Effects of Acid Deposition — Salamander Monitoring

Salamanders

Theme: Salamanders and the Effects of Acid Deposition
Best Time to Plan Trip: Fall or Spring

Unit Rationale

The Great Smoky Mountains are known as the "Salamander Capital of the World!" Salamanders are an especially abundant and diverse group in the Great Smokies. There are 30 species of salamanders within the boundaries of the Park. Since salamanders breathe through their skin they are more susceptible to water and air pollution. During this study students will work in groups to collect and record data in taking an inventory in monitoring many of the salamanders found in the park.

North Carolina Curriculum Correlations

Earth/Environmental Science Essential Standards and Clarifying Objectives

EEn.2.2 Understand how human influences impact the lithosphere
- EEn.2.2.1 Explain the consequences of human activities on the lithosphere past and present.
- EEn.2.2.2 Compare the various methods humans use to acquire traditional energy sources.

EEn.2.5 Understand the structure of and processes within our atmosphere
- EEn.2.5.5 Explain how human activities affect air quality.

EEn.2.7 Explain how the lithosphere, hydrosphere, and atmosphere individually and collectively affect the biosphere.
- EEn.2.7.2 Explain why biodiversity is important to the biosphere.
- EEn.2.7.3 Explain how human activities impact the biosphere.

Biology Essential Standards and Clarifying Objectives

Bio.2.1 Analyze the interdependence of living organisms within their environments
- Bio.2.1.1 Analyze the flow of energy and cycling of matter (such as water, carbon, nitrogen and oxygen) through ecosystems relating the significance of each to maintaining the health and sustainability of an ecosystem.
- Bio.2.1.2 Analyze the survival and reproductive success of organisms in terms of behavioral, structural, and reproductive adaptations.
- Bio.2.1.4 Explain why ecosystems can be relatively stable over hundreds or thousands of years, even though populations may fluctuate.

Bio.2.2 Understand the impact of human activities on the environment (one generation affects the next).
- Bio.2.2.1 Infer how human activities may impact the environment.
- Bio.2.2.2 Explain how the use, protection and conservation of natural resources by humans impact the environment from one generation to the next.

Bio.3.5 Analyze how classification systems are developed upon speciation.
- Bio.3.5.2 Analyze the classification of organisms according to their evolutionary relationship.

AP Biology Goals and Objectives

Competency Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.
- 1.01 The learner will identify questions and problems that can be answered through scientific investigations.
- 1.02 The learner will design and conduct scientific investigations to answer questions about the physical world.

1.03 The learner will formulate and revise scientific explanations and models using logic and evidence.

1.04 The learner will apply safety procedures in the laboratory and in field studies:

Competency Goal 6: The learner will develop an understanding of the unity and diversity of life.

6.02 The learner will survey the diversity of life.

6.03 The learner will analyze and apply current phylogenetic classification.

6.05 The learner will examine the structure and function of plants and animals.

Competency Goal 7: The learner will develop an understanding of basic ecological principles.

7.01 The learner will analyze population dynamics.

7.02 The learner will examine the actions and interactions of communities and ecosystems.

7.03 The learner will assess current global issues.

AP Earth and Environmenatl Science (APES) Goals and Objectives

Competency Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.01 The learner will identify questions and problems in the earth and environmental sciences that can be answered through scientific investigations.

1.02 The learner will design and conduct scientific investigations to answer questions related to earth and environmental science.

1.03 The learner will formulate and revise scientific explanations and models using logic and evidence.

1.04 The learner will apply safety procedures in the laboratory and in field studies:

Competency Goal 2: The learner will build an understanding of the interdependence of Earth's systems.

2.05 The learner will investigate the biosphere.

Competency Goal 5: The learner will build an understanding of air, water, and soil quality.

5.01 The learner will analyze the sources of major pollutants.

5.02 The learner will investigate the effects of pollutants.

Competency Goal 6: The learner will build an understanding of global changes and their consequences.

6.03 The learner will investigate effects and consequences on biota:

Competency Goal 7: The learner will build an understanding of environmental decision making.

7.04 The learner will develop an awareness of environmental options.

Table of Contents

Planning a Successful Trip

At Purchase Knob

Schedule for a day of activities in Great Smoky Mountains National Park at Purchase Knob

- Meet park ranger at Purchase Knob
- Use restrooms
- Large group introduction
- Break into two groups
- Participate in activities
- Lunch
- Switch groups
- Large group conclusion

• Check the weather before you go. Lunch will be eaten outside.

• School buses can park at the program site.

• The pre-visit activities included in this packet are specific to the theme of your program and should be presented prior to your scheduled visit. The post-visit activities are designed to reinforce and build upon the park experience.

• A map to the Appalachian Highlands Science Learning Center Purchase Knob can be found on page 6

• All students, teachers, and chaperones will meet the park rangers at the Appalachian Highlands Science Learning Center at Purchase Knob.

• The maximum number of students for this trip is 60. We require an adult or teacher for every ten students to create a positive and rewarding experience. The on-site instruction is conducted by a park ranger. However, your assistance is needed with discussion and discipline. Please feel free to contact the park at (828) 926-6251 if you have any further questions.

•Restrooms and Water
Restrooms and water fountains will be available at the program site.

At Mingus Mill

Schedule for a day of activities in Great Smoky Mountains National Park at Mingus Mill

- Meet park ranger at Mingus Mill
- Use restrooms
- Large group introduction
- Break into two groups
- Participate in activities
- Lunch
- Switch groups
- Large group conclusion

•Check the weather before you go. Lunch will be eaten outside.

•School buses can park at the program site.

•The pre-visit activities included in this packet are specific to the theme of your program and should be presented prior to your scheduled visit. The post-visit activities are designed to reinforce and build upon the park experience.

