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

December 2007

Developed by Pacific Education Institute
Margaret Tudor, Ph.D. and Lynne Ferguson, Co-Executive Directors

For Association of Fish and Wildlife Agencies, North American Conservation Education Strategy
Funded by Sport Fish and Wildlife Restoration Program Multistate Grant

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Preface

This volume—*Field Investigations: Using Outdoor Environments to Foster Student Learning of Scientific Processes*—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 studies. In particular, this volume demonstrates how to use descriptive and comparative methodologies for field studies.

Scientific inquiry is essential to the study of the natural world and the environmental issues that currently confront society. To identify the key methodologies employed by professional researchers for field science inquiry, 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 inquiry methodologies thus reflect the contemporary inquiry processes used by practicing field biologists in fish, wildlife habitat, forests and water related studies.

The Association of Fish and Wildlife Agencies (AFWA) engaged the Pacific Education Institute to provide the field investigation guidelines for teachers to help them implement meaningful science inquiry 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.

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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* was 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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Special thanks to all the teachers who have participated in workshops and shared their insights.

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Section 1
Field Investigations as Inquiry: A Conceptual Framework

> ***". . .science is not a fixed body of knowledge but an evolving attempt by humans to create a coherent description of the physical universe." —White, 2003, p. 174***

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 an investigative 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, learn the skills of scientific inquiry, and understand that science doesn't 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.

Systems Thinking

When planning and conducting field investigations, students and scientists grapple with the difficulties of working in a natural system and at the same time develop an understanding of its complexities and subsystems. Systems-thinking involves thinking about relationships, rather than about individual objects. A system can be defined in a number of ways:

- An assemblage of inter-related parts or conditions through which matter, energy, and information flow (Washington State EALR's).
- An organized group of related objects or components that form a whole (NRC).
- A collection of things and processes (and often people) that interact to perform some function. The scientific idea of a system implies detailed attention to inputs and outputs and interactions among the system components (AAAS).

Scientific Inquiry

State and national science education standards encourage instruction that focuses on problem-solving and inquiry—activities which characterize the pursuits of scientists. In field investigations, students pose a research 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 preservation and use of environmental resources?

Science Beyond the Laboratory or Classroom

Field investigations help students become informed citizen scientists who add knowledge to the community's understanding of an area in order to make issues of concern visible and share differing points of view about the preservation and use of community natural resources.

How are field investigations different from controlled laboratory experiments?

Classroom science often overemphasizes experimental investigation in which students actively manipulate variables and control conditions. In studying the natural world, it is difficult to actively manipulate variables and maintain "control" and "experimental" groups, so field investigation scientists look for descriptive, comparative, or correlative trends in naturally occurring events. Many field investigations begin with counts (gathering baseline data). Later, measurements are intentionally taken in different locations (e.g., urban and rural, or where some natural phenomenon has created different plot conditions), because scientists suspect they will find a difference. In contrast, in controlled experiments, scientists begin with a hypothesis about links between variables in a system. Variables of interest are identified, and a "fair test" is designed in which variables are actively manipulated, controlled, and measured in an effort to gather evidence to support or refute a causal relationship.

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. These three types of studies are often used in combination to study the natural world.

A Model for Field Investigation

Table 1 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 happened?	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
Collect and Organize Data	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		
		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.	

<table>
<tr><th></th><th>Descriptive</th><th>Comparative</th><th>Correlative</th></tr>
<tr><td rowspan="2">Analyze 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</td></tr>
<tr><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">Use Evidence to Support a Conclusion</td><td colspan="3">Answer the investigative question
Use data to support an explanation. What does the data mean?
Limit conclusion to the specific study site.
Compare data to standards.</td></tr>
<tr><td>Does the data summary answer the investigation question?</td><td colspan="2">Does the evidence support the prediction or hypothesis?</td></tr>
<tr><td>Discussion</td><td colspan="3">How does the data compare to other similar systems/models?
What factors might have impacted my research?
How do my findings inform the essential questions and/or understanding of the system?
What are my new questions? What other data do I need?
What action should be taken? Why?</td></tr>
</table>

Documenting the Field Investigation Process

Essential Question

Big picture questions that cannot be answered with one investigation.

Investigation Question

Researchable question that can be answered with qualitative or quantitative observations or measurements.

Hypothesis/Prediction

Predictions are not typically made for descriptive studies. For comparative studies, 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.

Materials

List the materials needed to perform the investigation.

Procedure

- Logical steps to do the investigation; steps written clearly so someone else could follow procedure.
- What variables are under study? What is changed (manipulated)? What is measured (responding)?
- 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.

Collecting, Organizing, and Analyzing Data

- Observe /Record 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) is recorded.
- Organize Results—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).
- Analyze Data to Look for Patterns and Trends—Populations are estimated; means, modes, medians, t-values and r-values are calculated; graphs, tables, or maps are analyzed for patterns; data are compared to standards.

Conclusion

- Provide a clear conclusive statement that answers the investigation question or states whether the hypothesis or prediction was correct. For descriptive investigations, provide a detailed description or model of results.
- Restrict conclusions to the time and place the investigation took place.
- Compare data to standards when appropriate.
- Use data to support the conclusion, description, or model.
- Use explanatory language to connect supporting data to the conclusion, description, or model.

Discussion

- 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.
- Describe any other reasons/observations that could explain results.
- Discuss how results inform the essential question and/or system understanding.
- Provide new questions about the system or model.
- Recommend future actions and explain why.

Section 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 investigation. First, students learn about the kinds of questions that guide field investigations; then, students conduct a descriptive field investigation; and finally, students 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, collecting, organizing and analyzing data, and writing conclusions.

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 Section 3 and 4 of this guide.

Lessons in this section include:

What Questions Can I Investigate?

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

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

Section 2: Preparing Students to Conduct Field Investigations

Part 1: What Questions Can I Investigate?

Objectives

Students will:

1) distinguish between three different types of investigative questions, and

2) suggest questions that can be asked about the natural world.

Science Grade Level Expectation

Questioning: Understand how to ask a question about objects, organisms, and events in the environment.

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?

Background

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 cannot be answered with one field investigation.

Asking a testable question is central to scientific inquiry. 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 gives way to 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?”

There are many types of questions. In addition to the three types of investigative questions, students may ask **essential** questions, **why** questions and book/internet **research** questions.

Lesson

Focus

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. Distribute the handout and discuss the three types of field investigation questions. You might ask students questions to help them notice differences in the three types of questions.
   - What patterns do you notice in each type of question?
   - What words are important to look for when identifying each type of question?

Explore

3. Divide the class into teams of three. Hand each team an envelope set of investigative questions, and ask them to sort the questions into three categories—descriptive, comparative, and correlative.

Reflect

4. Give the teams time to think about each question and agree on the categories. You can facilitate this process by asking the questions below as you circulate the room.
   - Did you all agree to this category? Explain how you came to this decision.
   - Can each one of you come up with a justification as to why these questions fall into the categories they do?
   - Do you have an uncertainty pile…if so, why? What more do you need to know?
   - What questions do you have about your categories?
   - Can you write your own examples of each type of question?
5. After about 10 minutes, have the class share their categories by asking about a sample of the questions you handed out. With a chart at the front of the class, have students from various groups place a question in the category they selected and have them say why they chose that category.
6. Discuss why scientists need to think about the questions they pose before working in the field.

Assessment

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.

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, fruit, babies born)
- 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 in at least two different (manipulated 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 ______ at 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 these questions on to card stock and cut into sentence strips

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 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?

Section 2: Preparing Students to Conduct Field Investigations

Part 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, and
3) pose descriptive and comparative questions based on their observations.

Science Grade Level Expectation

Characteristics of Living Matter: Observe and describe characteristics of living organisms.

Planning and Conducting Safe Investigations: Plan and conduct an observational investigation that collects information about characteristics or properties.

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

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 systematically collecting data over time at the same site, students can begin to see patterns.

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, first noting their overall observations, 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

Focus

1. Write the investigative question on the board: "What plants and animals use the school yard habitat?" Discuss strategies for observing—using four of the five senses (sight, hearing, touch, smell) and recording observations (drawing, using numbers, labeled diagrams writing). Hold up an object (e.g., pinecone, leaf, twig, rock) and ask students to describe its physical properties and characteristics. To prompt student thinking you might model drawing and/or writing observations as you ask:
   - 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

2. Divide the class into pairs before going outside. Students spend multiple lesson sessions journaling observations. Students can record measurements. They can use paint chips to name colors they observe in nature. Providing a wide range of green paint chips for example helps to expand students' color vocabulary beyond "green." Below are sentence starters that will help students generate questions about the system (Fulwiler, 2007).
   - I am curious about . . .
   - It surprised me that . . .
   - I wonder how this part effects another part of 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.

   Day 3: Looking Down. Students look down (to the ground) and record observations and questions.

   Day 4: Looking in the Middle. Students look at eye level and record observations and questions.

Reflect

3. After each observation session ask students to share their findings and questions.
4. Categorize the questions students pose (descriptive, comparative, correlative, essential, why, researchable).

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 tree 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?

Special Study Area

Explore

5. Divide the class into pairs and give each pair a hula hoop and yard stick.
6. Students select a study area and place the yard stick in the middle of the hula hoop to create a transect line and two observation quadrats. 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).
7. 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.
8. Students use field guides to identify plants and animals.

Reflect

9. 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?
10. Students formulate two descriptive questions and two comparative questions about the larger study site based upon their observations.
11. Ask students to reflect on the investigative question by writing or discussing, “What plants and animals use the school yard habitat?”

Assessment

Review students’ observations for a range of representational forms including numbers, words, labeled diagrams, and drawings. Descriptions might include size, shape, color texture, or smell. As you review student work you can look for

--drawings fill the notebook page

--small objects/organisms are enlarged

--drawings are detailed

--parts of an organism/object are labeled

--color is added as appropriate

--drawings have captions or titles and note the date and place recorded

In addition, in discussion with students as they observe, you can assess their insights and what they reflect about the quality of the observations.

5th grade students at Arlington Elementary School in Tacoma, Washington recorded counts of the animals in Oak Tree Park and then 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 tree?

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?

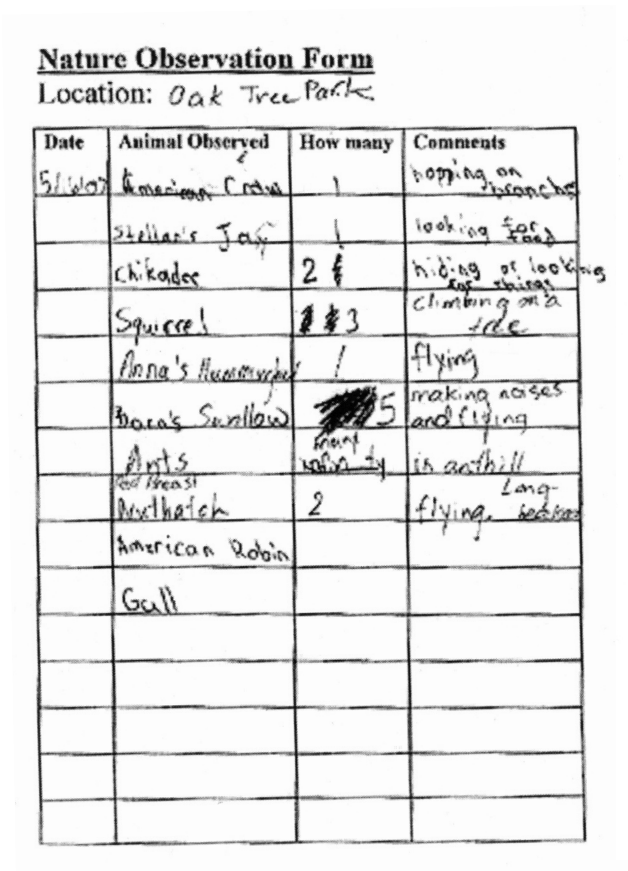
How many different types of ants are there in Oak Tree Park?

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?

