Phenology

Theme: Phenology
Best Time to Plan Trip: Fall or Spring

Unit Rationale

The study of climate change includes phenology. Phenology is the study of biological events that change in response to their environment. For example, bird migration is a phenomenon associated with climate and season. Likewise, the appearance of flowers is a response to the local weather and climate. On an annual basis, many biological events respond to weather, whereas over long periods of time the phenomena shift gradually, earlier or later in the year, in response to climate. During this lesson students will develop an understanding of the relationship between weather, climate change, and phenology. Students will be able to calculate their own carbon footprint and determine actions they can do to reduce their own carbon footprint. In the park students will be able to collect phenological data on the field trip. Additionally, students will graph, analyze, and interpret weather and phenological data and see how climate change is impacting the National Park and many geographical areas in the United States.

Tennessee Curriculum Correlations

Biology I

Embedded Inquiry: Understandings about scientific inquiry and the ability to conduct inquiry are essential for living in the 21st century.

- ✓ 3210.Inq.2 Conduct scientific investigations that include testable questions, verifiable hypotheses, and appropriate variables to explore new phenomena or verify the experimental results of others.
- ✓ 3210.Inq.3 Select appropriate tools and technology to collect precise and accurate quantitative and qualitative data.
- ✓ 3210.Inq.4 Determine if data supports or contradicts a hypothesis or conclusion.
- ✓ 3210.Inq.5 Compare or combine experimental evidence from two or more investigations.
- ✓ 3210.Inq.6 Recognize, analyze, and evaluate alternative explanations for the same set of observations.
- ✓ 3210.Inq.7 Analyze experimental results and identify possible sources of experimental error.

Embedded Mathematics: Science applies mathematics to investigate questions, solve problems, and communicate findings.

- ✓ 3210.Math.2 Analyze graphs to interpret biological events.
- ✓ 3210.Math.3 Make decisions about units, scales, and measurement tools that are appropriate for investigations involving measurement.
- ✓ 3210.Math.5 Apply and interpret rates of change from graphical and numerical data.

Interdependence: All life is interdependent and interacts with the environment.

- ✓ 3210.2.1 Analyze human population distribution graphs to predict the impact on global resources, society, and the economy.
- ✓ 3210.2.4 Investigate an outdoor habitat to identify the abiotic and biotic factors, plant and animal populations, producers, consumers, and decomposers.
- ✓ 3210.2.5 Conduct research on how human influences have changed an ecosystem and communicate findings through written or oral presentations.

Biodiversity and Change: A rich variety and complexity of organisms have developed in response to changes in the environment.

- ✓ 3210.5.1 Create graphic organizers to demonstrate the relationship between form and function in representative organisms.
- ✓ 3210.5.2 Explain how natural selection operates in the development of a new species.
- ✓ 3210.5.5 Use a dichotomous key to identify an unknown organism.

Biology II

Embedded Inquiry: Understandings about scientific inquiry and the ability to conduct inquiry are essential for living in the 21st century.

- ✓ 3216.Inq.2 Conduct scientific investigations that include testable questions, verifiable hypotheses, and appropriate variables to explore new phenomena or verify the experimental results of others.
- ✓ 3216.Inq.3 Analyze the components of a properly designed scientific investigation.
- ✓ 3216.Inq.4 Select appropriate tools and technology to collect precise and accurate quantitative and qualitative data.
- ✓ 3216.Inq.5 Determine if data supports or contradicts a hypothesis or conclusion.
- ✓ 3216.Inq.6 Recognize, analyze, and evaluate alternative explanations for the same set of observations.
- ✓ 3216.Inq.7 Evaluate the accuracy and precision of data.
- ✓ 3216.Inq.10 Analyze experimental results and identify possible sources of experimental error.
- ✓ 3216.Inq.11 Formulate and revise scientific explanations and models using logic and evidence.

Embedded Mathematics: Science applies mathematics to investigate questions, solve problems, and communicate findings.

- ✓ 3216.Math.2 Analyze graphs to interpret biological events.
- ✓ 3216.Math.3 Make decisions about units, scales, and measurement tools that are appropriate for problem situations involving measurement.

Interdependence: All life is interdependent and interacts with the environment.

- ✓ 3216.2.1 Analyze the ecological impact of a change in climate, human activity, introduction of non-native species, and changes in population size over time.
- ✓ 3216.2.2 Investigate how fluctuations in population size in an ecosystem are determined by the relative rates of birth, death, immigration, and emigration.
- ✓ 3216.2.3 Investigate how human changes to the environment have led populations to adapt, migrate, or become extinct.
- ✓ 3216.2.4 Contrast accommodations of individual organisms with the adaptation of a species.

Biodiversity and Change: A rich variety and complexity of organisms have developed in response to changes in the environment.

- ✓ 3216.5.1 Predict how variation within a population affects the survival of a species.
- ✓ 3216.5.5 Explain how amount of biodiversity is affected by habitat alteration.

Botany: Plants are essential for life to exist.

- ✓ 3216.7.2 Employ a dichotomous key to identify plants based on their structural characteristics.
- ✓ 3216.7.7 Prepare a presentation about plants that are harmful or beneficial to humans.

Ecology

Embedded Inquiry: Understandings about scientific inquiry and the ability to conduct inquiry are essential for living in the 21st century.

3255.Inq.1 Develop a testable question for a scientific investigation.
3255.Inq.2 Develop an experimental design for testing a hypothesis.
3255.Inq.3 Select appropriate independent, dependent, or controlled variables for an experiment.
3255.Inq.4 Perform an experiment to test a prediction.
3255.Inq.5 Gather, organize, and transform data from an experiment.
3255.Inq.6 Analyze and interpret the results of an experiment.
3255.Inq.7 Use knowledge and data-interpretation skills to support a conclusion.
3255.Inq.11 Analyze experimental results and identify the nature and sources of experimental error.
3255.Inq.13 Develop a logical argument about cause-and-effect relationships in an experiment.

Individuals: The individual organism is the basic unit of ecology.

3255.1.2 Use a dichotomous key to identify at least five species found in a local ecosystem.
3255.1.8 Investigate techniques and findings of the All Taxa Biodiversity Inventories (ATBI) underway in the Great Smoky Mountains National Park and Tennessee State Parks.
3255.1.9 Explore careers in conservation biology and bioinformatics.

Ecosystems: An ecosystem is a community that interacts with the physical environment.