• A map to Mingus Mill can be found on page 6

•The maximum number of students for this trip is 50. We require an adult or teacher for every ten students to create a positive and rewarding experience. The on-site instruction is conducted by a park ranger. However, your assistance is needed with discussion and discipline.

•Restrooms and Water
Restrooms and water fountains will be available at the program site.

Background Information

Park Description:

The National Park Service is charged with the management and preservation of the nation's most precious natural and cultural resources. These resources are woven into our natural heritage, and they provide opportunities for recreation, appreciation of beauty, historical reflection, cultural enrichment, and education.

Great Smoky Mountains National Park is one of the largest protected land areas east of the Rocky Mountains. With over 500,000 acres (800 square miles) of forest, the Smokies contain an enormous variety of plants and animals. In terms of biological diversity, a walk from a mountain's foot to its peak is comparable to the 2,000 mile hike on the Appalachian Trail from Georgia to Maine.

Because the National Park Service is charged with protecting resources and natural systems, the park engages in comprehensive research programs, such as air quality monitoring, to foster an understanding of park resources and to show how they are affected by local, regional, and global influences. Since the Smokies are so biologically diverse, the park is designated as an International Biosphere Reserve by the United Nations. The international system contains over 320 reserves in over 80 countries with the primary objectives of conserving genetic diversity and coordinating environmental education, research, and monitoring.

The Smokies also have a rich cultural history. Native Americans have lived in this area for thousands of years, and permanent white settlement began around 1800. The coming of commercial logging around 1900 stripped trees from two-thirds of what is now park land. Established in 1934, the park was created from more than 6,000 tracts of private and commercial land that was bought mostly with money raised and privately donated. Centrally located within a two-day's drive for half of the nation's population, Great Smoky Mountains National Park has the highest visitation of all the national parks in the country.

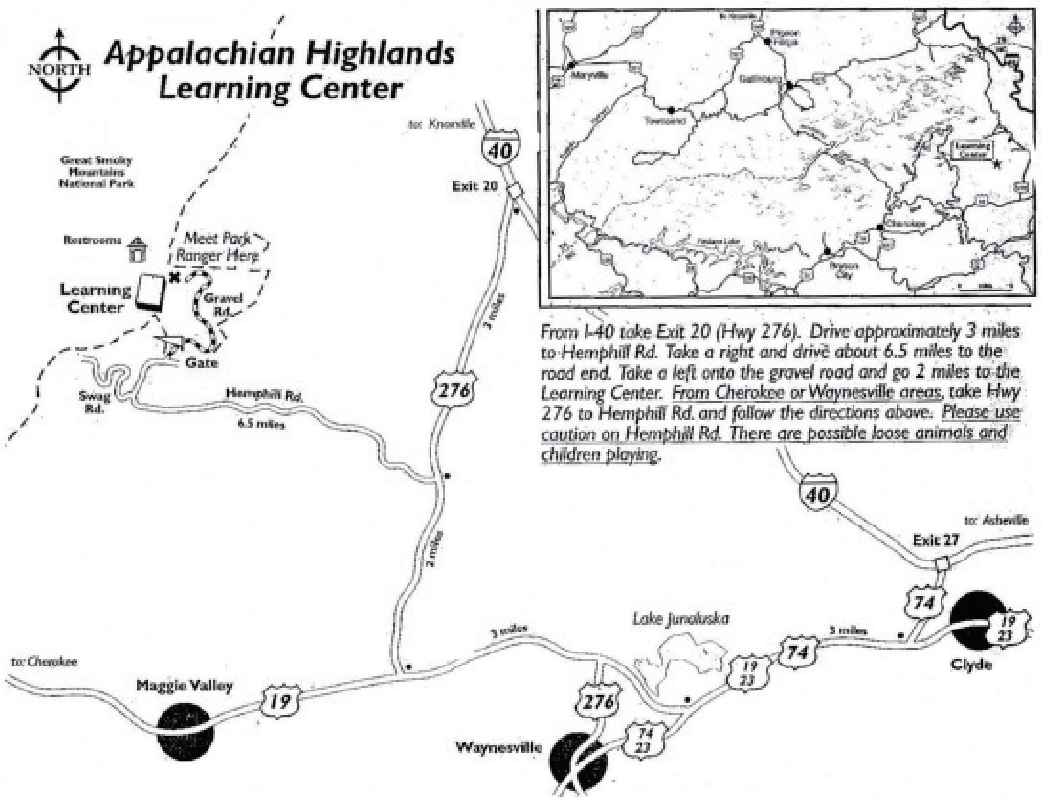
Purchase Knob Description:

The Purchase Knob property, over 530 acres in size, was donated to Great Smoky Mountains National Park by Katherine McNeil and Voit Gilmore in January 2001. Situated at an elevation of over 5,000 feet, the area contains old-growth forests, mountain meadows and high elevation wetlands. It also rests on geological formations that aren't found anywhere else in the park, lending to a unique and diverse habitat for the study of plants and animals. The house is the location of the Appalachian Highlands Science Learning Center, whose mission is to provide a space for researchers to perform biological inventory and monitoring while offering education programs for students and teachers on these same subjects.

