Program Name: Shenandoah Salamander: Climate Change Casualty or Survivor?

Suggested Grade Level: 6th – 8th Life Science, Environmental Science

Maximum Group Size: 25 students (plus chaperones)

Overview

Climate change is defined as any significant change in the climate lasting for decades or longer. Climate patterns can vary naturally, but today's climate changes are being accelerated by human activity. Although scientists cannot predict with certainty what the long-term impacts from climate change will be, there is ample evidence that climate change effects are already being felt. In this lesson, students will research climate change and the potential impact on two salamander species found in Shenandoah National Park, the endangered Shenandoah salamander and the more common red-backed salamander. Students will conduct field research on the red-backed salamander to compare the two species' habitat requirements and determine if climate change and competition for habitat are impacting the survival of the Shenandoah and red-backed salamanders.

Learning Objectives

Following the park experience and classroom activities, the students will be able to

1. Define *climate change* and list examples of natural and human-influenced contributors to climate change;
2. Conduct a salamander population study to determine habitat preferences and environmental conditions in Shenandoah National Park;
3. Assess/predict the potential impact of climate change and species competition on the survival of the Shenandoah and red-backed salamanders;
4. Determine ways people can reduce contributions to climate change;
5. Create a persuasive media message to educate others on the impacts of climate change and ways people can reduce their carbon footprint.

Virginia Life Science Standards of Learning:

All Grade Levels:

<u>Scientific and Engineering Practices</u>

The student will demonstrate an understanding of scientific and engineering practices by

a) asking questions and defining problems
b) planning and carrying out investigations
c) interpreting, analyzing, and evaluating data
d) constructing and critiquing conclusions and explanations
e) developing and using models
f) obtaining, evaluating, and communicating information

Sixth Grade Science

6.9 The student will investigate and understand that humans impact the environment and individuals can influence public policy decisions related to energy and the environment. Key ideas include
- a) natural resources are important to protect and maintain;
- b) renewable and nonrenewable resources can be managed;
- c) major health and safety issues are associated with air and water quality
- e) preventive measures can protect land-use and reduce environmental hazards; and
- f) there are cost/benefit tradeoffs in conservation policies.

Life Science

LS.8 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time. Key ideas include
- a) organisms respond to daily, seasonal, and long-term changes;
- b) changes in the environment may increase or decrease population size; and
- c) large-scale changes such as eutrophication, climate changes, and catastrophic disturbances affect ecosystems.

LS.9 The student will investigate and understand that relationships exist between ecosystem dynamics and human activity. Key ideas include
- a) changes in habitat can disturb populations;
- b) disruptions in ecosystems can change species competition; and
- c) variations in biotic and abiotic factors can change ecosystems.

Earth Science

ES.11 The student will investigate and understand that the atmosphere is a complex, dynamic system and is subject to long-and short-term variations. Key ideas include
- c) natural events and human actions may stress atmospheric regulation mechanisms; and
- d) human actions, including economic and policy decisions, affect the atmosphere.

ES.12 The student will investigate and understand that Earth's weather and climate are the result of the interaction of the sun's energy with the atmosphere, oceans, and the land. Key ideas include
- e) changes in the atmosphere and the oceans due to natural and human activity affect global climate.

Background Information

Climate change is any significant change in the climate lasting for decades or longer. Climate patterns (e.g. temperature, rain, snow) can vary naturally, but modern climate changes are accelerated by human activity. Although scientists cannot predict with certainty what the long-term impacts from climate change will be, there is ample evidence of climate change effects already being felt.

Major *greenhouse gases* - carbon dioxide (CO^2), methane (CH^4), and nitrous oxide (N_2O) - trap some of the sun's heat in the atmosphere. At natural levels, this is enough heat to keep earth from freezing and helps to sustain life as we know it. Natural sources of greenhouse gases include plant respiration, volcanic eruptions, and natural decomposition of living things.

Human activities, such as burning fossil fuels (oil, coal, and natural gas), increase greenhouse gas levels. These extra gases trap even more heat, resulting in global warming and unprecedented rates of climate change. The total amount of greenhouse gas emissions caused by a person, household, event, or organization is called its "carbon footprint". This value can be calculated to help understand fossil fuel use and to help make personal choices to reduce the amount of carbon released into the environment.

Global warming is an increase of temperatures in the atmosphere and oceans around the world. Greenhouse gases are a major contributor to increasing global temperatures. This warming can change global climate factors such as temperature, humidity, rainfall, snowfall, and storm frequency and intensity.

Worldwide, there are many species residing in the *microclimates* of higher elevations that are at risk of extinction. One factor contributing to this risk could be increases in temperature due to climate change. Locally, scientists are predicting dramatic alterations in temperature and moisture gradients in the Appalachian Mountains in the future. Many of these higher elevation habitats that support unique ecosystems are located within the boundaries of Shenandoah National Park.

Salamanders are amphibians like frogs and toads. Most need water or moisture in which to reproduce. They live in a wide variety of habitats from swift-moving mountain streams to moist forests. In many habitats, they are the most abundant vertebrates. Of the more than 400 species of salamanders found worldwide, 130 to 150 live in North America. Over 40 percent of these are considered to be at risk. The greatest diversity of salamanders in the world is found in the Southeastern United States. Currently, 11 species are on the federal endangered or threatened species list in the United States.

Salamander habitat is being destroyed, modified, and fragmented, seriously diminishing the diversity and number of salamanders in the United States and around the world. Climate change is another factor that could impact their survival. Although these secretive creatures are unknown to many people, they are an important part of our natural world and in serious need of our protection.

Shenandoah National Park (SNP) serves as a refuge for many species of animals otherwise pressured by human activities such as development and other land uses. There are over 200 resident and transient bird species, over 50 mammal species, 51 reptile and amphibian species, and over 35 fish species found in the park. Shenandoah is home to 14 species of salamanders. The Shenandoah salamander (*Plethodon shenandoah*) is an *endemic* species – it lives nowhere else on the planet except a few rocky mountaintops in the park and is one of three federally endangered animal species found in the park.