3255.4.4 Explore a local area and examine the abiotic and biotic factors relating to succession and ecosystem structure.
3255.4.5 Summarize how disturbance contributes to succession and ecosystem stability.
3255.4.6 Identify how nutrient availability affects terrestrial and aquatic ecosystems.

Humans and Sustainability: Human activities have reduced the earth's biodiversity.

3255.6.1 Differentiate the purposes of State and National Parks, Wildlife Refuges, and Forests.
3255.6.3 Research and paraphrase local, national, and international environmental legislation enacted to sustain biodiversity (e.g., The Lacy Act, Endangered Species Act, National Marine Fisheries Act, TWRA Hunting and Fishing Regulations, CITES).
3255.6.4 Develop a timeline that illustrates major local, national and international environmental legislation enacted to sustain biodiversity.

Table of Contents

Planning a Successful Trip
Phenology

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

• Arrive at Twin Creeks Science and Education Center for restrooms and to meet rangers
• On-site activities with lunch in between activities
• Reload bus and return to school

Planning a Successful Trip

• The location for this trip is at the Twin Creeks Science and Education Center near Gatlinburg. Park rangers will direct your bus driver where to park.

• There is no cost to use this site.

• Arrange to have a teacher or chaperone available for every 10 students.

• Safety is of the utmost importance, especially in a National Park. Be sure to read the safety information provided on the following page. You may wish to take the page with you on your trip or send it to your chaperones prior to the on-site experience.

Safety Considerations and Other Important Information

• Great Smoky Mountains National Park is a federally protected public use area. Please help the rangers keep all of the plants and animals protected in the park by not picking the plants or taking anything from the park.

• Please remind your students to wear appropriate footwear and clothing for this extended outdoor experience. Flip flops, slip-on shoes, or sandals are not appropriate for the program.

• Temperatures in some parts of the park can be 10-15 degrees colder than at your school. Long pants and layers are suggested for the program. Pants are the best precaution against cool temperatures, bee stings, ticks, and poison ivy.

• Within the park, cell phones are not always reliable. Rangers will follow the on-site agenda. If an unexpected problem occurs, rangers do carry park radios to make contact with the park dispatch office. For non-emergencies, call the Park Ranger dispatch at 865-436-1230 or contact a park employee.

Animals and Plants of Concern in the park

• All animals in the park are wild and their behaviors are unpredictable. Treat all animals with caution.

• Venomous snakes - Two species of venomous snakes live in the Smokies, the copperhead and timber rattlesnake. Students should be cautious where they place their hands and feet.

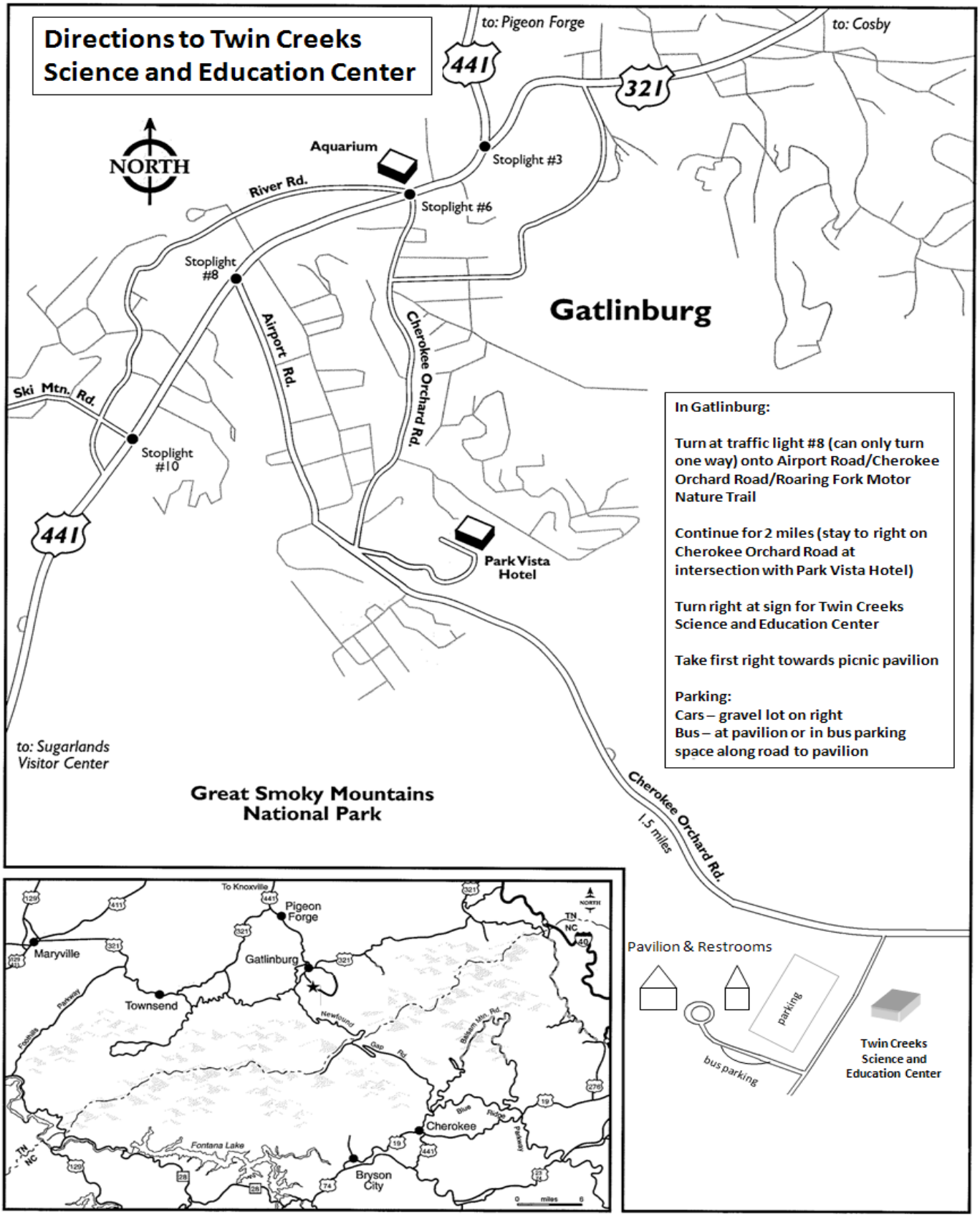
• Insects - Yellow jacket wasps are the insects of greatest concern. They build nests in the ground along trails and streams and are aggressive when disturbed. Stings cause local swelling and can lead to severe allergic reactions in sensitive individuals. Such persons should carry epinephrine kits.

