FIELD INVESTIGATIONS

Using Outdoor Environments to Foster Student Learning and Recreation

Developed for Association of Fish and Wildlife Agencies' North American Conservation Education Strategy

This resource was funded by the U.S. Fish and Wildlife Service's Multistate Grant Program (#F20AP00160), which is jointly managed by the Association of Fish and Wildlife Agencies and the Service's Wildlife and Sport Fish Restoration Program.

WILDLIFE & SPORT FISH RESTORATION

ASSOCIATION of FISH & WILDLIFE AGENCIES

TABLE OF CONTENTS

PREFACE

Welcome! This resource is the next generation of a product that was created by the Association of Fish and Wildlife Agencies in the early 2000's. The Education Working Group of the Education, Outreach, and Diversity committee received a multi-state grant in 2020 to update this resource and several others from the North American Conservation Education Strategy toolkit and make it relevant to educators today.

This resource is an update to the work of generations of wildlife educators from across the country. We honor their work by updating, not replacing, this incredibly useful resource that can be used by conservation educators and classroom teachers across North America. A sincere thank you to everyone who created the original resource as well as DJ Case & Associates who brought this resource into the current era of education.

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ACKNOWLEDGEMENTS

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Heather Hubbard, Colorado Parks and Wildlife
Julie Watson, Nevada Department of Wildlife
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"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."

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 by developing their understanding of science, which does not only happen in a laboratory or classroom. These types of investigations provide students with opportunities to engage in science through a three-dimensional approach by integrating the scientific content with the science and engineering practices and cross cutting concepts.

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.

How to use this guide:

This guide is designed for K-12 teachers. The chapters progress from Novice, to Intermediate, to Advanced Learner. Begin where you need to, based on the needs of your students.

- Section one focuses on fostering outdoor observation and data collection skills as a way to introduce novice learners to the ideas of field investigations and to hone their observational skills.
- Section two, for the intermediate learner, demonstrates two different types of field investigations – descriptive and comparative – as a means to bring the learner deeper into the way scientists' work.
- Section three, for the advanced learners, brings it all together - observation and data collection skills, descriptive and comparative field investigations - in the form of a unit study. The in-depth unit study provided in this section equips teachers with lessons specifically designed to scaffold the students' learning. Progressing through each activity, the learner engages with the area found in or nearby the school site through guided inquiry.

Each lesson begins with objectives and materials needed for activities within that lesson. Each activity in sections one and two is structured using the 5E Instructional Learning Model. Section three is divided into sequential lessons and includes overall objectives and materials at the beginning of each, followed by step-by-step activity instructions.

[1]Schweingruber, H., Keller, T., & Quinn, H. (Eds.). (2012). A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. National Academies Press.

THE 5E INSTRUCTIONAL LEARNING MODEL FOR FIELD INVESTIGATIONS

The 5E Instructional Model provides a format for lessons that builds on what students already know. The 5E's sequence the learning experiences so that the learners construct their understanding of a concept across time. Each phase of the learning sequence can be described using five words that begin with "E": Engage, Explore, Explain, Elaborate, and Evaluate. All lessons in this manual are set up using the 5E model.

Stage of 5E Instructional Model 2 (superscript)	**What students do:**	**What the teacher does:**
Engage: The purpose for the ENGAGE stage is to pique student interest and get them personally involved in the lesson, while pre-assessing prior understanding.	• Students are introduced to the concept • Students make connections to prior knowledge and what is to be studied • Student thinking is clarified. • Students become mentally engaged in the new learning experience.	• The teacher asks questions of students and engages them in the guided inquiry lessons. • They make connections between the past and present learning experience. • The teacher sets a level of anticipation. This could be an introduction to the scientific concepts the investigation involves.
Explore: The purpose for the EXPLORE stage is to get students involved in the topic; providing them with a chance to build their own understanding.	• Students have the opportunity to get directly involved with phenomena and materials. • As they work together in teams or individually, students build a set of common experiences which prompts sharing and communicating. • Students are given time to think, plan, investigate, and organize and analyze collected information. • Emphasis is placed on: Questioning, planning and carrying out investigations, data analysis and critical thinking.	• The teacher acts as a facilitator, providing materials and guiding the students' focus by asking probing questions to clarify understanding of the content and practices. • The teacher may scaffold how students organize and analyze their data.
Explain: The purpose for the EXPLAIN stage is to provide students with an opportunity to communicate what they have learned so far and find out what it means.	• Students verbalize their understandings from the explore phase. • They interpret their data by looking for patterns and cause and effect to describe what they observed and begin to communicate what they have learned. Communication occurs between peers, with the facilitator, and through the reflective process. • Students construct arguments/ explanations supporting them with evidence from their explorations.	• The teacher facilitates by asking probing questions that encourage students to look for patterns or irregularities in their data. • Teachers set up opportunities for students to discuss their understanding with other students to refine their arguments/explanations.

[2]Adapted from: Bybee, R. W., Taylor, J.A.,et.al. (2006). The BSCS 5e Instructional Model: Origins, Effectiveness, and Applications. Colorado Springs, CO.

Stage of 5E Instructional Model 2 (super-script)	**What students do:**	**What the teacher does:**
Elaborate: The purpose for the ELABORATE stage is to allow students to use their new knowledge and continue to explore its implications	• Students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways. This could include further investigations or research into scientific concepts that their investigations highlighted.	• The teacher provides learning opportunities for students to apply their knowledge to the real world context and to gain a deeper understanding of science concepts.
Evaluate: The purpose for the EVALUATION stage is for both students and teachers to determine how much learning and understanding has taken place.	• Students use self –evaluation tools such as rubrics and check lists to self-assess their knowledge and process skills throughout the field investigation process. They use these self-evaluation tools with investigation plans, data collections, and written argument/explanations. • Students answer questions, pose questions, and illustrate their knowledge (understandings) and skill (abilities).	• The teacher diagnoses student understanding through on-going process. Assessment can be either formative (on-going and dynamic) and/ or summative (end of the lesson final test or product). • The teacher uses rubrics, observations, student interviews, portfolios, project and problem-based learning products to evaluate student achievement. Other ways students can demonstrate their understanding is through science notebooks, drawings, models and performance tasks.

NEXT GENERATION SCIENCE STANDARDS AND THE NATIONAL COUNCIL OF SOCIAL STUDIES STANDARDS

Below are the identified standards representative of the Next Generation Science Standards and the National Council of Social Studies Standards (NGSS codes for the Disciplinary Core Ideas can be found in Appendix A). These specifically align with the lessons and activities included in this resource guide. Because of the broad nature of these standards they are easily adapted into classrooms and can easily match to state specific standards. The NGSS standards are provided for the novice learner (grades 3-5, which is the focus of section one), intermediate learner (grades 6-8, the focus of section two), and the advanced learner (grades 9-12, the focus of section three). The NCSSS standards are for grades 3-8 (sections one and two) and high school (section three). Educators can find the specifics about each of the standards listed below in Appendix A.

NGSS Standards Novice:

Grade 3: Interdependent Relationships in Ecosystems; Weather and Climate; Engineering Design
Grade 4: Earth's Systems; Structure, Function, and Information Processing; Engineering Design
Grade 5: Earth's Systems; Matter and Energy in Organisms and Ecosystems; Engineering Design

NCSSS Standards Novice and Intermediate (Grades 3 – Middle School):

People, Places, and Environments; Science Technology and Society

NGSS Standards Intermediate:

Middle School: Earth's Systems; Weather and Climate; Interdependent Relationships in Ecosystems; Natural Selection and Adaptations; Matter and Energy in Organisms and Ecosystems; Human Impact

NGSS Standards Advanced:

High School: Earth's Systems; Biological Evolution: Unity and Diversity; Ecosystems: Interactions, Energy, and Dynamics; Interdependent Relationships in Ecosystems

NCSS Standards Advanced (High School):

People, Places, and Environments; Science Technology and Society

[3]Adler, Susan A; 2010. National Council for the Social Studies.National curriculum standards for social studies : a framework for teaching, learning and assessment. Silver Spring, Md : National Council for the Social Studies. Bulletin (National Council for the Social Studies), 111.

NGSS Lead States. 2014. Next generation science standards: for states, by states. Washington, District of Columbia : National Academies Press

SECTION 1: FOSTERING OUTDOOR OBSERVATION AND DATA COLLECTION SKILLS

In this first section Novice Learners will be introduced to activities aimed at deepening their outdoor observation skills. Observation skills are key to field investigations and require practice and support for novice learners. Many of the activities in this section are drawn from Coyote's Guide to Connecting with Nature and offer practices to deepen natural observation and connection to the natural world. Outdoor observation skills are developed through continued practice. Similar to skills required in reading or writing, students need to continuously practice and apply outdoor observation skills to become proficient at interpreting their environment.

The first set of activities is aimed at establishing core routines for nature study, getting students comfortable in the outdoors as a place for learning. These activities are followed by activities aimed at improving observation skills. Activities like "As big as what?" and "Identification by tracks" help students to really begin paying attention in the outdoor world.

Furthermore, this section also introduces data collection skills, again a necessary skill for more in-depth field investigations. Several data collection activities can be found in the final portion of this chapter. Activities focused on estimation, mapping, and GPS skills will help students to begin asking and answering questions about the world around them.

These activities are set up using the 5E model and lessons begin by providing the stated objectives and materials list for all activities in a given lesson. These lessons can build on one another moving novice learners along the continuum towards greater comfort and skill in their environmental knowledge. Once these skills are honed, advancing into more in-depth field investigations will be a natural next step. These are found in the next chapter.

[4] Young, Jon, Ellen Haas, and Evan McGown. 2010. Coyote's guide to connecting with nature. Shelton, Wash: OWLLink Media.

Lesson 1.1: Establishing Core Routines

Objectives: The Core Routines will help students of all ages get accustomed to observing the outdoors in an attentive way. The establishment of these core routines will help students to become more keen observers of the world around them.

Materials:

- Science notebooks
- Data collection forms (found after Activity 1)
- Flip Chart
- Various collected objects found in nature (such as leaves, twigs, rocks, etc.)
- Grid paper
- Pens and pencils (including colored pencils)
- Pictures taken either from Internet sites or personal photography of various animals and birds (such as the American Robin and porcupines, etc.)