Across the country, scientists are studying potential impacts of a warming climate. Shenandoah National Park collaborated with the Smithsonian Institution, University of Virginia, and the U.S. Geological Survey to assess potential climate change impacts on its high elevation species. Research and experiments focusing on the Shenandoah salamander investigated how climate change might affect the species' use of habitat, feeding success, growth, and competition for habitat with red-backed salamanders. This research will help resource managers understand the habitat needs of these and other species that are highly adapted to mountaintop living and to develop strategies that will help protect these species.

In this lesson, students will NOT sample the Shenandoah salamander due to its rare and endangered status. They will be performing field investigations which duplicate the techniques that the Shenandoah salamander researchers used in their three-year study. Students will

- learn how to do a transect study on the more common red-backed salamander
- gather and analyze red-backed salamander data (size, location, behavior, and color morph)
- determine abiotic factors in red-backed salamander habitat (air temperature, humidity, soil moisture and pH)
- compare their research results to the Shenandoah salamander research
- make conclusions/predictions on the survival of the Shenandoah salamander and the red-backed salamander in the park.

This lesson will help students to understand how climate change and competition with the red-backed salamander could impact the survival of the endangered Shenandoah salamander. By doing this lesson, students will understand the plight of the Shenandoah salamander, will be able to educate others about the Shenandoah salamander and climate change, and will be able to make educated lifestyle choices that reduces their carbon footprint.

Vocabulary

- **amphibian –** a cold-blooded vertebrate that spends some time on land but must breed and develop into an adult in moist areas. Frogs, salamanders, and toads are amphibians
- **carbon footprint –** the amount of carbon dioxide (CO_2) we emit individually in any one-year period. CO_2 is produced from many sources and is the primary gas responsible for changes in our climate

- **climate change –** long-term alteration in global weather patterns, especially increases in temperature and storm activity. These changes can result from natural and/or human-induced processes such as the greenhouse effect due to increased use of fossil fuels
- **competition –** the process of trying to win or do better than others
- **ectothermic –** body temperature varies with environmental surroundings; cold-blooded
- **endangered species –** a species whose numbers are so few, or are declining so quickly, that the animal, plant, or other organism may soon become extinct. Endangered species are sometimes protected under national or international law.
- **endemic –** native to or confined to a certain region
- **endothermic –** maintaining a constant body temperature despite changes in the temperature of the environment; warm-blooded
- **extinction –** condition in which a species no longer exists or is living
- **greenhouse gases –** any of the atmospheric gases that contribute to the greenhouse effect by absorbing infrared radiation produced by solar warming of the Earth's surface. They include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_2), and water vapor. Although greenhouse gases occur naturally in the atmosphere, the substantially elevated levels especially of carbon dioxide and methane that have been observed in recent decades are directly related to human activities such as the burning of fossil fuels and the deforestation of tropical forests
- **habitat –** the environment in which a plant or animal lives
- **microclimate –** the average weather or the regular variations in weather over a period of years in a confined space or small geographic area
- **morph –** natural variations in a gene, DNA sequence, or chromosome that have no adverse effects on the individual and frequently occur in the general population. The Shenandoah and red-back salamanders have two color morphs: striped – with a reddish dorsal stripe, and unstriped or “lead-backed” - with no dorsal stripe
- **preservation –** the guarding of something from danger, harm, or injury
- **protection –** the act of preventing something from being harmed or damaged, or the state of being kept safe

Time considerations
Pre-visit lessons: 90 minutes (up to 3 class periods)
Park Field Trip: 2 hours on site in Shenandoah National Park plus travel time
Post-visit lessons: 90 minutes (up to 3 class periods)

Pre-Visit Activities

Prior to beginning the Shenandoah salamander unit study, have the students take the **Pre-Visit Assessment**. Record the scores on the **Pre-Visit/Post-Visit Score Sheet**. Begin the unit study and incorporate as many of the following pre-visit activities as possible into your lesson plan to prepare the students for their park field trip.

Materials for Pre-visit Activities
Computer and internet access for research, Shenandoah National Park climate change and salamander videos (links found in References and Resources section), KWL sheet, Venn diagram sheet, and, Salamander graphic organizer (attached)

For the practice transect study (4 research teams): Artificial salamanders (or small photos) and various items to conceal artificial salamanders **(for practice transect at school only),** flagging tape or small marker flags, hand sanitizer (60-70% ethyl alcohol), zip-top plastic baggies, 4 reel-type 10 meter measuring tapes, 4 portable weather stations, 2 soil moisture and pH meters, field data sheets, clipboards and pencils Optional: GPS device, cell phone/camera - video and/or still

1. Shenandoah National Park Needs Your Help.
Begin the KWL chart on Shenandoah National Park and the Shenandoah salamander.

> Tell the students, *"Shenandoah National Park researchers need help in their study of the Shenandoah salamander (Plethodon shenandoah) which lives nowhere else on the planet except a few rocky mountaintops in the park. It one of three federally endangered animal species found in the park. It is suspected that competition with red-backed salamanders and the impacts of climate change could cause a serious decline in the population of the Shenandoah salamander. Park managers are responsible to preserve and protect species and all resources for future generations so the need for the scientific data is critical."*

Divide the class into 4 research teams. Explain that each team will be conducting research on the Shenandoah salamander. Have each team discuss what they know about Shenandoah National Park, climate change, and the endangered Shenandoah salamander. Have teams fill out the "Know – (K)" and "Want to Know" (W) column of the KWL sheet and share their findings with the other teams.

2. Climate change and Shenandoah's salamander video(s)
Have the research teams watch two videos on climate change and the Shenandoah salamander (links in the References and Resources section). Guide the teams in a discussion of what they should find out to prepare for their research and field investigation.

a. Watch the climate change video for an overview of climate change.

b. Watch the Shenandoah salamander video, pausing at the listed intervals to allow time for discussion.