• Poison Ivy - Poison ivy is a three-leaved plant which can grow on the ground as well as on "hairy" vines up trees. To avoid chances of an allergic reaction wear long pants, stay on trails, and avoid direct contact with vegetation. If contact occurs or is a concern, wash affected parts in cold soapy water immediately.

• Pets are not allowed on most park trails. Please do not bring them on the field trip.

• For more information about the park (Things to Know Before You Come) please visit the park's website: http://www.nps.gov/grsm/planyourvisit/things2know.htm

Map To Twin Creeks



Pre-Site Activity
Weather, Climate, and Phenology

Grade Level: Middle or High School

Subject Area: Science

Activity time: 60 minutes

Setting: Classroom

Skills: Analyzing; Applying; Assessing; Calculating; Collecting information; Comparing; Connecting; Decision making; Evaluating; Gathering information; Graphing; Hypothesizing; Inferring; Interpreting; Summarizing

Vocabulary: climate; phenology; weather

Objective:
Students will describe the difference between weather and climate, improve their understanding of phenology, and graph and interpret data sets.

Materials:
• Phenology worksheets (pages 8-14)

Background:
In this lesson students will develop an understanding of the relationship between natural phenomena, weather, and climate change: the study known as "phenology." First, students will learn or reminded of the differences between weather and climate and what is and what is not phenology. Next they will graph, analyze, and interpret weather and phenological data from the Great Smoky Mountains Institute at Tremont.

Procedure:
Have students (individually or in pairs) complete the Climate Versus Weather and Phenology worksheets. After students have finished the worksheet have a classroom discussions of their findings. Have students share one new thing they have learned about climate versus weather and one new thing they have learned about phenology.

Have students (individually or in pairs) complete the Phenology graphing activities (pages 10-14). Use the teacher answer key as a guide for questions (pages 15-16). After students have finished the graphing activities have a classroom discussions of their findings. What are some things that they expected or not expected? What are some questions that they would want to explore more about these activities?

Extensions:
• Have students interview a family member, neighbor, or friend who could have observed natural events 40-60 years ago. Do they remember natural events happening later or earlier than they do now? Do they believe the climate is changing based on their own observations of the natural world?
• Have students develop a Phenology Calendar focused on natural events in the schoolyard. Some annual events might include sounds of the first robin, first maple tree budding or showing color in the fall, first emergence of worms on the school grounds, etc.

References:

• Blooming Thermometers http://eo.ucar.edu/educators/ClimateDiscovery/LIA_lesson6_9.28.05.pdf
• Climate for Action Glossary = http://www.epa.gov/climateforaction/learn/glossary.htm
• Discover Life in America (DLIA) = http://www.dlia.org/atbi/species/index.shtml
• Ecosystem Phenology = http://dnr.wi.gov/org/caer/ce/eek/teacher/Climateguide/PDF/03-4245-phenology.pdf
• National Sustainable Agriculture Information Service = http://attra.ncat.org/attra-pub/phenology.html
• USA National Phenology Network = http://www.usanpn.org/about/phenology
• Weather versus Climate = http://www.theweatherprediction.com/habyhints2/454/

Pre-Site Activity
Weather, Climate, and Phenology (continued)

The difference between weather and climate is a measure of time. Weather is what conditions of the atmosphere are over a short period of time, and climate is how the atmosphere "behaves" over relatively long periods of time. In short, climate is the description of the long-term pattern of weather in a particular area. An easy way to remember the difference is that climate is what you expect, like a very hot summer, and weather is what you get, like a hot day with pop-up thunderstorms. Some scientists define climate as the average weather for a particular region and time period, usually taken over 30 years. It's really an average pattern of weather for a particular region. Just because we have an extra hot summer or an extra cold winter does not mean that the climate is changing. Such extremes may even out over time.

The reason studying climate and a changing climate is important, is that climate change will affect people around the world. Rising global temperatures are expected to raise sea levels, and change patterns of precipitation and other local climate conditions. Changing regional climate could alter forests, crop yields, and water supplies. It could also affect human health.

Weather or Climate or Both?
For each of the 14 statements below, classify them as weather or climate or both.

1. It snowed 5 inches last night. _____
2. Helps you decide what clothes to buy. _____
3. It has not rained this month yet. _____
4. Typically rainfall in June is under 1 inch. _____
5. This winter should be colder than normal. _____
6. Helps you decide what clothes to wear. _____
7. The barometric pressure is falling. _____
8. Type and amount of precipitation for the last two weeks. _____
9. There is a severe thunderstorm watch for the local area. _____
10. It has never gone above 100 F in the month of May. _____
11. Air temperature outside today. _____
12. The low temperature last night was 10 degrees above normal. _____
13. The skies are clearing. _____
14. Katrina was the strongest hurricane to hit New Orleans. _____

Phenology

Phenology is derived from the Greek word *phainomai*, meaning to appear or come into view. It is the study of recurring plant and animal life cycle events, or phenophases, such as leafing and flowering, maturation of agricultural plants, emergence of insects, and migration of birds. Phenology is simply the study of nature's calendar.
Phenology observes the relationship between 1) discrete phenological events, 2) events and the season, 3) events and local weather conditions, and 4) events and climatic changes. Changes in phenological events like flowering is among the most sensitive biological responses to climate change. Across the world, many spring events are occurring earlier—and fall events are happening later—than they did in the past. However, not all species are changing at the same rate.

The timing of phenological events is important for:

- health (allergens and infectious diseases)
- recreation (wildflower displays and fall colors)
- agriculture (planting and harvest times, pest control)
- management of natural resources (water and timber)
- understanding hazards (monitoring and prediction of drought and fire risk)
- conservation (abundance and diversity of plants and animals)

Pre-Site Activity
Weather, Climate, and Phenology (continued)

An example of Phenology or Not an example of Phenology?
For each of the 14 statements below, classify them as an example of phenology (write: example) or Not an example of phenology (write: not an example).

15. When the red maple trees are in full bloom. _____
16. First bee activity of the year recorded. _____
17. How many birds come to my feeder. _____
18. Latest bloom of the wildflower, Mountain Gentian. _____
19. How many times I hike to the top of Clingmans Dome during the month of June. _____
20. When the elk start to rut. _____
21. Date of when there are no more leaves on the buckeye trees at my work. _____
22. The number of days that you can see the mountains in the Smokies. _____
23. The emergence of the bears in the Smokies from hibernation in late February. _____
24. Last monarch butterfly seen for the season. _____
25. The number of cars seen in the parking lot seen at Sugarlands visitor center. _____
26. Breeding season of the Northern Cardinal. _____
27. The date Lady Gaga releases her newest album. _____
28. The time the bus arrives to take us on a field trip. _____

Phenological Sayings and Observations
Many of the common folk lore and weather sayings are based on observations of nature's cycles and rhythms, and gardeners still follow many of these phenology indicators and observations.