Activity 1: Using a Science Notebook

Pre-Lesson Preparation	Writing in a science notebook involves keeping a regular record of any and all outdoor experiences. This may be done in drawings and/or in words. Create a large wall chart with columns on which students will record their sensory observations. Students will learn the importance of using a science notebook and keeping reliable data, such as the date, time, weather, and location of events. Samples of science notebooks from previous students or field experts can be of benefit. Elicit good habits by asking questions and instructing students to make comprehensive recordings while in the field, including feelings associated with what they see, hear, touch, or smell. Note that this is a building process and will require modeling and practice. Encourage students to look at their environment with a questioning eye. Ask questions such as "I wonder what would happen if…?" and "I wonder if…?" Instruct the students to keep a list of these questions in their science notebooks, as they can lead to further investigations. Convey to the students that the information found in the students' science notebooks will be used to fill out data collection forms at a later time.
Engage	Show an example of a field science notebook and describe the components such a notebook should contain, including a consistent heading for every entry (e.g., date and time, weather conditions, and location) and scientific drawings. Demonstrate the process of recording observations in a science notebook by looking closely at something to sketch, such as a leaf. Focus the students' attention on what they see, rather than on the task of drawing the leaf. Examine part of the edge of the leaf and talk about what it looks like; then draw that part. Have additional nature objects located around the room, and have students practice their drawing using these objects.
Explore	Make sure each student has a pencil and their science notebook. In addition, colored pencils, a ruler, and other tools add to the data collection experience. Having a zippered pencil bag works to hold all of the tools together. Before going outside, have the students begin with a clean page and add the heading information for date, time, weather, and location. Review what the students should record in their science notebooks. Utilizing the sit spot previously established, instruct the students to return to that location. While there, have them choose one or more of the following activities: • Describe the weather; • Try to spot a bird, and if successful, describe in drawings and/or words what the bird is doing; • Write down "who, what, when, where, and why" about a nearby plant; • Draw three plants found near your sit spot and write about them; • Find something that is interesting; draw and label it; • Write about what something looks like close-up; write about what is going on around it; write how you feel about what has been witnessed; and/or • Write three "I wonder" questions. Once the allocated time period has passed, have the students return to the classroom.
Explain	Share with the class what was experienced. Discuss how the data was collected in the science notebook, and how the data may change over time (e.g., seasons, weather events, etc.).

Elaborate	Encourage the students to take one “I wonder” question and investigate it further to find an answer which can be shared with the class.
Evaluate	Ask the students what they learned about observations and the benefits of recording them in science notebooks. Have each student complete an exit ticket containing the following questions: • What did you learn today? • What question still remains? • How will you use what was learned today in future learning experiences?

Data Collection Form								
Observer’s Name				City/County/State				
Date	Time	Temp	Species Name Description	How Observed? (saw, heard, tracks, etc.)	Latitude	Longitude	How many did you see?	Is this an estimate?

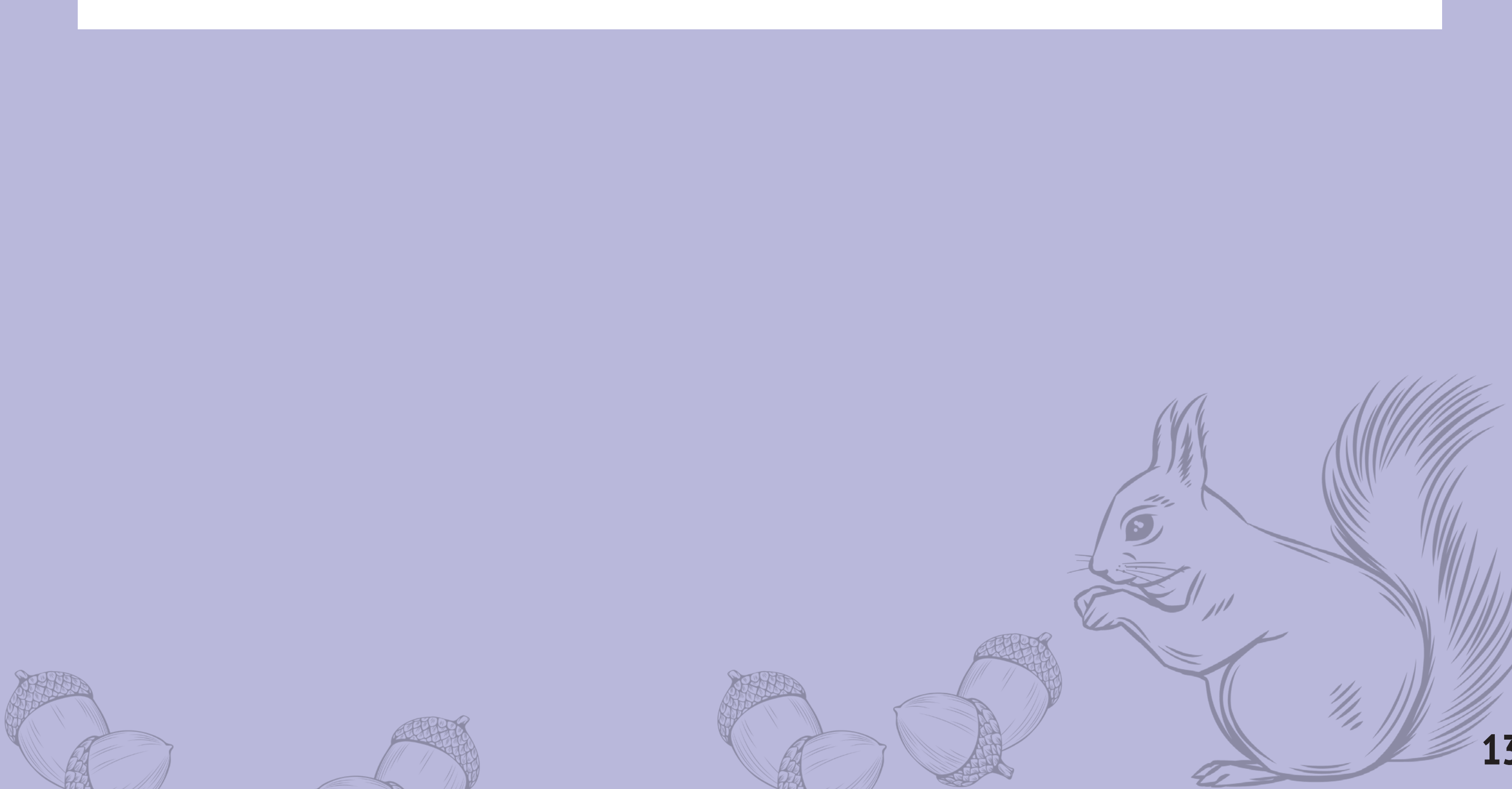
Activity 2: Sit Spots

Pre-Lesson Preparation	A Sit Spot is a site selected by each student where they can sit for 20 minutes (rain, shine, or snow) and make observations. Using pictures and words, the students record in their science notebooks what they see, hear, smell, and feel. The Sit Spot should be located outside (or at a place that has a view of the outside) and be in an area that you can visit regularly. Depending on the age and ability of the students, it may take a lot of practice to make Sit Spots worthwhile. The level of expectation you set and the behavior you model during these experiences will determine your students' success in the field when you are not there to supervise. Once you have identified a suitable area, inform students that they will be going outside to find a Sit Spot on the school grounds. Next, discuss with students this generic list of hazards and the precautions everyone should take. Know your school regulations for taking students on field trips. Examples of hazards might include: • Bees, yellow jackets, and wasps - walk lightly around ground nests and keep your ear tuned for a buzzing sound. • Venomous snakes and spiders - carry a stick and go out early in the day. Be careful where you put your feet and hands, especially in dark places. • Ticks - check each other. Where on your body will they likely be? • Poison ivy and poison oak - look at plants before touching. • Dead-falls from limbs - look up; don't sit under a dead tree branch.
Engage	Spend time in class explaining what a Sit Spot looks like and sounds like. Model the behavior you expect to see during this activity and have students practice. Make sure your expectations are clear to all students and that students know the boundaries of the area where they will sit. To help students select their Sit Spots, plan one or both of the following games: • Eagle-eye - close your eyes and pretend to be an eagle soaring over this area. The eagle needs a place to land that is its own special place. Go find a place to land. • Cat-walking - walk as if you are a cat. Slip along quietly in the shadows on the edge of cover. Walk a few steps and then stand still to sense danger. Turn your eyes and whiskers left, right, behind, and up. Use your "body radar" to feel which way to go next. Walk a few more steps, then again stop, look, listen, and adjust your course. Keep walking with cat-like awareness until the perfect spot attracts you, and you settle in.
Explore	Each student will: • Choose a spot that they find comfortable; • Sit far enough away from other students that they cannot talk to each other; • Sit in the same spot each time they go out; • Be quiet; • Contact the teacher only in an emergency; and • Return quickly and quietly to their starting point when the teacher gives the signal. While in the sit spot, students will record in their science notebook sights, sounds, and smells experienced. The method of recording can include words and/or drawings.
Explain	Return to the classroom once the signal has been given by the teacher. Discuss in class what was experienced. Did several students document the same sighting, sound, or smell? Were there others that did not see, hear, or smell the same things? Discuss why this might have been? Share how the students felt while in their sit spots. Document if this changes over time, possibly as the students become more acquainted with their spot.

Elaborate	Allow the students to research and read about an animal, bird, or plant they experienced while at their Sit Spot. Providing nature guides - books or technology-assisted - will assist students in the identification of what was seen or heard. Students can either share in a report their findings, or in a presentation utilizing technology.
Evaluate	Ask the students what they learned from participating in a Sit Spot today. Have each student complete an exit ticket containing the following questions: • What did you learn today? • What questions arose today? • How will you use what was learned today in future learning experiences?

Activity 3: Story of the Day

Pre-Lesson Preparation	Gather together the materials required of this lesson plan, specifically including flip chart paper and markers. Ensure that each learner has their science notebook and writing utensils prior to beginning.
Engage	Gather students (with their science notebooks in hand) around a flip chart. Make a sketch on the flip chart of the area where the sit spots are located, and include landmarks the students can identify. Take turns sharing things seen or heard, while adding words or symbols to the map. When done, save the map for additional information from future sit spot activities. Use different colors to record information that was gathered on previous days, so that students can begin to see patterns.
Explore	When students are comfortable with the basic sit spot expectations, try a mind's eye experience. This builds students' brain/memory and awareness skills and ensures that students are aware and using their senses while at their sit spot. Send students to their sit spot without their science notebooks. After the allocated time has passed, call the students back into the classroom. Once seated, have the students record their observations during the sit spot activity. In addition, ask the students to draw a sketch from memory.
Explain	Return the class to the sit spot flip chart, and add the information from today's activity. Ask the students if the mind's eye experience helped them see objects differently than previous sit spot experiences. How did it possibly increase their awareness and memory skills?
Elaborate	Have various field guides scattered around the room and accessible to students. Give students 10 minutes to read/scan through a field guide of their choosing. After the allocated time, have the students return their field guides to the original location. Each student will take their science notebook and begin to record what they read/saw in the field guide. In the recordings, encourage students to sketch, measure, draw, color, and label the objects.
Evaluate	Have each student complete an exit ticket containing the following questions: • What did you learn today? • What question still remains? • How will you use what was learned today in future learning experiences?



Lesson 1.2: Improving Observation Skills

Objectives: In these activities students will learn to better observe the world around them. They will begin by acquiring the skills of note-taking and measuring items found in the natural world.

Materials:

- Science Notebooks
- Photos of Owls (found at the end of Activity 1)
- Bird Field Guides or Animal Fact Sheets for Birds and Other Taxonomic Groups
- Track Data Collection Form (found at the end of Activity 2)
- Track Patterns Example Sheets (found at the end of Activity 2)
- Pet Measurement Forms and Instructions (found at the end of Activity 2)
- Rulers and Measuring Tapes
- Grid Paper
- Pens and Pencils

Activity 1: As Big as What?