Segment 1, Time 0 – 2:13, Pause
Discussion Questions:

- Why is the Shenandoah salamander a federally endangered species? (Rarity, restricted range)
- What makes microclimates or "islands in the sky" different? (support unique ecosystems and species not found elsewhere)

- Describe the habitat of the Shenandoah salamander and its needs (cooler temperatures and higher humidity).
- How do we know the earth's temperature is changing? (climate models show a trend for future temperature increase)
- What is causing unprecedented climate change? (human activities are causing more greenhouse gas emissions)

Segment 2, Time 2:13 – 4:10, Pause

Discussion Questions:

- What will be the impact of climate change on the Blue Ridge Mountains in Shenandoah National Park? (rhetorical question posed)
- How will a changing climate alter the microclimates on the summits of Shenandoah's highest peaks? (rhetorical question posed)
- How will a changing climate affect the limited range where the Shenandoah salamander lives? (rhetorical question posed)
- Why has the Shenandoah salamander retreated up the mountainside causing a more isolated, restricted range? (cooler temperatures)
- What other factor is involved in putting pressure on the survival of the Shenandoah salamander? (competition for habitat from the red-backed salamander)
- What conditions are projected due to climate change? (warmer temperatures, periods of drought, violent storms, increased wildfires)
- How could climate change be a factor in the population decrease of the Shenandoah salamander? (increased temperatures in already small and isolated habitats)
- What are the options for the future of the Shenandoah salamander? (Adapt? Migrate? Extinction?)

Tell the students that scientists are conducting research to determine the environmental conditions in high elevation habitats necessary for the survival of salamanders.

Segment 3, Time 4:11 – 5:17, Pause

Discussion Questions:

- Who are the partners in this research and what are they studying? (Shenandoah National Park, University of Virginia, US Geological Survey, Smithsonian Institution)
- What type of climate data is being collected and analyzed to predict the future of the climate in Shenandoah National Park? (temperatures over 75 years at Big Meadows weather station in Shenandoah National Park, temperature sensors ("hobos") on Hawksbill Mountain)

Tell the students: *"When we go to Shenandoah National Park, you will be conducting research and a habitat field study on the **red-backed salamander**. We will be doing our research on the red-backed salamander since it is in competition for habitat with the Shenandoah salamander. You will search for*

salamanders, measure them, and collect environmental data (air temperature, humidity, soil moisture and pH) where you find a salamander. Here is what researchers have been doing in Shenandoah National Park on the Shenandoah salamander so far."

Segment 4, Time 5:17 – 6:59, Pause

Discussion Questions:

- What type of research is being done on the Shenandoah salamander in Shenandoah National Park? (mapping the range of the Shenandoah salamander)
- What is the purpose of the project? (studying the impact of temperature and moisture change on the Shenandoah salamander will help the National Park Service make good decisions about preserving and conserving this species)
- How are the habitat requirements of the Shenandoah salamander (*Plethodon shenandoah*) and the red-backed salamander (*Plethodon cinereus*) similar/different? (both like cool, humid areas, leaf litter, a little soil, invertebrates to eat, but the red-backed will occupy the best sites and appears to exclude the Shenandoah salamander. Within high elevation areas, the Shenandoah salamander seems to be able to tolerate drier habitats, mostly rock with less leaf litter and soil, which might lead to slightly warmer conditions.
- What are the two abiotic climate factors being studied that might be affecting the Shenandoah salamander? (increased temperature and decreased humidity)
- What biotic factors are being studied that might affect the Shenandoah salamander? (competition with red-backed salamander)

Segment 5, Time: 7:00 – end

Discussion Questions:

- What does the researcher mean by "looming stress of climate change"?
- What might be your idea for the best strategy for the protection and preservation of the Shenandoah salamander? (open-ended discussion)
- What can people do now to protect this species for future generations? (Reference the Climate Change video previously shown)

a. Have the teams add what they learned to the "L" section of their KWL sheet.

3. Screen Time! Background Research

Explain to the teams that they will be using **primary source** resources from Shenandoah National Park to do their research. Have them complete the attached Venn diagram to differentiate between the two salamanders and the salamander graphic organizer for recording characteristics of the Shenandoah salamander using information from the video(s) and websites provided in the References and Resources section. Give a brief review of using only credible websites and avoiding plagiarism. Explain that this is why they are using the selected sites.

Tell the teams: *"Now that we know about the park's research, we need to prepare for our field experience. We will compare and contrast the red-backed salamander and the Shenandoah salamander using a Venn diagram. Visit at least three websites and make notes on each species on your Venn diagram. Work with your team to compare and contrast these two species. Next, complete a Shenandoah salamander graphic organizer with species notes."*

Collect the teams' KWL sheets, Venn diagrams, and Shenandoah salamander graphic organizers. Display the graphic organizers around the classroom as cues for their field trip preparation. You will hand all three activity sheets back to them at a later time for use in creating multimedia presentations and public service messages.

4. Visiting a National Park - Leave No Trace

The mission of the National Park Service is to preserve and protect the natural and cultural resources of the nation for all people to enjoy. It is important for today's park visitors to practice good stewardship ethics and behaviors in order to pass these unique natural and historical treasures on to future generations in an unimpaired condition.

We recommend following Leave No Trace (LNT) principles when going on a field trip. There are seven LNT principles:

- Plan Ahead and Prepare
- Travel (and Camp) on Durable Surfaces
- Dispose of Waste Properly
- Leave What You Find
- Minimize Campfire Impacts
- Respect Wildlife
- Be Considerate of Other Visitors

To prepare for your field trip to Shenandoah National Park, share with your students the mission of the National Park Service. Explain that they can help protect the beauty and natural resources of Shenandoah National Park by using good environmental stewardship practices.

a) Introduce the *Leave No Trace* principal "Respect Wildlife." The students will be conducting research and a habitat study on the commonly found red-backed salamander modeled on the Shenandoah salamander research done in Shenandoah National Park. Review the goals of the park research a) to determine what affect changing climate factors such as temperature and moisture conditions may have on high elevation habitats and b) how competition with the closely related red-backed salamander may impact the survival of the Shenandoah salamander. Option: Have the research teams develop a hypothesis statement on the habitat requirements of the red-backed salamander. What conditions do they expect to find and what environmental conditions would

impact its survival? Remember the hypothesis should be an 'If……, then……' statement.

b) Explain that the salamander researchers used a transect sampling technique. Transect techniques involve sampling along a line. There are many variations, but most involve stopping at intervals along that line and collecting data, i.e., searching under rocks, logs, and leaf litter for salamanders. Data is recorded at every location in which a salamander is found. Even if no salamanders are found along the transect, temperature, humidity, and soil readings are still recorded. The teams will practice this sampling technique before going into the field.