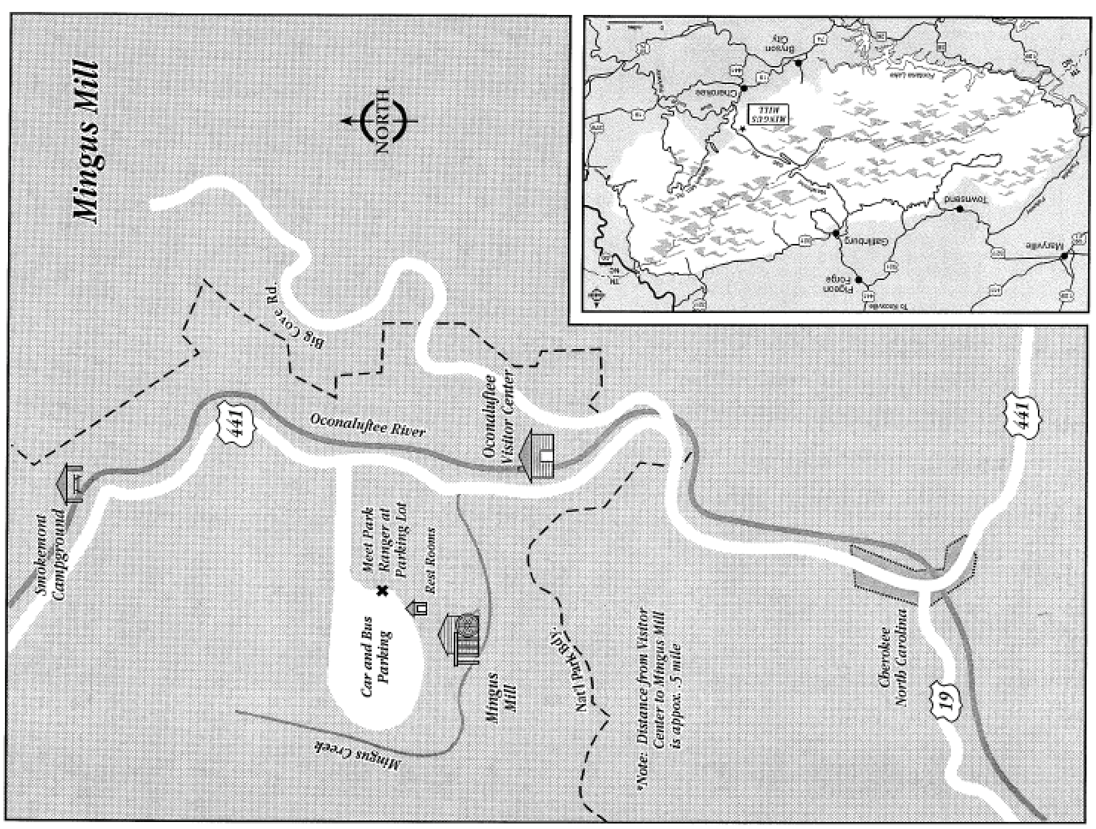
Mingus Mill Description:

The Mingus Mill is located a half-mile north of the Oconaluftee Visitor Center on US-441. Situated at an elevation of 2,100 feet the area contains cove hardwood forests. The historic grist mill, built in 1886 uses a water-powered turbine instead of a water wheel to power all of the machinery in the building. Located at its original site, Mingus Mill stands as a tribute to the test of time.

Map To Purchase Knob



Map To Mingus Mill



Pre-Site Activity
Salamander Information

Grade Level: High School

Subject Area: Science

Activity time: 60 minutes

Setting: Classroom

Skills: Analyzing, Classifying, Collecting information, Connecting, Contrasting, Formulating questions, Interpreting, Researching

Vocabulary:

•**All Taxa Biodiversity Inventory:** also called the ATBI. A research project in the Great Smoky Mountains National Park to inventory every life form in the park. It is estimated that we currently know only 14,000 of an estimated 100,000 species.

•**Baseline Information**: information about how things are now, at this point in time, so we will know if there is a change the next time we look at it.

•**Biodiversity:** the variety, distribution and abundance of life forms and ecological processes in an ecosystem; includes the ways in which different life forms interact.

•**Biological Inventory:** a technique used by scientists to study the various life form in a given area. In the Great Smoky Mountains National Park, inventories are done in study plots.

•**Biological Monitoring**: a technique used by scientists to check the condition of a particular species or ecosystem over time.

•**Canopy:** the top layer of the forest, the treetops.

•**Density**: the number of individuals of a given species within a certain area.

•**Dichotomous Key:** an identification method that narrows down a species in question using a series of pairs of choices.

•**Ecosystem**: a system formed by the interaction of groups of organisms with each other and their environment.

•**Hypothesis**: a proposition based on assumptions that can be evaluated scientifically.

•**Vertebrate**: an animal that has a backbone.

•**Taxonomy**: the classification of plants and animals according to their natural relationships.

Materials:

•Vocabulary (page 7)
•“Inventory and Monitoring” worksheet (page 9)
•Salamander Information worksheets (pages 10-11)
•Computer with internet connection.

Objectives:

1) use the scientific method while studying biodiversity
2) describe the steps in scientific inquiry
3) learn the identifying characteristics between different species of salamanders
4) understand the biodiversity of the Great Smoky Mountains National Park
5) recognize the threats to aquatic and terrestrial salamanders

Background:

When students visit the Smokies on their field trip one group will be collecting data as part of a Salamander study. This lesson will introduce the scientific method and use the identifying anatomical characteristics to key different species of salamanders.

To be a scientist you don’t necessarily have to have an advanced degree. All you need to have is the ability to observe the world around you and to ask good questions. Why do things happen? How do they happen? Scientists use a systematic method to find answers to their questions. The approach is known as the scientific method or scientific inquiry. The key components to this method are: making careful observations using your senses (sometimes that includes noticing what is not there as well as what is), asking a question that is clear and specific, gathering information from literature to develop a procedure for study and to discover what is already known about your question, forming a hypothesis (possible answers to the question), testing the hypothesis (surveys, experiments and field observations are techniques), interpreting the results (make sense of your data by creating graphs or charts), drawing conclusions (was the hypothesis correct, what can you learn from your results, what factors were not in your control...), and sharing your results.

Procedure:

Have the students read the "Inventory and Monitoring" worksheet (page 9). Discuss why it is important for a park to develop an Inventory and Monitoring program.

Have the students read the "Salamander Information" worksheets (pages 10-11). Discuss the 1) Characteristics of a salamander, 2) What the term "lungless" salamanders mean in terms of how the salamanders breathe, 3) Differences between salamanders and lizards, 4) Different ways salamander monitoring is done in the park, 5) Correct method of measuring the length of a salamander, and 6) Differences between dusky and woodland salamanders.

