Field Investigations

Using Outdoor Environments to Foster Student Learning of Scientific Practices

ASSOCIATION of FISH & WILDLIFE AGENCIES

Pacific Education Institute
Real Life. Real Knowledge.

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Field Investigations:

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Developed By
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Preface

The "Field Investigations: Using Outdoor Environments to Foster Student Learning of Scientific Practices" guide is a framework of scientific practices that scientists use in the field. The Guide was developed to help K-12 teachers introduce their students to the methodologies used for scientific field research and guide them through the process of conducting field investigations using these scientific practices. In particular, this guide demonstrates how to use descriptive and comparative methodologies for field studies typically used in the environment and natural resource sectors. The guide has been updated to address how the three dimensions of the Next Generation Science Standards (NGSS) may be used to integrate the field investigation scientific practices with real world content through crosscutting concepts that practicing field scientists and engineers tackle in their role as professionals.

Scientific investigations are essential to the study of the natural world and provide valuable information for problem solving through engineering practices to tackle environmental issues that currently confront society. To identify the key methodologies employed by professional researchers for field science investigation, the Pacific Education Institute (PEI) conducted a nationwide study. From the results of this study, PEI, a public-private consortium of natural resource and education agencies and organizations, developed the field investigation methodologies presented in this publication. These field investigation methodologies thus reflect the contemporary scientific practices used by field biologists in environment and natural resource sectors (fish, wildlife, habitat, forests and water related studies).

The Association of Fish and Wildlife Agencies (AFWA) engaged the Pacific Education Institute to provide a NGSS perspective of field investigations for teachers to help them implement meaningful science and engineering practices with their students. The guidelines fulfill expectations of the K-12 plan for the North American Conservation Strategy, funded by a Multistate Grant of the Sport Fish and Wildlife Restoration Program.

The Field Investigation Guide has been updated to demonstrate how these scientific practices may be integrated with the Next Generation Science Standards (NGSS) three dimensions of science education.

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Acknowledgements

Education should prepare both students and the public to understand the natural resources on which we all depend. It should also provide opportunities for students and other citizen scientists to investigate natural resource concerns and make meaningful contributions to our understanding of the natural environment. The guidelines for Field Investigations were developed to help facilitate this critical advance in education. For its creation and publication, we are especially indebted to those at the Washington State Department of Fish and Wildlife who recognized that an informed and engaged public is critical to the mission of natural resource agencies and who therefore championed this seminal education project: Dr. Jeff Koenings, Director of the Washington Department of Fish and Wildlife (WDFW), John Pierce, Chief Wildlife Scientist, Richard "Rocky" Beach, Wildlife Division, and Michael O'Malley, Watchable Wildlife Program.

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Chapter 1

Field Investigations and the Next Generation Science Standards

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

What are field investigations?

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

Why conduct field investigations?

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

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

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

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

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

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

Crosscutting Concepts

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

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

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

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

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

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

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

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

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

Science and Engineering Practices

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

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

Science beyond the laboratory or classroom

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

How are field investigations different from controlled laboratory experiments?

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

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

Are all field investigations the same?

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

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

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

A model for field investigation

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

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

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

Documenting the Field Investigation Science Practice

Identify the Phenomenon to Be Investigated

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

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

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

Make a Prediction (Initial Claim)

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

Decide on Materials

The materials needed to perform the investigation are listed.

Plan the Field Investigation

The investigation plan includes:

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

Carry out the Investigation (Collect the Data)

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

Analyze and Interpret Data

Organize Data

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

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

Identify Relationships

Patterns and trends in the data are observed and described.

Interpret Data

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

Construct an Argument/Explanation

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

- **A claim**

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

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

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

Extend the Investigation

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

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

Chapter 2

Preparing Students to Conduct Field Investigations

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

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

Lessons in this section include:

1. What Questions Can I Investigate?

2. Descriptive Field Investigation: What Plants and Animals use the Schoolyard Habitat?

3. Comparative Field Investigation: How Does Surface Temperature Vary With Location?

Chapter 2: Preparing Students to Conduct Field Investigations

Lesson 1: What Questions Can I Investigate?

Objectives

Students will:

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

Student Outcomes

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

Thinking Skills

Comparing/Contrasting, Classifying

Learning Experience

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

Materials

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

Next Generation Science Standards (NGSS)

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

Background

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

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

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

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

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

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

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

Lesson 1: What Questions Can I Investigate?

ENGAGE

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

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

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

EXPLORE

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

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

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

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

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

EXPLAIN

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

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

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

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

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

    d. What questions do you have about your categories?

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

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

ELABORATE

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

EVALUATE

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

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

Student page - Three Types of Field Investigation Questions

Descriptive Questions

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

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

Comparative Questions

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

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

Correlative Questions

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

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

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

Does more salal (type of plant) grow in riparian, forest, or field habitats?

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 Pileated Woodpeckers live in Schmitz Park?

How many deer live in Olympic National Park?

How many eggs does a salmon lay in the fall in Longfellow Creek?

How often do Swallowtail Butterflies lay eggs in a season in Eastern Washington?

What is the depth of McLane Creek at Delphi Road in September?

What is the air temperature at your school throughout the school year?

What kinds of plants grow in ___ Forest?

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

When do robins in western Washington nest?

When do hemlock trees pollinate?

What is the range of black bears living in Snoqualmie Pass?

What is the number and range of cougars in the Cle Elum, Roslyn 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 the Olympic Rain Forest?

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

Are there more black bears per acre on Snoqualmie Pass or Olympic National Forest?

Are there more snowberry bushes near streams or away from streams in the Grasslands/Steppe in eastern Washington?

Are deer more active during the dawn or the dusk in _____?

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 _____?

Do temperatures differ between forested and non-forested streams in _____?

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

How does Douglas-fir seed production time change as elevation changes in the north Cascade mountains?

How does dissolved oxygen change as water temperature goes up in ___ stream?

How do mouse populations change as hawk populations increase in the Puget Sound area?

How do heron populations change as eagle populations increase in the Puget Sound watershed?

As elevations increase, how does the number of grand fir trees per acre change in the south Cascades?

What is the relationship between number of days over 60° 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 salmon eggs hatching in a stream?

Chapter 2: Preparing Students to Conduct Field Investigations

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

Objectives

Students will:

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

Student Outcomes

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

Thinking Skills

Observing, Finding Evidence

Learning Experience

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

Materials

Per Class

- Field Guides

Per Pair of Students

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

Per Student

Clipboards
Ruler
Hand Lenses

Next Generation Science Standards (NGSS)

Dimension from the Framework	Connections to the 3 Dimensions of NGSS
Disciplinary core idea: • LS4.D Biodiversity and Humans	Students observe living things in a specific habitat. This is a foundational activity for understanding in this Disciplinary Core Idea and can connect to multiple NGSS Performance Expectations such as: • 2-LS4-1 Make observations of plants and animals to compare the diversity of life in different habitats. • 3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
Crosscutting concepts: • Patterns • Systems and Systems Models	• Students look for patterns in which living things live in the schoolyard. • Students clarify the schoolyard ecosystem as a system by identifying the living parts of the system.
Science and engineering practice: • Planning and carrying out investigations • Analyzing and interpreting data • Obtaining, evaluating, and communicating information	• Students plan and conduct observations of the schoolyard. • Students analyze and interpret the data to answer the question, "What lives in the schoolyard?" • Students communicate their findings from the investigation.

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

Background

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

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

Lesson 2: Descriptive Field Investigation:

What Plants and Animals Use the Schoolyard Habitat?

ENGAGE

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

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

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

Large Study Area

EXPLORE

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

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

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

EXPLAIN

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

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

Special Study Area

EXPLORE

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

EXPLAIN

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

ELABORATE

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

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

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

EVALUATE

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

    a. drawings that fill the notebook page

    b. small objects/organisms are enlarged

    c. drawings are detailed

    d. parts of an organism/object are labeled

    e. color is added as appropriate

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

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

Examples of Student Questions

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

What is the most occurring plant at Oak Tree Park?

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

What is the lifecycle of each species?

What are the eatable plants?

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

How big is Oak Tree Park?

How many different kinds of trees are there?

What the most common trees?

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

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

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

Is there water at the park during spring?

How many different animals live in the forest?

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

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

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

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

How many total square miles is Oak Tree Park?

