South Carolina Aquarium

3-5 Sculpting South Carolina Activity

Overview

Focus Question
How do you think precipitation, elevation and the geology of an area affect what types of wildlife communities you might find there?

Activity Synopsis
Students will explore the six geographic regions of South Carolina while taking special notice of each region's elevation, average precipitation and overall basic geology. Students will create a model of South Carolina that delineates elevations and portrays differences in the basic geology of an area. After creating the model, students will research how the physical features of each region support the life of different types of organisms and thus different types of communities.

Time Frame
1-2 days

Objectives
The learner will be able to:
- Construct a three-dimensional map that illustrates the location and spatial distribution of South Carolina's physical features
- Delineate and describe the six major geographic regions of South Carolina on a map
- Interpret and describe how elevation, temperature, and precipitation help shape the different wildlife communities found in the different regions of the state

Student Key Terms
- abiotic
- biotic
- clay
- climate
- Coast
- Coastal Plain
- community
- ecosystem
- elevation
- Mountain
- Ocean
- Piedmont
- precipitation
- region
- Sandhills
- soil
- temperature

Teacher Key Terms

- igneous rock
- loam
- metamorphic rock
- sedimentary rock
- topography

Standards

South Carolina College- and Career-Ready Science Standards 2021

3-5 Sculpting South Carolina Activity

3rd Grade: 3-LS4-3, 3-ESS2-1, 3-ESS2-2
4th Grade: 4-LS1-2, 4-ESS1-1, **4-ESS2-2**
5th Grade: 5-LS1-1, 5-ESS2-1

*** Bold standards are the main standards addressed in this activity**

2014 Academic Standards and Performance Indicators for Science

3rd Grade: 3.S.1A.1, 3.S.1A.2, 3.S.1A.4, 3.S.1A.6, 3.S.1A.8, 3.E.4A.1, 3.E.4A.2, 3.E.4B.1, 3.E.4B.3, **3.L.5A.1**, 3.L.5B.1, 3.L.5B.2
4th Grade: 4.S.1A.1, 4.S.1A.2, 4.S.1A.4, 4.S.1A.6, 4.S.1A.8, 4.E.2A.1, 4.E.2A.2, **4.E.2B.1**, 4.E.2B.2, 4.E.2B.3
5th Grade: 5.S.1A.1, 5.S.1A.2, 5.S.1A.4, 5.S.1A.6, 5.S.1A.8, 5.E.3B.1, 5.L.4A.1, 5.L.4A.2, 5.L.4B.4

*** Bold standards are the main standards addressed in this activity**

South Carolina College- and Career-Ready Science Standards 2021

Third Grade Performance Expectations
3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can thrive, struggle to survive, or fail to survive.
3-ESS2-1 Represent data in tables and graphical displays of typical weather conditions during a particular season to identify patterns and make predictions.
3-ESS2-2 Obtain and combine information to describe climate patterns in different regions of the world.

Fourth Grade Performance Expectations
4-LS1-2 Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.
4-ESS1-1 Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.
4-ESS2-2 Analyze and interpret data from maps to describe patterns of Earth's features.

Fifth Grade Performance Expectations
5-LS1-1 Support an argument with evidence that plants obtain materials they need for growth mainly from air and water.
5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

2014 Academic Standards and Performance Indicators for Science

Third Grade Performance Indicators
3.S.1A.1 Ask questions that can be (1) answered using scientific investigations or (2) used to refine models, explanations, or designs.
3.S.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.
3.S.1A.4 Analyze and interpret data from observations, measurements, or investigations to understand patterns and meanings.
3.S.1A.6 Construct explanations of phenomena using (1) scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.
3.S.1A.8 Obtain and evaluate informational texts, observations, data collected, or discussions to (1) generate and answer questions, (2) understand phenomena, (3) develop models, or (4) support explanations, claims, or designs. Communicate observations and explanations using the conventions and expectations of oral and written language.
3.E.4A.1 Analyze and interpret data from observations and measurements to describe and compare different Earth materials (including rocks, minerals, and soil) and classify each type of material based on its distinct physical properties.

3.E.4A.2 Develop and use models to describe and classify the pattern distribution of land and water features on Earth.
3.E.4B.1 Develop and use models to describe the characteristics of Earth's continental landforms and classify landforms as volcanoes, mountains, valleys, canyons, plains, and islands.
3.E.4B.3 Obtain and communicate information to explain how natural events (such as fires, landslides, earthquakes, volcanic eruptions, or floods) and human activities (such as farming, mining, or building) impact the environment.
3.L.5A.1 Analyze and interpret data about the characteristics of environments (including salt and fresh water, deserts, grasslands, forests, rain forests, and polar lands) to describe how the environment supports a variety of organisms.
3.L.5B.1 Obtain and communicate information to explain how changes in habitats (such as those that occur naturally or those caused by organisms) can be beneficial or harmful to the organisms that live there.
3.L.5B.2 Develop and use models to explain how changes in a habitat cause plants and animals to respond in different ways (such as hibernating, migrating, responding to light, death, or extinction).

Fourth Grade Performance Indicators
4.S.1A.1 Ask questions that can be (1) answered using scientific investigations or (2) used to refine models, explanations, or designs.
4.S.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.
4.S.1A.4 Analyze and interpret data from observations, measurements, or investigations to understand patterns and meanings.
4.S.1A.6 Construct explanations of phenomena using (1) scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.
4.S.1A.8 Obtain and evaluate informational texts, observations, data collected, or discussions to (1) generate and answer questions, (2) understand phenomena, (3) develop models, or (4) support explanations, claims, or designs. Communicate observations and explanations using the conventions and expectations of oral and written language.
4.E.2A.1 Obtain and communicate information about some of the gases in the atmosphere (including oxygen, nitrogen, and water vapor) to develop models that exemplify the composition of Earth's atmosphere where weather takes place.
4.E.2A.2 Develop and use models to explain how water changes as it moves between the atmosphere and Earth's surface during each phase of the water cycle (including evaporation, condensation, precipitation, and runoff).
4.E.2B.1 Analyze and interpret data from observations, measurements, and weather maps to describe patterns in local weather conditions (including temperature, precipitation, wind speed/direction, relative humidity, and cloud types) and predict changes in weather over time.
4.E.2B.2 Obtain and communicate information about severe weather phenomena (including thunderstorms, hurricanes, and tornadoes) to explain steps humans can take to reduce the impact of severe weather phenomena.
4.E.2B.3 Construct explanations about regional climate differences using data from the long term weather conditions of the region.

Fifth Grade Performance Indicators
5.S.1A.1 Ask questions that can be (1) answered using scientific investigations or (2) used to refine models, explanations, or designs.
5.S.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.
5.S.1A.4 Analyze and interpret data from observations, measurements, or investigations to understand patterns and meanings.
5.S.1A.6 Construct explanations of phenomena using (1) scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.
5.S.1A.8 Obtain and evaluate informational texts, observations, data collected, or discussions to (1) generate and answer questions, (2) understand phenomena, (3) develop models, or (4) support explanations, claims, or designs. Communicate observations and explanations using the conventions and expectations of oral and written language.
5.E.3B.1 Analyze and interpret data to describe and predict how natural processes (such as weathering, erosion, deposition, earthquakes, tsunamis, hurricanes, or storms) affect Earth's surface.
5.L.4A.1 Analyze and interpret data to summarize the abiotic factors (including quantity of light and water, range of temperature, salinity, and soil composition) of different terrestrial ecosystems and aquatic ecosystems.
5.L.4A.2 Obtain and communicate information to describe and compare the biotic factors (including individual organisms, populations, and communities) of different terrestrial and aquatic ecosystems.
5.L.4B.4 Construct scientific arguments to explain how limiting factors (including food, water, space, and shelter) or a newly introduced organism can affect an ecosystem.

Cross Curricular Standards

3-5 Sculpting South Carolina Activity

South Carolina College and Career Standards for Social Studies
3.1

South Carolina College and Career Standards for ELA
Inquiry (I) – 3-1.1, 3-2.1, 3-3.1, 3-3.2, 3-4.1, 3-4.2, 3-4.3, 3-5.1, 3-5.2, 3-5.3, 4-1.1, 4-2.1, 4-3.1, 4-3.2, 4-4.1, 4-4.2, 4-4.3, 4-5.1, 4-5.2, 4-5.3, 5-1.1, 5-2.1, 5-3.1, 5-3.2, 5-4.1, 5-4.2, 5-4.3, 5-5.1, 5-5.2, 5-5.3
Communication (C) – 3-1.1, 3-1.4, 4-1.1, 4-1.4, 5-1.1, 5-1.4

Common Core ELA Standards
Reading Informational – 3.1, 4.7, 5.7
Writing – 3.9, 4.7, 4.8, 5.8

Background

Key Points
Key Points will give you the main information you should know to teach the activity.

South Carolina is divided into five separate geographic land regions: the **Mountain**s, the **Piedmont**, the **Sandhills**, the **Coastal Plain** and the **Coast**. Each **region** has unique physical characteristics.

1. The Mountain region, part of the Blue Ridge Mountains, forms the northwestern corner of the state and is the southward continuation of the Appalachian Mountains. Underlain by **metamorphic rock**s and **igneous rock**s, the **topography** is rugged with sharp relief. **Elevation** ranges from 1,400 to 3,500 feet above sea level. **Soil**s tend to be high in organic content. High altitudes, relative to the rest of the state, cause cooler **temperature**s and considerable rainfall. Average annual rainfall in the Mountains ranges between 60 and 80 inches. Because of the sharp **elevation** differences, rainwater runoff forms waterfalls and fast-flowing streams. The average temperature in January is between 38 and 40 degrees Fahrenheit. The average temperature in July is between 71 and 74 degrees Fahrenheit.
2. The Piedmont region is found between the Mountains and the mid-line of the state near Columbia. Like the Mountains, it is also underlain by metamorphic and igneous rocks. Lower in elevation than the Blue Ridge, its topography is characterized by rolling hills and valleys with moderate slopes. Elevation ranges from 300 feet to 1400 feet and descends closer to the coast. Soils consist primarily of red and yellow **clay**s. The streams of the Mountains, as well as rainwater runoff on the impermeable clay of the Piedmont, join together to form large rivers in the Piedmont. Average annual rainfall ranges between 46 and 54 inches. The average temperature in January is between 40 and 44 degrees Fahrenheit. The average temperature in July is between 74 and 81 degrees Fahrenheit.
3. The **Sandhills** constitute a unique region formed by the remains of an ancient coastline. The Sandhills also mark an approximate boundary between the Piedmont and Coastal Plain. The topography consists of rolling hills with gentle slopes. The Sandhills range in elevation from 300 to 725 feet above sea level. Soil texture is mostly sandy with some areas of loam, and internal drainage is rapid and even excessive. Sandhills soils are generally low in plant nutrients, moisture and organic material because the soil texture allows rapid leaching. The area receives an average annual rainfall of about 45 inches. The average temperature in January is between 42 and 46 degrees Fahrenheit. The average temperature in July is between 79 and 81 degrees Fahrenheit.
4. The **Coastal Plain** may be divided into inner and outer subregions because of topographic differences. The Inner Coastal Plain is gently rolling, whereas the Outer Coastal Plain is flatter. Both are underlain by unconsolidated **sedimentary rock**s. Rivers meander through broad floodplains characterized by cut-off lakes and swamp vegetation. Elevation differences range from 300 feet at the border of the Sandhills to sea level at the border of the Coast. Soils consist of a mixture of sand, clay and organic materials. The area receives an average annual rainfall of about 46 to 52 inches. The average temperature in January is between 42 and 48 degrees Fahrenheit. The average temperature in July is between 79 and 81 degrees Fahrenheit.
5. The Coast is a dynamic merger of land and water and is characterized by wide beaches, barrier islands and marshes. Tides, currents and storms are constantly remolding its morphology, and it is a diverse region. The topography is flat and elevation ranges from sea level to a few feet above sea level. Soils consist of sand and organic material. The area receives an average

annual rainfall of about 48 to 50 inches. The average temperature in January is between 46 and 50 degrees Fahrenheit. The average temperature in July is between 80 and 81 degrees Fahrenheit.