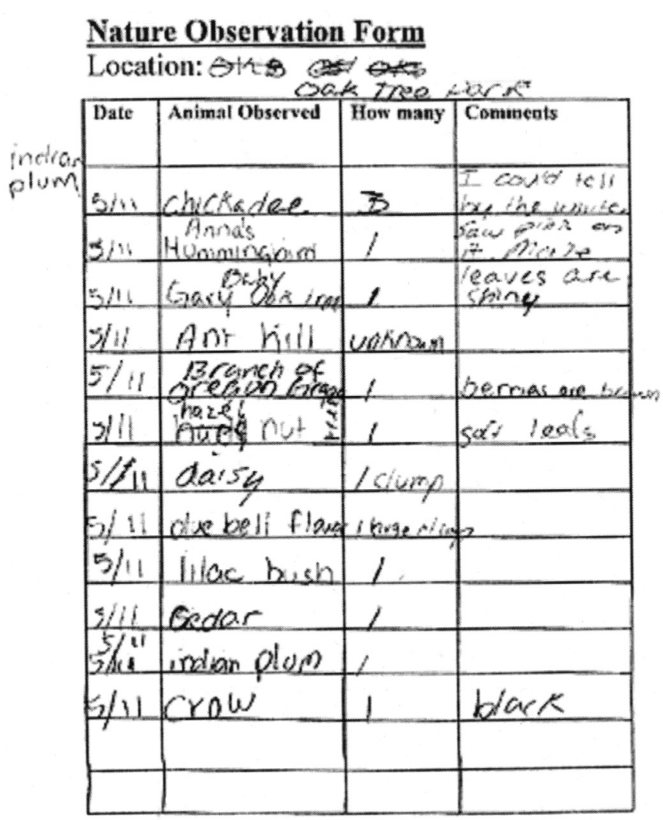
How many different species of plants are in Oa



Nature Observation Form

Location: Oak Tree Park

Date	Animal Observed	How many	Comments
5/1/0?	American Crow	1	hopping on branches
	Steller's Jay	1	looking for food
	Chikadee	2	hiding or looking for things
	Squirrel	3	climbing on a tree
	Anna's Hummingbird	1	flying
	Barn's Swallow	5	making noises and flying
	Ants	many infinity	in anthill
	Red Breast Nuthatch	2	flying. Long-beaked
	American Robin		
	Gull		



Nature Observation Form

Location: 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 pics on it. Male?
5/11	Oaky 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 large 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 shared by pre-service teachers who conducted the special study area investigation. The insights are accompanied by comments about their observations.

"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.

The next page shows how a 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?

Section 2: Preparing Students to Conduct Field Investigations

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

Objectives

Students will:

1) measure surface temperature,
2) write a detailed procedure,
3) analyze trends in the data, and
4) write a conclusion.

Science Grade Level Expectation

Planning and Conducting Safe Investigations: Understand how to plan and conduct scientific investigations.

Explaining: Constructing a scientific explanation using evidence.

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

Background

Now that students have sorted investigative questions and conducted a descriptive field investigation of the school yard 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, 38-42, for additional background information about temperature.

In comparative field investigations, data is collected on different groups, or under different conditions, to make a comparison. In this investigation, students gather temperature data to answer the comparative question, "Which location—on the open grass, under the bushes, or on the black top—has the highest surface 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 a conclusion 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.
Conducting comparative field investigations involves identifying the manipulated, responding, and controlled variables.

Manipulated (Changed) Variable: The factor of a system being investigated that is deliberately changed to determine that factor's relationship to the responding variable (OSPI, 2005, p. 53)*. In this investigation, the location is the manipulated variable.

Responding Variable: The factor of a system being investigated that changes in response to the manipulated variable and is measured (OSPI, 2005, p. 54)*. In this investigation, the temperature is the responding 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 (OSPI, 2005, p. 52). In this investigation, the thermometers, laying the thermometer flat on the ground, wail time, and light exposure are all kept the same.

* OSPI Office of Superintendent of Public Instruction, Washington State. (2005) *Science K-10 grade level expectations: A new level in specificity.* Washington State's Essential Academic Learning Requirements. OSPI Document Number 04-0051.

Lesson 1: Planning and Conducting a Comparative Field Investigation

Focus

1. Review the investigation question, "Which location—on the open grass, under the bushes, or on the black top—has the highest surface temperature?"
2. Tell students that good investigation questions describe what we will manipulate (changed variable). Have students underline the manipulated variable in the question (location).
3. Good comparative questions also describe what to measure (responding variable). Have students double underline the responding variable in the question (temperature).
4. As students become more proficient at writing procedures they can write procedures before actually conducting an investigation. We have found it is helpful for students new to the procedure writing process to conduct a trial measurement before writing the procedure.
5. Take students outside. Students leave a thermometer flat on the ground for a determined number of minutes, shading the thermometer from direct sunlight, and record the temperature one time at one location (on the open grass, on the black top, and under the bush). Now that students have experienced the measurement process, they are ready to write a complete procedure.

   Teacher Tip: Marking locations with numbered flags or tape ahead of time helps groups quickly find a sampling site.

6. Students return to the classroom and write a prediction, along with their reasons, under the question in their notebooks.
7. Students write the materials needed for the investigation.
8. Ask students, "When we go outside and take the surface temperature, what do we all need to do the same each time (controlled variables)?" List controlled variables on the board and summarize procedure.
9. Review the importance of recording the date, time, and weather, and for describing the study site.
10. Review the importance of multiple trials and explain that every team will go to all three locations and take three trials at each location. High school students should select sampling sites that are representative of the site (see map for an example).
11. Have students create a data table below their predictions. 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

Explore

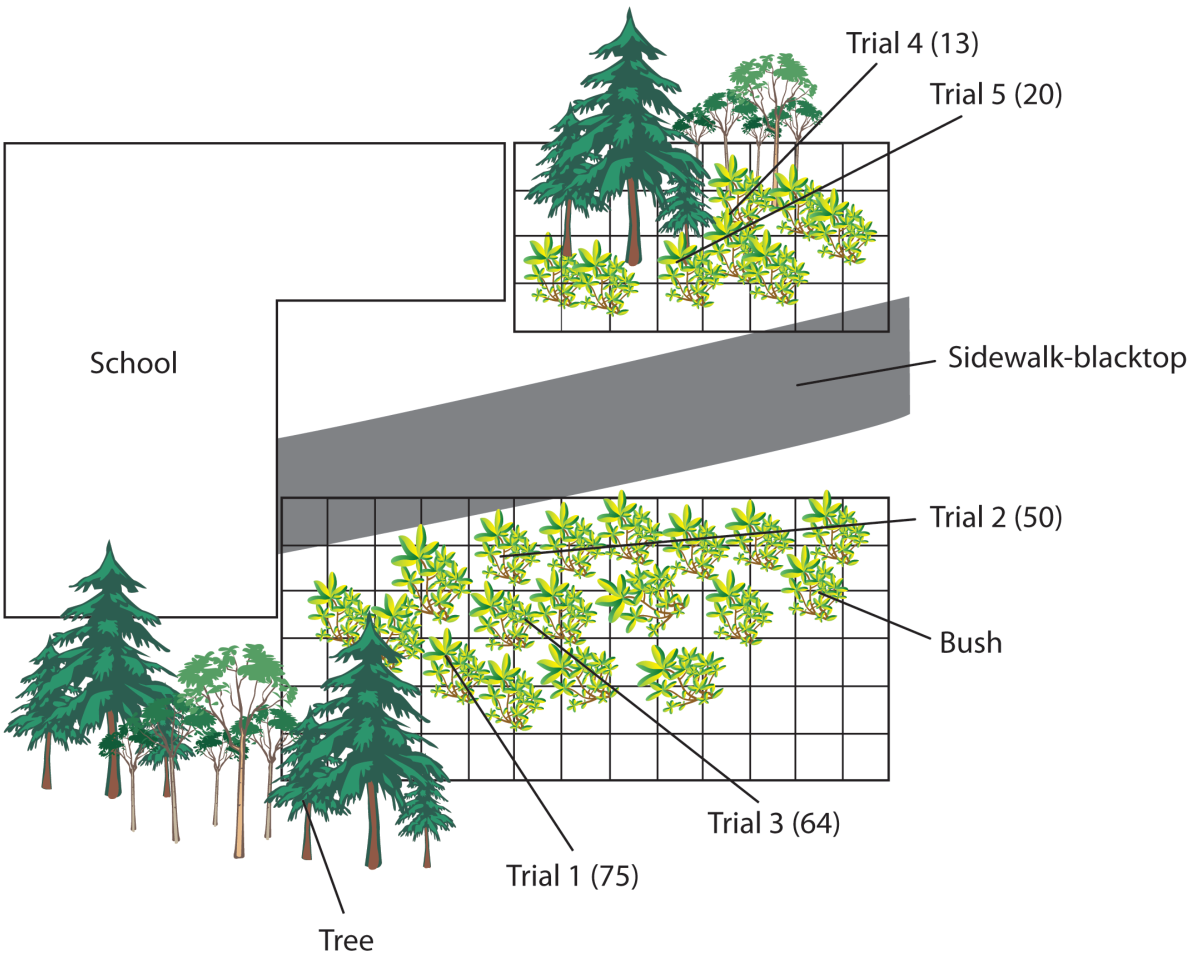
12. Secondary students choose random sample sites to take and record surface temperature (see map).
13. Students go outside to conduct the comparative investigation
    - Record date, time, and place where investigation takes place (study site).
    - Describe the weather and site of the investigation.
    - 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 black top, and under the bush).

Reflect

14. Students calculate the average surface temperature for each location.
15. Share and discuss similarities and differences in the data that each group collected.

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. Then, 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 surface 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, 97. Spots 13, 20, 50, 64, 75 were used because in those locations bushes are present.

Assessment

Review students' written procedures for the four important attributes of a procedure: 1) prediction, 2) materials, 3) variables identified, and 4) logical steps in which trials are repeated. See Appendix B for a weighted rubric.

Prediction/Hypothesis	Student states which location (manipulated variable)—under bushes, on the grass, or on the black top—will have the highest/lowest temperature (responding variable). Secondary students should also give a reason for their prediction.
Materials	Student lists all materials needed to conduct the investigation. For this investigation: · Thermometer · Stop Watches · Paper or other material to shade the thermometers
Controlled Variable (kept the same)	Student states at least one way that measuring variables and/or sampling are kept the same. · Temperature taken on top of ground each time · Wait the same # of minutes each time before reading temperature · Thermometer laid flat on the ground · Thermometer shaded from direct sun
Manipulated Variable (changed)	Student states what is changed. Secondary students should also state how the sites were chosen randomly at each location. For this investigation: · Location is implied or stated as the variable that is changed/ manipulated in the investigation
Responding Variable (measured)	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.

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), shade from direct sunlight 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	Manipulated (changed) Variable
Double underlined	Responding (measured) Variable
Circled	Controlled (kept the same) Variables
*	Multiple trials

Sample Data Sheet

How Does Surface Temperature Vary With Location?

Comparative Question: Which location—on the open grass, under the bushes, or on the back top—has the highest surface (on top of the ground) temperature °C?

Prediction/Hypothesis: ____

____

Date: ____________________ Time: ____________________

Study site (location): ____

Study site Description: ____

____

____

Weather: ____

Location vs. Surface Temperature °C

Location	Surface Temperature °C			
	Trial 1	Trial 2	Trial 3	Average Temperature
Open Grass				
Under Bushes				
Black Top				

Lesson 2: Analyzing Data and Writing a Conclusion

Focus

1. Review the procedure

Explore

2. Students complete data analysis by calculating averages for each location
3. Students display data in graphic form
4. Students write a conclusion

Reflect

6. Students write or participate in a discussion that considers the following questions:
    - How could the procedures be improved?
    - What other factors may have influenced the data?
    - Is any data inconsistent? Explain why.
    - What are the pros and cons of the different graphs?
    - How might this information be important?
    - How does this information add to my understanding of the school yard ecosystem?
    - How might this information inform actions or decisions?
    - What are my new questions?

Assessment

Review students' charts and graphs to see if they include: 1) accurate averages, 2) an appropriate graph for the data, 3) title, 4) correct units. In addition, students should reflect on the pros and cons of different graphical displays.

Review students' written conclusions for the five important elements of a conclusion: 1) limits conclusion to study place, date and time, 2) includes a conclusive statement, 3) gives lowest supporting data, 4) gives highest supporting data, 5) uses explanatory language. See the example conclusion that follows. Sample data is given below.

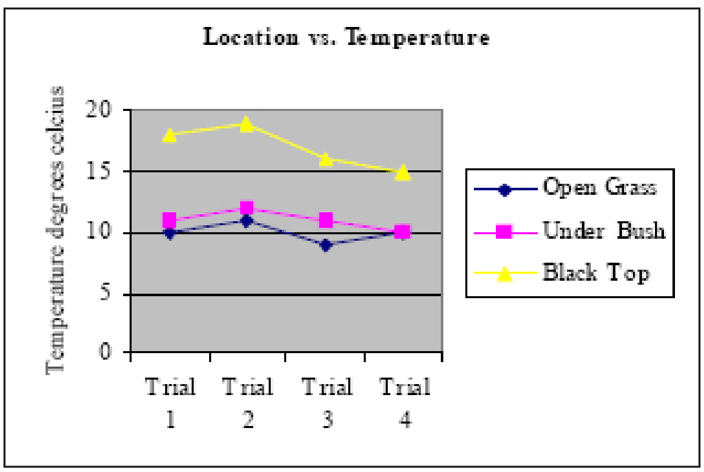
Sample Data:

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

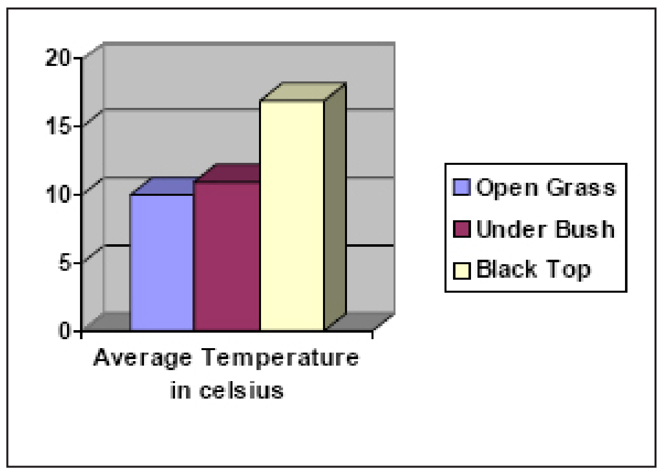
Location vs. Surface Temperature °C					
Location	**Surface Temperature °C**				
	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Average**
On the open Grass	10	11	9	10	10
Under Bushes	11	12	11	10	11
On the Black Top	18	19	16	15	17

Data Analysis

Students can analyze temperature data by calculating the average surface temperature in each 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 student see median and mode when comparing only two locations

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

Sample Conclusion

Which location—on the open grass, under the bushes, or on the black top—has the highest surface temperature?