Have the students read over the Vocabulary associated with the Salamander program (page 7). All of the definitions will be used within the salamander inventory session. Students will probably be familiar with most of the definitions but reviewing the list before the trip is essential.

Inventory and Monitoring

The Science of Discovering What's There & How it is Doing

When someone knocks on your door and you ask, "Who is it?," you have just taken a simple inventory of the people at the other side of your door. When you let them in and they ask, "How are you?" they have conducted a simple monitoring program to determine your health. Of course, the accuracy of the data depends on how truthful the answer is. Conducting a biological inventory or ecological monitoring makes use of most of the tools of science, but it does not involve developing a hypothesis to test. Instead it involves making careful observations of how things are (inventory) and how things may or may not change over time (monitoring).

If you are given a box full of stuff to use and protect, one of the first things you'll probably want to do is open it to take an inventory of what is inside so you could do your best job of using and protecting it. A biological inventory may involve developing a simple list of species or may include estimates of populations size (how many), mapping their range (where they are), and even what other species they associate with - their ecological community. An inventory is most useful if it occurs over a brief period of time because over a long period of time things can change and your inventory stops being accurate. An inventory is best as a snap-shot in time. A good inventory produces baseline data which is the standard against which you can compare what happens over time (for example there may have been changes in the environment, such as air pollution, or a change in the way people use the resource). We usually don't know what things were like 500 years ago, but we can find out what things are like now, which might let us determine if things are changing, becoming less or more diverse the next time we look. The All Taxa Biodiversity Inventory is a huge inventory project started in Great Smoky Mountains National Park in 1998 to determine what species live in the park, their distribution, and their ecological community. It is estimated that as many as 100,000 species of plants, animals, and fungi live in the park. Right now, biologists have found 14,000 of these species. That leaves a lot of stuff in the "box" that park managers don't know about.

Though an inventory is conducted over a brief period of time, a monitoring program could be designed to go on forever. Usually a monitoring program is set up to help detect if an unexpected change is happening to a protected area or a population of rare species, or to determine if an expected change is happening as we thought it would. If a population of rare plants is being protected, it would be better to know that the population is declining while it is still large and you can do something about it, rather than go out one day and discover it is all gone. Great Smoky Mountains National Park monitors air quality, forest recovery after fires, rivers, populations of endangered species, and many other systems.

Inventory and monitoring are important parts of managing a National Park or any natural area. Findings from these projects allow managers to make informed decisions on when and how to act, and when to keep hands-off. Inventory and Monitoring programs also develop many questions that may be answered by hypothesis testing and other scientific methods.

Salamander Information in the Great Smoky Mountains National Park

Two major groups of amphibians occur in Great Smoky Mountains National Park: the salamanders (30 species) and the frogs and toads (13 species).

Great Smoky Mountains National Park is known as the "Salamander Capital of the World!" Salamanders are an especially abundant and diverse group in the Smokies. The majority of park vertebrates (the animals with back bones) are salamanders. We estimate that there are more salamanders than all of the park's mammals combined.

Five families of salamanders are represented in the park: Cryptobranchidae, Proteidae, Salamandridae, Ambystomatidae, and Plethodontidae.

The southern Appalachian Mountains, including the Great Smokies, are a major center of evolutionary diversification for the family Plethodontidae, commonly known as the lungless salamanders. There are 24 species of lungless salamanders in the park. The family has undergone an extraordinary level of evolutionary diversification in the southern Appalachian Mountains. As their family name implies, these salamanders lack lungs. They "breathe" (exchange oxygen and carbon dioxide) through the walls of tiny blood vessels in their skin and linings of their mouths and throats. Lungless salamanders occur everywhere in the Great Smokies, in and along streams and under rocks, logs, and leaf litter in the forests.

Salamanders are commonly called "spring lizards" in the southern Appalachians. Lizards and salamanders are, however, very different sorts of animals: salamanders are amphibians while lizards are reptiles. The skins of salamander lack scales and are moist or slimy to the touch. Their eggs are surrounded by clear jelly. Lizards, on the other hand, have scales on their skin, and are dry to the touch. They lay eggs with leathery shells.

Amphibian life cycles are tremendously varied, and some are highly adapted for life on land. Amphibians as a group; however, are semi-aquatic or at least moisture-loving creatures.

Adult amphibians are carnivorous. Frogs and many lungless salamanders use their tongues to capture small prey, while other salamanders capture their prey by grasping them in their jaws. Amphibians generally feed on any prey small enough to be subdued and eaten. Insects and other small invertebrate animals comprise the bulk of salamander and adult frog diets.

Larval salamanders are also carnivorous, feeding mainly on small aquatic animals such as the immature stages of aquatic insects. Frog and toad larvae (tadpoles) are aquatic herbivores and scavengers, feeding on algae, aquatic plants, and bits of decaying organic matter.

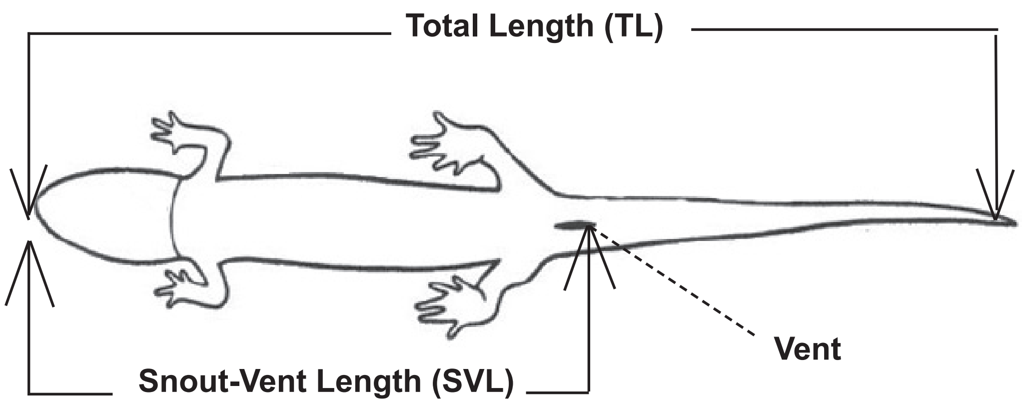
Salamanders can drastically range in size. The Hellbender, the largest in the park, can grow up to almost 3 feet in length, has teeth, and roams stream bottoms at night. The smallest species in the Smokies is the Pigmy, at under 2 inches.