Transect Sampling Procedure
1. Select a location where the transect line will cross several potential salamander hiding places.
2. Survey the study area for any potential safety concerns such as poison ivy, stinging nettle, ant/insect nests, other animals such as snakes, or broken overhanging limbs. Look carefully above and around each rock, log, or leaf litter that you will search under
3. From a starting point, decide a compass direction line using a GPS unit. Record the direction and measure a 10 meter line in that direction for the study transect line.
4. Find and record the latitude/longitude coordinates of starting point using a GPS.
5. Keep the measuring tape or string transect on the ground to keep the sampling in a straight line. Mark each end of transect line with flagging tape or marker flags.
6. Sanitize your hands to prevent contamination of the study site or organisms.
7. Search for salamanders within one-half meter along either side of the transect line (10 square meters).
8. Turn over rocks and logs and leaf litter using the proper searching/handling protocol.
9. For each salamander found, measure and record required data in pencil (pen ink can run if it gets wet). Record up to 15 samples.
10. Document on data sheet if no salamanders are found.

Salamanders must be handled with care. Provide this background information and review proper handling procedures.

An amphibian's thin, moist skin absorbs oxygen from the atmosphere and the skin can also absorb anything else that it comes into contact with. If you have perfume, insecticide, hand lotion, or even soap residue on your hands when you handle the salamander, it will absorb whatever is on your skin, perhaps with fatal results. When you handle a salamander, you may also transfer diseases to the animal from your hands. Therefore, use an appropriate 60-70% ethyl alcohol sanitizer on your hands prior to sampling in any salamander habitat.

In addition, compared to the ambient temperature of a salamander or frog, your

hands are hot. The heat from your clean hands and the stress of being handled can actually cause unnecessary stress or death to the salamander. Over-handling can rub off the amphibian's protective mucous coating on the skin. This mucous provides anti-bacterial and anti-fungal protection to the amphibian to prevent infection and illness. Therefore, direct contact with the salamanders' skin should be avoided. You will be using re-sealable plastic baggies to handle the salamanders and take measurements.

How to Search For and Handle Salamanders	
a.	Sanitize your hands to prevent contamination of the study site or organisms.
b.	Search under all cover objects by gently and slowly pulling the rock, log, or leaf litter TOWARDS YOU with both hands. This will provide an escape route for animals that might be there and will be a safety barrier for you.
c.	As you slowly pull the rock/log/leaves toward you, quickly look under it. Gently place the rock, etc., in a safe location.
d.	When a salamander is found, record its location in meters along your transect from the starting point.
e.	Turn the plastic baggie inside out and place your hand inside. Gently scoop up the salamander into the baggie and invert to seal the bag slightly to contain the salamander. Avoid holding it in your hands very long as your hot hand may be uncomfortable.
f.	Replace the rock/log/leaves under which you found the salamander.
g.	Hold the bag by the zipper top. Gently place the plastic bag on a flat surface and quickly measure the salamander's length in cm. Record on data sheet.
h.	After measuring the salamander, open the bag and release it next to the rock/log/leaves that you have replaced without holding it in your hand. It will most likely scoot safely under the cover avoiding light and seeking dampness.

c) Conduct Practice Transect
To practice the sampling procedure and handling technique, randomly distribute artificial salamanders (or pictures) in an open area inside or on the school grounds. Conceal the salamanders under pails, plates, or other items that represent rocks/logs/leaves.

Have the four research teams review the data collection sheet. Within each team, assign tasks for searching, measuring, and recording data. Rotate assignments if desired. Students will lay out a transect line, search for "salamanders", take measurements, and record data while practicing proper searching and handling techniques.

5. Final preparation and planning for the field trip to Shenandoah National Park.

- Approximately 2 weeks before the field trip, the lead ranger for the program will contact the lead teacher to discuss the final details of the field trip.
- Share field trip details with all teachers going on the field trip.
- Review appropriate dress and behavior for the field trip and remind students they will still be in school while at the park.

- ✓ Recommend dress: Long pants, closed toed shoes (No sandals or flip-flops) and extra layers – it is often 10+ degrees cooler on the mountain than at school.

- Recruit enough competent chaperones to assist on the field trip. The park requires 1 adult (including teachers) for every 10 students.
- Arrange for transportation and know the travel route to the program location in the park.
- Plan for lunch. School groups are welcome to picnic in the park after the program. Picnic areas offer picnic tables and restrooms, but there are no shelters for inclement weather.
- Contact your lead ranger if you have any last minute questions or changes in your planning.

Shenandoah National Park Field Trip

The in-park program will generally take a minimum of 2 hours. Plan for adequate travel time from your school to meet the ranger(s) at the scheduled time and location in the park. For an effective learning experience, please remember the following:

- Before arriving at the park, divide the students into the research teams and assign chaperones to each group.
- Provide nametags for all participants, including adults.
- Upon arrival, meet the ranger(s) and coordinate a bathroom and snack break prior to the in-park program.
- Let the ranger(s) know how much time you have in the park and your travel schedule requirements for returning to school.
- Present a short, 5-minute introduction at the program site in the park to bridge what you have done in the classroom with the park experience.
- Separate the students into the pre-determined teams with assigned chaperones.
- The ranger(s) will lead the research teams on an outdoor field investigation using exploration, observation, and critical thinking skills to collect data and make conclusions. Assist the ranger(s) as needed while on the program.

Field Research in Shenandoah National Park!

1. Meet the park ranger at the scheduled time and location in Shenandoah National Park. Have the students share with the ranger what they have learned about climate change and the Shenandoah salamander and what they hope to discover on the field trip.

2. **Red-backed Salamander Transect Study**
   At the field research site, the ranger will guide the students to follow the sampling procedures practiced at the school. Divide students into the four research teams, review sampling and salamander handling procedures, and distribute transect study equipment and materials. Review task assignments for searching, measuring, and recording data. Students will lay out their transect line, search for salamanders, take measurements, and record data while practicing proper searching and handling

techniques. When completed, each team will keep their data record sheets for analysis back in the classroom.