At Dearborn Park Elementary on March 18, 2005 at 2:30 pm on the black top had the highest average surface temperature, 17°C. Under the bushes had the lowest average surface temperature of 10°C. Our prediction that the black top would have the highest temperature was correct. The black top had the highest average surface temperature of any of the three locations.

Important Attributes of a Conclusion

See Appendix B for a weighted rubric.

Limits conclusion to place, date, and time of study

Gives location, date, and time where field study took place.

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

A Conclusive Statement

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

the black top had the highest average surface temperature

Lowest Supporting Data

Gives location and temperature for location with the lowest degrees °C. (Not applicable if the average temperatures are the same).

Under the bushes had the lowest average surface temperature of 10 °C

Highest Supporting Data

Gives location and temperature for location with the highest degrees °C. (Not applicable if the average temperatures are the same).

On the black top had the highest average surface temperature of 17 °C

Explanatory Language

An explanation of how the given data supports the conclusion is stated or implied-comparative explanation using words like highest, lowest.

black top had the highest average surface temperature of 17 °C

Temperature Investigation
Scoring Your Conclusion

Attributes of a conclusion to a field investigation	Value Points
Limits conclusion to place, date, and time of study Gives location, date, and time where field study took place	1
A conclusive statement clearly describes which location has the highest temperature OR describes that there are no differences in temperatures at the three locations.	1
Lowest supporting data: Gives location and temperature for location with the lowest degrees °C OR gives °C if all average temperatures are the same (5th grade students may use range or trial data to support; 8th and 10th must use average data)	1
Highest supporting data: Gives location and temperature for location with the highest degrees °C if temperatures are different (5th grade students may use range or trial data to support; 8th and 10th must use average data)	1
Explanatory Language is used to connect or compare the supporting data to a correct conclusion. An explanation of how the given data supports the conclusion is stated or implied-comparative explanation using words like highest, lowest would get this point.	1
Total	5

Sample Conclusion Sheet

How Does Surface Temperature Vary with Location?

Which location on the black top, on the grass, or under a bush has the highest temperature on the school campus?

- Give data to support your answer
- Explain how the data supports your answer

Discussion:

- What factors might have impacted my research?
- What are my new questions?

3rd grade students at Loyal Heights Elementary in Seattle, WA investigated the soil temperature on the north side and south side of the school yard. They recorded temperature data and wrote conclusions about which side of the school yard would be the best place to plant. Note that although both students conclude that the south side of the school yard is the best for planting because the soil temperatures are warmer, only one of the students includes the actual data points.

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

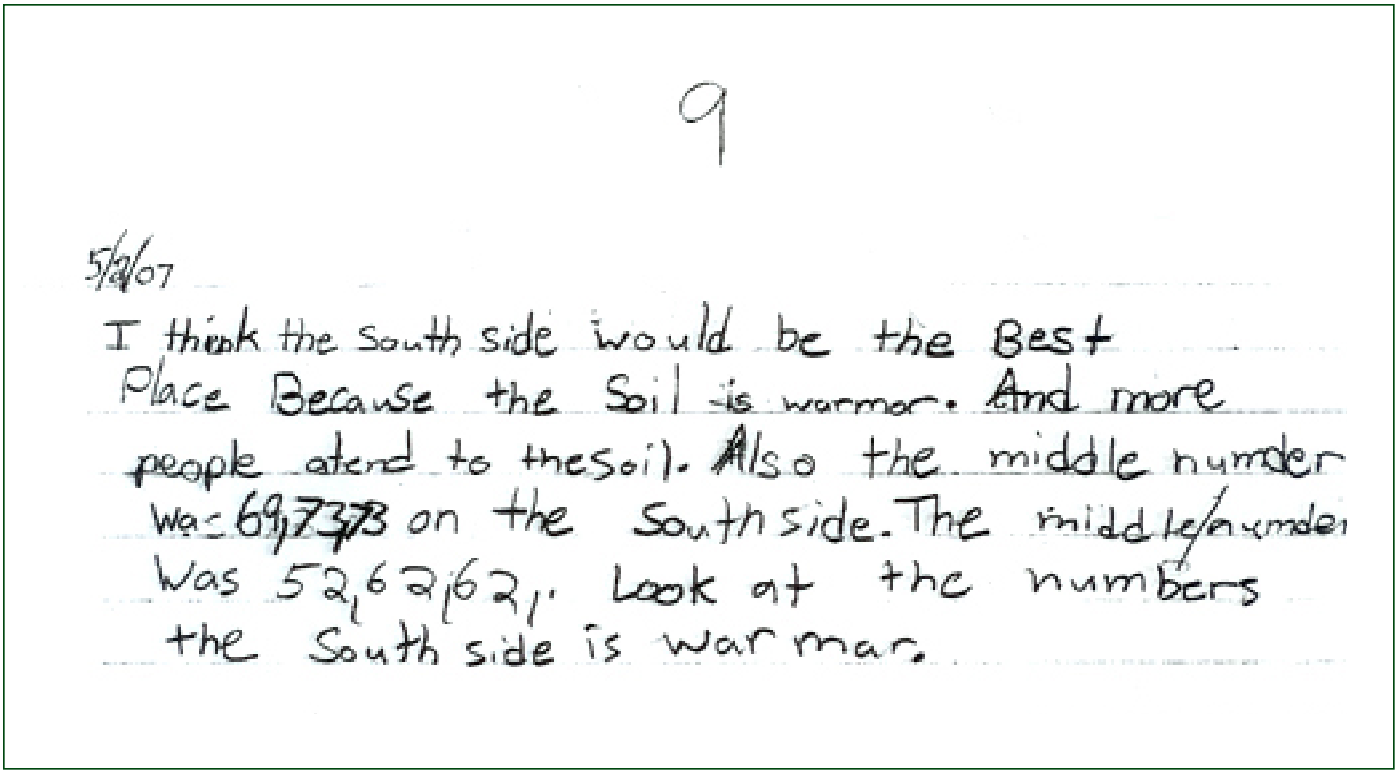
School Loyal Hight Elem

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

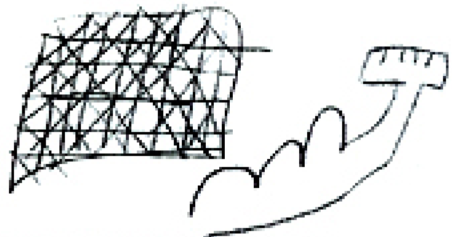
6



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 69,73 on the South side. The middle number was 52,62,62,. Look at the numbers the South side is warmar.



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

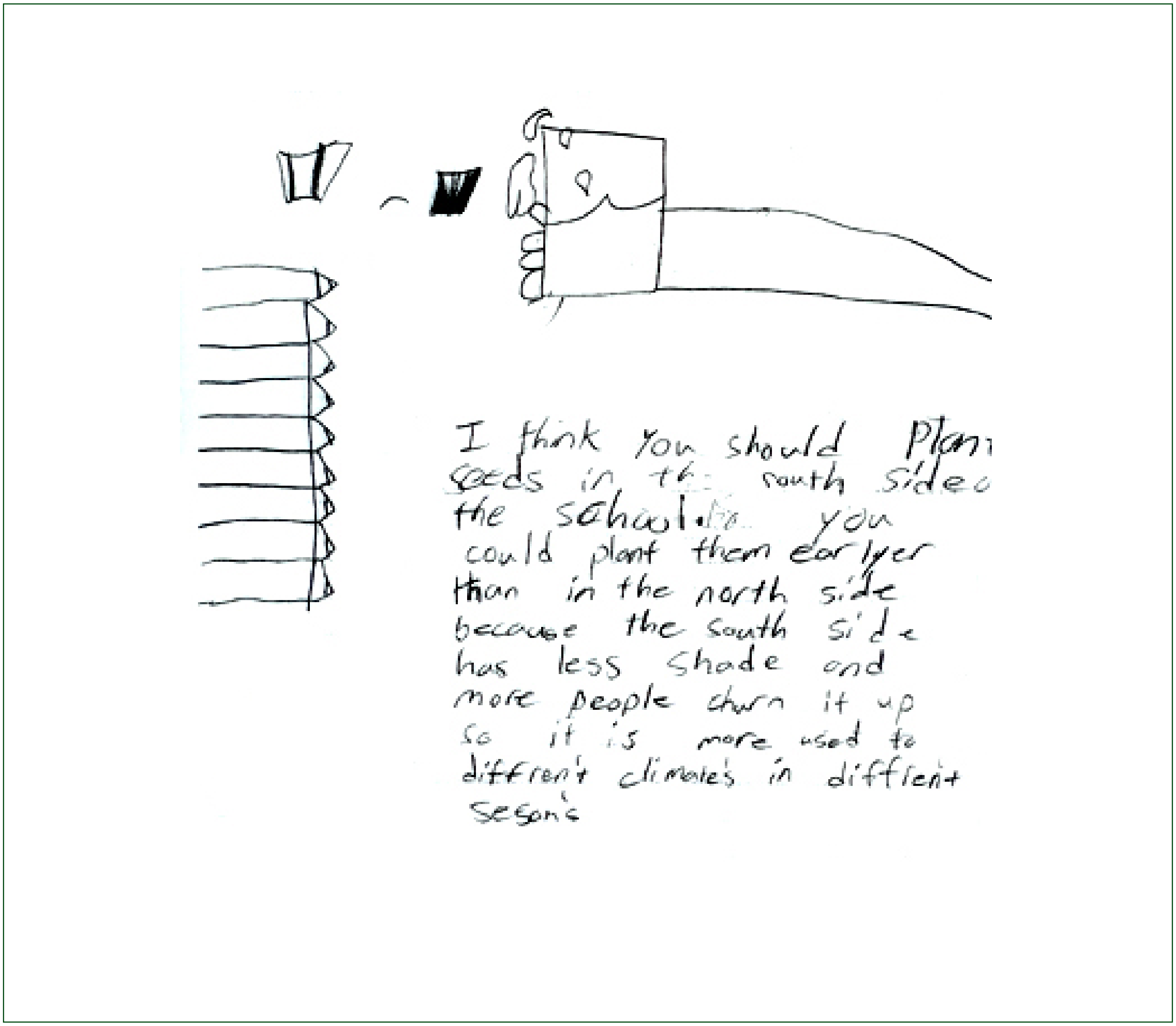
School loyal Heights

Study site description [illegible]

Weather Sun cloud low 50s

55 - nice

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	66F	67°F	66°F	66°F
South	73°F	71°F	70°F	71 °F


I think you should Plant
seeds in th south side
the school. 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
diffrent climate's in diffrent
seson's

Below are three conclusions written by high school students who conducted the surface temperature field investigation. In the first two, the students give both the highest and lowest temperature and make a conclusive statement. In addition, each student tries to explain what environmental factor might be causing the temperature differences—surface color and absorption of sunlight. The third student makes a conclusive statement, but does not support that conclusion by giving the highest and lowest temperature; instead, she states the difference in temperature between the environments. It is interesting to note that because the question asked "how," students go beyond giving data to try to explain the temperature differences. We have found "how" questions to be problematic; asking what is the effect? focuses students on the data they collected rather than tying to explain the phenomenon.

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 opengrass, 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.

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.

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.

Section 3: Building Field Investigations from Student Questions

The four 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. First, students go outside and journal about whatever they find interesting in the schoolyard or park. Second, students observe, draw, and label the parts of a deciduous tree/shrub to answer a descriptive question about that tree. Third, students' observe, draw and label twigs in winter to answer a descriptive question about twigs. Finally, students plan and conduct a comparative investigation about twigs.

Lessons in this section include:

Descriptive Field Investigation: Schoolyard Habitat

What Plants and Animals Use the Schoolyard Habitat?

Descriptive Field Investigation: Trees/Shrubs

What Does This Tree/Shrub Look Like?