Most people go to the doctor for a yearly checkup to make sure they are healthy. Park biologists do a similar thing for the plants and animals in a park, only the periodic checkup is called monitoring. Salamander monitoring in the Smokies is done in several different ways. One way is using a nearby stream and forest. A length of stream is marked off into one meter sections, and students on field trips enter the stream to look for and hopefully catch salamanders. Another way is to use a forested area to the side of the stream that is also marked off into one meter sections, and students enter the forest to look for salamanders on the forest floor. A third method is to look under tree cross sections ("Tree cookies"). These tree cookies are designated by letter and number and are placed on the forest floor. All three groups need to note the flag number or tree cookie where they caught their salamander and bring it to the data collection station by the stream's edge. There, each salamander is identified to species, weighed, and measured.

One of the reasons it is important to monitor salamanders is because they are considered bioindicators due to their sensitivity to environmental change. Salamanders lay eggs in water. The eggs have no outer covering or protective shell like chicken eggs. This makes their eggs very vulnerable to chemical pollutants, ultraviolet radiation, and other things that disturb growth. Also, salamanders skin is permeable, meaning it allows water and gases to enter and leave; they're 'environmental sponges.' When the water is healthy, they're healthy, and the eggs are healthy. Things like acid rain affect the water in which salamanders live and lay their eggs. When there's a low population of salamanders in a water source, that may be an indication of low water quality.

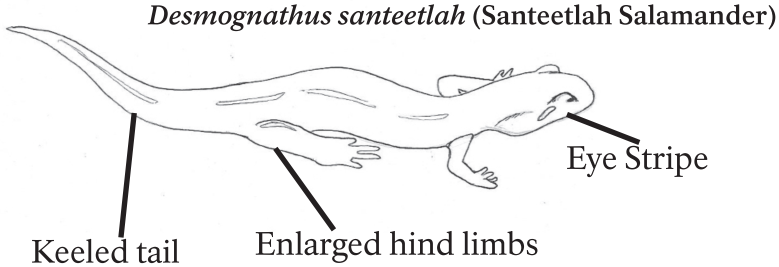
Anatomical Information for Identification

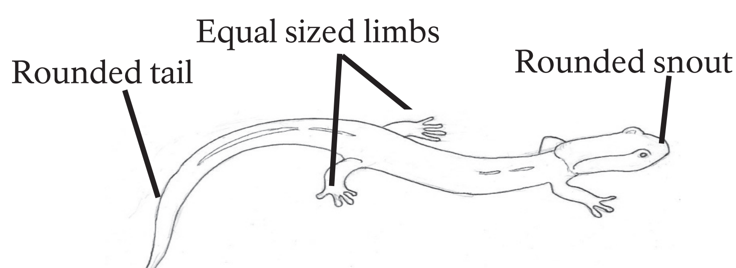
Total Length (TL) is the length from the tip of the snout to the tip of the tail. Snout-Vent Length (SVL) is the length from the tip of the snout to the back of the vent (the opening of the cloaca, or the all-purpose opening from which both wastes and sex cells leave the body). To measure the salamander in the field a Snout-Vent Length (see below) will be used since the salamander may have lost part or all of its tail in the past.



Most salamanders have four digits (fingers) on their front limbs and five digits on their hind limbs. The size and shape of the tail in cross-section are important in identification. The tail may be rounded, oval shaped, or keeled (knife-like) (see picture below of rounded versus keeled tail). Dusky salamanders can be distinguished from other lungless (Plethodontid) salamanders by their general body form. They all have strongly enlarged hind legs. A light line extending from the rear corner of the eye to the angle of the jaw is visible in nearly all specimens. As their name implies, most dusky salamanders are rather dully colored, in shades ranging from light brown to nearly black (see picture below of enlarged hind limbs versus equal sized front and hind legs).

Desmognathus santeetlah **(Santeetlah Salamander)**





Plethodon jordani **(Jordan's Red-cheeked Salamander)**

Genus Desmognathus (dusky salamanders)
- often difficult to identify to species
- have a pale diagonal line running from the eye to the angle of the jaw "eye stripe"
- hind legs often larger and thicker than fore limbs
- keeled tail

Genus Plethodon (woodland salamanders)
- all four limbs are about the same size
- rounded snout
- rounded tail

On-Site Activity
Salamander Study

Grade Level: High School

Subject Area: Science

Activity time: 75 minutes

Setting: Outside in the park

Skills: Analyzing, Applying, Calculating, Classifying, Collecting information, Communicating, Comparing, Confirming, Contrasting, Describing, Discussing, Formulating questions, Hypothesizing, Implementing investigations, Measuring, Predicting, Recording data, Reporting, Summarizing, Writing.

Materials:
•Clipboards
•Data sheets
•Pencils
•Salamander collecting supplies

Objectives:
1) explain why it is important to study animal populations
2) demonstrate the ability to collect and record data

Background:
The ranger will explain the research project. The students will be asked why it is important to monitor species populations. The ranger will explain to students that the Smokies are considered the salamander capital of the world because we have a relatively large diversity of species within the boundaries of the park (30 species).