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

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

Nature Observation Form

Location: Oak Tree Park

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

Nature Observation Form

Location: ~~[illegible]~~ Oak Tree Park

indian plum

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

Educator Insights

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

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

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

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

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

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

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

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

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

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

Descriptive ?'s

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

Comparison ?'s

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

Chapter 2: Preparing Students to Conduct Field Investigations

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

Objectives

Students will:

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

Student Outcomes

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

Thinking Skills

Observing, Finding Evidence, Inferring

Learning Experience

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

Materials

- Thermometers
- Stopwatches

Next Generation Science Standards and Common Core ELA and Math

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

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

Background

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

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

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

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

Independent (Manipulated) Variable: The factor of a system being investigated that is being compared (collecting different samples of data under different conditions). (NGSS Appendixes Volume 2, p. 55). In this investigation, the type of surface is the independent variable.

Dependent (Responding) Variable: The factor of a system being investigated that changes in response to the manipulated variable and is measured or observed. In this investigation, the surface temperature is the dependent (measured) variable. It is important that students actually record multiple measurements at one location so they experience repeating trials.

Controlled Variables: The conditions that are kept the same in a scientific investigation to provide for a fair test. In the case of field investigations not all conditions are under the control of the investigator. In this investigation, using the same type of thermometer, how thermometers are positioned, wait time, and light exposure are all controlled variables.

Lesson 3: Comparative Field Investigation:

How Does Surface Temperature Vary with Location?

ENGAGE

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

Elicit responses

EXPLORE

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

Practices:
Questioning

Planning and carrying out investigations

Cross cutting concepts:
Patterns

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

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

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

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

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

EXPLAIN

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

ELABORATE

Here are some ideas for elaboration:

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

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

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

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

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

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

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

EVALUATE

Procedure - Student Self Evaluation:

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

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

See Procedure Scoring Rubric page 36.

Data Collection-Student Self Evaluation:

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

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

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

Argument/Explanation Evaluation:

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

This rubric is given on page 38.

Claim

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

Evidence

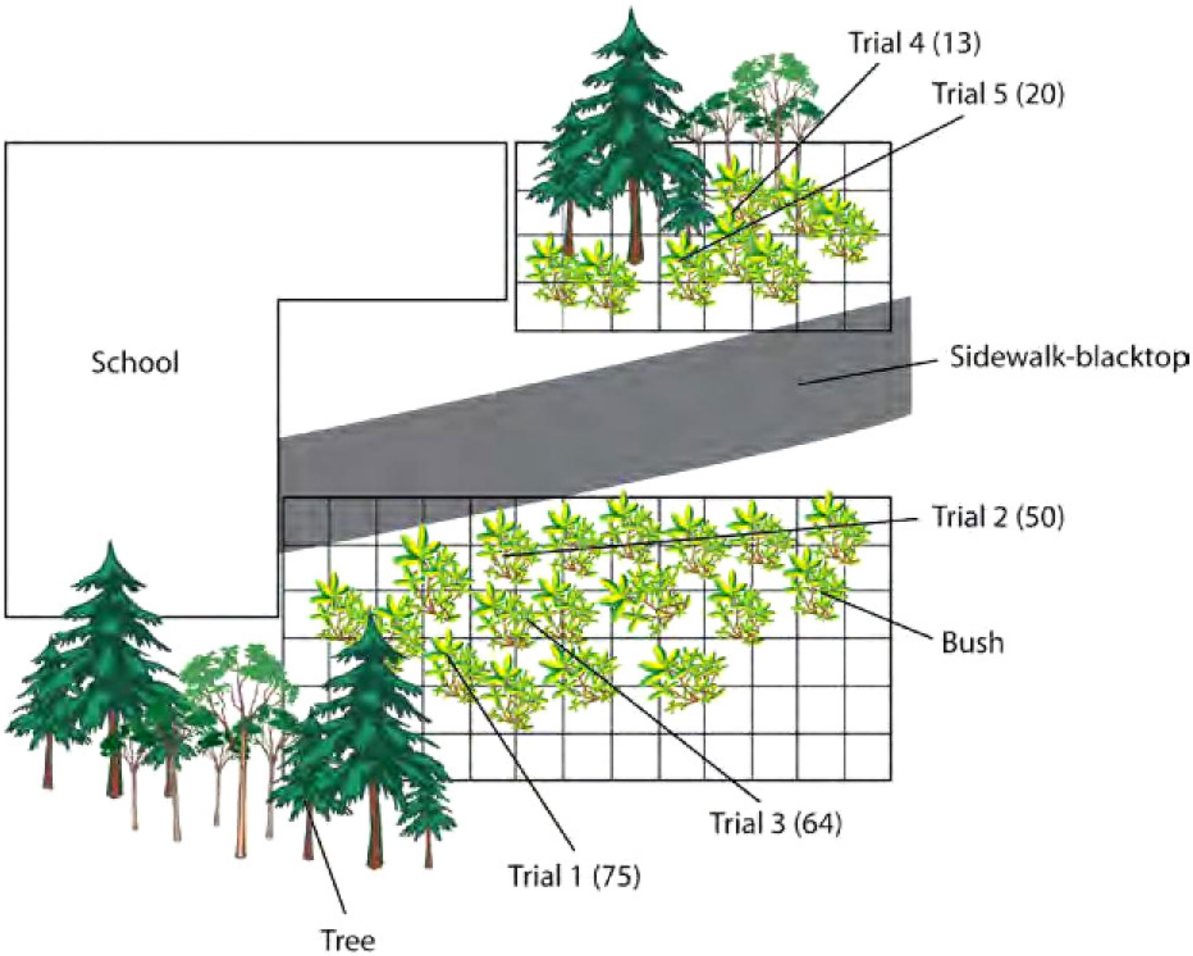
- **Appropriate** - gives average temperature data.
- **Sufficient** - gives average temperature data for the all three surfaces, but doesn't give all the data.

Reasoning

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

Map of Random Site Selection

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



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

Self - Evaluation: Procedure Rubric

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

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

Sample Procedure

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

Key

Underlined ➡	Independent Variable (manipulated variable - what is changed to make a comparison)
Double underlined ➡	Dependent Variable (responding variable - what is measured or observed for data)
Circled ➡	Controlled Variables (what is kept the same in the investigation)
* ➡	Multiple trials

Important Attributes of an Argument/Explanation

See Appendix B for a generic rubric.

Claim:

Directly and clearly responds to the question.

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

Limits claim to location, date, and time where field study took place.

Evidence

Appropriate: Gives average temperature data.

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

Reasoning

Stands-out: Does not repeat claim or evidence.

Link: Tells why there is enough evidence to support the claim.

Science Concept: Possible examples include:

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

Sample Data Sheet

How Does Temperature Vary With Surface?

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

Prediction/Hypothesis:____

____

Date______________________________Time_______________________________

Study site (location)____

Study site description____

____

____

Weather____

Type of Surface vs. Temperature °C

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

Sample Argument/Explanation Student Page

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

Claim Did I clearly answer the question? Did I limit the claim to the date, time, and place of the field study?
Evidence Did I use the right data? Did I give enough data?
Reasoning Did I tell why there is enough evidence to support the claim? OR Did I use a science concept to explain why my evidence supports the claim?

EXAMPLE 1- Data with a difference

Sample Data:

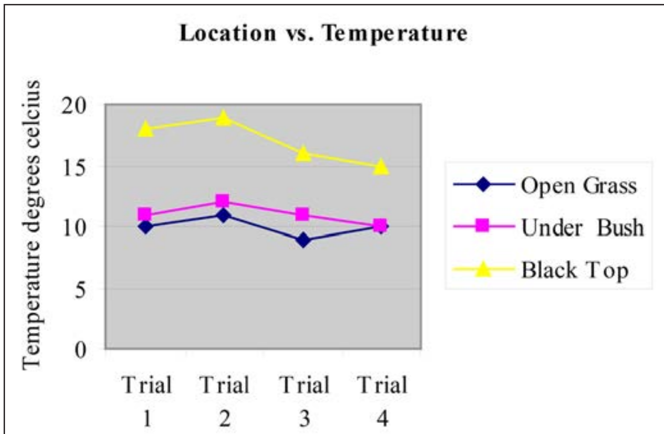
March 18, 2005, 2:30 pm
Dearborn Park Elementary, Seattle, Washington
Sunny afternoon

Location vs. Surface Temperature °C

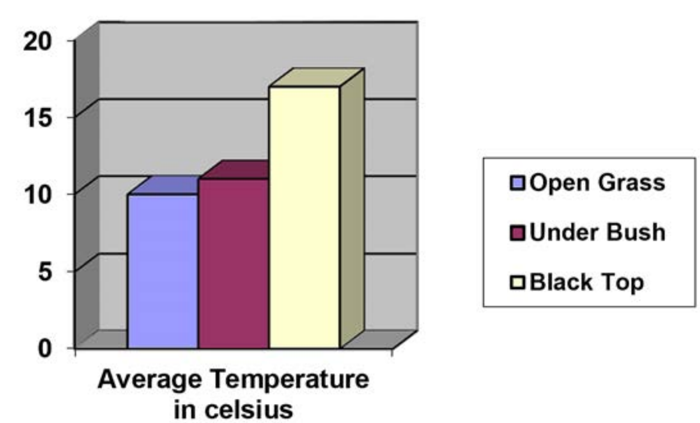
Location	Surface Temperature °C				
	Trial 1	Trial 2	Trial 3	Trial 4	Average
On the Open Grass	10	11	9	10	10
Under Bushes	11	12	11	10	11
On the Black Top	18	19	16	15	17

Data Analysis

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



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



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

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

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

Example 1- Constructing Arguments/Explanations

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

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

Claim

At Dearborn Park Elementary on March 18, 2005 at 2:30 pm the blacktop had the highest average surface temperature.