Because of the unique physical characteristics of each region of South Carolina, each region also contains its own unique wildlife **community**.

1. The high elevation of the Mountains causes cooler temperatures and high rainfalls. These support forest vegetation, such as white pine and hemlock, not found in the rest of South Carolina and characteristic of more northerly latitudes. The high rainfalls support lush vegetation. Cooler temperatures lead to a predominance of warm-blooded mammals over cold-blooded reptiles in the community. The sharp relief forms fast-moving, shallow and chilly streams. Fish such as trout and darters, adapted to this type of aquatic habitat, thrive in these streams where other fish cannot.
2. The mild climate of the Piedmont leads to a variety of plant life in this region. Because it is warmer and more humid than the Mountains, hardwood and pine trees predominate. The rolling, forested hills provide habitat for a variety of mammals, reptiles and birds. The large rivers provide habitat for fish adapted to fast water, such as darters, as well as those adapted to slow-moving water such as sunfish. The construction of dams in these regions to create man-made reservoirs has resulted in habitats in which only fish adapted to slow-moving water can survive.
3. The Sandhills receive less rainfall than other regions of the state. This along with the sandy soils found in this region, which drain rainwater rapidly and cannot hold water well, leads to plants in the community that must be adapted to dry soils. The distinctive vegetation is dominated by long leaf pines and turkey oaks, which can survive in dry soils. Most animals in this region are not permanent residents, but migrate in from the moister Piedmont and Coastal Plain regions. Certain types of reptiles, though, such as the box turtle, are well-adapted to surviving in arid conditions and are lifelong residents.
4. The Coastal Plain is warm and humid and receives a good deal of rain. This leads to lush vegetation where pine trees and hardwood trees predominate. Because of the flat terrain, the Coastal Plain is the only region in which swamps can occur. Large areas of flat land provide places for standing water. Animals such as alligators and plants such as cypress trees that are adapted to this type of habitat thrive here.
5. Because of its proximity to the ocean, the animals and plants in the wildlife community of the Coast must be adapted to the effects of salt and saltwater. In areas that are immersed by the tides, only certain plants able to withstand being flooded by saltwater can survive, such as Spartina grass. Areas above the tides, such as the maritime forest of barrier islands, have to have plants that are resistant to salt spray picked up off the **ocean** by the wind. Many trees have waxy leaves to protect them from this, such as live oaks and wax myrtles. The coast is a place where three different environments (land, freshwater and saltwater) meet. Because of this, animals and plants from each of these environments may be found in the Coast at different times. Animals and plants that are adapted to the constantly changing conditions, such as periwinkles and Spartina grass, are permanent residents of the Coast.

Detailed Information

Detailed Information gives more in-depth background to increase your own knowledge, in case you want to expand upon the activity or you are asked detailed questions by students.

Communities are defined by the group of organisms that share an environment. The environment shared by the **community** can be as small as a rotten log or as large as a continent. Communities only contain **biotic** (living) things but they are heavily determined by the **abiotic** (nonliving) things around them. **Topography**, **climate**, **soil** types, water quality and many other factors can all determine what type of community develops in that environment.

South Carolina is divided into five separate geographic land regions, each with its own unique topography. These regions are the **Mountain**s, the **Piedmont**, the **Sandhills**, the **Coastal Plain** and the **Coast**. Though some animals can be found in all five regions, each **region** contains unique communities determined by the physical features of the region. For example, the American alligator, found throughout the Coastal Plain of South Carolina, is not found in the Mountain region. This animal is adapted for living in large pools of standing water, such as swamps and ponds. Because of the sharp relief in the Mountains, water in most places is always flowing and a swamp habitat cannot exist. Also, the climate is often too cool for the cold-blooded alligator. Conversely, the trout that are abundant in the cool, shallow, fast-moving streams of the Mountains are not able to survive in the warm, slow-moving, murky waters of the blackwater swamps of the Coastal Plain. Spartina grass, which dominates the saltmarsh because of its tolerance to saltwater, cannot compete in freshwater habitats with other plants and so is not found out of the brackish waters of the Coast habitat. In all these cases, the abiotic factors of the regions determine which organisms can live there and thus what communities develop there.

Below are excerpts from the excellent book South Carolina: The Making of a Landscape by Charles F. Kovacik and John J. Winberry. In these excerpts you can find just about everything you could possibly want to know about the abiotic factors found in each region of South Carolina as well as much about the biotic communities that develop there.

Kovacik, C. and J. Winberry. *South Carolina the Making of a Landscape*, pp. 13-48. University of South Carolina Press, (1987).

The natural environment is an entity in its own right and forms the framework within which humans have structured history, in this case the history of South Carolina. A common misconception is that the physical environment is a pristine setting formed exclusively by natural processes. In truth, virtually all parts of the world have been affected in some fashion by human occupation or transgression, and South Carolina is no exception. Probably 15,000 years ago, native North Americans first occupied a Piedmont formed by hundreds of millions of years of uplift and metamorphism and a Coastal Plain laid down beneath an ocean tens of millions of years ago. Their use of fire modified the vegetation; the later agricultural economies of the colonial and cotton-growing eras introduced new plants and contributed to severe erosion and the loss of topsoil. Modern-day construction of reservoirs, destruction of sand dunes and coastal marshes, and planting of pine trees continue this pattern of human-induced change. As we look at the natural setting, therefore, we must remember that it was created not only by natural processes but also by human actions.

South Carolina extends 225 mi (360 km) north to south and 285 mi (459 km) east to west. With a 31,113-sq-mi (80, 583-sq-km) area, it is the smallest of the Deep South states (the others are Virginia, North Carolina, Georgia, Alabama, Mississippi, and Louisiana) and ranks only fortieth in size among the 50 states of the Union. Its small area is deceptive because South Carolina extends literally from the mountains to the sea, and its physical geography varies considerably in form and origin. In this and the next chapter, we will focus on that diversity as we look at the state's landforms, climate, soils, and vegetation.

Landform Regions

The topography of South Carolina ranges from moderately high mountains to rolling hills to some of the flattest areas in the United States. In the first geography of the state, *A View of South Carolina,* written in 1802, John Drayton divided South Carolina into the "lower, middle, and upper country." As we noted already, these general terms are still used, but for our purposes we will organize the state into the five landform regions shown on Map 2.2: Blue Ridge, Piedmont, Sandhills, Coastal Plain (which can be divided into Inner and Outer Coast Plains) and Coastal Zone. This regionalization is based on a number of criteria, including relief, rock types, and geologic history.

<u>Blue Ridge Mountains</u>

South Carolina's Blue Ridge Mountains are a small portion of the Appalachian Mountain system. Situated in the extreme northern parts of Oconee, Pickens, and Greenville counties, these 600 sq mi (1,554 sq km) of rugged terrain constitute only about 2 percent of the state's surface area. With **elevation**s ranging from 1,400 to over 3,500 ft (427 to 1,067 m), the Blue Ridge provides the greatest relief and steepest slopes in the state. The highest peaks include Sassafras Mountain, at 3,554 ft (1,083 m) the highest point in the state, and Pinnacle Mountain, 3,425 ft (1,044 m), the highest mountain totally within the state. Even though elevations in South Carolina do not approach Mount Mitchell's 6,684 ft (2,037 m) in the Blue Ridge of North Carolina, the area is described accurately as rugged and truly mountainous. The best views of this region are along State Route 11 between I-26 and the Walhalla area, along U.S. Route 25 north from Route 11 toward Hendersonville, North Carolina, and along U.S. 276 between Cleveland and Caesars Head.

The rocks that form the Blue Ridge are predominantly crystalline schists and gneisses. These **metamorphic rock**s were formed hundreds of millions of years ago by the subjection of igneous and **sedimentary rock**s to the tremendous heat and pressure associated with mountain building. Most are very resistant to erosion, and this accounts for the steep slopes and narrow stream valleys that form the area's rugged topography.

South Carolina's **mountain**s certainly are not as impressive as those in Alaska and western North America, which soar to altitudes of 15,000 to 20,000 ft (4,572 to 6,096 m) with steep walls and angular peaks. Not only are they lower, but they appear more rounded in form and worn down. One reason for this is that the Rockies, Sierra Nevadas, and Cascades were uplifted only about 100 million years ago, whereas the Blue Ridge was formed more than 350 million years ago. As a result, the forces of erosion have been at work much longer in the Blue Ridge, and the effect is very evident. Another factor relates to **climate**. Moderate **temperature**s and greater **precipitation** in the eastern part of the country have hastened weathering and erosion that have tended to round off the mountains by a process called "creep," the gradual movement of material downhill.

Piedmont

The Piedmont (from a French word meaning "foot of the mountains") consists of a 100-mi-wide (161-km) belt between the Blue Ridge and the Sandhills. It covers some 10, 500 sq mi (27, 195 sq km) within South Carolina, one-third of the state's total area. Elevations range from about 300 ft (91 m) at the Sandhills margin to 1,200 ft (366 m) toward the northwest near the Blue Ridge, which is separated from the Piedmont by a northeast-southwest trending fault line called the Brevard Zone. The land surface varies from gently rolling in its southeastern part to extremely hilly toward the northwest.

The Piedmont and Blue Ridge have a complex geologic history. The basement rock of both regions is an estimated 1 billion to 1.3 billion years old. Current explanations for the formation of the Blue Ridge and Piedmont rely on concepts of continental drift and global tectonics, and these new theories have invalidated many of the traditional interpretations of mountain building. The rock types are primarily metamorphic, mainly schists, gneisses, and slates, with some granite **igneous rock**s where intrusive activity took place. Metamorphism, the tremendous heat and pressure that transformed sedimentary and igneous rocks into the crystalline schists and gneisses that characterize the Blue Ridge and Piedmont today, occurred a number of times as a result of major continental movements.

During the late Precambrian, some 600 million years ago, what is now the Piedmont existed as a continental fragment, an island off the coast of the proto-North American continent. But about 470 million years ago this island joined North America in a collision that began the formation of the Blue Ridge Mountains. Metamorphism recurred when the proto-North American continent, whose leading edge was the Piedmont, continued to drift eastward and collided with northwest Africa to form the massive ancient continent of Pangaea about 350 million years ago. The continents began to separate some 225 million years ago, and present-day North America began to take shape as the landmass drifted westward and northward to its present location.

Another process going on about the same time, which complicated matters, was intrusive activity. Magma, the molten material below the earth's crust, can move toward the surface of the earth in response to pressure and heat. In the South Carolina Piedmont, it did not reach the surface but instead moved between large and small cracks and joints in the existing stata and filled large cavity areas, where it eventually cooled to form isolated granitic plutons that are the foci of the state's granite quaries. These forces of metamorphism and intrusion soon settled down, and running water became the major agent of earth sculpture. Streams have flowed across the region for millions of years, removing material and cutting into the land to create the forms we see today.