Post-Visit Activities

Following your field trip to Shenandoah National Park, use as many of the following post-visit activities as possible to conclude the unit of study. Give the students the **Post-Visit Assessment.** Record the scores on the **Pre-Visit/Post-Visit Score Sheet.** Complete the **Program Evaluation Form.** Return the program evaluation and pre/post-visit score sheet to:

Shenandoah National Park
3655 US Hwy 211 East
Luray, VA 22835
Attention: Education Office

Materials for Post-visit Activities

KWL sheets, Venn diagram sheets, and Salamander graphic organizers from the pre-visit activity, computer and internet access for research and carbon footprint calculator, carbon footprint pledge (attached), supplies/materials for culminating media message activity

1. **Field Data Analysis**
   Have the research teams analyze their data collected in the field and make conclusions about the red-backed salamanders found in that area. What were the abiotic conditions at the transect site (air temperature, relative humidity, soil moisture and pH)? Were any salamanders found? Were they active? Were both red-backed color morphs found and how many of each type? Were other salamander species found? If no salamanders were found, propose possible reasons why. Did the field data support what was expected (hypothesis statement)? Design and construct charts and graphs to report findings.

2. **Putting All The Pieces Together**
   Return KWL, Venn diagram, and graphic organizer sheets to students. Have the teams review these documents focusing on these points:
   - How are the two salamanders alike in appearance and behavior?
   - Where do they live? What habitats do the two salamanders prefer?
   - Where did we find red-backed salamanders?
   - Did they all look alike? Were any other species of salamanders found?
   - What were the temperature, humidity, and soil readings in the transect area?
   - Why didn't we find Shenandoah salamanders in our study area?

   Next, lead a discussion on what the students learned about climate change, the two salamander species, and their transect study experience. Have the students answer the following:
   - What is the relationship between red-backed salamanders and Shenandoah salamanders in Shenandoah National Park?

- If climate conditions change (increase in temperature and reduction in moisture), what might happen to the Shenandoah and red-backed salamanders? Which species is better equipped to survive climate changes?
- Since it is restricted to few high elevation mountaintops, where could the Shenandoah salamander go to find suitable (cooler, wetter) habitat? Would it still compete for habitat with the red-back salamander?
- What could park resource managers do to protect/preserve necessary habitat for the endangered Shenandoah salamander, as well as the common red-backed salamander?
- If there was a major change in your community, such as a new road, housing development, or shopping center, how would the habitat change for the residents (plants, animals, and people)? Could they all adapt to the changes?
- How can citizens help improve habitats, even those far from their own community?
- What can citizens do to reduce their contributions to climate change that would help to improve environmental conditions and protect/preserve habitats for endangered species?

3. **Investigate how humans contribute to climate change**
   Learn more about climate change and carbon footprint. Refer to links in the References and Resources section or do internet search for "*Carbon Footprint Calculator*" to find an age-appropriate calculator for students. Have the students determine their own carbon footprint and *create a pledge* to make lifestyle choices that can reduce their carbon footprint and contributions to climate change.

4. **Spread the Word about the Shenandoah salamander and climate change**
   Now that students know about the Shenandoah salamander and the National Park Service's concern for its fragile situation, in what ways can the public be informed about climate change, the Shenandoah salamander, and the importance of preserving the high elevation habitats where it lives? Brainstorm a list of ideas for informative and persuasive media messages. Possible topics include:
   - the Shenandoah salamander is an indicator species of high elevation ecosystem changes possibly due to changes in the climate
   - research done in Shenandoah National Park has investigated how climate change may affect the Shenandoah salamander and other high elevation ecosystems
   - the importance of reducing the use of fossil fuels to reduce human-caused climate change (i.e. increased global temperature and CO_2 levels)

   Working in the research teams or as a class, create a public service type message or a program to present to the school board, PTA, park managers, or local citizens' groups. Use multimedia programs such as Glogster, Powerpoint, Voicethread, Photostory, or social media to create a podcast, movie, or publication. These programs should demonstrate students' views on the importance of preserving high elevation habitats and the Shenandoah salamander, and ways that individuals can reduce the use of fossil fuels to slow down climate change.

Unit Assessment

1. Completed KWL chart
2. Completed Shenandoah salamander graphic organizer
3. Completed Venn diagram
4. Ability to follow scientific investigation procedures
5. Analysis of Field Data Sheet
6. Public Service Media message
7. Carbon Footprint analysis and pledge

Going Further

1. Research other resource issues in Shenandoah National Park using links found in the References and Resources section.

   Air and Water Quality
   - Acid Deposition
   - Ozone
   - Visibility and Haze
   - Water Quality

   Invasive Species
   - Hemlock trees/Wooly adelgid
   - Hardwood forests/Gypsy moth
   - Ash trees/Emerald Ash borer

2. Investigate “success stories” of other imperiled species using links found in the References and Resources section.
   - Peregrine Falcon
   - Bald Eagle

3. Research other national parks that have serious resource management challenges and report on those to the class.

References and Resources

Pre-visit Activity Links

Climate Change Video
https://www.nps.gov/shen/learn/photosmultimedia/our-changing-world.htm

Shenandoah Salamander Video
https://www.nps.gov/shen/learn/nature/shenandoah-salamander-film.htm

Red-backed salamander info:

- Shenandoah National Park Amphibians
  https://www.nps.gov/shen/learn/nature/amphibians.htm
- Virginia Fish and Wildlife
  https://vafwis.dgif.virginia.gov/fwis/booklet.html?Menu=_.Taxonomy&bova=020043&version=15684
- Virginia Department of Game & Inland Fisheries
  https://www.dgif.virginia.gov/wildlife/information/eastern-red-backed-salamander/
- Virginia Herpetological Society
  https://www.virginiaherpetologicalsociety.com/amphibians/salamanders/eastern-red-backed-salamander/red-backed_salamander.php
- University of Michigan Animal Diversity Web
  https://animaldiversity.org/site/accounts/information/Plethodon_cinereus.html

Shenandoah salamander info:

- Shenandoah National Park
  http://www.nps.gov/shen/naturescience/shenandoah_salamander.htm
- Virginia Fish and Wildlife
  http://www.vafwis.org/fwis/booklet.html?Menu=_.Taxonomy&bova=020045
- Virginia Department of Game & Inland Fisheries
  https://www.dgif.virginia.gov/wildlife/information/shenandoah-salamander/
- Virginia Herpetological Society
  https://www.virginiaherpetologicalsociety.com/amphibians/salamanders/shenandoah-salamander/shenandoah_salamander.php
- Fish and Wildlife Service
  https://www.fws.gov/northeast/pdf/ShenandoahSalamander.pdf