Evidence

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

Reasoning

The blacktop was 7 °C warmer than on the open grass so this was enough of a difference even with our small sample size to indicate that the blacktop was the hottest surface. The blacktop had the highest temperature of any of the 3 surfaces on this sunny day because dark colors just like my black T-shirt absorb more sunlight and get warmer than other colors. Both on the grass and under the bushes had green plants covering the surface so they didn't absorb as much light and didn't get as warm.

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

Important Attributes of an Argument/Explanation

See Appendix B for a generic rubric.

Claim

Directly and clearly responds to the question.

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

the black top had the highest average surface temperature

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

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

Evidence

Appropriate: Gives average temperature data.

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

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

Reasoning

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

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

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

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

Example 2 - Data with no difference among surfaces

Sample Data:

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

Location vs. Surface Temperature °C

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

Example 2 - Constructing Arguments/Explanations

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

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

Claim

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

Evidence

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

Reasoning

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

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

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

Important Attributes of an Argument/Explanation

See Appendix B for a weighted rubric.

Claim

Directly and clearly responds to the question.

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

all the surfaces -blacktop, open grass, and under bushes- had the same temperature

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

At the Tumwater District Office on December 7, 2005

Evidence

Appropriate: Gives average temperature data.

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

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

Reasoning

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

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

Link - *There were four trials so I think this was enough evidence to make a claim about the surface temperatures at this location.*

Science Concept: *The surfaces received no direct sunlight during the morning and probably for days. All the surfaces were the same since there was no direct sunlight to be absorbed to make darker surfaces warmer.*

Calibrating Thermometers

For thermometers with no calibration ability:

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

For thermometers with calibration ability:

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

Calibration in Ice Water

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

Calibration in Boiling Water

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

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

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

Next Generation Science Standards

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

Disciplinary Core Ideas:

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

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

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

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

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

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

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

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

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

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

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

Soil Temperature Investigation

Soil Temperature Investigation Procedure:

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

Date 5/1/07

School Loyal Hight Elem

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

Weather Sunny partly cloudy, low 50s

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

6

9

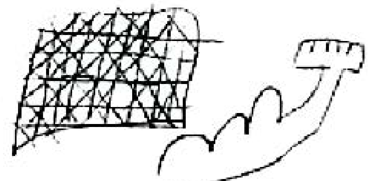
5/2/07

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

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

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

Soil Temperature Investigation



Soil Temperature Investigation Procedure:

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

Date 5-1-07

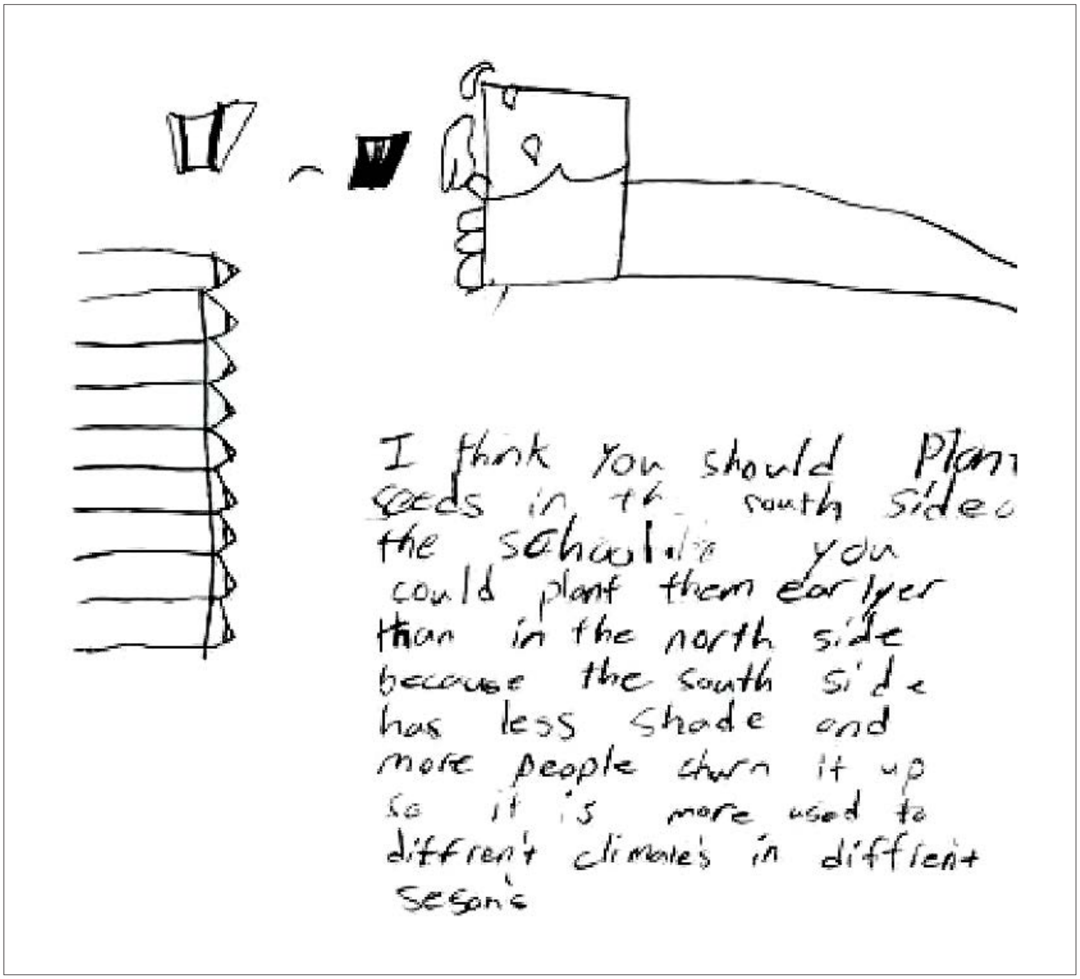
School loyal Heights

Study site description [illegible]

Weather Sun Cloud low 50s

55 in tree

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


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

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

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

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

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

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

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

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

Chapter 3

Building Field Investigations from Student Questions

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

Lessons in this section include:

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

   What Does This Tree/Shrub Look Like?

   What are the Physical Characteristics of this Tree/Shrub?

2. **Descriptive Field Investigation**: Twigs

   What do Twigs Look Like Each Month?

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

3. **Comparative Field Investigations**: Twigs

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

   Do Buds on ______________Type of Tree/Shrub or ___________Type Tree/Shrub Burst Earliest in Spring?