Pre-Lesson Preparation	Field guides are usually organized in a taxonomic order, which means that similar species are grouped together. For example, sea birds, ducks, gulls, birds of prey, and woodpeckers are grouped together. Likewise, turtles, tortoises, lizards, and snakes are grouped together. Use the indexes of the field guides to find the species that are listed on the List of Common Species found in Urban Areas (or whatever area you are in).
Engage	Begin the exercise by asking, "If you saw an animal, what clues would you use to identify it?" Show the images of a Great-horned owl, a Western screech owl, and an Easter screech owl. All are found at the end of this lesson. Explain that the pictures make it appear that all of the birds are of equal size, so you cannot judge the relative difference in sizes until you look up the measurements for each bird. Because owls hunt at night, their eyes have to be large in order to capture all the available light. The eyes are so big that the eyeballs are literally stuck in their eye sockets. When something moves, an owl will turn its head to focus on the source of the movement. Many think that owls can turn their heads 360 degrees, or all the way around. However, they can only turn about 300 degrees.
Explore	We will now explore owl eyes versus eagle eyes. First, we will consider the owl eyes. Instruct the students to get into two lines facing away from each other. They will then open their arms until they cannot see their fingers. Have the students wiggle their fingers and bring their arms in until they can see the wiggling fingers. At that point, they are to drop their arms to their sides. The teacher will mark the spot where they are standing. At that exact point, have the students remain fixed with no head turning. Each student will name something in front of them, something on the right side of them, and something on the left side of them. The teacher will record the items named. Next, the students will pretend to be an eagle that can see far away. Instruct the students to bend the fingers of both hands and put them together like a set of binoculars. Bring their hands up to their eyes and without turning their head, ask students if they can see the same objects as they could when mimicking the owl. Allow the students to spend time looking at all of the field guides, specifically for eagles and owls. Notice the placement of the eyes and compare/contrast the locations. Notice any other differences and similarities seen between owls and eagles.
Explain	What did you notice differently between owls and eagles?
Elaborate	As students discuss differences between owls and eagles, it is typical that size be mentioned. Have the students think back to the first three images they saw in this lesson of the Great-horned owl, the Western screech owl, and the Eastern screech owl. Using the field guides, read the measurements of each bird. Ask them, "What part of your body is about the same size as these birds?" If they struggle with this question, use your and and arm to show the difference between the Western and Eastern screech owls. The hand is about the size of the screech owls and the arm is about the size of the Great-horned owl. For additional practice, have the students look up a black-capped chickadee and a house sparrow. Encourage the students to find a body part that is about the same size. Finally, have students choose two animals in the field guide by using the index. Once the animals have been selected, they will then locate the size measurements for each and record them into their science notebook. The student will then explain the size of each animal in relation to their body. Drawing the images is encouraged.
Evaluate	Have each student complete an exit ticket containing the following questions: • What did you learn today? • What question still remains? • How will you use what was learned today in future learning experiences?

Great-horned owl

Western screech owl

Eastern screech owl

Activity 2: Identification by Tracks

Pre-Lesson Preparation	People who read animal tracks are called trackers. They "read" the story of what the animal was doing during the day (or night). Students will become trackers as they measure the tracks of the striped skunk. Using the "Track Data Collection" form and the "Pet Measurements" form and instructions, they will measure the length and width of an animal's front and rear paws, its step, and the width of its trail (the width of the body of the animal). Mind's Eye Imagining helps students use evidence drawn from an animal's tracks to estimate the size of the animal and interpret what it was doing.
Engage	Ask, "Where in town or in your neighborhood have you seen an animal's track?". Maybe the track was seen in mud, or snow, or even concrete. A visit or even a discussion of these would lead to inquiry questions and predictions about the origin and story of the tracks. Ask, "Did you know that you can tell from a track which way an animal was looking when it was standing still?" Have the students get down on their hands and knees and look left. What arm are they putting the most pressure on? Would the arm with the most pressure leave a deeper track in the mud or snow than the other arm? Ask, "Do all animals walk the same way?" Discuss how some animals move first the legs on one side of their bodies and then the legs on the other side. This might be how a skunk, bear, or raccoon moves. Others might move opposite legs, such as dogs and cats, and others jump moving their front legs first and then their back legs, such as river otters and rabbits. Pass out the Tracking Data Collection forms and show the class the skunk tracks. Give each student a copy of the life-size skunk tracks and place the skunk tracks where the class can see them. Using the tracks, discuss how skunks walk. Skunks move their front left and rear left legs at the same time. They have short legs, so their steps are not long, unless they are running. Discuss how the size of the animal affects the length of its steps and the space between its front legs (trail width). The wider the animal, the more space between its legs. Note that different animals have different track patterns: Pacer walking pattern, diagonal walking pattern, galloper walking pattern, and bounder walking pattern. Demonstrate how to measure the length and width of the skunk's front and rear feet.
Explore	Divide the class into teams of 2-3 students to record the measurements of the skunk's tracks using rulers and measuring tapes. Students should draw the front and rear tracks in their science notebooks, label the tracks as front and rear, and write the name of the animal. Record the measurements on the Tracking Data Collection form. Make sure the students complete the form. Verify with each team the accuracy of their measurements, comparing their measurements to the table data for striped skunk.
Explain	Begin the discussion about variation of foot sizes. • Ask, "Do all skunks have the same size paws? Discuss differences between humans of all ages; then relate the differences to other animals. • Ask, "How can we tell the difference between two individuals?" • Ask, "What else can we measure to know if different skunks made the tracks?" • Ask, "Can you think of other clues that can help us to identify mammals?"

Elaborate	As students discuss differences between owls and eagles, it is typical that size be mentioned. Have the students think back to the first three images they saw in this lesson of the Great-horned owl, the Western screech owl, and the Eastern screech owl. Using the field guides, read the measurements of each bird. Ask them, "What part of your body is about the same size as these birds?" If they struggle with this question, use your and and arm to show the difference between the Western and Eastern screech owls. The hand is about the size of the screech owls and the arm is about the size of the Great-horned owl. For additional practice, have the students look up a black-capped chickadee and a house sparrow. Encourage the students to find a body part that is about the same size. Finally, have students choose two animals in the field guide by using the index. Once the animals have been selected, they will then locate the size measurements for each and record them into their science notebook. The student will then explain the size of each animal in relation to their body. Drawing the images is encouraged.
Evaluate	Have each student complete an exit ticket containing the following questions: • What did you learn today? • What question still remains? • How will you use what was learned today in future learning experiences?

Tracking Data Collection Form

Team and Your Name:

Date:

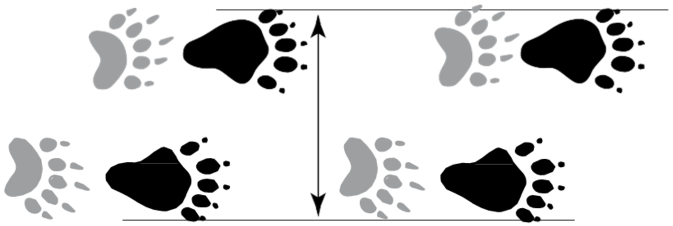
Measurements						
Species	Length Front Track	Length Back Track	Width Front Track	Width Back Track	Step	Trail Width (Straddle)
striped skunk	1.75”-2.25”	1.75”-2”	1”-1.25”	1”-1.25”	6.5	2.5”-4.5”

Track Patterns

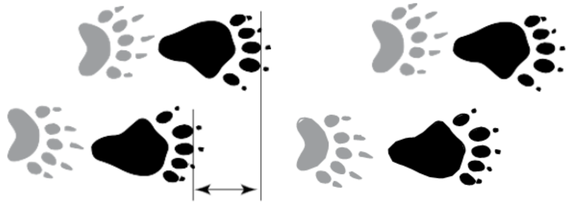
Pacer Walking Pattern - (moving in --> this direction)

(Example of striped skunk tracks)

Trail Width



Step



	Length Front Track	Length Rear Track	Width Front Track	Width Rear Track	Step	Trail Width (Straddle)
Black bear	5”-6.25	6”-7.75”	3.75”-5.5”	3.5”-5.5”	17”-23”	9.5”-14.5”
Raccoon	2”-3”	2.25”-3.75”	1.75”-2.5”	2.25”-2.5”	8”-14”	3.6”-6”
Striped skunk	1.75”-2.25”	1.75”-2”	1”-1.25”	1”-1.25”	6.5	2.5”-4.5”

Rear Track means the same as Hind Track
If the Front and Rear measurement range are the same in the table, an individual’s rear track will be the smaller number in the range.

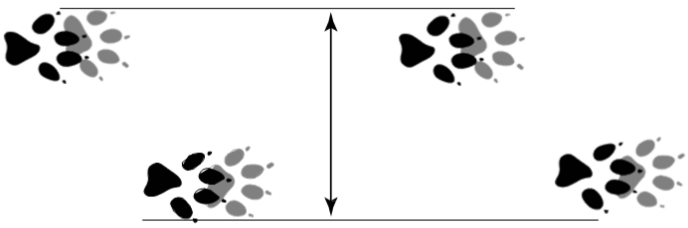
Skunk tracks - Actual size

Track Patterns

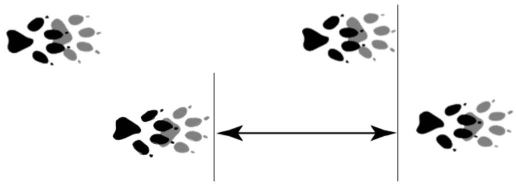
Diagonal Walking Pattern - (moving in --> this direction)

(Example of Canid tracks)

Trail Width



Step

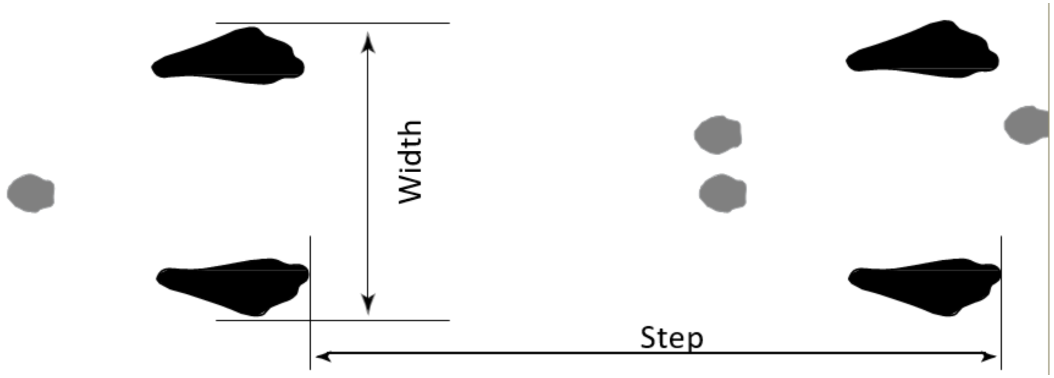


	Length	Length	Width	Width	Step	Trail Width
	Front Track	Rear Track	Front Track	Rear Track		(Straddle)
Ungulates						
Elk	3.75”-4.75”	3.75”-4.75”	3.25”-4.75”	3.25”-4.75”	22”-42”	7”-11”
Mule Deer	1.25”-3.5”	1.25”-3.5”	1.25”-2.75”	1.25”-2.75”	18”-26”	5”-8”
Canids (Dog)						
Coyote	2.5”-3.25”	2.5”-2.75”	1.75”-2.25”	1.5”-2”	17.5”-26”	2.5”-5.5”
Red Fox	2.25”-2.75”	1.75”-2.5”	1.75”-2.5”	1.5”-1.75”	13”-18.75”	2”-3.75”
Felids (Cat)						
Cougar	3”-4.25	3”-4.25”	3.25”-4.75”	3.25”-4.75”	20”-32”	8”-11”
Bobcat	1.75”-2.5”	1.75”-2.5”	1.5”-2.5”	1.5”-2.5”	11.5”-25”	3”-5.25”
Domestic Cat	1”-1.75”	1”-1.75”	1”-1.75”	1”-1.75”	8”-14”	2.25”-4.75”
Other						
Porcupine	2.25”-3.25”	2.75”-3.75”	1.25”-2”	1.5”-2”	6”-11”	5”-9”
Beaver	2.75”-3.75”	5”-7”	2.75”-3.5”	3.25”-5.25”	6”-10”	6”-10.5”

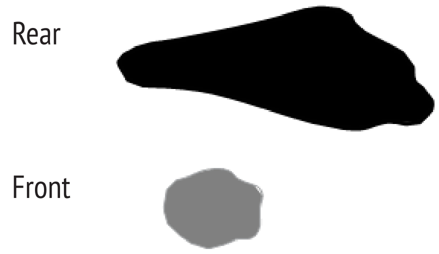
Rear Track means the same as Hind Track
If the Front and Rear measurement range are the same in the table, an individual’s rear track will be the smaller number in the range.