Post-visit Activity Links

Climate Change and Carbon Footprint

- National Park Service (NPS)
  http://www.nps.gov/subjects/climatechange/index.htm
- Environmental Protection Agency (EPA)
  https://www.epa.gov/climate-indicators
  https://archive.epa.gov/climatechange/kids/index.html
- National Oceanic and Atmospheric Administration (NOAA)
  http://www.climate.gov/
  http://www.cpc.ncep.noaa.gov/

- National Aeronautics and Space Administration (NASA)
  http://climate.nasa.gov/
  http://pmm.nasa.gov/science/climate-change
  http://climatekids.nasa.gov/
- Carbon Footprint Calculator
  https://depts.washington.edu/i2sea/iscfc/calculate.php

Going Further

Resource Issues

- Park Air Profiles - Shenandoah National Park
  https://www.nps.gov/articles/airprofiles-shen.htm
- Non-native Species
  http://www.nps.gov/shen/naturescience/nonnativespecies.htm
- Nonnative Species Management
  https://www.nps.gov/shen/learn/nature/nonnative-species-management.htm
- Hemlock Woolly Adelgid
  http://www.nps.gov/shen/naturescience/eastern_hemlock.htm
  https://www.fs.fed.us/research/invasive-species/insects/hemlock-wooly-adelgid.php
- Emerald Ash Borer
  http://www.emeraldashborer.info/

Success Stories of other imperiled species

- Peregrine Falcons at Shenandoah National Park
  http://www.nps.gov/shen/naturescience/falcon.htm
- Endangered Species Success Stories, US Fish and Wildlife Service
  https://www.fws.gov/endangered/map/index.html
- 12 Conservation Success Stories
  https://www.endangered.org/12-conservation-success-stories-for-endangered-species-day/

Teacher resources

K-W-L Chart Printout. Readwritethink.org. IRA/NCTE. Web. 2013.
http://www.readwritethink.org/classroom-resources/printouts/chart-a-30226.html

Pre-visit Activity #1
KWL Chart

Name: _____ Date: _____

In the first column, write what you already know about climate change and the Shenandoah salamander. In the second column, write what you want to know about climate change and the Shenandoah salamander. **After** you have watched the videos and completed your research, write what you learned in the third column.

What I **K**now	What I **W**ant to Know	What I **L**earned

Pre-visit Activity #3

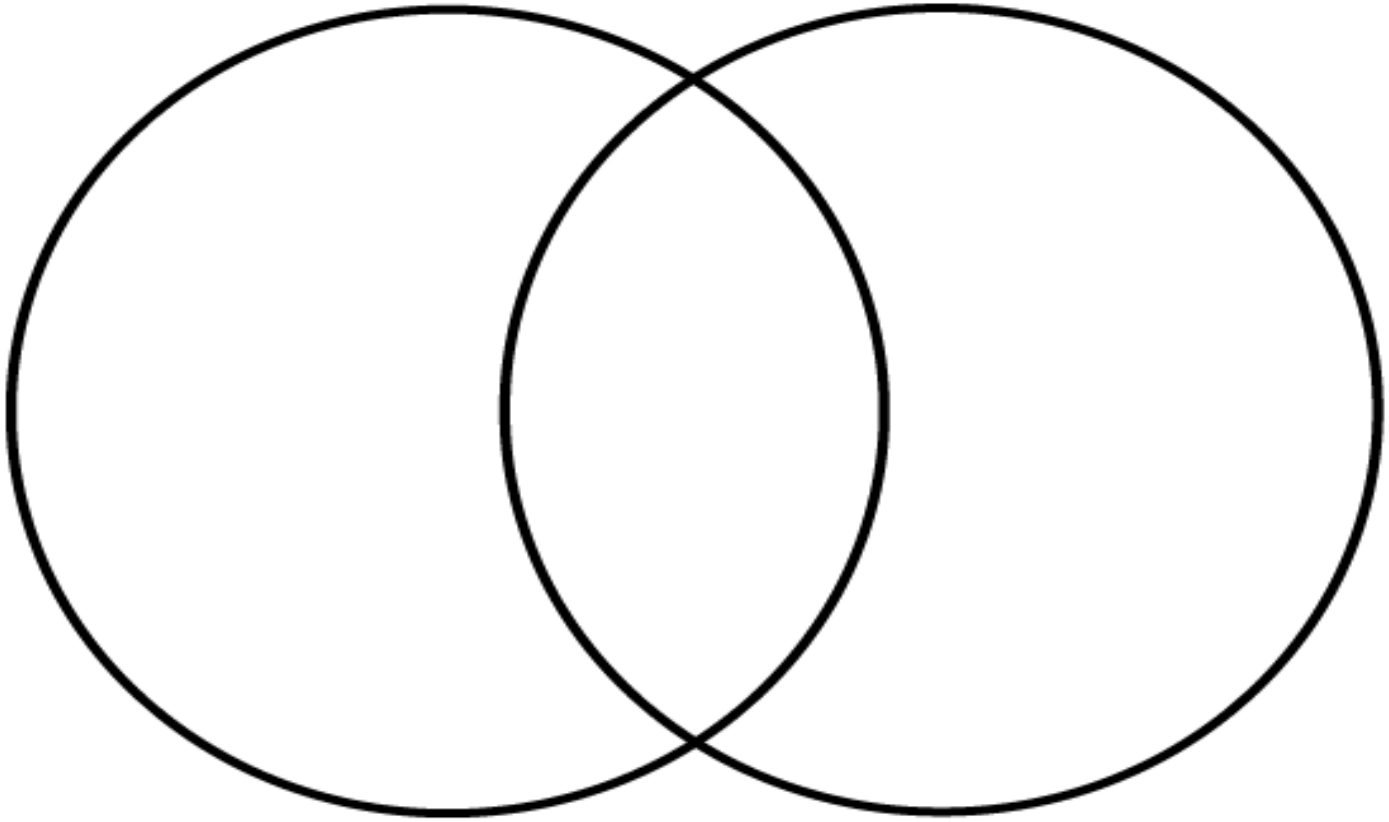
Venn Diagram

Name: _____ Date: _____

Use the Venn diagram to take notes. Compare and contrast the Shenandoah Salamander and the red-backed salamander. Include differences and similarities like habitat, food, temperature requirements and identifying physical characteristics