Although both the Blue Ridge and Piedmont have a similar geologic history and are underlain by basically the same rock types, the two are differentiated by topography, elevation, and relief. The Blue Ridge is characteristically rugged with steep-sided, almost V-shaped stream valleys separated by narrow ridge tops. Streams are short and fast flowing, with clear water, many rapids and waterfalls and few tributaries.

The Piedmont, on the other hand, has a more rolling, hilly topography. Its river valleys, although quite steep walled in some cases, usually are sloped more gently and are much wider. Piedmont rivers are long, have many tributaries, and their waters are discolored by a heavy sediment load. The valleys are separated by broad upland areas, or interfluves, whose elevations do not vary significantly within local areas and whose relief is much less than that of the mountains. A typical Piedmont landscape may be seen along U.S. route 321 north from Columbia and along U.S. Route 21 north of Ridgeway. In addition, many road cuts reveal the process of soil formation.

One interesting feature found in the Piedmont landscape is the monadnock, or inselberg. Looking like a small isolated mountain that stands above the surrounding uplands, a monadnock is a residual feature that is formed because the rock of the monadnock is more resistant to erosion than the rock surrounding it; monadnocks frequently are of granite. Perhaps the most well known is Stone Mountain, Georgia, but the best examples in South Carolina are Paris Mountain and Glassy Mountain near Greenville, King's Mountain east of Blacksburg, and Table Rock Mountain north of Pickens. Most monadnocks in South Carolina occur within 20 mi (32 km) of the Blue Ridge and all are within 100 mi (161 km). Some were probably spurs or extensions of the main ridge that were separated from it by stream erosion; the common rock material and similar trend of structure support such an interpretation. Other monadnocks are of granitic rocks and sometimes quartzite that formed beneath the surface of the original landscape. As the overlying material eroded, these structures were exposed. Their more-resistant composition retarded erosion, and they became prominent as the surrounding land surface was worn down more rapidly. Commonly, erosion of these features is in the form of exfoliation, and slabs of granite are scattered on their lower slopes.

Sandhills

The Sandhills are a narrow, discontinuous northeast-southwest trending band of rolling hilly **topography** situated in portions of Aiken, Lexington, Richland, Kershaw, Sumter and Chesterfield counties. The rounded hills have gentle slopes and generally moderate relief, although in certain places the relief can be as great as 200 ft (61 m). These hills generally define the Midlands of South Carolina, and they constitute a distinctive landscape formed by sands and **clay**s deposited millions of years ago.

The Sandhills overlap what is called the Fall Line, which runs northeast-southwest through the Midlands and separates the Piedmont and Coastal Plain. Along the Fall Line the resistant crystalline rocks of the Piedmont about the more easily eroded **sedimentary rock**s of the Coastal Plain. This difference in resistance to erosion results in rock outcrops and many rapids that may extend more than a mile (1.6 km) along some river course. The exact position of the Fall Line is difficult to define because some rivers have cut through the sedimentary into the underlying crystalline rock, and rapids can shift locations during periods of high and low water. Many geographers, therefore, feel that the Fall Line is a misnomer and prefer Fall Zone as a more accurate term.

We usually associate sand with **ocean** beaches, but the Atlantic is over 100 mi (161 km) away from the Sandhills. Millions of years ago, however, this was not the case. As late as the Eocene, about 55 million years ago, the sea covered a large portion of eastern and southern South Carolina, and its shoreline corresponded to the present-day Sandhills. Marine sediments were laid down beneath the ocean to form the near-horizontal strata of sedimentary rocks that today constitute the Coastal Plain.

The weathering and erosion of the Piedmont and the Blue Ridge provided the clays and sand that were carried by rivers and deposited at their mouths. The ocean waves reworked these materials to form beaches and sand dunes along this ancient coastline, just as the oceans are forming shore-zone features along South Carolina’s present-day coast. The sea began retreating about 40 million years ago to approximately its present location. Examples of old dunal features may be seen along State Route 261 south of Wedgefield and north of Pinewood in the Manchester State Forest. In several areas the road cuts through the top of old beach ridges; along both sides of the road, these ridges appear in profile as a series of small hills.

Coastal Plain

The Coastal Plain is the largest landform region in South Carolina. It extends 120 to 150 mi (193 to 241 km) from the Sandhills to the Atlantic Ocean and covers nearly 20,000 sq mi (51, 800 sq km), about two-thirds of the state’s total area. Its topography varies from nearly flat and featureless to a rolling surface similar to the lower Piedmont. **Elevation**s range from sea level near the coast to about 300 ft (91 m) at the edge of the Sandhills.

The Coast Plain has a geologic history that is much less complicated than that of the Blue Ridge and Piedmont. The sedimentary rocks that underlie it are made up of muds, silts, sands, and other substances of marine origin. After deposition, these materials were consolidated by compaction and cementation to form shales, sandstones, conglomerates, and coquinas. Over the tens of millions of years during which Coastal Plain sedimentary rocks were laid down, they formed a series of horizontal layers. Because the underlying crystalline basement structure slopes at a steep angle toward the coast, the sedimentary layer is only a few feet thick at the Fall Zone, but attains a thickness of about 3,500 ft (1,067 m) at the coastline. The oldest surface rocks in the Coastal Plain are found nearest to the Piedmont margin, and the youngest occur adjacent to the coast.

This landform region can be divided into the Inner Coastal Plain and the Outer Coastal Plain. The topography of the Inner Coastal Plain is rolling and hilly and is very difficult, in most cases, to differentiate from the topography of the Sandhills and the lower Piedmont. Elevations range from about 300 ft (91m) near the Sandhills to 220 ft (67 m) at the Citronelle Escarpment (Orangeburg Scarp). Some 20 to 30 million years ago, this terrace marked a temporary shoreline as the ocean gradually retreated to its position. Southeast of the escarpment lies the Outer Coastal Plain, whose topography is flatter and almost featureless. The land slopes almost imperceptibly towards sea level at the coast in a series of 10 broken terraces formed by marine and fluvial processes. Among the sediments that formed beneath this ancient ocean are the phosphate beds that extend through the Outer Coastal Plain. Formed by insoluble phosphate material and marine fossils, these deposits became the focus of the state’s phosphate industry after the War Between the States and continued to be mined into the early twentieth century.

3-5 Sculpting South Carolina Activity

Despite its relative flatness, the Outer Coastal Plain is not without features. The sea withdrew initially from the Sandhills and then from the Citronelle Escarpment, but during the 2-million-year Pleistocene Epoch sea level rose and fell in response to advances and retreats of the glaciers. The glaciers themselves did not reach into South Carolina, extending only about as far south as the Ohio River, but they did affect the state's physical geography. As they formed and grew, these continental sheets of ice locked up great quantities of water, and sea level fell as much as 450 ft (137 m) below what it is today, exposing South Carolina's continental shelf up to 50 mi (80 km) beyond the present-day coastline. When the glaciers melted, water was returned to the ocean, and sea level was even higher than it presently stands, reaching perhaps as far as 60 mi (97 km) inland of the modern coastline. This advance and retreat of the ocean across the Coastal Plain formed a number of temporary shorelines, which persist today as terraces.

Beside the terraces, various other coastal features were formed as the ocean moved inland and then stabilized with each retreat of the glaciers. But as the glaciers renewed their growth, the sea withdrew once more; and the former shorelines and their beach ridges, ocean terraces, and deltas were abandoned far inland. Some of these remnant features have diverted rivers and streams from a straight course to the sea. The abrupt northeastward turn of the Black River is due to old beach ridges, whereas the sharp southward bend in the Edisto River at Givhan's Ferry apparently results from its following an old distributary channel in an ancient delta formation.

Distinctive among landform features of the Coastal Plain province are the Carolina bays. Perhaps one-half million of these strangely regular features occur in the Coastal Plain from Maryland to Florida. Confusion exists as to the origin of their name, which does not refer, as is commonly thought, to the embayments of water that often form their centers but, in fact, derives from the bay trees that characterize the vegetation found on their edges. Oval or elliptically shaped depressions, Carolina bays are identified easily on a topographic map because of their distinctive shapes, but in the field they look like isolated swamps with standing water and buttressed trees. For a long time, bays were uncultivated and bypassed by settlement, but the rich organic **soil**s that underlie them have enticed farmers to drain and convert many of the bays to agriculture. They range in size from 4 or 5 acres (1.6 to 2 ha) to the thousands of acres that make up big Swamp in Manchester State Forest in Sumter County.

In addition to their common shape, the bays' axes regularly parallel each other; in South Carolina they all are oriented in a northwest-southeast direction. A sandy ridge may encircle a bay but commonly forms only the southeastern rim. These peculiar characteristics have led to considerable speculation about the bay's origin. Several theories focus on two major ideas: Either some single catastrophic event occurred that formed the bays, or the bays are the result of ongoing processes that are observable today. The most popular of the catastrophic theories is that the depressions actually are meteorite scars, left by a huge meteor that, just prior to striking the earth, broke apart into hundreds of thousands of pieces that dug depressions into the Coastal Plain surface. Pieces of a meteor hitting the earth from a northwesterly direction could explain the oblong shape and parallel arrangement of the bays. It is an interesting idea, but no meteor remains have been found near the bays, and measurement of the magnetism that normally is associated with such remains has given ambiguous results.

A second theory is based on studies of similarly shaped lakes in other parts of the world and on laboratory models. It argues that the peculiar shape of the bays results from prevailing winds that cause basins to form ovals whose axes are perpendicular to the wind direction. South Carolina's southwesterly winds would, therefore, form bays with northwest-southeast axes. The buildup of sand on the southeastern rim would result from the very strong northwesterly winds associated with infrequent but intense winter storms. Needless to say, a fully accepted explanation for the origin of Carolina bays has not yet come along.

Although seismic activity characterizes almost the entire state, the most sever episode occurred in the Coastal Plain-the famous Charleston earthquake of August 31, 1886, which probably ranked a 10 on the Mercalli 12-point scale of earthquake intensity. The epicenter of the Charleston quake lay between the city and Summerville, about 20 mi (32 km) to the northwest. The shocks lasted more than four days, caused damage estimated at about $23 million, and left 60 dead. Tremors were felt as far west as the Mississippi River. Many rural people who experienced the quake developed a folk calendar around its occurrence, referring to events as so many years before or after the "Shake."

Some 300 aftershocks were recorded during the 35 years after 1886, and mild earth tremors continue to characterize the Piedmont. Over the last decade, seismic activity again has occurred in the Coastal Plain. Studies have indicated the existence of a major South Carolina-Georgia seismic zone that runs northwest-southeast for more than 300 mi (483 km) across the entire state. Among the faults that form it is the northeast- southwest trending Woodstock Fault near Charleston. No other earthquake in the state has equaled the severity of the one at Charleston, and few seismologists predict a recurrence any time soon. Nevertheless, the history of the

Charleston episode has resulted in the classification of eastern South Carolina as a major earthquake risk area. Old Charleston houses bear scars of the experience. After the earthquake, long rods were inserted between the opposite walls of a house to brace them and were held in place by plates placed on the outside of the walls. The plates are visible on these houses today.