Track Patterns

Galloper Walking Pattern - (moving in --> this direction)



(Example of snowshoe hare tracks)



	Length	Length	Width	Width	Step	Trail Width
	Front Track	Rear Track	Front Track	Rear Track		(Straddle)
Snowshoe hare	2”-3”	4”-6”	1.5”-2”	2”-3.5”	10”-48”	6”-8”
Mountain cottontail (Nuttall’s)	1”-1.5”	3”-3.5”	1”-1.5”	1”-1.5”	7”-36”	4”-5”

Rear Track means the same as Hind Track
If the Front and Rear measurement range are the same in the table, an individual’s rear track will be the smaller number in the range.

Pet Measurement Instructions

<u>Track Length and Width</u>

Place a piece of white paper on the ground. Place your pet on the paper so the animal is standing on it.
Have someone hold the pet and draw around the pet's left front and left rear paw. Take measurements from the drawing and write the measurements on the Track Sheet. (Student Pages My Cat's Tracks, My Dog's Tracks)
Draw what your pet's tracks (or the tracks of any pet you know) would look like. (You can walk them in a few inches of snow, or let them get their feet wet and make them stand on a paper towel.)

Trail Width:
While your pet is standing still, measure the distance between the outside of the paws.

Step:
- *Option 1:* Walk your pet outdoors in the snow. Draw a line across the tracks as shown in the diagram. Measure the distance between the two lines.
- *Option 2:* While your pet is standing, measure the distance from the back of the left front paw to the toes of the left rear paw.

Student Page My Cat’s Tracks

My name is:

My cat’s name is:

Photo

Width

Width

Length

Length

Front Track

Back Track

Student Page My Dog's Tracks

My name is:

My dog's name is:

Photo

Width

Width

Length

Length

Front Track

Back Track

Lesson 1.3: Data Collection Processes

Objectives: In these activities students use their observation skills to collect data about the natural world. They will use data collection forms and begin thinking about how to organize data they have collected.

Materials:

- Science Notebooks
- Close-up image of an ant mound (found via Google image search)
- Ant mound with example zoom in area (found after Activity 1)
- Data Collection Form example (found after Lesson 1.1 Activity 1)
- Compass
- Compass Wheel (found after Activity 2)
- Popsicle sticks and other small objects
- Butcher Paper
- Post-its
- Globe
- GPS Units
- Pens and pencils

Activity 1: Introduction to Group Estimates and the Grid System

Pre-Lesson Preparation	Your class sees a flock of birds, and based on the size and shape of the birds, you decide they are rock doves (e.g., pigeons). How many birds did you and your students see before the flock disappeared from sight? Estimation is a tool used to count large numbers of animals or objects. Grids are useful for counting objects that are stationary. Animals, however, are moving most of the time, so there are other techniques designed to count them quickly. Before your students can estimate the number of animals within a group, they need to try different ways to count the individuals. This lesson demonstrates techniques for counting in groups of five or ten. Make copies of a close-up picture of an ant mound (Google image search). Also, create a large chart (with at least four columns) and mount it on the wall. Throughout the lesson, record data on this chart. Refer to the data collection form and introduce the sections that relate to number and estimates. Explain that scientists need good estimates to determine the populations of different species across the country.
Engage	Ask the students the following questions. The students should record their answers/ideas in their science notebooks: • What do you see? • What questions do you have about the images shown? • How many ants do you think are in the close-up image? • How did you decide? Ask each student or pair of students to mark on the class chart their estimates of the number of ants shown in the image provided. (You may want to arrange these in numerical order so the class can find the median, mode, mean, and range of answers). Record on the class chart the different methods the students came up with to determine the number of ants.
Explore	Pass out a copy of the close-up image to each student or pair of students. Ask them to select one method and use it to make another estimate of how many ants are in the picture. (Some students will count by ones, some will circle groups of 5, 10, or more.) The students should record their estimates and their methods in their science notebooks.
Explain	When all have their estimates, record their new estimates on the group chart. (Again, record in numerical order and find mode, median, mean, and range.) Ask, "What do you notice about the two groups of estimates?" (Most likely, the numbers in the second group will be more similar and have a smaller range.)
Elaborate	Still using the example of the ant mound, ask students to speculate: "How would they determine the number of ants without counting all of them - for example, if they encountered an ant mound outdoors?" Display the same photo of the entire ant mound. Using the box drawn over the ant mound as your model, draw more boxes on the photo until you have created a grid covering the entire ant mound. Ask students how they would use the grid to determine the number of ants. Remind them that the hill is also on the other side of the tree. Students can use calculators. Explain to the students that scientists use a grid system to estimate large numbers of animals in nature. Count the number of animals in one box and multiply by the total number of boxes.
Evaluate	Have each student complete an exit ticket containing the following questions: • What did you learn today? • What question still remains? • How will you use what was learned today in future learning experiences?

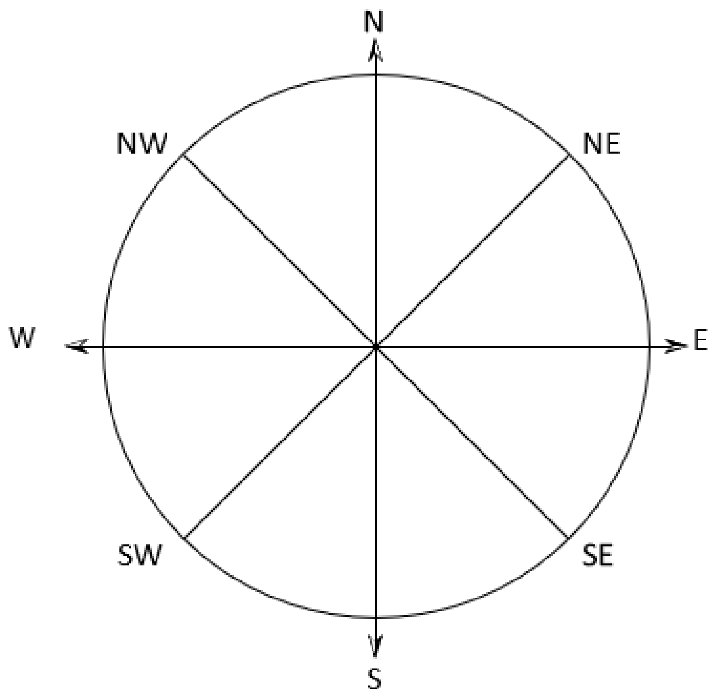
Close up picture of an ant mound

Data Collection Form

Observer's Name:					City/County/State:			
Date	**Time**	**Temp**	**Species Name Description**	**How observed?**	**Latitude**	**Longitude**	**How many did you see?**	**Is this an estimate?**

Activity 2: Creating Our Own Maps with Cardinal Directions

Pre-Lesson Preparation	Explorers and current-day scientists record their locations on maps. The Nature-Mapping program asks the public not only to “tell us what you see (plants, animals), but also where you see it (location).” There are multiple ways to describe a location with geographic precision. This unit will help you to teach your students both basic directional skills and some of the more complex directional skills so they can navigate nature and the greater biosphere.
Engage	Have the students close their eyes and ask them: • Who is sitting next to you on your right? • The person across from you wears what color of shoes? • What direction are the clouds moving? • Where is the sun right now? • Looking from where we are right now, where will the sun rise? • Were there any birds in the tree we just passed? • What flowers are blooming right now? • Where is north? Be sure to ask questions that at least a few people will get right. Try to vary the questions to emphasize different skills. Try to include questions that address all of the senses.
Explore	Go outside and sit in a circle in an open spot. Show students the compass wheel. Ask: • Where does the sun come up? • Where does the sun go down? • What direction is the sun? • Which way is north? • What is the direction between north and east? Explain what a compass is and how it functions. Use a compass to test the accuracy of the students’ placement of objects to mark directions. Say the different directions out loud and ask students to point to where the direction is on a compass wheel or on a makeshift wheel outside. You can also hand out cards with directions for students to place on the wheel.
Explain	Go inside the classroom and ask students to find north and other directions in the classroom. Ask students to make direction markers and post them on the walls of the classroom in the correct location. Use the compass to double-check the location.
Elaborate	Draw a collective map on the whiteboard. The map should show where your class went and what they saw. First, draw the sun, then identify the directions of north, south, east, and west. Fill in the big landmarks, the walking trail, and anything else that caught the students’ attention.
Evaluate	Have each student complete an exit ticket containing the following questions: • What did you learn today? • What question still remains? • How will you use what was learned today in future learning experiences?