Shenandoah salamander

Red-backed salamander

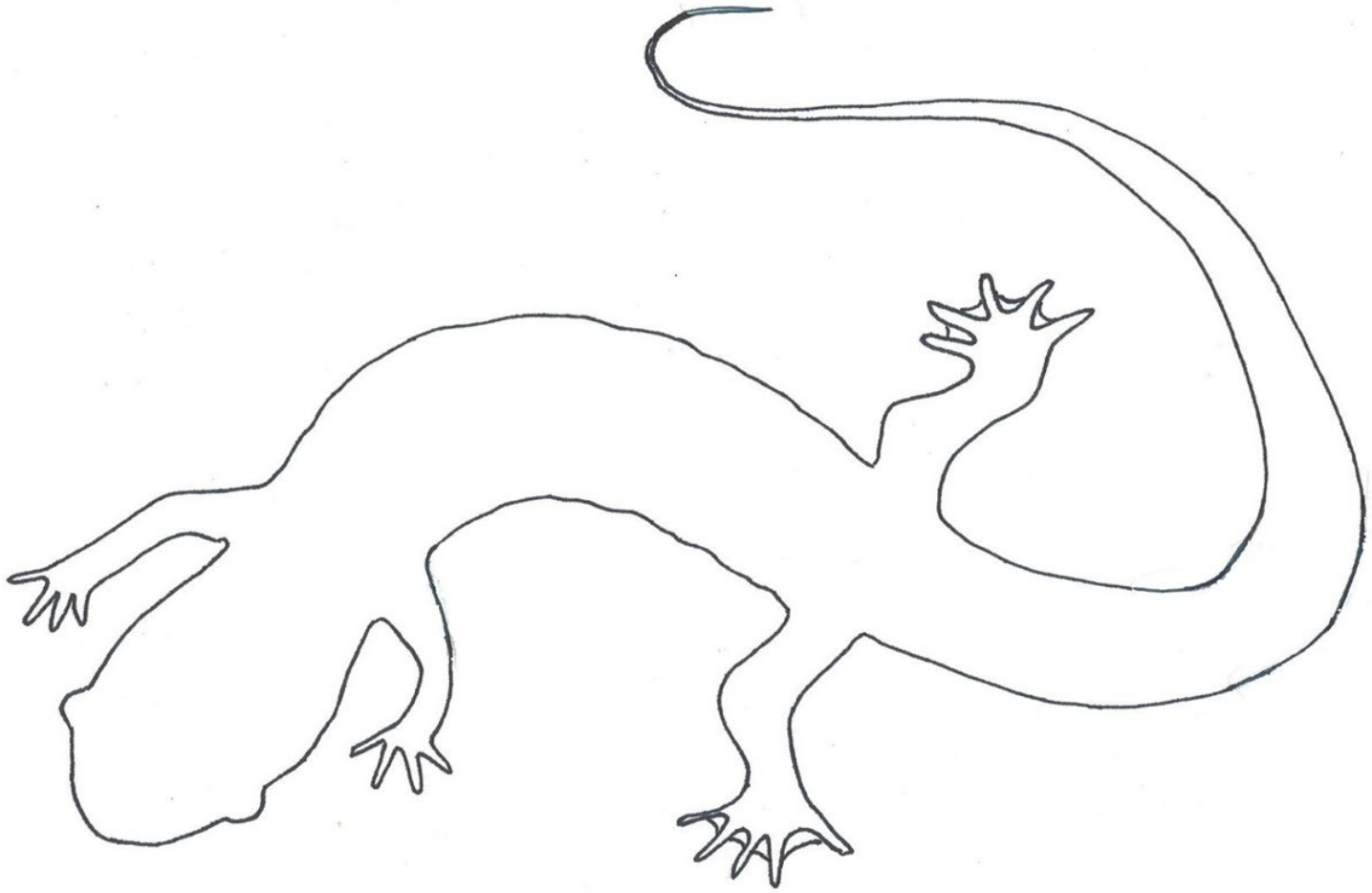


Pre-visit Activity #3

Salamander Graphic Organizer

Name: _____ Date: _____

Use this graphic organizer to take notes as you complete your research on the Shenandoah salamander.



Shenandoah National Park Education Program

Transect Field Data Sheet

Research Team: _____ Date: _____ Time: _____

Transect #: ____ Compass Direction: _____ Starting point – Latitude: _____ Longitude: _____

Wind Speed: _____ Air temperature: _____ Relative Humidity _____ Soil moisture_____ Soil pH _____

Weather (circle): Clear, partly cloudy, overcast Rain in the last 24 hours? Yes No

Hypothesis:

_____

_____

Materials (provided by ranger): sanitizer, measuring tape, flagging tape or marker flags, field data sheet, clipboard, pencils, zip-top plastic baggies, small metric rulers, portable weather stations, soil moisture/pH meter, GPS unit.

Transect Sampling Procedure

1. Select a location where the transect line will cross several potential salamander hiding places.
2. Survey the study area for any potential safety concerns such as poison ivy, stinging nettle, ant/insect nests, other animals such as snakes, or broken overhanging limbs. Look carefully above and around each rock, log, or leaf litter that you will search under.
3. From a starting point, decide a compass direction line using a GPS unit. Record the direction and measure a 10 meter line in that direction for the study transect line.
4. Find and record the latitude/longitude coordinates of starting point using a GPS.
5. Keep the measuring tape on the ground to act as a guide. Mark each end of transect line with flagging tape or marker flags.
6. Sanitize your hands to prevent contamination of the study site or organisms.
7. Search for salamanders within one-half meter along either side of the transect line (10 square meters).
8. Turn over rocks, logs, and leaf litter using proper the searching/handling protocol.
9. For each salamander found, measure and record required data in pencil (pen ink can run if it gets wet). Record up to 15 samples.
10. Document on the data sheet if no salamanders are found.