A feel for the Coastal Plain topography may be acquired along any highway toward or along the coast. A fine overview of the Outer Coastal Plan may be had from U.S. Route 378, east of Shaw Air Force Base, just outside Sumter. Here, from the Citronelle Escarpment, the broad, flat Outer Coastal Plain stretches off to the coast. The rock outcrops and rapids marking the Fall Zone are evident on the Broad and Saluda rivers Columbia. An excellent example of a Carolina bay is Woods Bay State Park, just north of Turbeville in Clarendon County. Other bays, both cleared and uncleared, are found in its vicinity.

<u>Coast</u>

South Carolina's coastline is about 185 mi (298 km) long. The Coastal Zone extends some 10 mi (16 km) into the interior to encompass about 1.2 million acres (486,000 ha) of land and water. South Carolina's coast may be seen as a transition from North Carolina's strand to Georgia's Sea Islands and can be divided into three zones. The first is the 60-mile-long (96 km) arcuate strand that extends, almost unbroken by tidal inlets, from the North Carolina boundary to the area of Winyah Bay. The relatively stable strand is built on a 100,000-year-old barrier sand formation and is paralleled by the Waccamaw River, which flows southward just inland from it. This section of South Carolina's coast is called the Grand Strand and today is the focus of the state's major recreational development that includes large hotels, motels, and resort condominiums. Despite the shoreline's stability, erosion does occur along its beaches and especially endangers the hotels that are built near the water's edge. A series of storms in the winter of 1982-1983 caused considerable erosion, and hundreds of sandbags were used to protect these structures. In the spring of 1986 Myrtle Beach began a beach nourishment program and trucked sand from inland relict dunes to replenish the resort's beaches.

The Santee delta forms the second subdivision of the Coastal Zone. It is about 20 mi (32 km) wide and is the largest deltaic complex on the east coast. It is a cuspate, or pointed, delta, but is has suffered severe erosion over the last 40 years, retreating almost 900 ft (274 m) at certain locations. This is largely because of the decreased sediment load in the Santee River that has resulted from the completion of Lakes Marion and Moultrie in 1942 and the diversion of the Santee's waters into the Cooper River and Charleston Harbor, as well as the creation of other reservoirs on the Piedmont tributaries of the Santee system. As a stream enters one of these lakes, the velocity of its flow drops sharply, and this reduces its ability to carry sediment. The reservoirs, therefore, accumulate much of the alluvial material that otherwise would have been deposited on the coast.

South of the Santee delta lies the Sea Island complex that extends for more than 100 mi (160 km) to the Savannah River and into Georgia. There is considerable diversity among these islands in size, origin, and development. Some, such as Kiawah, Fripp, and Hilton Head, have been developed commercially, whereas others, including Bull, Hunting, and Daufuskie, remain in a more pristine state. North of the Edisto River, extensive marsh areas separate the islands from the mainland, but toward the south the islands are separated from the mainland and from each other by embayments, such as Port Royal Sound and St. Helena Sound; numerous tidal inlets; and extensive interior waterways.

The Sea Island province comprises two types of islands: erosion remnant islands and active barrier islands. For example, St. Helena Island, off Beaufort, is inland from the **ocean** and is classified as an erosion remnant. This means that it was at once time part of the mainland. But as seal level declined during the glacial advances of the Pleistocene Epoch, streams began cutting down behind it to from river valleys. As the **ocean** returned at the end of the Ice Age, about 10,000 years, these river valleys were flooded, and St. Helena and similar areas became islands.

Hunting and Fripp are right on the ocean and are referred to as barrier or beach ridge islands. They are anchored by beach ridges and sand dune complexes, and, in contrast to the erosion remnant islands, they are dynamic and constantly changing. The origin of barrier islands has been much debated. The classic theory explains their formation from offshore sandbars built up by wave action, but a new theory based on emergence and submergence of the coast during the Pleistocene Epoch has been offered. As sea level declined during the glacial period and the ocean retreated from the coast, dunes were built along the new coastline, and the old dunes were left inland. But, as the ocean returned and inundated the former dune ridges, parts of them remained above water to become the cores of coastal islands. Wind and wave action built additional sand dunes on them, and the barrier islands developed.

These islands are still subject to active modification by marine processes. Waves and tidal action constantly alter their beaches; storms bring marked changes, and the prevailing currents slowly wash material away and transform their shapes.

3-5 Sculpting South Carolina Activity

Generally, the northern ends of the islands experience erosion, whereas deposition occurs on the southern ends. This erosion is a natural process that will continue to occur, but people seem unaware of this as they vigorously but ineffectively try to arrest the changes with jetties, groins, seawalls, and beach nourishment programs. A very limited success sometimes is realized, but it must be emphasized that the coast is naturally a dynamic area and that barrier islands are always subject to change.

The Barrier Islands Act, initiated by the federal government in 1983, removed undeveloped barrier islands from federal flood insurance programs and ended subsidies for the construction of roads and sewer systems on them. The act affected 13 locations in the Sea Islands of South Carolina (Waites Island complex, Litchfield Beach, Pawley's Inlet, Debidue Beach, Dewees Island, Morris Island complex, Bird Key complex, Captain Sam's Inlet, Edistor complex, Otter Island, Harbor Island, St. Phillips Island, and Daufuskie Island) and will make their development more difficult. Though opposed initially by some groups, this action is seen now as logical recognition of the peculiarities of barrier islands and their susceptibility to sudden and pronounced changes. The Sea Island landscape may be seen along various coast roads, especially U.S. Route 21 north and south of Beaufort and U.S. Route 278 approaching Hilton Head Island. A spectacular view of a barrier island may be had from atop the old lighthouse in the Hunting Island State Park.

Rivers and Streams

The rivers and streams of South Carolina have been and continue to be active forces in shaping the state's physical geography, but they also have influenced the formation of the cultural landscape. Native North Americans often located settlements near streams, and many of their trails paralleled the course of streams. Advancing colonial settlement penetrated the interior by following rivers, and waterways were major avenues of commerce prior to the completion of the railroads. Streams provided power and water supply needed for the initial growth of industry and were crucial to the early urban development. Today, rivers serve a variety of economic and recreational purposes.

South Carolina is drained by three major river systems, the Pee Dee, the Santee, and the Savannah, as well as a number of smaller streams. These generally follow the topographic slope of land from northwest to southeast across the state. The headwaters of the major rivers form on the slopes of the Blue Ridge in North Carolina, east of the Appalachian Divide. Smaller rivers and streams, such as the Combahee, Edisto, and Ashley, form at the edge of the Sandhills are situated entirely within the state. In contrast to the large river systems draining the Piedmont, whose waters are colored yellow and red by heavy loads of silt and clay, streams originating in the Coastal Plain are called "black-water rivers." They transport very little sediment, and their dark color comes from a high tannic-acid content resulting from the decomposition of swamp hardwoods and their leaves. A characteristic black-water river is the Black River that heads in Lee County and flows through Williamsburg and Georgetown counties.

We have already discussed the characteristics of streams in the Blue Ridge and Piedmont. Rivers in the Coastal Plain typically meander and form wide, flat floodplains. As a meander grows it develops an increasingly narrow neck of land that the river will cut through during periods of high water. This forms a new channel, and the old channel becomes a remnant lake known as a cut-off, or oxbow, lake. This process allows the widening of the floodplain as new channels form to cut more deeply into the adjacent bluffs. A good example of a meander and cut-off lake is Bates Old River, in the Congaree floodplain, which may be seen from the U.S. Highway 601 causeway, just south of Wateree Store.

Large rivers with considerable flow and carrying a quantity of sediment, such as the Santee, usually form deltas through the buildup of alluvial material at their mouths. On the other hand, smaller rivers carry little sediment and have less potential for delta formation; estuaries or deep embayments usually develop where they enter the ocean. Examples of these include Charleston Harbor, St. Helena Sound, and the Port Royal Sound, all of which form the mouths of black-water rivers.

Of South Carolina's three major river systems, the largest is the Santee. It and its tributaries in the Piedmont and Blue Ridge drain nearly 40 percent of the state's total area. The Great Pee Dee River winds 197 mi (317 km) from the North Carolina line to the Atlantic Ocean, and its system drains the eastern quarter of the state. The Savannah River drains about 15 percent of South Carolina's total area. The larger part of its basin is in Georgia; South Carolina's portion is about 260 mi (418 km) long but is only 15 to 60 mi (24 to 97 km) wide. A number of smaller rivers, including the Ashley, Edisto, and Combahee, form a fourth drainage basin south of the Santee system. Lying totally within South Carolina and originating at the edge of the Sandhills, these rivers together drain about 20 percent of the state's area.

Lakes and Waterways

The free-flowing rivers described by the early colonists have been modified considerably over the past century. Not only has erosion in the Piedmont-a result of constant cropping of the land-added great quantities of sediment to streams and caused flooding in the Outer Coastal Plain, but the construction of dams has created a number of large lakes. Impoundments of water are not recent innovations, and many of the hundreds of small millponds that dot the Piedmont date to the eighteenth and nineteenth centuries. Only within about the last 50 years, though, have dams and reservoirs been built that cover tens of thousands of acres. These reservoirs have been created on every major river in South Carolina except the Pee Dee. The major impounded water bodies in South Carolina were all constructed during the twentieth century and include Lakes Wateree (formed in 1919, Wiley (1925), Murray (1930), Greenwood (1940), Marion (1942), and Moultrie (1942) on the Santee and its tributaries; and Lakes Clarks Hill (1954), Hartwell (1963), Keowee (1971), Jocassee (1974), and Russell (1984) on the Savannah system.

These reservoirs were constructed primarily to produce hydroelectric power, but in one notable instance a successful project created a serious problem. In the 1930's construction began on the two earth-fill dams that formed the 155-sg-mi (401-sq-km) Lake Marion on the Santee River and the 95-sq-mi (246-sq-km) Lake Moultrie on the Cooper River. A 7.5-mi-long (12-km) diversion canal connected the lakes and effectively directed much of the Santee River's waters through Lake Moultrie into the Cooper River. As a result, the flow in the Cooper River was increased from about 100 to over 15,000 cu ft per sec (from 3 to 425 cu m/sec). This allowed electric power generation for the Outer Coastal Plain, but Charleston Harbor, important for shipping and as major naval base began to experience silting and shoaling, and the alluvium had to be removed expensive dredging.

The Corps of Engineers determined that this resulted almost exclusively from the increased flow of fresh water into the harbor. The fresh water did not mix well with the salt water and gave rise to upstream density currents that blocked the movement of sediments out of the harbor and caused shoaling. To remedy this situation, the Corps projected a rediversion of the flow from the Cooper River back into the Santee. This was accomplished by at 12-mi-long (19-km) rediversion canal from Lake Moultrie, completed in 1985, that is supposed to return about 80 percent of the presently diverted flow back into the Santee. Experiences such as this make us acutely aware of the interrelatedness of our environment, and we now realize that one action may affect a number of unintended and unwelcome results. In an attempt to anticipate such new problems, the National **Ecosystem**s Team of the U.S. Fish and Wildlife Service is now studying the potential impact of this rediversion project on the Santee delta and the adjoining Coastal Zone.

The waterways of South Carolina offer one of the best examples of human modification of natural systems. Vegetation and erosion are subtle indicators of this impact, but the numerous vast lakes are highly visible. As we consider the physical setting, we must realize that human activity remains one of its most important shapers.

Climate, Soils, and Vegetation

Another component of the physical setting is the climate, the regional classification of atmospheric conditions. Climate and weather are often confused, but they are different in terms of their time perspective. Weather focuses on atmospheric conditions over a day or a few days and is based on immediate observations. Climate, on the other hand, deals with the annual cycle of atmospheric conditions derived from analysis of observations over a long period of time, usually 30 years. Climate and its elements-temperature and precipitation-in turn have a major effect on two other components of the physical setting: soils and vegetation.