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

Chapter 3: Building Field Investigations from Student Questions

Lesson 1: Descriptive Field Investigation: Trees/Shrubs

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

Objectives

Students will:

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

Student Outcomes

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

Thinking Skills

Observing, Classifying, Finding Evidence, Inferring

Learning Experience

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

Materials

- Journals
- Rulers
- Compass
- String

Additional Resources

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

Project Learning Tree - Adopt a Tree, pg. 97

Project Learning Tree - Bursting Buds, pg. 277

Project BudBurst, www.budburst.org

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

Sky Tree by Thomas Locker

Next Generation Science Standards and Common Core

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

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

Background

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

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

Lesson 1: Descriptive Field Investigation: Trees/Shrubs

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

ENGAGE

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

EXPLORE

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

Examples of Descriptive Questions about Trees and Shrub

EXPLAIN

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

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

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

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

ELABORATE

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

EVALUATE

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

Student Examples of Tree Drawings

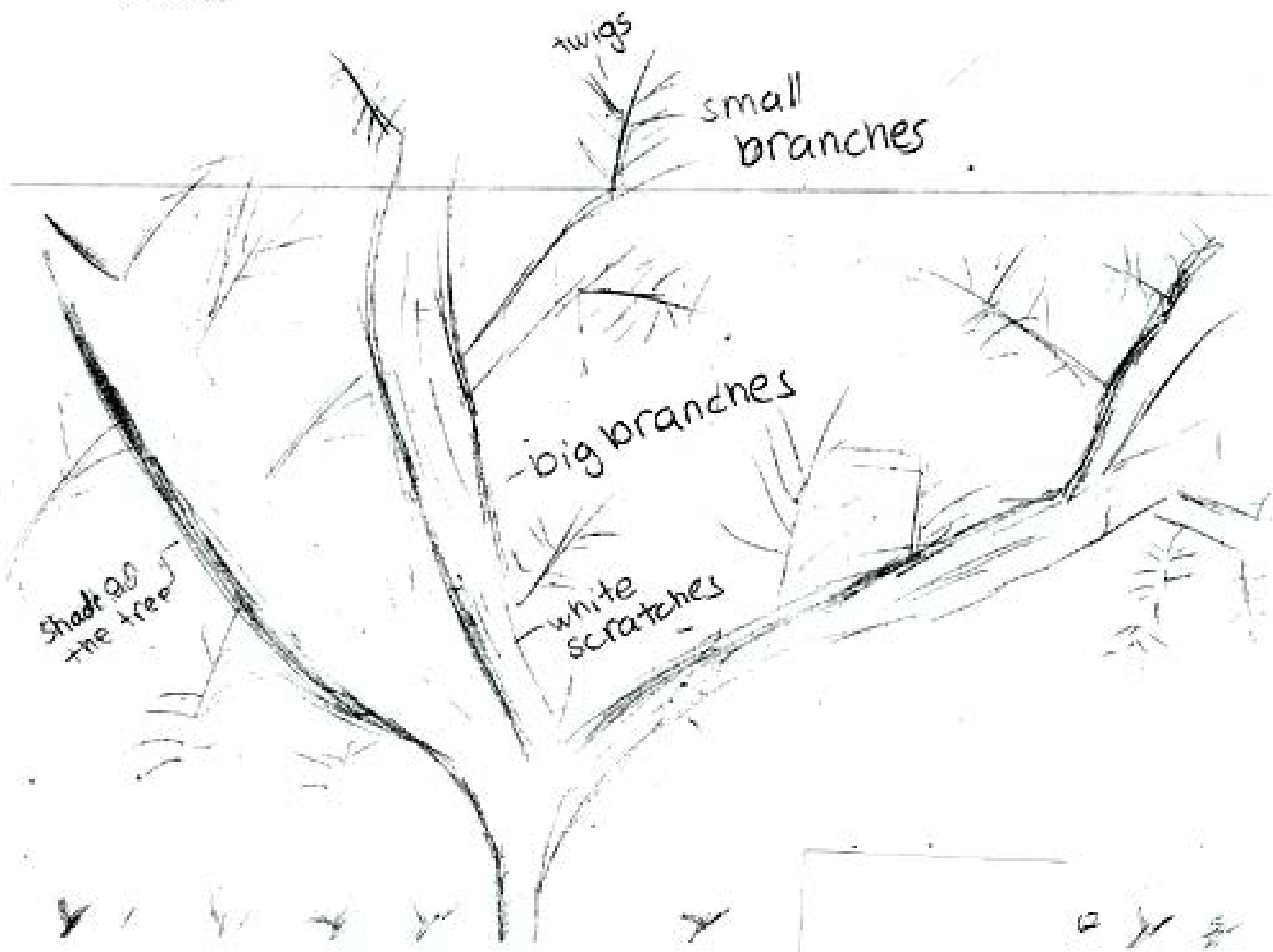
4th grade students at Sunny Hills Elementary in Issaquah, Washington drew trees and recorded their observations. Students were observing how their tree provided habitat for other organisms. The first student uses detailed observational evidence to support her answers to the questions (e.g., "The tree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

Trees as Habitats

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

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

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



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

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

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

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

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

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

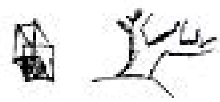
7. The plants at the bottom of the tree may give it [more] food or water.

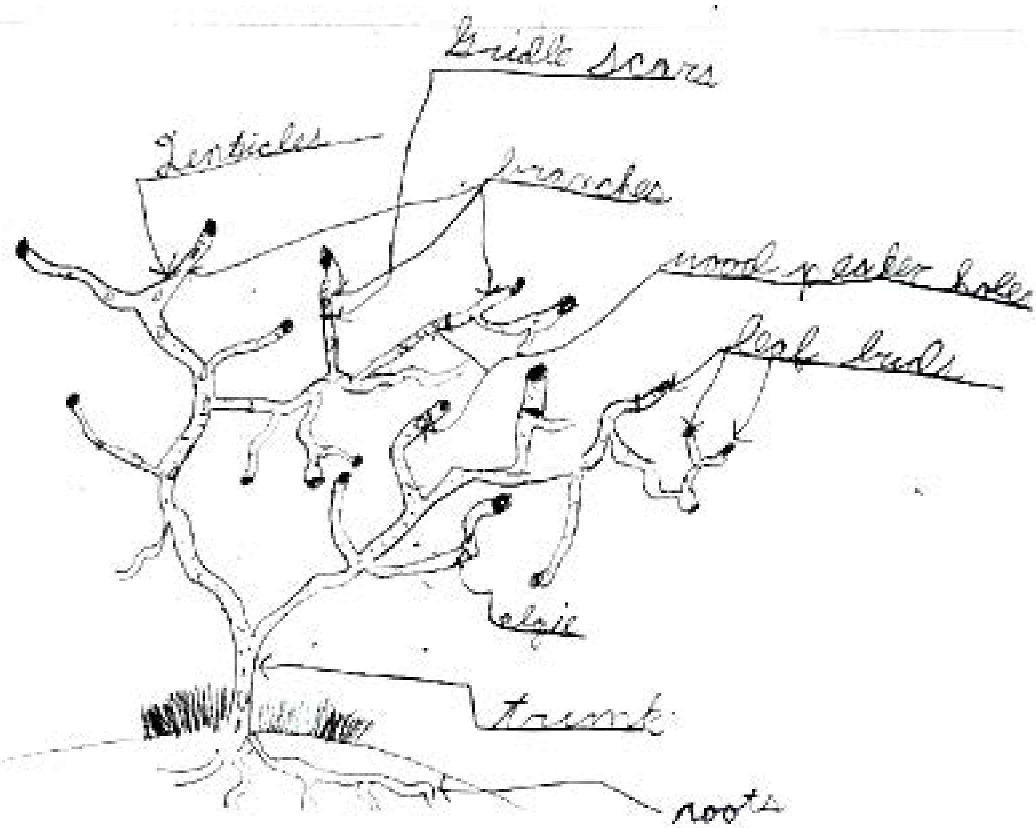
Trees as Habitats

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

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

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





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

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

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

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

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

Q6. The tree may be effected by the algie.

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

Lesson 2: Descriptive Field Investigation: Twigs

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

ENGAGE

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

EXPLORE

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

EXPLAIN

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

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

ELABORATE

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

EVALUATE

When assessing the journal descriptions and drawings, look for:

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

Date__________________________Time_________________________ Name____

What are the physical characteristics of your twig? Weather____

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

Questions I have about the twig:

Describe the twig:

____

____

____

____

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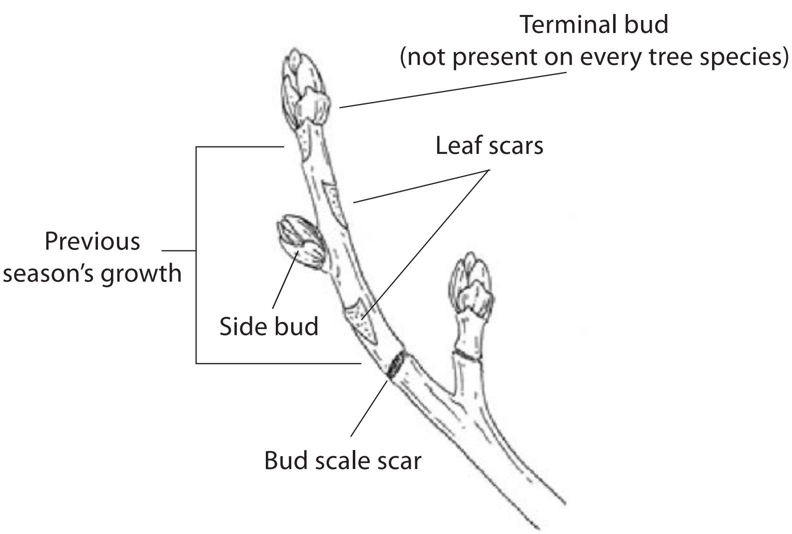
Amount of twig growth last year:

TWIG DIAGRAM



Lesson 3: Comparative Field Investigation: Twigs

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

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

ENGAGE

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

Comparative Questions

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

EXPLORE

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

EXPLAIN

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

ELABORATE

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

EVALUATE

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

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

EXAMPLE 1- Investigation Plan and Data Sheet

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

Prediction:____

Materials: Compass, ruler, string, scissors or marker

Procedure:

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

Side of Tree/Shrub vs. Twig Growth

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

Sample Data:

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

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

Side of Spindle Bush vs. Twig Growth

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

Sample Data:

Orchard Elementary, Spokane, Washington

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

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

EXAMPLE 1- Investigation Plan and Data Sheet

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

Prediction:____

Materials: Calendar

Procedure:

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

Date_______________________Time_____________________________Place____________________

Description of Study Site:

____

____

____

Location of Study Site:

____

____

____

Data Sheet

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

Chapter 4

Using Data Collected Over Time to Identify Patterns and Relationships

Water Quality and Macroinvertebrate Study

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

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

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

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

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

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

Students collecting macroinvertebrates

Students sorting macroinvertebrates

What research questions guide the field investigation?

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

Descriptive Questions

What are the physical characteristics of the stream?

What is the surrounding land use?

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

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

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

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

Comparative Questions

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

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

Correlative Question

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

What is the field investigation design?

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

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

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

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

How is data collected and organized?

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

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

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

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

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

Water Quality Tests

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

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

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

Figure 1

Figure 2

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

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

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

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

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

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

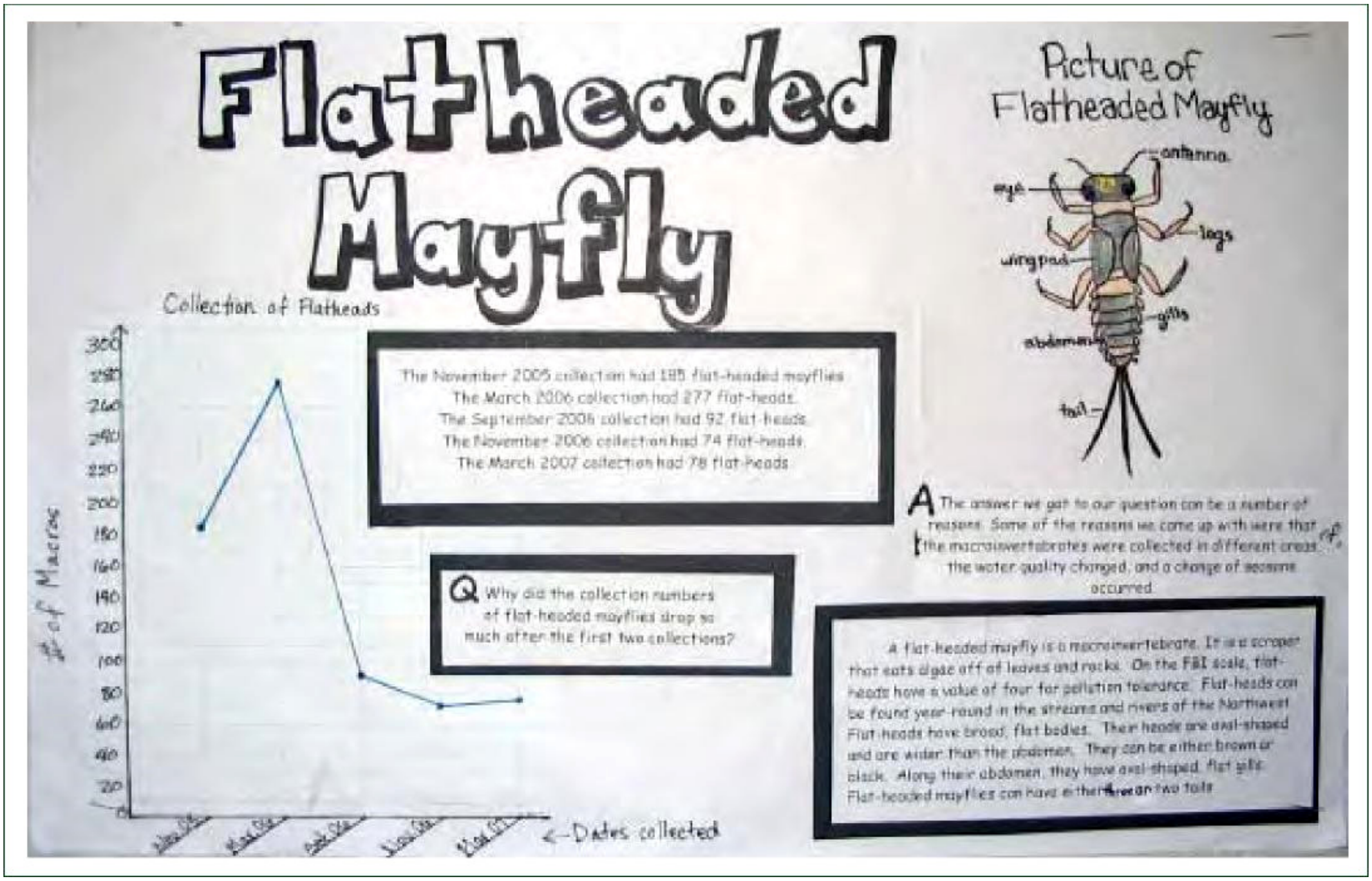
The activity presented below is an example of how students transition from following collection protocols to leading a scientific investigation. They pursue their own, self-selected analysis of the data and communicate their findings in the form of a poster and classroom presentation. In this poster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

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

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

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

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



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

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

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

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

Chapter 5

Case Examples of Field Investigation in Washington Schools

In Washington State, students, teachers, and wildlife biologists collaborate to conduct field investigations. Below are profiles of two field investigation projects: collaboration between elementary students and farmers to study short-horned lizard behavior, and a district-wide initiative to study cougar/human interactions. By systematically collecting data over time, students and scientists build knowledge about the environment and understand environmental systems. These projects require a long-term commitment from both classroom teachers and natural resource agency biologists.

Cases in this section include:

- **Elementary Students: Adopt-a-Farmer Project: Short-horned Lizard (Horny Toad)**
- **Middle and High School Students: Project CAT: Cougars and Teaching**

Adopt-a-Farmer Project: Short-horned Lizard (Horny Toad)

http://naturemappingfoundation.org/natmap/projects/waterville/index.html
Contributed by Diane Petersen, Teacher, Waterville Elementary and Karen Dvornich, Fish and Wildlife Cooperative Research Unit, University of Washington

Students at Waterville Elementary School in Waterville, Washington and local area farmers have worked together since 1999 to investigate short-horned lizard biology.

What research questions guide the field investigation?

How do horny toads and farmers exist together in the farm fields?	
Descriptive Questions	**Comparative Questions**
What do horny toads eat? What do they do during the winter? What is the movement/range of the horny toad?	Is the farm field a source or a sink? What are most horny toads close to, road, fields, homes, or stream?

What is the field investigation design?

There are two levels to our investigative design. Farmers collect data and students track the movement of horny toads using radio collars.

Farmers Collect Data

We realized the students couldn't collect observational data themselves, since most of the sightings occur during the summer. Thus, we invited local farmers to partner with us. We listed all the farmers we knew and composed a letter asking them to be "adopted."

We designed a data collection sheet based on the questions we had. We identified the habitats common to the area and translated them from ecologist language to language familiar to the farmers. We included the habitat list with the data collection sheets. We also sized the data collection form so that it was easy for farmers to use. During the summer months, the farmers record their observations. At the beginning of each new school year, farmers come into the classroom with their forms and partner with students to share data.

Habitats of Waterville

(Revised 11/5/06)

Agriculture

Habitat Code: 321 – Maintained pasture
322 – Crops (wheat, canola, etc.)
324 – Conservation Reserve Program (CRP) land

Developed

204 – Alongside of roads or between a road and field
231 – Home

Disturbed non-forested habitats – areas people use a lot

612 – Man-made scab patch
616 – A dried stream bank inside or along farm fields or hedgerow

Non-disturbed habitats – areas people rarely use

622 – A naturally occurring scab patch
626 – A dried up stream bank with sagebrush around it

Students Track Range Using Radio Collars

Students collect two to three horny toads larger than four grams in a farm field near the school. The lizards are brought back to school to get weighed (if they are too small, they are put back into the fields). Students attach a radio collar to each lizard using silicon glue, and the lizards are released where they were found.