What are the Physical Properties/Characteristics of this Tree/Shrub?

Descriptive Field Investigation: Twigs

What do Twigs Look Like Each Month?

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

Comparative Field Investigation: 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?

Objectives

Students will:

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

Science Grade Level Expectation

Analyze how the parts of a system go together and how these parts depend on each other.

Describe the life function of a part of a living system.

Planning and Conducting Safe Investigations: Understand how to plan and conduct scientific investigations.

Constructing a scientific explanation using evidence.

Thinking Skills

Observing, Classifying, Inferring, Finding Evidence

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

Background

The more time students have in the natural environment to observe, the greater their ability to ask questions. Outdoor journaling or year long 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.

Section 3: Building Field Investigations from Student Questions

Part 1: Descriptive Field Investigation
What Plants and Animals Use the Schoolyard Habitat?

Lesson

Focus

1. Review the thinking skill of observation. Also review the use of descriptive words: Every sentence needs adjectives and adverbs. Hold up an object (e.g., leaf, pinecone, twig) and ask student to make observations. Record observations as students share.

Explore

2. Students go outside and journal about whatever they find interesting in the schoolyard or park. Below are some sentence starters for observations. (For helpful observation prompts, see Fulwiler, 2007.)
    - I see…
    - I hear…
    - I smell…
    - I touch…
    - This environment makes me feel…
    - It reminds me of…because…

Reflect

3. Students write down any questions that come to mind.
    - As I sit here I wonder…
    - I was surprised that…
    - I wonder what would happen if…

Assessment

4. Review student observations. Do they include:
    - Sentences or sentence fragments rather than just lists of words?
    - Multiple adjectives and adverbs to describe color, shape, size, texture, smell, edges, and arrangement?
    - Questions and wonderings that are linked to recorded observations?
    - Labeled drawings that are clear and large enough to show detail?

Section 3: Building Field Investigations from Student Questions

Part 2: Descriptive Field Investigation: Trees/Shrubs
What Does This Tree/Shrub Look Like?
What are the Physical Properties/Characteristics of this Tree/Shrub?

Lesson

Focus

1. Students write what they already know about trees/shrubs and draw and label a tree/shrub from memory (See Project Learning Tree Lesson 61, The Closer You Look).

Explore

2. Ask the question: What are the parts of the ___________ tree? Or, What are the physical properties/characteristics of the ______________tree? (See *Project Learning Tree Lesson 21, Adopt a Tree*)
3. Students record the date, time, place, air temperature, and weather.
4. Students go outside and draw and label the parts of a deciduous tree in late winter. Measuring the tree and its parts helps students make drawings to scale.
5. Students write down questions they have about the tree

Examples of Descriptive Questions about Trees and Shrubs

- 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?
- Do all the leaves turn the same color?
- Is each leaf a single color in the fall?
- What colored pigments are in leaves?
- How old is this tree?
- What plants live on this tree?
- What are the physical characteristics of this tree? (e.g., height, crown spread, shape of tree, shape of leaves, size of leaves)
- 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?

Reflect

6. Students reflect (in writing or in discussion) on the parts of the tree by comparing their memory-tree to the actual tree.

7. Students reflect (in writing or in discussion) on the function of the parts of a tree and how they are interconnected.

8. Students share and categorize questions by type (e.g. descriptive, comparative, correlative, essential, why, researchable) see p. 16.

Assessment

When assessing tree drawings and journal 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…)
- Appropriate use of color
- Captions or titles that identify drawings and note the date and place recorded

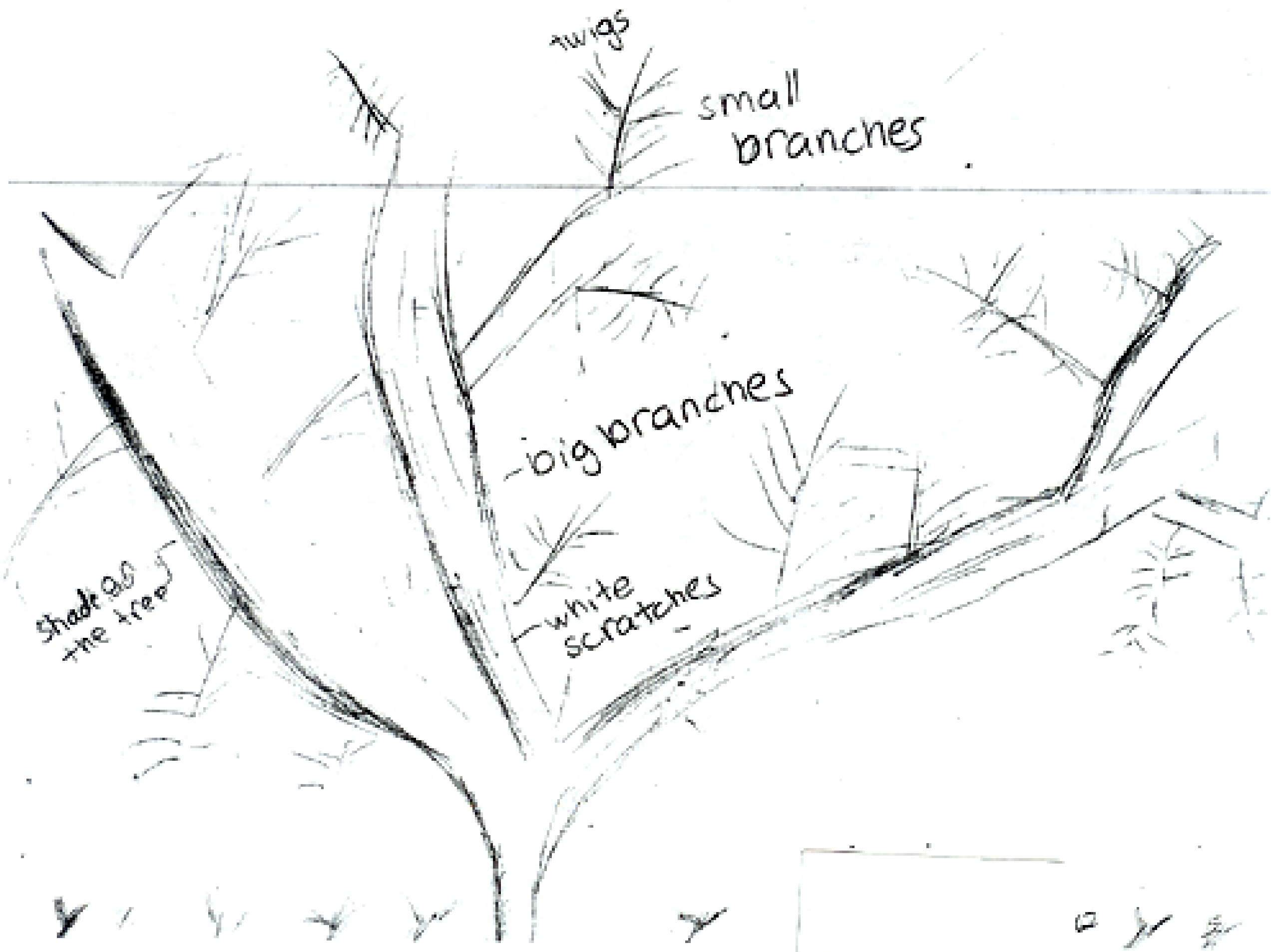
4th grade students at Sunny Hills Elementary in Issaquah, Washington drew trees and recorded their observations. The first student uses detailed observational evidence to support her answers to the questions (e.g., "The tree doesn't have leaves yet, but I can see there's little indents where they are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

Trees as Habitats

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

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

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



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

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

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

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

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

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

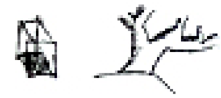
7. The plants at the bottom of the tree may give it more food or water.

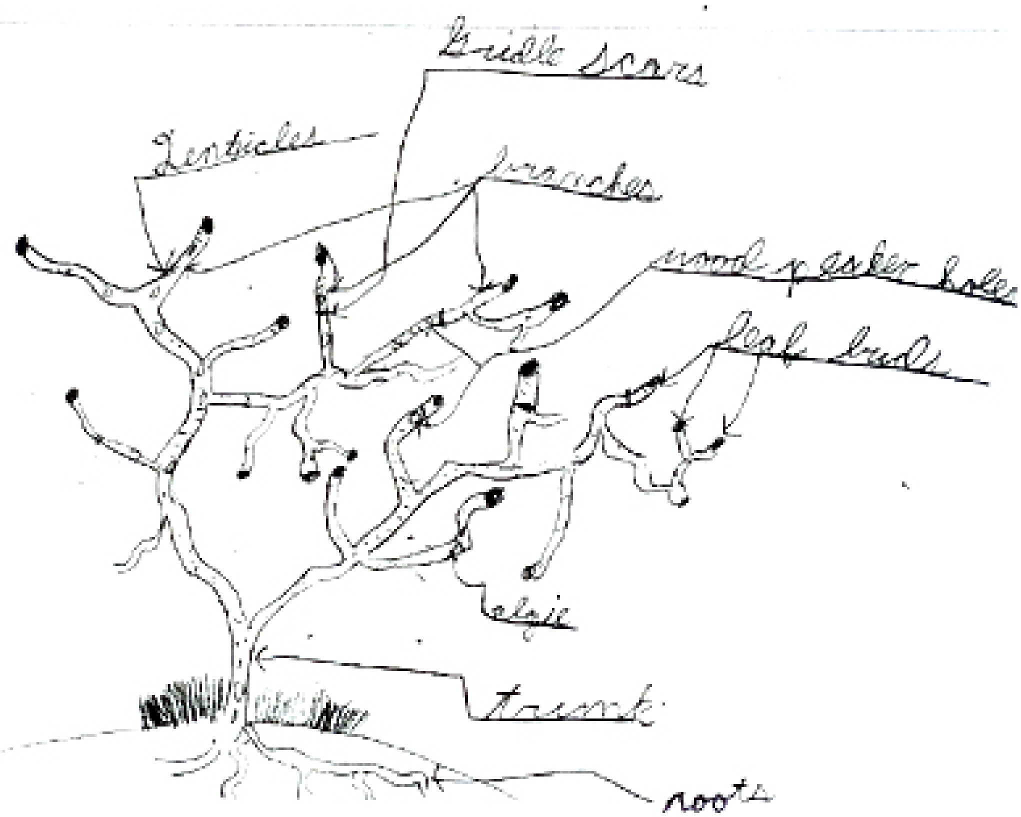
Trees as Habitats

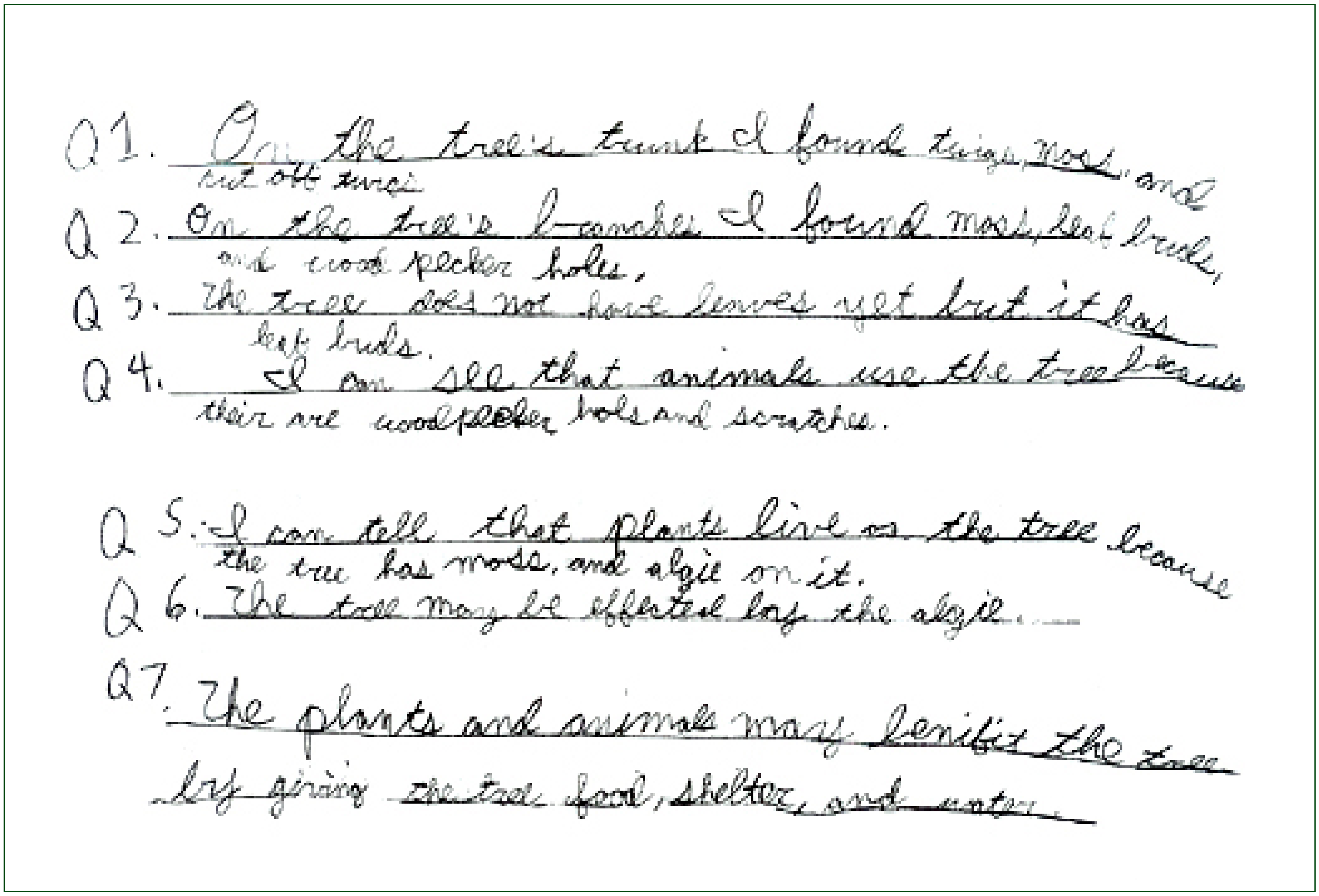
Examine a tree-Draw and Label the parts of the tree

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

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







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

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

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

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

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

Q6. The tree may be effected by the algie.