<u>Climate</u>

Climatically, South Carolina is classified as humid subtropical, typical of many areas situated on the mid-altitude eastern margins of large continents. An abundant precipitation is distributed fairly evenly throughout the year, and temperatures show some seasonal variation. Summers are hot and humid; winters, though usually having some below-freezing temperatures, generally are mild. Within this general framework, South Carolina's climate does vary from one part of the state to another. The average annual precipitation in South Carolina is about 49 in. (124 cm), but it varies from 81 in. (206 cm) recorded in the mountains at Caesars Head to between 45 and 46 in. (114 to 117 cm) in portions of the Sandhills and Inner Coastal Plain. Average annual temperatures generally decrease from the southernmost Outer Coastal Plain to the Blue Ridge region.

<u>Precipitation</u>

South Carolina receives almost all of its precipitation as rainfall, but snow, sleet, and hail do make a small contribution from one year to the next. Although the state records precipitation in every month, the amount fluctuates from season to season as a result of two separate processes: convectional and frontal. Convectional precipitation occurs primarily during the summer months and is characterized by often violent, late afternoon and early evening thunderstorms. The rainfall is brief but heavy and commonly is accompanied by locally high winds, thunder, and lightning.

The convectional rainfall process develops through as a succession of stages. To begin with, the warm, moist air of a tropical mass dominates South Carolina's atmosphere during the summer. At the same time, the land surface receives intense solar radiation. As the summer day wears on, the temperature of the earth's surface rises, and it begins to warm the layers of air just above it. This causes convection currents in the lower atmosphere, and as these updrafts continue and intensify, the moisture-laden air is lifted to an elevation at which it cools to the point of condensation. Cumulus clouds then develop, and continued convectional uplifts and further cooling create the familiar threatening thunderhead clouds. The sky grows dark and precipitation soon follows. Summer weather forecasts usually include a chance of showers because the conditions necessary for the development of these convectional systems, their intensity, and geographical location make them difficult to predict.

A very different precipitation process occurs during the winter. Called frontal precipitation, it is related to the movement of warm and cold air masses. In contrast to the summer thunderstorm, frontal precipitation can include snow or sleet but usually is a drizzle or a steady rain that may last for hours. It normally involves no thunder or lightning and, in the case of cold fronts, is associated with a sharp drop in temperature. This type of precipitation may be related to either warm or cold fronts. Typically, however, frontal precipitation occurs when a mass of cold air overtakes a warm air mass. Being denser, the cold air wedges itself beneath the warm air. As the warm air is forced to rise, it cools, and rainfall or snowfall results. Because fronts move at different speeds and air masses vary in intensity, it is difficult to generalize about the time necessary for this sequence of events to unfold. Normally, it involved a day or more. The typical scenario for a cold front starts with the presence of warmer, moist air, cloudy or partly cloudy skies, and generally southerly winds. When the front approaches, the sky becomes grayer as clouds build up and precipitation begins. As the hours of rain continue, **temperature**s drop sharply. Once the cold air mass following the front establishes itself, the sky clears, cold **temperature**s prevail, and northerly winds dominate.

Seasonal Climatic Differences

These different precipitation processes are but one indicator of South Carolina's annual cycle of climatic variation. Although the state is not characterized by extreme wet and dry periods or wide ranges in temperatures, it does experience a notable seasonality.

South Carolina can be affected by warm, moist air from the Gulf of Mexico, but winter normally is typified by the presence of cold, dry continental air masses. December, January, and February, therefore, are the coldest months of the year. Two to five very cold outbreaks of polar air occur each year, and they substantially lower temperatures for several years. The full thrust of most cold fronts is weakened or deflected by the Blue Ridge Mountains, and southerly winds often bring in warmer maritime air from the Caribbean and South Atlantic. Mild winter days are not common and occasionally can be truly hot. Columbia, for instance, recorded 84° F (29° C) in January 1970 and again in February 1973. Coastal temperatures are moderated by the Atlantic Ocean and especially the warm Gulf Stream, whereas the higher elevations of the upper Piedmont and Blue Ridge experience significantly colder temperatures.
Snowfall is rare in the Outer Coastal Plain, occurs at least once in 9 of 11 winters in Columbia, and is more common in the upper Piedmont and Blue Ridge. February is statistically the snow month, and the state's record snowfall occurred in February 1973. This once-in-a-century phenomenon paralyzed South Carolina, but even light snowfalls cause snarled traffic, closed schools and offices, and a general holiday spirit. The true scourge of winter, however, is the ice storm, which causes serious traffic hazards, fallen trees, power outages, and often severe discomfort to many South Carolinians.

March, April and May represent a transition from winter temperatures and precipitation to those of summer. The frequency of cold fronts declines during the spring as continental air masses are replaced by warmer maritime air, and more convectional precipitation occurs. Despite a general warming, temperatures can vary considerably from year to year. Columbia recorded 90° F (32° C) in March 1974 and 18° F (-8° C) in March 1975. Spring marks the beginning of the growing season, or frost-free period, which is the number of days between the last killing frost of spring and the first killing frost of fall. The average length of the growing season varies from just over 290 days, immediately adjacent to the coast in the Sea Islands near Beaufort and Charleston, to less than 200 days in the Blue Ridge near Pickens and Walhalla. The average last spring frost occurs about February 19 in the Sea Islands and along the coast, during the last week of March near Columbia, and in last April in the mountains. This two-month difference between the average last spring frost on the coast and in the mountains is related to the moderating effect of the Atlantic Ocean and Gulf Stream on the immediate coastal area as well as to the higher elevations of the upper Piedmont and Blue Ridge.

3-5 Sculpting South Carolina Activity

Tornadoes form during all seasons of the year and at all hours of the day, but about one-third of the annual total is recorded in April and May. Conditions favorable to the formation of tornadoes occur when the atmosphere consists of sharp temperature contrasts between layers of air. These can develop rapidly when a mass of cold air approaches during the late afternoon. At that time, surface heating from solar radiation is at its peak and the lower layers of air at their warmest. This causes an intense low pressure to develop, and violent winds, blowing in a counterclockwise direction, are drawn into it. Tornadoes can be very destructive and are always dangerous. A series of tornadoes that followed two separate paths, one across the upper Piedmont from Anderson to York counties and the other through the Midlands from Aiken to Florence counties, left 77 people dead and 800 injured on April 30, 1924. Another serious incident involved 8 or 9 separate tornadoes that touched down in McCormick, Abbeville, Newberry, Fairfield, and Marlboro counties in the early evening of March 28, 1984.

Twenty-one people died and 448 were injured, and property damage was estimated in excess of $100 million. South Carolina averages about 10 tornadoes a year and has the highest tornado frequency of any South Atlantic coast state.

Summer's hot and humid weather prevails from June through August, and the heat is relatively unbroken. In contrast to winter patterns, temperatures are about the same across much of the state, although Blue Ridge locations are noticeably cooler because of higher elevations (Map 3.4). Strong solar heating causes daytime temperatures to rise, whereas nights tend to be humid and warm. The single most important factor influencing South Carolina's summer weather is the Bermuda High, and extremely large high-pressure cell centered over the Atlantic. The clockwise circulation around the Bermuda High causes a prevailing southerly flow of warm and humid maritime tropical air from the Gulf of Mexico and South Atlantic Ocean into the state during the summer months. Normally, this steady supply of moist air, coupled with strong solar heating of the land surface, provides ideal conditions for the convectional precipitation. Frequent thunderstorms during these three months account for 33 percent of the state's annual rainfall, making summer the wettest season of the year.

The Bermuda High, however, frequently stalls or becomes stationary off the coast and tends to block or divert frontal systems before the reach South Carolina. Because of this and the presence of the Blue Ridge Mountains, few cold fronts pass through the state during the summer, and there is little relief from the high temperatures and humidity. Furthermore, the stable subsiding air of the Bermuda High can become so intense that it prevents the convectional process necessary for cloud development and thunderstorm activity. When this occurs, host, sunny days prevail, drought threatens, and the stagnant air exacerbates atmospheric pollution problems. Sometimes these dry conditions last for weeks or even months. July is usually Columbia's wettest month with a mean of 5.65 in (14.35 cm) of precipitation, but in 1973 only 0.57 in. (1.45 cm) was recorded.

The sea breeze plays an important role on the coast during the summer months. During the day, the land absorbs solar radiation very rapidly, and convection currents begin to form. The ocean waters, however, maintain a more constant temperature than does the land surface. The warm air over the land rises, creating a zone of low pressure, and the relatively cooler and denser air above the ocean flows onshore to take its place. This results in a refreshingly cool breeze off the ocean during late summer afternoons and evenings. Also, during last summer afternoons while cumulonimbus clouds, large and fluffy but with a menacing dark underline, form inland, the sky above the ocean remains clear. Rain often will fall inland but usually does not occur on or near the coast, where convectional activity is suppressed by the cooler, more stable air coming onshore from the ocean as a result of the sea-breeze effect.

Between September and November, temperatures slowly become cooler, and the high summer humidity diminishes. Drier continental air masses become more frequent, and the continued presence of the Bermuda high also contributes atmospheric stability. As a result, South Carolina receives only about 20 percent of its annual **precipitation** in the fall; October and November are statistically the two driest months of the year. Nearly one-half of all fall days are warm and sunny with bright blue skies, whereas nights are cool to cold.

Fall also marks the end of the growing season. The first freeze comes earliest in the mountains and latest along the coast. On the average, it occurs in Walhalla toward the end of October, in Greenville in early November, and at Charleston during the first week in December. Because of the drainage of cold air along the river valleys from the upper Piedmont, the initial freeze occurs in Columbia as early as the first week of November. Cool to cold overnight temperatures result from the nocturnal cooling of the earth's surface. Because there is little cloud cover, the earth rapidly loses the heat it absorbed during the day, and surface temperatures drop quickly at night.

This rapid nocturnal cooling and the stagnant circulation associated with the Bermuda High frequently create temperature inversion that causes fog during the night and early morning. A temperature inversion occurs when the normal lapse rate-that is, the pattern of progressively cooler air temperatures with increasing altitude-is replaced by a situation in which cooler air is trapped beneath a layer of warmer air. Temperature inversions often occur on clear, still nights when heat reradiated from the earth's surface during the day had warmed the atmosphere. The cool surface at night chills the lower layers of the atmosphere, and as the air is cooled, its water vapor begins to condense and form fog. The fog typically "burns off" during the morning as solar radiation heats the earth's surface. When the lower layers of air are warmed, normal lapse rate conditions are reestablished.

Similar to such inversions, but lasting for days in some instances, are stagnant air conditions related to very stable high-pressure systems. These are associated during the late fall with cool air masses that settle over the state. The results are much like the situations during the summer and early fall when a stalled Bermuda High dominates the region. The high pressures, like the Bermuda High, tend to block advancing frontal systems and can also limit convectional activity. Skies are clear, and the weather is generally pleasant. The stable atmospheric conditions that cause this ideal weather also create a serious potential for air pollution. Stable air provides little opportunity for the dispersal of pollutants and traps them over their point of origin. The frequency of such atmospheric conditions in Piedmont South Carolina is among the highest of any region in the eastern part of the country and makes air pollution a potentially dangerous situation. Special concern must be given, therefore, to the types of industries that locate in the Midlands and Piedmont, and awareness of this potential pollution problem should be an integral part of any development plan.

A very dangerous climate phenomenon for coastal South Carolina is the hurricane. Hurricanes are most common in late summer or early fall and pose the greatest threat in September. A large tropical storm with surface winds of at least 74 mi per/hr (119 km per hr), a hurricane develops out of an "easterly wave," a line of low pressure that moves with the prevailing easterly winds flowing across the warm tropical waters of the Atlantic and Caribbean. As the storm forms out of one of these atmospheric disturbances, its winds converge in a spiraling counterclockwise fashion around a developing center of low pressure and reach speeds of up to 200 mi per hr (322 km per hr). These high winds and great quantities of rainfall can range up to about 400 mi (644 km) in diameter, but at the center of this intense low pressure is the "eye," an area of relative calm between 10 and 15 mi (16 o 24 km) in diameter.
Part of the damage along the coast is caused by high winds, but most death and destruction result from the storm surge, which raises tides 8 to 15 ft (2 to 5 m) above normal levels and carries them towards shore at speeds of 50 to 50 mi per hr (80 to 97 km per hr). Tornadoes sometimes develop out of this system, and torrential rains always accompany it. The high wind speeds diminish rapidly as the storm moves inland, but heavy rainfall continues. The greatest amount of precipitation recorded in a 24-hour period in South Carolina was associated with the passage of a hurricane.

<u>Soils</u>
Soils are perhaps the most complex but least appreciated aspect of the physical setting. South Carolina has **soil**s representing 5 of the 10 soil classification orders-Ultisols, Alfisols, Entisols, Inceptisols, and Spodosols-although the state is covered primarily by Ultisols, or what formerly were called the red-yellow Podzols. These **soil**s are typical of forested, humid, subtropical areas and generally are below average in fertility and suitability for row crop agriculture. Although most Ultisols are now under forest in South Carolina and across the South, almost all of them were cultivated at one time. Even today, crops are grown successfully on the Ultisols of South Carolina's Inner Coastal Plain. The soil is characterized by leaching, which is the solution of plant nutrients and other minerals by rainwater and their removal from the top layers of the soil by downward percolation. The remnant insoluble iron and aluminum as well as clays are thus concentrated in the upper zones of the soil, and their oxidation gives the soils a characteristic red or red-yellow color.

<u>Soil Characteristics</u>
Only within the last few decades have **soil**s received proper attention after more than a century and a half of poor management and exploitative land use. Continuous row crop agriculture removed their nutrients and resulted in severe erosion during the nineteenth and early twentieth century's. By the 1930s the Piedmont in South Carolina was one of the most severely eroded areas in the United States, so scarred and gullied that much of the land had become unsuitable for cultivation. It is estimated that from the beginning of the "King Cotton Era" in the 1800s through the 1930's much of the South Carolina Piedmont lost almost 10 in (25 cm) of topsoil and in some large areas more than 12 in (30 cm).

Texture is one of the most important characteristics of soils. It determines the rate at which water drains through particular soil and the amount of water that it can hold for use by plants during dry periods. Texture is dependent on the sizes of particles that make up the soil's mineral matter. Normally, these range from sands-the largest particles-through silts to **clay**s, which are finest particles.

Sands allow water to drain through quickly and provide little moisture storage, whereas clays, with minimal space between particles, permit little water to drain through and exhibit maximum retention. Between these extremes are various combinations such as sandy clays, silty clays, and **loam**s. Loams provide ideal textures for cultivation and are made up of 20 percent or less clay, 30 to 50 percent silt, and the remainder sand. They are easily cultivated and are characteristically neither too dry nor too wet for plant growth.

Regional Soil Types

The Blue Ridge Mountains in South Carolina are characterized by a narrow band of Inceptisols, which are young, poorly developed soils that lack levels of clay accumulation beneath the surface. They are moderately deep soils and usually are loamy in texture. Their suitability for row crops ranges from mostly poor to fair, and they are used largely for pasture or forest. The small amount of agriculture practiced in this area is confined to ridge tops or narrow stream floodplains, referred to as "bottoms," where slopes are not so steep.

Piedmont soils are dominantly Ultisols, but there are scattered occurrences of Alfisols, especially in Fairfield, Chester, and Greenwood counties. The Alfisols also have clayey subsoils but are brownish to reddish in color and normally have higher concentrations of calcium, magnesium, potassium, and other minerals. The topography of the Piedmont provides for good surface drainage, but internal soil drainage is relatively poor because the Ultisols and Alfisols are compact and clayey in texture. As a result, rainfall does not readily percolate through the soil, and runoff potential is considerable, creating a high risk of erosion. Overall suitability for row crops is ranked fair to poor. The Alfisols are considered adequate for field crops in some areas, such as broad, relatively flat interfluves of northern Fairfield, Chester, and Newberry counties. Most of the Piedmont, however, is devoted to pasture of forest.

The soils of the Sandhills are classified as Entisols, and their sandy parent material extends down to depths of 80 in. (203 cm). The rolling uplands of the Sandhills allow good surface drainage; and, as soil texture is mostly sandy with some areas of loam, internal drainage is rapid and even excessive. Sandhills soils are generally low in plant nutrients and organic material because the soil texture allows rapid leaching. Agriculture in the region never has been especially prosperous, and most of the soils have little potential for row crops. Although traditionally used for woodland, Sandhills soils, with proper management, can support the successful cultivation of vegetable crops and peaches.

Ultisols also characterize the Inner Coast Plain, but here their texture tends to be loamy with good surface and internal drainage. Well over half the Inner Coastal Plain is forested, but the good physical qualities of its soils contribute to its being the state’s major agricultural zone. The Ultisols in the Outer Coastal Plain, however, suffer from poor surface drainage, and the high water table has resulted in the formation of a gley horizon beneath the surface. This heavy, claylike layer causes poor internal drainage because it hampers percolation. Although these soils have good agricultural potential, their wetness discourages such use. They are excellent for forest, and slash pines are planted through much of the Outer Coastal Plain.

A band of Entisols extends across Colleton and into Hampton County. Remnant of the advance and retreat of the ocean during the Pleistocene Epoch, the parent material of these soils comprises sandy and loamy Coastal Plain sediments. Forests occupy a good portion of the area, but truck crops and especially watermelons are grown successfully in Hampton County.

In the Coastal Zone, a strip of land, as narrow as 3 mi (5 km) in the Myrtle Beach area and gradually widening to more than 25 mi (40 km) near Beaufort, consists of **soil**s developed on former tidal marshes, beach ridges, and dunes. These include Entisols along the coast and a band of Alfisols just inland. North of Charleston, poor drainage generally leaves the area unsuitable for row crops, and forests have been planted widely. South of Charleston, though, certain areas have loamy, better-drained **soil**s. Good management practices, including artificial drainage systems, have allowed profitable truck farming to develop.

The major rivers flowing across the Coastal Plain are bordered by wide floodplains that have agricultural potential. Classified generally as Inceptisols, these soils are rich in alluvial material. They are usually loamy but also can be clayey, depending upon the nature of the riverine sediments. In either case, they are high in plant nutrients and organic matter, but both surface drainage and internal drainage is good or the land has been drained artificially, the soils are suitable for row crops ad may be very productive. Such areas in the Outer Coastal Plain and in the Coastal Zone were the focus of the prosperous Carolina rice industry during the colonial and antebellum eras. In most cases, however, extensive floodplain forests, like the Congaree Swamp, predominate.

3-5 Sculpting South Carolina Activity

Vegetation

South Carolina's humid subtropical climate causes the state's vegetation to be lush. Forests cover some 65 percent of South Carolina, and trees largely define the vegetation complexes that dominate much of the state.

Mountains

The Blue Ridge Mountains are characterized by a predominantly hardwood forest that extends southward from New England. The vegetation has distinctly northern attributes because of the higher elevations. Many species became established in South Carolina during the Pleistocene Epoch, when the region experienced much colder temperatures. Today, the Appalachian forest is restricted to the northwestern corner of the state, although it does extend beyond the mountains to form a transition to the oak-hickory-pine forests of the Piedmont.

The vegetation of the Blue Ridge was classified originally as an oak-chestnut forest, and species of these trees dominated the native stands. But in the early twentieth century a fungus called the oriental Chestnut Blight reached the United States and ravaged the American chestnut trees *(Castanea dentate*) in the eastern part of the country. Today, dead trunks and rotting stumps are all that are left of these once mighty trees. As the chestnut tree disappeared from the **mountain**s, oaks, especially the chestnut oak (*Quercus prinus*), and the tulip popular (*Liriodendron tulipifera*) competed to replace it on the topmost canopy of the forests.

Other trees with northern associations include the hemlock (*Tsuga canadensis*), white pine (*Pinus strobes*), beech (*Fagus grandifolia*), and yellow birch (*Betula alleghaniensis).* Shrubs like the flame azalea (Rhododendron calendulaceum), pink azalea (R. nidiflorum), and rhododendron (R. maximum) constitute the understory and give the mountains a yellow, pink, and white brilliance in late spring and summer (Fig 3.4). Near the streams, the vegetation complex is adapted to a wetter habitat and includes such trees as the alder (*Alnus serrulata*), cottonwood (*Populus deltoids*), and sycamore (*Platanus occidentalis*), all of which are found also along rivers in the Piedmont.

Piedmont

Humans have played the major role in determining the floral complex that we see in the Piedmont today. Native North Americans occupied Piedmont South Carolina for thousands of years, and eighteenth-century travelers and botanists passing through the area described the stands of hardwoods and short leaf pines (*Pinus echinata*) that then constituted the mature forest. Not until the nineteenth century and the introduction of cotton and the plantation was the vegetation markedly changed.

As late as 1945, over 2 million acres (810,000 ha) of the piedmont were in crop-land. The 1950s saw a sharp decline in this acreage, and fewer than 700,000 acres (283, 500 ha) were planted by the mid-1970s. As these lands were abandoned, a succession of vegetational changes began. This succession expectedly would lead through various stages to a mature oak-hickory forest like that which existed before the initial clearing. Biogeographers refer to this vegetation assemblage as a "climax forest," and it includes the trees and plants that normally occur under the prevalent conditions of climate, soil, topography, etc. Successions vary in length, but more than a century is necessary before a mature climax-forest stage can be reached in the Piedmont.

The Piedmont landscape today comprises fields and woods at different stages of this succession. Because most land has been taken out of cultivation only within the last 40 years, the climax forest has been reached in a very few areas. After a field is abandoned, it becomes an ecologic vacuum. Taking advantage of the open field and abundant sunlight, plants such as dog fennel (*Eupatorium compositifolium*) and rabbit tobacco (*Gnaphalium obtusifolium*) become the initial occupants. They create an ecologic setting that allows the grasses, and specifically broomsedge (*Andropogon virginicus*), to establish themselves. A few pine seedlings also appear along with red cedar (*Juniperus virginiana*) and wild cheery (*Prunus serotina*). After about 35 years, pines are the principal trees, but beneath them grow the seedlings of the hardwoods. The oaks (*Quercus spp*), hickories (*Carya spp*), dogwoods (*Cornus florida*), and red maples (*Acer rubrum*) slowly begin to dominate the forest floor. This is the stage that has been reached by most fields taken out of cultivation and not replanted by timber companies or pulp and paper companies.

Both the hardwoods and pines will reach maturity within about 70 to 75 years after a field's abandonment. The tops of the pines will rise above the forest, but few pine seedlings will be found on the forest floor. They need the sun that has been blocked out by the hardwoods' leafy canopy, and either the seeds cannot germinate or the pines do not survive the seedling stage. A century after the field's abandonment, the pines will begin to die off, and the forest will be dominated by an oak-hickory canopy with an understory of dogwood, red maple, and sourwood (*Oxydendrum arboreum*). Only in areas of poorer lands or where the forest canopy is opened by lightning, fire, or some other destructive event would we find pines.

Two plants of special interest in the Piedmont are the loblolly pine (*Pinus taeda*) and the kudzu vine (*Pueraria lobata*). Both occur throughout the area today and contribute to the Piedmont's characteristic floral landscape. Interestingly, though, neither is native to the immediate area. The loblolly pine was called "old field pine" because of is widespread presence in the succession stage of abandoned agricultural fields. Today, it is the most common tree in the Piedmont, and it has been and is being planted widely by paper companies and state foresters. The loblolly pine was not mentioned by eighteenth- and early-nineteenth-century travelers and botanists who journeyed through the Piedmont (they noted the short-leaf pine as the native pine). It therefore must have been introduced from the Coastal Plan sometime during the nineteenth century.

A bit more is known about the kudzu vine. This plant is native to Japan but was introduced into the United States during the last decades of the nineteenth century. Known initially as the "porch vine," it was used as a garden ornamental and also was grown on the sides of porches to provide shade during the summer. The 1930s and 1940s saw its widespread use for erosion control and soil restoration. South Carolina agricultural agents especially encouraged the planting of kudzu, and perhaps 50,000 acres (20,250 ha) of the vine were growing across the state by 1950. The plant lost its popularity during the 1960s and thereafter was considered a weed. Kudzu's tendency to climb trees and seemingly smother them made it undesirable as forestry became an increasingly important economic activity. The plant still is widespread, covers acres of land and trees, and creates eerie scenes of long, hanging vines. But probably fewer than 10,000 acres (4,040 ha) of it remain in the state today, and none is being planted.

<u>Sandhills</u>
Sandhills vegetation is as unique as the landform region itself. In an area that annually receives about 45 in. (114 cm) of rain, we encounter a floral regime that is xerophytic, or adapted to dry conditions. This aridity results from the excessive internal drainage of the sandy **soil**s. The vegetation complex is distinguished by a broken canopy, a dispersed distribution of plants, and expanses of bare soil. Predominant in the natural forest cover are the long leaf pine (*P.palustris*) and the turkey oak (*Q. laevis*), a stunted and gnarled lower-story tree. Despite their unsuitability for crops, the Sandhills have been burned, cleared, and cultivated, and now are planted to loblolly pine and slash pine (*P. elliottii*), neither of which is native to the area. Although modified by human activity, much of the Sandhills maintains its distinctive flora. A number of shrubs and plants, including species of sparkleberry (*Caccinium spp*), the wild rosemary (*Ceratiola ericoides*), and the rare wooden goldenrod (*Chrysoma pauciflosculosa*), and the sand myrtle (*Leiophyllum buxifolium*), give character to this distinct vegetation complex.

Stands of long leaf pines once dominated the Sandhills, but now that fire is controlled, they share their dominant role with the scrubby oaks. The pines are pyrophilious-that is, they are not harmed by fire-but the oaks would be removed if the area were subjected, as it once was, to periodic burning. Fire is a natural event, caused by lightning throughout the Southeast, but for millennia it has also been used by humans. Native Americans used fire to hunt and to increase browse for deer and other game animals, and early settlers burned the forests to provide grazing for their livestock. Perhaps this frequent burning over of areas was the basis of an apparent symbiotic relationship between fire and plants. The vegetation of the Sandhills seems to have been selected by fire, as evidenced by the predominance of the long leaf pine; similar relationships between fire and plants may be found in other parts of the state.

<u>Coastal Plain</u>
Travelers crossing the Coastal Plain commonly complain of the seemingly endless miles of pines. Pines do constitute an important component of the Coastal Plain landscape, but many other plants contribute to the region's vegetation. On higher ground in the Inner Coastal Plain, especially on the bluffs overlooking the rivers, a pine-hardwood community is dominated by loblolly pine, hickory, and various oaks, including post oak (*Q. stellata*) and southern red oak *(Q. falcate*). On lower slopes, the wetter conditions are preferred by white oak (Q. alba), sweet gum (*Liquidambar syraciflua*), willow oak (*Q. phellos*), and black gum (*Nyssa sylvatica*). In the river floodplains, on the other hand, we find sweet gum, laurel oak (*Q. Laurifolia*), water hickory (*Carya aquatica*), overcup oak *(Q. lyrata*), cypress, and tupelo.

Distinctly characteristic of the Coastal Plain are the thousands of Carolina bays that dot the landscape. Red bay (*Persea borbonia*), sweet bay (*Magnolia virginiana*), and loblolly bay (*Gordonia lasianthus*) typically are found along their edges. The centers of the large bays are usually swamps dominated by bald cypress (*Tasodium distichum*) and water tupelo (*Nyssa aquatica*). The standing water that forms the swamp limits the depth of the root systems. Swamp trees, as a result, have buttressed or flared bases for support, and the cypress develops its characteristic knees. These trees also occur in low bottomlands, cut-off lakes, and deep swamps through much of the Outer Coastal Plain.

3-5 Sculpting South Carolina Activity

Although the Coastal Plains are largely forested, there are scattered zones of open grasslands called savannas. Dominated by various grasses (*Aristda spp, Androgpogon* sp, *Panicum spp*) and long leaf pines, savannas are usually associated with a high water table. Besides excess moisture, another factor contributing to savanna formation and perhaps the most important is the occurrence of fires. For thousands of years, humans have used fire in the Coastal Plain for various purposes. Fire destroyed competing vegetation and encouraged the growth of grasses and pines that characterize the savannas today. Widespread planting of both slash pines and long leaf pines for pulp mills and the use of controlled burning to manage these tree plantations are also responsible for today's pine-dominated Coastal Plain forest.

<u>Coast</u>
Except along the Grand Strand, South Carolina's coast does not form a sharp break between land and water, and inlets, marshes, and barrier islands characterize the shore from Georgetown to Turtle Island. To simplify the diversity of landforms and plant types, we can group the coastal vegetation into four zones-fresh marshes, maritime forests, salt marshes, and sand dunes (moving from the most inland Coastal Zone vegetation type shoreward-each of which is characterized by a specific botanic complex.
Fresh marshes are inundated by fresh water and are protected from salt-water intrusion by old beach ridges. They support a marsh vegetation dominated by rushes and, in contrast to swamps, contain no trees or bushes. This complex includes bulrush *(Scirpus validus*), cattail (*Typha spp*), and various black rushes (*Juncus spp*), although the last are more common to brackish marshes.

Old beach ridges reflect the dynamic character of the coast. Active dunes at one time, they were left behind as the ocean retreated or the coast built seaward. Once stabilized, they were occupied by a specific floral complex. Located away from the beach and surrounded by fresh and salt marshes, their distinct vegetation results from their elevation. The plants are not inundated by fresh or brackish water and thus are different from those in the surrounding marshes. This complex is referred to as a maritime forest because, in contrast to the marshes, trees and shrubs are dominant. Although located at a distance from the shoreline, the vegetation still is affected strongly by salt spray and coastal winds. Certain trees, such as the live oak (Q. *virginiana*) and the palmetto (*Sabal palmetto*), are particularly tolerant of these conditions and typify the maritime forest. The live oak is native to the coast but has been planted as an ornamental throughout the state. Other trees and shrubs of the maritime forest include slash pine, magnolia, holly, wax myrtle (*Myrica cefifera*), and wild olive (*Osmanthus Americana*). With Spanish moss hanging from the oaks and light filtering through the canopy, the maritime forest creates an image of solitude and beauty.

Closer to the ocean and inundated at high tide are the salt marshes. Cordgrass (*Spartina spp*) and black rushes (*Juncus spp*) cover some 90 percent of the tidal areas. Other plants include the glasswort (*Salicornia virginica*) and sea oxeye (*Borrichia furtescens*). These marshes, dotted with oyster beds, play a major role in the life of cycle of many species of marine life, including all the commercially and recreationally caught fish and shellfish. The marshes remain a major resource for South Carolina and the nation, and their economic and ecologic importance increasingly has been realized. Both the state and federal government have sponsored legislative restrictions on the rampant destruction and loss of these valuable areas, a fate that has befallen salt marshes on the coastline of neighboring states.

On the shoreline itself are the sand dunes, created by the interaction of land, waves, and wind. Dominating the fore dune, or that nearest the ocean, and anchoring it are sea oats (*Uniola paniculata*). These beautiful grasses, with waving heads virtually symbolize the coast, are protected by law in most coastal communities. Also common on the fore dune is the marsh elder (*Iva imbricata*), and on the dune's protected backslope are the pennywort (*Hydrocotyle bonariensis*) and sandspurs (*Cenchrus tribuloides*), the latter making barefoot walks to the beach so painful. In the depression behind the fore dune is an area protected from the salt spray; here we find yaupon (*Ilex vomitoria*), wax myrtle, dwarfed live oak, Spanish bayonet (*yucca aloifolia*) and other plants. The secondary dunes, though somewhat protected by the fore dune, have a similar arrangement of vegetation.

Procedure

Materials

- South Carolina Regions Map
- Topographic map of South Carolina (optional)
- South Carolina Region Research

3-5 Sculpting South Carolina Activity

- South Carolina Research Datasheet
- South Carolina Research Datasheet Answer Key
- Blank South Carolina Map
- Glue
- Q-tips
- Various materials to represent each geographic region. Suggestions for materials to use for each region:
    - Mountains: Medium-sized rocks, rocks that would be used in a fish tank are best (to represent the high elevation and rocky terrain of the Mountain region)
    - Piedmont: Clay, shaped into hills, with small pieces of cat litter placed on top (to represent the rolling hills and clay soils of the Piedmont region)
    - Sandhills: Large grain sand or rice (to represent the sandy soils of the Sandhills)
    - Coastal Plain: Small grain sand or grits (to represent the flat land of the Coastal Plain region). Can use both and separate the inner and outer Coastal Plain
    - Coast: Cornstarch and salt mixture (to represent the sandy beach and the saltwater of the ocean)
- Small cups – it's easiest to put each of the materials in small cups at a group of desks
- Paperboard (optional, but helps keep map from bending)
- Powerpoint of step by step directions (Provided by Education Leadership Partner, Tammy Cannada)
- Sculpting SC Data Table Poster (optional)

Procedure
To aid in your directions to students use the Powerpoint provided to go step by step through the procedure. Thanks to Tammy Cannada, teacher at Mountain View Elementary and Aquarium Education Leadership Partner, for providing this Powerpoint.

1. Give each student a copy of South Carolina Region Research and Research Datasheet. Could do this individually or in groups.

2. Have students read over the first page of the Region Research to discover information on the physical characteristics (elevation, soil types, geologic history, average annual precipitation, average annual temperature) of the five geographic regions of the state (Mountains, Piedmont, Sandhills, Coastal Plain, Coast). As they find the information, they should fill in the Research Data Sheet (All except last column. They'll do that one later). Could also have the research online to find answers.

3. Go over the Research Datasheet answers as a class. If you have a poster maker, you can use the Sculpting SC Data Table Poster to go through the datasheet with the class.

4. Present each student with a blank map of South Carolina.

5. Have students draw lines on their map to separate each region. They may need to use the SC Regions Map as a reference.