Ash before oak,
We're in for a soak.
Oak before ash,
We're in for a splash.

Gardeners activities are sometimes based on phenological indicators:
* When the daffodils begin to bloom it is time to plant peas
* When the blossoms of the apple tree begin to fall, plant your corn seeds
* When dandelions are blooming plant beets and carrots
* Plant potatoes when the shadbush flowers
* When elm leaves are the size of a penny plant kidney beans

Although several phenology records exist, we still need more information to answer lots of questions, ranging from simple questions like "What regulates the pace at which a particular species develops?" to more complex questions like "How does phenology affect where organisms live? With sufficient phenological observations, we can document patterns of phenology for critical plant and animal species across the United States, and then use this information to build models to help humans understand and adapt to changing landscapes and climates.

In the Great Smoky Mountains National Park, the Great Smoky Mountains Institute at Tremont have been recording phenological events and weather data since 1991. This data collection is an ongoing project.

29. Why can we not use this data from the Great Smoky Mountains Institute at Tremont yet as evidence of climate change?

Pre-Site Activity
Weather, Climate, and Phenology (continued)

The Great Smoky Mountains Institute at Tremont in the Great Smoky Mountains National Park have been recording phenological events and weather data since 1991. Below are excerpts of these recordings. Use the data set below to develop hypotheses, graphs, and conclusions on the month and day of the first frost from 1991 to the present.

A. Develop a hypothesis for the data set. Is there a relationship between the year and month and day of the first frost? If there is a relationship, then is it a positive relationship (first frost is getting later in the year) or a negative relationship (first frost is getting earlier in the year)? Write the hypothesis in the blank below.

30. Hypothesis A: _____

31. Based on your hypothesis, draw what you expect your graph to look like.

B. Graph the First frost of the year as a scatterplot. A scatterplot is a way of representing the scores of a group in a graphic fashion. A scatterplot shows two scores (X and Y) for each individual (for this example: date and year of first frost) and plots the individual in terms of the X and Y scores.

C. After graphing the data set, estimate the regression line, the line of "best fit". Imagine that the points enclose an area, then cut that area in half. If you use a ruler to draw the line you can move it around until you find a place where approximately half the points are on each side of the line. If the slope is going up - from left to right - then it is a
positive relationship. If it is going down -from left to right - then the slope is a negative relationship.

Year	Month	Day
1991	October	7
1992	October	18
1993	October	22
1994	October	26
1995	October	29
1996	October	9
1997	October	22
1998	October	22
1999	October	23
2000	October	10
2001	October	8
2003	October	28
2002	No data recorded	
2004	November	9
2005	October	27
2006	October	24
2007	October	31
2008	October	28
2009	November	6

Title of Graph: _____

Y axis: _____

X axis: _____

Pre-Site Activity
Weather, Climate, and Phenology (continued)

32. Is there a relationship? If so, is it positive or negative?

33. Look back at your Hypothesis A, did the data support or reject your hypothesis?

Use the data set below to develop hypotheses, graphs, and conclusions on the month and day of the last frost from 1991 to the present.

D. Develop a hypothesis for the data set. Is there a relationship between the year and month and day of the last frost? If there is a relationship, then is it a positive relationship (last frost is getting later in the year) or a negative relationship (last frost is getting earlier in the year)? Write the hypothesis in the blank below.

34. Hypothesis B: _____

35. Based on your hypothesis, draw what you expect your graph to look like.

E. Graph the Last frost of the year as a scatterplot.

F. After graphing the data set, estimate the regression line, the line of "best fit". Imagine that the points enclose an area, then cut that area in half. If you use a ruler to draw the line you can move it around until you find a place where approximately half the points are on each side of the line. If the slope is going up - from left to right - then it is a
positive relationship. If it is going down -from left to right - then the slope is a negative relationship.

Year	Month	Day
1992	May	8
1993	April	28
1994	April	7
1995	April	4
1996	April	10
1997	April	16
1998	April	10
1999	April	19
2000	April	10
2001	April	19
2002	No data recorded	
2003	May	1
2004	April	15
2005	April	19
2006	May	9
2007	May	13
2008	April	25
2009	April	8

Y axis: _____

Title of Graph: _____

X axis: _____

36. Is there a relationship? If so, is it positive or negative?

37. Look back at your Hypothesis B, did the data support or reject your hypothesis?

A line in a two dimensional or two-variable space is defined by the equation Y=m*X+b; in full text: the Y variable can be expressed in terms of a slope (m) times the X variable plus a y-intercept (b). To interpret the direction of the
relationship between variables, look at the signs (plus or minus) of the slope. If the slope is positive, then the relationship of this variable with the dependent variable is positive (example: first frost is getting later in the year); if the slope is negative then the relationship is negative (example: first frost is getting earlier in the year). Of course, if the slope is equal to 0 then there is no relationship between the variables. Instead of just "eye-balling" a regression line as you have done, scientists use statistics to find the best regression line. Computers with the right software make this easy.

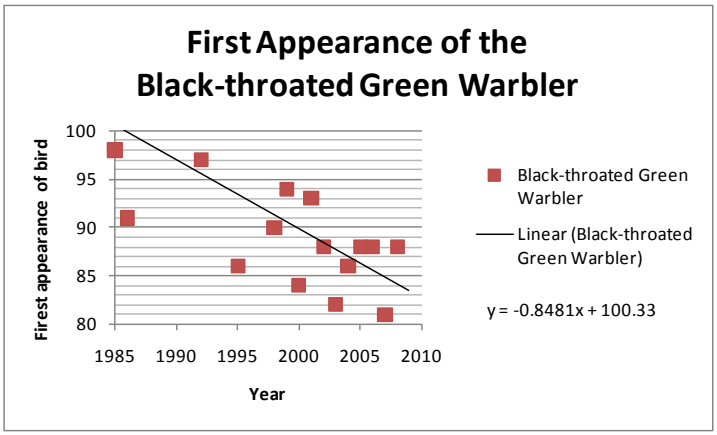
38. Calculation was made using a computer and the regression line in slope intercept form was $y = 0.9195x + 287.02$ for the first frost of the year. Does the slope (0.9195) confirm or refute your findings from your line of "best fit" from the First frost of the year graph?

