat?
- What do twigs look like after the leaves have fallen off?
- What do twigs look like each month?
- When do twig buds burst?
- Which buds become flowers and which buds become leaves?
- How old is this tree?
- What colored pigments are in leaves?
- What animals use this tree for their habitat?

- Is each leaf a single color in the fall?
- Do all the leaves turn the same color?
- What do twigs look like after the leaves have fallen off?
- What do twigs look like each month?
- When do twig buds burst?
- Which buds become flowers and which buds become leaves?

1. Have students compare their drawings from memory to their drawing from observations.
2. Students share with a partner their descriptions and drawings of their tree adding any details they may have missed.
3. Students share the parts of the tree they labeled with their partner, labelling any parts they missed.
4. Partners identify the function of each of the parts of the tree they labeled.
5. Students share and categorize their questions by type.

Type of Question	Examples
Book/Internet Research	What is the name of this tree or shrub? How tall does this tree grow? Where does this tree grow?
Essential-Life Pondering, Always Wonder	How do trees alter climate?
Descriptive	What do twigs look like in winter? What plants live on this tree? What animals use this tree for their habitat? How does this tree produce seeds?
Comparative	Which type (species of tree) grows the fastest? Are deciduous or broadleaf evergreen leaves stronger?
Correlative	How is fall leaf color related to the number of sunny days in fall? How is hot weather related to disease in pine trees?
Why Questions	Why are there deciduous and evergreen trees?

ELABORATE

1. Have students use identification books/internet/applications (apps) to identify their trees.
2. Have students observe their tree every month or season noting differences.
3. Choose one - several of the students' questions to investigate or research.
4. Have students investigate their tree as habitat looking for evidence of plants and animals as they did in the examples.
5. Ask students to think about the tree as a system and talk about inputs/outputs and changes in the system.
6. Do a lesson on photosynthesis to give background for inputs and outputs.

EVALUATE

1. When evaluating observations, tree drawings and descriptions, look for:
    - Words describing details of color, shape, size, branch angle, texture, smell.
    - Sentences or sentence fragments instead of lists of words.
    - Detailed drawings that fill the notebook page.
    - Labels indicating the parts of the tree (branches, twigs, roots, trunk, etc.).
    - Appropriate use of color.
    - Captions or titles that identify drawings and note the date and place recorded.
2. Evaluate the parts and functions of the parts of the tree/shrub by checking for accuracy of both.

Student Examples of Tree Drawings

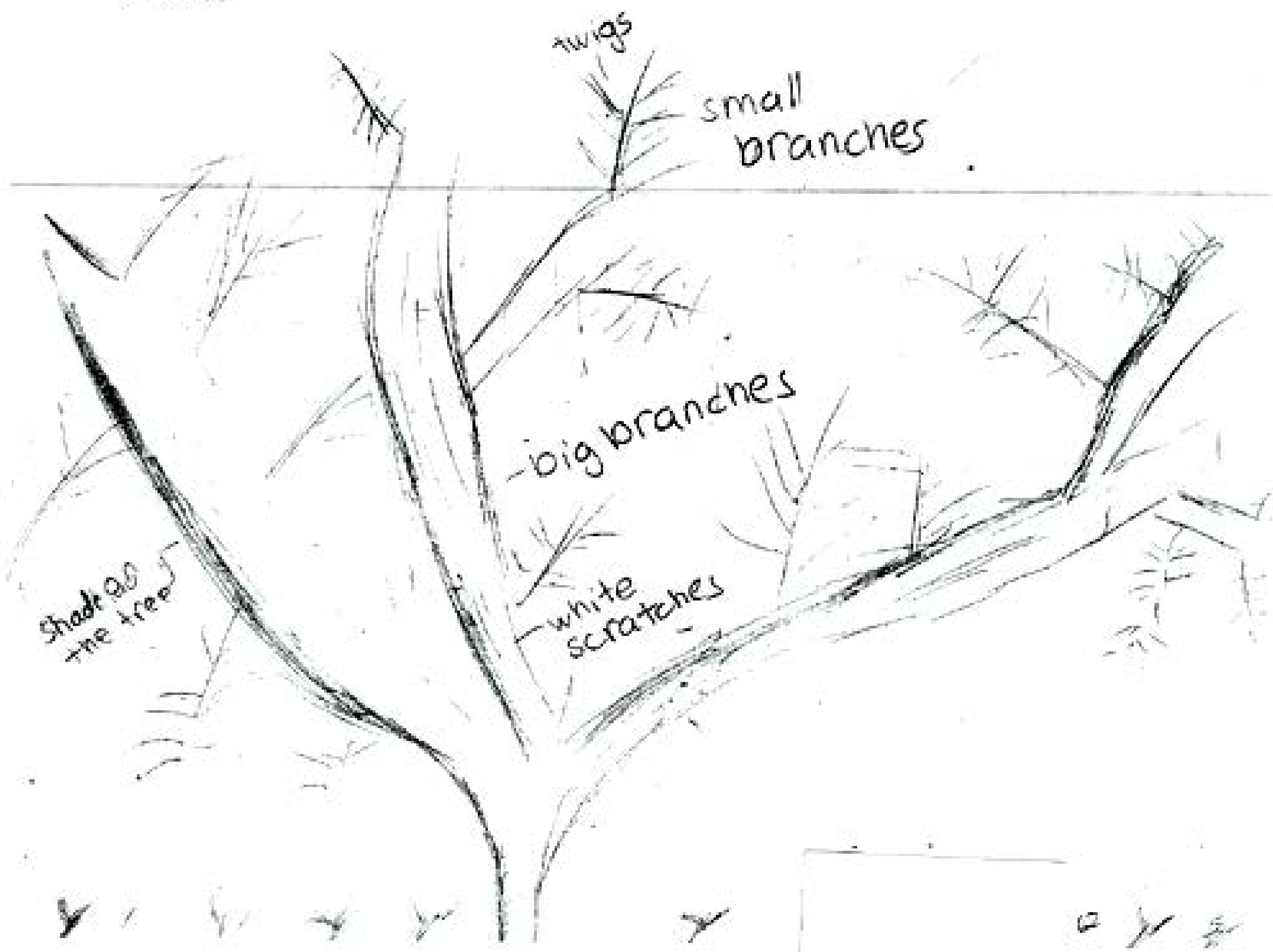
4th grade students at Sunny Hills Elementary in Issaquah, Washington drew trees and recorded their observations. Students were observing how their tree provided habitat for other organisms. The first student uses detailed observational evidence to support her answers to the questions (e.g., "The tree doesn't have leaves yet, but I can see there's little indents where they are going to be."). The second student uses technical vocabulary (e.g. bud, algae, scar, and lenticels) and has realistic detail in her drawing. Her drawing includes more parts of the tree.

Trees as Habitats

Examine a tree-Draw and Label the parts of the tree

1. • What do you find on the tree's trunk?
2. • What do you see in the tree's branches?
3. • What do you see on the tree's leaves?
4. • What evidence do you see or hear that indicates animals use the tree?
5. • What evidence do you see that other plants are using the tree as a habitat?
6. • How might the tree be affected by the plants and animals that live on it?
7. • Do any of the plants and animals you observed seem to benefit the tree? In what ways?

Draw and label one observation that indicates other plants and/or animals use the tree



1. knots on the tree, sharp flat cuts where a branch was cut off, different colors - brown with white marks

2. I see lots of and lots little branches on one big branch, 3 big branches and one branch on each of them and then lots of small branches on those, the smallest branches have little round indents on them

3. The tree doesn't have leaves yet, but I can see there's little indents where they are going to be.

4. I see little white scratches all over the tree that a bird might of pecked at it.

5. No ~~plants~~ are using the tree but there's a lot of little plants on the ground surrounding it.

6. The tree's bark may be affected by maybe a bird that is scraping off the bark.

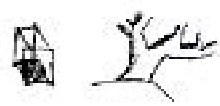
7. The plants at the bottom of the tree may give it more food or water.

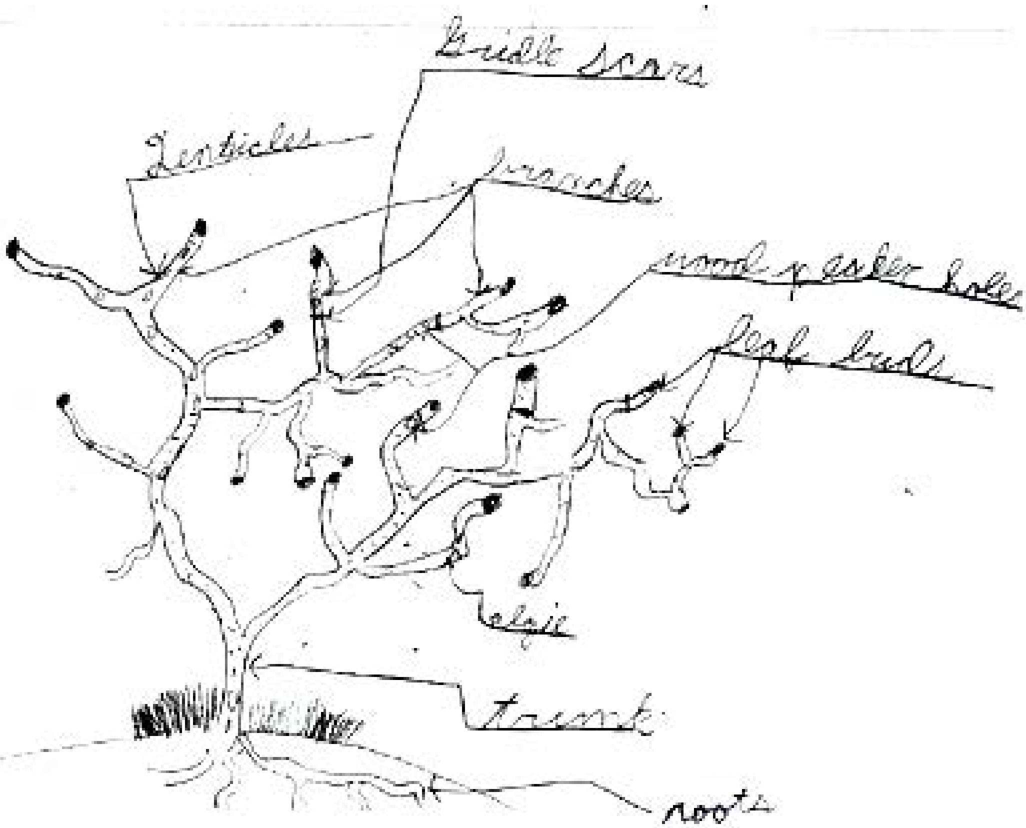
Trees as Habitats

Examine a tree-Draw and Label the parts of the tree

- **What do you find on the tree's trunk?**
- **What do you see in the tree's branches?**
- **What do you see on the tree's leaves?**
- **What evidence do you see or hear that indicates animals use the tree?**
- **What evidence do you see that other plants are using the tree as a habitat?**
- **How might the tree be affected by the plants and animals that live on it?**
- **Do any of the plants and animals you observed seem to benefit the tree? In what ways?**

Draw and label one observation that indicates other plants and/or animals use the tree





Q1. On the tree's trunk I found twigs, moss, and cut off twigs.