Compass Wheel or Compass Rose

Activity 3: Using a GPS Unit to Record Locations

Pre-Lesson Preparation	Tape together butcher paper to make a 3X5-foot sheet which will be used to create a second schoolyard map.
Engage	Ask students to validate the location of objects placed on the map made in Lesson 1.3, Activity 2. Refer to the previously-completed data collection form and spotlight the section on recording latitude and longitude. Show the students a globe and explain to them the lines of latitude and longitude. Lines of latitude run horizontally and provide locations in the north/south directions; north is depicted as a positive number and south as a negative number. Lines of longitude run vertically and provide locations in the east/west directions. Explain that each number reflects location in degrees, minutes, and seconds. Each degree of latitude represents 69 miles, each minute 1.15 miles, and each second 0.02 miles. Degrees of longitude vary in size, decreasing as one moves toward either of the poles.
Explore	• Introduce a GPS unit. • Set the GPS to record decimal degrees. • Take the class outside so the GPS unit can acquire the satellite data. • Pair students together and equip each pair with a GPS unit. Explain that one student will read the unit while the other records the readings in his or her science notebook. • Ask the students to walk the schoolyard from south to north, documenting the latitude numbers acquired. • Repeat the step for writing longitude numbers from east to west.
Explain	Return to the classroom and ask students what they observed and if there was a number pattern. Use a globe/map to review why the numbers increase and decrease. Talk about satellites and show how they work.
Elaborate	Explain to the students that when you put the latitude and longitude numbers together, it is considered an exact location. Students will use the GPS unit to test the precision of the landmarks placed on their first schoolyard map. Use the numbers they collected with the GPS unit to create a grid on a piece of butcher paper (3X5 feet), which will become their new schoolyard map. Students will pair up and visit the locations of the landmarks they originally put on the first schoolyard map. Students record the latitude and longitude at each corner of the item recorded in their science notebooks. Students will discuss the numbers acquired. Did all numbers change or did some stay the same? Students will observe the information that has been collected and recorded on the map.
Evaluate	Number ten popsicle sticks (from 1 to 10) and place them around the school grounds so that all students can see when they are close by one of the sticks. Give students a list of the latitude and longitude numbers. Using a GPS unit, each student (or team of students) will record the number of the popsicle stick with it matching latitude and longitude. Have each student complete an exit ticket containing the following questions: • What did you learn today? • What question still remains? • How will you use what was learned today in future learning experiences?

SECTION 2: FIELD INVESTIGATIONS AS INQUIRY

Field investigations help students become informed citizen scientists and engineers. They contribute knowledge to their community's understanding of natural resources in order to make issues of concern visible. Students can learn and share differing points of view about the preservation and use of those resources.

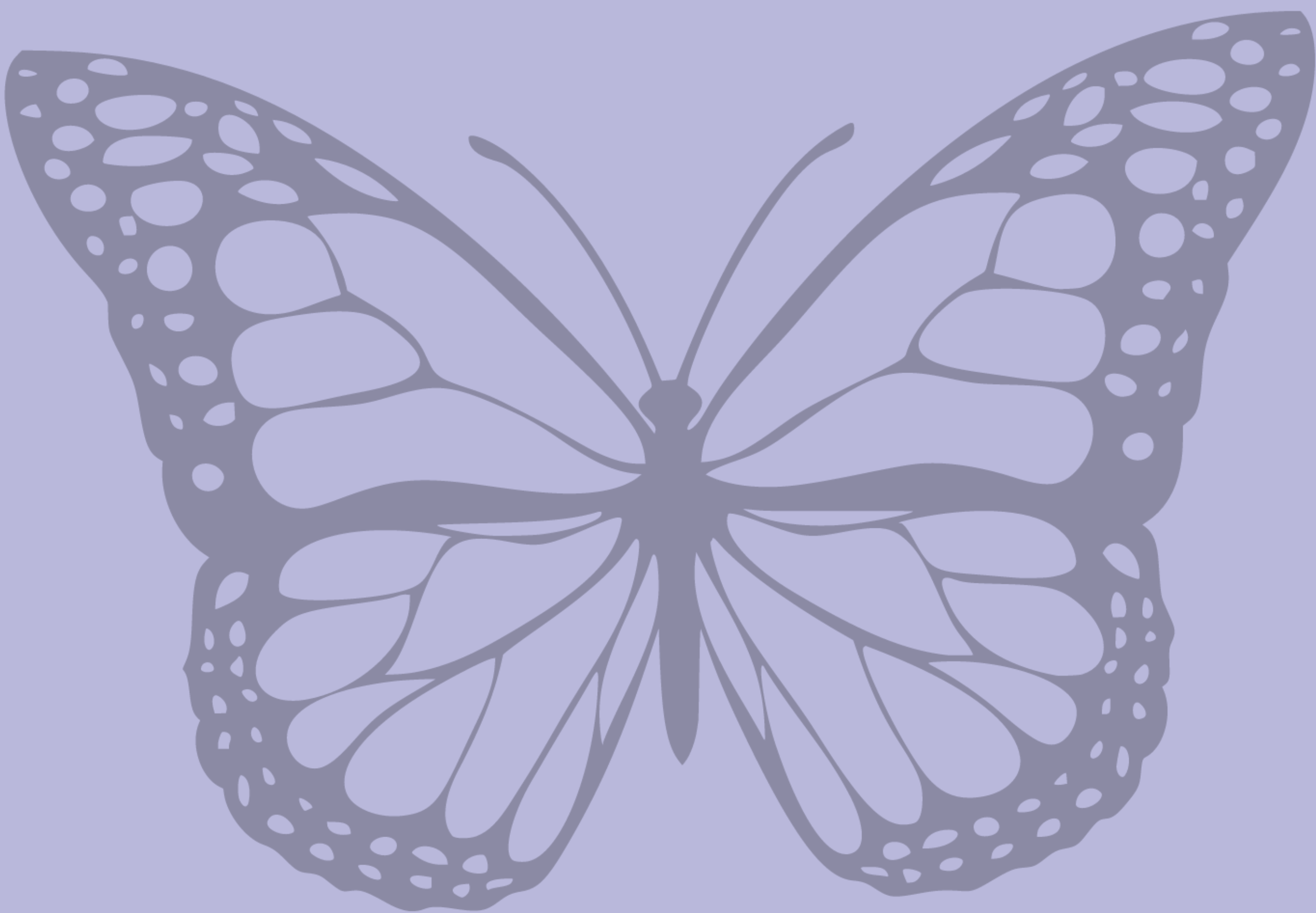
Classroom science often overemphasizes experimental investigation in which students actively manipulate variables and control conditions. Experiments begin with a hypothesis regarding links between variables in a system followed by identifying those variables of interest and designing a "fair test" where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

Field investigations often take place when it is difficult to manipulate variables and maintain "control" and "experimental" groups. Instead, scientists look for descriptive, comparative, or correlative trends in the study area. For conceptual clarity in this section, we focus on two types of field investigations that can easily take place in classroom or other learning settings – Descriptive and Comparative.

Descriptive Field Investigations involve describing and/or quantifying parts of a natural system, while Comparative Field Investigations involve collecting data on different populations/organisms or under different conditions (e.g., times of year, locations, etc.) to make a comparison. (Correlative investigations involve measuring or observing two variables and searching for a pattern; e.g., "Do animal tracks increase with greater forest canopy cover?" Including Correlative investigations as extensions after students understand descriptive and comparative investigations is a potential extension option once students demonstrate understanding on the lessons provided here.)

The table below outlines the differences and similarities between the two types of field investigations in this guide and relates these to the essential features of inquiry. [5]

[5] 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.



Two Types of Field Investigations

<table>
<tr><td>Essential Questions</td><td colspan="2">• 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?</td></tr>
<tr><td></td><td>Descriptive</td><td>Comparative</td></tr>
<tr><td>Formulate Investigative Question</td><td>How many?
How frequently?
When did it happen?</td><td>Is there a difference between groups, conditions, times, or locations?
Make a prediction or hypothesis about differences.</td></tr>
<tr><td>Identify Setting within a System</td><td colspan="2">Identify geographic scale of investigation (e.g., school yard, nearby stream or forest, urban garden, etc.).

Identify time frame of the investigation (e.g., season, hour, day, month, year).</td></tr>
<tr><td>Identify Variables of Interest</td><td>Choose measurable or observable variables.</td><td>Choose a measured variable in at least two different (manipulated variable) locations, times, organisms, or populations.</td></tr>
<tr><td rowspan="2">Carry out Investigations</td><td colspan="2">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>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="2">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?

Typical representations of the data to build descriptive and comparative models:

• Charts
• Line Plots
• Bar Graphs
• Maps</td></tr>
</table>

Construct an Evidence-Based Explanation or Argument	Makes a claim that answers the investigative question. Use evidence from observations collected to support the claim.
	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?
Discussion	• 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 fi How does this data help us to understand the entire system? • Did we identify any problems that might need to be solved?

The first sets of activities in this section include descriptive field investigations and include: What Questions can I investigate? What Plants and Animals use the Schoolyard Habitat? What are the Physical Characteristics of a tree or shrub and how do they differ each month?

The second sets of activities include Comparative Field Investigations and include: *How does Surface Temperature Vary with Location?* and *Is There More Twig Growth on the North or South Side?*

All Field investigation activities are for the intermediate learner, those who have already honed their observation and data collection skills presented in the first section of this guide. These activities can be done on the school grounds or while visiting parks or other natural areas. As with Section one, all activities are presented in the 5E format and each lesson begins with the stated objectives and materials needed for the activities contain within each the given lesson.

Lesson 2.1: Descriptive Field Investigations

Objectives: The descriptive field investigation activities provide students with opportunities to use their observation skills in a way that addresses scientific questions about the environment around them. These investigations include the recording of data for further analysis.

Materials:

- Science Notebooks
- Pens and Pencils (including colored pencils)
- Sets of Investigative Questions (found after Activity 1)
- Pictures of the schoolyard or local area
- Paint Chips
- Graph Paper
- Field Guides
- Hula Hoops
- Yard or Meter Sticks
- Hand Lenses
- String
- Tape Measures
- Tree Identification Websites and Apps

Activity 1: What Questions Can I Investigate?

Pre-Lesson Preparation	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.
Engage	Review the essential questions. These big picture questions are why we conduct field investigations. 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 they may have about their schoolyard. Have students share their questions with a partner or make a class list of them.
Explore	Give groups of students the cards with examples of investigative 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, as well as what patterns they noticed in each type of question. Discuss the three types of field investigation questions, with an emphasis on Descriptive and Correlative. You may want to give them broad examples of each type. Descriptive - Lewis and Clark, Going to Mars, Comparative-Darwin comparison, and Correlative - CO_2 levels and temperature across the globe or predator/prey relationships. If needed ask students questions to help them identify differences in the questions: What patterns do you see in each type of question? What words are important to look for when identifying each type of question? Ask students to now sort the questions into three categories - descriptive, comparative, and correlative.
Explain	Give the groups time to think about each question and agree on the categories. When they have their questions categorized, facilitate a discussion by asking the questions below or have the groups discuss before sharing with the class. • Did you all agree on the category? Explain how you came to this decision. • Can each one of you come up with a justification as to why these questions fall into the categories that they do? • Do you have an "uncertain pile"? If so, why? What more do you need to know? • What questions do you have about your categories? • Think of your own examples of each type of question? Using a chart identifying the different question categories, have students place a question in the category they selected and have them say why they chose that category.
Elaborate	Discuss why scientists need to think about the questions they pose before working in the field. Have the students 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 classify each question. Have them 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 into more than one category. What is important is that students can justify their thinking for each category. Have each student complete an exit ticket containing the following questions: • What did you learn today? • What question still remains? • How will you use what was learned today in future learning experiences?

Investigative questions for sorting (fill in with locally relevant information and 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 playground in March?

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

Which habitat (in the forest, in a field or by a stream) has the greatest percentage of sand in the soil?

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

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 American Robins Live on the school grounds? How many deer live in (a nearby) County Park?

How many eggs does a (local fish species) lay in (nearby river) each breeding season?

How often do (local species) Butterfly lay eggs in a season in (your region)?

What is the depth of (local body of water) in September?

What is the air temperature at your school throughout the school year? What kinds of plants grow in (nearby) Forest?