How to Search For and Handle Salamanders

a. Sanitize your hands to prevent contamination of the study site or organisms.
b. Organize the transect group into pairs. One partner will search on one side of the transect line, and the other partner will search on the other side of the transect line. Try to stay together as much as possible, as the pair will need to work together when a salamander is found.
c. Search under all cover objects by gently and slowly pulling the rock, log, or leaf litter TOWARDS YOU with both hands. This will provide an escape route for animals that might be there and will be a safety barrier for you. Note: you may have to move your body in order to lift rocks and logs towards you.
d. As you slowly pull the rock/log/leaves towards you, quickly look under it. Gently place the rock, etc. to the side.
e. When a salamander is found, have your partner turn the plastic baggie inside out and place his/her hand inside. Gently scoop the salamander into the baggie and invert to seal the bag and contain the salamander. Avoid holding it in your hands very long as your hot hand may be uncomfortable.
f. After the salamander has been placed in the baggie, replace the rock/log/leaves.
g. Record the salamander's location in meters along your transect from the starting point.
h. Hold the bag by the zipper top. Gently place the plastic bag on a flat surface and quickly measure the salamander's length in cm. Record on the data sheet.
i. Observe the salamander for coloring, unique features, and behavior. Record observations on the sheet.
j. After measuring and observing the salamander, open the bag and release it next to the rock/log/leaves that you have replaced without holding it in your hand. It will most likely scoot safely under the cover avoiding light and seeking dampness.

Shenandoah National Park Education Program

Sampling Data Sheet

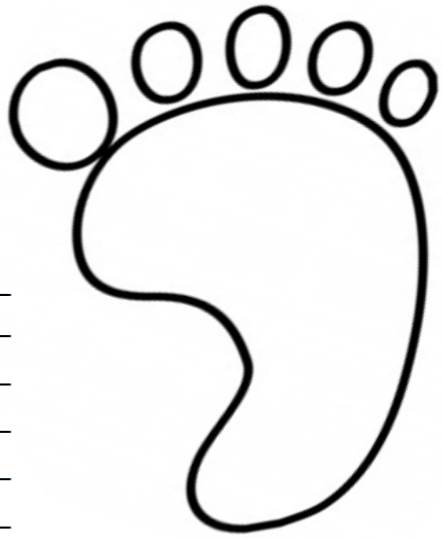
Salamander Caught	Salamander Location: meters from start point	Size in cm – Snout to tip of tail	Color Morph: Striped or Lead-backed?	Salamander Notes/Behavior
1st				
2nd				
3rd				
4th				
5th				
6th				
7th				
8th				
9th				
10th				
11th				
12th				
13th				
14th				
15th				

Post-visit Activity #3

Carbon Footprint and Pledge

Calculate your carbon footprint using a Carbon Footprint Calculator found on the internet. Think of actions you can do to reduce your carbon footprint and contributions to climate change. Complete the carbon footprint pledge to record your commitments.

Carbon Footprint Pledge



I, _____

(write your name here)

Hereby pledge that I will…

_____

_____

_____

_____

_____

_____

(write your activity here)

Shenandoah Salamander
Pre-Visit/Post Visit Assessment

Name _____ **Date** _____

Instructions: Read each question carefully and choose the one best answer. Circle the letter of your choice.

1. Which of the following is an ***endangered*** species of salamander?
   a. Spotted salamander
   b. Northern dusky salamander
   c. Red-backed salamander
   d. Shenandoah salamander

2. What does it mean when a species is ***endangered***?
   a. Humans have decided to hunt them for food and protect other species.
   b. The number of organisms is shrinking and the species could completely die out.
   c. The species has completed died out so there are no more in the world.
   d. The species is starting to cause problems for humans so we must limit the population.

3. The Shenandoah salamander is ***endemic*** to Shenandoah National Park which means _
   a. it is found nowhere else.
   b. it migrated to that place.
   c. it no longer exists.
   d. it has lost its habitat.

4. What is the preferred habitat of red-backed and Shenandoah salamanders?
   a. In warm, dry soil
   b. High up in trees
   c. In cool, moist soil
   d. In the middle of lakes

5. The struggle for habitat resources between red-backed and Shenandoah salamanders in an environment is called _
   a. an ecosystem
   b. competition
   c. endangered species
   d. cooperation

6. *Climate change* is defined as _
   a. a summer drought.
   b. increased snowfall for 4 years in a row.
   c. significant long-term change in the expected average weather patterns.
   d. cooler than average temperatures over 5 years.

7. Which of the following statements correctly describes weather and climate?
   a. Weather refers to the more current conditions, while climate refers to the long-term conditions
   b. Weather and climate are the same
   c. Climate refers to the more current conditions, while weather refers to the long-term conditions

8. What do greenhouse gases do to atmospheric temperatures?
   a. Decrease the temperatures
   b. Increase the temperatures
   c. They do not change the temperatures

9. Which of the following releases carbon dioxide directly into the atmosphere?
   a. Cutting down trees
   b. Watering the lawn during a drought
   c. Littering
   d. Burning fossil fuels

10. Which of these actions would reduce a person's carbon footprint?
    a. Sharing rides and carpooling
    b. Drive an electric or fuel efficient vehicle
    c. Insulate your home
    d. All of these actions can reduce the carbon footprint

Shenandoah Salamander
Pre-Visit/Post Visit Assessment Key

1. Which of the following is an *endangered* species of salamander?
   d. Shenandoah salamander

2. What does it mean when a species is *endangered*?
   b. The number of organisms is shrinking and the species could completely die out.

3. The Shenandoah salamander is *endemic* to Shenandoah National Park which means
   a. it is found nowhere else.

4. What is the preferred habitat of red-backed and Shenandoah salamanders?
   c. in cool, moist soil

5. The struggle for habitat resources between red-backed and Shenandoah salamanders in an environment is called
   b. competition

6. *Climate change* is defined as
   c. significant long-term change in the expected average weather patterns.

7. Which of the following statements correctly describes weather and climate?
   a. Weather refers to the more current conditions, while climate refers to the long-term conditions.

8. What do greenhouse gases do to atmospheric temperatures?
   b. Increase the temperatures

9. Which of the following activities releases carbon dioxide directly into the atmosphere?
   d. Burning fossil fuels.

10. Which of these actions would reduce a person's carbon footprint?
    d. All of these actions can reduce the carbon footprint