Groups of three or four students go out after school hours (as many nights as are possible) and some Saturdays during the six weeks the radios are transmitting. Following protocol developed by a Central Washington University graduate student, they locate the lizards and record the latitude/ longitude and temperature at multiple heights and distances from the scab patch. Data are entered into a spreadsheet and plotted onto ArcView[11].

How is the data collected and organized?

Farmers come into the class, and each of their sightings is given a unique number. Students work with their farmers and go to multiple stations (e.g., topographic maps, paper graphs) for each of the attributes the farmers collected. Farmers are trained by the students to digitize their sightings over aerial photos in ArcView and add the unique number in the associated table.

Two students use the data collection forms to enter data into a spreadsheet that contains all of the attributes of the data collection form, plus the unique identification code that relates to the GIS file.

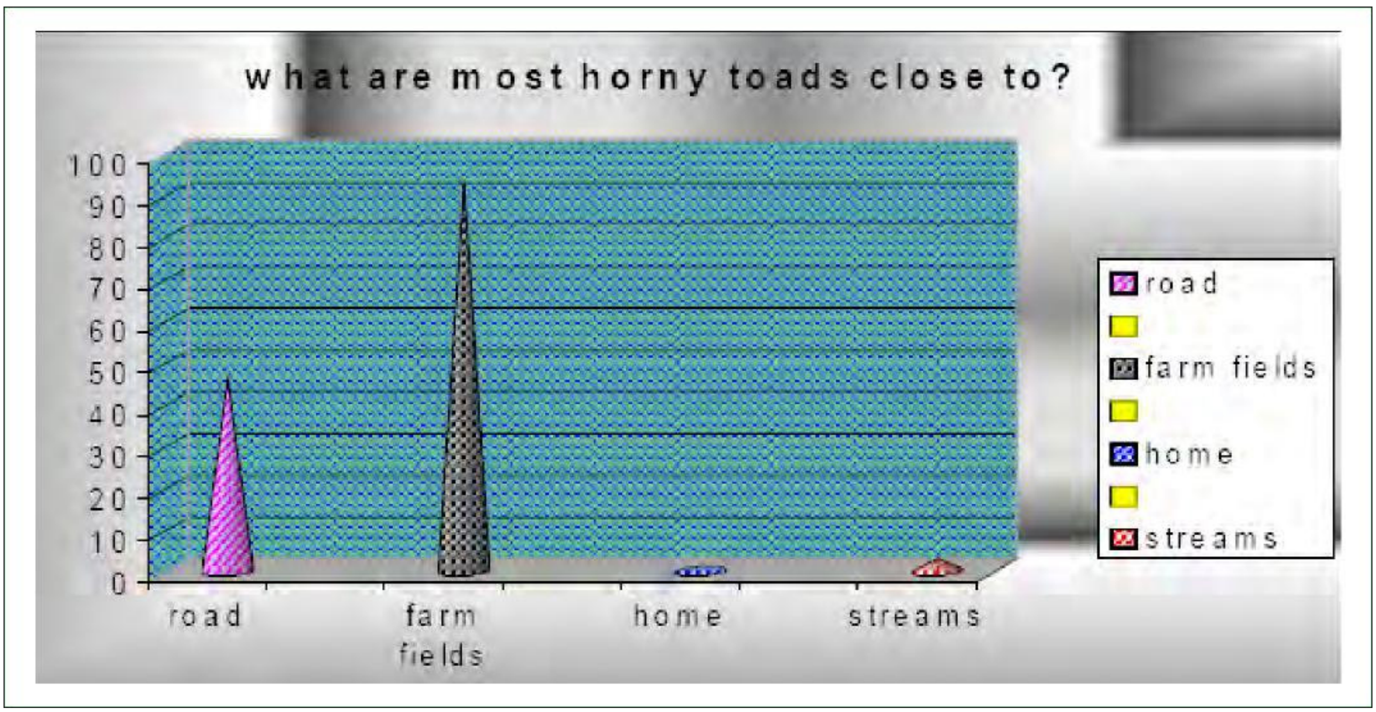
[11]ArcView (now called ArcGIS for Desktop Basic) is a GIS software solution that allows you to visualize, manage, and analyze your GIS data.

Two other students go over the same data to proof read it. Each pair of students chooses a question and selects the data column to answer their question. They sort the column(s) and group it to make graphs depending on their question. They choose comparative or descriptive questions. This past year, a correlative question was graphed. Students analyze each others' graphs to make sure they make sense and are accurate. The graphs that answer the questions the best are sent to the website at the University of Washington. Below are two graphs that were created by students, as well as their field investigation questions and interpretations of the data.

Question: What are most horny toads close to?

Prediction/hypothesis:
I think most horny toads are will be found by a wheat field because there are a lot of bugs in a wheat field.

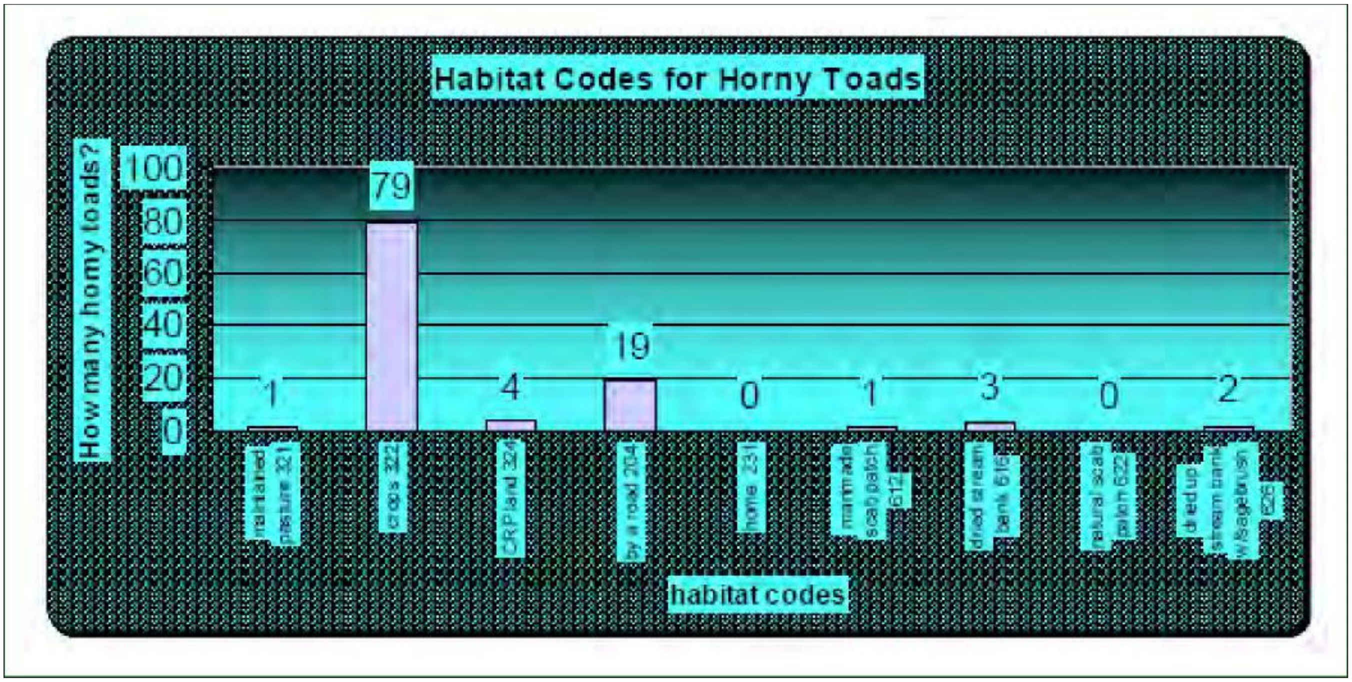
Conclusion:
My prediction that most horny toads would be found close to wheat fields was correct. The maximum number was 96 horny toads in wheat fields. The minimum number was 3 horny toads found by streams. For habitats like a manmade shelter there are 0 horny toads living there.



Question: what habitat code is used most often?

Prediction/Hypothesis: I think habitat code 322 will be found most often because they live there.

My prediction for habitat codes was correct. The maximum number was 78 in farm fields. The minimum number was 1 in a scab patch. For habitats 622,321,324 there were 0 seen.



What is your most important finding to date?

1. Horny toads do co-exist with farmers in the fields.
2. Their prey food is not exclusively ants. We have learned that they also eat medium sized grasshoppers and meal worms.
3. Their range of movement is greater than what has been written in literature. We found ranges up to four times the range of the lizards in Southern California.