Procedure:
Students will be split into their working groups and explain the methods and techniques for collecting and recording data. Students will be regrouped and will review the data collected.

Post-Site Activity
Graphing Trends

Grade Level: High School

Subject Area: Science

Activity time: 60 minutes

Setting: Classroom

Skills: Graphing, Analyzing, Applying, Assessing, Calculating, Charting, Evaluating, Formulating questions, Hypothesizing, Inferring, Interpreting, Predicting, Summarizing

Materials:

•"Graphing Salamander Trends" Worksheets found on pages 14-18

• Pen/pencil

Objectives:

1) demonstrate the ability to graph data
2) determine through inference and graphing the greatest predictor of salamander behavior between three variables

Background:

When students visited the Smokies on their field trip they participated in the Salamander study. They may not have participated in the tree cookie study, but were made aware of the study during their time in the Smokies. This lesson will allow students to graph using the previously collected data from the Hands on the Land website. After graphing the data, the students will make inferences in determining the greatest predictor of salamander behavior between three variables.

Procedure:

Have the students complete the "Graphing Salamanders Trends" worksheets (pages 14-18) individually, in pairs, or in small groups. A teacher answer key is provided on pages 19-21.

Graphing Salamander Trends

Determine the greatest predictor of number of salamanders found by creating three separate graphs for each of the three Wood Cookie Sets (total of 9 graphs): Diameter of average cookie (cm) to # of Salamanders found, Thickness of cookie (cm) to # of Salamanders found, and Distance from Stream (m) to # of Salamanders found. The Number of Salamanders found is placed on the Y-axis.

Wood Cookie Identification	Diameter of cookie (cm)	Thickness of cookie (cm)	Distance from Stream (m)	Number of Salamanders
A1	39.5	10.2	0	11
A2	40.8	9	10	5
A3	38.8	9.6	20	5
A4	41.7	9.4	30	8
A5	34.4	8	40	6
A6	32.2	10	50	4
A7	33.2	8.4	60	1
A8	34.7	9	70	1
A9	31.4	9.6	80	7
A10	38.4	7.8	90	2

Wood Cookie Identification	Diameter of cookie (cm)	Thickness of cookie (cm)	Distance from Stream (m)	Number of Salamanders
B1	32.1	9	0	10
B2	35.7	8	10	2
B3	35.1	9.6	20	3
B4	33.1	9.2	30	4
B5	32.4	8.2	40	6
B6	33.8	9	50	3
B7	31.4	9	60	3
B8	33.1	8.6	70	2
B9	30.8	9	80	3
B10	31.4	3.8	90	1

Wood Cookie Identification	Diameter of cookie (cm)	Thickness of cookie (cm)	Distance from Stream (m)	Number of Salamanders
C1	35.9	9.8	0	16
C2	32.6	8.8	10	10
C3	37.5	6.8	20	12
C4	33.2	7	30	7
C5	35.3	6.8	40	4
C6	34.8	8	50	3
C7	34.9	7	60	2
C8	31.5	6	70	3
C9	38.5	15.2	80	4
C10	32.1	3.8	90	0

"A" Wood Cookie Identification Graphing Set

For 1-3, graph the following for Wood Cookie set "A." Remember to label your axes.

1. Diameter of cookie (cm) to Number of Salamanders found
2. Thickness of cookie (cm) to Number of Salamanders found
3. Distance from Stream (m) to Number of Salamanders found

"B" Wood Cookie Identification Graphing Set

For 4-6, graph the following for Wood Cookie set "B." Remember to label your axes.

4. Diameter of cookie (cm) to Number of Salamanders found
5. Thickness of cookie (cm) to Number of Salamanders found
6. Distance from Stream (m) to Number of Salamanders found

"C" Wood Cookie Identification Graphing Set

For 7-9, graph the following for Wood Cookie set "C." Remember to label your axes.

7. Diameter of cookie (cm) to Number of Salamanders found
8. Thickness of cookie (cm) to Number of Salamanders found
9. Distance from Stream (m) to Number of Salamanders found

Graphing Trends Questions

10. What trends in salamander abundance are you seeing as diameter of cookie, thickness of cookie, and distance to stream change?

11. What is the best predictor variable to explain the number of salamanders found under each cookie?

12. What is the best way to know that the graphed results are dependable or just a one-time occurrence?

13. Combine all three replicate trials (A1+B1+C1, etc) of number of salamanders found and average the three to more clearly show the trend. Round to whole salamander (i.e. 5.9 = 6). Place information below.

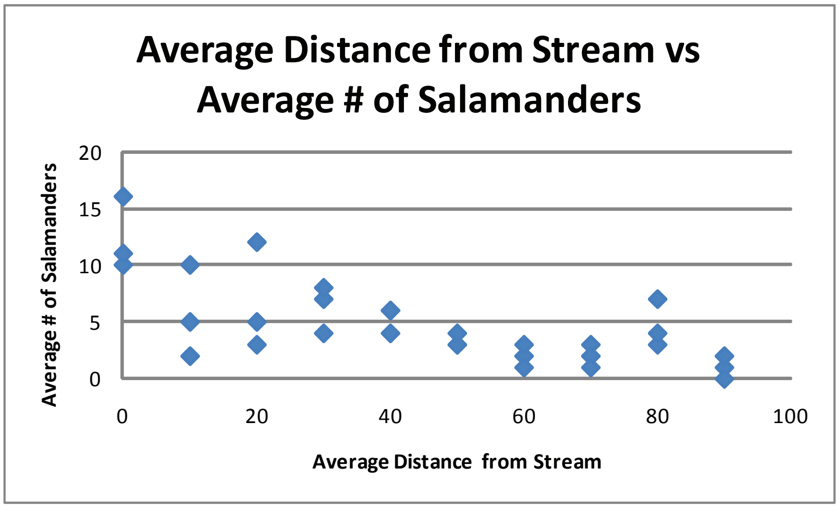
Wood Cookie Number	Average number of salamanders found
1	____________________
2	____________________
3	____________________
4	____________________
5	____________________
6	____________________
7	____________________
8	____________________
9	____________________
10	____________________

14. Graph the average number of salamanders found under each cookie number to distance in meters from the stream. Remember to label your axes.