39. Calculation was made using a computer and the regression line in slope intercept form was $y = -1.1986x + 112.69$ for the last frost of the year. Does the slope (-1.1986) confirm or refute your findings from your line of "best fit" from the Last frost of the year graph?

Pre-Site Activity
Weather, Climate, and Phenology (continued)

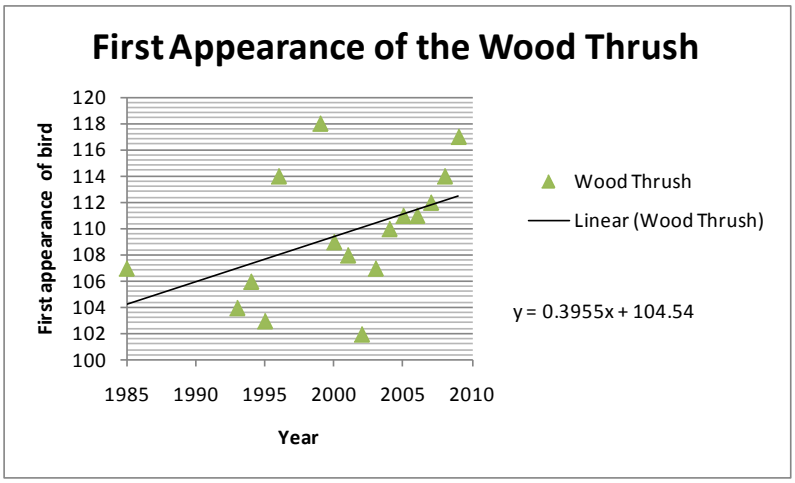
For the following plants and animals read the excerpt about the species and then analyze the graph to the right of the species' picture. Determine if the slope of the graph is positive or negative and describe what this graphed data might mean. The Y-axis is expressed in day number ([DDD] is the day of that year, from 001 for January 1 through 365 for December 31).

A. The Black-throated Green Warbler, *Dendroica virens*, is an abundant breeding bird in the park. It is common at all elevations during the summer months with highest densities occurring between 2,000 - 3,000 feet. This species is a neotropical migrant and migrates to eastern and southern Mexico, Central America and the northern edge of South America. Also, some birds will winter on the southern edges of Texas and Florida or in the Bahamas and the West Indies.



40. First appearance of the Black-throated Green Warbler
Is the slope positive or negative? _____
Describe what this graphed data might mean:

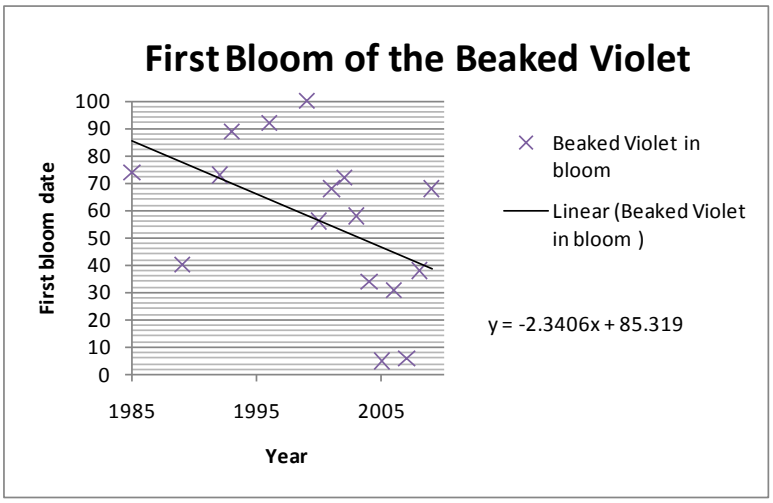
B. The Wood Thrush, *Hylocichla mustelina*, is a common breeding bird species in the park. This species is a neotropical migrant so it winters in Mexico and Central America, mostly along the coasts of the Atlantic and Pacific oceans.



41. First appearance of the Wood Thrush
Is the slope positive or negative? _____
Describe what this graphed data might mean:

Pre-Site Activity
Weather, Climate, and Phenology (continued)

D. The Beaked Violet, *Viola rostrata*, is occasionally seen in low to mid elevations in the park. It is a leafy-stemmed violet that varies from 4-16 in. tall with lilac-purple flowers. It is found in moist, rich woods, often near Eastern hemlock trees. In the Smokies, beaked violets bloom from April through May.



39. First bloom of the Beaked Violet
Is the slope positive or negative? _____
Describe what this graphed data might mean:

40. Why should scientists not simply trust the goodness of fit line to forecast the future?

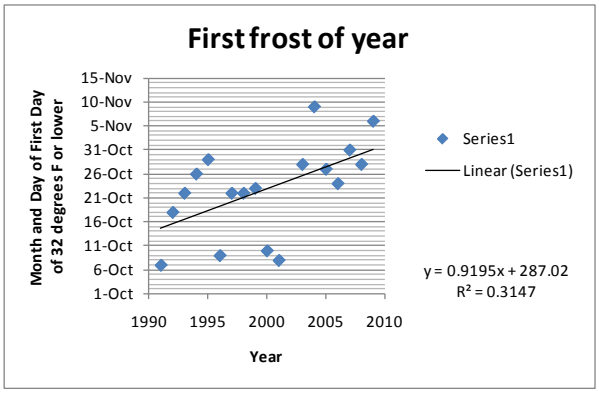
41. What further information would one need to link the analysis to the data and what other variables would one need to analyze if they were to look at the total picture and try to figure out why these trends might be occurring?