What challenges have you faced?

1. Weather
2. Money
3. Technology (purchasing, use)
4. Time
5. Data management (making sure your data are stored where they can't be erased or damaged)

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

Take one step at a time, begin simply, and get help from an expert. Don't be afraid to jump in and see where it goes. There's no way you can predict or plan for everything. Begin with the kids' questions. We always predict what we believe we will find out in our research. We look next at what the scientific literature (usually field guides) says. Then, we collect data and we see how the data compares to our predictions and our research.

- Find something that is real to the kids, that they are interested in and is do-able - think it through.
- Find a mentor who can advise and help train students. The Fish and Wildlife Cooperative Research Unit (UW) scientists and graduate students have been very helpful to us.
- Plan ahead on how you are going to store the information (where and how you are going to store it) and write it down.
- Develop a constant format for entering data (e.g., all caps, etc.).
- Put the data onto the spreadsheet as soon as possible and make sure you verify what was entered.
- Write notes of the problems and what you did because you will forget.
- Find local community support and involvement to help with the project - chaperones on field trips, donations from business for bus money, local professionals to help in the field, or in our case local farmers to collect data.
- Plan for changes to the protocols and database over time. For example, some of our questions were removed because other ones became more important.
- If you are going onto private land be sure to get permission from the land owner.
- If you are going to display pictures of students on the web, student picture release forms are needed.

What do students learn from the field investigation process?

Students learn how to conduct scientific projects that can be replicated. They discover the importance of consistent data collection and data entry (students do not like to fix other students' errors) and use data to make better sense of the local environment.

Students have a real reason for using math and writing skills. They learn how to analyze their data in multiple ways by presenting their results and discussing their methodology with natural resource professionals using PowerPoint, graphs, and a website. Thus, they learn they can make a real contribution to the scientific knowledge base and gain the personal skills of meeting people of different ages and vocations and feel comfortable discussing their work.

Project CAT: Cougars and Teaching

http://naturemappingfoundation.org/natmap/projects/cat/

Contributed by Trish Griswold, Teacher, Walter Strom Middle School and Gary Koehler, Ph.D., Wildlife Biologist, Washington Department of Fish and Wildlife.

Investigating where cougars go when their habitat is changed by human developments is a research collaboration between K-12 students in the Cle Elum-Roslyn (CER) School District in eastern Washington and biologists with the Washington Department of Fish and Wildlife. Students work with wildlife scientists to study the indigenous cougar's ecology and behavior to understand how to better manage human-cougar interactions.

What research questions guide the field investigation?

Where do cougars go when their habitat is changed by housing development?	
Descriptive Questions	**Comparative Questions**
What areas do cougars select to hunt?	How much space do male and females cougars occupy during each season? Is there a difference in numbers of deer and elk (cougar prey) killed by male and female cougars?

What is the field investigation design?

Middle school students collect and analyze data over time. They work alongside wildlife biologists, capture cougars, tag them with global positioning system (GPS) collars (which provide more than 2,000 location readings for each animal per year), mark them with ear tags, and collect physical data that includes length, neck girth, chest girth, length, weight, and condition of canine teeth. Students plot coordinates of cougar locations on computer-generated maps of the study area, and use computer programs to calculate the space each cougar travels annually. The location information allows scientists to study what habitats cougar use and where cougars prey on deer and elk. Students present their findings at scientific conferences and through a program called Cougar Wise in which they inform community members how to coexist with cougars.

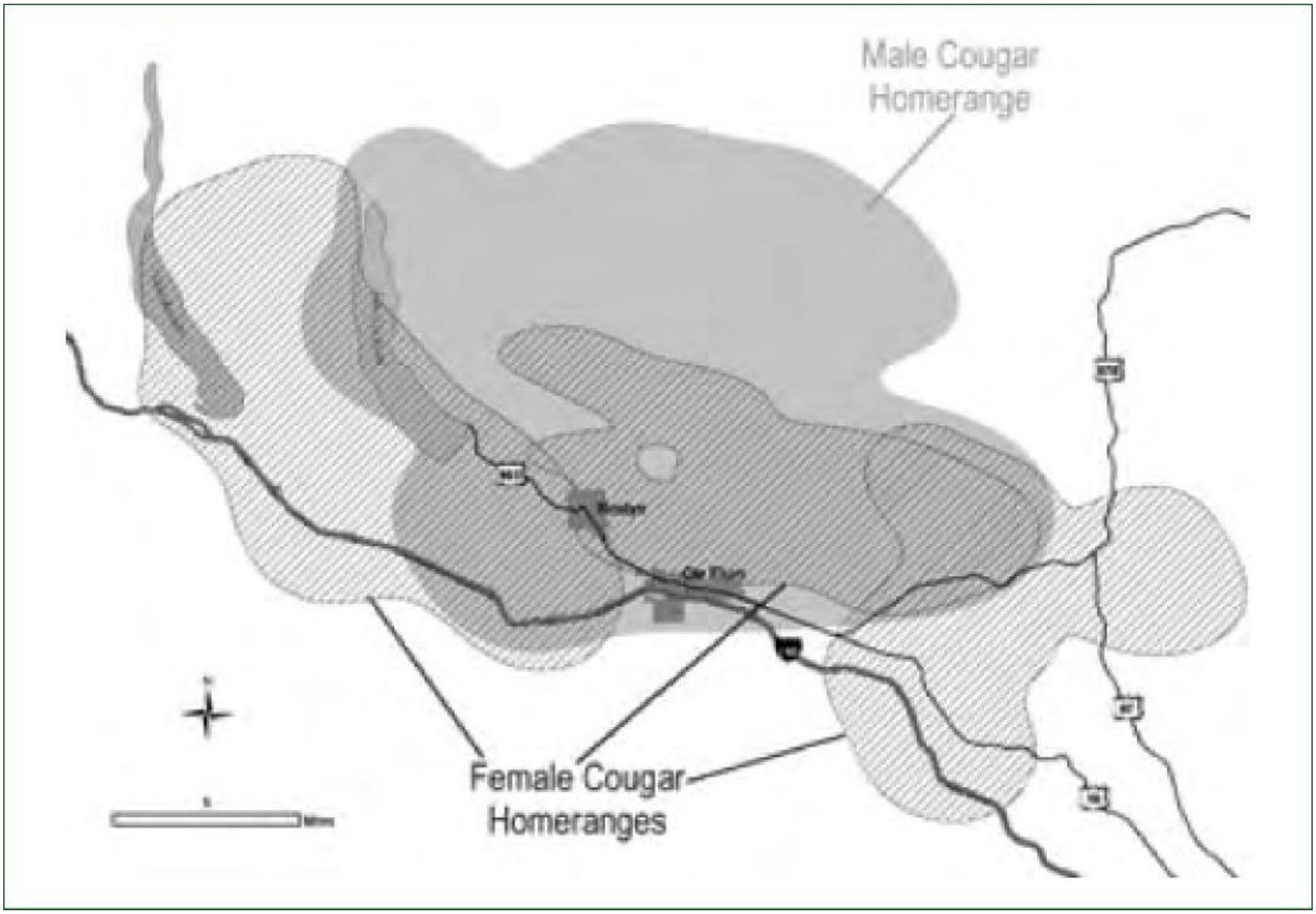
How is data collected and organized?

GPS collars collect location coordinates at four hour intervals throughout the year. Location data is downloaded onto spreadsheets and onto computer generated maps of the study area. Coordinates for clusters of GPS locations are inputted onto a hand-held GPS to help students and the research team to navigate to the cluster site to investigate what may have attracted the cougar to the location. Evidence of prey remains (bones, skulls, and hair) is collected and the species identified. Data from site inspections is categorized into age and sex of cougars, date the cougar was present, species of prey remains, as well as whether no remains were identified. Information on sex and age of cougar is compiled and correlated with species of prey remains to assess whether different ages and sexes of cougars select different species of prey animals.

What has been your most important finding to date?

In the Cle Elum area, a mature male cougar can defend about 150 square miles; dominant males constantly patrol their territory to protect prey and females from other males. Within this territory, there may be two or three females, each one demanding about 50 square miles of territory to meet her needs to raise a litter. GPS data has documented young male cougars traveling as far as 160 miles through rugged mountain and desert terrain to establish their own territory. We have also observed that male cougars tend to select for larger prey species like elk, while females tend to select for smaller sized deer.

Map of Cougar Homerange



What challenges have you faced?