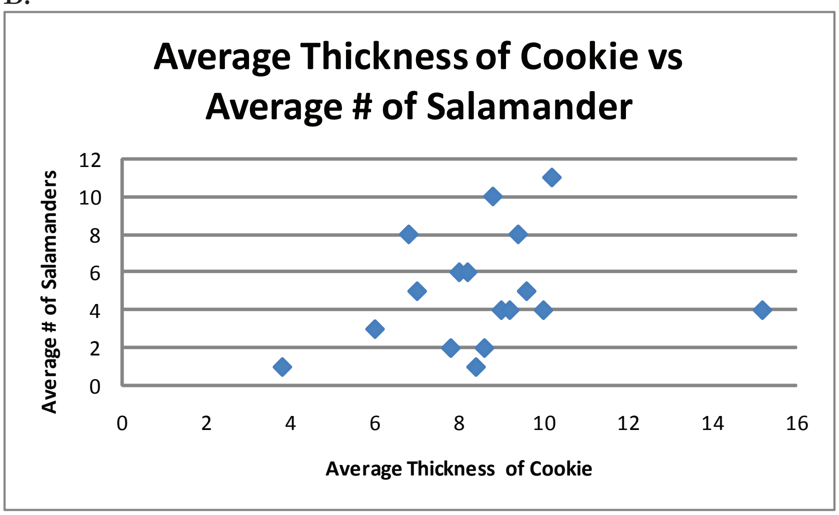
15. After graphing #14 wait for your teacher to give out a Comparison Graph worksheet. Check your completed graph from #14 to Graph A. Compare the three average graphing sets and decide what the best predictor variable is for explaining the number of salamanders found under each cookie.

Comparison Graphs

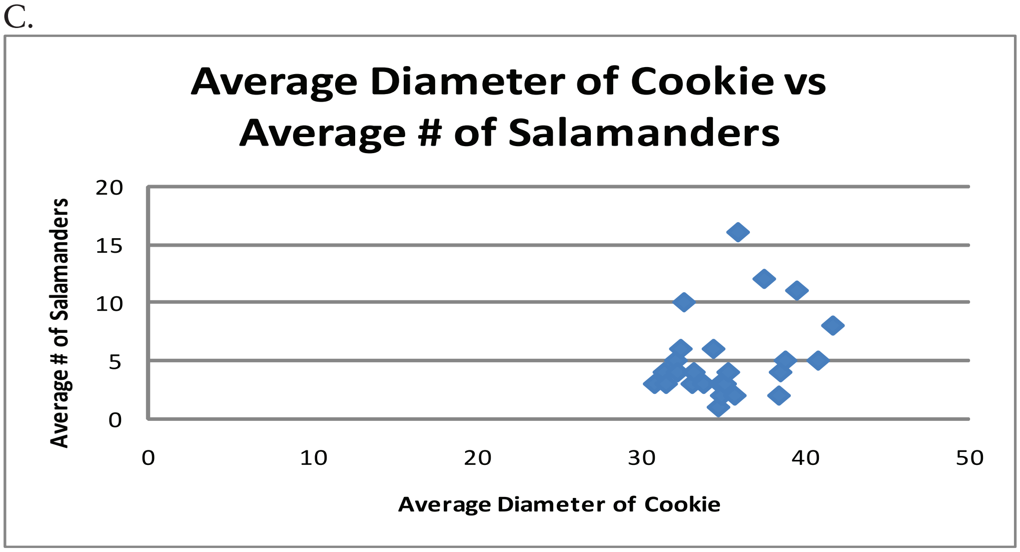
A.



B.



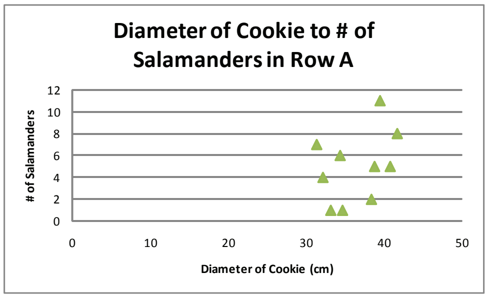
C.



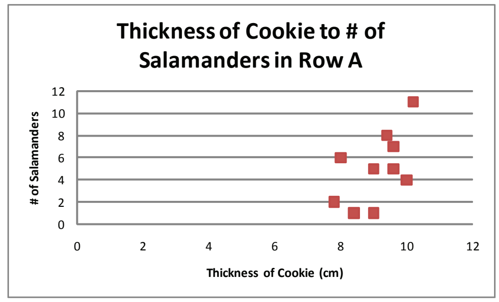
Graphing Salamander Trends
Teacher Answer Key

"A" Wood Cookie Identification Graphing Set

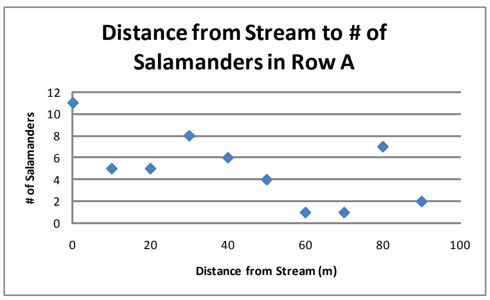
1. Diameter of cookie (cm) to Number of Salamanders found