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

Section 3: Building Field Investigations from Student Questions

Part 3: Descriptive Field Investigation: Twigs

What do Twigs Look Like Each Month?

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

Lesson

Focus

1. From questions generated by students (see examples in Part 2), choose one question that has to do with twigs on the tree. Discuss what happens in spring in terms of weather and sunlight. Ask, "Where do new leaves come from?" (See Project Learning Tree Lesson 65, Bursting Buds)

Explore

2. Ask the descriptive investigation question:

   What do twigs on ___________tree look like in winter? OR, What are the physical properties/characteristics of twigs on __________tree in winter?
3. Students record date, time, place, air temperature, and weather.
4. Students observe, draw, and label a twig from the tree. They label the twig-tree system.
5. Students look up a labeled twig diagram in a book and label more parts of their twig diagram (see example below).
6. Measuring from the twig tip to the first bud scale scar, students record last year's growth.
7. Students write questions they have about the winter twigs on trees using the following observation prompts.
   - I wonder…about tree growth or twig growth
   - I have questions about…
   - I wonder what would happen if. . . .
   - A comparative question I could investigate is…

Reflect

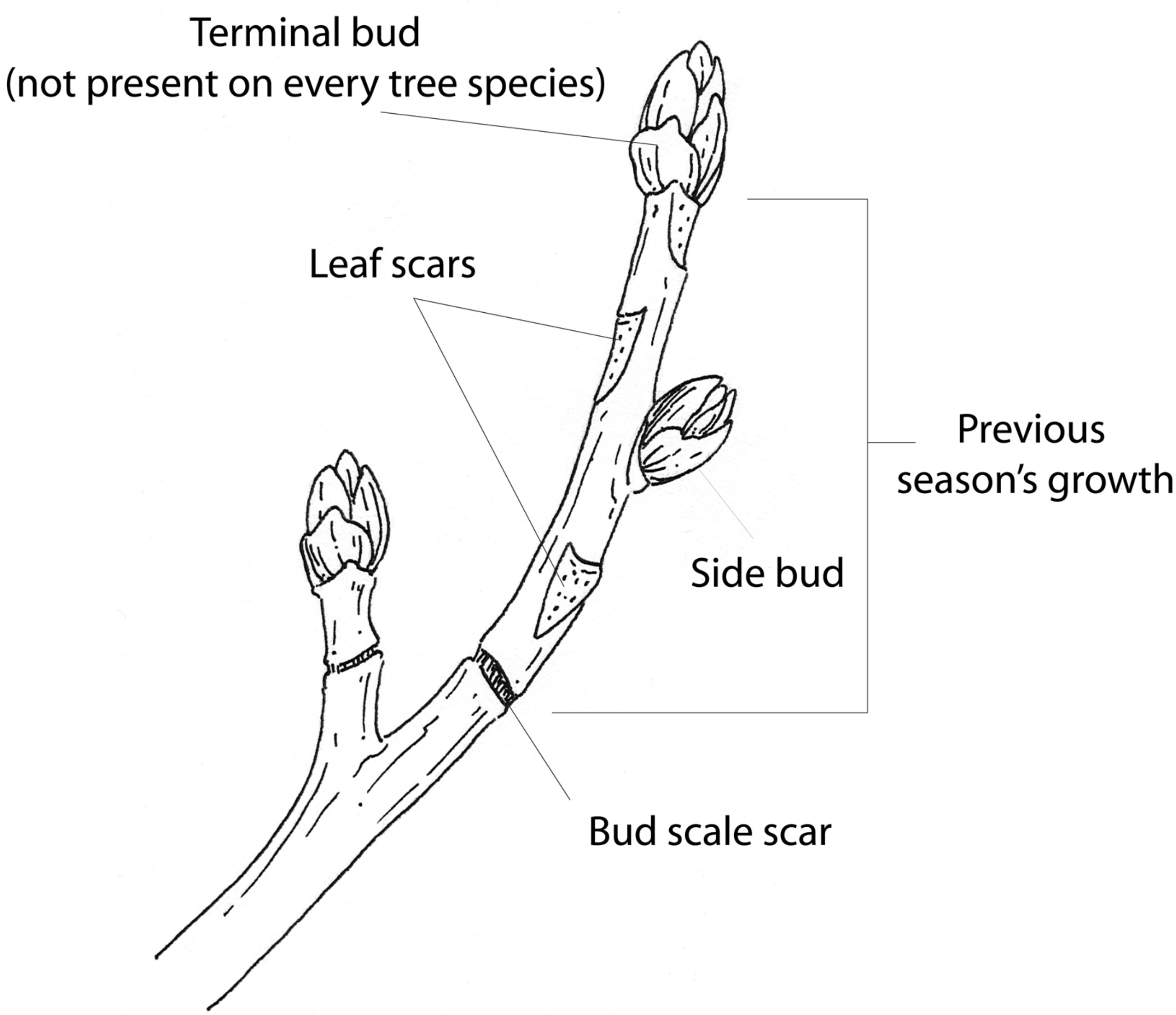
8 Students share and categorize questions by type.
   - Book/internet Research
   - Essential-Life Pondering, Always Wonder
   - Descriptive
   - Comparative
   - Correlative
   - Why questions?

9. Discuss bud development by asking some of the following questions:
   - When do buds form on trees?
   - What do buds become on trees and shrubs?
   - What did the leaf scars originally connect to?
   - What were the dots in the leaf scars connected to?

Assessment

When assessing the journal descriptions and drawings, look for:

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



Section 3: Building Field Investigations from Student Questions

Part 4: Comparative Field Investigation:
Is There More Twig Growth on the North or South Side of the Twig/Shrub?

Focus

1. Have students look at the comparative questions the class has come up with. Have students decide which questions they have the materials and access to conduct. For example, comparing upper twigs on a tall tree with lower twigs may not be feasible due to lack of a ladder.

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?**
- **Do buds on ____________type of tree/shrub or _______________ type of tree/shrub burst earliest in spring?**

Explore

2. Students choose a comparative question to investigate.
3. Students gather the materials needed for the investigation.
4. Students write a procedure of the investigation and create a data sheet including a data table. For the two questions above in bold we have created example data sheets.
5. Students conduct the investigation.
6. Students analyze data and create charts and graphs.

Reflect

7. Students write a conclusion for their data.
8. Student participate in or write a discussion about their data.

Example 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					

Sample Data:

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

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

Example Investigation Plan and Data Sheet

Comparative Investigation Question: Do buds on _______________type of tree/shrub or ____________ type tree/shrub burst earliest in spring?

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 one other tree/shrub 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 vs. Number of Buds' Bursting				
Type of Tree/Shrub				
Date				
Number of Buds on Plant 1				
Number of Buds on Plant 2				
Type of Tree/Shrub				
Date				
Number of Buds on Plant 1				
Number of Buds On Plant 2				

Section 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 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 – Water Module online database (http://www.depts.washington.edu/natmap/water/index.html).

This section describes one teacher's efforts to integrate an understanding 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.

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) and Oregon Water Enhancement Board (OWEB) (macroinvertebrate) protocols, and the River Continuum model?

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, …), make observations of the site conditions (weather, land use, …), take measurements (or estimates) of stream characteristics (depth, width, temperature, …), 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.

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

<table>
<tr><th>Date
Time</th><th>Nov. 18, 2005
11:15 AM</th><th>Mar. 21, 2006
11:15 AM</th><th>Sep. 28, 2006
11:30 Am</th><th>Nov. 16, 2006
11:30 AM</th><th>Mar. 27, 2007
11:30 AM</th><th>Sep. 25, 2007
11:00 AM</th></tr>
<tr><td>Air Temperature</td><td>7° C</td><td>10° C</td><td>21° C</td><td>11° C</td><td>5° C</td><td>15° C</td></tr>
<tr><td>Rainfall
(2 days prior)</td><td>None</td><td>Light</td><td>None</td><td>Heavy</td><td>Moderate</td><td>None</td></tr>
<tr><td rowspan="2">Water Temperature</td><td>7.6° C</td><td>8° C</td><td>12° C</td><td>9° C</td><td>4° C</td><td>8.5° C</td></tr>
<tr><td colspan="6">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*, temperatures should not exceed 16 degrees centigrade
Temperatures which exceed 21° C are not acceptable</td></tr>
<tr><td rowspan="2">DO (mg/L)
Dissolved Oxygen</td><td>10</td><td>10</td><td>9</td><td>9</td><td>9.8</td><td>10</td></tr>
<tr><td colspan="6">Optimal Levels for Salmonids:
Optimal (Class AA*) 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</td></tr>
<tr><td rowspan="2">PH
(acid - base)</td><td>7.4</td><td>7.5</td><td>7.8</td><td>7.3</td><td>7.5</td><td>8.0</td></tr>
<tr><td colspan="6">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*)</td></tr>
<tr><td>Phosphate</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>0</td><td>0.1</td></tr>
<tr><td rowspan="2">Turbidity (NTU)</td><td><5</td><td><5</td><td><5</td><td><5</td><td><5</td><td><5</td></tr>
<tr><td colspan="6">Turbidity Levels
Class AA* = <5 NTU; Class B* = <10 NTU</td></tr>
<tr><td>Stream Flow (cfs)</td><td>~630</td><td>~770</td><td>~47</td><td>~1850</td><td>~1600</td><td>~38</td></tr>
<tr><td rowspan="2">Fecal Coliform
(colonies/100 mL)</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td>60</td><td>53</td></tr>
<tr><td colspan="6">Fecal Coliform (Bacteria) Levels
Class AA* = <50
[drinking water = <1; swimming/full contact = <200; boating/partial contact = <1000]</td></tr>
<tr><td rowspan="2">PTI</td><td>20</td><td>16</td><td>26</td><td>29</td><td>26</td><td>26</td></tr>
<tr><td colspan="6">PTI (Pollution Tolerance Index) Scale using macroinvertebrates
Poor = <11 Fair = 11 - 16 Good = 17 – 22 Excellent = >22</td></tr>
<tr><td rowspan="2">OWEB</td><td>26</td><td>22</td><td>30</td><td>28</td><td>28</td><td>26</td></tr>
<tr><td colspan="6">OWEB (Oregon Watershed Enhancement Board) Scale using macroinvertebrates
Severe Impairment = <17 Moderate Impairment = 17 - 22 No Impairment = >22</td></tr>
<tr><td colspan="7">* Water Quality Standards for Surface Waters of Washington, June 1998 (http://depts.washington.edu/natmap/water/index.html)</td></tr>
</table>

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

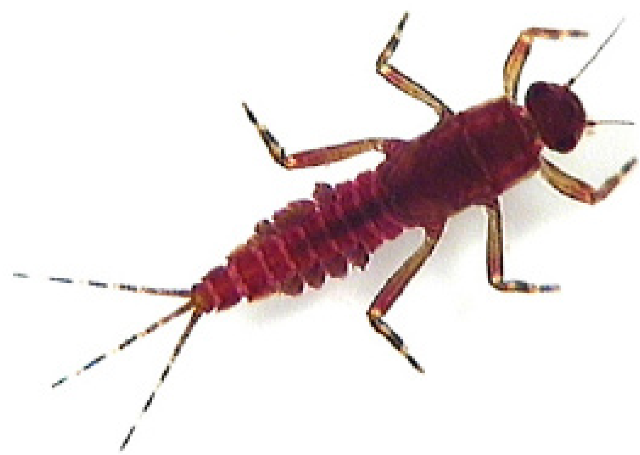


Figure 2

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 Water Enhancement Board) Level II and an examination of functional feeding groups (FFG). 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.