I have included field investigations in 8th grade science because I desire to share my passion and training in forestry/wildlife science and encourage curiosity in science related areas. The field work is a perfect venue for teaching thinking skills, inquiry methods, and career connections. The challenge has been getting students to focus their work on one specific question, one question that they own. Working in the field allows students to see that science is "messy" and that mistakes are as valuable as successes. In addition, when they study a large animal like the cougar, students learn that their actions affect other species.

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

Truth about Science, a NSTA publication is a great place to start. The lessons walk the teacher and students through designing a quarter-long research project, from writing a good question through data analysis. Students will be outside in an organized way and gaining a sense of place. Teachers will become more confident. In the second phase, a class discussion focused on local issues will help create a relevant and personal research question on a larger scale. Students need to be involved in all steps of defining the problem and designing a solution. Professional scientists can assist at any time or bring their research question to the students and possibly allow them to participate. Motivation comes from passionate students! At some point, they will want to share their passion, so projects like CougarWise come to be.

What do students learn from the field investigation process?

Students educate the community and are learning firsthand the impact humans have on cougar behavior. They participate in the science and then, using their findings, they educate the public. This next year they hope to take the next step by sponsoring a voters' initiative to stop wildlife feeding. The students have learned that feeding wildlife like deer creates a lot of the human/wildlife conflicts.

Kevin White, wildlife ecology major at Washington State University, began his involvement with Project CAT as a high school junior. He shares what he has learned by studying cougar/human interactions, "As Cle Elum gets more developed there will be more sightings of cougars and the potential for more cougar/human encounters. The cougars have such a large home range; it is impossible for them to not walk by people's houses. Since I began working in 2003 more houses have been built in prime cougar habitat. The cougars I have documented kill deer and elk amongst people's property. In several instances I have found kill sites within 200 meters of homes and yet the owners were unaware of a cougar's presence in the area. That is what I enjoy about what I do; these cougars can kill a deer in the open, conceal it and itself in dense brush and no one knows they're even there."

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Appendices

Appendix A: The 5E Instructional Model

Appendix B: Rubric for Argument/Explanation-Claim, Evidence, Reasoning

Appendix C: Investigation Questions Sorting Key

Appendix D: Matrix of Descriptive and Comparative Activities in Project WILD, Project WET, and Project Learning Tree Curriculum Guides

APPENDIX A

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 5Es 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*.

Adapted from BSCS 5E Instructional Model. (Bybee, 2006)

Stage of 5 E Instructional Model	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, 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 figure 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.

Stage of 5 E Instructional Model	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 journals, drawings, models and performance tasks.

Appendix B- Claim, Evidence, Reasoning Rubric

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

Important Attributes for Argument/Explanation

Note: Not all attributes will be in every explanation

Claim:

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

Evidence:

Appropriate:

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

Sufficient:

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

Reasoning

Stands-out: Does not repeat claim or evidence.

Link:

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

Science Concept:

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

Appendix C: Investigative Questions Sorting Key

Excerpt from *Project-Based Learning Model: Relevant Learning for the 21st Century* (Baker, 2011) (Foundation, 2012) (Education, 2014) (Education C. f., 2000)

Descriptive
• How many Pileated Woodpeckers live in Schmitz Park? • How many deer live in Olympic National Park? • How many eggs does a salmon lay in the fall in Longfellow Creek? • How often do Swallowtail Butterflies lay eggs in a season in Eastern Washington? • What is the depth of McLane Creek at Delphi Road in September? • What is the air temperature at your school throughout the school year?* • What kinds of plants grow in ___ Forest? • What types of birds use the school habitat during the school year?* • When do robins in western Washington nest? • When do hemlock trees pollinate? • What is the range of black bears living in Snoqualmie Pass? • What is the number and range of cougars in the Cle Elum Roslyn area?
Comparative
• Does more salal (type of plant) grow in riparian, forest, or field habitats? • 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? • Is there a difference in the size of the range of a screech owl and barred owl in Washington's lowland forests? • Are mature (greater than 30 cm diameter) conifer trees taller than mature deciduous trees in the Olympic Rain Forest? • Which location (under bushes, open grass, or on black top) has the highest temperature at 7:00 a.m. at Cedar River Middle School? • Are there more black bears per acre on Snoqualmie Pass or Olympic National Forest? • Are there more snowberry bushes near streams or away from streams in the Grasslands/Steppe in eastern Washington? • Are deer more active during the dawn or the dusk in____? • 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 ___? • Do temperatures differ between forested and non-forested streams in____? • Do birds sing more from 8:30-9:00 a.m. or from 3:00-3:30 p.m.?

Correlative
• How does Douglas-fir seed production time change as elevation changes in the North Cascade Mountains?* • How does dissolved oxygen change as water temperature goes up in ___ stream? • How do mouse populations change as hawk populations increase in Puget Sound area? • How do heron populations change as eagle populations increase in the Puget Sound watershed? • As elevations increase, how does the number of grand fir trees per acre change in the South Cascades?* • What is the relationship between number of days over 60 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 salmon eggs hatching in a stream? *Some questions could fall into a different category depending on how the investigation is set up.

Appendix D

Field Investigation Resources: Project WILD, Project WET, and Project Learning Tree

*These guides contain activities which are easily adapted for use in descriptive and comparative field investigations.

Project WILD is a wildlife-focused conservation education program for K-12 educators and their students.
www.projectwild.org
K-12 Curriculum and Activity Guide
K-12 Aquatic Curriculum and Activity Guide
Science and Civics: Sustaining Wildlife (Secondary)*

Project WET Project Wet's mission is to reach children, parents, teachers and community members of the world with water education that promotes awareness of water and empowers community action to solve complex water issues.
www.projectwet.org
Project WET Curriculum and Activity Guide
Healthy Water, Healthy People (Secondary)*

Project Learning Tree (PLT) is an award-winning environmental education program designed for teachers and other educators, parents, and community leaders working with youth from preschool through grade 12.
www.plt.org
PreK-8 Environmental Education Activity Guide
Focus on Forests (Secondary)*
Municipal Solid Waste (Secondary)

Field Investigation Resources

Project WILD

Project WILD
Grasshopper Gravity
Bearly Growing*
How Many Bears Can Live in This Forest?
My Kingdom for a Shelter
Tracks!
Spider Web Geometry
Oh Deer!*
Graphananimal
Wildlife is Everywhere
Urban Nature Search
Rainfall and the Forest
Environmental Barometer
Habitrekking
Microtrek Treasure Hunt
Ants on a Twig
Seed Need
Owl Pellets*
Eco-Enrichers*
Birds of Prey*
Who Fits Here?
Forest in a Jar
Forest Ecologies
Ecosystem Facelift
Drawing on Nature
World Travelers
Turkey Trouble
From Bison to Bread: The American Prairie
Bird Song Survey*
Wildlife Research*
Dropping in on Deer*
Improving Wildlife Habitat in the Community

Aquatic WILD

Water Canaries
Marsh Munchers
Micro Odyssey
The Edge of Home
Where does Water Run?
Where have all the Salmon Gone?
The Glass Menagerie
Deadly Waters
Blue Ribbon Niche

Project WET

Adventures in Density
Back to the Future*
Cold Cash in the Icebox *
Easy Street
Every Drop Counts*
H2O Olympics
Irrigation Interpretation
The Pucker Effect*
Rainy Day Hike
Sparkling Water
Stream Sense
Thirsty Plants
Water Log
Water Meter *
Wet Vacation
Wetland Soils in Living Color*
What's Happening
Where are the Frogs*

Healthy Water Healthy People

Snapshot in Time*
Benthic Bugs*
Invertebrates as Monitors*
Water Quality Monitoring*

Project Learning Tree Pre-K Guide

Sounds Around*
Planet Diversity*
Invasive Species*
Adopt a Tree
Trees as Habitats*
Fallen Log*
Nature's Recyclers*
Pollution Search
How Plants Grow*
Sunlight and Shades* of Green
Have Seeds, Will Travel*
Water Wonders*
Web of Life
School Yard Safari
Are Vacant Lots Vacant?
Loving it Too Much?
Field, Forest, Stream*
The Closer You Look
Looking at Leaves*
Bursting Buds*
Germinating Giants*
How Big Is Your Tree?*
Name that Tree
Soil Stories*
Watch on Wetlands*
Trees in Trouble*
Signs of Fall*
Tree Lifecycle
Nothing Succeeds Like Succession?
Air We Breathe
Waste Watchers
The Global Climate*

Focus on Forests Secondary Guide:

Monitoring Forest Health
Forest Invaders
Climate Change and Forests

* These activities are particularly suited for adaption to descriptive and comparative field investigations.

NOTES: