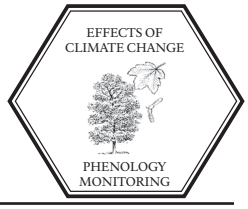
Phenology



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.

North Carolina Curriculum Correlations

North Carolina Earth and Environmental Science Essential Standards

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

EEn.2.5 Understand the structure of and processes within our atmosphere
- EEn.2.5.1 Summarize the structure and composition of our atmosphere.
- EEn.2.5.5 Explain how human activities affect air quality.

EEn.2.6 Analyze patterns of global climate change over time.
- EEn.2.6.1 Differentiate between weather and climate.
- EEn2.6.2 Explain changes in global climate due to natural processes.
- EEn.2.6.3 Analyze the impacts that human activities have on global climate change.
- EEn.2.6.4 Attribute changes to Earth's systems to global climate change.

EEn.2.7 Explain how the lithosphere, hydrosphere, and atmosphere individually and collectively affect the biosphere.
- EEn.2.7.1 Explain how abiotic and biotic factors interact to create the various biomes in North Carolina
- EEn.2.7.2 Explain why biodiversity is important to the biosphere.
- EEn.2.7.3 Explain how human activities impact the biosphere.

EEn.2.8 Evaluate human behaviors in terms of how likely they are to ensure the ability to live sustainably on Earth.
- EEn.2.8.4 Evaluate the concept of "reduce, reuse, recycle" in terms of impact on natural resources.

North Carolina Biology Essential Standards

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

Bio.2.2 Understand the impact of human activities on the environment (one generation affects the next).
- Bio.2.2.1 Infer how human activities may impact the environment.

Bio.2.2.2 Explain how the use, protection and conservation of natural resources by humans impact the environment from one generation to the next.

Bio.3.5 Analyze how classification systems are developed upon speciation.

Bio.3.5.2 Analyze the classification of organisms according to their evolutionary relationship.

AP Biology Goals and Objectives

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

1.01 The learner will identify questions and problems that can be answered through scientific investigations.

1.02 The learner will design and conduct scientific investigations to answer questions about the physical world.

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

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

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

6.02 The learner will survey the diversity of life.

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

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

7.01 The learner will analyze population dynamics.

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

7.03 The learner will assess current global issues.

AP Earth and Environmental Science (APES) Goals and Objectives

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

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

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

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

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

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

2.05 The learner will investigate the biosphere.

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

5.01 The learner will analyze the sources of major pollutants.

5.02 The learner will investigate the effects of pollutants.

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

6.03 The learner will investigate effects and consequences on biota:

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

7.04 The learner will develop an awareness of environmental options.

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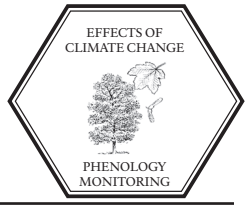

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Planning a Successful Trip

Schedule for a day of activities in Great Smoky Mountains National Park at Your Park Location (Purchase Knob, Mingus Mill, or Deep Creek)

- Meet park ranger at the designated location (see below)
- Use restrooms
- Large group introduction
- Break into two groups
- Participate in activities
- Lunch
- Switch groups
- Large group conclusion

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

• School buses can park at the program site.

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

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

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

At Purchase Knob

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

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

At Mingus Mill

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

• All students, teachers, and chaperones will meet the park rangers in the parking lot at Mingus Mill.

At Deep Creek

• A map to Deep Creek can be found on page 7

• All students, teachers, and chaperones will meet the park rangers at picnic shelter parking lot across from the Deep Creek campground.

Background Information

Park Description:

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

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

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

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

Purchase Knob Description:

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

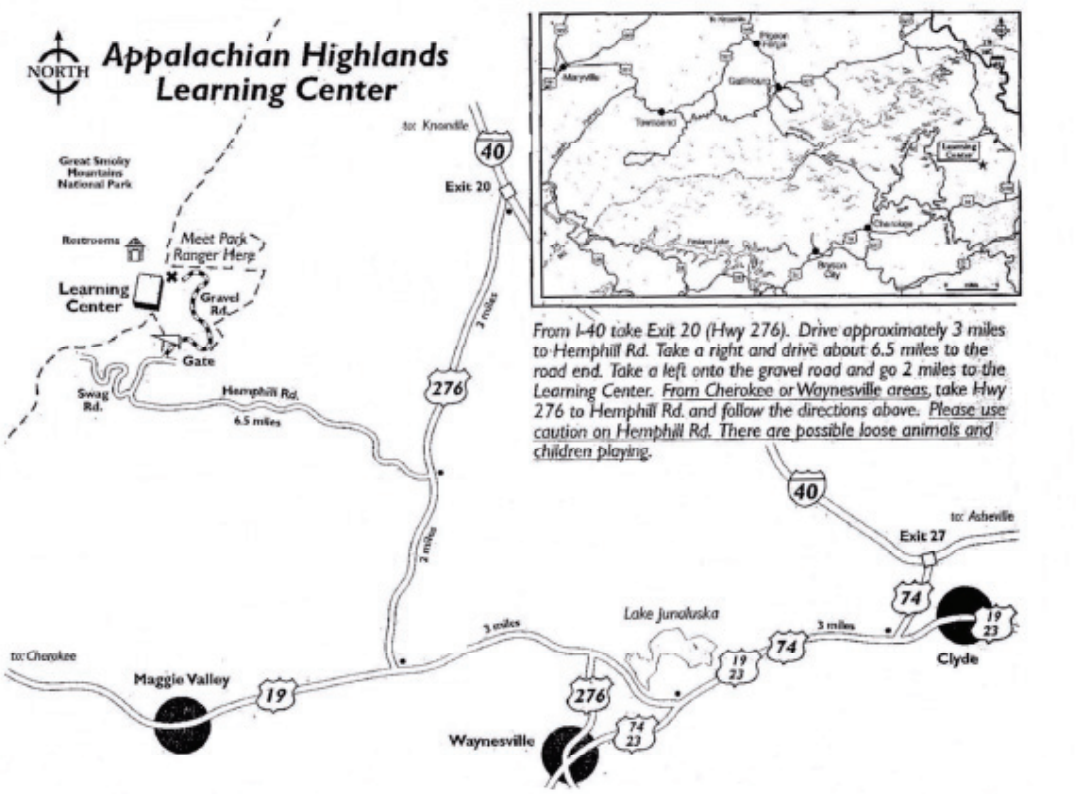
Mingus Mill Description:

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

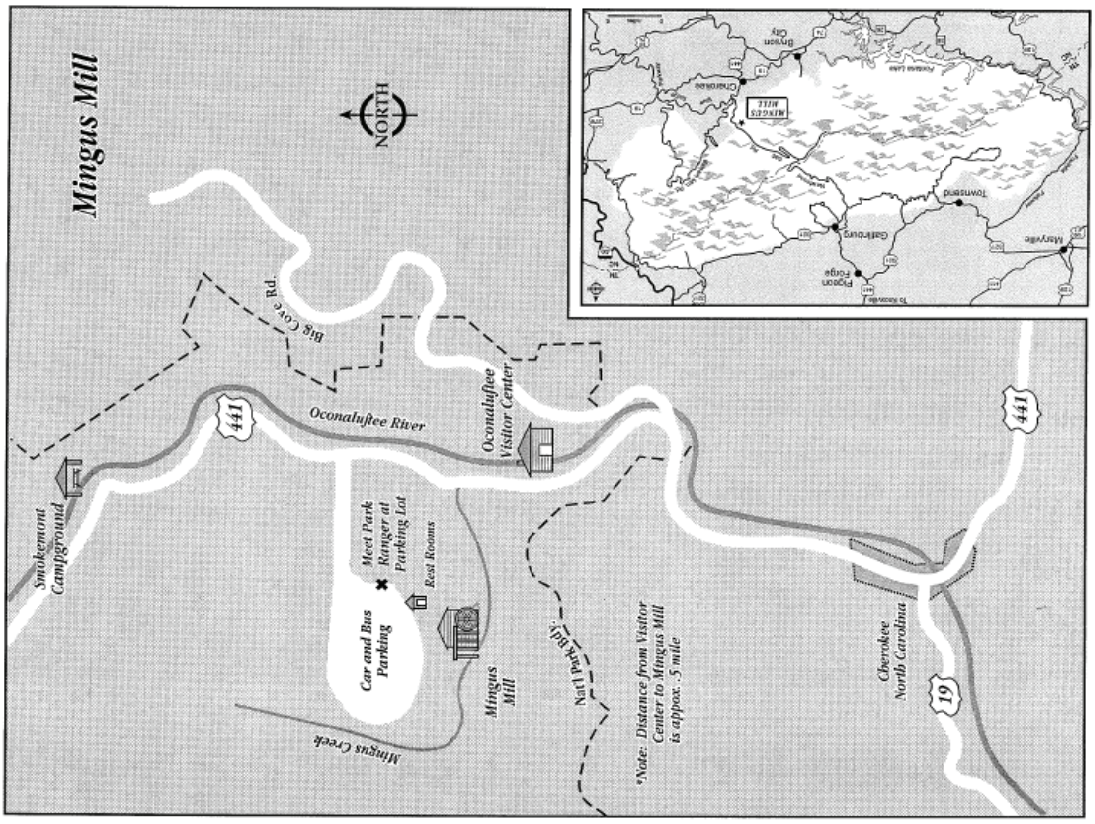
Deep Creek Description:

Deep Creek is located three miles outside of the town of Bryson City, NC . Situated at an elevation of 1,800 feet, the area contains cove hardwood forests. Deep Creek is appropriately named by the swift flowing stream that serves as a watershed for Clingmans Dome between the Noland and Thomas Divide. It is where "Kituhwa" was located, one of the first Cherokee town sites that botanist Williams Bartram visited in the early 1800s. Later it was settled by families who planted crops, fished and worked on the railroad and sawmills. The forests along the Deep Creek watershed remained largely old growth forest at the time of acquisition by the park in the late 1920s. Today, Deep Creek is popular with tubers, fisherman, campers and hikers.

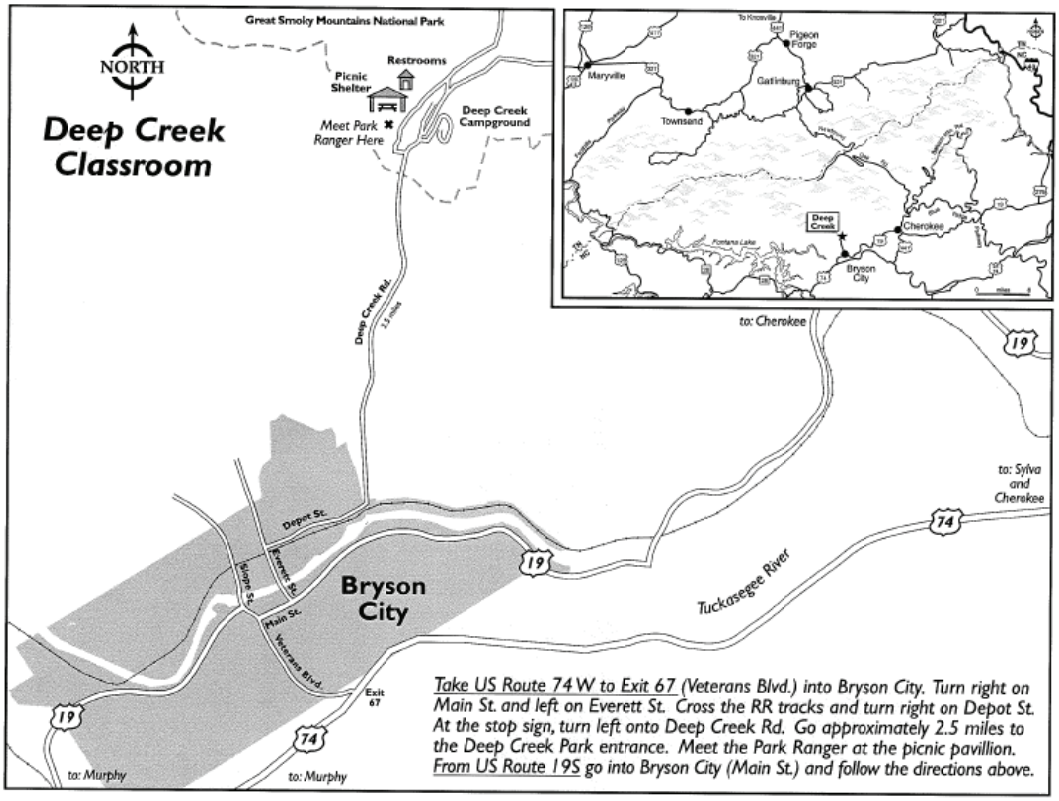
Map To Purchase Knob



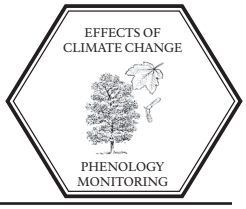
Map To Mingus Mill



Map To Deep Creek



Pre-Site Activity
Weather, Climate, and Phenology



Grade Level: 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: The average weather (usually taken over a 30-year time period) for a particular region and time period.

• Weather: The specific condition of the atmosphere at a particular place and time.

• Phenology: A branch of science dealing with the relations between climate and periodic biological phenomena (as bird migration or plant flowering)

Materials:

•Phenology worksheets (pages 9-15)

Objectives:

1) Describe the difference between climate and weather
2) Improve understanding of phenology
3) Graph data sets and interpret graphs

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 Weather Versus Climate and Phenology worksheets (pages 9-10). 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 11-15). Use the teacher answer key as a guide for questions (pages 16-17). 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?

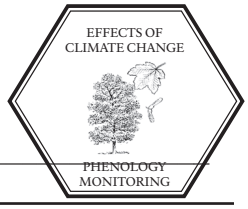
•Have students develop a Phenology Calendar focused on natural events in the schoolyard. Some annual events might include sounds of the first robin, first maple tree budding or showing color in the fall, first emergence of worms on the school grounds, etc.

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/

Climate versus Weather

Name _____



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)

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?

Exploring Weather Data

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

Y axis: _____

Title of Graph: _____

X axis: _____

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

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

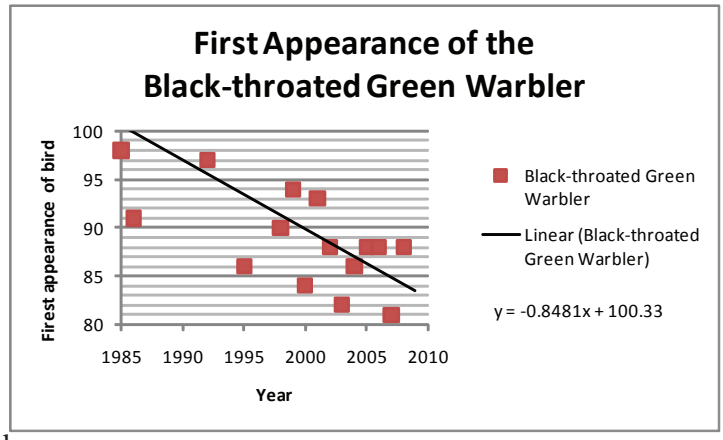
A line in a two dimensional or two-variable space is defined by the equation Y=m*X+b; in full text: the Y variable can be expressed in terms of a slope (m) times the X variable plus a y-intercept (b). To interpret the direction of the relationship between variables, look at the signs (plus or minus) 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 regresssion 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?

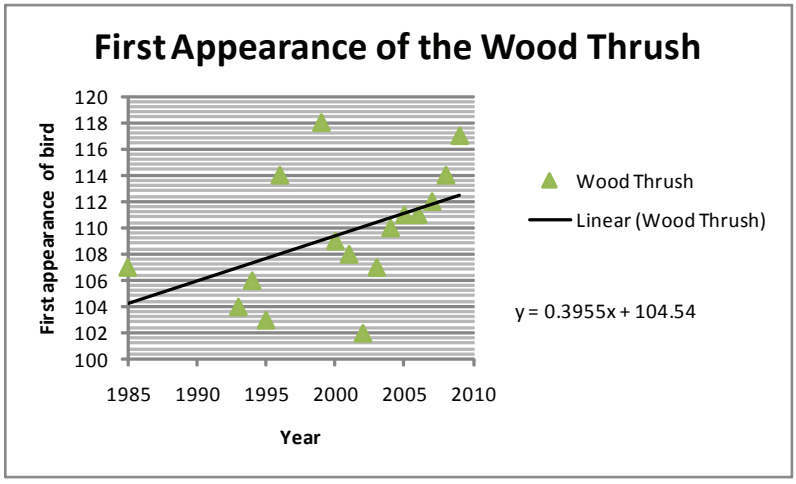
For the following plants and animals read the excerpt about the species and then analyze the graph to the right of the species' picture. Determine if the slope of the graph is positive or negative and describe what this graphed data might mean. The Y-axis is expressed in day number ([DDD] is the day 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.



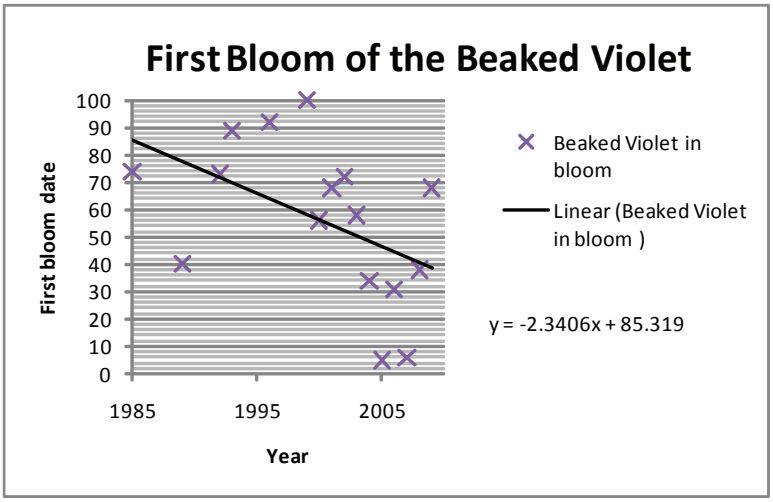
40. First appearance of the Black-throated Green Warbler
Is the slope positive or negative? _____
Describe what this graphed data might mean:

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:

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.



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

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

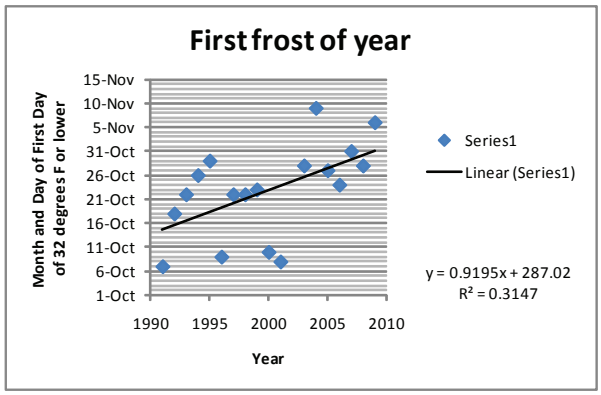
44. What further information would one need to link the analysis to the data and what other variables would one need to analyze if they were to look at the total picture and try to figure out why these trends might be occuring?

Teacher Answer Page

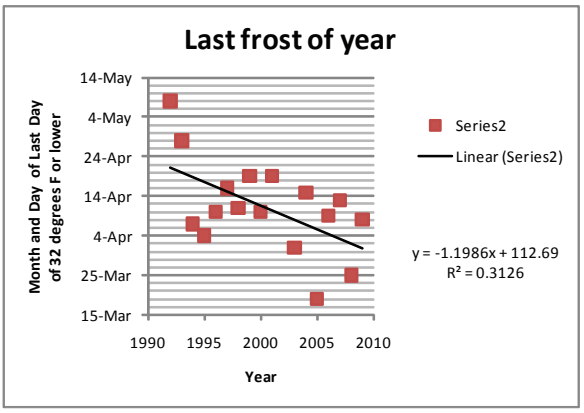
1. It snowed 5 inches last night. *Weather; recent weather event of snow*
2. Helps you decide what clothes to buy. *Climate; typical conditions during that time of year*
3. It has not rained this month yet. *Weather; no weather has produced rain this month*
4. Typically rainfall in June is under 1 inch. *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*_____

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*

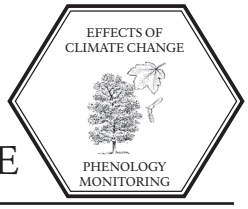
41. *Positive, bird appearing later; students description will vary*

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

43. 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.

44. 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: Computer room

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

Vocabulary:
•Carbon footprint: A measure of the greenhouse gases that are produced by activities of a person, a family, a school or a business that involve burning fossil fuels.

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

Objectives:
1) calculate your personal carbon footprint
2) create a measurable personal action plan to reduce your footprint
3) discuss ways to become a climate change leader in your household and community

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.

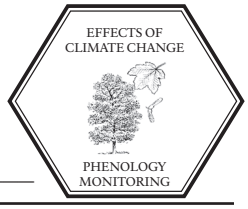
Procedure:
Have students bring the Personal Carbon Footprint (Homework) worksheet home to complete with their parent/guardian(s). The following day in class (computer room) have the students complete the Personal Carbon Footprint (Classwork) worksheet in class using the computers. After students have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

References:
•Carboon 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.

Personal Carbon Footprint Homework

Name _____



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.
_____%

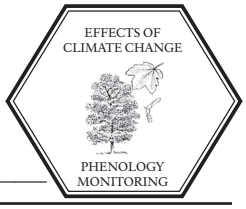
5. How many miles do you and your family travel per week for each mode of transportation?
Automobiles: _____x 52 = _____ miles per year
Bus: _____x52 = _____ miles per year
Rail: _____x52 = _____ miles per year
Air travel: _____x52=_____ miles per year

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

Personal Carbon Footprint Classwork

Name _____



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 = _____ %

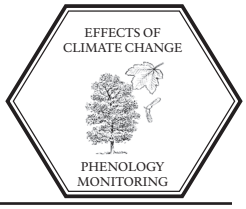
11. What are three specific steps to Reduce your Carbon Footprint?
    1.
    2.
    3.

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
Phenology and Carbon Sequestration Study



Grade Level: High School

Subject Area: Science

Activity time: 75 minutes

Setting: Outdoors in the park

Skills: Analyzing, Applying, Assessing, Calculating, Charting, Classifying, Collecting information, Comparing, Describing, Estimating, Gathering information, Hypothesizing, Identifying cause and effect, Interpreting, Recording data, Summarizing

Materials:

- Phenology laminated sheets w/ ID'd trees (1 to 2 trees/group)
- Measuring tapes (1/group)
- Binoculars (1/group)
- ½ data sheet (1/group)
- Calculator (1/group)
- Pre-recorded lbs CO2/trees
- Tree ID dichotomous keys

Objectives:

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

Background:

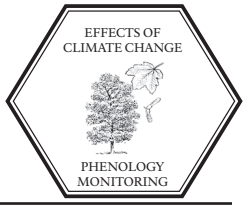
During this program, students will be monitoring the progression of phenology on deciduous trees in an established study plot. The goal is to document timing and duration of each life cycle event for the trees. Data collected today will be relevant in thirty to fifty years when we analyze whether yearly 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 one or two trees. 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



Grade Level: High School

Subject Area: Science

Activity time: 30 minutes

Setting: Computer Room

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

Materials:
•Computer(s) with internet connection
•"Climate Friendly Parks" worksheet (see page 23)

Objectives:
1) learn the science and impacts of how climate change is impacting national parks
2) learn how parks are developing specific strategies to address climate change
3) learn what the parks are doing to address the issue

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.

Climate Friendly Parks

Name _____

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.

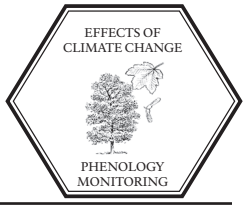
Go to the National Park Service's response to Climate Change at http://www.nature.nps.gov/ClimateChange/response.cfm

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



Grade Level: High School

Subject Area: Science

Activity time: 30 minutes

Setting: Computer Room

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

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

Objective:
1) Learn the impacts of how climate change is impacting different geographical regions of the United States.

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 of 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.

Geographical Impacts of Climate Change

Name _____

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.