What types of birds use the school habitat during the school year? When do robins nest (in your area)?

When do (local species) trees pollinate?

What is the range of (large mega fauna of choice) in (your area)?

Is there a difference in the size of the range of a screech owl or barred owl in Washington's lowland forests?

Are mature (greater than 30 cm diameter) conifer trees taller than mature deciduous trees in (local) Forest?

Which location (under bushes, open grass, or on black top) has the highest temperature at 7:00 a.m. at your school?

Are deer more active during the dawn or the dusk in (nearby park)?

Do more ferns grow close to the water or away from the water?

Do tree species, tree density, tree diameter, or tree height differ between north and south facing slopes in (local park or forest)?

Do temperatures differ between forested and non-forested streams in (local parks)?

Do birds sing more from 8:30-9:00 a.m. or from 3:00-3:30 p.m.?

How does dissolved oxygen change as water temperature goes up in (local) stream?

How do mouse populations change as hawk populations increase in the (local park) area?

How do heron populations change as eagle populations increase in the (local) watershed?

As elevations increase, how does the number of (locally abundant tree species) per acre change in the (regional mountains)?

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

What is the relationship between the amount of sunshine and red color in leaves in fall?

How does pH affect the number of (local fish) eggs hatching in a stream?

Activity 2: What Plants and Animals Use the Schoolyard Habitat

<table>
<tr><td>Pre-Lesson Preparation</td><td>Gather pictures taken from either the schoolyard or nearby regions to assist in the discussion and engagement of the lesson.</td></tr>
<tr><td>Engage</td><td>Ask students, "What do you think when you hear the word habitat?"

Have students do a think-pair-share and then come up with a class definition or have students define their own habitat.

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 (e.g., sight, hearing, touch, smell) and recording observations (e.g., 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 students' thinking, model drawing and/or writing observations.
• What does it look like?
• What does it feel like?
• What does it smell like?
• What does it sound like?</td></tr>
<tr><td>Explore</td><td>Divide the class into pairs before going outside. Students should have multiple opportunities to create observation in their science notebooks and record data/measurements. As an extension, paint chips may provide students an understanding that there are multiple shades and names of a color 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 overhead?

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 or 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?

Special study area: Divide the class into pairs and give each pair a hula hoop and a yard stick.

Students select a study area and place the yard stick in the middle of the hula hoop to create a transect line and two observation quadrants. 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.

Students record observations using written words/phrases, drawings, labeled diagrams, and numbers to describe the area within the hula hoop, to contrast the two observations quadrants, or to note items along the transect line.

Students are encouraged to use field guides to identify plants and animals.</td></tr>
</table>

Explain	After each observation session, ask the students to share their findings and questions. Ask them, "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. Optional: Have students categorize the types of organisms they found in the schoolyard habitat and summarize their findings. As a class categorize the questions students posed (descriptive, comparative, correlative, essential questions, why questions, questions we can look up). Special Study Area: 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? Students formulate two descriptive questions and two comparative questions about the special study site based upon their observations. Ask students to answer the investigative question by writing or discussing, "What plants and animals use the schoolyard habitat?" Create a map of the school grounds identifying organisms in each study area.
Elaborate	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 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 a habitat? Using student maps of the school grounds, students look for patterns and come up with questions about those patterns. As an extension, students might carry out an investigation of one of the questions they came up with during the lesson.
Evaluate	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: • Drawings that are included in the notebook; • Small objects/organisms that are enlarged; • Drawings that are detailed; • Parts of an organism/object that are labeled; • Color that is added as appropriate; • Drawings that have captions or titles and note the date and place recorded. During student observations, assess their insights and what they reflected on regarding the quality of the observations made. Assess their descriptive and comparative questions to check understanding of those categories. Assess the accuracy of their maps for displaying their observational data. Use Claim, Evidence, Reasoning rubric to evaluate how they communicate about their observations. Have each student complete an exit ticket containing the following questions: • What did you learn today? • What question still remains? • How will you use what was learned today in future learning experiences?

Activity 3: What are the Physical Characteristics of a Tree or Shrub and How do They Differ Each Month?

Pre-Lesson Preparation	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 students can 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.
Engage	Students write what they already know about trees and shrubs. They then draw and label a tree and shrub from memory.
Explore	• Ask the question: What are the parts of this tree? What are the physical characteristics of this tree? • Students record the date, time, place, air temperature, and weather in their science notebook. • Students go outside to draw and label the parts of the deciduous tree in either fall or winter. Measuring the tree and its parts helps students make their drawings to scale. • Students write down questions they have about the tree.
Explain	• Have the students compare their drawings from memory to their drawings from observations. • Students share with a partner their descriptions and drawings of their tree adding any details they may have missed. • Students share the parts of the tree they labeled with their partner, labeling any parts they missed. • Partners idenTify the function of each part of the tree labeled. • Students share and categorize their questions by type.
Elaborate	• Have students use identification books, internet sites, and apps to identify their trees. • Have students observe their tree every month or season noting differences. • Choose one of the questions posed by the students to investigate or research. • Have students investigate their tree as habitat looking for evidence of plants and animals as they did previously. • Ask students to think about the tree as a system and talk about inputs and outputs and changes in the system. • Do a lesson on photosynthesis to give background for input and output.
Evaluate	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. • Labels indicating the parts of the tree. • Appropriate use of color. • Captions or titles that identify drawings and note the date and place recorded. Evaluate the parts and functions of the parts of the tree and shrub by checking for accuracy of both. Have each student complete an exit ticket containing the following questions: • What did you learn today? • What question still remains? • How will you use what was learned today in future learning experiences?

Lesson 2.2: Comparative Field Investigations

Objectives: In this lesson learners apply their skills of observation and data collection to compare two or more variables in these field investigation activities. Data collection and analysis skills will be highlighted.

Materials:

- Science Notebooks
- Thermometers
- Stop Watches
- Temperature Variation Data Sheet (found after Activity 1)
- Claim, Evidence, Reasoning Template (found after Activity 1)
- Tree Identification Guides
- Compass
- Physical Characteristics of Your Twig Worksheet (found after Activity 2) Twig Growth Example Data Sheets (found after Activity 2)
- Calendar
- Rulers
- String
- Scissors
- Pens and Pencils (including colored pencils)

Activity 1: How does Surface Temperature Vary with Location?

Pre-Lesson Preparation	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. 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 Appendices Volume 2, p. 54). Carrying out 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 Appendices 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.
Engage	Have students think about and discuss the question: “Is the temperature outside in the schoolyard the same in every place? Elicit responses from students by asking, “Have you ever stood in the sunlight in a black shirt?” Again, have the students discuss their answers. Review the investigation question, “Which surface - on the open grass, under the bushes, or on the black top - has the highest temperature?” Have the students write the question in their science notebooks or use the data sheet provided. Tell the students that good investigative questions describe what we will manipulate (independent variable). Have students underline the manipulated (independent) variable in the question (surface). Good comparative questions also describe what to measure (dependent variable). Have students double underline the responding (dependent) variable in the question (temperature).

Explore	Take students outside to visit the site where they are to carry out the investigation and to practice with the equipment (thermometers). 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. Students return to the classroom and write a prediction of which surface type will have the highest temperature. Review the importance of recording the date, time, and weather including air temperature, and for describing the study site. 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. Have students create a data table or provide data sheets from the end of this lesson. Be sure to include: • Clear title for the table • Locations to the left side (manipulated variable) • Temperature labeled across the top with approximate units (responding variable) • Multiple trials labeled • A place for averages Ask students, "When we go outside and take the surface temperatures, what do we need to do the same each time (controlled variable) to provide for a fair test?" List the controls on the board and have them write the list in their science notebooks. Have students select sampling locations that are representative and random of the site. 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), and how they will take measurements (controls). Students carry out the surface temperature comparative investigation following their procedure. This includes recording the date, time, and place where the investigation takes place; describing the weather and site of the investigation recording air temperature; and leaving the thermometer flat on the ground for the determined amount of minutes, shading the thermometer from direct sunlight, and recording the temperature four times at each of the three locations (in the open grass, on the blacktop, and under the bush).
Explain	Students calculate averages (mean, median, or mode) for each location. Students display data in graphic form or on maps. Students discuss which graphic representation is best and why. Students review the procedure and make any changes to include what they actually did in the field. Argumentation - in groups, students discuss: • Patterns in the data • The procedure • Any factors that may have influenced their data • Any inconsistent data Students share in a whole class discussion and record. 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. Students construct an argument/explanation using data as evidence to answer the investigation question. Use the Claim, Evidence, Reasoning Template.

Elaborate	Have students discuss using some of these questions: • What are possible reasons the temperature was or was not different for different surfaces? • What is the effect of plants on surface temperature? • What inputs to the system might cause the surface temperature to be higher in one location than another? • What inputs or changes to the system might change the surface temperature data collected? • How does this information add to my understanding of the schoolyard ecosystem? Have students continue their research and/or investigations to add to their argument/explanations, such as: • Communicate their investigations by creating posters or PowerPoint presentations. • Explain what different surface temperatures means for microclimates and/or heat islands. • Read articles describing the energy transfer/transformations from the sun to the thermometers. Students should be given the opportunity to discuss and revise their Claims, Evidence and Reasoning.
Evaluate	Have students self-evaluate their procedures to make sure they included: • What is being changed to make a comparison between three different surfaces? • What is being measured in terms of temperature? • What is being controlled in terms of how measurements were taken? • Was there indication of multiple trials? Have students review their charts and graphs to see if they included: • Title and columns and/or axes labeled correctly • Correct units • Appropriate graphs • Explanation of graphic displays Have students review their constructed arguments/explanations for elements of a good argument/explanation. Have each student complete an exit ticket containing the following questions: • What did you learn today? • What question still remains? • How will you use what was learned today in future learning experiences?

How Does Temperature Vary With Surface? Data Sheet

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?

<u>Claim</u> Did I clearly answer the question? Did I limit the claim to the date, time, and place of the field study?
<u>Evidence</u> Did I use the right data? Did I give enough data?
<u>Reasoning</u> 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?

Activity 2: Is There More Twig Growth on the North or South Side?

Engage	Have students discuss ideas for comparative field investigation questions about trees. Examples might include: • 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?
Explore	Students choose a comparative question to investigate. Students gather the materials needed for the investigation. Students might first observe twigs more closely to understand their parts and characteristics, using the physical characteristics of your twig worksheet. Students make a prediction. Students write a procedure of the investigation and record their data in a Twig Growth Data Sheet. Students carry out the comparative investigation.
Explain	Students analyze data and create charts and graphs. Students discuss in groups the meaning of the data. Students do research on factors that affect twig growth. Students do a turn-and-talk about the reading and take notes about what they learned. Students write a conclusion for their data or write a claim, evidence, reasoning statement. Students participate in or write a discussion for their data.
Elaborate	Students identify their shrub/tree using a winter botany identification guide. Students do the same investigation on another type of tree or shrub to see if the north versus south growth differences are species-specific or if a general pattern may be seen. Students do research on what scientists are studying related to tree growth. Students view videos or read articles on what affects tree and shrub growth.
Evaluate	Check graphs and tables for accuracy of titles, labels, numbers, and units. Have each student complete an exit ticket containing the following questions: • What did you learn today? • What question still remains? • How will you use what was learned today in future learning experiences?