Pre-Site Activity: Weather, Climate, and Phenology Teacher Answer Page

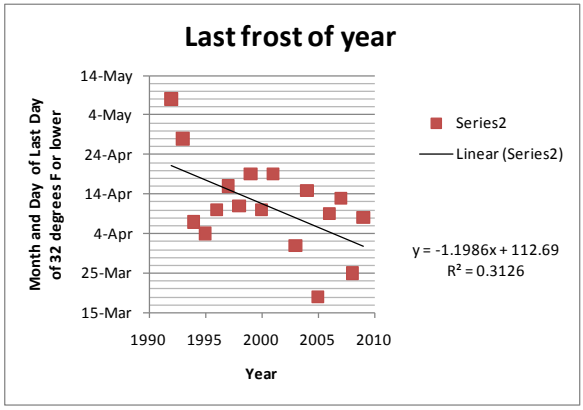
1. It snowed 5 inches last night. *Weather; recent weather event of snow*
2. Helps you decide what clothes to buy. *Climate; typical conditions during that time of year*
3. It has not rained this month yet. *Weather; no weather has produced rain this month*
4. Typically rainfall in June is under 1 inch. *Climate; reference to typical conditions and a value of typical rainfall*
5. This winter should be colder than normal. *Both, because the forecast is for weather and the comparison is the climate norms.*
6. Helps you decide what clothes to wear. *Weather; current conditions*
7. The barometric pressure is falling. *Weather; recent weather change*
8. Type and amount of precipitation for the last two weeks. *Weather; current conditions*
9. There is a severe thunderstorm watch for the local area. *Weather; current weather conditions are leading to the potential of severe thunderstorms in the near term*
10. It has never gone above 100 F in the month of May. *Climate; reference to a weather extreme*
11. Air temperature outside today. *Weather; current conditions*
12. The low temperature last night was 10 degrees above normal. *Both weather (10 degrees) and climate (normal for that time of year).*
13. The skies are clearing. *Weather; current conditions*
14. Katrina was the strongest hurricane to hit New Orleans. *Climate, compares recent hurricane to previous hurricanes*

Below are listed the computer generated graphs using the First frost data and Last frost data. Students can compare their line of "best fit" to the computer generated line.

B.



E.



15. When the red maple trees are in full bloom. __*Example*_____
16. First bee activity of the year recorded. ____*Example*_____
17. How many birds come to my feeder. ____*Not an example*_____
18. Latest bloom of the wildflower, Mountain Gentian. ____*Example*_____
19. How many times I hike to the top of Clingmans Dome during the month of June. _*Not an example*_
20. When the elk start to rut. ____*Example*_____
21. Date of when there are no more leaves on the buckeye trees at my work. __*Example*____
22. The number of days that you can see the mountains in the Smokies. __*Not an example*____
23. The emergence of the bears in the Smokies from hibernation in late February. __*Example*___
24. Last monarch butterfly seen for the season. ___*Example*_____
25. The number of cars seen in the parking lot seen at Sugarlands visitor center. __*Not an example*___
26. Breeding season of the Northern Cardinal. ___*Example*_____
27. The date Lady Gaga releases her newest album. __*Not an example*_____
28. The time the bus arrives to take us on a field trip. __*Not an example*_____

Pre-Site Activity: Weather, Climate, and Phenology Teacher Answer Page (continued)

29. Why can we not use this data yet as evidence of climate change? *Since we have only recorded 18 years of weather data through 2009 the data can only be used as weather data, not climate data.*

30. *Students hypothesis*

31. *Students answer*

32. *Students answer*

33. *Students answer*

34. *Students hypothesis*

35. *Students answer*

36. *Students answer*

37. *Students answer*

38. *Students answer*

39. *Students answer*

40. *Negative, bird appearing earlier; students description will vary*

41. *Positive, bird appearing later; students description will vary*

42. *Positive, tree blooming later; students description will vary*

43. *Negative, wildflower blooming earlier; students description will vary*

44. Why should scientists not simply trust the goodness of fit line to forecast the future?
One cannot forecast or assume any causality or significance without further tests or a large sample size. This could be due to other variables also.

45. What further information would one need to link the analysis of the data and what other variables would one need to analyze if they were to look at the total picture and try to figure out why these trends might be occurring?
Is anything happening to the species worldwide? For example: What is going on in the countries where the bird is migrating from? What is happening to its food source here and there? A full picture means much more work and is the type of puzzle that scientists have to work with.

Pre-Site Activity
Take Action - Living a Climate Friendly Lifestyle

Grade Level: High School

Subject Area: Science

Activity time: 15 minutes homework assignment, 30 minutes computer assignment in class, and 20 minute class discussion

Setting: Classroom

Skills: Analyzing, Applying, Assessing, Calculating, Collecting information, Comparing, Connecting, Decision making, Evaluating, Fathering information, Interpreting, Summarizing

Vocabulary: carbon footprint

Objectives: **Students will calculate their personal carbon footprint, create a measurable personal action plan to reduce their footprint, and discuss ways to become** a climate change leader in their household and community.

Materials:
- Computer
- Worksheets (pages 19-20)

Background:
By measuring the carbon footprint of an individual we can assess our pressure on the planet, which helps us manage our ecological assets more wisely and take personal and collective action in support of a world where humanity lives within the Earth's bounds. In this activity, students will calculate their household's carbon footprint using the Center for Sustainable Economy's Ecological Footprint calculator. This calculator will calculate if everyone on the planet lived the student's lifestyle how many earths would be needed, their footprint in global acres by consumption category, and their footprint share by biome. In addition, students will be asked to write down actions they can do personally to reduce their footprints from the listed suggestions.

Procedure:
Have students bring the Personal Carbon Footprint (Homework) worksheet home to complete with their parent/guardian(s). The following day in class (computer room) have the students complete the Personal Carbon Footprint (Classwork) worksheet in class using the computers. After students have finished their calculations and their reduction of carbon footprint actions have a classroom discussions of their findings.

References:
- Carbon Footprint Basics = http://www.footprintnetwork.org/en/index.php/GFN/page/footprint_basics_overview/
- Carbon Footprint Calculator= http://www.myfootprint.org/
- Climate For Action = http://www.epa.gov/climateforaction/learn/glossary.htm
- Progress Energy green program = http://progress-energy.com/custservice/carres/renewableenergy/ncgreenpower.asp

Extension:
Ask students to discuss their carbon footprint with their families and to possibly adopt one carbon dioxide emissions reduction strategy.

Pre-Site Activity: Take Action
Living a Climate Friendly Lifestyle (continued)

Before you complete this assignment in class you should ask the following questions to your parent/guardian at home tonight:

HOMEWORK

1. What is the size of your home in square feet? _____ square feet
(Circle one): a. 500-1000 sq ft or less, b. 1000-15000 sq ft, c. 1500-2000 sq ft,
d. 2000-2500 sq ft. or e. 2500 sq ft or larger

2. Which of the following energy sources do you use in your home?
(Circle as many as you use) a. Electricity, b. Natural gas, propane, liquefied petroleum gas,
c. Heating oil, d. Wood or biomass

3. Ask your parent/guardian if they are enrolled in the Progress Energy green program. If they are, 100 kWh per month come from green energy and will need to figure out the % from your total monthly usage. (Circle one): a. yes b. no

If they aren't enrolled, see if they would think about doing so as a way to reduce their impact. Check out the following internet address for more information regarding the Progress Energy green program at **http://progress-energy.com/custservice/carres/renewableenergy/ncgreenpower.asp**