6. Let them know that they are going to use different materials to make a topographic map showing the different elevations of the land throughout South Carolina. Show them a topographic map if you have one and explain how to read the map.

7. Show the students the materials they have to make their map. See if they can put the materials in order of largest to smallest.

8. Now, have each student make a 3-D topographic map that will represent some of the characteristics they have learned about each region, such as elevation and soil types. For example, large rocks are glued in the Mountain region and cornstarch/salt is glued in the Coast region to show that the Mountains have the highest elevation and the Coast has the lowest elevation. The students' maps should visibly show through the materials they select for each region that elevation decreases across the state as you travel from the mountains to the sea.

9. A couple hints:

- Have students begin by gluing their blank map to paperboard or some other thick sheet (cereal box, pizza box, cardboard box,…).

- Tell students to only glue one region at a time. DO NOT put glue all over the map at the beginning!
- Use the Q-tips to spread the glue throughout the region.
- Don't use glue under the clay in the Piedmont region, just have students spread the clay in a thin layer on the paper and press firmly.
- After each material is applied, have students pour excess materials in to the trash.

10. Using the 3-D models of the state, encourage students to compare the regions based on the attributes (elevation, temperature and precipitation) that make each region unique. Discuss.

11. Next, have students read the second page of the Region Research to discover information on how the physical characteristics of each region can affect the wildlife communities that can live there. Have them fill in the rest of their Research Datasheet as they read.

12. Split the class into groups. Assign each student team a particular region and have them describe in writing the elevation, precipitation and basic geology of that region and to describe how they think these abiotic, physical factors impact which animals and plants can survive there (what type of communities are found there).

Assessment

Assessment #1:

Student teams will design and construct a map of the state delineating the five geographic regions. They will also create a written response explaining some of the characteristics of each region. An exemplary model should include:

- Clear representation of regional delineations, labeled
- A written response, in complete sentences, describing average temperature values for each region, the elevation, precipitation and basic geology of a particular region and how these physical factors might dictate which animals and plants can survive in that region.

Scoring rubric out of 100 points

Clear representation of regional delineations	**20 points**
Correct labeling of each region	**20 points**
Correct average temperature values for each region	**20 points**
Descriptions of the elevation, precipitation and basic geology of each region	**20 points**
Descriptions of how physical factors affect wildlife found in each region	**20 points**

Assessment #2:

Have students label each South Carolina land region on the SC Region Quiz. There are 2 versions of this assessment; one with the region names listed and one without. You decide which your students is ready for.

- SC Region Quiz
- SC Region Quiz (region names given)
- SC Region Quiz Answer Key

Scoring rubric out of 100 points

20 points for each region labeled correctly

Extra Credit: Which ocean is found off the coast of South Carolina?

Cross Curricular Extensions

STEM Extension
Have each student think about an environmental issue in their region (habitat loss, pollution,…). Then have students design a plan to solve the issue. Who would need to be involved? Would it be a quick and easy solution?

Social Studies and Science Extension
Construct another map that delineates the different regions with salt dough so that elevation differences are clearly shown. Have students use herbs to represent different wildlife communities found in the state and a key to show what each herb symbolizes (For example: Dill could represent salt marsh communities). Students can also use different colors of food-color dye to show where the different major watersheds are found in South Carolina.

Language Arts Extension
Have students write letters to classes in the other regions of South Carolina. In the letters, students should describe what the physical features are of their region and what some of the wildlife communities in their region are like. Students should ask the other classes to send back descriptions of the region they live in, as well as any materials they can send, such as soil samples, rocks, leaves, etc.

Art Extension
Divide class up in teams by the South Carolina regions. Have each student team research the indigenous flora and fauna of their **region** and create a diorama.

Third Grade Language Arts Extension by SCA Master teacher, Derenda Phillips

Fourth Grade Math Extension

- Blank South Carolina Map

Resources

Teacher Reference Books
Barry, John M. Natural Vegetation of South Carolina, University of South Carolina Press, Columbia, 1980.
A look at the vegetation communities in each of the regions of South Carolina as well as the abiotic factors that influence them.

Bennett, Stephen H. and Thomas M. Poland. South Carolina: The Natural Heritage, University of South Carolina Press, Columbia, 1989.
A look at the biotic and abiotic features of all the regions of South Carolina.

Blagden, Jr., Tom. South Carolina's Wetland Wilderness: The ACE Basin, Westcliffe Publishers, Inc., Englewood, Colorado, 1992.
A book of beautiful photography of the ACE Basin in the Coast and Coastal Plain regions of South Carolina as well as information on these regions.

Blagden, Jr., Tom and Thomas Wyche. South Carolina's Mountain Wilderness: The Blue Ridge Escarpment, Westcliffe Publishers, Inc., Englewood, Colorado, 1994.
A book of beautiful photography of the Mountain region of South Carolina as well as information on this region.

Edgar, Walter. South Carolina: A History, University of South Carolina Press, Columbia, 1998.
A comprehensive history of the state of South Carolina, which shows how the different regions of the state affected the human communities that developed there.

Godfrey, Michael A. Field Guide to the Piedmont, The University of North Carolina Press, Chapel Hill, NC, 1997.
A look at the characteristics and wildlife communities of the Piedmont region that stretches from New York through South Carolina to Alabama.

Plummer, Charles C. and David McGeary. Physical Geology, Wm. C. Brown Publishers, Dubuque, IA, 1991.
This college textbook explains the geologic processes that have created the different landscapes of the different regions of South Carolina as well as other places in the world.

Keener-Chavis, Paula and Leslie Reynolds Sautter. Of Sand and Sea: Teachings From the Southeastern Shoreline, SC Sea Grant Consortium, Charleston, 2000.
An excellent look at the biotic and abiotic factors that characterize the Coast and Ocean regions of South Carolina.

Kovacik, Charles F. and John J.Winberry. South Carolina: The Making Of a Landscape, University of South Carolina Press, Columbia, 1987.
Information on the geology, ecology and cultural history of the different landforms and regions of South Carolina.

Meyer, Peter. Nature Guide to the Carolina Coast, Avian-Cetacean Press, Wilmington, NC, 1998.
An informative look at the characteristics and wildlife of the Coast and Ocean regions of South and North Carolina.

Murphy, Carolyn Hanna. Carolina Rocks!: The Geology of South Carolina, Sandlapper Publishing Co., Inc., Orangeburg, 1995.
Information on the geology, topography and formation of all of the regions in South Carolina.

Ricklefs, Robert E. and Gary L. Miller. Ecology, W.H. Freeman Company, 1999.
This college textbook is a great resource for finding out how wildlife communities interact with each other as well as the abiotic factors of their environment.

South Carolina Wildlife magazine, published by the South Carolina Department of Natural Resources.
This award-winning magazine regularly features articles and photography on the habitats and wildlife of all of the regions of South Carolina.

Teal, John and Mildred. Life and Death of the Salt Marsh, Ballantine Books, New York, 1969.
An in-depth look at the characteristics and organisms found in the salt marshes of the Coast region.

Weidensaul, Scott. Mountains of the Heart: A Natural History of the Appalachians, Fulcrum Publishing, Golden, Colorado, 1994.
An in-depth look at the biotic and abiotic features of the mountain range that intersects South Carolina to form its mountain region.

Teacher Reference Websites

The Learning Network
http://www.factmonster.com/ce6/us/A0861200.html
"Fact Monster!" information page on South Carolina Geography. Great for kids!

South Carolina Department of Natural Resources (SCDNR)
http://www.dnr.sc.gov/
Information on the wildlife and geology of all of South Carolina.

South Carolina Geographic Alliance
http://www.cas.sc.edu/cege/
Go to the “Resource” page to find what you need.

South Carolina's Information Highway
http://sciway.net/weather/
Links to South Carolina's weather, tides, and natural disasters. Shows how landforms can affect weather in the state. Also has a hurricane tracking link.

U.S. Geological Survey
www.usgs.gov/
This site offers valuable earth science information on a variety of topics.

Student Reference Books

Clifford, Dr. Nick. Incredible Earth, DK Publishing, Inc., New York, 1996.
An amazing book that uses illustrations, photographs and text to show how various natural processes have shaped the Earth.

Duncan, Beverly K. Explore the Wild, HarperCollins Publishers, New York, 1996.
Children examine illustrations of different environments found in North America to search for the organisms that make up the environment's wildlife community. Includes information on each organism in the community.

Eyewitness Books: Pond & River, Alfred A. Knopf, Inc, New York, 1988.
This book uses photographs, illustrations and text to teach the reader about the plants and animals that make freshwater habitats their home.

Eyewitness Books: Ocean, Alfred A. Knopf, Inc, New York, 1995.
This book uses photographs, illustrations and text to teach the reader about the plants and animals that make ocean habitats their home.

Hoffman, Nancy. Celebrate the States: South Carolina, Benchmark Books, New York, 2001.
A children's book on the history and culture of South Carolina as well as sections on the geography and wildlife of the region of the state.

Kent, Deborah. America the Beautiful: South Carolina, Children's Press, Danbury, CT, 1990.
A children's book on the history and culture of South Carolina as well as sections on the geography and wildlife of the region of the state.

Look Closer: Swamp Life, Dorling Kindersley, New York, 1993.
Using photographs, illustrations and text this book teaches the reader about the plants and animals that live in swamps.

Matthews, Downs. Wetlands, Simon & Schuster Books, New York, 1994.
This book describes different types of wetlands and the plants and animals found there.

Redfern, Martin. The Kingfisher Young People's Book of Planet Earth. Kingfisher Publications, New York, 1999.
Another amazingly illustrated book that looks at the geology and natural history of Earth.

Simon, Seymour. Mountains, Morrow Junior Books, New York, 1994.
This book uses photographs and text to describe many aspects of the Mountains.

Smithey, William K. American Coastlines: The Beauty of America's Natural Habitat, Gallery Books, New York, 1990.
An introduction to habitats from the Pacific Ocean to the Atlantic Ocean, this book uses text and photographs to introduce students to the coastlines of America.

Taylor, Barbara. Earth Explained: A Beginner's Guide To Our Planet, Henry Holt and Company, New York, 1997.
This is a wonderfully illustrated reference book for young reader's on many aspects of the Earth's geology, climate and oceanography.

Waterlow, Julia. The Atlantic Ocean, Raintree Steck-Vaughan Publishers, Austin, TX, 1997.
This book uses photographs and text to describe many aspects of the Atlantic Ocean.

Student Fiction Books

George, Jean Craighead. My Side of the Mountain, Puffin Books, New York, 1959.
A boy from New York City runs away to live by himself in the Catskill Mountains and must learn to survive in this environment.

Hite, Sid. It's Nothing to a Mountain, Henry Holt and Company, New York, 1994.
A story of two children learning to live in the environment of the Blue Ridge Mountains of Virginia.

O'Dell, Scott. Island of the Blue Dolphins, Bantam Doubleday Dell Books, New York, 1960.
A girl is left behind on an island in the Pacific and must learn how to survive in this ocean environment.

Paulsen, Gary. The River, Delacorte Press, New York, 1991.
The story of a boy trapped on a remote river who must learn to survive from the river environment.

Curricula

Aquatic Project WILD
Aquatic Project WILD is an interdisciplinary curriculum for K-12 teachers on aquatic wildlife and **ecosystems**. The activities cover a broad range of environmental and conservation topics.
For more information click on http://www.projectwild.org/ProjectWILDK-12AquaticcurriculumandActivityGuide.htm

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