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:

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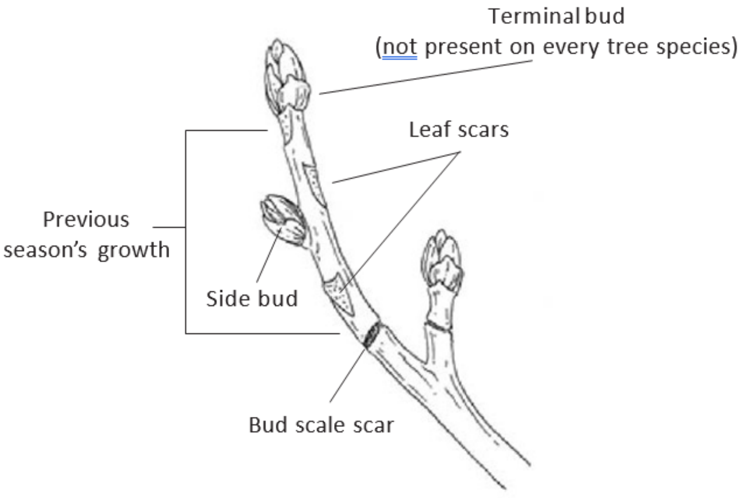
TWIG DIAGRAM



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 in 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 306 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 pm
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)				
	Trial 1 (twig 1)	Trial 2 (twig 2)	Trial 3 (twig 3)	Trial 4 (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?

Side of Tree/Shrub	Length of the Twig Growth in Millimeters for the Red Dogwood				
Location of Twig	Trial 1	Trial 2	Trial 3	Trial 4	Average
North Side	36	42	7	39	41
South Side	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 it 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:

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Location of Study Site:

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Map of Area:

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				

SECTION 3: SCHOOLYARD BIODIVERSITY - BRINGING IT ALL TOGETHER

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).

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.

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 final section of this Field Investigation Guide takes the skills learned in Sections one and two and applies them to the specific unit study of the schoolyard. These activities are for the intermediate learner but teachers can modify as they see fit for their students. These activities, more than in the previous sections build on one another as a whole Unit study, hence this section is set up more sequentially and not in the 5E model of the previous sections. Each Lesson begins with the objectives and materials needed for the activities in that lesson.

Lesson 3.1: Defining Biodiversity

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

Materials:

- Science Notebooks
- Post-its
- Strips of paper
- Tree information cards – such as found here http://www.wnps.org/education/resources/plantid_cn.html, these should be laminated

Activity 1: 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 science notebooks.

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. Optional: Students can also create simple illustrations of their final definitions.

6. Post and share sentence strips. Look at similarities and differences between the definitions, circling and/or highlighting key words in all definitions.

Activity 2: Biological Diversity - Preventing Complete Loss of Habitat Due to Disease

This is a 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.[7]

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: this activity can be modified to local tree species)

*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 the 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).

[7]Modified from: How It Stops Disease From Spreading written by Kathy Paris, Modified from original activity by Erica Baker (http://www.accessexcellence.com/AE/ATG/data/ released/0534-KathyParis/index.php).

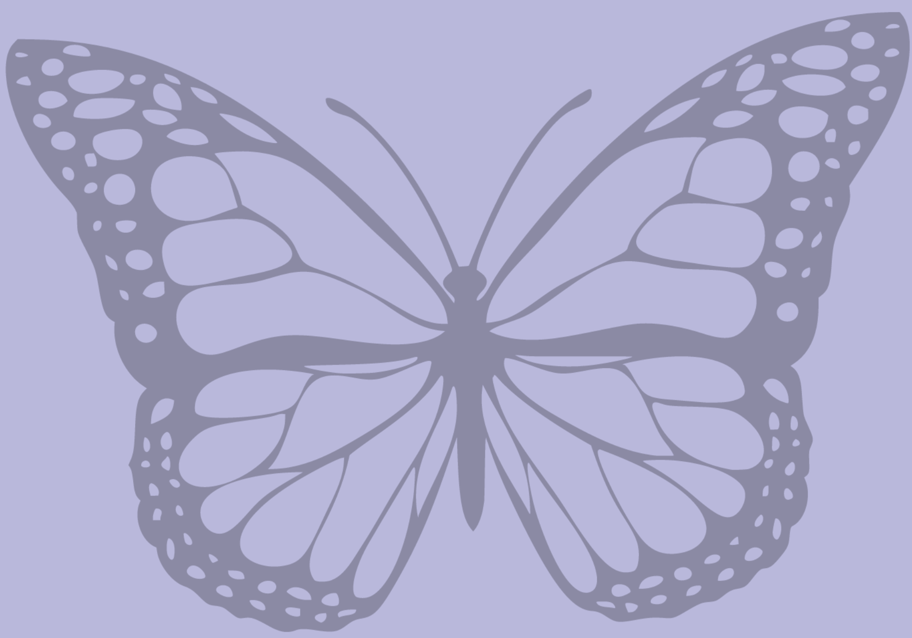
Simulation 2: The Second Set of Cards:

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.
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 science notebook 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?



Lesson 3.2: Conducting a Biodiversity Investigation

Objectives: In this lesson students will conduct an investigation on the school grounds. These lessons will use skills of mapping, observation, and data collection. Students will begin to see and understand the diversity of both flora and fauna just outside their school.

Materials:

- Science Notebooks
- Pens and Pencils (including colored pencils)
- Campus Maps
- Butcher Paper
- Grid Paper
- Alien Planet Worksheet (found after Activity 2)
- Vegetation Survey, Student Instructions, and Data Sheet (found after Activity 2)
- Wildlife Survey, Student Instructions, and Data Sheet (found after Activity 3)

Activity 1: Mapping the School Grounds

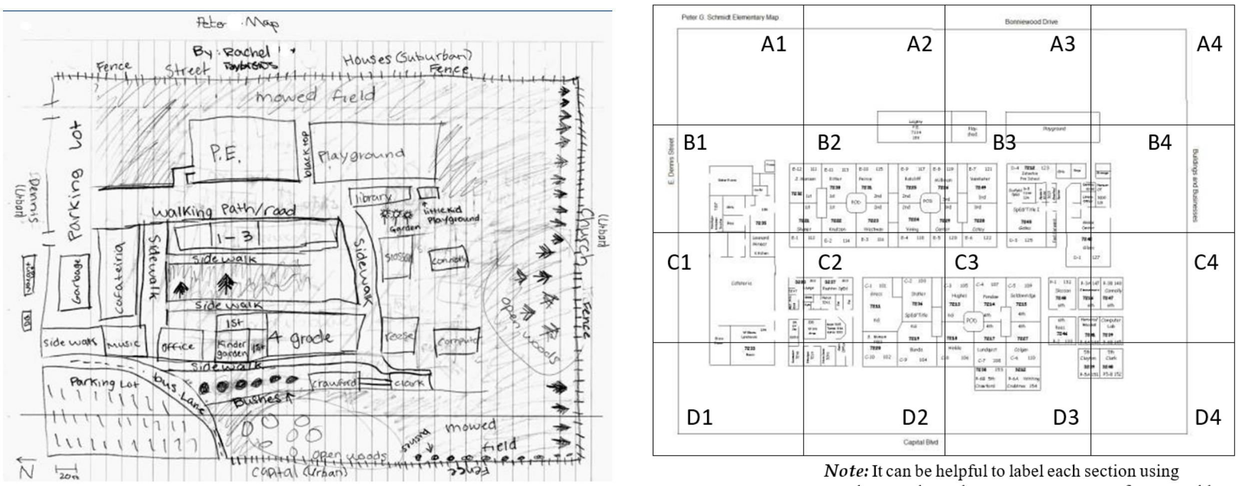
School maps can be created by individual students, partners or small groups in a variety of ways:

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.



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

Example of student-created map

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)

Activity 2: Conducting a Vegetation Biodiversity Survey

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

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

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:

   - Take the students through the data collection process using the Alien Planet Habitat and Key (found at the end of this activity) 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.
   - 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.

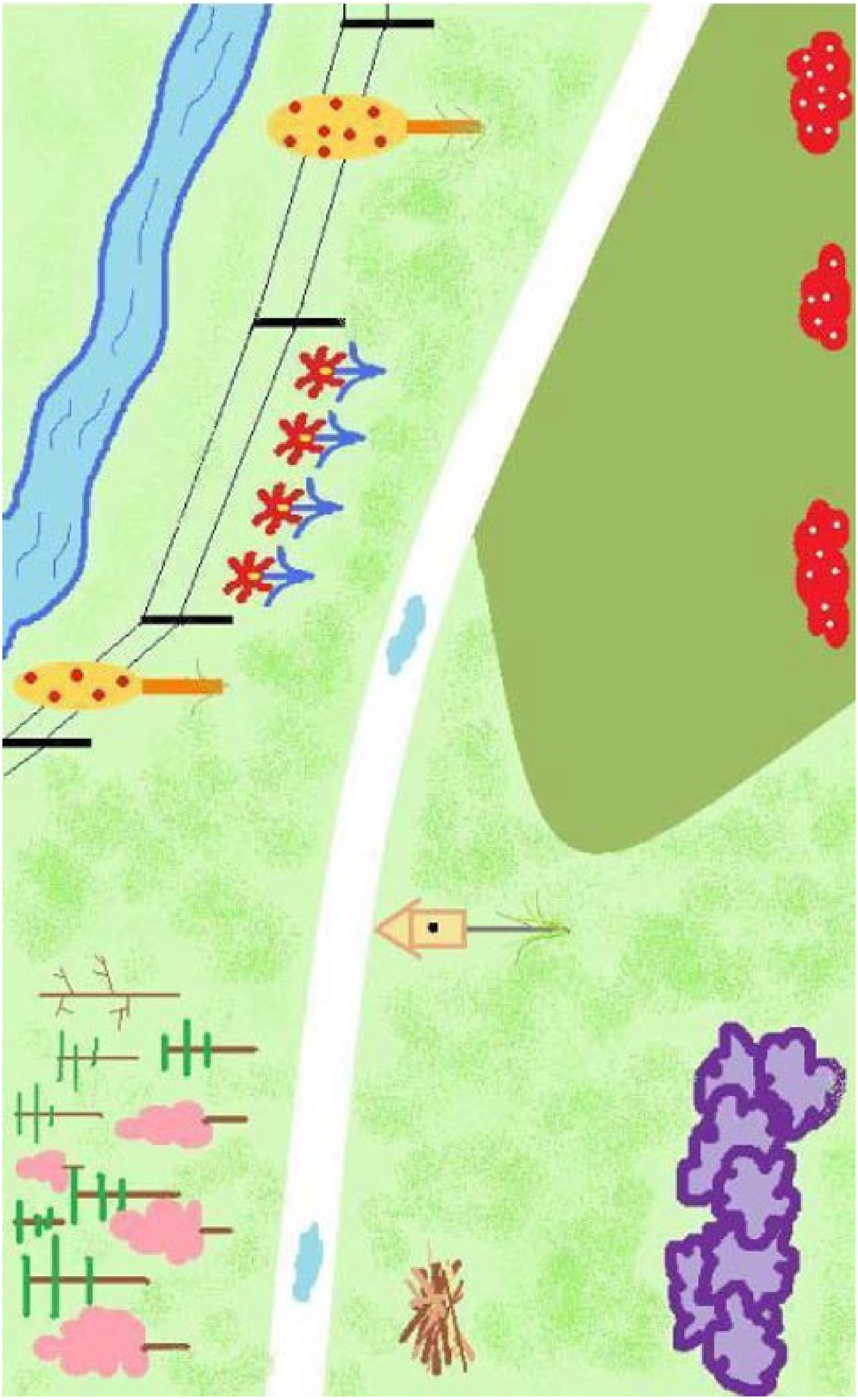
5. Students should create their plots as instructed. If surveying the entire school grounds, plots should not overlap and gaps between plots should not exist.