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.

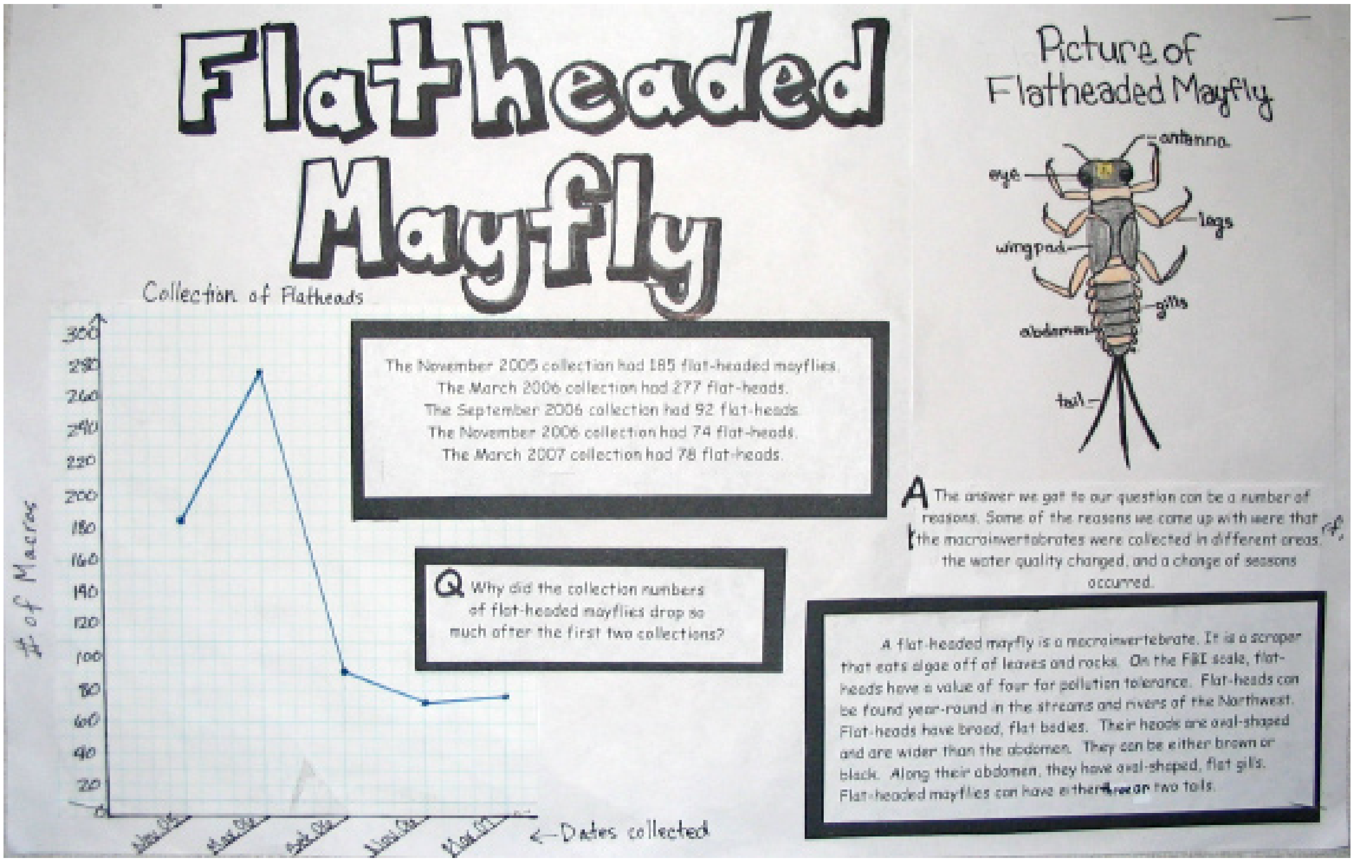
The activity presented below is an example of how students transition from following collection protocols to leading a scientific investigation. They pursue their own, self-selected analysis of the data and communicate their findings in the form of a poster and classroom presentation. In this poster 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.

Section 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: A 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://depts.washington.edu/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, WA 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 What do horny toads eat? What do they do during the winter? What is the movement/range of the horny toad?	**Comparative Questions** Is the farm field a source or a sink? What are most horny toads close to, road, farm 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

321 – Maintained pasture
322 – Crops (wheat, canola, etc.)
324 – 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 were 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 the protocol developed by a Central Washington University graduate student, they locate the lizards and record the latitude/longitude and temperature measurements at multiple heights and distances from the scab patch. Data are entered into a spreadsheet and plotted onto ArcView.

How is the data collected and organized?

Farmers come into the class, and each of their sightings is given an unique number. Students work with their farmers going to multiple stations (e.g., topographic maps, paper graphs) for each of the attributes farmers collect. 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 an Excel spreadsheet that contains all of the attributes of the data collection form, plus the unique identification code to relate to the GIS file.

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.

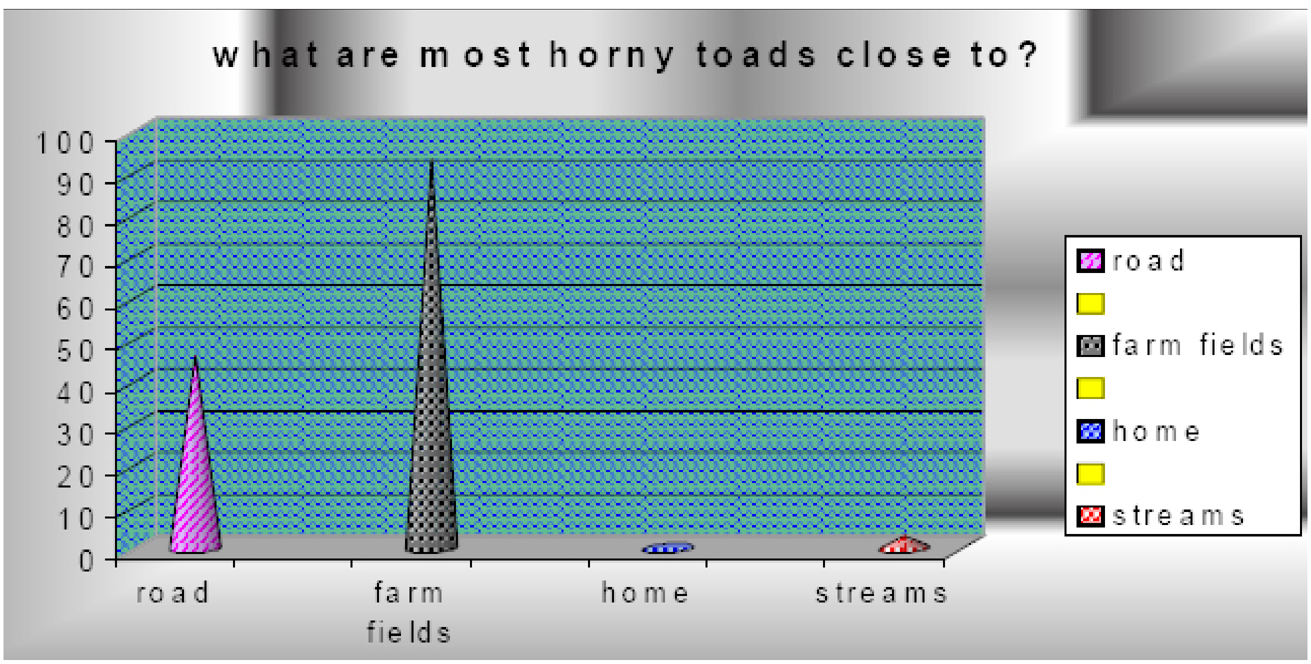
Question: What are most horny toads close to?

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:

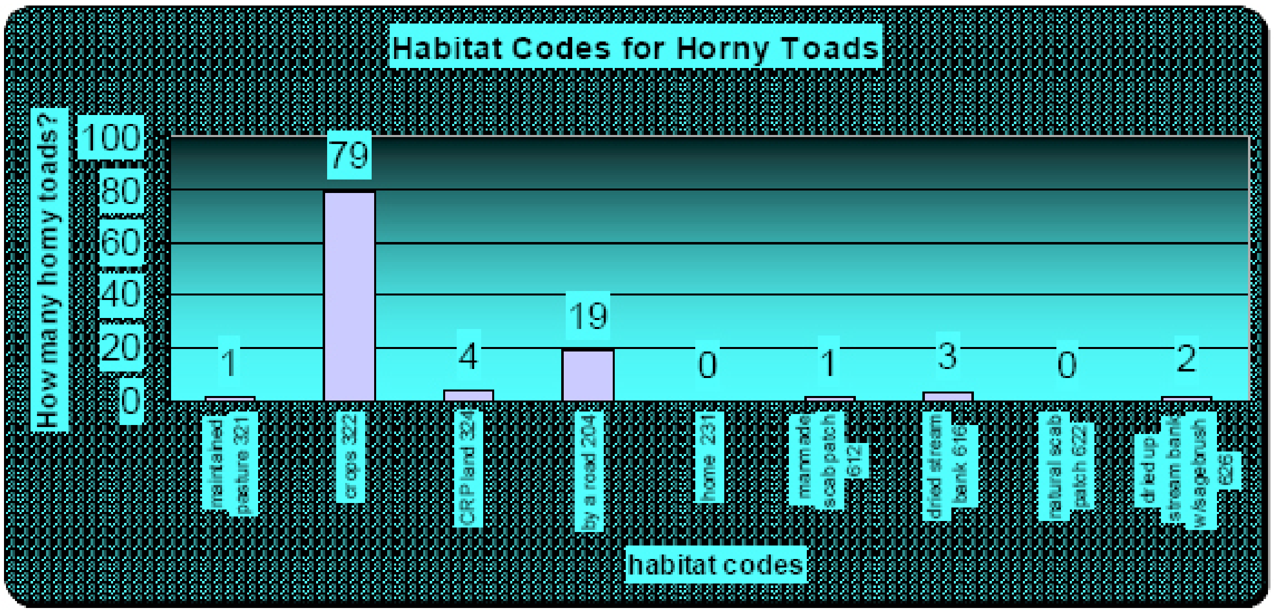
My prediction that most horny toads would be found close to wheat fields was correct. The maximum number was 96 horny toads in wheat fields. The minimum number was 3 horny toads found by streams. For habitats like a manmade shelter there are 0 horny toads living there.



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 as up to fours 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://depts.washington.edu/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 along side 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.

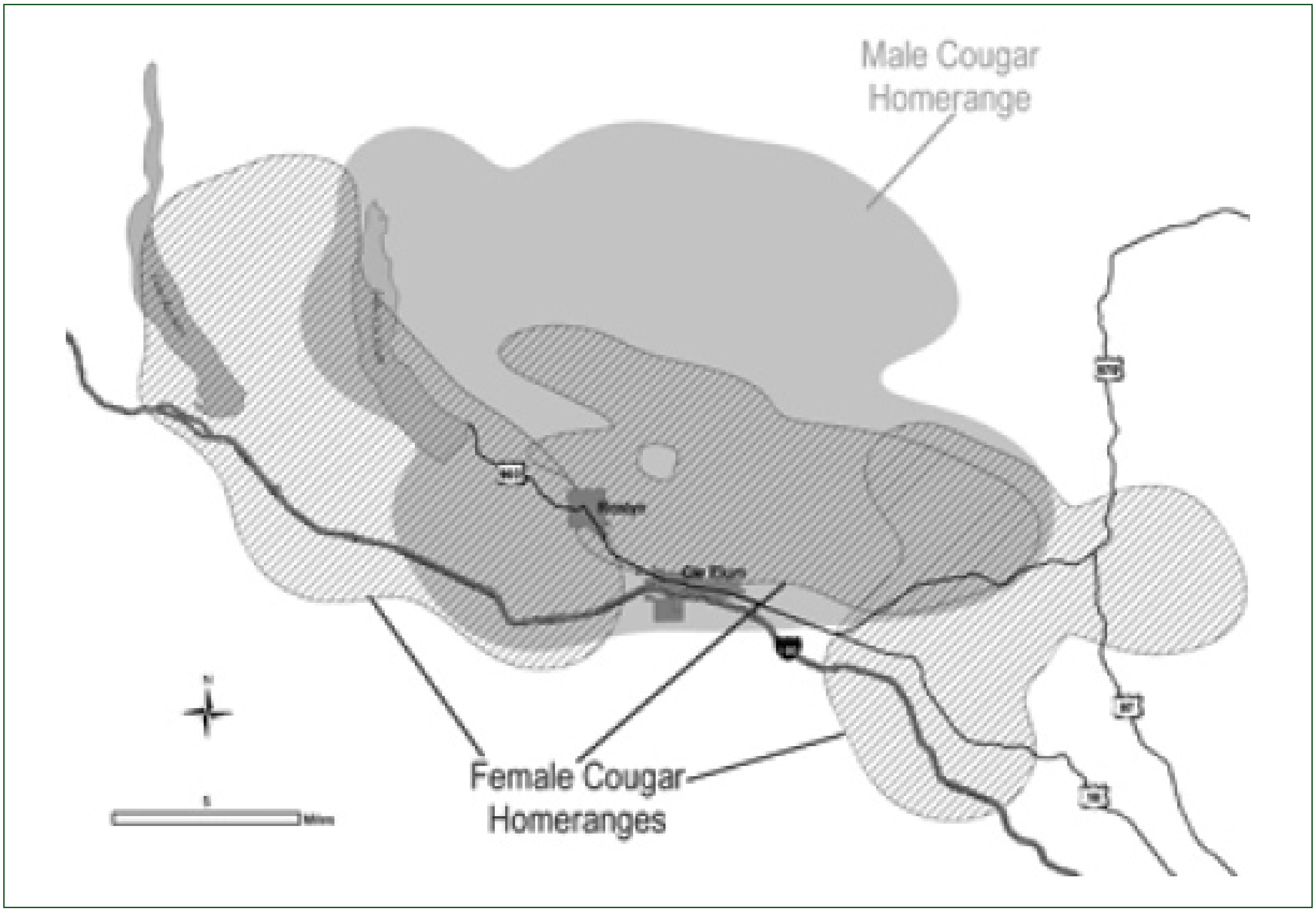
How is data collected and organized?