2. Thickness of cookie (cm) to Number of Salamanders found

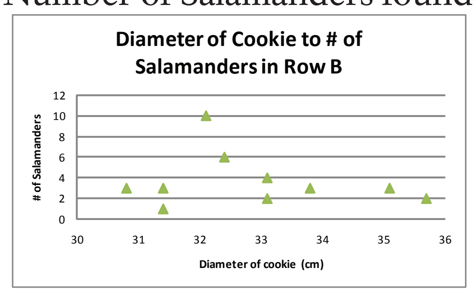


3. Distance from Stream (m) to Number of Salamanders found

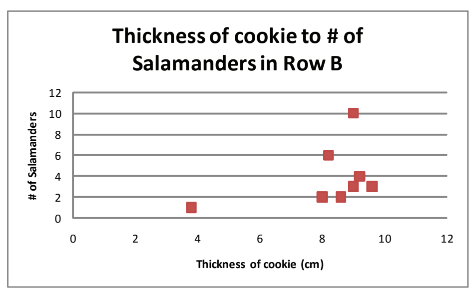


"B" Wood Cookie Identification Graphing Set

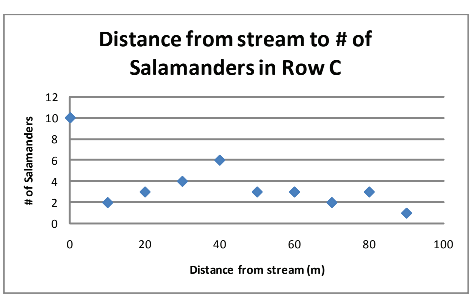
4. Diameter of cookie (cm) to Number of Salamanders found



5. Thickness of cookie (cm) to Number of Salamanders found

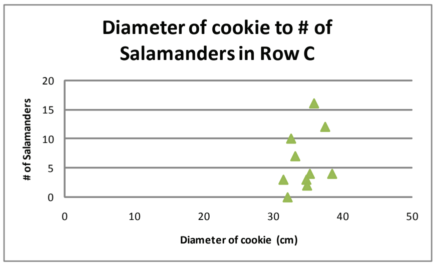


6. Distance from Stream (m) to Number of Salamanders found

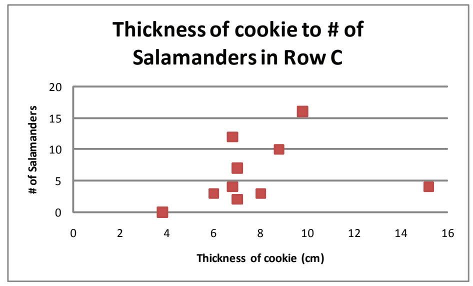


"C" Wood Cookie Identification Graphing Set

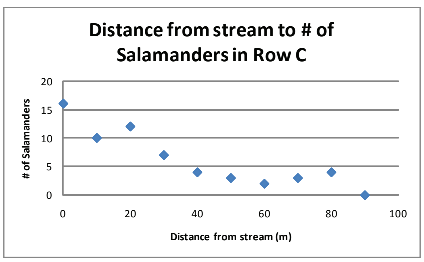
7. Diameter of cookie (cm) to Number of Salamanders found



8. Thickness of cookie (cm) to Number of Salamanders found



9. Distance from Stream (m) to Number of Salamanders found



Graphing Trends Questions

10. What trends are you seeing?

There seems to be no correlation between the diameter of cookie to number of salamanders found. There may be a weak trend towards more salamanders under thicker cookies, but this may not seem obvious to your students. The clearest trend is a correlation between distance from stream to number of salamanders found.

11. What is the best predictor variable of the three graphs?

The distance to stream to number of salamanders found shows the clearest trend of the three.

12. What is the best way to know that the graphed results are dependable or just a one-time occurrence?

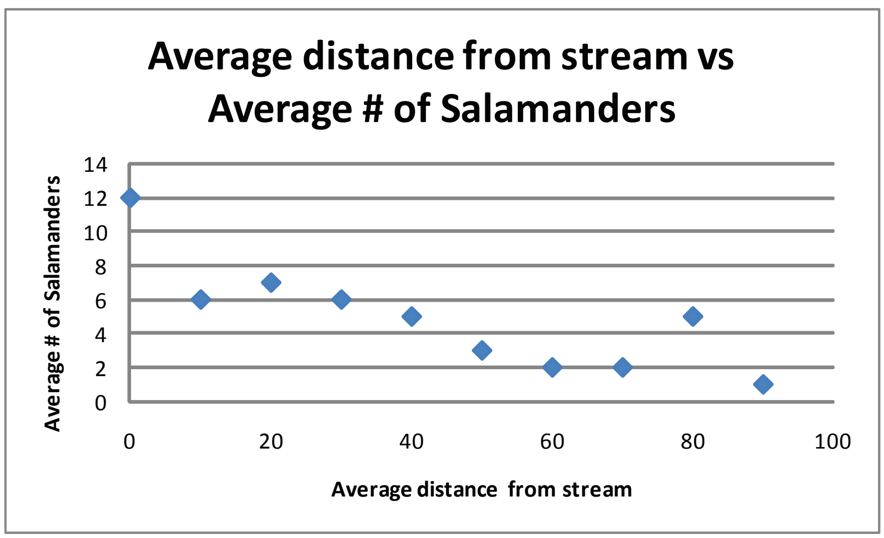
Replication is important. Replication in science helps make science a self-correcting system. One might go back on different days to determine if the new data has the same trends or combine the data from the three sets of cookies.

13. Combine all three replicate trials (wood cookie A plus B, etc.) of number of salamanders found and average the three to more clearly show the trend. Place information below.

Wood Cookie Number	Average number of salamanders found
1	12
2	6
3	7
4	6
5	5
6	3
7	2
8	2
9	5
10	1

14. Graph the average number of salamanders found to average distance from stream (m).

Distance from stream	Average number of salamanders found
0	12
10	6
20	7
30	6
40	5
50	3
60	2
70	2
80	5
90	1



15. What is the best predictor variable for explaining the number of salamanders found under each cookie.

The best indicator for number of salamanders found is distance from the stream.