4. If your house uses electricity, what percentage is generated from renewable hydropower, wind, biomass, or solar sources (use percentage from #3 question)? If unsure, place 8.29% for the country average.
_____%

5. How many miles do you and your family travel per week for each mode of transportation?
Automobiles: _____x 52 = _____ miles per year
Bus: _____x52 = _____ miles per year
Rail: _____x52 = _____ miles per year
Air travel: _____x52=_____ miles per year

6. Ask your parent/guardian if they have purchased offsets for carbon emissions associated with your home energy use and transportation. (Circle one): a. yes b. no

7. Was your home or any portion of it built with recycled materials, wood certified as sustainably harvested, or any other green design features? (Circle one): a. yes b. no

Pre-Site Activity: Take Action
Living a Climate Friendly Lifestyle (continued)

Calculating one's carbon footprint is a measure of humanity's demand on nature. Everything we do has consequences. Find out how much "nature" your lifestyle requires.
Calculate your own carbon footprint by going to **http://www.myfootprint.org/**

8. If everyone on the planet lived your lifestyle, we would need how many earths?_____

9. My Footprint in Global Acres by Consumption Category: _____

10. My Footprint Share By Biome:
    Marine Fisheries footprint = _____ %
    Forestland footprint = _____ %
    Pastureland footprint = _____ %
    Cropland footprint = _____ %

11. What are three specific steps to Reduce your Carbon Footprint?
    1.
    2.
    3.

12. What are three specific steps to Reduce your Food Footprint?
    1.
    2.
    3.

13. What are three specific steps to Reduce your Housing Footprint?
    1.
    2.
    3.

14. What are three specific steps to Reduce your Goods and Services Footprint?
    1.
    2.
    3.

On-Site Activity
Park Ranger Directed Lessons

EFFECTS OF CLIMATE CHANGE
PHENOLOGY MONITORING

Grade Level: High School

Subject Area: Science

Activity time: **1.5 hours**
*** Program can be 3 hours (if paired with another HS activity)**

Class Size: **Maximum of 60 students**

Setting: Outdoors

Skills: Analyzing; Applying; Assessing; Calculating; Classifying; Collecting information; Comparing; Contrasting; Describing; Discussing; Estimating; Evaluating; Gathering information; Hypothesizing; Identifying cause and effect; Listening; Observing; Proposing solutions; Recording data; Summarizing

Materials: Rangers will provide all materials

- Phenology laminated sheets w/ ID'd trees
- Measuring tapes (1/group)
- Binoculars (1/group)
- Data sheet (1/group)
- Tree ID dichotomous keys

Objectives:

1) recognize different tree phenophases
2) learn about tree identification
3) learn about carbon sequestration

Background:

During this program, students will be monitoring the progression of phenology on deciduous trees in an established study plot. The goal is to document timing and duration of each life cycle event for the trees. Data collected today will be relevant in thirty to fifty years when we analyze whether yearly weather changes are showing trends of a changing climate as evidenced by the trees.

Scientists have documented that the earth is warming and that this is due to increased levels of greenhouse gases in our atmosphere. One of the major contributors to this issue is the extraction of carbon stored in fossil fuels buried deep within the earth. The release of this previously unavailable carbon creates an imbalance in the carbon cycle resulting in more carbon available than can be stored in carbon sinks such as trees and the oceans. As students collect phenology data, they will also determine how much carbon each tree they study can sequester.

Procedure:

Everyone will work with a partner to monitor 20 trees within a plot. It is important to look at multiple places on the tree to determine the phenophases. Students will be determining the leaf, flower, and fruit phenophase of the tree. The students will additionally take the tree's DBH to determine how many pounds the tree can sequester this year.

Post-Site Activity
Climate Friendly Parks

EFFECTS OF CLIMATE CHANGE
PHENOLOGY MONITORING

Grade Level: High School

Subject Area: Science

Activity time: 30 minutes

Setting: Classroom

Skills: Analyzing, Applying, Collecting information, Connecting, Interpreting, Listing, Research, Reporting, Summarizing

Vocabulary: **Varying vocabulary depending on research**

Objectives:

Students will learn the science and impacts of how climate change is impacting national parks, how parks are developing specific strategies to address climate change, and what parks are doing to address the issue.

Materials:

- Computer(s) with internet connection
- "Climate Friendly Parks" worksheet (page 23)

Background:

Scientists who observe Earth's climate have documented a warming trend caused by human activity, and the consensus is for the trend to continue. These changes have consequences to all, including the National Parks. Climate change transforms the natural and cultural landscapes of national parks and impacts the user's national park adventure. However, the National Park Service is managing with the best available science, making resources more resilient, reducing the service's carbon footprint, and helping staff and the public appreciate the implications of a changing climate.

Procedure:

Have the students work through the "Climate Friendly Parks" worksheet using the provided web addresses on the worksheet. After the class has completed the assignment have a group discussion of their findings.

Post-Site Activity
Climate Friendly Parks: Worksheet

National Parks have the unique opportunity to serve as climate friendly models for millions of visitors annually. In this section you will find several resources on what the National Park Service is doing.

Go to Climate Change is Real at http://www.nature.nps.gov/ClimateChange/overview.cfm

1. Name two ways that climate change could affect your experience in a national park.

2. Over the past 50 years, average global temperature has risen ____ degrees Fahrenheit (____ Celsius).

3. Atmospheric concentrations of CO2 began a marked increase that coincides with the Industrial Revolution of the late 1800s. CO2 levels rose by more than _____ percent in the 50-year period 1958-2008.

Go to Climate Change Myths at http://www.nature.nps.gov/ClimateChange/myths.cfm

4. List two myths and a short one sentence summary of the science against the myth
   a.

   b.

Go to Climate Effects: Climate Change Has Consequences for Parks, People, and the Planet at http://www.nature.nps.gov/ClimateChange/effects.cfm

5. List two "Climate Drivers" and the explanation behind each.
   a.

   b.

Go to the National Park Service's response to Climate Change at http://www.nature.nps.gov/ClimateChange/response.cfm

6. List the four areas of emphasis for the National Park Service.
   1.
   2.
   3.
   4.

Go to The Choices We Make Affects Parks at http://www.nature.nps.gov/ClimateChange/involved.cfm

7. List three Climate Friendly Actions and activities that the National Park Service are undertaking.
   1.
   2.
   3.

Post-Site Activity
Geographical Impacts of Climate Change

EFFECTS OF CLIMATE CHANGE
PHENOLOGY MONITORING

Grade Level: High School

Subject Area: Science

Activity time: 30 minutes

Setting: Classroom

Skills: Analyzing, Collecting information, Connecting, Interpreting, Listing, Research, Reporting, Summarizing

Vocabulary: Varying vocabulary depending on research

Objective:
Students will learn the impacts of how climate change is impacting different geographical regions of the United States.