Q2. On the tree's branches I found moss, leaf buds, and wood pecker holes.

Q3. The tree does not have leaves yet but it has leaf buds.

Q4. I can see that animals use the tree because their are woodpecker hols and scratches.

Q5. I can tell that plants live on the tree because the tree has moss, and algie on it.

Q6. The tree may be effected by the algie.

Q7. The plants and animals may benifit the tree by giving the tree food, shelter, and water.

Lesson 2: Descriptive Field Investigation: Twigs

What are the Physical Characteristics of Twigs on This Tree in Winter?

ENGAGE

1. In late fall or winter choose one question generated by students (see examples in Lesson 1 in this chapter) that had to do with twigs on a tree. Ask, "Where do new leaves come from?" Have students discuss in groups.
2. Share with students what happens in the spring in terms of weather and sunlight. (See Project Learning Tree Lesson 65, Bursting Buds).

EXPLORE

1. Ask a descriptive investigation question like:
    a. What do twigs on ___________tree look like in winter? (For younger students)
    b. What are the physical characteristics of twigs on __________tree in winter?
2. Students look up a labeled twig diagram in a book and see the parts of a twig in a diagram (see example page 68).
3. Students go outside and observe a twig.
4. Students record date, time, place, air temperature, and weather.
5. Students describe, draw, and label a twig from the tree. Students should include the size, shape, and placement of the buds, leaf scars, and bud scale scars. (Student Page).
6. Measuring from the twig tip to the first bud scale scar, students record last year's growth.
7. Students create questions about the winter twigs using the following observation prompts.
    a. I wonder _____ about tree growth or twig growth
    b. I have questions about…
    c. I wonder what would happen if. . . .
    d. A comparative question I could investigate is…

EXPLAIN

1. Have students read a non-fiction article or video about buds bursting and what influences the time the buds burst.
2. Discuss bud development by asking some of the following questions:
    a. When do buds form on trees?
    b. What are the functions of the parts of the twig?
    c. What do buds become on trees and shrubs?
    d. What did the leaf scars originally connect to?

   e. What factors (inputs) influence when buds burst into leaf or flower?
   f. If temperatures increase (the spring is warmer than average) what might happen to the time (when during the year) twigs burst into leaf?
3. Students share and categorize questions by type.
   a. Book/internet Research
   b. Essential-Life Pondering, Always Wonder
   c. Descriptive
   d. Comparative
   e. Correlative
   f. Why questions?

ELABORATE

1. Students could identify their winter twigs using a winter botany identification guide.
2. Students could teach younger children about twigs.
3. Students could compare and contrast their twig to another group's.
4. Students continue to observe their twigs weekly or monthly recording the changes.
5. When spring is approaching they could begin observing their buds daily and submit when their buds burst to Project BudBurst, www.budburst.org.
6. Students carry out investigations based on the questions they come up with (comparative question described in the next lesson).

EVALUATE

When assessing the journal descriptions and drawings, look for:

1. Words describing details of color, shape of twig and bud, size, leaf scars, bud placement, bud scale scars, texture.
2. Sentences or sentence fragments instead of lists of words.
3. Detailed drawings that fill the notebook page (details include shape of twig and buds, leaf scars, bud placement, and bud scale scars).
4. Labels indicating the parts of the twig (leaf scar, bud, bud scale scars).
5. Appropriate use of color.
6. Captions or titles that identify drawings and note the date and place recorded.

Date__________________________Time__________________________ Name____

What are the physical characteristics of your twig? Weather____

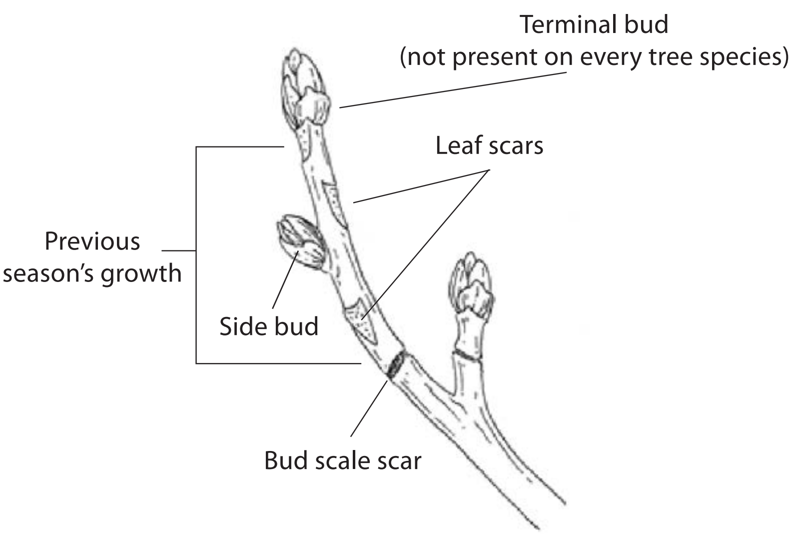
Draw and describe your twig, including the size, shape, and placement of the buds, leaf scars, and bud scale scars.

Questions I have about the twig:

Describe the twig:

Amount of twig growth last year:

TWIG DIAGRAM



Bursting Buds

In early spring, the tiny, bright green leaves of many trees burst forth. Where do the leaves come from? How do they form? In this activity, your students will find the answers to these questions on their own by observing tree buds throughout the year.

Activity
65

Levels
Grades K-6

Subjects
Science, Visual Arts, Math

Concepts
- Populations of organisms exhibit variations in size and structure as a result of their adaptation to their habitats. (4.1)
- While every organism goes through a life cycle of growth, maturity, decline, and death, its role in the ecosystem also changes. (5.3)

Skills
Observing, Ordering and Arranging, Identifying Attributes and Components, Concluding

Technology Connections
Digital/Video Cameras

Materials
Trees (preferably deciduous) with branches low enough for the students to be able to look closely at them, paper and pencils

Time Considerations
Preparation: 20 minutes
Activity: Three to four 30-minute periods spread out over the school year, particularly in the fall and spring.

Note: This activity includes observing a tree or shrub every few months throughout the year. In temperate climates, this observation begins in the fall.

Related Activities
Adopt a Tree, Name That Tree, Looking at Leaves, Tree Lifecycles

OBJECTIVE

- Students will describe the stages that leaf buds go through as the leaves develop throughout the year.

ASSESSMENT OPPORTUNITIES

- Have students assemble their collection of drawings and observations into a notebook. Then, at the end of their notebooks, have them create a pictorial representation or write a description of how buds change into leaves. Possible criteria for assessing the descriptions include:
  - Buds and stems of branches clearly labeled with details such as color, twig shape, leaf scars, bud shape, and bud scales
  - Buds placed accurately on the stem
  - Bud development is represented in the correct order
  - Drawings/descriptions dated or general time of year represented
  - Branch or twig labeled as to what type it is if known
  - Drawings/descriptions are neat with few errors

BACKGROUND

By the time a tree's leaves drop in the fall, its leaves for the next spring are already formed. Tiny leaves, stems, and sometimes even the flowers are located on the twigs in packages called buds. These buds are made of tough scales that form a waterproof case around the miniature tree parts. In spring, as the temperature warms and days become longer, sap rises from the roots to the branches; the scales fall off the buds; and the tree's leaves, stems, and flowers begin to unfurl and grow. During the summer, the tree begins to develop new buds for the following year.

For many animals, tree buds are a concentrated food source. During the winter, animals such as grouse, deer, squirrels, and rabbits feast on buds.

GETTING READY

You will need to find one or more trees that have branches low enough for the students to see them. Shrubs will work also, but the buds will be smaller. If the students have already adopted trees (see Activity 21, "Adopt a Tree"), they can use their adopted trees for this activity, as long as the tree is deciduous and has branches low enough for the students to study. Copy the "Twig Diagram" on the next page onto a large sheet of paper.

DOING THE ACTIVITY

1. In late fall, after trees have lost their leaves, ask them where the new leaves will come from? (buds) When are buds formed? (Usually the previous summer.) Are there buds on the tree? (Yes, if it's the fall.) Encourage students to share their ideas.

2. Take the students outside to look closely at tree branches. Hold a branch so that the students can examine the tree's buds. Have the students point out different features they notice on the branch. (bark pattern, leaf scars, buds, thorns, etc.) Then use your fingernail or pocketknife to split a bud in half lengthwise to reveal the tiny leaves tucked inside. Ask the students to describe what they see.

3. Show students the twig diagram you made in Getting Ready. Go over the diagram, identifying the different parts of the twig.

4. Explain that they are going to observe buds over a long period of time. Have each student choose a live twig to examine. (If students have already adopted trees, you may want to have them use their adopted trees for this activity.) Tell students to take notes about what their twig and its buds look like. Older students should try to identify the different parts of the twig: buds, terminal bud (not every tree has one), leaf scars, and ring of terminal bud scars (bud scale scars). All students should draw a picture of the twig and a close-up of one or more of its buds. You may also have the students mark the twigs with flagging tape or some other marker so that they can return to the same twig each time they make their observations.

5. Have students visit the tree and observe the twig and buds at least once in the winter. They should look for changes in the bud and any signs of animals eating the buds. Have them make notes and draw pictures of what they see.