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 first hand 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: Generic Rubrics for Assessing Data Sheets, Written Procedures, and Conclusions

Appendix B: Washington State Weighted Rubrics for Assessing Data Sheets, Written Procedures, and Conclusions

Appendix C: Washington State Generic Weighted Rubrics for Assessing Written Procedures and Conclusions

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

Appendix E: Field Investigation Resources

Appendix F: Scientific Field Investigations described in Washington State Science Standards (2005)

Appendix G: Science as Inquiry. National Science Education Standards. (National Reseach Council 1996) Guide to Content Standard Grades K-4, 5-8, 9-12)

Appendix A

Generic Rubrics for Assessing Data Sheets, Written Procedures, and Conclusions

Assessing Data Sheets

Review students' data sheets for four important attributes: 1) question/prediction, 2) study site conditions, 3) study site description, and 4) data table.

Question and Prediction	Student states investigative questions and a prediction.
Study Site Conditions	Date, time, location, and weather conditions are noted.
Study Site Description	A written description of the study site is included.
Data Table	Clear title describes what is changed (manipulated variable) and what is observed/measured (responding variable). Manipulated (changed) variable is on left hand side of the data table Observations/counts/measurements are made with proper units. Table includes: blank space to record data for planned investigation, manipulated variable is labeled in the left column, responding variable is labeled across top row. There is a place on the data table for multiple trials to be recorded.

Appendix A

Generic Rubrics for Assessing Data Sheets, Written Procedures, and Conclusions

Assessing Written Procedures

Review students' written procedures for the four important attributes of a procedure: 1) prediction, 2) materials, 3) variables identified, and 4) logical steps in which trials are repeated. See Appendix C for a weighted rubric.

Prediction/Hypothesis	Student predicts how manipulated variable (e.g., time, location, organism, population) impacts the responding variable. Secondary students should provide a reason for their prediction/hypothesis.
Materials	Student lists materials and tools needed to perform the investigation.
Controlled Variable (kept the same)	Student states or implies at least one way that measuring variables and/or sampling are kept the same. High school students state or imply at least two ways.
Manipulated Variable (changed)	Student states what is changed (e.g., location, substrate, habitat, time, organism, or population).
Responding Variable (measured)	Student states how data is measured/observed and recorded.
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.

Appendix A

Generic Rubrics for Assessing Data Sheets, Written Procedures, and Conclusions

Assessing Conclusions

Review students' written conclusions for the five important attributes of a conclusion: 1) limits conclusion to study place, date and time, 2) includes a conclusive statement, 3) gives lowest supporting data, 4) gives highest supporting data, 5) uses explanatory language. See Appendix C for a weighted rubric.

Limits Conclusion to Place, Date, and Time of Study	Student gives location, date, and time where field study took place.
A Conclusive Statement	Student makes a conclusive statement that clearly answers the investigation question or explains whether or not the prediction was correct. In descriptive investigations, the conclusive statement may be a detailed description or model of observations.
Lowest Supporting Data	Student gives data for lowest measurement. For descriptive investigations, trend data or descriptive data are given. For comparative investigations, data points (or data averages) or observations are given for the "lowest" condition. If there is no difference, all conditions are stated.
Highest Supporting Data	Student gives data for highest measurement. For comparative investigations, data points (or data averages) or observations are given for the "highest" condition. If there is no difference, all conditions are stated.
Explanatory Language	An explanation compares what happened between or among changed (manipulated) variable conditions and states how the given data supports the conclusion. For comparative investigations, student gives a comparative explanation using words like highest, lowest, largest, most or only.

Appendix B

Washington State Weighted Rubrics for Surface Temperature Comparative Investigation

Scoring the Procedure

Review students' procedure for the following procedure attributes:

Procedure Attributes		Points
Prediction	Student predicts which location under the bushes, on the grass, or on the black top has the highest temperature by stating which location (manipulated variable) will have the highest/lowest temperature (responding variable).	1
Prediction Reason	Secondary students must give a reason for the prediction	1
Materials	Student lists materials and tools needed to perform the procedure. Thermometer, stopwatch, devise to shade thermometer	1
Study Site	Student describes recording date and time and weather	1
Controlled Variable (kept the same)	5th and 8th grade students must describe or imply one controlled variable in the procedure or the materials list. 10th grade students must describe or imply two controlled variables. Examples: · Temperature taken on top of ground each time · Wait the same # of minutes each time before reading temperature · Thermometer laid flat on the ground · Thermometer shaded from direct sun	1
Manipulated Variable (changed)	Location is implied or stated as the variable that is changed in the investigation.	1
Responding Variable (measured-5th, dependent-10th)	The responding (measured) variable of temperature is identified or implied.	1
Validity Measures (10th)	10th grade. Extra validity measures e.g. random sampling; calibrate thermometers; wait for # of minutes for thermometer to calibrate.	1

Appendix B

Washington State Weighted Rubrics for Surface Temperature Comparative Investigation

Record Measurements	The temperature is recorded after so many minutes lying on the ground.	1
Trials Repeated	The temperature is measured more than once at each location.	1
Logical Steps	The steps of the procedure are detailed enough to repeat the procedure effectively.	1
	Total Points	9-11

Possible point conversions for the various grade levels

5th grade	8th grade	10th grade	Rubric score
7-9	8-10	9-11	4
5-6	6-7	7-8	3
3-4	4-5	5-6	2
2	2-3	3-4	1
0-1	0-1	0-2	0

Appendix B

Washington State Weighted Rubrics for Surface Temperature Comparative Investigation

Scoring the Conclusion

Review students' conclusions for the following conclusion attributes:

Conclusion Attributes		Points
Limits Conclusion to Place, Date, and Time of Study	Student gives location, date, and time where field study took place.	1
A Conclusive Statement	Student clearly describes which location has the highest temperature OR describes that there were no differences among the temperatures.	1
Lowest Supporting Data	Student gives location and temperature for location with the lowest degrees °F/°C OR gives the data that supports there were no differences among the locations.	1
Highest Supporting Data	Student gives location and temperature for location with the highest degrees °F/°C if data is different.	1
Comparison to Standards	Compare data to standards if applicable	N/A
Explanatory Language	Student uses explanatory language to connect or compare the supporting data to a correct conclusion. An explanation of how the given data supports the conclusion is stated or implied by using words like highest or lowest. Notes: 1. Points may be awarded even without supporting data given as long as conditions (manipulated variables) are given with a general trend of the responding variable. Example: The black top was the hottest and under the bushes was the coolest. 2. Points may be awarded when derived data is given. Example: The black top was 4 °F warmer than under the bushes.	1
	Total	5

Note:

1. When no conclusion is given data points are not awarded
2. A "data point' is numerical values for both the manipulated and responding variables (at 5th grade the changed or manipulated variable may simply be referenced)
3. When derived data is given explanatory language points are given along with both the highest and lowest supporting data points.

Example: The black top was 4 °F warmer than under the bushes.

Value Points	Score Points
4-5	2
2-3	1
0-1	0

Appendix C

Washington State Generic Weighted Rubrics for Assessing Written Procedures and Conclusions

Scoring the Procedure

Review students' procedure for the following procedure attributes:

Procedure Attributes		Points
Prediction	Student predicts what manipulated variable (time, location, organism, population) will do to the responding variable.	1
Prediction Reason	8th and 10th grade students must give a reason for the prediction.	1
Materials	Student lists materials and tools needed to perform the procedure.	1
Study Site	Student describes recording the description of study site-location, weather, date, and time	1
Controlled Variable (kept the same)	5th and 8th grade students must describe or imply one controlled variable in the procedure or the materials list. 10th grade students must describe or imply two controlled variables.	1
Manipulated Variable (changed)	Only one manipulated (changed) variable is identified or implied. What was changed to make a comparison is identified, for example, change in location, habitat, time, organism, population, or substrate	1
Responding Variable (measured-5th dependent-10th)	The responding (measured) variable is identified or implied. Procedure describes how data are measured/observed.	1
Validity Measures (10th)	Extra validity measures are included (e.g. random sampling, representative sampling, taking both sampling repeated trials and measurement repeated trials, rinsing equipment between measurements)	1
Record Measurements	Student states or implies measurements are recorded periodically or gives a data table.	1
Trials Repeated	Student describes or implies that either samples and/or measured data are repeated.	1
Logical Steps	The steps of the procedure are detailed enough to repeat the procedure effectively.	1
	Total Points	9-11

Possible conversions for the various grade levels

5th grade	8th grade	10th grade	Points
7-9	8-10	9-11	4
5-6	6-7	7-8	3
3-4	4-5	5-6	2
2	2-3	3-4	1
0-1	0-1	0-2	0

Appendix C

Washington State Generic Weighted Rubrics for Assessing Written Procedures and Conclusions

Scoring the Conclusion

Review students' procedure for the following conclusion attributes:

Conclusion Attributes		Points
A Conclusive Statement	Student clearly answers the investigative question or explains whether or not the prediction was correct.	1
Limits Conclusion to Place, Date, and Time of Study	Gives location, date, and time where field investigation took place.	1
Lowest Supporting Data	Data points (or derived data-averages) or observations are given for the "lowest" condition OR data that supports the "null" hypothesis that there is no difference-all conditions are identified. 8th and 10th grade must use averages or final data for support.	1
Highest Supporting Data	Data points (or derived data-averages) or observations are given for the "highest" condition when there is a difference. 8th and 10th grade must use averages or final data for support.	1
Comparison to Standards	Compare data to standards if applicable	1
Explanatory Language	Student uses explanatory language to connect or compare the supporting data to a correct conclusion. Explanation of how the given data supports the conclusion is stated or implied by using comparative words like highest or lowest. Student compares what happened between or among changed (manipulated) variable conditions. Notes: 1. Points may be awarded even without supporting data points as long as conditions (manipulated variables) are given with a general trend of the responding variable. Example: The grass with the most light grew the tallest. The grass with the least light grew less than grass given more light. 2. When derived data is given explanatory language points are given. Example: Twig growth on north side had an average of 8cm more growth than twigs on the south side of the bush.	1
	Total	5-6

1. A response with an incorrect conclusive statement or no conclusive statement may not be credited any value points.
2. A "data point' is numerical values for both the manipulated and responding variables (at 5th grade the changed or manipulated variable may simply be referenced)
3. When correct derived data is given explanatory language points are given The supporting data points are also given if derived data comes from both the high and low supporting data points.

Value Points	Score Points
4-6	2
2-3	1
0-1	0

Appendix D

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

The curriculum and activity guides listed below are useful resources. Each contains activities which can be used to prepare students to conduct field investigations. The list on the following page identifies field investigation activities. Activities or guides marked with an asterisk (*) are particularly suited for adaptation to comparative field investigations or learning the skills required to do comparative field investigations.

Project WILD focuses on wildlife

www.projectwild.org
K-12 Curriculum and Activity Guide
K-12 Aquatic Curriculum and Activity Guide
Science and Civics: Sustaining Wildlife (Secondary)*

Project WET focuses on water

www.projectwet.org
Project WET Curriculum and Activity Guide
Healthy Water, Healthy People (Secondary)*

Project Learning Tree focuses on the forest

www.plt.org
PreK-8 Environmental Education Activity Guide
The Changing Forest: Forest Ecology (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 Off after School?
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

Sounds Around*
Planet Diversity*
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*

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

Appendix E
Field Investigation Resources

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Appendix F

Scientific Field Investigations described in Washington State Science Education Standards (2005)

Appendix E: Scientific Field Investigations

Field investigations allow students to connect abstract ideas to the world around them, starting from their immediate environment in the lower grades to the world as planet Earth in the upper grades. Field investigations generally take place in the outdoors. However they may encompass investigations of human systems such as water treatment facilities. The important point of field investigations is that students are able to make connections to the real world of ideas they may have learned about from print and media resources and laboratory investigations. Using the environment as a context for learning creates opportunities for multiple intelligences, critical thinking, and problem solving while opening possibilities to integrate reading, writing, mathematics, social studies, visual arts, speaking, and listening. The following charts summarize important attributes of scientific field investigations.

Grades Kindergarten through 2

Essential (general) question: Identifies and asks overreaching question about the system being investigated.

Question: Ask the question being investigated in the field study.

Planning the field investigation:

- Ask questions about objects and events in the immediate environment, and develop ideas about how those questions might be answered.
- Demonstrate and describe ways of using materials and tools to help answer the question.
- Describe the study site and time frame.
- Make a list of what is to be measured or observed.
- Record how, when, and where samples are taken.
- Record logical steps so that the field study could be repeated.
- Identify and follow all safety rules for exploring the immediate environment.

Collecting and analyzing data:

- Record data (measurements) in a systematic way using drawings, tables, charts, graphs, or maps.
- Identify patterns and order in objects and events studied: create drawings, graphs, tables, or maps.
- Work with others and share and communicate ideas about explorations during the investigation.
- Undertake personal actions to care for the immediate environment and contribute to responsible group decisions.

Grades 3 through 5

Essential (general) question: Identifies and asks overreaching question about the system being investigated.

Question: Ask the question being investigated in the field study.

Planning the field investigation:

- Predict (hypothesize), when appropriate, comparative and correlative studies.
- List materials.
- Describe the study site and time frame.
- Identify manipulated or changed variable(s).
- Identify consistent sampling (controls).
- Record responding variable(s) (measured or observed) when appropriate.
- Record how, when, and where samples are taken.
- Record logical steps so that the field study could be repeated.
- Identify and follow all safety rules for a field investigation.

Collecting and analyzing data:

- Record data (measurements) in a systematic way using drawings, tables, charts, graphs, or maps.
- Organize and analyze data to look for patterns and trends. When appropriate sort measurements (observations) into categories; calculate means, modes, or medians; and create graphs, tables, or maps.
- Construct a reasonable explanation using evidence: Answer the investigative (study) question or respond to the prediction using supporting data.

Appendix F

Scientific Field Investigations in the Washington State Science Essential Academic Learning Requirements

Grades 6 through 8

Essential (general) question: Identifies and asks overreaching question about the system being investigated.

Question: Ask the question being investigated in the field study.

Planning the field investigation:

- Predict (hypothesize), when appropriate, comparative and correlative studies.
- List materials.
- Describe the study site and time frame.
- Record manipulated (changed) variable(s).
- Record consistent sampling (controls).
- Conduct representative (random) sampling when appropriate.
- Record responding (dependent) variable when appropriate.
- Record how, when, and where samples are taken.
- Identify and account for extraneous factors — factors that might have an effect on the focus variable(s).
- Record logical steps so that the field study could be repeated.
- Understand and follow all safety rules for a field investigation.

Collecting and analyzing data:

- Record data (measurements) in a systematic way using tables, charts, graphs, or maps.
- Organize and analyze data to look for patterns and trends. When appropriate sort measurements (observations) into categories; calculate means, modes, or medians; create graphs, tables, or maps; and compare data to standards.

Constructing a reasonable explanation using evidence:

- Answer the investigative (study) question or respond to the prediction using supporting data.
- Compare data to other studies, when appropriate, to answer essential (general) question.

Grades 9 through 10

Essential (general) question: Identifies and asks overreaching question about the system being investigated.

Question: Ask the question being investigated in the field study.

Planning the field investigation:

- Predict (hypothesize), when appropriate, comparative and correlative studies.
- List materials.
- Describe the study site and time frame.
- Record manipulated variable(s).
- Record consistent sampling (controls).
- Conduct representative (random) sampling when appropriate.
- Record responding (dependent) variable (measured, observed, changed, or continuous) when appropriate.
- Record how, when, and where samples are taken.
- Identify and account for extraneous factors — factors that might have an effect on the focus variable(s).
- Record logical steps so that the field study could be repeated.
- Plan, explain, and follow safety rules for a field investigation.

Collecting and analyzing data:

- Record data (measurements) in a systematic way using tables, charts, graphs, or maps.
- Organize and analyze data to look for patterns and trends. When appropriate sort measurements (observations) into categories; calculate means, modes, or medians; create graphs, tables, or maps; compare data to standards; and perform statistical analysis to correlate continuous variables (10th grade).

Constructing a reasonable explanation using evidence:

- Answer the investigative (study) question or respond to the hypothesis using supporting data.
- Compare data to other studies, when appropriate, to answer the essential question.
- Compare data to standards, when appropriate, to answer a larger question.

Appendix G

Science as Inquiry. National Science Education Standards. (National Reseach Council 1996) Guide to Content Standard Grades K-4, 5-8, 9-12)

Science as Inquiry

National Science Education Standards (NRC 1996)

Guide to the Content Standard K-4

Fundamental abilities and concepts that underlie this standard include

ABILITIES NECESSARY TO DO SCIENTIFIC INQUIRY

ASK A QUESTION ABOUT OBJECTS, ORGANISMS, AND EVENTS IN THE ENVIRONMENT. This aspect of the standard emphasizes students asking questions that they can answer with scientific knowledge, combined with their own observations. Students should answer their questions by seeking information from reliable sources of scientific information and from their own observations and investigations.

PLAN AND CONDUCT A SIMPLE INVESTIGATION. In the earliest years, investigations are largely based on systematic observations. As students develop, they may design and conduct simple experiments to answer questions. The idea of a fair test is possible for many students to consider by fourth grade.

EMPLOY SIMPLE EQUIPMENT AND TOOLS TO GATHER DATA AND EXTEND THE SENSES. In early years, students develop simple skills, such as how to observe, measure, cut, connect, switch, turn on and off, pour, hold, tie, and hook. Beginning with simple instruments, students can use rulers to measure the length, height, and depth of objects and materials; thermometers to measure temperature; watches to measure time; beam balances and spring scales to measure weight and force; magnifiers to observe objects and organisms; and microscopes to observe the finer details of plants, animals, rocks, and other materials. Children also develop skills in the use of computers and calculators for conducting investigations.

USE DATA TO CONSTRUCT A REASONABLE EXPLANATION. This aspect of the standard emphasizes the students' thinking as they use data to formulate explanations. Even at the earliest grade levels, students should learn what constitutes evidence and judge the merits or strength of the data and information that will be used to make explanations. After students propose an explanation, they will appeal to the knowledge and evidence they obtained to support their explanations. Students should check their explanations against scientific knowledge, experiences, and observations of others.

[See Teaching Standard B]

COMMUNICATE INVESTIGATIONS AND EXPLANATIONS. Students should begin developing the abilities to communicate, critique, and analyze their work and the work of other students. This communication might be spoken or drawn as well as written.

UNDERSTANDINGS ABOUT SCIENTIFIC INQUIRY

[See Content Standard G (grades K-4)]

[See Program Standard C]

- Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
- Scientists use different kinds of investigations depending on the questions they are trying to answer. Types

Appendix G

Science as Inquiry. National Science Education Standards. (National Reseach Council 1996) Guide to Content Standard Grades K-4, 5-8, 9-12)

of investigations include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting).

- Simple instruments, such as magnifiers, thermometers, and rulers, provide more information than scientists obtain using only their senses.
- Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations.
- Scientists make the results of their investigations public; they describe the investigations in ways that enable others to repeat the investigations.
- Scientists review and ask questions about the results of other scientists' work.

Guide to the Content Standard 5-8

Fundamental abilities and concepts that underlie this standard include

ABILITIES NECESSARY TO DO SCIENTIFIC INQUIRY

IDENTIFY QUESTIONS THAT CAN BE ANSWERED THROUGH SCIENTIFIC INVESTIGATIONS. Students should develop the ability to refine and refocus broad and ill-defined questions. An important aspect of this ability consists of students' ability to clarify questions and inquiries and direct them toward objects and phenomena that can be described, explained, or predicted by scientific investigations. Students should develop the ability to identify their questions with scientific ideas, concepts, and quantitative relationships that guide investigation.

DESIGN AND CONDUCT A SCIENTIFIC INVESTIGATION. Students should develop general abilities, such as systematic observation, making accurate measurements, and identifying and controlling variables. They should also develop the ability to clarify their ideas that are influencing and guiding the inquiry, and to understand how those ideas compare with current scientific knowledge. Students can learn to formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations, and critique explanations and procedures.

USE APPROPRIATE TOOLS AND TECHNIQUES TO GATHER, ANALYZE, AND INTERPRET DATA. The use of tools and techniques, including mathematics, will be guided by the question asked and the investigations students design. The use of computers for the collection, summary, and display of evidence is part of this standard. Students should be able to access, gather, store, retrieve, and organize data, using hardware and software designed for these purposes.

DEVELOP DESCRIPTIONS, EXPLANATIONS, PREDICTIONS, AND MODELS USING EVIDENCE. Students should base their explanation on what they observed, and as they develop cognitive skills, they should be able to differentiate explanation from description—providing causes for effects and establishing relationships based on evidence and logical argument. This standard requires a subject matter knowledge base so the students can effectively conduct investigations, because developing explanations establishes connections between the content of science and the contexts within which students develop new knowledge.

Appendix G

Science as Inquiry. National Science Education Standards. (National Reseach Council 1996) Guide to Content Standard Grades K-4, 5-8, 9-12)

THINK CRITICALLY AND LOGICALLY TO MAKE THE RELATIONSHIPS BETWEEN EVIDENCE AND EXPLANATIONS. Thinking critically about evidence includes deciding what evidence should be used and accounting for anomalous data. Specifically, students should be able to review data from a simple experiment, summarize the data, and form a logical argument about the cause-and-effect relationships in the experiment.

Guide to the Content Standard 9-12

Fundamental abilities and concepts that underlie this standard include

ABILITIES NECESSARY TO DO SCIENTIFIC INQUIRY

IDENTIFY QUESTIONS AND CONCEPTS THAT GUIDE SCIENTIFIC INVESTIGATIONS. Students should formulate a testable hypothesis and demonstrate the logical connections between the scientific concepts guiding a hypothesis and the design of an experiment. They should demonstrate appropriate procedures, a knowledge base, and conceptual understanding of scientific investigations.

DESIGN AND CONDUCT SCIENTIFIC INVESTIGATIONS. Designing and conducting a scientific investigation requires introduction to the major concepts in the area being investigated, proper equipment, safety precautions, assistance with methodological problems, recommendations for use of technologies, clarification of ideas that guide the inquiry, and scientific knowledge obtained from sources other than the actual investigation. The investigation may also require student clarification of the question, method, controls, and variables; student organization and display of data; student revision of methods and explanations; and a public presentation of the results with a critical response from peers. Regardless of the scientific investigation performed, students must use evidence, apply logic, and construct an argument for their proposed explanations.

USE TECHNOLOGY AND MATHEMATICS TO IMPROVE INVESTIGATIONS AND COMMUNICATIONS. A variety of technologies, such as hand tools, measuring instruments, and calculators, should be an integral component of scientific investigations. The use of computers for the collection, analysis, and display of data is also a part of this standard. Mathematics plays an essential role in all aspects of an inquiry. For example, measurement is used for posing questions, formulas are used for developing explanations, and charts and graphs are used for communicating results.

FORMULATE AND REVISE SCIENTIFIC EXPLANATIONS AND MODELS USING LOGIC AND EVIDENCE. Student inquiries should culminate in formulating an explanation or model. Models should be physical, conceptual, and mathematical. In the process of answering the questions, the students should engage in discussions and arguments that result in the revision of their explanations. These discussions should be based on scientific knowledge, the use of logic, and evidence from their investigation.

RECOGNIZE AND ANALYZE ALTERNATIVE EXPLANATIONS AND MODELS. This aspect of the standard emphasizes the critical abilities of analyzing an argument by reviewing current scientific understanding, weighing the evidence, and examining the logic so as to decide which explanations and models are best. In other words, although there may be several plausible explanations, they do not all have equal weight. Students should be able to use scientific criteria to find the preferred explanations.

November 27

It's early. Like, birds-aren't-even-chirping-yet early. But the way the grass crunches under my feet in this frost almost makes 7 a.m. bearable.

Using the GPS device to tell our group we're exactly 2,912 ft. above sea level definitely makes it worth it. We hike north with our instructor – I announce our exact longitude and latitude – into deep forest. Signs are all around us. Signs, the instructor says, of cougars. We all laugh nervously.

Everyone works together.

We collect evidence – cougar evidence – that we'll use in our classroom labs over the next few weeks. We're not only learning how cougars hunt and live and survive, but we're actually using math and science to figure it all out.

Best of all, my work could actually help make a difference for the cougars.