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.

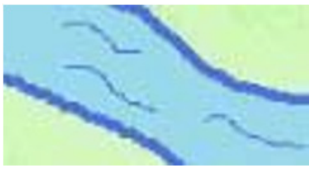
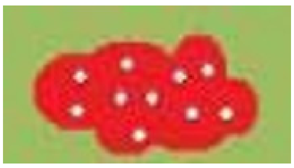
7. Students return to classroom upon completion of data collection.

8. Once in the classroom, students can analyze their data and write their conclusions. For diversity calculations, see the next lesson, Calculating Biodiversity.

Alien Planet Habitat



Alien Planet Habitat Key

Object	Brief Description	Object	Brief Description
	**Cotton Candy Tree** This tree is a deciduous tree (loses its leaves in the fall/ winter). It grows up to 50 feet in height.		**Mowed Tuff Tuff Grass** This is the type of grass preferred for lawns and playgrounds. It is chemical resistant and grows in dense, tough mats.
	**Dead Cotton Candy Tree** (Snag)		**Wild Monkey Grasses - Not Mowed** This wild grass is frequently found in open areas. It can grow up to 12 inches tall.
	**Telephone Pole Tree** This coniferous tree (has cones) is a native to only one area of the planet. It can grow as tall as 80 feet when the conditions are right.		**Ripple Creek** This creek flows year-round and feeds into the Big Ol' River.
	**Funkyfruit Tree** The funkyfruit tree blooms in the winter and bears fruit in the spring. It resembles a lollipop when it is a young tree and can grow to heights of 100 feet or more		**Puddle** This puddle is a result of last night's heavy rain.
	**Purple People Eater Bush** Tourists beware! This carniverous bush grows from 1 to 4 feet high and can remove a person's finger or toe with ease. And we thought stinging nettles were bad!		**Brush Pile** This is a pile of branches that were collected from a storm last year.
	**Little Berry Bush** This bush provides a tasty berry for native wildlife. Its roots give off a chemical that prevent most other plants from growing within 1 or 2 feet of it.		**Sidewalk**
	**Ruby Butterfly Flower** This flower's distinctive scent can be smelled up to 100 feet away. As a rich nectar source, it is a favorite flower for numerous birds and insects.		**Fence**
	**Nest Box**	***Assume plants are native or non-native unless the description says otherwise.**	

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. Wait for instructions from your teacher on heading 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 the 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 you 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)			

Activity 3: Conducting a Wildlife Biodiversity 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

Student instruction sheets can be found at the end of this lesson.

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 study sites to reduce the amount of disturbance to wildlife in the area. They will 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 observations.

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 the next lesson, Calculating Biodiversity.

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 to reduce the amount of disturbance to wildlife in the area, 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:

<u>ON SITE (within the boundaries of the plot):</u>

- 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.

<u>OFF SITE (outside the boundaries of the plot):</u>

- DO NOT place a tally in the left-hand column labelled TOTAL Number of DIFFERENT SPECIES of Animals ON SITE.
- DO place a tally in the correct OFF SITE solumn 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 as 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

Temperature____________________

Circle all that apply:

Clear
Scattered Clouds
Complete Cloud Cover
Rain

Wind: calm breezy gusty

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

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

Lesson 3.3: Calculating Biodiversity

Objectives: 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.[8]

Materials:

- Science Notebooks
- Pens and Pencils
- Sample Biodiversity Chart (found after Activity 1)
- Sample Habitat Setup Chart (found after Activity 1)
- Small Bottles
- Multi-Colored Beads
- Biodiversity Index Data Collection Sheet (found after Activity 2)

[8]Modified from: How It Stops Disease From Spreading written by Kathy Paris, Modified from original activity by Erica Baker (http://www.accessexcellence.com/AE/ATG/data/ released/0534-KathyParis/index.php).

Activity 1: Introducing the Biodiversity Index

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 Biodiversity data collection chart. Create the same table on the board.

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 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.

Activity 2: Analyzing Schoolyard Data to Measure Biodiversity

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 (from lesson 3.2)

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.

E. Pass out the Wildlife Biodiversity Index Data Collection Document

F. 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.

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

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:

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

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 Sample Habitat Setup Chart). 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 identifying 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).

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

Temperature____________________

Circle all that apply:

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				

Extension Activities for Schoolyard Biodiversity Investigations

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

<u>Analyzing at different scales</u>
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

<u>Analyzing for habitat differences</u>
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.

<u>Analyzing for temporal (time) differences in diversity over the year</u>
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.

<u>Analyze for diversity types</u>
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.

<u>Analyze for behavior</u>
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

APPENDIX A: NGSS AND NCSSS STANDARDS

NGSS: Grade 3

(pdfs 3.Interdependent Relationships in Ecosystems
3. Weather and Climate

NGSS: Grade 4

(pdfs: 4: Earth's Systems
4. Structure, Funtion and Information Processing)

NGSS: Grade 5
5. Earth's Systems
5. Matter and Energy in Organisms and Ecosystems

NGSS: Grades 3-5
(Pdf 3-5ETS-Engineering Design)

NGSS: Middle School
MS.Earth's systems
MS. Weather and Climate
MS. Interdependent Relationships in Ecosystems
MS. Natural Selection and Adaptations
MS. Matter and Energy in Organisms and Ecosystems
MS. Human Impact

NGSS: High School
HS. Earth's Systems
HS. Biological Evoution, Unity and Diversity
HS. Ecosystems, Interactions Energy and Dynamics
HS. Interdependent Relationships in Ecosystems

NCSSS: Grades 3-8

People, Places, and Environments	Purposes: This theme helps learners to develop their spatial views and perspectives of the world, and to understand the relationships between people, places, and environments. Learners examine where people, places, and resources are located, why they are there, and why this matters. They explore the effects of the environment on human activities, and the impact of these activities on the environment. This area of study is crucial to informed civic decision-making about human-environmental relationships.	Knowledge: Learners will understand: • The theme of people, places, and environments involves the study of the relationships between human populations in different locations and geographic phenomena such as climate, vegetation, and natural resources • Concepts such as location, region, place, and migration, as well as human and physical systems • Past and present changes in physical systems, such as seasons, climate, and weather, and the water cycle, in both national and global contexts • Human modifications of the environment • The use of a variety of maps, globes, graphic representations, and geospatial technologies to help investigate the relationships among people, places, and environments	Processes: Learners will be able to: • Research, organize, analyze, synthesize, and evaluate information from atlases, databases, grid systems, charts, graphs, maps, geospatial technologies, and other tools to interpret relationships among geographic factors and historic events • Acquire, organize, and analyze information and use geographic tools to draw conclusions about historic or current national and global environmental change • Calculate distance, scale, and area, to inform study of historic or current national and global environments	Products: Learners demonstrate understanding by: • Examining current land-use policies in this nation and one other one that are related to the use of natural resources, and making a chart comparing similarities and differences
Science, Technology, and Society	Purposes: This theme explores how developments in science and technology impact individuals, groups, institutions, and societies. Wants and needs stimulate advances in science and technology. An understanding of science and technology in their social contexts allows learners to question and analyze the impact of science and technology on society, both in the past and the present, as well as to evaluate what the future may bring in these areas.	Knowledge: Learners will understand: • Science is the result of empirical study of the natural world, and technology is the application of knowledge to accomplish tasks • Society often turns to science and technology to solve problems • Science and technology have changed peoples' perceptions of the social and natural world, as well as their relationship to the land, economy, and trade, their concept of security, and their major daily activities	Processes: Learners will be able to: • Use scientific findings and forms of technology to formulate possible solutions to real-life issues and problems, and predict outcomes	Products: Learners demonstrate understanding by: • Discussing current and past issues involving science and technology, and their consequences for society • Selecting a local problem related to science or technology, exploring several perspectives, and preparing a multimedia presentation with supporting evidence for a proposed solution

NCSSS Grades High School

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Science, Technology, and Society	Purposes: This theme explores how developments in science and technology impact individuals, groups, institutions, and societies. Wants and needs stimulate advances in science and technology. An understanding of science and technology in their social contexts allows learners to question and analyze the impact of science and technology on society, both in the past and the present, as well as to evaluate what the future may bring in these areas.	Knowledge: Learners will understand: • Science is based upon the empirical study of the natural world and technology is the application of knowledge to accomplish tasks • Science and technology have had both positive and negative impacts upon individuals, societies, and the environment in the past and present • That the world is media saturated and technologically dependent • Consequences of science and technology for individuals and societies • Decisions regarding the uses and consequences of science and technology are often complex because of the need to choose between or reconcile different viewpoints • Prediction, modeling, and planning are used to focus advances in science and technology for positive ends • Findings in science and advances in technology sometimes create ethical issues that test our standards and values • The importance of the cultural contexts in which media are created and received • Science, technology, and their consequences are unevenly available across the globe • Science and technology have contributed to making the world increasingly interdependent • That achievements in science and technology are increasing at a rapid pace and can have both planned and unanticipated consequences • Developments in science and technology may help to address global issues	Processes: Learners will be able to: • Ask and find answers to questions about the impact of science and technology in the past and present, and in different places and societies • Use diverse types of media technology to access, analyze, evaluate, create, and distribute messages • Seek and evaluate varied perspectives when weighing how specific applications of science and technology have impacted individuals and societies in an interdependent world • Identify and select appropriate information from multiple sources with varied perspectives for research into issues related to science and technology • Identify the purposes, points of view, biases, and intended audience of reports and discussions related to issues involving science and technology • Select, organize, analyze, and evaluate information, and communicate findings regarding the impact of science or technology on a society today or in the past • Identify and analyze reactions to science and technology form the past or present, and predict ongoing effects in economic, geographical, social, political, and cultural areas of life • Formulate possible solutions that utilize technology, address real-life issues and problems, weigh alternatives, and provide reasons for preferred choices and plans of action	Products: Learners demonstrate understanding by: • Creating and explaining two political cartoons that take opposing stands on a controversial scientific or technological issue or advance • Creating a short documentary on a current or past scientific or technological issue that highlights societal consequences and the varied positions of those impacted • Using graphic software to create a timeline depicting a scientific idea or the evolution of a technological innovation, and predicting how that idea or technology might develop in the next 10-20 years • Selecting a local problem related to science or technology, exploring several perspectives, and preparing a multimedia presentation with supporting evidence for a proposed solution • Drafting a proposal to the state legislature to consider the use of technology to increase the participation of voters in upcoming elections