6. Have students visit their trees again several times in the spring and record their observations during each visit. Students may measure the stem growth on several different twigs.

Enrichment

- In early spring, have the students bring in small twigs. Make cross sections (both length and width) of a few buds on each twig and have students compare the buds of different trees. (Use magnifying glasses if possible.)

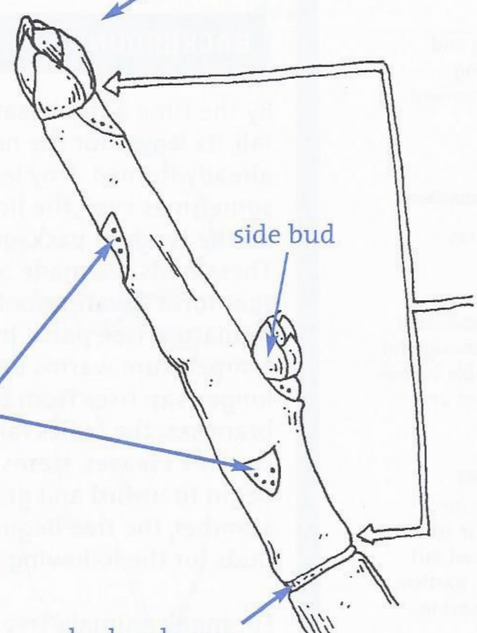
- In early spring, before the buds have opened, bring in some branches of one or more flowering trees, such as apple, dogwood, maple, oak, etc. Place the branches in water and observe them for several days. What happens? Ask students why the buds on these branches open before the buds on the same kinds of trees outside. (You may want to have older students collect small twigs from a tree and design a simple experiment to test their theories.)

- Students can cut one bud off their "observation" tree every one or two months between fall and spring. These buds should be quickly frozen or dried to stop their growth. Buds can be arranged chronologically and mounted on poster board as an exhibit.

Note: For the sake of the tree's health, each student should use a different tree and take buds off different twigs.

- Use a digital camera to record the changes of the bud over time.

Twig Diagram



READING CONNECTIONS

Anthony, Joseph P. and Cris Arbo. *The Dandelion Seed.* Dawn Publications. 1997. A dandelion can teach much about seeds, seasons, cycles, and the big world that a wind-blown seed can travel, but it can also spark appreciation in overcoming challenges. This book is at once simple and profound. Grades PreK-3. ISBN: 188322067X.

Arno, Jon. *Trees.* Discovery Books. 2000. Which tree was used by the ancient Greeks to treat asthma and coughs? Why do leaves turn orange and gold during autumn? Trees, an Explore Your World™ handbook, answers these and other questions in a captivating blend of information and entertainment. Grades 5+. ISBN: 1563318407.

Gibbons, Gail. *The Seasons of Arnold's Apple Tree.* Harcourt Brace & Company. 1991. The story of the seasonal development of an apple tree. The tree provides Arnold and his family with fruit and juice and helps Arnold use his imagination to play. Grades PreK-2. ISBN: 0152712453.

Markle, Sandra. *Outside and Inside Trees.* Simon and Schuster. 1993. Discusses various parts of trees and their functions, including the bark, sapwood tubes, roots, and leaves. Grades K-3. ISBN: 0027623130.

Podendorf, Illa. *Trees.* Children's Press. 1982. Introduces the parts of a tree and their functions, as well as the different kinds of trees and their place in the environment. Grades K-4. ISBN: 0516016571.

COMPARATIVE FIELD INVESTIGATION

from Field Investigations: Using Outdoor Environments to Foster Student Learning of Scientific Practices

Lesson 3: Comparative Field Investigation: Twigs

Is There More Twig Growth on the North or South Side of the Twig/Shrub? Which type of tree/shrub do buds burst earlier in the spring?

Resource: *Winter Twig Investigation lesson in NSTA Press Citizen Science: 15 Lessons That Bring Biology to Life, 6-12.*

ENGAGE

1. Have students look at the list of comparative questions the class created. Students should decide which questions they have the materials and access to address. For example, comparing upper twigs on a tall tree with lower twigs may not be feasible since students could not reach the upper twigs.

Comparative Questions

- Which type of tree will have the largest leaves?
- Which type of tree has the largest buds in March?
- Which type of tree has the most twig growth?
- Are buds larger on the south or north side of the tree?
- Are leaves larger on the south or north side of the tree?
- Is last year's twig growth greater in maple trees on the north or south side of the building?
- Did taller maple trees (over a certain height) or shorter maple trees have more twig growth last year?
- Which year (last year or 2 years ago) had the greatest twig growth on the tree?
- **Was there more twig growth on the north or south side of ___________tree/shrub last year?**
- **Which type of tree/shrub do bud** (Otto, 2013)s **burst earlier in the spring?**

EXPLORE

1. Students choose a comparative question to investigate.
2. Students gather the materials needed for the investigation.
3. Students make a prediction.
4. Students write a procedure of the investigation and create a data sheet including a table. For the two questions above in bold we have created example data sheets.
5. Students carry out the comparative investigation.

EXPLAIN

1. Students analyze data and create charts and graphs.
2. Students discuss in groups the meaning of the data.
3. Students do a non-fiction read on the factors that affect twig growth.
4. Students do a turn and talk about the reading and take notes about what they learned.
5. Students write a conclusion for their data or write a claim, evidence, reasoning.
6. Students participate in or write a discussion for their data.

ELABORATE

1. Students could identify their shrub/tree using a winter botany identification guide.
2. Students could do the same investigation on another type of tree/shrub to see if the north versus south growth differences is species specific or a general pattern of tree/shrub growth.
3. Students could do web research of what types of research scientists are doing on tree growth.
4. Students could view videos or read articles on what affects tree/shrub growth.

EVALUATE

1. Check graphs and tables for accuracy of titles, labels, numbers and units.
2. Use the rubrics for Explanations to evaluate student work.

Fifth grade students from Orchard Center Elementary in West Valley School District, Washington, measuring the previous year's twig growth on trees.

EXAMPLE 1- Investigation Plan and Data Sheet

Comparative Investigation Question: Is there more twig growth on the north or south side of our____________tree/shrub?

Prediction:____

Materials: Compass, ruler, string, scissors or marker

Procedure:

1. Record date, time, and location of tree/shrub.
2. Describe study site.
3. Determine the north and south sides of the tree/shrub.
4. Choose four twigs (each twig is a new trial) at random on the north side of the tree/shrub.
5. Measure the last season's growth with the string on each of the 4 twigs and either cut or mark the string (growth is measured from the tip to the bud scale scar).
6. Measure the string with a ruler to determine centimeters of growth and record as trials 1 through 4.
7. Repeat steps 3-6 for the south side of the tree/shrub

Side of Tree/Shrub vs. Twig Growth

Side of Tree/Shrub	Twig Growth (cm)				
	Trial 1 (twig 1)	Trial 2 (twig 2)	Trial 3 (twig 3)	Trial 4 (twig 4)	Average growth
North Side					
South Side					
Observations					

Sample Data:

Issaquah Valley Elementary, Issaquah, Washington
March 29, 2007, 2:00 p.m.
Cool, sunny day

Question: Is there more twig growth on the north or south side of the spindle bush?

Side of Spindle Bush vs. Twig Growth

Side of Tree/Shrub	Twig Growth (cm)				
	Twig 1	Twig 2	Twig 3	Twig 4	Average growth
North Side	30	32	28	30	30
South Side	21	24	23	20	22

Sample Data:

Orchard Elementary, Spokane, Washington

Question: What effect will the North side or South side of a bush have on the length of growth on a twig from the red dogwood?

	Length of the Twig Growth in Millimeters for the Red Dogwood				
Location of Twig	Trail 1	Trial 2	Trial 3	Trial 4	Average
North Side	36	42	7	39	41
Southside	81	47	74	62	66

EXAMPLE 1- Investigation Plan and Data Sheet

Comparative Investigation Question: Is there more twig growth on the north or south side of our____________tree/shrub?

Prediction:____

Materials: Calendar

Procedure:

1. Start recording observations in late winter.
2. Record the date, time, place, and types of the trees/shrubs.
3. Observe the number of buds that have burst on type 1 tree/shrub and record under the correct date.
4. Observe the number of buds that have burst on type 2 tree/shrub under the correct date.
5. Repeat with two other trees/shrubs of each type at the same time and record the number of buds burst on trial 2 and 3 charts.
6. Repeat steps 2 through 4 daily until the buds have burst on both types of trees/shrubs.

Date_______________________Time_____________________________Place____________________

Description of Study Site:

____

____

____

Location of Study Site:

____

____

____

Data Sheet

Type of Tree/Shrub Date and Number of Buds Burst				
Type of Tree/Shrub				
Date				
Number of buds that have burst on tree 1				
Number of buds that have burst on tree 2				
Number of buds that have burst on tree 3				
Type of Tree/Shrub				
Date				
Number of buds that have burst on tree 1				
Number of buds that have burst on tree 2				
Number of buds that have burst on tree 3				

BIODIVERSITY INVESTIGATION

from Schoolyard Biodiversity Investigation Educator Guide

Section 3
Conducting the Biodiversity Investigation

Teachers can work with students to determine the question or give them the investigation question.

Step 1: Vegetation Survey

During this step, students will look at the vegetation of the school grounds to determine the potential (possible) plant biodiversity.

Discussions and activities related to plant identification can be helpful. While students do not need to know the names of plants, the ability to look at certain characteristics of plants to determine differences can be helpful.

Investigation Process

For student instruction sheets, see Appendix B.

1. Work with students to look at the master map to determine the area or areas of your school grounds they will observe.

   For a descriptive study, the students may divide up the entire school grounds and each team can collect data in different sections.

   For a comparative investigation, the students should choose two sites that they think have the greatest potential biodiversity.

2. Explain the study site (or plot) size and shape for each area to the students. Square plots are recommended, but the size will vary depending upon the school site and the type of study/investigation being conducted. If comparing two sites, the plots should be the same size. Students can measure plots by using paces, pre-measured string or tape measures. To designate each plot, pencils or wooden stakes with ribbon or flagging tape tied to one end can be used to mark each of the 4 corners.

   Note: If you plan to compare the school site to other locations, you may want to keep in mind that 1/10th an acre would be a square plot with 66' sides. While this can be too large an area for students to work with, it can be used to inform an appropriate plot size.

3. Before the students leave the classroom:

   a. Take the students through the data collection process using the Alien Planet Habitat and Key (See Appendix E) while in the classroom. It can be helpful to have students actually fill out a data sheet. To conserve paper, this step can be done in small groups.

   Note: The Vegetation Survey is much easier to complete outdoors when students first practice and understand how to fill out the boxes, etc.

b. Once students are comfortable filling out the data sheets, provide them with fresh/clean copies and have them fill out the basic information at the top of the data sheet, including name, school, date, the investigation question, their prediction/hypothesis (if desired), the site location (where it is on the school grounds), and plot size (if needed).

4. Outside, students can record the current weather by entering the temperature and circling the proper descriptions on the data sheet. If each student team takes a thermometer with them, it should remain in the study area/outside for at least 5 minutes before reading. Determine with the class where the thermometer should be placed – such as on the ground, hung from a tree or held by a student.

5. Students should create their plots as instructed. If surveying the entire school grounds, plots should not overlap and gaps between plots should not exist.

6. Once plots are established, students should document the number of different types of plants and total numbers of plants (estimating the grass coverage within the plot area) on their data sheets using tally marks.

7. Students return to classroom upon completion of data collection.

8. Once in the classroom, students can analyze their data and write their conclusions. For diversity calculations, see Chapter 4.

Step 2: Schoolyard Biodiversity Wildlife Survey

During this step, students will look for wildlife and/or signs of wildlife on the school grounds, typically within the same plots that were established to study plant biodiversity. The variety (different types) and abundance (amount) of wildlife also affect the area's biodiversity.

Before going outside:

* Discussions and activities related to animal identification can be helpful. While students do not need to know the names of animals, the knowledge of field marks or ways to look for animal signs can be helpful.
* Practice using the data collection sheet.
* Work with your students on the proper way to observe wildlife – quietly and calmly. The less they make their presence known, the more likely they are to see live critters!

Investigation Process

For student instruction sheets, see Appendix C.

1. If students have completed a habitat survey, they will return to the same area observed for that survey. (If students are conducting the wildlife survey first, see steps a and b below.)

    a. First, work with students to look at the map to determine the area or areas of the school grounds they will observe. Students may choose two sites that may have the greatest potential biodiversity, one area with a high potential and one with a low potential, or a random site (if every team in the class is observing an area).

    b. Establish the size of the study area. If comparing two sites, they should be the same size. Students can measure plots by using paces, pre-measured string or tape measures. To designate each plot, pencils or wooden stakes with ribbon or flagging tape tied to one end can be used to mark each of the 4 corners.

    Note: If you plan to compare the school site to other locations, you may want to keep in mind that 1/10th an acre would be a square plot with 66’ sides. While this can be too large an area for students to work with, it can be used to inform an appropriate plot size.

2. Before students leave the classroom, they should fill out the basic information at the top of the data sheet, including name, school, site location (where it is on the school grounds), date, and survey beginning time, length of stationary wildlife observation and number of observations the students should conduct.

    Students should also determine the locations(s) where they will make their stationary observation(s), marking the location(s) on the master map, if desired.

3. Once outside, students will QUIETLY and CALMLY walk to their sites, find their stationary observation location and sit down (if the ground is wet, trash bags or student-made sit-upons can be used as seats).

4. Students then record the current weather and temperature. If taking a thermometer out, they should wait at least 5 minutes before reading it. Determine with your class where the thermometer should be placed – such as on the ground or held by a student.

5. While sitting, students conduct the first (or only) observation for the designated length of time. As wildlife observations are made, students record findings on the data sheet.

6. Once the (first) stationary observation is complete, students continue to stay QUIET and CALM while moving to a second location within the site, if needed. As second and/or third stationary observations are conducted, students will continue to add to their data sheets.

7. After stationary observations are completed, students may QUIETLY and CALMLY (remind them that other students may still be conducting stationary observations) move around the site, looking for other animals or signs of animals. Students use the second page of the Schoolyard Biodiversity Wildlife Study data sheet to record their findings (see Student Instruction Sheet for Wildlife Study, Appendix C).

8. Students return to classroom upon completion of data collection.

9. Once in the classroom, students can analyze their data and write their conclusions. For diversity calculations, see Chapter 4.

Appendix B
Student Instructions for Vegetation Survey

Materials

Pre-measured rope or tape measure

"Flagged sticks" (sticks or pencils with flagging tape tied on top) – 4 per plot

Clipboard

Student Instructions for Vegetation Survey (this paper)

Schoolyard Biodiversity Investigation – Vegetation Survey – Data collection sheet

Invasive Plant Identification Cards

Instructions

INSIDE:

1. Work with your teacher and classmates to look at the campus map and decide where your team's plot will be located.
2. After learning how to fill out the Schoolyard Biodiversity Investigation – Vegetation Survey data collection sheet, collect the other materials listed above from your teacher.
3. Calmly and quietly walk outside with your class.

OUTSIDE:

4. Locate the area for your plot. Place one flagged stick in the ground, flagged end up.
5. Stretch out the pre-measured rope or tape measure (using the designated plot size) from the stick. Place another flagged stick in the ground at the other end of the rope. *PAY ATTENTION – be sure you are marking off the proper area.
6. Continue using the rope and sticks to measure off a box shape. This is your plot study area.
7. Now search the area for grass. Be sure to tally the Different Species of grass, if you find more than one, and estimate the percentage of the plot covered by grass. (It can help to think of the area as a grid divided into 4 smaller squares and each square is 25%.)
8. After writing down grasses, look for flowers. Are there any invasive flowers? If so, mark each type in the Tally of Different Species column and tally the total number of all invasive flowers in the Tally of All Plants Found section.

9. Now do the same for native and non-native flowers.

10. Repeat steps 8 and 9 for Thick Ground Cover, Thick Brush and Bushes, Loosely Spread Out Shrubs or Bushes, Trees, and Fungus, Mosses or Lichens.

    BE SURE to tally different species as well as the total number of all plants found for each plant section.

11. Let your teacher know when you are finished.

Biodiversity Investigation – Vegetation Survey

Name ______________________________ **School:**______________________________ **Date** __________

Site Location_____________________________ **Transect #**_______ **Length**__________________

Current Weather **Circle all that apply:**

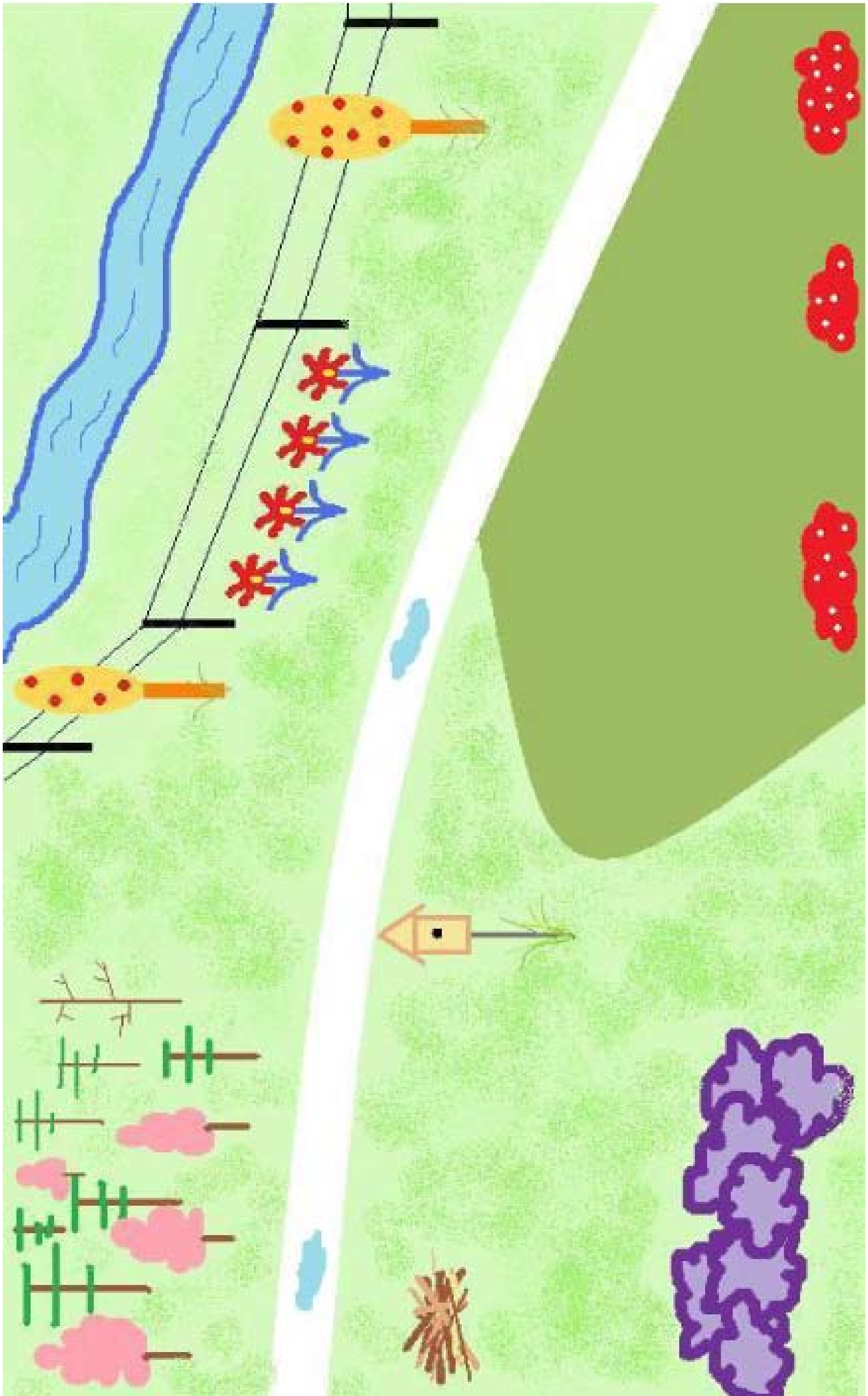
Temperature_________ °F or °C

Clear
Scattered Clouds
Complete Cloud Cover
Rain

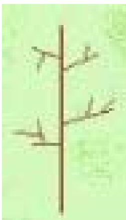
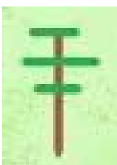
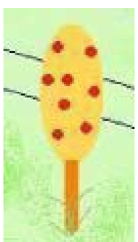
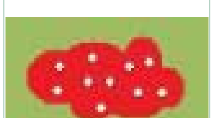
Wind: calm breezy gusty

Item/Type and Description		TALLY of DIFFERENT SPECIES of Plants	TALLY of ALL Plants Found (or Percentage of Area Covered or Estimated #)
		***If none, X through and skip to the next Item/Type.**	
Grass	Mowed lawn/grass		
	Meadow or tall grass (not mowed)		
Flowers (growing individually, annuals or perennials, not bushes or trees)			
Ground Cover (outer edges less than 12 inches apart and less than 12 inches tall)			
Bushes or Shrubs (more than 12 inches tall, but typically less than 15 feet tall)			
Trees (mature trees more than 15 feet tall)			
Fungus, Mosses or Lichens (can be found growing on trees, logs or the ground)			
TOTALS (Numbers)			

Insert your school grounds map here!



Schoolyard Habitat Key

Object	Brief Description	Object	Brief Description
	**Non-Native, Invasive Tree** Such as Japanese Bush Honeysuckle		**Non-Native, Mowed Grass**
	**Non-Native, Ornamental Tree** Such as Ornamental Pear		**Native Grasses – Not Mowed**
	**Native Coniferous Tree** Trees native to Kansas		**Creek**
	**Native Deciduous Tree** Trees native to Kansas		**Puddle**
	**Non-Native Bush** Bushes not native to Kansas		**Brush Pile**
	**Native Bush** Bushes native to Kansas, may provide food for wildlife		**Sidewalk**
	**Beneficial Wildlife Plants** Flowers, herbs, provide food for pollinators and other wildlife		**Fence**
	**Nest Box**	**Add your own key here**	

Appendix C
Student Instructions for Wildlife Survey

* Remember: If you want to see and hear wildlife, BE STILL AND QUIET!

1. Once you are outside, QUIETLY and CALMLY walk to your Stationary Observation location and sit down.
2. Record the current weather. If necessary, wait 5 minutes before recording the temperature. (Remember to place the thermometer where your class determined.)
3. While sitting, set your timer for the Stationary Observation time. Start the timer and begin making observations, recording your findings on the front page of your Schoolyard Biodiversity Wildlife Survey data sheet.

Every time you see or hear a species of animal:

ON SITE (within the boundaries of the plot):

- If it is the first time you have seen or heard this animal, place a tally mark in the column labeled TOTAL Number of DIFFERENT SPECIES of Animals ON SITE.
- Then place a tally in the correct ON SITE column under the TOTAL Number of ALL Animals for that first animal seen or heard.

OFF SITE (outside the boundaries of the plot):

- DO NOT place a tally in the left-hand column labeled TOTAL Number of DIFFERENT SPECIES of Animals ON SITE.
- DO Place a tally in the correct OFF SITE column under the TOTAL Number of ALL Animals for that animal seen or heard.

* HANGING OUT: An animal is considered hanging out if it is sitting, standing or crawling/slithering/running but generally staying in an area.

* PASSING THROUGH: An animal is considered passing through if it is flying over or moving so far away it disappears into the distance.

4. Once your (first) stationary observation is complete, stay QUIET and CALM and complete the total number of stationary observations listed on your sheet.

5. You may now walk QUIETLY and CALMLY around the site, looking for other animals or signs of animals. Be sure to describe your findings with enough detail that you will be able to write about them later.

   * REMEMBER: Other students may still be conducting stationary observations. DO NOT DISTURB other groups.

   * Don't just look down at the ground. Look up in the trees, behind bushes and even under rocks. Just remember – you're messing with somebody's home!

   * ALWAYS be gentle and put things back the way you found them.

     DO NOT completely lift large rocks. You may roll them up and look below IF it is OK with your teacher. When placing a rock back down and there are insects or other animals in its space, put a small rock towards the edge of the space and lower the larger rock down on it gently. This will ensure animals have room to move and not get squished!

   * Accurately record where you find evidence of wildlife (on or off site) by placing a tally mark in the proper column each time you find something different. For example:

     - An on-going trail of the same-sized animal tracks = one tally mark

     - More than one cluster of animal tracks or trails of animal tracks of different sizes = more than one tally mark (each cluster or different size of track = one tally mark)

     - The remains of an animal (including bones); a cluster of feathers or tuft of fur; or something similar = one tally mark each

     - A clump of scat = one tally mark

     - If you find something that is not on the data table, such scratches on trees or a deer rut, thoroughly describe it in the Other section.

6. Once you have completed the wildlife survey, return to your classroom.

Schoolyard Biodiversity Wildlife Survey

Student Name ____________________________ **Date** ________________

Name of School __________________________________ **Site Location** _____________________________

Question____

____

Hypothesis____

____

Survey Timing Beginning Time_____________**am/pm** **Ending Time**___**am/pm**

Stationary Observation(s)________________**min.** **Number of Times to Sit/Observe**___________

Current Weather **Circle all that apply:**

Temperature____________________

Clear

Scattered Clouds

Complete Cloud Cover

Rain

Wind: calm breezy gusty

Wildlife Seen or Heard	TOTAL Number of DIFFERENT SPECIES of Animals ON SITE	TOTAL Number of ALL Animals Seen or Heard: On SITE		TOTAL Number of ALL Animals Seen or Heard: Off SITE	
		Hanging Out	Passing Through	Hanging Out	Passing Through
Birds					
Mammals					
Reptiles or Amphibians					
Insects or Spiders					

Schoolyard Biodiversity Wildlife Survey – Continued

Evidence of Wildlife	Description (What does it look like? Where exactly was it found? Other observations…)	Total Number	
		Found On Site	Seen Off Site
Scat			
Tracks			
Feathers			
Fur			
Nests			
Chewed Food			
Other (bones, scratches, ruts, etc.)			

CALCULATING A BIODIVERSITY INDEX

from Schoolyard Biodiversity Investigation Educator Guide

Section 4: Calculating Biodiversity

Calculating a Biodiversity Index: A Simplified Model for Schoolyard Studies

From Kathy Paris (http://www.accessexcellence.com/AE/ATG/data/released/0534-KathyParis/index.php)

Modified from original activity by Erica Baker

Background:

Biodiversity is a broad term used to describe the diversity of genes, species and ecosystems in a region (Enger & Smith, 2010). Genetic Diversity describes the number of different kinds of genes present in a population or a species. Species Diversity is a measure of the number of species present in an area. Ecosystem diversity is the measure of the number of kinds of ecosystems present in an area. Scientists use a variety of tools and methods to determine biodiversity. While some debate exists as to the most accurate means of calculating biodiversity, the Simpson and Shannon Indexes are the most widely accepted.

The simplified biodiversity index model used for these schoolyard studies enables students to learn how scientists use math to calculate the diversity index of a selected habitat. By comparing calculations, they will observe that the closer the diversity index is to 1, the more likely it is that the habitat is diverse and healthy. The students are then able to analyze their own Schoolyard Biodiversity Investigation data to determine the potential diversity of their schoolyard.

Lesson 1: Introductory Activity

A. Introduce the term Biodiversity Index to the students. Discuss the purpose of placing a numerical value on the biodiversity of an area (to compare with other areas, to determine changes over time, to determine how to manage a site, etc.) If desired, also discuss random sampling and how scientists frequently cannot count every plant or animal in an area. Explain that instead they use various techniques to take samples of data (counting in a certain area) and then average those samples.

B. Explain that the students will practice how to determine the Biodiversity Index for simulated samples before they determine the Biodiversity Indices for their school site.

C. Pass out copies or have the students set up a chart like the one below. Create the same table on the board.

Sample Biodiversity Data Collection Chart

Habitat	TALLY of DIFFERENT SPECIES of Animals	TALLY of EACH SPECIES Found: (SPECIES #:TALLY)	TOTAL Number of ALL Animals Found:	Diversity Index # OF SPECIES/ TOTAL ANIMALS
Example	I I I I (4 different species counted)	Species 1: I I I (3) Species 2: I I I I (4) Species 3: I (1) Species 4: I I I (3)	11	4/11 = .3636
Tropical Rain forests				
Coniferous forests				
Deciduous forests				
Deserts				
Grasslands				
Lawn or wheat fields				

D. Each team of 2 students is then given a bottle (such as a vitamin bottle) full of beads that represents the animals that live in a 1 square meter area of a particular habitat (the sample size/area). The habitat bottles are labeled by habitat name and the bottles are filled with different types of beads representing the different types of animals living within that habitat. The 15 different habitat bottles should be filled as follows:

Habitat Sample Setup

Habitat Type	How Many Different Types/ Colors of Beads* (Species)?	How Many of Each Bead (Species)?	Total Number of All Beads (Animals) in the Bottle	Simplified Biodiversity Index # OF SPECIES/ TOTAL ANIMALS (according to the number of beads)
Bottles 1-4: Tropical Rain Forests	30	2 beads each for 15 different species, 1 bead each for 3 different species	33	30/33 = .91
Bottles 5-6: Coniferous Forests	12	2 beads each for 6 different species, 1 bead each for 4 different species	16	12/16 = .75
Bottles 7-8: Deciduous Forests	12	2 beads each for 6 different species, 1 bead each for 4 different species	16	12/16 = .75
Bottles 9-10: Deserts	5	3 beads each for the 5 different species	15	5/15 = 0.333
Bottles 11-12: Grasslands	5	3 beads each for the 5 different species	15	5/15 = 0.333
Bottles 14-15: Lawn or Wheat Fields	2	100 beads for 1 species and 5 beads for the other species	105	2/105 = 0.019
*Any type of small object will work: beads, beans, coins, etc.				

E. Students then predict the biodiversity of their "sample" based on the habitat name and their background knowledge of that particular habitat.

   Note: The highest diversity in this activity is .91. It may actually be higher or lower in nature.

F. Then students remove the beads from the bottle, one at a time, and record their data on the table. The beads should be set aside once they are counted.

G. Once all beads are counted, students can calculate the biodiversity index for the habitat. (The highest diversity will be the tropical rain forests and the lowest diversity will be the lawn or wheat fields.)

   The Simplified Diversity Index is a decimal number between 0 and 1. The closer the diversity index is to 1 then the more the habitat is diverse and healthy (WDNR, 2005).

      Diversity Index value of 0 indicates no diversity

      Diversity Index value of 1 indicates high diversity

      Diversity Index value of 0.5 indicates area is relatively diverse

      Diversity Index of a healthy forest would typically range around 0.7- 0.8

      Diversity Index of an agricultural field would typically range from 0.02 or less

H. If desired, have students switch/rotate bottles, so that they have opportunities to practice calculating the biodiversity index for a variety of habitats. Either way, post the student findings in the chart on the board.

I. Share and discuss results.

   a) How might scientists use this data to make decisions?

   b) What if a site has 10 trees, but they are 10 different species? Technically your biodiversity is 1…is this really a biodiverse site? Why or why not?

   c) Discuss richness and evenness:

      - Species Richness: the number of **different species** in an area.
      - Species Evenness: the number of **individuals of each species**.

Lesson 2: Analyzing Student Schoolyard Data to Measure Diversity

In the Schoolyard Investigation, students are examining Species Diversity which is the measure of the number of different species in an area. The Diversity Index for Species Diversity reflects both species richness and species evenness.

Evaluate the Data

A. Revisit the Schoolyard Biodiversity Surveys.

B. Discuss the data collected for vegetation and/or student observations of wildlife.

C. Look at the difference between the two data tables. Explain that the Vegetation Survey has specific numerical data that can be used "as-is" to determine the Diversity Index of the school campus, while the Wildlife Survey is more general. In order to calculate a Diversity Index, specific data must be collected.

D. Determine if students will calculate a Diversity Index for the Vegetation, Animals or both. If they will be determining a Diversity Index for Animals, continue with the next steps. If not, skip to ***Calculate the Simplified Diversity Index*** (page 14)**.**

D. Pass out the ***Wildlife Biodiversity Index Data Collection Document*** (Appendix D)**.**

E. Discuss data collection protocols and procedures:

- Students will again go outside to make observations of wildlife, but this time they will be more specific in the data they collect.
- Students will only count and tally the animals found/observed ON SITE (and/or in their sample area).
- Students will tally the total number of different species, the total number of each species and the total number of all species found/observed for each group of animals. (see *SAMPLE Wildlife Biodiversity Index Data Collection Document)*
- Diversity will be calculated back in the classroom after observations are completed.

Note: To calculate a Diversity Index for the schoolyard, students must make intentional observations about the animals on the school site. While they do not need to know the name of every animal, they must first have some training on identification so that they are at least able to distinguish one species of animal from another (how to look at colors, patterns and structures). See ***Fostering Outdoor Observation Skills*** by the Pacific Education Institute for more information on building student observation skills.

F. Take students outside and allow them time to complete their diversity data collection.

SAMPLE Wildlife Biodiversity Index Data Collection Document

Animal Group	TOTAL Number of DIFFERENT SPECIES of Animals (Species Richness)	TOTAL Number of EACH SPECIES Found (Species Evenness)	TOTAL Number of ALL Animals Found:	Simplified Diversity Index
Birds	~~IIII~~ III	Species 1: I Species 2: I Species 3: I Species 4: I Species 5: I Species 6: I Species 7: I I Species 8: I I	10	8/10 = 0.8
Mammals	I	Species 1: I	1	1/1 = 1
Reptiles & Amphibians	I I	Species 1 (reptiles): ~~III~~ I Species 2 (amphs): ~~III~~ I	12	2/12 = 0.16
Insects & Spiders	I I I	Species 1 (ants): ~~III~~ ~~III~~ ~~I~~ ~~II~~ ~~III~~ Species 2 (spider): I I Species 3 (spider): I I I	25	3/25 = 0.12
Total Wildlife in Schoolyard	14		48	14/48 = .29

Calculate the Simplified Diversity Indices

Students can calculate the Simplified Diversity Index for each species category and for the total species in the habitat, using the following equation:

Simplified Diversity Index = $\dfrac{\text{TOTAL Number of DIFFERENT SPECIES}}{\text{TOTAL Number of ALL PLANTS OR ANIMALS FOUND}}$

Analyze the Simplified Diversity Index – What does it all mean?

This Simplified Diversity Index measures how diverse each animal group is in their schoolyard. The closer the number is to 1, typically the more diverse the group of animals. A lower value for the Simplified Diversity Index may be due to the fact that there is a large number of the same species (a high species evenness). A higher value for the Simplified Diversity Index may be due to many different species, with only a few of each of the species present (a high species richness).

a. **Species Richness:** Count the Number of DIFFERENT SPECIES (specify plants or animals) in an area of the schoolyard

b. **Species Evenness:** Count the Number of ALL SPECIES (specify plants or animals) in the same area

Animals seek food and shelter in areas where there is adequate habitat, which includes the type and variety of plants and their arrangement in an area. Frequently, the types of plants on a school campus are affected not only by the types of activities that take place on the site, but also on the surrounding habitats and how the landscaping on the site is managed. Therefore, students may discover a correlation between their campus plant diversity and the animal biodiversity.

When students analyze their data, they can also compare their diversity index to the sample chart for habitats. Their Schoolyard will likely fall between the diversity index of a lawn or wheat fields and grasslands (see ***Habitat Sample Setup***). The sample Total Wildlife Schoolyard Diversity Index in the example above is .29 which falls in the range between lawns and grassland diversity indices.

Discussion Questions

- If we collected vegetation or animal data at a different time of the year, would we get the same Diversity Index calculations? Why or why not?
- An area with lots of weeds might score a high Diversity Index. Does a high Diversity Index always mean a habitat is healthy? Why or why not?
- What are some limitations or problems with random sampling to calculate diversity? (random samples don't cover all areas; students may not have collected data from enough sample areas; some people have more experience indentifying differences in plants and animals, etc.)

When the Numbers Don't Make Sense

Sometimes, anomalies in the data can occur. For example, in the sample wildlife data table, you will find an anomaly in the variety of the number of mammal species in the example. The Diversity Index is 1. However one mammal of one species does not indicate true diversity. While this anomaly does not change the diversity index, when making the calculation for the whole area, scientists use a variety of tools and data to adjust and accommodate for these types of occurrences.

What Affects the Schoolyard Diversity Index?

Random Sampling affects the Diversity Index. A scientist assigned to measure biodiversity of plants or animals in an area would not count every plant or animal in an area. A scientist would take sample counts in the area, using random sampling techniques to minimize the error in an accurate measure of biodiversity. Random sampling is used to study populations of organisms. Scientists will take several samples, using random sampling and average the results.

Student teams will likely have different Simplified Diversity Indices due to:

a. **Random observations**: Student teams observing in the outdoors will see animals often by chance, or their walking/talking movements scare away animals that will not get counted.

b. **Inaccurate Observations**: Students will possibly tally incorrectly or not recognize the variety of species.

c. **Different areas or habitats visited**: The student teams visited different areas that included different habitats with a different species presence.

Improving the Accuracy of the Simplified Diversity Index

a. **Student teams sample same area:** Student teams sampling the same area may not have the same diversity index. However the results of each team can be averaged to create an average diversity schoolyard Simplified Diversity Index

b. **Using signs of animal presence**: Students can include in their diversity index signs of animal presence if they can determine that the sign (e.g. scat or fur) does not belong to one of the animals they have already observed.

Extensions

When students calculate the Simplified Diversity Index, they will have a decimal number between 0 and 1, which does not mean much on its own. However, this type of index allows scientists to compare diversity between areas or in the same area over time. In the same way students can compare the diversity of two areas (to places on the school campus, the school campus compared to a nearby site, etc.) by taking the following steps:

Step 1: Conduct a biodiversity investigation (descriptive field investigation) to determine what species are be observed in the area and calculate the diversity index. The diversity index calculated from the survey results can then be used in a comparison with survey results from another area.

Step 2: Survey another area, or the same area at another time, and calculate the diversity index using the survey results. Compare the diversity index between the original survey results and the second survey results, to determine relative biodiversity (a comparative field investigation).

Appendix D: Wildlife Biodiversity Index Data Collection Document

Wildlife Biodiversity Index Data Collection Document

Student Name ____________________________ **Date** ________________

Name of School _________________________________ **Site Location** _____________________________

Survey Timing Beginning Time_____________**am/pm** **Ending Time**___**am/pm**

Stationary Observation(s)________________**min.** **Number of Times to Sit/Observe**___________

Current Weather **Circle all that apply:**

Temperature____________________

Clear

Scattered Clouds

Complete Cloud Cover

Rain

Wind: calm breezy gusty

Animal Group	TOTAL Number of DIFFERENT SPECIES of Animals (Species Richness)	TOTAL Number of EACH SPECIES Found (Species Evenness)	TOTAL Number of ALL Animals Found	Simplified Diversity Index
Birds				
Mammals				
Reptiles & Amphibians				
Insects & Spiders				
Total Wildlife in Schoolyard				

IDENTIFYING PATTERNS AND RELATIONSHIPS USING BIODIVERSITY INDEX DATA

from Field Investigations: Using Outdoor Environments for Foster Student Learning of Scientific Practices

Chapter 4

Using Data Collected Over Time to Identify Patterns and Relationships

Water Quality and Macroinvertebrate Study

http://www.bgsd.k12.wa.us/hml/macros
http://nwnature.net/macros

Contributed by Peter Ritson, Ph.D., Science Programs, Washington State University and Michael Clapp, CAM Junior High

Students at CAM Junior High in Battle Ground, Washington, have participated in the Watershed Monitoring Network[5] in Clark County since the fall of 2001. Their field investigations involve collecting physical, chemical, and biological data for the East Fork of the Lewis River at Lewisville Park. Of particular interest to the students and their teacher has been the study of benthic macroinvertebrates found in the stream. Benthic macroinvertebrates are organisms without backbones that inhabit the substrate at the bottom of the stream. Typically, these include the larval forms of many insects that mature and take flight, such as dragonflies, mayflies, and stoneflies. There are other aquatic macroinvertebrates, as well, that spend their entire lives underwater, such as different types of worms, snails and mussels. For classrooms in Washington State, physical conditions and chemical properties data can be stored and shared by posting the results to the state-wide NatureMapping[6] – Water Module online database (***http://www.fish.washington.edu/naturemapping/ water/index.html***).

This section describes one teacher's efforts to integrate an understanding (Kelsey, 2001) of ecological principles through the combined assessment of a stream's physical characteristics, chemical conditions, and aquatic macroinvertebrate populations. While strongly influenced and supported by the testing protocols established by the Watershed Monitoring Network in Clark County, Washington, the teacher also incorporates a unique blend of background materials, testing protocols and classroom activities to prepare and facilitate the class (corporate) and student (individual/small group) investigations. In addition, a number of original resources have been developed to assist the students in the collection of data, the identification of aquatic organisms, and the analysis of student-generated data.

[5]The Watershed Monitoring Network trains students and teachers to monitor water quality and habitat in Clark County streams, lakes, rivers or wetlands. More than 1,000 students, from kindergarteners through high school students, collect water quality and habitat data during the school year.

[6]Washington NatureMapping links natural resource agencies with citizens and schools through biodivesity data collection and analyses.

Students collecting macroinvertebrates

Students sorting macroinvertebrates

What research questions guide the field investigation?

What are the environmental conditions of the East Fork of the Lewis River at Lewisville Park? Is the river ecologically healthy?

Descriptive Questions

What are the physical characteristics of the stream?

What is the surrounding land use?

What are the chemical conditions of the stream (dissolved oxygen, pH, ...)?

How many different types (taxa) of macroinvertebrates are present?

What portion of the macroinvertebrates collected are sensitive, moderately sensitive, or tolerant to pollution?

What are the percentages for the different macroinvertebrate feeding groups (scrapers, shredders, collectors, predators)?

Comparative Questions

How does the macroinvertebrate population change over time (seasonally and annually)?

How do our chemical tests and biological samples compare to the state standards, the Pollution Tolerence Index (PTI)[7] and Oregon Watershed Enhancement Board (OWEB)[8] (macroinvertebrate) protocols, and the River Continuum model[9]?

Correlative Question

How does the macroinvertebrate analysis compare to the physical conditions and chemical test standards for the site?

What is the field investigation design?

The students visit their study site three times a year - once at the end of September, again during November, and a final trip in March. The field excursions involve two classes of 30 students that each have about one hour to conduct various chemical tests (dissolved oxygen, pH, etc.), make observations of the site conditions (weather, land use, etc.), take measurements (or estimates) of stream characteristics (depth, width, temperature, etc.), and collect samples of macroinvertebrates. The class is divided into pre-assigned groups to complete the various tasks and a staff member or a volunteer with the Water Resources Education Center assists each team of students. These responsibilities are rotated each trip so students have a chance to be involved in all of the tasks throughout the year. The last half of each field experience is devoted to sorting, identifying and recording the macroinvertebrates collected at the site. Sub-samples are created of the macroinvertebrates and the students work in pairs to examine the number and types of organisms found. At the end of the experience, all data sheets are collected as students board the bus. Results of the water quality tests are shared and macroinvertebrate counts are tallied during the next classroom session. Subsequent classroom sessions are devoted to analyzing and discussing the results of the data.

[7]The Pollution Tolerance Index (PTI) is a means of measuring stream quality based on indicator organisms and their tolerance levels.

[8]The Oregon Watershed Enhancement Board (OWEB) is a state agency that provides grants to help Oregonians take care of local streams, rivers, wetlands and natural areas.

[9]The River Continuum is a model for classifying and describing flowing water, in addition to the classification of individual sections of waters after the occurrence of indicator organisms.

How is data collected and organized?

Summaries of our water quality tests and macroinvertebrate counts are shown below:

Location: E. Fork of the Lewis R. at Lewisville Park
Date: November 2005 - September 2007
Sample #/ID: CAM Jr. High - 7th gr. Science

	Functional Feeding Group (FFG***)	Nov 2005	Mar 2006	Sep 2006	Nov 2006	Mar 2007	Sep 2007
Mayflies (*Ephemeroptera*)							
ameletid minnow mayfly*	collector-gatherer	2	3	2	4	77	2
small minnow mayfly	collector-gatherer	50	98	27	23	58	48
flatheaded mayfly	scraper	185	277	92	74	78	205
spiny crawler mayfly	collector-gatherer	13	22	23	16	73	23
pronggilled mayfly	collector-gatherer	1	1	6	20	21	8
Stoneflies (*Plecoptera*)							
golden stonefly	predator	5	7	12	10	21	16
yellow stonefly	predator	20	11	16	10	8	6
little green stonefly*	predator	7	15	1	9	5	1
little brown stonefly*	shredder	2	5	2	5	6	0
slender winter stonefly*	shredder	0	0	1	4	1	1
giant stonefly*	shredder	1	0	1	0	0	0
rolled-winged stonefly	shredder	0	1	1	0	0	0
Caddisflies (*Tricoptera*)							
northern case-maker caddisfly	shredder	2	32	21	29	79	10
saddle case-maker caddisfly*	scraper	3	2	2	5	0	2
net-spinner caddisfly	collector-filterer	9	5	48	5	3	21
free-living caddisfly*	predator	1	1	8	1	3	0
finger-net caddisfly*	collector-filterer	1	0	5	3	3	3
lepidostomatid/humpless	shredder	4	0	1	27	2	2
Dobsonfly and Alderfly (*Megaloptera*)							
dobsonfly/hellgrammite*	predator	0	0	0	0	0	0
alderfly*	predator	0	0	0	0	0	0
Dragonflies & Damselflies (*Odonata*)							
dragonfly*	predator	0	0	0	2	0	0
damselfly*	predator	0	0	0	0	0	0

True Bugs (*Hemiptera*)								
	water boatman	collector-gatherer””	0	0	0	1	0	0
	water strider	predator””	0	0	0	2	1	2
Water Beetles (*Coleoptera*)								
	riffle beetle - larva	collector-gatherer	2	1	16	4	3	15
	riffle beetle - adult	collector-gatherer	1	0	22	7	1	29
	predaceous beetle”	predator	0	1	1	0	1	0
	water penny”	scraper	0	0	0	0	0	0
True Flies (*Diptera*)								
	midge	collector/predator	8	162	43	6	63	41
	black fly	collector-filterer	2	5	9	6	13	22
	crane fly	shredder/predator	0	4	5	4	2	7
Other Aquatic Macroinvertebrates								
	flatworm (*Platyhelminthes*)	predator/collector	1	0	7	3	5	12
	aquatic earthworm (*Annelida*)	collector-gatherer	35	13	54	31	13	78
	gilled snail (*Mollusca*) - right-side opening	scraper	1	0	3	2	1	1
	pouch snail (*Mollusca*) - left-side opening”	scraper	0	0	0	0	0	0
	snail (other - coiled shell, ...)	scraper	0	0	0	0	0	0
	clam/mussel (*Mollusca*)	collector-filterer	0	0	0	0	0	0
	water mite (*Arachnida*)	predator/scavenger	13	13	42	22	26	67
	scud (*Crustacea*)”	collector-gatherer	1	0	0	0	0	0
	aquatic sowbug (*Crustacea*)”	collector-gatherer	0	0	0	0	0	0
	crayfish (*Crustacea*)	collector-gatherer	0	0	2	14	4	1
		Total Macros	370	679	473	349	571	623
“show macroinvertebrate to teacher								

“”FFG from: Freshwater Invertebrates (Voshell/McDonald & Woodward)
“””FFG from: Macroinvertebrates of the Pacific Northwest (Jeff Adams/Xerces Society)

Water Quality Tests

Date **Time**	**Nov. 18, 2005** **11:15 AM**	**Mar. 21, 2006** **11:15 AM**	**Sep. 28, 2006** **11:30 Am**	**Nov. 16, 2006** **11:30 AM**	**Mar. 27, 2007** **11:30 AM**	**Sep. 25, 2007** **11:00 AM**
Air Temperature	7° C	10° C	21° C	11° C	5° C	15° C
Rainfall (2 days prior)	None	Light	None	Heavy	Moderate	None
Water Temperature	7.6° C	8° C	12° C	9° C	4° C	8.5° C
	Optimal Levels Hatching salmonids: ~ 9° C; Salmonid: < 12.8° C; Non-salmonid: <17.8° C For a stream or river to be rated Class AA's, temperatures should not exceed 16 degrees centigrade Temperatures which exceed 21° C are not acceptable					
DO (mg/L) Dissolved Oxygen	10	10	9	9	9.8	10
	Optimal Levels for Salmonids: Optimal (Class AA's) Acceptable Poor >9.5 mg/L 7-8 mg/L 3.5-6 mg/L A DO level > 11 mg/L needed for spawning salmonids A DO level < 5 mg/L is stressful to most vertebrates and causes mortality to some invertebrates					
PH **(acid - base)**	7.4	7.5	7.8	7.3	7.5	8.0
	Optimal Levels pH values between 7.0 and 8.0 are optimal for supporting a diverse aquatic ecosystem A pH range between 6.5 and 8.5 is generally suitable (meets Class AA*)					
Phosphate	NA	NA	NA	NA	0	0.1
Turbidity (NTU)	<5	<5	<5	<5	<5	<5
	Turbidity Levels Class AA* = <5 NTU; Class B* = <10 NTU					
Stream Flow (cfs)	~630	~770	~47	~1850	~1600	~38
Fecal Coliform (colonies/100 mL)	NA	NA	NA	NA	60	53
	Fecal Coliform (Bacteria) Levels Class AA* = <50 [drinking water = <1; swimming/full contact = <200; boating/partial contact = <1000]					
PTI	20	16	26	29	26	26
	PTI (Pollution Tolerance Index) Scale using macroinvertebrates Poor = <11 Fair = 11 - 16 Good = 17 – 22 Excellent = >22					
OWEB	26	22	30	28	28	26
	OWEB (Oregon Watershed Enhancement Board) Scale using macroinvertebrates Severe Impairment = <17 Moderate Impairment = 17 - 22 No Impairment = >22					

* Water Quality Standards for Surface Waters of Washington, June 1998
(http://depts.washington.edu/natmap/water/index.html)

An important part of the study has been the collection of macroinvertebrate data. This requires students to sort, identify, and count a number of distinct groups (called “taxa”) of organisms. Sufficient time must be given to train students in recognizing distinctive morphologic features. By magnifying and photographing, we were better able to compare our organisms with descriptions and illustrations found in various guides. This also provides a meaningful opportunity to discuss other important biological concepts with the students, such as invertebrate anatomy, adaptations, and classification. Below are two examples of macroinvertebrates. Can you see any distinctive characteristics?

Figure 1

Figure 2

Make some observations. What is similar and what is different between the two?

Both have six legs (insects). They have antennae, legs are jointed. #1 has two tails while #2 has three. #1 has hairy (gills) armpits while #2 doesn’t. Here is what a field guide would tell you: Figure 1 is a stonefly: thorax divided into three parts; all have two tails; no gills along abdomen. Figure 2 is a mayfly: two segments to thorax; may have two or three tails; gills along abdomen.

The level of classification students can achieve influences the type of analysis possible. Simply looking at the presence or absence of certain “Orders” of macroinvertebrates will enable the use of the Pollution Tolerance Index (PTI). Taking identification to the next level - identifying the respective “Families” of the insects - makes it possible to use other indices, such as OWEB (Oregon Watershed Enhancement Board) Level II and an examination of Functional Feeding Groups (FFG)[10]. Looking at FFGs also permits an enriching discussion of energy roles in the aquatic environment and comparison of student data to the River Continuum model for understanding stream ecology.

[10]Functional feeding groups (FFG) are a classification approach that is based on morpho- behavioral mechanisms of food acquisition rather than taxonomic group.

As part of the process of using these protocols, students are also asked to make predictions about the water quality of their stream site, organize and quantify the field data, and evaluate the results based on existing standards or models.

Much of the preliminary instruction and post-trip analysis described above is teacher directed. That is, the students are assigned specific lessons, some background informational reading, and a series of analysis worksheets. The data set developed, however, is very rich and provides many opportunities for discussion, including student-generated observations and questions.

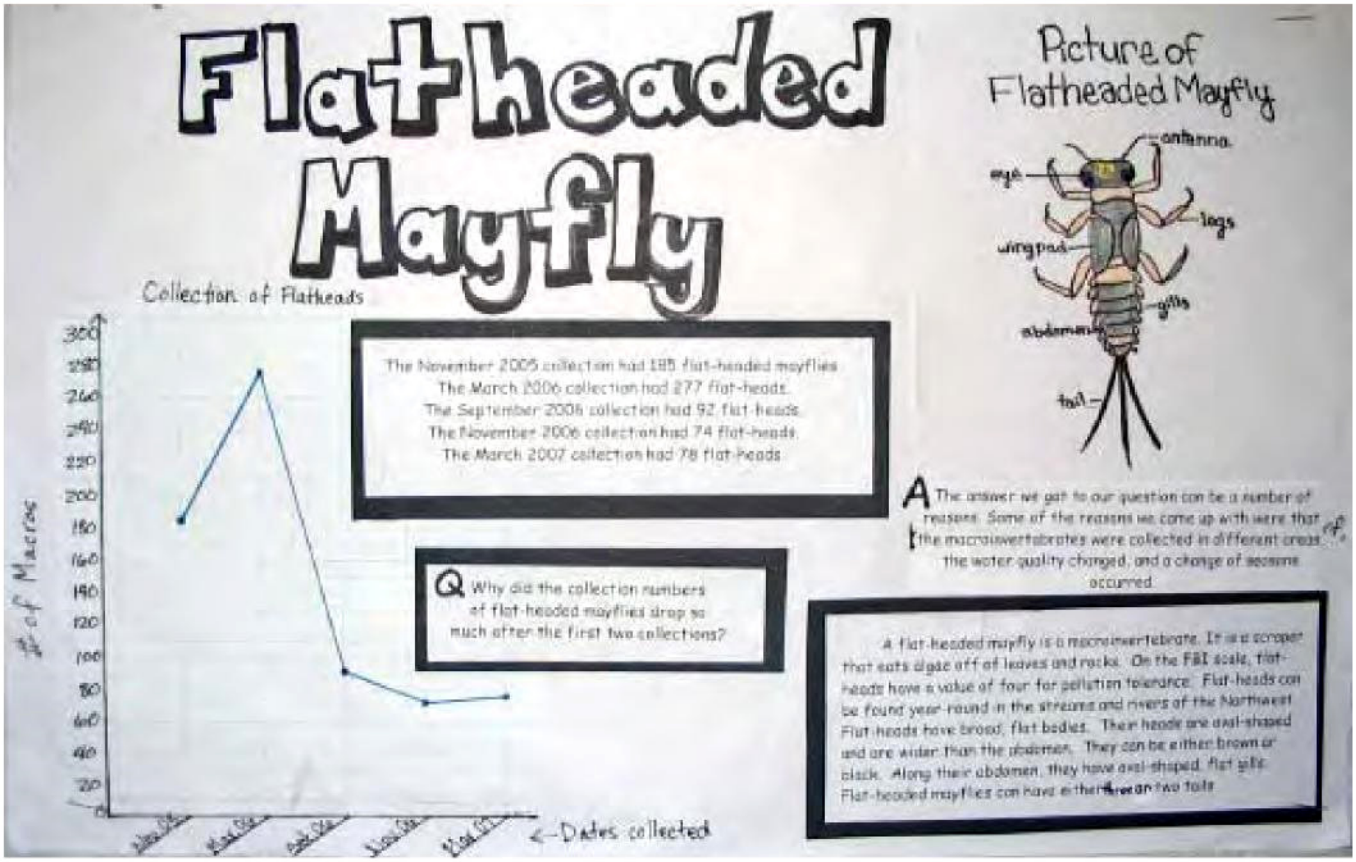
The activity presented below is an example of how students transition from following collection protocols to leading a scientific investigation. They pursue their own, self-selected analysis of the data and communicate their findings in the form of a poster and classroom presentation. In this poster project, students are in charge of exploring, identifying, and describing patterns or trends they identify in the data using graphical and quantitative tools, and preparing a summary analysis of their selected information.

Learning how to pose questions based on observations is an important data analysis skill. Look at the data table of macroinvertebrate counts and ask either a descriptive or comparative question about variations in macroinvertebrates, and then make a graph to answer your question.

Now, let us look at what students do. In preparing their projects, students are asked to:

1. Provide a title and pose a testable question.
2. Use applicable information from the data sets.
3. Create a table, chart or graph relevant to their topic.
4. Provide a written summary of the changes or comparisons observed in the data.
5. Present a reasonable explanation for the results.
6. Provide some background information about their topic and include an illustration.

A sample project created by a 7th grade student is shown below:



This student decided to examine temporal trends in the population of specific mayfly genera. Although not explicitly stated, she considers the comparative question, how does mayfly population vary by month? She has given several possible explanations of the population decrease, including collection area, water quality, and changing seasons. Note the importance of visiting the field site and participation in the data collection in building her explanation, as she notes the field conditions, "the macroinvertebrates were collected in different areas." She remembered that we had to move the collection site off the main channel because the main part of the river was flowing too fast.

Field investigations involving water quality monitoring and benthic macroinvertebrates provide a dynamic and engaging context for developing science concepts and processes with students. The collection and recording of data over time also creates a rich data set that can be used by students to identify patterns (seasonal variations in temperature), changes (from year-to-year in macroinvertebrate populations), and even correlations (seasons and percentages of feeding groups) in water quality parameters and populations of aquatic organisms. Since students have been involved in the process of collecting, analyzing, and adding information to the data set, they have ownership and insight into how the information was generated and some potential reasons for the changes and correlations they might identify.

What advice do you have for a teacher who would like to design and organize a long-term field investigation?

- Keep it simple at the start of a project; build as you go.
- Seek help from local organizations or partner with another teacher.
- Find appropriate resources to support your project and assist your students.
- If you can't find good resources, modify existing ones or try make your own.
- Take lots of pictures.
- Save the results for future groups to build on and compare.
- Share the results with others: Science is about learning and sharing.
- Be prepared to make changes as you go.
- Don't be afraid to make mistakes. Even with thoughtful planning, there's a lot of trial and error in science.
- Doing science takes time; preparing to teach science takes even more time.

EXTENSIONS

from Schoolyard Biodiversity Investigation Educator Guide

Section 5: Biodiversity Investigation Extensions

As students further develop their investigation skills, they can expand their studies to include:

Analyzing at different scales

The Schoolyard Biodiversity Investigation uses the scale of a schoolyard. Students can observe and investigate how the diversity changes if **the space** being studied is extended to:

1. the **perimeter immediately outside the schoolyard** (e.g. 100 feet from perimeter) – where students observe and report the presence of species
2. the **adjoining neighborhood** where the students live

Analyzing for habitat differences

Most animal species are habitat specific, and as you enlarge the search area, the area will likely include more species. The *diversity* of species is dependent on pockets of habitat such as a group of trees, a creek or water feature, a home with a *wild* garden or even a home with a landscaped garden. Students can:

1. Predict and investigate how species counts differ between pockets of habitat in the surrounding area
2. Predict and compare the species counts in the schoolyard with the species counts in a neighboring area.

Analyzing for temporal (time) differences in diversity over the year

How does the diversity change over the seasons of the year? Some animals live permanently in the location you and your students are studying. However there are animal species that will migrate through the area over the seasons. Students can compare the seasons for the types of diversity observed. In spring they will observe species that migrate into the area (e.g. swallows and warblers) and in the fall they may observe species dominated by ducks and geese.

Analyze for diversity types

Students can investigate differences between species observed at a chosen location. For example, they can compare the land bird versus water bird counts at a local park. Additionally, students could investigate the different scientific orders of birds that reside in an area such as raptors, owls, song-birds and ducks.

Analyze for behavior

Evidence of specific animal behaviors, such as feeding or breeding, could also be the subject of student investigations. These investigations could involve data collected that indicates a behavior, such as the presence of a nest indicates an active breeding pair of birds or nibbled plants indicate an animal foraging, or observe and describe specific animal behaviors, such as:

- Birds have landed, perched, singing, feeding, on the ground, flying overhead
- Swallows are foraging, hawks soar overhead looking for food