Materials:
- Computer(s) with internet connection
- "Geographical Impacts of Climate Change" worksheet (page 25)

Background:
The web pages on the global climate change impacts in the United States summarizes the science and the impacts of climate change on the United States, now and in the future. It focuses on climate change impacts in different regions of the United States and on various aspects of society and the economy such as energy, water, agriculture, and health.

Procedure:
Have the students work through the "Geographical Impacts on Climate Change" worksheet using the provided web addresses on the worksheet. After the class has completed the assignment have a group discussion of their findings.

Post-Site Activity: Geographical Impacts of Climate Change Worksheet

For each of the geographical areas listed below write three key issues that are affecting that specific geographical area.

• Northeast: http://www.globalchange.gov/images/cir/region-pdf/NortheastFactSheet.pdf

1.

2.

3.

• Southeast: http://www.globalchange.gov/images/cir/region-pdf/SoutheastFactSheet.pdf

1.

2.

3.

• Midwest: http://www.globalchange.gov/images/cir/region-pdf/MidwestFactSheet.pdf

1.

2.

3.

• Great Plains: http://www.globalchange.gov/images/cir/region-pdf/GreatPlainsFactSheet.pdfSouthwest

1.

2.

3.

• Northwest: http://www.globalchange.gov/images/cir/region-pdf/NorthwestFactSheet.pdf

1.

2.

3.

• Southwest: http://www.globalchange.gov/images/cir/region-pdf/SouthwestFactSheet.pdf

1.

2.

3.

• Coasts: http://www.globalchange.gov/images/cir/region-pdf/CoastsFactSheet.pdf

1.

2.

3.

• Alaska: http://www.globalchange.gov/images/cir/region-pdf/AlaskaFactSheet.pdf

1.

2.

3.

• Islands: http://www.globalchange.gov/images/cir/region-pdf/IslandFactSheet.pdf

1.

2.

3.

Post-Site Activity
Stewardship

Grade Level: High School

Subject Area: Science

Activity time: 30 minutes

Setting: Classroom

Skills: Applying; Communicating; Connecting

Vocabulary: conservation; protection; stewardship

Objectives: To understand what the term "Stewardship" means and how students can become a steward in their school and their community.

Materials: Internet access

Procedure:
To view the Stewardship podcast video go to **http://www.thegreatsmokymountains.org/eft/10modules.html** Turn the microscope knob that appears on the computer screen to Section 7, Backyard Stewardship. Click "Watch Video" and view video. Ask students how they can become stewards within their own school and community.

Post-Site Activity
Explore Your National Parks

EFFECTS OF CLIMATE CHANGE
PHENOLOGY MONITORING

Grade Level: High School

Subject Area: Science

Activity time: 30 minutes

Setting: Indoors

Skills: Varying skills depending on activities selected

Vocabulary: Varying vocabulary depending on activities selected

Objective: To teach students about the various aspects of the National Park Service.

Materials: Internet access

Background:

The Great Smoky Mountains are world renowned for their diversity of plant and animal species. This great variety makes the park an exemplary outdoor laboratory for the study of relatively undisturbed native flora, fauna, physical environs, and processes of the Southern Appalachians. The park is the largest federally preserved and protected upland area east of the Mississippi River offering park visitors a refuge from the stresses of everyday life.

You and your students can learn more about this special place as well as participate in on-line activities to further your knowledge of the National Park Service and other federally protected lands.
Please check out the following web addresses:

Especially for Kids

To learn how to become a web ranger for the National Park Service, go to:
www.nps.gov/webrangers

To learn how to become a Junior Park Ranger at Great Smoky Mountains National Park or other parks, go to:
www.nps.gov/learn/juniorranger.htm

Especially for Teachers

For a comprehensive understanding of the background and development of the National Park Service, that is perfect for teachers and others those who need the maximum amount of accurate information in the minimum amount of time, go to: **http://www.ParkTraining.org**

The U.S. Department of Education is pleased to announce the newly remodeled and updated Federal Resources for Education Excellence (FREE) website. It now provides richer, more expansive resources to teachers and students alike. There are over 1,500 resources to take advantage of at FREE ranging from primary historical documents, lesson plans, science visualizations, math simulations and online challenges, paintings, photos, mapping tools, and more. This easily accessible information is provided by federal organizations and agencies such as the Library of Congress, National Archives, National Endowment for the Humanities (NEH), National Gallery of Art, National Park Service, Smithsonian, National Science Foundation (NSF), and National Aeronautics and Space Administration (NASA). Go to:
http://www.free.ed.gov/

Parent/Chaperone Letter

Greetings Parents/Chaperones:

Park rangers are pleased to be presenting an educational program to the students in Great Smoky Mountains National Park. In order to achieve the goals for a successful program, the park rangers will need your assistance in the following ways:

(These points will help to ensure that park rangers and teachers will be able effectively conduct the lessons and activities throughout the trip.)

- The program will be conducted outside and there will be some hiking throughout the trip. Prepare your student with appropriate footwear, long pants, layers, and rain gear.

- If your child is bringing a lunch from home, we recommend that students bring water to drink and a lunch with minimal packaging. Soft drinks are usually left unfinished by students, and remaining sugary drinks cannot be poured out on the ground. (Minimally packaged lunches lead to less trash being left behind or scattered by the wind. Additionally, this reduces the accumulated trash to be disposed.

If you are a chaperone attending the field trip:

-Please be an active part of the lessons. Keep up with the group and listen to the information being given in the case that you may be called upon to assist (handing out materials, sub-dividing groups etc.).

-Please do not hold conversations with other chaperones or use a cellular phone while the rangers are teaching the students.

-Refrain from smoking during the trip. If you must smoke, please alert a ranger or teacher and remove yourself from the group.

-Please be aware that the program will be conducted outside and that there will be some hiking throughout the trip. Prepare yourself with appropriate footwear, long pants, layers, and rain gear.

-We recommend that parents and students bring a small towel in their backpacks to sit on at lunch (there are no picnic tables at the program site).

Thank you for your needed assistance. We look forward to meeting you on the program!

Sincerely,

The Education Staff at Great Smoky Mountains National Park