2019

Florida Science: The Science that Makes Florida Different

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Cover art by
T. Cavanaugh

This book was created to assist students with their understanding of how science occurs in Florida. When teaching science or any subject it's important to remember to begin with the concrete and then move to the abstract. I have found that it has helped my students when I begin by teaching science concepts in a concrete manner and expand from there. For example, when I taught about topographic maps, the students were much more successful in their learning when I started with local topographic maps that included the school and the surrounding area than with places that had mountains or the Grand Canyon. This book is to support concrete teaching as it involves and applies facts and descriptions about tangible objects and actions that can be found in Florida, ones that they have likely seen, or applies to them and their surroundings.

How to use this text

This book is designed to be a supplementary text used to enhance science instruction in secondary grades, providing state-based science as it is found and applied in Florida. The way that the text is used can be adjusted to your needs. Feel welcome to use just an area (Earth Science, Oceanography, Weather/Climate, Biology, Chemistry or Physics) or any subsection or the whole book. Students use the text digitally, download it, read it online, or print out any portions or the whole book as needed or desired. This text is accompanied by more than 100 color photographs and graphics illustrating science as it applies to or is found in Florida.

This book is divided into six parts: Earth Science, Oceanography, Weather/Climate, Biology, Chemistry, and Physics. Each of those parts is divided into topic sections. The book was divided into topic-based, independently readable sections that will inform students on that science as it occurs in Florida. Each module or topic section can be read independently, or the book can be read as a whole covering the parts listed before. While the book has 38 sections, it is by no means exhaustive of all the science that is found or performed in, or is different in Florida, it is a collection of science topics that can be applied to a variety of science classes.

Sections were designed to be quick reads. The book was designed to be readable by middle and high school students (with checked readability ranging between 6th and 9th grades using both the Flesch-Kincaid and SMOG Grade readability analysis).

At the end of many of the subsections, there are links to online interactive resources, simulations, and more to allow the student to further their exploration, visualization, and experimentation. If you are using a digital version of the book then the links should be live and clickable. If you are not using a digital version, all long addresses have been made available using a shortened version, type into your internet browser software the goo.gl address in the brackets which should automatically transfer the user to the long address.
(Example: [https://goo.gl/qmm8EV] and that address will direct the user to http://publicfiles.dep.state.fl.us/FGS/FGS_Publications/MS/MS146_StateGeologicMap/state_geologic_map.pdf).

Please note that there is no guarantee that all URLs presented in this book will continue to be functional at the time of reading. All the URLs presented in the subsections were verified as correct and active at the time of the writing of this book; however, there is no guarantee that the URLs for websites will remain functional over time, as URLs are subject to change at the discretion of the website owner.

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Figure: Earth Science (sand), Oceanography (Atlantic), Weather (Clouds), Biology (Laughing Gull), Chemistry (H_2O & NaCL), and Physics (orbit of the moon) all in one photograph. Photograph courtesy of T. Cavanaugh

Welcome to Florida Science

Florida is the southeastern state of the United States and has two basic parts. There is the Panhandle along the top that borders the states of Georgia and Alabama, and there is the peninsula section that sticks out to the southeast off the North American continent. A peninsula is just a section of land that extends out of a larger piece of land and is surrounded by water. Actually, Florida is the 11th largest peninsula in the world (the Arabian peninsula is the largest).

Some Florida facts

- 58,560 square miles
- 1197 miles of oceanfront
- 663 miles of beach
- Lake Okeechobee is 700 square miles, making it the 2nd largest lake in North America
- 27 first magnitude springs (most in North America)
- Southernmost point of land in the continental United States
- Highest point is 345 feet, making it the lowest highest state point in the nation.

Figure 1: Florida from space. Photograph courtesy of NASA.

1. Earth Science

Figure 1: Dry Tortuga Island off the Florida Keys. Photograph courtesy of T. Cavanaugh.

Most of Florida is a **peninsula** that juts to the southeast off the North American continent. A peninsula is just a section of land that extends out of a larger piece of land and is surrounded by water. Florida as a peninsula and the panhandle does have the longest coastline of any state in the continental United States (1,350 miles or 2,170 km), but only 663 miles (1667 km) of that is beach. It is the only state that borders both the Gulf of Mexico and the Atlantic Ocean. Geologically speaking Florida is a very calm place. Since it is not near any of the **tectonic boundaries** of the North American Plate, it doesn't see much in the way of earthquakes and volcanoes that most plate edges have. Florida does get some earthquakes, but not many. In 2006, there was an earthquake measured at 5.8 magnitude on the Richter scale with an epicenter about 260 miles (420 km) southwest of Tampa and west of Fort Myers out in the Gulf of Mexico and it had a focal depth of between 14 and 31 km. Florida has an extremely flat **terrain** with no mountains or high hills, making it the flattest state in the United States. The highest point in Florida is Britton Hill at 345 feet (105 meters) in Walton County, which makes it the lowest state highest point in the USA. The lowest land in Florida is, of course, where the where the ocean or gulf meets the beach at low tide, sea level.

Figure 2: State rocks of Florida. Photographs courtesy of the Florida Department of State.

State Stone: Agatized Coral. Agatized coral occurs when silica in the ocean water hardens, replacing the corals with a form of quartz known as chalcedony. Agatized coral can be found in Tampa Bay, the Econfina River, and the Withlacoochee/Suwannee river beds.

State gem: Moonstone (adopted based on the moon landing - made from feldspar, a rock not found in Florida - or on the Moon)

State soil: Myakka Fine Sand. Myakka soil, which is unique to Florida, occurs in more than one-and-a-half million acres of flatwoods, making it the single most extensive soil in the state.

State shell: Horse Conch. This shell is native to the marine waters around Florida and can grow to a length of twenty-four inches.

1.1 Barrier Islands

SC.6.E.6.2: Recognize that there are a variety of different landforms on Earth's surface such as coastlines, dunes, rivers, mountains, glaciers, deltas, and lakes and relate these landforms as they apply to Florida.
SC.912.E.6.4: Analyze how specific geologic processes and features are expressed in Florida and elsewhere.

Figure 3: The barrier island Captiva Island off the coast of Ft. Myers. Photograph courtesy of NASA & USGS.

Florida has more **barrier islands** than any other state in the U.S. Barrier islands are low, narrow islands that separate the Florida mainland from the Atlantic Ocean (see Figures 3 & 4). These barrier islands also help protect the mainland from **erosion** caused by the pounding waves and storms. Barrier islands are formed when sand, soil, shells, and other debris are swept up from the ocean floor by storm waves. Once the storm is over, it leaves leave behind a ridge of sand and other material. As the land builds up, plants take root and trap the sand, which helps stabilize the island. Some barrier islands, such as those in the keys have an ancient coral reef at their base, covered by only three to six feet of sand. Once formed, barrier islands are not static landforms, instead, they are dynamic, constantly changing in size and shape as winds and water constantly rework the island by moving the sand.

For barrier islands to form, several conditions must be met. First, there must be a source of sand, this could be from coastal or offshore deposits. Much of the sand that makes up the barrier islands along eastern Florida came from the erosion of the Appalachian Mountains. Next, the **topography** of the coastline must have a broad, gentle slope, like that found with Florida's continental shelf. Finally, the forces of waves, tides and currents must be strong enough to move the sand and deposit it in a location.

Figure 4: Talbot Island, a barrier island just north of Jacksonville. Photograph courtesy of T. Cavanaugh.

Some of Florida's Barrier Islands

Atlantic Coast: Amelia Island, Anastasia Island, Big Talbot Island, Canaveral National Seashore, Fisher Island, Fort George Island, Grove Isle, Hutchinson Island, Jacksonville beaches, Jupiter Island, Key Biscayne, Little Talbot Island, Miami Beach, North Hutchinson Island, Orchid Island, Palm Beach Island, Ponce de León Island, Sand Key, Vilano Beach, Virginia Key. *Actually, from the central to the northern Atlantic coast of Florida, the land is commonly considered a chain of barrier islands.*

Gulf Coast: Anclote Key, Anna Maria Island, Atsena Otie Key, Caladesi Island, Cape St. George Island, Captiva Island, Casey Key, Cayo Costa Island, Clearwater Beach Island, Dog Island, Don Pedro Island, Egmont Key, Estero Island, Gasparilla Island, Honeymoon Island, Keewaydin Island, Lido Key, Little Gasparilla Island, Longboat Key, Manasota Key, Marco Island, North Captiva Island, Perdido Key, Santa Rosa Island, Shell Key Preserve, Siesta Key, St. George Island, St. Vincent Island, Three Rooker Island, Treasure Island.

1.2 Karst topography

SC.6.E.6.1: Describe and give examples of ways in which Earth's surface is built up and torn down by physical and chemical weathering, erosion, and deposition.
SC.912.E.6.2: Connect surface features to surface processes that are responsible for their formation.
SC.912.E.6.4: Analyze how specific geologic processes and features are expressed in Florida and elsewhere.
SC.6.E.7.7: Investigate how natural disasters have affected human life in Florida.

Florida has a landform known as **Karst topography**. The term karst describes a distinctive surface features (topography) that shows dissolution (also called chemical solution) of underlying soluble rocks by surface water or groundwater. Throughout Florida, this occurs with **limestone** and **dolomite** rocks (carbonate rocks) which can be dissolved into the water underground and form the karst terrain, which can be identified at the surface by features like sinkholes along with roundish ponds and lakes.

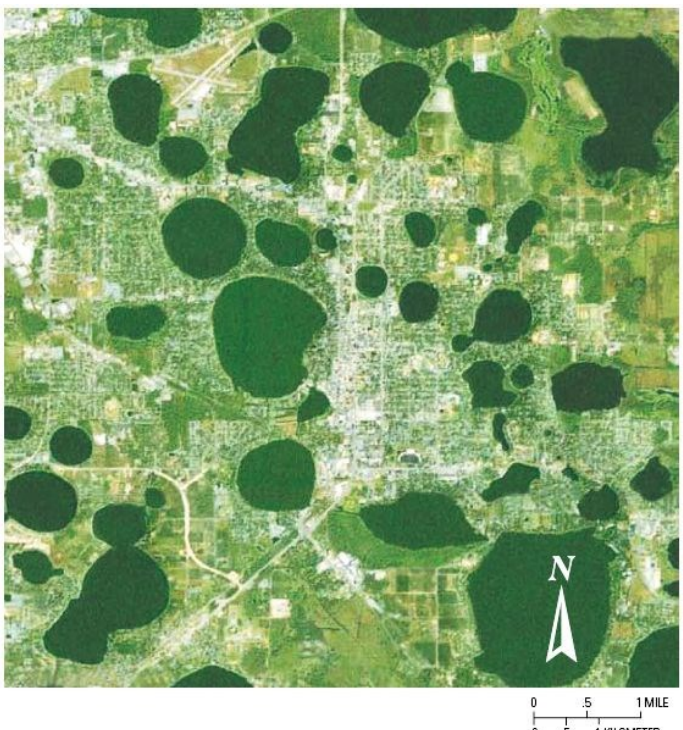


Figure 5: Sinkhole-formed lakes near Winter Haven Florida. Photograph courtesy of USGS.

1.3 Sinkholes

SC.912.E.6.2: Connect surface features to surface processes that are responsible for their formation.
SC.912.E.6.4: Analyze how specific geologic processes and features are expressed in Florida and elsewhere.
SC.6.E.7.7: Investigate how natural disasters have affected human life in Florida.

Figure 6: Winter Park Florida cover-collapse sinkhole of 1981. Photograph courtesy of USGS.

Florida is one of the states with the most damaging from **sinkholes**, the other states with sinkhole issues are Texas, Alabama, Missouri, Kentucky, Tennessee, and Pennsylvania. Sinkholes in Florida are common where the rock below the land surface is made of limestone or carbonate rock. These rocks can naturally be dissolved by groundwater circulating through them. As the rock dissolves, spaces and caverns develop underground. The sinkhole forms when the ground above collapses into space or cavern below. Sinkholes are dramatic because the land above usually appears intact until the underground spaces just get too big to support the land above. Then there is a sudden collapse of the land surface can occur. These collapses can be small such as a foot or two across or they can be huge bigger than the size of a house or parking lot, and they can have a depth from less than 1 to more than 100 feet (30.5 m) deep. Some sinkholes are shaped like shallow bowls, while others have steep walls and some will hold water to form natural ponds. Many of the round ponds and lakes found in the state were formed from sinkholes.

1.4 Types of Sinkholes

SC.912.E.6.2: Connect surface features to surface processes that are responsible for their formation.
SC.912.E.6.4: Analyze how specific geologic processes and features are expressed in Florida and elsewhere.
SC.6.E.7.7: Investigate how natural disasters have affected human life in Florida.

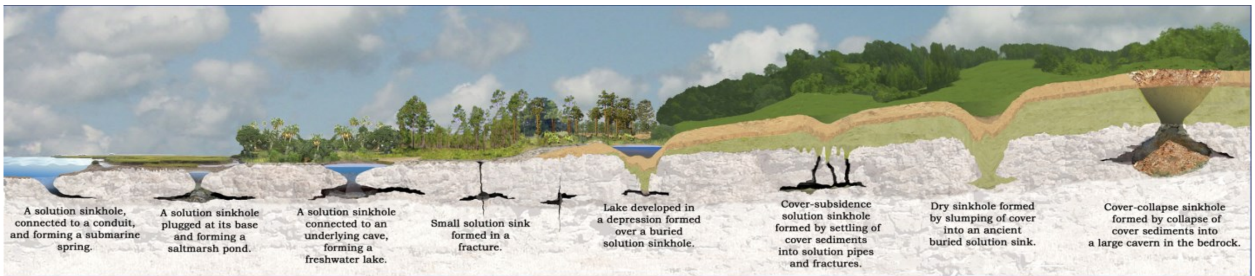


Figure 7: Types of sinkholes. Images courtesy of Florida Geological Survey

Solution sinkholes

The **dissolving** of the **limestone** rock is strongest where the water first comes in contact with the rock near the surface. This dissolving also occurs where the flow is in openings in the rock, such as in holes, joints, and fractures, it also occurs where at the top of the water-table where groundwater is in contact with the atmosphere. As rainfall and other surface water filter down through the joints or cracks, the limestone is **chemically eroded** by the slightly acidic water. The dissolved carbonate rock is then carried away from the surface and a small depression will gradually form. If the rock is exposed to the surface, the depression may become a place for water to drain into. The dirt, and, plants and other material carried may block the water from getting to the rock and flowing away, creating ponds or wetlands (see Figure 8).

Figure 8: Wetland created by a dissolution sinkhole in Duval County. Photograph courtesy of T. Cavanaugh

Cover-subsidence sinkholes

Cover-subsidence sinkholes tend to develop gradually where the covering sediments allow water to easily filter through (permeable) and contains sand. Then as the sediments from above slowly settle into underground spaces, a bowl-shaped depression forms at the surface. These sinkholes can take many years to form. In areas where cover material is thicker or sediments contain more clay and prevent water from flowing through, cover-subsidence sinkholes usually don't happen, are smaller, and may go unnoticed for long periods.

Cover-collapse sinkholes

Cover-collapse sinkholes may suddenly happen (over a period of hours) and can cause catastrophic damages, these are often the ones you might see on the news, such as when houses and cars fall in them (see Figure 6). They occur where the covering sediments contain a significant amount of clay. Under the ground, the carbonate rock is washed away and space opens is created under the ground. When the land above becomes too heavy for the for the top to be held up, it falls into the open space below (see Figure 9).

Figure 9: The Devil's Millhopper in Alachua County, is a cover-collapse sinkhole that is 120 feet deep (37 m) and 500 feet across (123 m). A wooden platform and stairway will allow visitors to go down in the sinkhole to the pond in the bottom. Photograph courtesy of T. Cavanaugh.

There are a number of really interesting sinkhole lakes in Florida that every so often will disappear and then reform over time (there are even disappearing streams). Two of these lakes are Lake Jackson near Tallahassee and Scott Lake near Lakeland. These lakes have sinkholes in them that get blocked or clogged with material that stops the water from flowing through into the ground. When blocked the water will continue to build up forming the lake. Then one day the pressure of the water or some sinking of the land the water breaks through the blockage in the sinkhole and within a few days the lake disappears, draining down into the sinkhole. Then the sinkhole fills with material as it drains and moves mud, muck, and sand into the hole, usually plugging the sinkhole again, and once plugged the empty lake will start to slowly refill again. Please note though that is a process that can take many years between drainings.

Sinkholes can also happen because of human actions. For example, sinkholes can form from certain land-use practices, such as from groundwater pumping when there is a land development project. Or when the weight of the material being put on the land becomes so great that it causes a cover collapse, such as when a 20,000+ pound cement truck with 10,000+ pounds of cement drives on top of an underground open space.

Online Exploration:

- **To see an interactive map of sinkhole locations that the state has received subsidence incident reports for visit SIRs Data - Map Direct** [**https://goo.gl/GAjcGg**] (http://ca.dep.state.fl.us/mapdirect/?focus=fgssinkholes)
- **You can virtually visit the Devils Millhopper on your computer or using VR glasses at the following site:** [**https://goo.gl/pKw5Vq**] https://www.360cities.net/image/devils-millhopper-gainesville-florida-boardwalk

1.5 Florida Caverns

SC.912.E.6.4: Analyze how specific geologic processes and features are expressed in Florida and elsewhere.
SC.6.E.7.7: Investigate how natural disasters have affected human life in Florida.

While many may not realize it Florida does have lots of caves and caverns. Most of the Florida cave systems while underground are also below the **water table** and so are underwater, but not all. Florida Caverns State Park is in the panhandle section of the state near the town of Marianna, not far from I-10. It is a natural limestone cave formation with a number of large underground rooms (see Figure 10). The caves are formed from Ocala Suwannee and Marianna limestones. Through the process of **chemical weathering**, slightly acidic underground water moves through pores in the limestone and reacts with the limestone and creates calcium hydrogen carbonate ($Ca(HCO_3)_2$), a compound that can be dissolved in water (soluble) and so is removed as the water flows through the rocks creating the caves (empty spaces left behind). Then as the water levels drop the caverns are no longer underwater and so become more accessible to people and animals. Although during heavy rainfall or during the rainy season, large sections of the cave begin to again fill with water.

Figure 10: Florida Caverns. Photograph courtesy of T. Cavanaugh.

ONLINE EXPLORATION:

Activity: Build a karst cave paper model from USGS with sinkhole:

- [**https://goo.gl/Y4Tfju**] https://pubs.usgs.gov/of/1997/0536a/report.pdf
- [**https://goo.gl/viiA65**] https://www.nps.gov/subjects/caves/karst-topography-model.htm

1.6 Florida Aquifer

SC.7.E.6.6: Identify the impact that humans have had on Earth, such as deforestation, urbanization, desertification, erosion, air and water quality, changing the flow of water.
SC.912.L.17.11: Evaluate the costs and benefits of renewable and nonrenewable resources, such as water, energy, fossil fuels, wildlife, and forests.
SC.912.E.6.4: Analyze how specific geologic processes and features are expressed in Florida and elsewhere.

The **Floridan aquifer** system is one of the world's most productive aquifers and supplies drinking water for nearly 10 million people. According to the United States Geological Survey, the total amount of water pumped from the Floridan aquifer system in 2000 was about 3,640 million gallons per day (Mgal/d), and the water was used for irrigation (49%), public water supply (33%), industrial purposes (14%) and domestic self-supply (personal wells) (4%). The Floridan aquifer system spans an area of about 100,000 square miles (260,000 km^2) in the southeastern United States and underlies all of Florida and parts of southern Alabama, southeastern Georgia, and southern South Carolina (see Figure 11). The Floridan aquifer averages to be about 1,000 feet (305 m) thick, and the freshwater can extend to a depth of 2,000 feet (610 m) below land surface. The freshwater is thickest below the central portions of the state and rapidly thins toward the coast and to the south. The Upper Floridan aquifer contains freshwater over much of its extent, although is **brackish** or slightly salty south of Lake Okeechobee. The carbonate rocks that make up the Floridan aquifer have highly variable properties concerning water, including **porosity** (how much water an amount of rock can hold) and **permeability** (how easily can water flow through the rock).

In some areas across Florida, the water in the aquifer is blocked at the top by a thick layer of clay and then by sandy soil up to the surface. When the water inside the aquifer is blocked like that, it builds up pressure from new water trying to flow in. This pressure can allow the aquifer's water to rise up, even all the way up to the surface, creating a spring. **Springs** are places where the pressure is so great that groundwater comes out to the surface through natural openings in the ground. Spring flow is controlled by the size of the replenishment area, the difference in altitude between the spring opening(s) and the water level in the aquifer, along with the size of the opening or openings through which the spring's water flows out.

The Floridan aquifer system is exposed to the surface in central and southern Georgia where the limestone, and its eroded remains, can be seen at the land surface. The aquifer system generally dips below land surface to the south where it becomes buried beneath surface sand deposits and clay. In areas depicted in brown (darker sections if your image is not in color) in the image, the Floridan aquifer system is exposed at the land surface. These regions are particularly prone to sinkhole activity due to how close the limestone aquifer is to land surface.

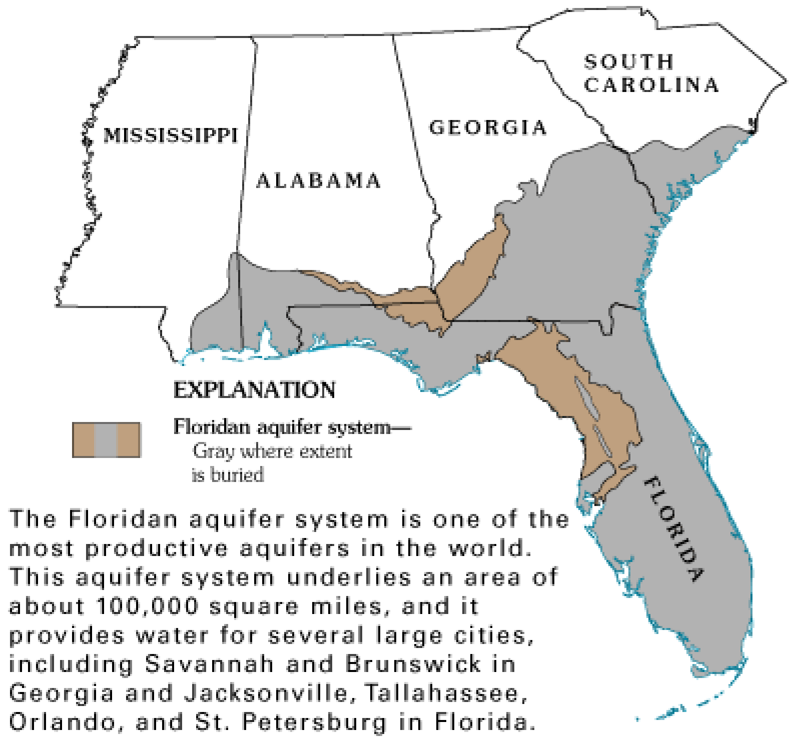


Figure 11: The Floridan aquifer system extends into portions of five states. Image courtesy of USGS.

ONLINE EXPLORATION:

Walking on Water **is an environmental education program that allows visitors to explore a portion of the aquifer's underwater cave system starting at Ginnie Springs through a virtual field trip. The program allows students to explore the cave system virtually through a series of 360 images as you swim into the winding tunnels of the aquifer. Visit the 360-degree virtual tour at the *Walking on Water* website** (http://discoverfloridasprings.com/wp-content/uploads/2016/09/GinnieVirtualTour/index.html [https://goo.gl/33KkFe]). *Note that Flash will be needed.*

1.7 Salt Water Intrusion

SC.7.E.6.6: Identify the impact that humans have had on Earth, such as deforestation, urbanization, desertification, erosion, air and water quality, changing the flow of water.
SC.912.L.17.11: Evaluate the costs and benefits of renewable and nonrenewable resources, such as water, energy, fossil fuels, wildlife, and forests.

Some of the water in the **aquifer** is very old, often over 17,000 years old. This is because of how long it takes for the water when it enters the ground to flow through the rocks from far up north, while other water can be new from a recent rain adding water to the aquifer locally. Unfortunately, in some areas, the water in the **Floridan aquifer** is not suitable for drinking, because it contains various minerals or salts. Sometimes this can be caused by pollution other times it can be caused by use or overuse, resulting in something called salt water intrusion. Salt water is present everywhere around the aquifer from the ocean and gulf that surrounds Florida and deep below the fresh water contained in the aquifer. Under natural conditions, the pressure and movement of freshwater in the aquifer prevents saltwater from moving into where the Florida aquifer is flowing. **Salt water intrusion** occurs when wells are drilled too deep or when too much freshwater is pumped from the aquifer, allowing salt water to move in and replace the freshwater. Groundwater pumping can reduce freshwater flow out toward coastal areas and cause saltwater to be pulled in to what used to be the freshwater zones of the aquifer. Saltwater intrusion occurs by many mechanisms, including sideways replacement from coastal waters as fresh water is removed from the aquifer near the coast and vertical **upconing** near wells that allow the saltwater to move up underneath from where the fresh water has been removed (see Figure 12).

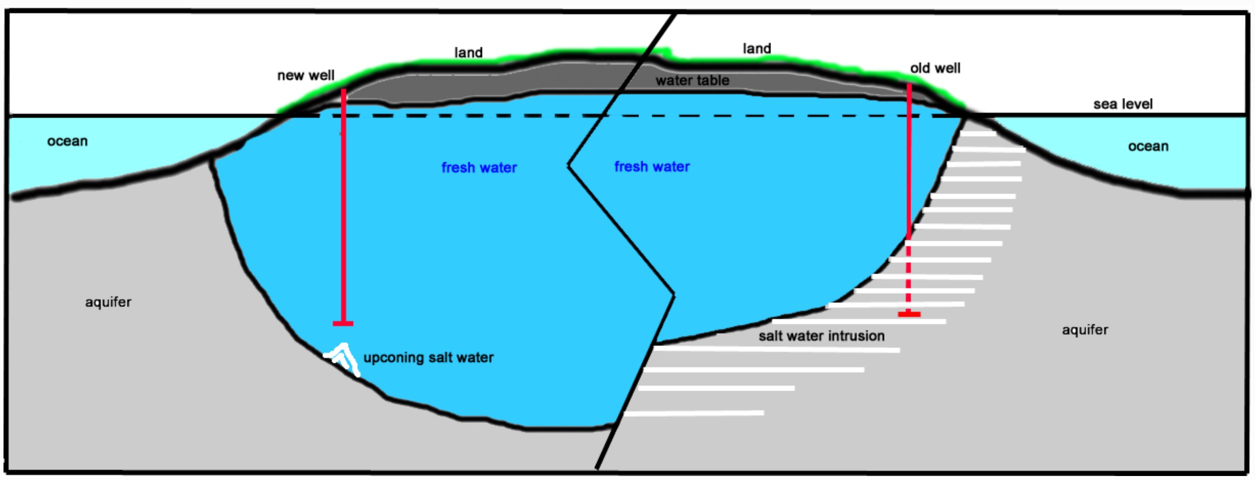


Figure 12: Impact of wells as the removal of fresh water will be replaced by salt water.

The water in the aquifer is replenished, or **recharged**, by rainfall. On average, Florida receives 51 inches of rain each year. However, not all of the rain reaches the aquifer. About 38 inches evaporates or runs off the land into surface waters, like lakes, rivers, and streams, before it has a chance to soak into the ground. This leaves, on average, 13 inches annually to recharge the aquifer in limited areas. Also, remember that the aquifer goes all the way up into other states, so their rainfall from years ago can also make a difference.

1.8 Springs

SC.6.E.6.1: Describe and give examples of ways in which Earth's surface is built up and torn down by physical and chemical weathering, erosion, and deposition.
SC.912.E.6.2: Connect surface features to surface processes that are responsible for their formation.
SC.912.E.6.4: Analyze how specific geologic processes and features are expressed in Florida and elsewhere.

Figure 13: Blue Springs in Marion County where manatees come in the winter for the “warmer” water is a first-magnitude spring that discharges 165 million gallons a day. Photograph courtesy of T. Cavanaugh

A **spring** is a point at which water flows from an aquifer to the Earth's surface (see Figure 15). Geologists from the Florida Department of Environmental Protection claim that the U.S. state of Florida may have the largest convergence of freshwater springs on the planet, with over 700 springs. Springs are naturally occurring places where water flows from the aquifer (underground) to the surface. Florida Geological Survey Bulletin (2004) identified 720 springs, of which 33 were **first-magnitude** (100 cubic feet per second: 740 gallons/second: 2800 liters/second or more), 191 were second-magnitude (10 to 100 ft^3/s), and 151 were third-magnitude (1 to 10 ft^3/s). Spring Creek Springs (2000 ft^3/s) in Wakulla County and Crystal River Springs (878 ft^3/s) in Citrus County have the largest first-magnitude discharges, and Silver Springs (799 ft^3/s) in Marion County is the largest first-magnitude inland spring. Researchers have found that spring outflow of water has decreased significantly since the 1990s, possibly from drought conditions and increased pumping from the **Floridan aquifer**, causing lesser flow from some springs and completely stopping others.

Spring water is forced to the surface by the change in elevation from the sources which create pressure in the groundwater, which is released at the surface at the spring and then flows away in a stream or river (see Figure 13). Think of the aquifer like a hose carrying the water from the higher up recharge area to exit through the lower elevation opening. Springs are like holes that got in the top of the hose, causing the water to shoot out. The groundwater continually dissolves bedrock such as limestone and dolomite, creating vast cave systems. Under the ground the temperature remains steady, this also causes the aquifer or groundwater to maintain a relatively constant temperature of between about 70°F (21°C) and about 75°F (24°C); so while the water flowing from a spring stays at the same temperature all year, it will be cooler than the air on a summer day, and but warmer than the air temperature in the winter.

People use springs in a variety of ways including drinking water, irrigation, mills, navigation, and electricity generation. Other modern uses include recreational activities such as parks, fishing, swimming, and floating; therapy; water for livestock; fish hatcheries; and supply for bottled mineral water (see Figure 14).

Figure 14: The Ichetucknee River, which is created by the Ichetucknee Springs State Park is popular for floating down the river. Photograph courtesy of T. Cavanaugh.

ONLINE EXPLORATION:

You can virtually visit some springs on your computer or using VR glasses at the following sites:

- **Ichetucknee Headspring: [https://goo.gl/67EzRm]**
  https://www.360cities.net/image/ichetucknee-headspring-usa
- **Little Devil at Ginnie Spring: [https://goo.gl/7UGysW]**
  https://www.360cities.net/image/little-devil-at-ginnie-springs-usa
- **Blue Springs: [https://goo.gl/ZSY35x]**
  https://www.360cities.net/image/jumping-into-blue-spring-usa

1.9 Rocks

SC.7.E.6.2: Identify the patterns within the rock cycle and relate them to surface events (weathering and erosion) and subsurface events (plate tectonics and mountain building).

Figure 15: Housing remains constructed of Tabby a concrete made with oyster shells, sand, ash, and water, similar to Coquina (a sedimentary rock), at Kingsley Plantation, Duval County. Photograph courtesy of T. Cavanaugh

Compared to most other states, Florida is limited in its number of kinds of local rocks and minerals that you can find. Rocks are made up of minerals, and there are three types of rocks: igneous, metamorphic, and sedimentary. **Igneous rocks** form where the temperature is enough to make the rock materials melt and then cool and harden, such as the rocks from volcanoes, but Florida doesn't have any igneous rocks. **Metamorphic rocks** are ones that have undergone a change, such as from great pressure, for example when limestone becomes marble, but for the exposed rocks in Florida, it doesn't have any of those either. What Florida does have in abundance is sedimentary rocks. **Sedimentary rocks** are formed underwater usually near the earth's surface, under normal temperatures and pressures. Sedimentary rocks usually have a layered structure from repeated laying down of the sediment which then forms a structure called stratification or bedding. These rocks can form **clastics** (cemented together from eroded other rocks), chemical precipitates (usually formed from evaporation like salt), and organic accumulations (such as peat).

Usually, on the surface, you will find that Florida is covered by deposits of **sands** and **clays**, with very few rock outcroppings. The principal industrial use of common clay and sand in

Florida is the construction of roads. Clays are also used in the manufacture of cement and lightweight aggregate. We do have a State Soil called **Myakka Fine Sand.** This Myakka fine sand is unique to Florida and occurs in more than one-and-a-half million acres of flatwoods, this makes it the single most extensive soil in the state. The Myakka soils are formed from ocean deposits and outside of the flatwoods, you can also find them in tidal areas, depressions and on barrier islands. The soil is usually a dark gray sand surface (about 5 inches thick) and under that, for about another 25 inches, it will be a lighter gray sand, which then goes from black to dark brown because of organic material.

Basically, Florida has about ten types of rocks including the clays, sands, and gravels (Rock photographs courtesy of the Florida Department of Environmental Protection):

Gravel: Loose material larger than 2 millimeters in diameter, frequently composed of quartz. Usually found in the western panhandle regions.

Figure 16: Gravel.

Sand: A loose material of grain size between 0.08 mm and 2 mm, frequently composed of quartz. Sand is found throughout Florida.

Figure 17: Sand.

Common Clay: Material with a grain size smaller than 0.08 millimeters in diameter, most often made up of clay minerals. Clays are usually sticky and composed of varying amounts of clay minerals, quartz sand, calcite, iron oxides, organic impurities, and other materials. Clays can be found throughout Florida.

Figure 18: Common Clay.

Fullers Earth: Fullers Earth is the name for certain types of clays that have the ability to absorb coloring matter from vegetable, mineral and animal oils. Fuller's earth beds can be found in the northern and southern parts of the state.

Figure 19: Fullers Earth.

Kaolin: Composed primarily of the clay mineral kaolinite, it can be white to grayish yellow in color, and is most commonly used for porcelain. Kaolinite is mined in the central part of the peninsula above Tampa and certain locations in the panhandle (https://www.mindat.org/locentries.php?m=2156&p=16149).

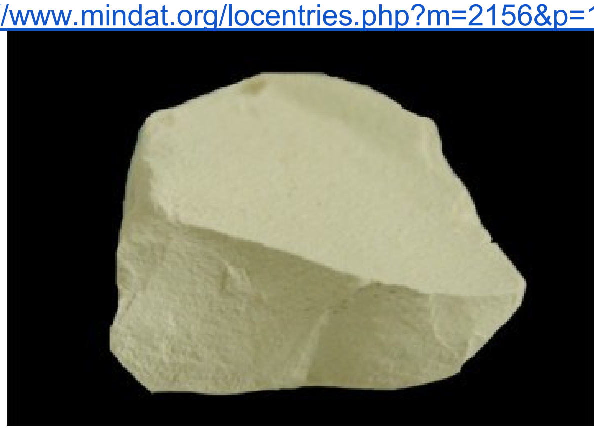


Figure 20: Kaolin.

Peat: An accumulation of partly decomposed and broken down organic materials derived mainly from woody parts of plants. Peat is used in the production of potting soils and as a general soil treatment. While peat can be found throughout the state the majority of peat resources in Florida lie predominantly in South Florida, in the Everglades and associated swampy areas.

Figure 21: Peat.

Sandstone: A sedimentary rock that is commonly composed of quartz sand grains cemented together by silica, calcite, iron oxide or other mineral substance. Depending upon the amount and character of the cementing agent, sandstones may be almost any color. Florida sandstone formations are usually found in the central peninsula and northwestern part of the state.

Figure 22: Sandstone.

Dolostone: A sedimentary rock that formed from the replacement of Magnesium (Mg) for Calcium (Ca) in limestones. Dolostone is used for the same purposes as limestone except that it is not used in cement manufacturing. The chemical test for is the same as for limestone and is done by adding a drop of cold dilute hydrochloric acid to the rock, which causes it to bubble slowly.

Figure 23: Dolostone.

Limestone: A sedimentary rock composed of cemented calcite, fossil fragments, and biogenic material. Various types of limestone are under all of Florida, Limestone is used for road base material, concrete and asphalt material, cement manufacturing, fertilizer, and soil conditioner. The chemical test for limestone is done by adding a drop of cold dilute hydrochloric acid to the rock, which causes the calcite particles to bubble quickly.

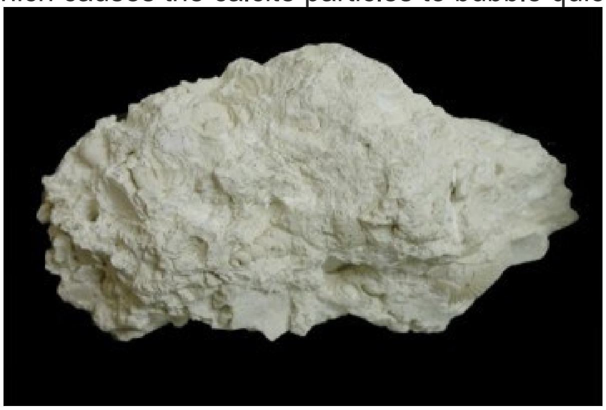


Figure 24: Limestone.

Coquina: A type of limestone made up almost entirely of cemented shell fragments. Coquina was used as a building material (see Figure 17 and Castillo de San Marcos in St. Augustine), but mining is now prohibited. Coquina deposits in Florida occur mostly along the eastern coast of the peninsula.

Figure 25: Coquina.

Agate (Chalcedony): A variety of quartz (SiO2). It is found in a variety of colors, typically gray, brown, black, white and sometimes red. Fossil corals and mollusks may be replaced with agate deposited by silica-rich groundwater percolating through limestone. Agates are classified as a semiprecious stone when it is of desirable quality and color or color banding which is then used as a gemstone. Agate is can be found in Tampa Bay, the Econfina River, and the Withlacoochee/Suwannee riverbeds.

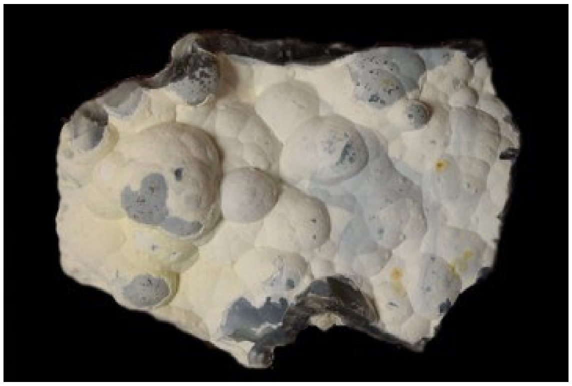


Figure 26: Agate.

Chert (Flint Rock): An extremely fine-grained variety of the mineral quartz. It is characterized by its extreme hardness (7.0 on the Mohs Scale of Hardness) and glass-like fracture. Florida cherts are generally gray in color, though some are bright shades of blue, red, yellow and orange. Chert has very few uses today, but it was historically important as a tool-making material in the past and as a firestarter as chert (flint) produces sparks when it is struck against steel. It is associated with limestone and so can be found throughout the state.

Figure 27: Chert.

Silicified Wood: The original wood has been replaced by silica (SiO_2) in solution or more rarely by clay minerals, making it a fossil rock. Often the fine details of the original tree bark are preserved. This form of petrified wood has been found in Polk County, Hamilton County, and in the river beds of the Suwannee and Santa Fe Rivers in Columbia and Gilchrist counties.

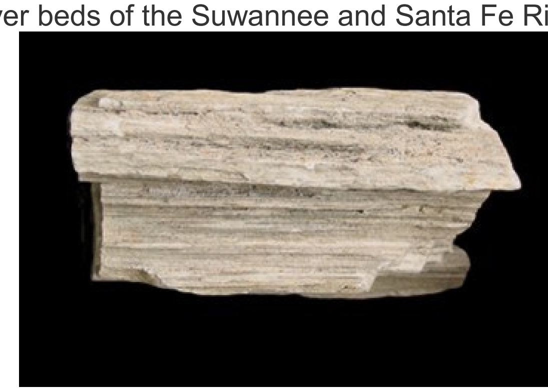


Figure 28: Silicified Wood

Shale: a fine-grained sedimentary rock formed from the compaction of silt and clay-size minerals and is fissile (splits into thin pieces along the layers) and laminated (made up of many thin layers). Florida shale is also associated with oil resources and is a point of controversy for many people concerning the drilling of wells and possible **fracking** to obtain the oil.

ONLINE EXPLORATION:

- **Interactive map of rocks and minerals(USGS): [https://goo.gl/Teqx63]** https://mrdata.usgs.gov/geology/state/map-us.html
- **Geologic Map of the State of Florida: [https://goo.gl/qmm8EV]** http://publicfiles.dep.state.fl.us/FGS/FGS_Publications/MS/MS146_StateGeologicMap/state_geologic_map.pdf
- **1987 Guide to Rocks and Minerals of Florida: [https://goo.gl/WYr45r]** http://publicfiles.dep.state.fl.us/FGS/FGS_Publications/SP/SP8revLaneRocksMinerals.pdf

1.10 Earth History of Florida

SC.912.E.6.2: Connect surface features to surface processes that are responsible for their formation.
SC.6.E.6.1: Describe and give examples of ways in which Earth's surface is built up and torn down by physical and chemical weathering, erosion, and deposition.
SC.7.E.6.5: Explore the scientific theory of plate tectonics by describing how the movement of Earth's crustal plates causes both slow and rapid changes in Earth's surface, including volcanic eruptions, earthquakes, and mountain building.
SC.7.E.6.2: Identify the patterns within the rock cycle and relate them to surface events (weathering and erosion) and subsurface events (plate tectonics and mountain building.

Scientists estimate the age of the Earth at more than 4.5 billion years. The Florida platform was formed about 530 million years ago (MYA) by a combination of volcanic activity and marine sedimentation in the supercontinent **Pangea**. Then Florida would have just been some land squeezed between where the North American, African, and South American tectonic plates were coming together. As these places began to separate during the Mesozoic (250 MYA), a section of the African plate broke off (Florida) and was pulled along with the North American plate. Then around the Jurassic age (150 MYA) a good portion of the state was underwater. By the time of the Cretaceous age (135 MYA) Florida would have been totally underwater. Sometime around the Miocene Epoch (15 MYA) some of Florida was land above the water level again. The land portion continued to expand through the Early Pliocene (see Figure 31) when a good portion of the peninsula was still underwater. But note that during the Pleistocene Epoch, which was also known as the Ice Age, sea levels were as much as 400 feet lower than today for Florida, causing the Florida peninsula to be **savannah-**like land hundreds of miles across instead of maxing at today’s 110 miles at the widest (see Figure 29).

Florida's land as we see it today was created during times of changing sea levels. With corals and shells being deposited and then forming **limestone** carbonates to when ocean currents were bringing silt, clays, and sands. When above sea level, the oceans would erode and reshape the land, while eroding and transporting the land to new locations. The **central ridge** of Florida is the portion of the peninsula with rolling hills and thousands of lakes begins just west of Jacksonville to about Interstate 75 and extend down through the middle of the state to Lake Okeechobee. This central ridge is what is left of ancient dunes that would have been where the beaches were during the then higher sea levels.

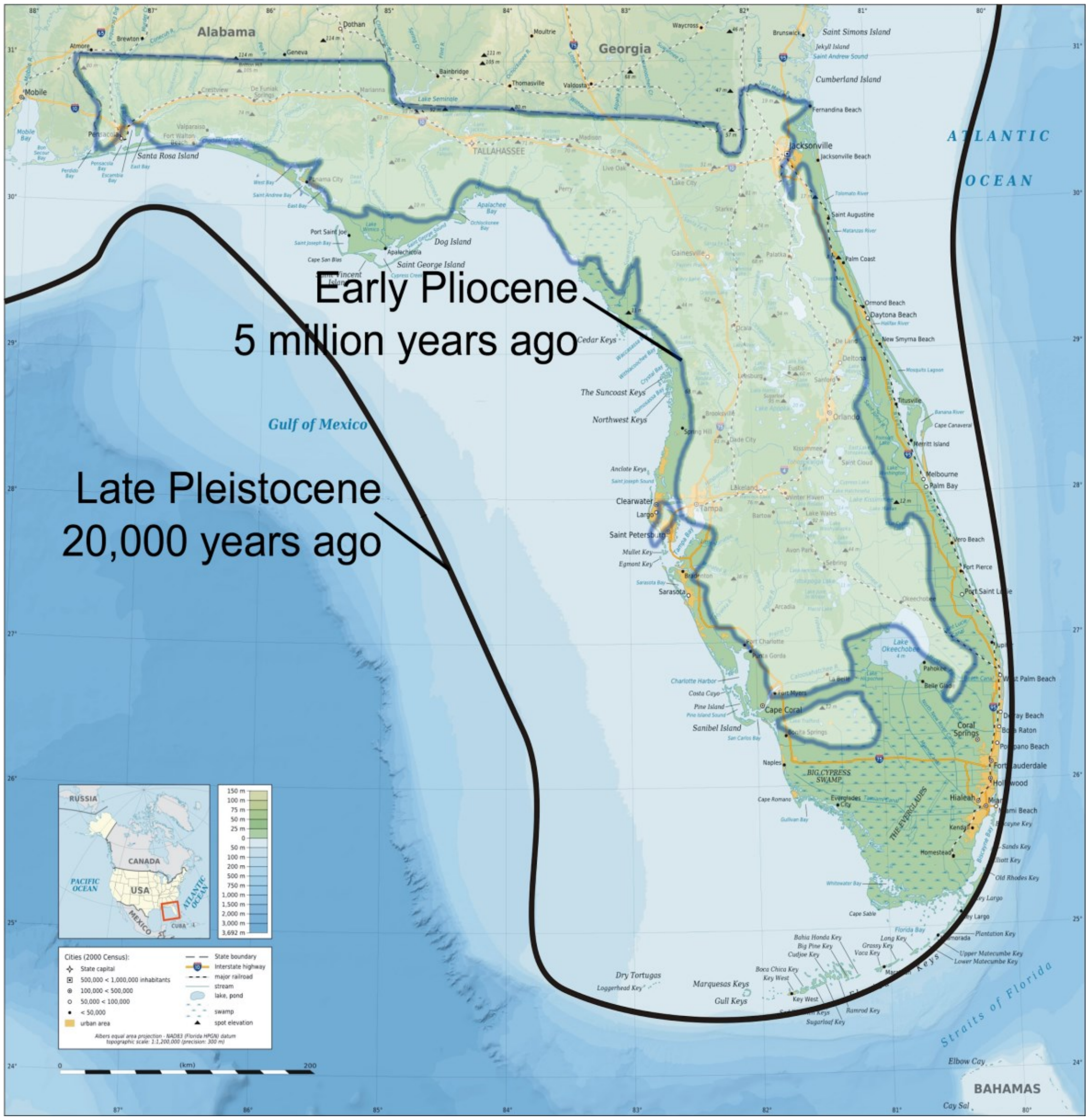


Figure 29: Florida today, 20,000 years ago and 5 million years ago.

ONLINE EXPLORATION:

Visit the interactive Florida's Geologic History website to see Florida through time. [**https://goo.gl/QYGDki**]
http://fdep.maps.arcgis.com/apps/MapSeries/index.html?appid=992bf1a70b734dbea8487aabb6ed5bee

1.11 Florida Fossils

SC.912.L.15.1: Explain how the scientific theory of evolution is supported by the fossil record, comparative anatomy, comparative embryology, biogeography, molecular biology, and observed evolutionary change.

Most of the rock under the sand, clay, and gravel that is covering Florida is limestone, which is a form of **fossil**, it should be no surprise Florida has a very rich fossil record. Its geologic history is a complex one, with changing **tectonic plates**, and being above and below water. It is important to note that with all the fossils that have been found in Florida, there have been no dinosaur fossils ever found in the state. There are still lots of fossils though, and you don't have to dig for them out of rocks, instead if you look hard enough you can find lots of Florida fossils just lying loose on the beach or on the bottom of a stream bed (see Figure 30).

Figure 30: Fossil shark teeth recovered from well tailings at 100 feet deep in Vero Beach Florida. Photograph courtesy of T. Cavanaugh.

First, among the Florida fossils, there is all the state's bedrock limestone. **Limestone** is made up of the shells of animals that used to live in the shallow sea that covered Florida. The limestone that makes up the Florida Keys consists mostly of fossilized corals. Then there are all the shells and shark teeth that can be found on the over six hundred miles of beaches and even the material from digging. Florida has the highest record of **vertebrate** animals in the fossil record for the eastern United States, with over 1,000 different species of vertebrate animals there were known to have lived in Florida over the past 35 million years. So while you can find fossil shells and shark teeth, you can also find the fossils of mastodon, mammoth, sloth, jaguar, alligator, dire wolf, sabercat, short-faced bear, lion, camel, tapir, and even giant armadillo.

If you are going to look for fossils, remember is that in Florida it is illegal to collect vertebrate fossils (excluding shark teeth) without a permit from lands owned by the state. In addition to shark teeth, invertebrate and plant fossils can also be collected without a permit (seashells, echinoids, and petrified wood). State lands include the bottoms of navigable waterways like rivers, lakes and some streams.

ONLINE EXPLORATION:

There are over 750 identified fossil locations in Florida where vertebrate animal fossils have been found, you can read about the sites using the Vertebrate Fossil Sites of Florida website [**https://goo.gl/vuDfCB**] (https://www.floridamuseum.ufl.edu/florida-vertebrate-fossils/species/), **and you can find out about the mammals that were walking around Florida 100,000 years ago by reading the 1958 publication *Fossil Mammals of Florida*** (pdf) **[https://goo.gl/RqqpBR**] (http://www.dep.state.fl.us/geology/geologictopics/floridas_fossil_mammals.pdf).

1.12 Geoarchaeology

SC.912.L.17.16: Discuss the large-scale environmental impacts resulting from human activity, including waste spills, oil spills, runoff, greenhouse gases, ozone depletion, and surface and groundwater pollution.
SC.7.E.6.6: Identify the impact that humans have had on Earth, such as deforestation, urbanization, desertification, erosion, air and water quality, changing the flow of water.

Shell Mounds/Shell Middens

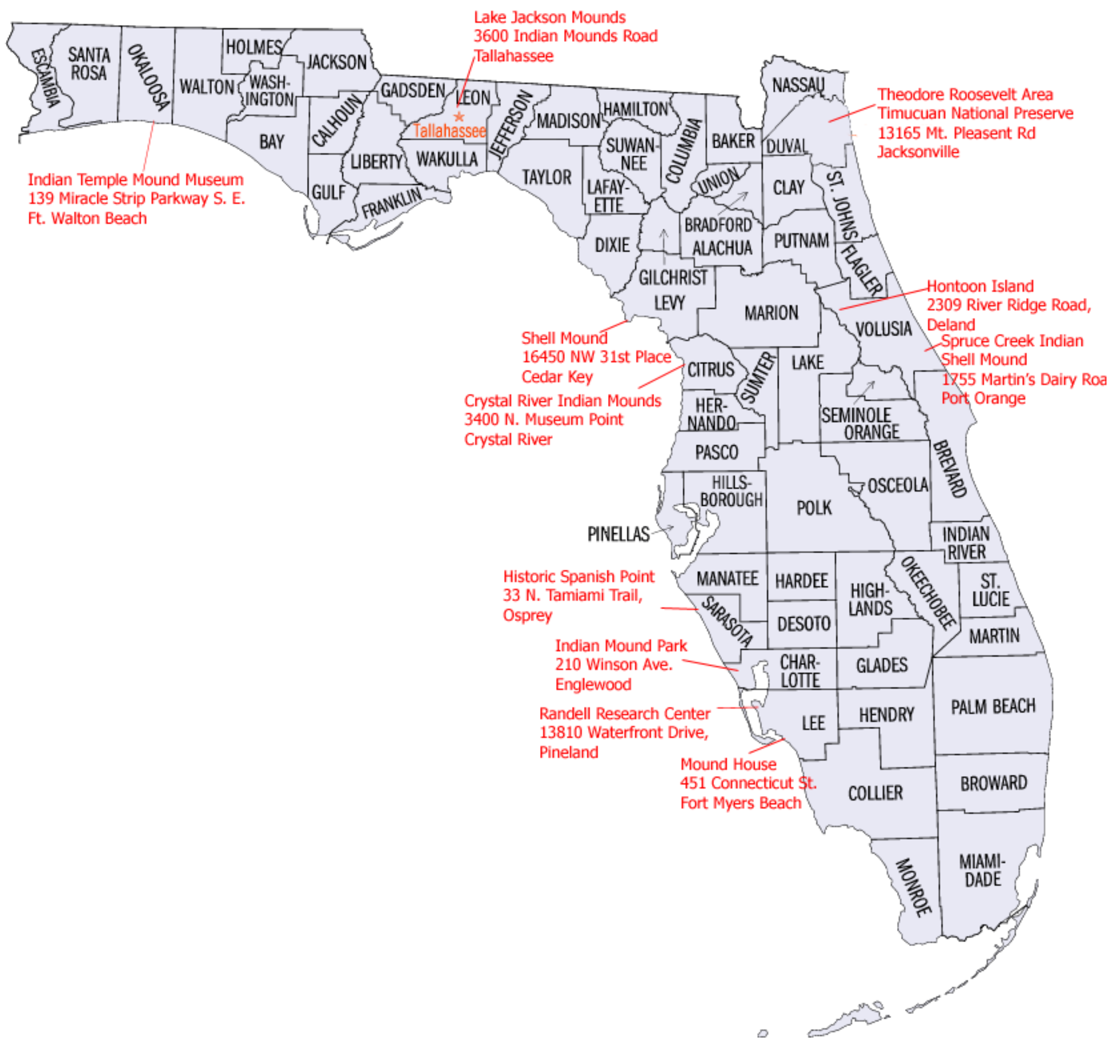


Figure 31: Map of Florida parks with shell mounds

St. Augustine, is known as the oldest continuously settled city in the United States, was officially founded in 1565 (42 years before British founding of Jamestown, Virginia, and 55 years before the Pilgrims landing at Plymouth Rock in Massachusetts). While St. Augustine is known as the oldest city in the United States, the people there were of course not the first peoples in Florida. These people, who lived on the land that would become Florida, depended mostly on fishing and foraging for foodstuffs. Their tools were made from shells, and other resources that could be found and adapted. Tools such as hammers, picks, and scrapers were made by creating small holes in conch, clam, and oyster shells and placing a stick within to form a handle. These were used for digging, hammering, picking, fishing, and performing other tasks. Fish bones and shark teeth were also utilized to create tools. Additionally, shells were used for making jewelry, ornaments. There are Native American sites are scattered all around Florida. One of the things that we still have from these people are the shell mounds that they built. In the early and mid-1900s these shell mounds in Florida were looted for road building materials, but today they are recognized **archeology** sites that contain **relics** (see Figure 31).

A shell midden or shell mound is an archaeological feature consisting mainly of mollusk shells (see Figure 32). Shell middens were formed over time from discarded shells that were left to collect over generations. After a time, ridges would develop in the middens, creating rows of large mounds in a village. These same efforts were then used to create platform mounds to build houses and community space. A midden, by definition, also contains the debris of human activity. Some shell middens are processing remains areas where resources were processed directly after harvest and prior to use or storage in a distant location. Other shell middens are associated with villages, as a designated village dump site. In other middens, the material is directly associated with a house in the village. Each household would dump its garbage directly outside the house. In all cases, shell middens are extremely complex and very difficult to excavate fully and exactly. The fact that they contain a detailed record of what food was eaten or processed and many fragments of stone tools and household goods makes them important objects of archaeological study. The shells also had other uses, such as was found in San Carlos Bay outside of Fort Myers, where archaeologist have discovered under the water the remains of a form of fish trap called a fish weir. This weir was made of two long, jetty like sections of oyster shells where fish would be able to swim in during high tide but could become trapped during low tide.

Figure 32: Shell mound over 30 feet tall and estimated to be 2,500 years old in The Theodore Roosevelt Area in Duval County. Photograph courtesy of T. Cavanaugh.

Another archeology site left from the indigenous people is the Miami Circle in downtown Miami (see Figure 33). It consists of a perfect circle measuring 38 feet (11.5m) of 600 **post molds** that contain 24 holes or basins cut into the limestone bedrock, on a coastal spit of land, surrounded by a large number of other 'minor' holes. It is the only known evidence of a prehistoric permanent structure cut into the bedrock in the Eastern United States, and considerably predates other known permanent settlements on the East Coast. Discovered in 1998, the site is believed to be somewhere between 1,700 and 2,000 years old.

Figure 33: The Miami Circle in downtown Miami. The photograph was taken by Marc Averette [CC 3.0 https://goo.gl/BF8h5A].

2. Oceanography

SC.912.E.7.4 Summarize the conditions that contribute to the climate of a geographic area, including the relationships to lakes and oceans.

One of the things that make Florida different is that it is located in between two different great bodies of water, to the east there is the Atlantic Ocean, and to the west (and south for the panhandle region) there is the Gulf of Mexico. From storms to currents, these great bodies of water have an ongoing influence on the **climate** and industry of Florida.

Figure1: Atlantic ocean off the Florida National Seashore in Volusia and Brevard Counties. Photograph courtesy of T. Cavanaugh

Atlantic Ocean
The Atlantic Ocean (see Figure 1) is the second largest of the world's oceans, with an area of about 41,100,000 square miles (106,460,000 square kilometers). It covers approximately 20 percent of the Earth's surface and about 29 percent of its water surface area. The **Gulf Stream** and its flow out of the gulf and then it flows north and then east towards Europe, and the North Atlantic Drift are thought to have at least some influence on climate. For example, the Gulf Stream helps moderate winter temperatures along the coastline of southeastern North America, keeping it warmer in winter along the coast than inland areas. The warm waters of the Gulf Stream also keep extreme temperatures from occurring on the Florida Peninsula.

Gulf of Mexico
The Gulf of Mexico (see Figure 2) formed approximately 300 million years ago as a result of **plate tectonics**. The Gulf of Mexico basin is roughly oval and is approximately 930 miles (1,500 km; 810 nautical miles) wide and the bottom is **sedimentary rocks** and recent sediments. It is connected to the Atlantic Ocean through the Florida Straits between the U.S. and Cuba, and

with the Caribbean Sea. With the narrow connection to the Atlantic, the Gulf experiences very small tidal change. The size of the Gulf basin is approximately 615,000 square miles (1.6 million km^2). Almost half of the basin is shallow continental shelf waters. The gulf's warm water temperature can feed powerful Atlantic hurricanes causing human death and other destruction. In the Atlantic, a hurricane will draw up cool water from the depths and making it less likely that further hurricanes will follow in its wake (warm water being one of the conditions necessary for hurricane formation). However, the Gulf is a shallow water body; so when a hurricane passes over, the water temperature may drop but it soon comes back up and becomes capable of supporting another tropical storm.

Figure 2: The Gulf of Mexico at Indian Rocks Beach in Pinellas County. Photograph courtesy of T. Cavanaugh

2.1 Longshore Currents

SC.912.L.17.3: Discuss how various oceanic and freshwater processes, such as currents, tides, and waves, affect the abundance of aquatic organisms.
SC.6.E.6.1: Describe and give examples of ways in which Earth's surface is built up and torn down by physical and chemical weathering, erosion, and deposition.

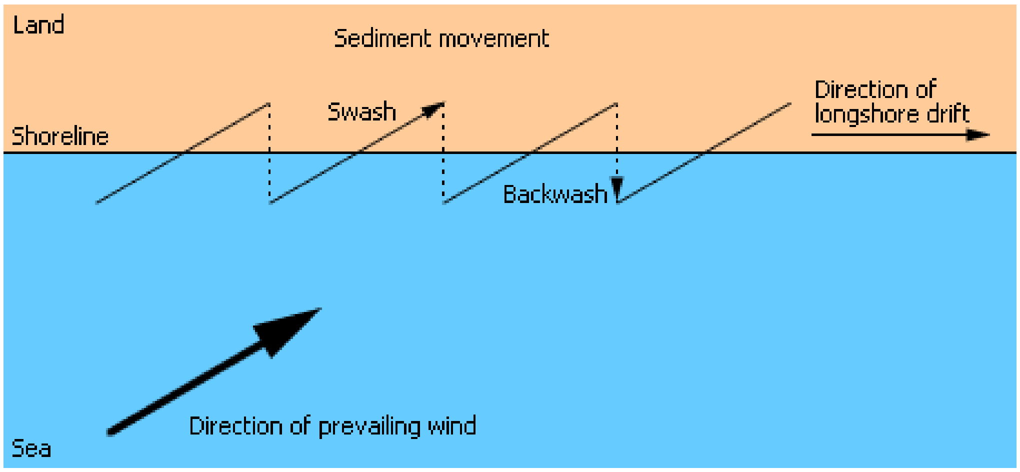


Figure 3: Longshore transport using swash and backwash. Image courtesy of Fiveless [CC-SA 3.0 https://goo.gl/BCx6tC].

Longshore current, also known as longshore drift, longshore transport or littoral drift is the name for the movement of water and sediments along the shore, parallel to the coast with the direction of the current generally from north to south along the Atlantic shore because the waves from the northeast have greater energy than those of southeastern waves. This movement of sediments is a result of wave action and the longshore currents that flow parallel to the coast (see Figure 3). A longshore current will form when waves approach the shoreline at an angle to the coast. The speed and direction that the wave has a vector, and that can be broken into two parts: the wave is both toward (perpendicular) and along (parallel) the shore. Beach sand is also moved with longshore currents, due to the wave action, the swash (incoming) and backwash of water on the beach. The breaking wave (surf) sends water up the beach (swash) at an angle and gravity then drains the water straight downslope (backwash) perpendicular to the shoreline (see Figure 4). This repeated zig-zag motion can move sand many tens of meters per day along the beach. On some beaches, more than 1 million tons of sand passes by a location on the beach by the process of longshore drift every year. If you look at the sand composition of Florida's northeast coast, there you will find that the sand is mostly the mineral quartz, a mineral which forms in igneous and metamorphic rocks - rocks not found on the surface of Florida. The sand in the northeast Florida beaches was originally formed from the weathering of the Appalachian Mountains and then moved by rivers to the Atlantic coast. At the coast, the sand was moved by longshore currents down the east coast until it eventually reached Florida.

Many people experience the effects of longshore currents without even realizing it. If you have ever gone swimming at the beach, you most likely were moved by a longshore current. For example, if you go out directly from a beach location (lifeguard station, your family/friends, a beach access point), and then start swimming around or floating (not touching the bottom), you should notice that you are moving along the coast. To stay in place you would have to swim against the longshore current.

Figure 4: Wrack line of material moved onshore by wave action (swash) along Jacksonville Beach in Duval County. Photograph courtesy of T. Cavanaugh.

ONLINE EXPLORATION:

You can explore the waters, currents, temperatures and more using [Earth: A visualization of Global Weather Conditions](https://earth.nullschool.net), this site uses current data and animation to show the conditions (this link is preset to show Florida, the Gulf and the Atlantic, showing surface water temperatures and currents): [**https://goo.gl/ZjoEYW**]
https://earth.nullschool.net/#current/ocean/surface/currents/overlay=sea_surface_temp/grid=on/orthographic=-84.83,27.00,3000/loc=163.958,-89.479

2.2 Beach Erosion

SC.6.E.6.1: Describe and give examples of ways in which Earth's surface is built up and torn down by physical and chemical weathering, erosion, and deposition.
SC.7.E.6.6: Identify the impact that humans have had on Earth, such as deforestation, urbanization, desertification, erosion, air and water quality, changing the flow of water

Just as sand can be moved and put down, to form beaches with barrier islands or on the upcurrent of jetties, beaches can also lose sand, this loss is called **beach erosion**. If too much of a beach is lost, then it can be identified as a critical erosion area (see Figure 5). "Critically eroded" is defined as "a segment of shoreline where natural processes or human activities have caused or contributed to erosion and recession of the coastal system to such a degree that upland development, recreation, wildlife habitat, or important cultural resources are threatened or lost." Critical erosion areas may also include nearby segments of shoreline or the spaces between critical erosion areas. This is because while they may be stable or slightly eroded now, they need to be included to help with the management of the whole coastal system or for how it could impact other nearby beach management projects.

Figure 5: 2004 beach erosion in Volusia County. Photograph courtesy of Florida Geologic Survey.

What can cause the beach to erode? This could be either from a natural cause or a man-made one. For example, when **jetties** are put out into the ocean, perhaps to protect shipping lanes or to create fishing jetties, the jetties change the longshore current flow, causing sand to be put down on the upcurrent side of the jetty, but removed from the downcurrent side (see Figure 6).

Figure 6: Jetties at Fort Pierce Inlet Fort Pierce Florida in St. Lucy County. Photograph by D. Ramey Logan from Wikimedia Commons [CC-SA 4.0 https://goo.gl/oZyyQG].

Nature can also cause beach erosion. Anything that might change the flow of coastal currents, a new **sandbar** or **barrier island** would change how sand is deposited and removed. If something changes in the rivers flowing into the ocean such as a change in the amount of water flowing or the river's speed (carrying more or fewer deposits), then the shape and structure of the beach where the river exits could change. One of the natural things that can cause a lot of erosion in a short period of time is a **hurricane**. Hurricanes can cause coastal erosion and other shoreline changes with their high winds, increased ocean water height (storm surge), and strong wave action along the coast. Several factors contribute to a storm's strength and destructive power, including wind speed, wind direction, wave action, and the status of the tide when the storm hits the land. The hurricane waves can carry the sand offshore, depositing and storing the sediment offshore such as in sandbars or moving it much further down the coast (see Figure 7).

Figure 7: Notice the movement of sand from before and after a hurricane. Photograph courtesy of NOAA.

2.3 Beach Reclamation

SC.7.E.6.6: Identify the impact that humans have had on Earth, such as deforestation, urbanization, desertification, erosion, air and water quality, changing the flow of water.

Depending on the situation it may be possible to rebuild or put back the beach through a **beach reclamation** or beach nourishment process. One of the more common ways to do beach reclamation is through offshore dredging. In this process, sand from just offshore is scooped up from the bottom and then pumped to the existing beach where it may be cleaned or filtered before it is spread along the shore (see Figure 8). The "new" sand is then moved to extend the shoreline to its original size and shape or extends the beach farther into the ocean.

Figure 8: Beach reclamation occurring along the Duval County beaches. Images courtesy of T. Cavanaugh

3 Weather/Climate

Some Florida Weather Facts

Rainfall

South Florida: 39.8-70.4 inches (101.3-178.8 centimeters)
Central Florida: 46.3-53.6 inches (117.6-136.1 cm)
North Florida: 49.0-71.0 inches (124.4-180.3 cm)
Florida Panhandle: 56.8-71.0 inches (144.2-180.3 cm)

Temperature

Florida is the warmest place in the continental United States. The main reason is the latitude of the peninsula, the state lies between 24°30'N and 31°N in the southeastern part of the country.

Average Annual Temperatures for Summer:
80.5 (F) degrees (26.9 C) (North Florida)
82.7 (F) degrees (28.2 C) (South Florida)

Average Annual Temperatures for Winter:
53.0 (F) degrees (11.7 C) (North Florida)
68.5 (F) degrees (20.3 C) (South Florida)

Figure: Clouds at sunset. Photograph courtesy of T. Cavanaugh

3.1 Climate

SC.6.E.7.6: Differentiate between weather and climate.
SC.912.E.7.4: Summarize the conditions that contribute to the climate of a geographic area, including the relationships to lakes and oceans.
SC.6.E.7.2: Investigate and apply how the cycling of water between the atmosphere and hydrosphere has an effect on weather patterns and climate.

Figure 1: Fort Lauderdale, Florida, is at risk from rising sea levels associated with climate change. Credit: Dave/Flickr Creative Commons/CC BY 2.0.

Climate is **weather** over a long period of time (weather is what is happening today). Florida falls within the borders of two climate zones – tropical and subtropical (and the bit of space between the two which can go either way depending on the weather that occurs that year) (see Figure 2). Although subtropical and tropical climates are very different from each other, there are some common features. For example, summers over the entirety of the state are very hot, humid, and quite rainy.

The **subtropical** climate zone of Florida covers most of the northern section of the state (north of Tampa). This climate usually has colder winters, a greater temperature difference between summer and winter temperatures. Temperatures average along the coast of Northern Florida are about 63°F (17°C) in January and reach to about 91°F (32°C) in August. The transitional climate zone is found between the latitude you find Tampa and Lake Okeechobee. The **tropical** climate zone of Florida has features such as the abundance of rainfall throughout the year, with a nice winter that is sunny, has a smaller number of rainy days and lower humidity. Temperatures in the tropical climate zone of Florida are high all year, ranging on average around 74°F(23°C) for the high during the day in January and about 88°F (32°C) as the average high during the day in August. At the northwestern point of the tropical climate zone, you will find Fort Myers, where the south side of the Caloosahatchee River is more tropical than that of the river's other side. This is one of the reasons why Edison was able to experiment by growing tropical rubber plants.

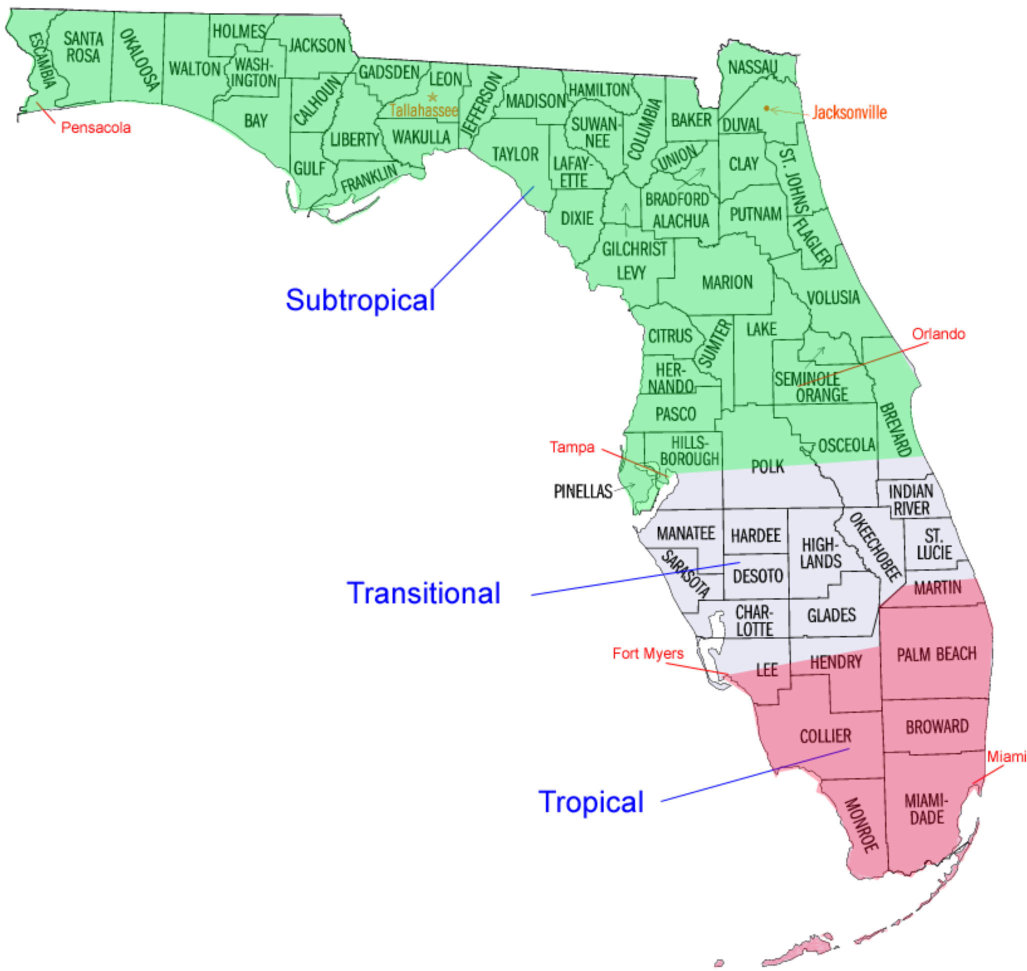


Figure 2: Florida climate zone map.

3.2 Land/Sea Breeze

SC.6.E.7.3: Describe how global patterns such as the jet stream and ocean currents influence local weather in measurable terms such as temperature, air pressure, wind direction and speed, and humidity and precipitation.

The **sea/land breezes** are local wind currents that are driven by the difference in temperature between the water and land surfaces. During the day, the air above the land will heat up faster than the air above the water. This warm air tends to rise and is replaced by cooler air over the ocean moving inland, this is a sea breeze. At night, the land tends to cool more rapidly than the water and the land temperature may become lower than the water temperature. This leads to the creation of a land breeze (the opposite of a sea breeze).

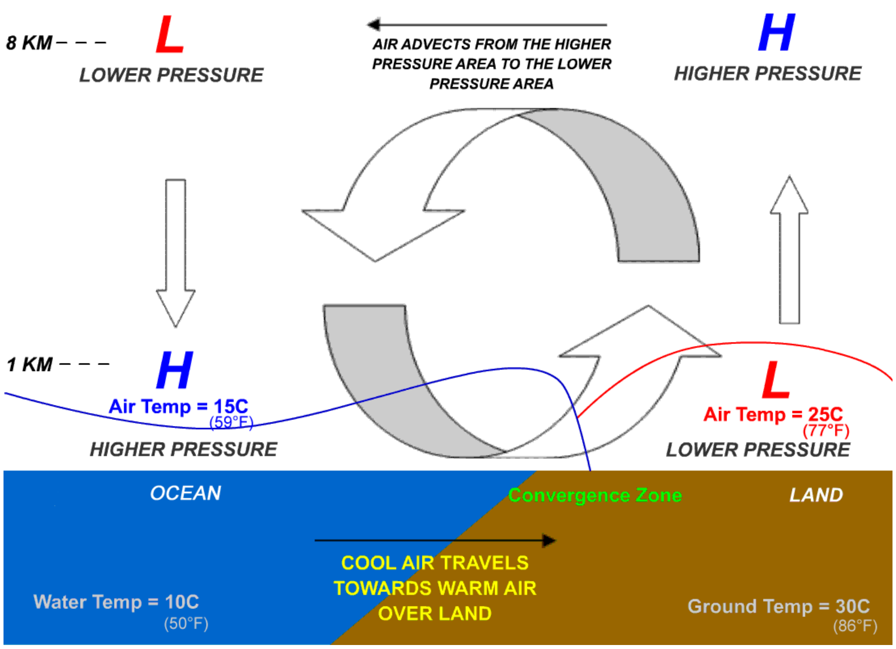


Figure 3: Uneven heating of the earth's surface causing sea breeze, image courtesy of Vaughan Weather [CC 3.0].

Usually throughout the peninsula during the spring and summer, there will be a daily change between a sea breeze and a land breeze. These air currents form in part due to the ocean's ability to absorb and store energy. During the day the sun heats the earth's surface, but since the ground's heat is kept near the surface, it can heat up rapidly and then begin warming the air. As the air over the ground heats up, it expands and its pressure decreases causing the air to move up, the cooler air over the water then moves in (sea breeze) to take the place of the air moving up over the land. Throughout the day as the moist air comes in from above the ocean to above the land, where it is heated and then rises. As it rises it cools and then forms clouds (see Figure 3). When the weather conditions are right, thunderstorms will develop because of this pattern in the later afternoon (see Figure 4). For example, in Florida, the amount of sunshine and way the surface wind moves over the state has a large impact on sea breeze thunderstorms. If the wind is relatively calm, then the sea breeze can move well inland but with only scattered thunderstorms occurring about a third of the way across the peninsula.

Figure 4: Typical summer afternoon sea breeze thunderstorm moving in from the Everglades to over Miami. Image courtesy of Marc Averette [CC 3.0 https://goo.gl/13xuKU].

The opposite of a sea breeze is a land breeze. While sea breezes occur during the day, land breezes occur at night. Despite the difference in times at which the land breezes and sea breezes occur, the reason for the land breeze's formation is basically the same as the sea breeze, but the role of the ocean and land is reversed. Land breezes can occur when the land's nighttime temperature is less than the sea surface temperature. They are most common during the fall and winter seasons when water temperatures are still fairly warm, and nights are cool. However, unlike the sea breeze, the land breeze is often much weaker. At night, the land temperature falls to below that of the ocean resulting in an increase in the air's density. Gravity's downward pull moves the now dryer air downhill spilling it over the water.

3.4 Major Storms

If you watch the weather on the TV news or the Weather Channel you will find that just every American city can have some kind of major storm. The major storms in the U.S. are heavy rainstorms, severe snowstorms, thunderstorms, and hurricanes. While we haven't had any severe snowstorms in Florida, throughout the state we do get the other three pretty regularly. Of the cities with populations of over a million people, Jacksonville, Miami, Orlando, and Tampa, all are known for their high counts of major rainstorms, thunderstorms, and hurricanes.

City	Average number of day with over 1 inch or more of rain per year.	Average number of day with thunderstorms per year	Number of hurricanes within 50 miles of city (1900-2011)
Miami	**18.6**	72.3	**22**
Jacksonville	15.6	68.4	6
Orlando	15.0	81.8	14
Tampa	14.2	**82.7**	10

About snow in Florida, it does happen, just not often and not much. Except for the northern areas of the state, most of the cities in Florida have rarely had enough snow to measure (usually just trace amounts), and the Keys there is no recorded instance of any kind of snow. The record snowfall for Florida was 1.9 inches (4.8 cm) in Jacksonville in 1899.

3.5 Thunderstorms

SC.6.E.7.7: Investigate how natural disasters have affected human life in Florida.
SC.6.E.7.8: Describe ways human beings protect themselves from hazardous weather and sun exposure.
SC.912.E.7.6: Relate the formation of severe weather to the various physical factors.

While Florida is known as the Sunshine State, it is also has a bad reputation for having thunderstorms and lightning strikes. The combination of heat, **humidity** and sea breezes from the Gulf and Atlantic coasts makes the ideal breeding ground for thunderstorms over the Florida Peninsula. When upper winds are light, two sea breeze fronts (from each side of the peninsula) may join up and produce thunderstorms. This is why over the Florida Peninsula during the late spring and summer you get thunderstorms so often during the late afternoon and early evening hours in the summertime. The number of thunderstorms in Florida drops off sharply in the fall. Virtually all summer rainstorms are accompanied by thunder and lighting. No other part of the United States has more thunderstorm activity than Florida (see Figure 5), some parts of the state have over 100 thunderstorm days, as compared to the west coast of the U.S. which has about only five days a year that have a thunderstorm.

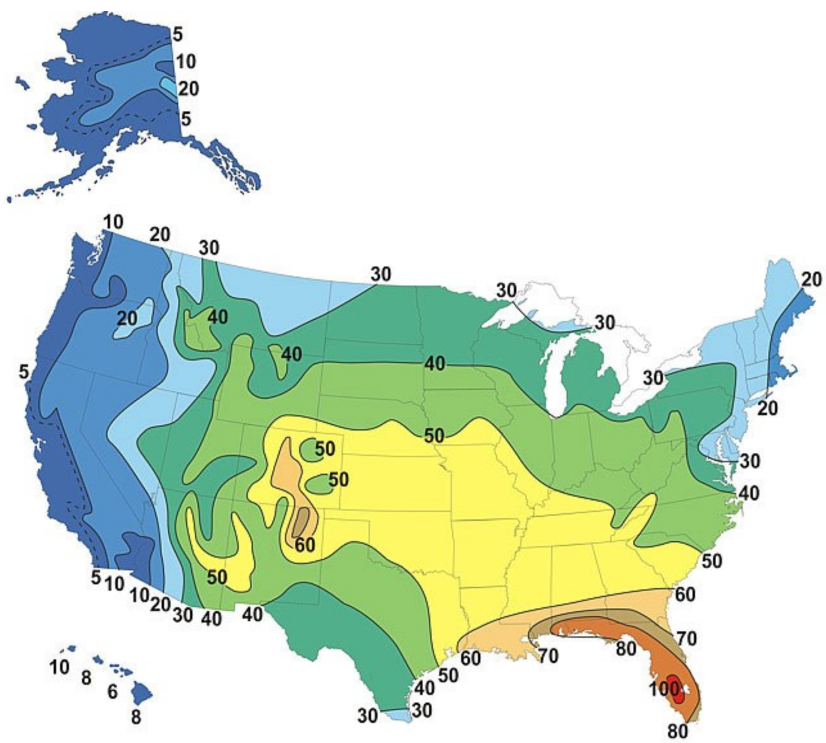


Figure 5: The average number of thunderstorm days each year throughout the U.S. with Florida getting between 70 and 100 thunderstorms a year. Courtesy of the National Weather Service.

The simplest definition of a **thunderstorm** is a local storm that produces lightning and thunder. The storm can be a single cumulonimbus cloud, a cluster of several thunderstorms, or a line of thunderstorms. For thunderstorms to form, there needs to be moisture and unstable air.

- Moisture - to form clouds and rain, such as air coming off an ocean.

- Unstable air - warm air that can rise rapidly, such as air over warm land that produces lift.

With these storms, you also get lightning and high winds. On average, Florida has 3,500 cloud-to-ground lightning flashes per day and 1.2 million flashes per year (see Figure 6). Lightning is the number two thunderstorm-related killer in the U.S. On average killing more people each year than deaths from tornadoes and hurricanes (flooding is the #1 killer).

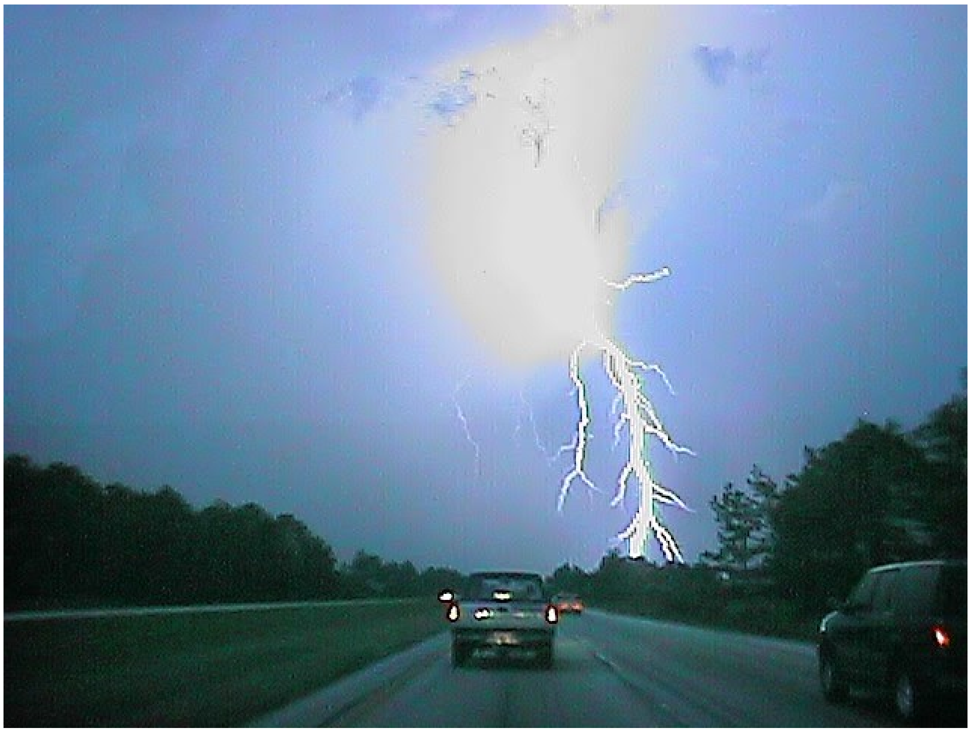


Figure 6: Cloud to ground lightning strike off of I-75 in Sarasota County. Photograph courtesy of T. Cavanaugh.

With the lightning, you also get the sound of thunder. Thunder is the sound or audio pressure (compression) wave produced by a giant static electrical spark known as lightning. Nearly all lightning is generated by thunderstorms. You can use the flash of lightning and then its sound of thunder to help protect yourself and others. The flash-to-bang method of protection uses the amount of time between when you see the lightning flash to when you hear the thunder. Light from lightning travels at the speed of light, is moving at about 186,000 miles per second (300,000 km/second) so the light gets to you in almost no time, thunder though travels at the speed of sound about 0.213 miles per second (a lot slower). So that means that there is a noticeable time delay between when you see the flash and when you hear the sound of the thunder. Every five seconds you can count between the flash and the sound means the lighting is another mile away, and if you can't count to five between flash and sound, then the lighting is really close. One lightning safety recommendation is the 30/30 Rule. Using the flash-to-bang method, lightning that has a 30-second count between the flash and the thunder is 6 miles (9.6 km) away or less, then you should get to a protected place. And that you should wait 30 minutes after hearing the last sound of thunder or seeing the last lightning in daytime before returning to any outside activity. Usually, thunder sounds are seldom heard beyond 10 miles (16 km), a 50-second time count. Distant thunder has characteristic low-pitched rumbling sounds, this rumbling sound is an effect from the fact that sound waves are emitted from different locations all along the lightning bolt, which are at varying distances from a person. The longer the lightning, the longer the sound of thunder. Florida actually holds the world record for thunder, as Tallahassee once had 24 hours of non-stop thunder.

Also with these thunderstorms, you can get a lot of wind. Damaging winds are more likely to be associated with thunderstorms than tornadoes. The source of the damaging winds is often the downdraft within the thunderstorm and can be mistaken for a tornado. A downdraft is a column of cool air that rapidly sinks to the ground that is usually accompanied by rain in a thunderstorm. These downdrafts or downburst can be classified as either **microburst** or **macrobursts**.

- Microburst: A downdraft that can affect an area of less than 2½ miles (4 Km) wide with peak winds lasting less than 5 minutes.
- Macroburst: A downdraft that can affect an area of at least 2½ miles (4 Km) wide and with peak winds lasting between 5 and 20 minutes. Intense macrobursts may cause tornado-force damage of up to F3 intensity (roofs and some walls tore off, lots of trees uprooted, cars lifted off the ground).

ONLINE EXPLORATION:

LightningMaps.org provided real-time lightning tracking, this site uses current data and animation to show the lightning conditions (this link is preset to show Florida, the Gulf, and the Atlantic): [**https://goo.gl/JGyZGQ**]
https://www.lightningmaps.org/?lang=en#m=oss;t=3;s=0;o=0;b=;ts=0;y=28.3189;x=-82.4908;z=7;d=2;dl=2;dc=0;

3.6 Hurricanes

SC.6.E.7.7: Investigate how natural disasters have affected human life in Florida.
SC.912.E.7.6: Relate the formation of severe weather to the various physical factors.
SC.912.E.7.5: Predict future weather conditions based on present observations and conceptual models and recognize limitations and uncertainties of such predictions.

Figure 7: Hurricane Isaac 2012. Photograph courtesy of NASA.

Hurricanes are powerful massive storms systems, that can be hundreds of miles across, that form over warm ocean waters and may move toward land (see Figure 7). Threats from hurricanes include powerful winds, heavy rainfall, storm surges, coastal and inland flooding, rip currents, tornadoes, and landslides. The Atlantic hurricane season runs from June 1 to November 30. The figure below shows the number of times a hurricane has come to a Florida county between 1900 and 2010, notice that Monroe county in the southwest corner of the state, but Monroe also includes the Florida Keys, has had the greatest number with 32 (see Figure 8).

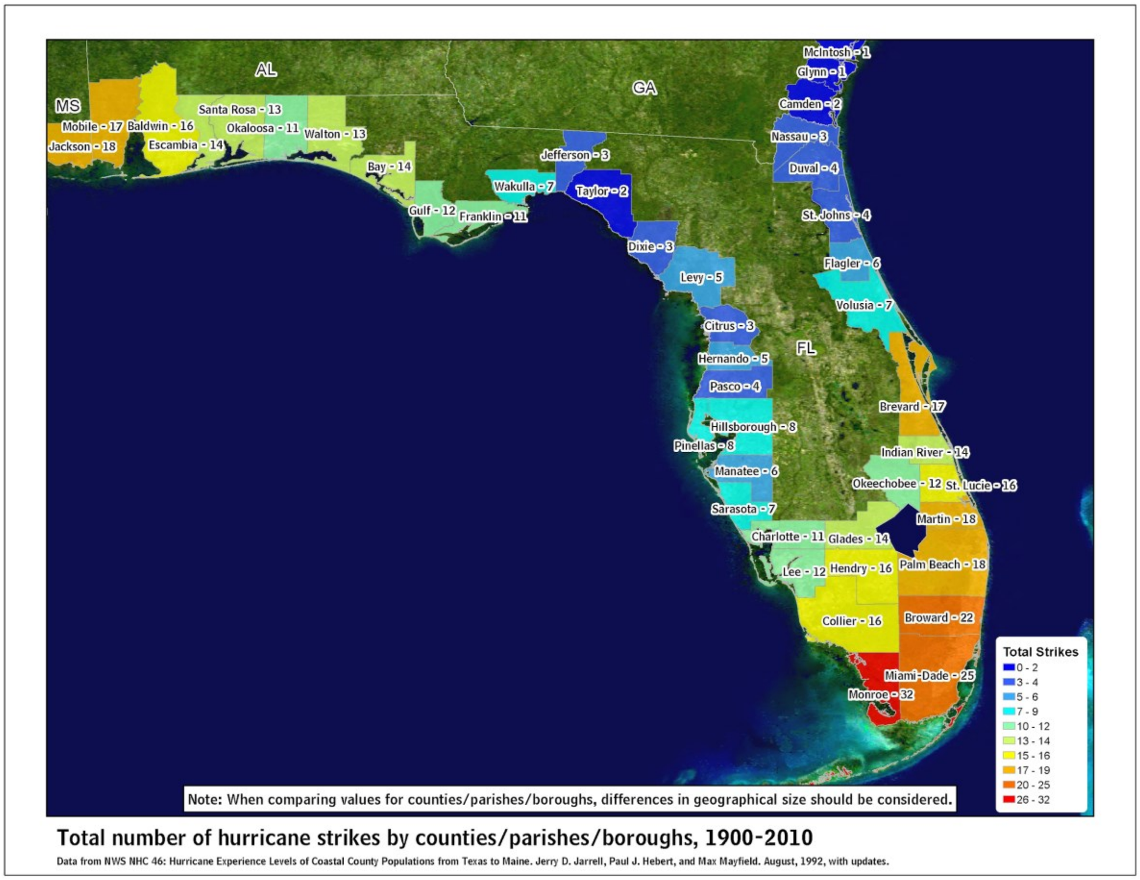


Figure 8: Hurricane strikes by county 1900-2010. Image courtesy of NOAA.

Hurricanes are the most violent storms on Earth. The scientific term for a hurricane is a **tropical cyclone**. Only tropical cyclones that form over the Atlantic Ocean or the eastern Pacific Ocean are called "hurricanes." These tropical cyclones use warm, moist air for the energy to form. That is why they form only over warm ocean waters near the equator. The warm, moist air over the ocean rises upward from near the surface. Because this air moves up and away from the surface, there is less air left near the surface, causing an area of lower air pressure, which is why these storms will start as a **tropical depression** (note: not all tropical depressions become big storms). As the air (at higher pressure) moves into the low-pressure zone, it too becomes warm and moist and rises. As the warm air rises the surrounding air spins or swirls in to take its place. When the warm moist air rises and cools off, it forms clouds. The whole system of clouds and wind spins and grows, powered by the ocean's heat and water evaporating from the surface, creating what is called a “tropical depression.” As the storm system grows stronger, it rotates faster and faster, and an **eye** (a clear zone) forms in the center. It is very calm and clear in the eye, with very low air pressure. When the winds in the rotating storm reach 39 mph, the storm is then called a "tropical storm." If the storm continues to grow stronger, then when the wind speeds reach 74 mph, the storm is officially a "tropical cyclone," or hurricane.

Hurricanes usually weaken when they hit land because they are no longer getting more power by the energy from the warm waters. However, they often move far inland, dumping many inches of rain and causing lots of wind damage before they die out completely. The storms are categorized by their wind speed, with the stronger the storm the higher the number (1-5).

Saffir-Simpson Hurricane/Tropical cyclone categories:			
Category	**Wind Speed (mph)**	**Damage at Landfall**	**Storm Surge (feet)**
1	74-95	Minimal	4-5
2	96-110	Moderate	6-8
3	111-129	Extensive	9-12
4	130-156	Extreme	13-18
5	157 or higher	Catastrophic	19+

ONLINE EXPLORATION:

- **If you want to see how many hurricanes have "hit" your location over the years, visit the NOAA Interactive hurricane search map:** https://coast.noaa.gov/hurricanes/ **.**
- **Weather Channel's Hurricane Storm Surge Simulation video:** [**https://goo.gl/UcUKuB**] https://www.youtube.com/watch?v=kfjKsfbLitY

3.7 Tornados

SC.6.E.7.7: Investigate how natural disasters have affected human life in Florida.
SC.912.E.7.6: Relate the formation of severe weather to the various physical factors.
SC.912.E.7.5: Predict future weather conditions based on present observations and conceptual models and recognize limitations and uncertainties of such predictions.

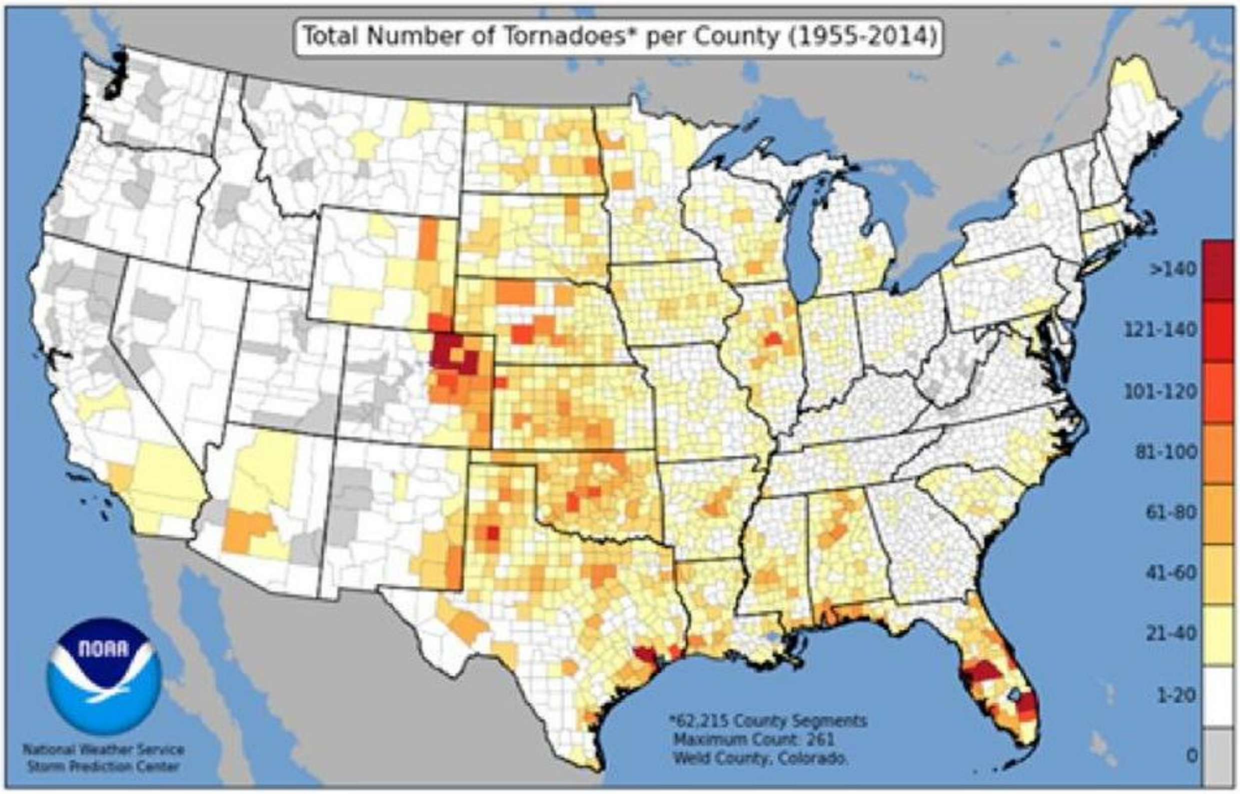


Figure 9: Total number of tornadoes per county (1955-2014). Image Source: NOAA Storm Prediction Center.

A **tornado** is a focused rotating column of air that comes in contact with the ground. They are associated with severe thunderstorms and occur below a spiraling updraft. They can produce wind speeds as high as 300 miles an hour and have been seen to be over a mile wide.

In the United States, there are two regions of the country that have a lot of tornadoes (see the Total number of tornadoes map from NOAA - Figure 9). The famous and often shown in movies "Tornado Alley" in the south-central United States is one region and Florida is the other. Florida has numerous tornadoes simply due to how often Florida has thunderstorms, which is almost daily. In addition, several tropical storms or hurricanes often cross onto or next to the Florida peninsula and panhandle each year. When these tropical systems move ashore, the moving air inside the storm’s rain bands often produces tornadoes. However, despite the violent nature of a tropical storm or hurricane, the tornadoes they create (some as waterspouts) tend to be weaker than those produced by non-tropical thunderstorms.

Many counties in Florida may have large numbers of tornadoes because, in addition to regular tornadoes, there are also a number of waterspouts, landspouts, and gustnadoes, these are tornado-like but not associated with supercells. Waterspouts fall into two categories: fair weather waterspouts and tornadic waterspouts. Waterspouts are tornadoes that form over water or move from land to water (see Figure 10). They have the same characteristics as a land tornado, in that they are often associated with thunderstorms (but they don't have to be severe), and are often accompanied by high winds and seas, large hail, and frequent dangerous lightning, but they are not as strong and are usually less than 100 yards wide (91 m). Florida is the number one region for waterspouts for the United States.

Figure 10: According to NOAA's National Weather Service, the best way to avoid a waterspout is to move at a 90-degree angle to its direction of movement. Photograph courtesy of NOAA.

ONLINE EXPLORATION:

Weather Channel tornado simulation with the EF scale:

[**https://goo.gl/LYHV3y**] https://www.youtube.com/watch?v=0cODBQqaGTw

4 Biology

Figure 1: Florida alligator in the Shark River region of the Everglades which is a Flooded Grasslands and Savannas biome, Miami-Dade County. Photograph courtesy of T. Cavanaugh.

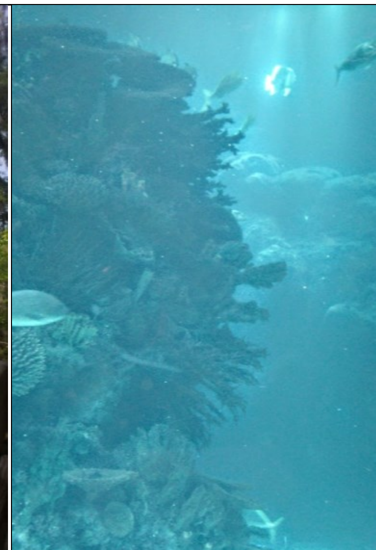
4.1 Biomes

SC.6.E.6.2: Recognize that there are a variety of different landforms on Earth's surface such as coastlines, dunes, rivers, mountains, glaciers, deltas, and lakes and relate these landforms as they apply to Florida.
SC.7.L.17.3: Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.

A **biome** is a community of plants and animals that have common characteristics for the environment they exist in. Biomes are distinct biological communities that have formed in response to a shared physical climate. A biome is a broader term than a **habitat**, as a biome can be made of a variety of habitats. While Florida may not have all of the biomes, such as ones that are colder, higher (like in the mountains), or desert-based we do have a number of terrestrial, freshwater and marine biomes.

Online Exploration:

- **For more information on biomes, visit the WWF page on biomes/ecoregions: https://www.worldwildlife.org/biomes**
- **NASA created Mission: Biomes! was designed for use in classrooms as a supplementary, interdisciplinary unit. Mission: Biomes and is appropriate for middle grades:** [**https://goo.gl/hfRKfw**] https://earthobservatory.nasa.gov/experiments/biome
- **Virtually visit other biomes with ASU's Virtual Biomes** (Computer/Smartphone/Googles): [**https://goo.gl/s4QPnf**] https://askabiologist.asu.edu/explore/Virtual-360-Biomes

Florida Biomes		
		
Terrestrial	**Freshwater**	**Marine**
• Tropical and subtropical moist broadleaf forests (South Florida hardwood hammocks) • Temperate coniferous forests (example: Ocala National Forest and Florida Scrub) • Flooded grasslands and savannas (The Everglades) • Mangrove (coastal along a large part of the peninsula)	• Large lakes (Lake Okeechobee) • Temperate coastal rivers (western panhandle) • Tropical and subtropical coastal rivers (Florida peninsula)	• Temperate shelves and sea (continental shelf Atlantic and Gulf) • Tropical coral (reefs off the Keys)

Images courtesy of T. Cavanaugh

4.2 Ecoregions/Ecosystems

SC.6.E.6.2: Recognize that there are a variety of different landforms on Earth's surface such as coastlines, dunes, rivers, mountains, glaciers, deltas, and lakes and relate these landforms as they apply to Florida.
SC.7.L.17.3: Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.

Ecological regions or Ecoregions are areas of similarity in ecosystems and in the type, quality, and quantity of environmental resources. Florida has 20 ecoregions that are spread across three regions of the state, they include:

Southeastern Plains (North Florida along the upper portion of the panhandle)

- Southern Pine Plains and Hills
- Dougherty Plain
- Tifton Upland
- Tallahassee Hills/Valdosta Limesink
- Southeastern Floodplains and Low Terraces

Figure 2: Suwannee River outside of White Springs, part of the Tallahassee Hills/Valdosta Limesink ecoregion (Hamilton County). Photograph courtesy of T. Cavanaugh.

Southern Coastal Plain (gulf coast of the panhandle and the Florida peninsula down to about Lake Okeechobee)

- Gulf Coast Flatwoods
- Southwestern Florida Flatwoods
- Central Florida Ridges and Uplands
- Eastern Florida Flatwoods
- Okefenokee Plains
- Sea Island Flatwoods
- Okefenokee Swamps
- Floodplains and Low Terraces
- Sea Islands/Coastal Marsh
- Gulf Barrier Islands and Coastal Marshes
- Big Bend Coastal Marsh

Figure 3: Marsh in the Timucuan Preserve, part of the Sea Islands/Coastal Marsh ecoregion (Duval County). Photograph courtesy of T. Cavanaugh.

Southern Florida Coastal Plain (south Florida below Lake Okeechobee)

Everglades
Big Cypress
Miami Ridge/Atlantic Coastal Strip
Southern Coast and Islands

Figure 4: Corkscrew swamp, part of the Big Cypress ecoregion (Collier County). Photograph courtesy of T. Cavanaugh.

ONLINE EXPLORATION:

For more detailed information on ecoregions, visit the EPA's Ecosystems research page: [https://goo.gl/Kgxw8n]
https://www.epa.gov/eco-research/ecoregion-download-files-state-region-4

4.3 Plants

State plants (images from the Florida Department of State)

Flower: Orange Blossom | Wildflower: Coreopsis | Tree: Sabal Palm

Figure 5: State plants of Florida

SC.912.L.17.8: Recognize the consequences of the losses of biodiversity due to catastrophic events, climate changes, human activity, and the introduction of invasive, non-native species.
SC.68.CS-CS.1.4: Interact with content-specific models and simulations to support learning, research and problem solving (e.g., immigration, international trade, invasive species).

Florida's having a peninsula, having karst topography, abundant freshwater (both above and under the ground) and having a climate that spans subtropical and tropical zones, all contribute to a variety of ecoregions and biodiversity. Florida has over 2800 native plant species, meaning that Florida has the greatest diversity of plant species in the U.S., and 295 of these plant species are found only in Florida and nowhere else in the world. A **Native** or **indigenous** plant is a term that is used to describe a plant species that has naturally existed in a region for an extended period of time (for Florida that means before the initial European contact) and not as a result of direct or indirect human influence. The Florida ecosystems that support such a variety of native life also can support a wide variety of non-native species too.

A number of wild Florida plants are also edible, some raw and others should be cooked, but you usually won't find them in your local grocery store. For example, plant leaves that can be eaten raw (or used in salads) include Dayflower, Dollarweed, Peppergrass, Meadow Beauty, Bullrush, Chickweed, Violet, and Cattail. While ones that are cooked include Cattail, Chickweed, Curly Dock, Pickerelweed, Dollarweed, young Pine needles, Spanish Needles, Pokeweed, Violet, Spiderwort and Catbrier. *Please note that many plants can have toxic effects, so it is suggested that before you collect plants to eat that you contact a regional expert, experienced botanist, or naturalist to help you identify edible plants and the proper way to prepare them.*

ONLINE EXPLORATION:

Visit the Florida-Friendly Plant Database to find out more about native plants and others recommended for planting. The database includes recommended trees, palms, shrubs, flowers, groundcovers, grasses, and vines. http://floridayards.org/fyplants/

4.4 Endangered Plants

SC.912.L.17.8: Recognize the consequences of the losses of biodiversity due to catastrophic events, climate changes, human activity, and the introduction of invasive, non-native species.

People usually think about animals when they hear about **endangered** or **threatened** species, but plants can be endangered and threatened too. Florida has more endangered plants than any state except California. Under Florida's Plant Protection Law, it's illegal to dig up or destroy any of the 600 plants on the regulated plant list. Why are these plants endangered? Usually, it is either because of invasive species or loss of habitat. Native habitats are being lost all the time, today over half of Florida's land area is in agricultural or urban land use. There are 448 endangered and 118 threatened native plant species identified on Florida's Endangered and Threatened Plant List. Of these, 54 species are also on the federal endangered plant species list and 14 are on the federal threatened species list.

Figure 6: The native pitcherplant is on Florida's Threatened and Endangered species list. Photograph courtesy of T. Cavanaugh.

Online Exploration:

- **Find out more about Florida's Endangered, Threatened and Commercially Exploited Plant list: [https://goo.gl/BJv78F]** https://www.freshfromflorida.com/Divisions-Offices/Plant-Industry/Bureaus-and-Services/Bureau-of-Entomology-Nematology-Plant-Pathology/Botany/Florida-s-Endangered-Plants/Endangered-Threatened-and-Commercially-Exploited-Plants-of-Florida
- **Find out more about Florida's Federally Listed Plant Species: [https://goo.gl/74wNsv]** https://www.freshfromflorida.com/Divisions-Offices/Florida-Forest-Service/Our-Forests/Forest-Health/Florida-Statewide-Endangered-and-Threatened-Plant-Conservation-Program/Florida-s-Federally-Listed-Plant-Species

- **Florida Statewide Endangered and Threatened Plant Conservation Program: [https://goo.gl/6PCLdX]** https://www.freshfromflorida.com/Divisions-Offices/Florida-Forest-Service/Our-Forests/Forest-Health/Florida-Statewide-Endangered-and-Threatened-Plant-Conservation-Program

4.5 Invasive Plants

SC.7.L.17.3: Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.
SC.912.L.17.8: Recognize the consequences of the losses of biodiversity due to catastrophic events, climate changes, human activity, and the introduction of invasive, non-native species.

Figure 7: The air potato, a form of yam, is a Category 1 Invasive exotic species of plant in Florida. While dormant in the winter come the growing season it can grow up to 8 inches per day blocking sunlight from native plants, additionally, the underground tubers and aerial bulbils may contain a variety of toxic compounds. Photograph

It isn't just animals that are invading the state, plants too can be **invasive**. The following is a list of the invasive plants (2017) that are Category 1 as identified by the Florida Exotic Pest Plant Council (FEPPC). Category 1 plants are plants that are changing the native plant communities and based on the ecological damage that they cause. According to the FEPPC plants are classified as Natives, Exotics, Naturalized exotics or Invasive exotics. A Native is a species whose natural range includes Florida. Exotics are a species introduced to Florida, purposely or accidentally, from a natural range outside of Florida. Naturalized exotic, is a plant that while an exotic it now sustains itself outside cultivation (it is still exotic; it has not "become" native). Invasive exotics are exotics that not only has naturalized but is expanding on its own in Florida native plant communities.

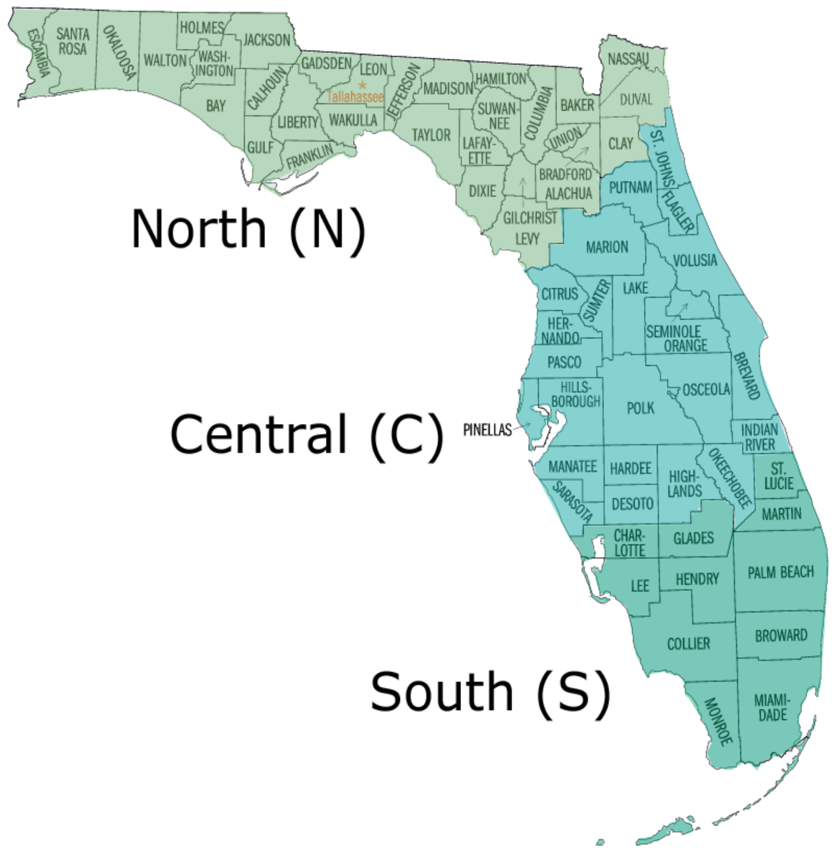


Figure 8: Zone map of invasive plant location.

Category 1 invasive plants (2017): Common name, scientific name, zone found.
The general zone that the plant is found in is represented by N = north, C = Central, and S = south regions of Florida (see Figure 7).

1. Air-potato *(Dioscorea bulbifera)*: N, C, S (see Figure 7)
2. Arrowhead vine *(Syngonium podophyllum)*: N, C, S
3. Asian sword fern *(Nephrolepis brownii)*: C, S
4. Asparagus-fern *(Asparagus aethiopicus)*: N, C, S
5. Australian-pine *(Casuarina equisetifolia)*: N, C, S
6. Australian-pine *(Casuarina glauca suckering)*: C, S
7. Beach vitex *(Vitex rotundifolia)*: N
8. Bishopwood *(Bischofia javanica)*: C, S
9. Black mangrove *(Lumnitzera racemosa)*: S
10. Brazilian jasmine *(Jasminum fluminense)*: C, S

11. Brazilian-pepper *(Schinus terebinthifolius)*: N, C, S
12. Burma reed *(Neyraudia reynaudiana)*: S
13. Caesar's weed *(Urena lobata)*: N, C, S
14. Camphor tree *(Cinnamomum camphora)*: N, C, S
15. Carrotwood *(Cupaniopsis anacardioides)*: C, S
16. Catclaw mimosa *(Mimosa pigra)*: C, S
17. Catclaw vine *(Macfadyena unguis-cati)*: N, C, S
18. Chinese privet *(Ligustrum sinense)*: N, C, S
19. Christmas cassia, Christmas senna *(Senna pendula var. glabrata)*: *C, S*
20. Cogon grass *(Imperata cylindrica)*: N, C, S
21. Coral ardisia *(Ardisia crenata)*: N, C, S
22. Crested floating heart *(Nymphoides cristata)*: C, S
23. Downy rose-myrtle *(Rhodomyrtus tomentosa)*: C, S
24. Earleaf acacia *(Acacia auriculiformis)*: C, S
25. Glossy privet *(Ligustrum lucidum)*: N, C
26. Gold Coast jasmine *(Jasminum dichotomum)*: C, S
27. Green hygro *(Hygrophila polysperma)*: N, C, S
28. Guava *(Psidium guajava)*: C, S
29. Halberd fern *(Tectaria incisa incised)*: S
30. Half-flower, beach naupaka *(Scaevola taccada)*: N, C, S
31. Hydrilla *(Hydrilla verticillata)*: N, C, S
32. Japanese climbing fern *(Lygodium japonicum)*: N, C, S
33. Japanese false spleenwort *(Deparia petersenii)*: N, C
34. Japanese honeysuckle *(Lonicera japonica)*: N, C, S
35. Japanese stiltgrass *(Microstegium vimineum)*: N
36. Java-plum *(Syzygium cumini)*: C, S
37. Jeweled maiden fern *(Thelypteris opulenta)*: S
38. Kudzu *(Pueraria montana var. lobata)*: N, C, S
39. Lantana, shrub verbena *(Lantana camara)*: N, C, S
40. Lather leaf *(Colubrina asiatica)*: S
41. Laurel fig *(Ficus microcarpa)*: C, S
42. Melaleuca, paper bark *(Melaleuca quinquenervia)*: C, S
43. Mexican-petunia *(Ruellia simplex)*: N, C, S
44. Mimosa, silk tree *(Albizia julibrissin)*: N, C
45. Nandina, heavenly bamboo *(Nandina domestica)*: N, C
46. Napier grass, elephant grass *(Pennisetum purpureum)*: *N, C, S*
47. Natal grass *(Melinis repens)*: N, C, S
48. Old World climbing fern *(Lygodium microphyllum)*: N, C, S
49. Orchid tree *(Bauhinia variegata)*: C, S
50. Para grass *(Urochloa mutica)*: N, C, S
51. Peruvian primrose willow *(Ludwigia peruviana)*: N, C, S
52. Popcorn tree, Chinese tallow tree *(Sapium sebiferum)*: N, C, S
53. Queensland umbrella tree *(Schefflera actinophylla schefflera,)*: C, S
54. Rosary pea *(Abrus precatorius)*: C, S
55. Santa Maria, mast wood *(Calophyllum antillanum)*: S
56. Sapodilla *(Manilkara zapota)*: S
57. Seaside mahoe *(Thespesia populnea)*: C, S
58. Serpent fern, wart fern *(Phymatosorus scolopendria)*: S
59. Sewer vine *(Paederia cruddasiana)*: S
60. Shoebutton ardisia *(Ardisia elliptica)*: C, S
61. Skunk vine *(Paederia foetida)*: N, C, S

62. Small-leaf spiderwort *(Tradescantia fluminensis)*: N, C
63. Soda apple *(Solanum viarum tropical)*: N, C, S
64. Strawberry guava *(Psidium cattleianum)*: C, S
65. Surinam cherry *(Eugenia uniflora)*: C, S
66. Sword fern *(Nephrolepis cordifolia)*: N, C, S
67. Torpedo grass *(Panicum repens)*: N, C, S
68. Tropical American watergrass *(Luziola subintegra)*: S
69. Uruguay water primrose *(Ludwigia hexapetala)*: N, C
70. Water spangles *(Salvinia minima)*: N, C, S
71. Water-hyacinth *(Eichhornia crassipes)*: N, C, S
72. Water-lettuce *(Pistia stratiotes)*: N, C, S
73. Water-spinach *(Ipomoea aquatica)*: C
74. West Indian dropseed *(Sporobolus jacquemontii)*: C, S
75. West Indian marsh grass *(Hymenachne amplexicaulis)*: N, C, S
76. Wetland nightshade *(Solanum tampicense)*: C, S
77. Wild taro *(Colocasia esculenta)*: N, C, S
78. Winged yam *(Dioscorea alata)*: N, C, S
79. Woman's tongue *(Albizia lebbeck)*: C, S
80. Wright's nutrush *(Scleria lacustris)*: C, S

Invasive plants can spread by being wind-blown, carried by animals or even moved in soil or water. Along with natural ways of spreading one large way is being spread by human activities unintentionally, sometimes accidentally as goods are shipped or being brought in as an ornamental house or garden plant that gets out into the surrounding ecosystem. The Brazilian pepper tree was introduced to Florida in the1800s as an ornamental plant that then spread across the state. The South American floating water hyacinths were introduced as an ornamental into the St. Johns River near Palatka in the late 1880s and soon after made navigation on the river for steamboat traffic almost impossible. In the early 1900s, the Australian melaleuca tree was intentionally introduced with the purpose to dry up the Everglades so that it could be used for other purposes. Later, a 1950s plant invader, hydrilla (a native of Southeast Asia) which was introduced as an aquarium plant, was released and began to infest and degrade Florida's lakes and rivers producing dense canopies along the surface.

ONLINE EXPLORATION:

- **Learn more about invasive plant species at the website FLIP: Florida Invasive Plants** (http://www.plantatlas.usf.edu/flip/)
- **Early Detection and Distribution Mapping System (EDDMapS), allows users to search for sightings of invasive species (plants/insects/wildlife)** [**https://goo.gl/JQAaVJ**] https://www.eddmaps.org/florida/distribution/

4.6 Land management: Prescribed fire

SC.912.L.17.17: Assess the effectiveness of innovative methods of protecting the environment.

Figure 8: Prescribed fire or controlled burn as seen from above. Photograph courtesy of T. Cavanaugh.

Naturally-occurring fires caused by lighting once played a major role in forming and maintaining much of Florida's pinelands, sandhills, scrub areas, prairies, and wetlands. Without regular fire, wildlife becomes scarce as shrubs and small trees shade out native grasses and wildflowers. In addition to naturally occurring fires, **prescribed fire** can be used (see Figure 8). Prescribed fire reduces hazardous fuel buildups of overgrown brush and forest litter, thus also providing protection to people, their homes and the forest. The fire can also improve access to the land and allow the land to be used for recreation, like hiking, bicycling, and wildlife viewing. Many wildlife species depend on the nourishing vegetation that burst from fire-enriched soils. State conservation organizations use safely-controlled prescribed fires to improve and maintain habitats for deer, quail, turkey and many other wildlife species. Some of Florida's fire-adapted plants and animals that cannot thrive without fire include the red-cockaded woodpecker, fox squirrel, gopher tortoise, indigo snake, and Florida scrub-jay.

Figure 9: Resulting growth, three years after a prescribed burn in Duval County. Notice the difference in vegetation growth on the left (unburned) and the right (prescribed burn) sides of the trail. Photograph courtesy of T. Cavanaugh.

When a fire is needed for an area, then a specific detailed plan or prescription is created that describes the burn area, the preferred weather conditions, the per-sonnel and equipment needed, the emergency contacts and other specifics neces-sary to conduct a safe and effective burn. When the weather conditions are appropriate, the Fish and Wildlife Conservation Commission will get a burn authorization from the Florida Forest Service before starting the prescribed burn. When the burning is to take place there are a number of conditions to be met. These conditions include wind speed, humidity of the air, moisture level of ground material, temperature, recency and amount of rainfall, and air stability. For example, ideally wind within the trees should be about 1-3 miles per hour, air humidity around 30-55%, the moisture level of the of the material on the ground that will burn should be around 10-20%, and atmosphere should be neutral to slightly unstable so smoke will rise and dissipate. After the burn, It is normal for the area to smell smoky for a day or two and you also may see ash during and after a burn.

Prescribed burns in Florida happen at vari-ous times of year to produce the best mix of grasses and shrubs for the local wildlife species. How often a burn is done on a particular site varies by type of natural community and historical fire frequency. Similar to burning during different seasons, varying the burn interval (time between burns) provides a better mix of food and cover for wildlife. For example, a burn interval for pine flatwoods could be every 18 months to four years (see Figure 9).

ONLINE EXPLORATION:

Florida Forest Service's Fire Management Information Systems (FMIS) Internet Mapping Tool offers an internet-based mapping tool that allows the general public to access information concerning fire management activity across the state[**https://goo.gl/WhgxJa**]**:**
http://tlhforucs02.doacs.state.fl.us/fmis.dataviewer.

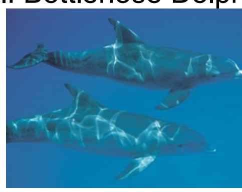
4.7 Animals

State Animals (images from the Florida Department of State)

Animal: Florida Panther | Marine mammal: West Indian Manatee

Saltwater mammal: Bottlenose Dolphin | Saltwater fish: Sailfish

Freshwater fish: Florida Largemouth Bass | Reptile: American Alligator

Insect: Zebra Butterfly | Bird: Northern Mockingbird

Figure 11: Florida state animals.

SC.912.L.17.8: Recognize the consequences of the losses of biodiversity due to catastrophic events, climate changes, human activity, and the introduction of invasive, non-native species.
SC.68.CS-CS.1.4: Interact with content-specific models and simulations to support learning, research and problem solving (e.g., immigration, international trade, invasive species).
SC.7.L.17.3: Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.

Figure 12: Manatees wintering at Blue Springs for the warm water. Photograph courtesy of T. Cavanaugh.

Florida is rich in a variety of ecoregions and **biodiversity**. In Florida, you can find over 2800 native plant species, over 700 native vertebrate species, and more than 30,000 invertebrate species. These numbers mean that Florida has the greatest diversity of plant species in the U.S., and many of these species are found only in Florida and nowhere else in the world (295 plants, 88 vertebrates, and 261 invertebrates). The Florida ecoregions that support such native life also can support a wide variety of **non-native** species too.

Florida has a great variety of unique animals that can be found in the trees, on the land, and in the water. Florida has manatees (Figure 12), sea turtles (Figure 13), key deer, Florida panthers, swallow-tailed kites, and even its own conch. Florida has some of the smallest and largest, as Florida's Key Deer are the smallest subspecies of the North American white-tailed deer, and the Florida Horse Conch is one of the largest **gastropods** in the world, growing up to two feet long and weighing up to 11 pounds. There is even a colony of polydactyl cats (domestic cats with extra toes on their front paws) that live in Key West.

Figure 13: Sea turtles in the Miami waters. Photography courtesy of T. Cavanaugh.

The animals are also adaptable to man's impact on the environment. For example, you can often find large birds using man-made features such as power poles or other structures to build their nests (see Figure 14). Manatees while large aquatic animals actually have very little insulating body fat, and so are unable to withstand extended low temperatures. Because of that need for warm water, manatees, since before the first Spanish landed on Florida, have wintered in Florida's many warm water springs (see Figure 12), today they have also adjusted to coming up the rivers also go to the power plants, where they relax in the plant's warm-water outflow. Lately, a new species can be found throughout the state, as the coyote's natural range first expanded into the state back in the 1970's and now they can be found in all terrestrial, marsh, urban and suburban habitats.

Figure 14: Blue herons nesting in electricity transmission tower along the St. Johns River. Photograph courtesy of T. Cavanaugh.

ONLINE EXPLORATION:

- **To see where some manatees are, visit the Manatee Rescue & Rehabilitation Partnership which has live GPS tracking of select manatees at [https://goo.gl/yFVDNx]** (http://manatees.mapntracker.com/wildtracks/map/biography/13717)
- **To see where the tracked Sea Turtles are, visit the Sea Turtle Conservancy [https://goo.gl/MFTeQ1]** (https://conserveturtles.org/sea-turtle-tracking-active-sea-turtles/)

4.8 Insects:

SC.912.L.17.8: Recognize the consequences of the losses of biodiversity due to catastrophic events, climate changes, human activity, and the introduction of invasive, non-native species.
SC.912.L.15.3: Describe how biological diversity is increased by the origin of new species and how it is decreased by the natural process of extinction.

Figure 15: The Eastern Lubber Grasshopper (*Romalea miroptera*) which can grow close to four inches long. Photograph courtesy of T. Cavanaugh.

It has been documented that insects are the most diverse group of organisms, with the greatest number of species, more than any other group. Worldwide it is estimated that there are over 900 thousand different species of insects, making insects around 80% of the world's species. Florida has over 12,500 insect species, including natural, some intentionally introduced, and some are new invasive species. Some of the most common insects you can see include ants, spiders, butterflies, moths, crickets, and grasshoppers. Florida also has some large insects, like the Florida Keys giant centipede (7-10 inches in length; 18-25 cm), the giant swallowtail butterfly (about 7-inch wingspan; 18 cm) and the eastern lubber grasshopper (up to 4 inches in length; 10 cm - see Figure 15), and while not the largest spider, the Banana spider is one of the largest web weavers found in the United States (see Figure 16).

Figure 16: The banana spider, is one of the largest web weavers in the U.S. Photograph courtesy of T. Cavanaugh.

ONLINE EXPLORATION:

- **You can explore for detailed information about Florida insects by using the [Insect identification Database](https://www.insectidentification.org/insects-by-state.asp?thisState=Florida)** (https://www.insectidentification.org/insects-by-state.asp?thisState=Florida [**https://goo.gl/DCkRpH**]), **that has information on 646 Florida insects.**
- **Visit the [100 Common Florida Insects](http://entnemdept.ufl.edu/extension/outreach/field-guide/100-common-florida-insects/) at the at University of Florida's Entomology and Nematology Department for more insect information** (http://entnemdept.ufl.edu/extension/outreach/field-guide/100-common-florida-insects/ [**https://goo.gl/7pi1v1**]).

4.9 Florida Mosquitoes

SC.7.L.17.3: Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.

Figure 17: A Florida yellow fever mosquito (Aedes aegypti). Photograph courtesy of the USDA-ARS.

Because Florida ranges from subtropical to tropical it should be of no surprise about the large insect population. One of the more famous insects of Florida is the **mosquito** (see Figure 17). You might think that a mosquito is just a mosquito, but actually, Florida has 80 different mosquito species (of the over 3000 possible). This means that there are more mosquito species in Florida than in any other state, and of that 80, only about 33 bother people. An adult mosquito may live 5–6 months under the right conditions, although most adult females live for two to three weeks. Once the female lays her eggs they can dry out for eight months and then once it gets warm and humid they can still hatch. In the ecosystem they do more than just bite people, they are a food source for a number of species including fish, frogs, bats, and birds, and they act as plant pollinators. Even the larvae have an environmental impact as they eat the detritus, microbes, plankton, and algae in the water, actually helping to clean it.

When you hear a mosquito, that sound comes from the beating of the wings, usually between 300 to 600 times a second, and it is actually a mating noise. Both male and female mosquitoes make the buzzing sound, but you rarely hear male mosquitoes, because they don't bite people. The female mosquito is the one that stings you and needs blood, the male mosquitoes actually feed on flower nectar. The females require blood for the development of their eggs. Not all mosquito species feed on people, there are only about 200 of the over 3000 species of mosquitoes that bite humans. A number of mosquitoes specialize on other animals, such as *Culiseta melanura*, it focuses exclusively on birds, and *Uranotaenia sapphirina* feeds on reptiles and amphibians.

Those species that do take blood from people can cause a lot of problems. The female that needs the blood for her eggs has to get it from someplace. She hunts by searching for carbon dioxide (CO_2) that animals breathe out. When the female mosquito sense CO_2, it will fly back and forth following the CO_2 gas plume until she locates the animal, and then lands to collect the blood with her proboscis (it is the salvia on the proboscis that lubricates the insertion and causes the stinging associated with mosquito bites). The small loss of blood isn't the problem, instead, the problem is that of the 33 species of mosquitoes that bother people in Florida, 13 of them can make people sick. This is because mosquitoes can carry a large number of diseases, including malaria, West Nile virus, dengue fever, yellow fever, Zika, Chikungunya, and encephalitis. There are also another 13 species of mosquito that can bring diseases to dogs, horses and other animals, such as heartworm, which can be lethal to dogs.

The 13 species that people need to be concerned with include: *Aedes aegypti, Aedes albopictus, Aedes triseriatus, Anopheles albimanus, Anopheles barberi, Anopheles crucians, Anopheles grabhamii, Anopheles punctipennis, Anopheles quadrimaculatus, Anopheles walkieri, Culex declarator, Culex nigripalpus, Culex quinquefasciatus*, and the *Culex tarsalis.* Not all of these species can get to everyone in Florida, some are very localized, for example the *Culex tarsalis* is located in northwestern and western coastal Florida, *Culex declarator* are found around Monroe and Indian River counties, and *Anopheles grabhamii* is found in the Keys, while other species like the *Anopheles crucians* are found throughout the state.

To help identify which diseases are being spread by mosquitoes one tool commonly used is the **sentinel chicken**. Florida's sentinel chicken program began in 1978, as a means to detect mosquito-borne illnesses before they spread to residents. The way the program is run, special chicken coops with about six chickens are placed in areas where the health department believes to be endemic to infected mosquitos. Once the coop is in place, the chickens are treated just like any other farm chicken, except that on a regular basis, blood is drawn from the chickens and tested for viruses known to be carried by mosquitoes. One reason that chickens are used is because unlike humans, chickens don't get sick from the diseases they contract from mosquitoes, but they still will test positive if infected.

If you are trying to do mosquito control around your home, remember that all it takes is just a few inches of standing water for a female to deposit her eggs. The mosquito larvae develop in just a few days into flying adults, so birdbaths, roof gutters, and anything in your yard that can hold water can be a breeding ground. If you want the water to stay, such as for animals or a birdbath, then just add a drop or two (1/16 of a teaspoon) for each gallon of water to kill off the mosquitos. If you have a pond consider catching some mosquito fish and adding them to the pond, to the eat the larvae.

ONLINE EXPLORATION:

- **CDC Map of Arboviral Disease Activity in the United States tracks any of a group of viruses that are transmitted by mosquitoes, ticks, or other down to the county level.** [**https://goo.gl/98YoH4**] https://wwwn.cdc.gov/arbonet/maps/ADB_Diseases_Map/index.html
- **Mosquito Hearing Video**:[**https://goo.gl/QvSo6w**] https://www.youtube.com/watch?v=F9uVyCInhhI

4.10 Endangered and Threatened Animals

SC.7.L.17.3: Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.
SC.912.L.17.8: Recognize the consequences of the losses of biodiversity due to catastrophic events, climate changes, human activity, and the introduction of invasive, non-native species.

Figure 18: A threatened manatee in Blue Springs for the warm spring water during the winter. Photograph courtesy of T. Cavanaugh.

As of 2018, Florida has 76 species recognized to be on the Federal **Endangered** and **Threatened** Species List (41 endangered & 38 threatened), with an additional 39 species on the State Threatened Species list. While many may think of this list with species like the manatee, the Key deer, and the Florida panther, there are quite a variety of species beyond mammals. Actually, the Endangered and Threatened Species List for Florida contains fish (5), amphibians (2), reptiles (6), birds (15), mammals (17), crustaceans (1), insects (7), mollusks (16), and corals (7). According to the U.S. Fish & Wildlife Service, a species will be added to the list when it is determined to be endangered or threatened because of any of the following factors:

- the present or threatened destruction, modification, or curtailment of its habitat or range;
- overuse for commercial, recreational, scientific, or educational purposes;
- disease or predation;
- the inadequacy of existing regulatory mechanisms; or
- other natural or manmade factors affecting its survival.

One of the reasons species become endangered or threatened in Florida is the degradation or loss of habitat. In 2018 there were 1000 people moving into the state every day, they will need homes and food and all of that takes resources, including land. So with land being repurposed to home sites or farms, pollution impact, and even activities like people hunting can cause the environment to change and threaten the species that live there. Many species are threatened or endangered due to invasive species. But it isn't all bad news, many species that were put on the list have been helped and increased their populations. The Florida manatees were put on the list back in 1973 when there were only a few hundred manatees left and then efforts were made to improve their situation. Today there are over 6,600 Florida manatees and they were moved in 2017 from endangered to threatened (see Figure 18). While everyone seems to know about the Florida Alligator, not as many know that Florida also has crocodiles. American crocodiles primarily are found in south Florida living in brackish and saltwater habitats such as ponds, coves, and creeks of mangrove swamps south of Miami. Recently crocodiles have moved northward within their range and even inland into freshwater areas of southeast Florida. The American crocodile is another endangered species success story because since 1975 their numbers have increased from less than 300 to more than 1,500 adults. Today, they too are classified as a threatened species, no longer endangered. Another example of work being done to protect endangered species is efforts made for the numerous species of sea turtles that nest along the coast, their nests are identified and protected with a covering under the sand (see Figure 19) along with cities and town having light regulations to help ensure that the hatchlings survive.

Figure 19: Sea turtle nest flagged and with protective cover, National Seashore. Photograph courtesy of T. Cavanaugh.

ONLINE EXPLORATION:

To find out more about endangered and threatened species in Florida visit the following:

- **Florida Department of State**: [**https://goo.gl/KyhNba**] https://www.flrules.org/gateway/ruleNo.asp?id=68A-27.003
- **Florida Fish and Wildlife Conservation**: [**https://goo.gl/Zchgaa**] https://myfwc.com/wildlifehabitats/wildlife/

- **Florida Fish and Wildlife Conservation: Florida Endangered and Threatened Species list:** [**https://goo.gl/xMpkNL**]
  https://myfwc.com/media/1945/threatened-endangered-species.pdf
- **Species Profiles**:[**https://goo.gl/c2Vxf2**]
  http://myfwc.com/wildlifehabitats/profiles/
- **Managed Species (programs that address their conservation, management or recovery):** [**https://goo.gl/u9KiSd**]
  http://myfwc.com/wildlifehabitats/managed/

4.11 Bridges and Tunnels for Animals

SC.912.L.17.8: Recognize the consequences of the losses of biodiversity due to catastrophic events, climate changes, human activity, and the introduction of invasive, non-native species.
SC.912.L.17.17: Assess the effectiveness of innovative methods of protecting the environment.

Some of the endangered and managed populations have an issue because they don't stay in one place, instead, they move around. For example, the endangered Florida panther can have a **range** from 70 to over 200 square miles. So when the panther population was rising, the number of panthers killed by collisions with vehicles also has increased. Some of the early ways used to reduce such deaths from vehicle collisions included lowering the speed limit at night on stretches of highways, widening road shoulders to increase visibility, public information campaigns, and rumble strips. Although these measures may have helped reduced wildlife collisions, they did not eliminate the problem. The most effective, but also the most expensive measure, has been to create wildlife crossings for state highways.

The first wildlife crossings in Florida were installed in Collier County and were tunnels under Interstate 75 as the road crossed between the coasts at the bottom of the state. On I-75 24 wildlife crossings that went under the road, as well as a continuous barrier fence that directed animals to the crossings. Additional crossings for highways have been made using different sizes and shapes of crossings, each suited to the particular needs of a specific location. The picture below (Figure 20) is a bridge crossing created for animals to use to cross I-97 outside of St. Augustine.

Figure 20: Animal crossing bridge on I-95. Photograph courtesy of T. Cavanaugh.

ONLINE EXPLORATION:

Florida Fish and Wildlife Conservation Commission's TRGIS: Terrestrial Resource Geographic Information System, is an interactive map that allows users to explore recent data on bears in Florida, such as bears with GPS collars, bear sightings, bears killed by vehicle strikes (roadkill), and bear captures. Information on other species including panthers and bald eagles is also provided. [https://goo.gl/t3A8uS] http://ocean.floridamarine.org/TRGIS/

4.12 Invasive/Intrusive/Nonnative Species

SC.7.L.17.3: Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.
SC.912.L.17.17: Assess the effectiveness of innovative methods of protecting the environment.
SC.912.L.17.8: Recognize the consequences of the losses of biodiversity due to catastrophic events, climate changes, human activity, and the introduction of invasive, non-native species.

An **invasive** species is any kind of living organism: amphibian, plant, insect, fish, fungus, bacteria, seeds or eggs — that is not native to an ecosystem and causes harm to the environment, economy, or health. A number of invasive species grow and reproduce quickly, and spread aggressively, and with their potential to cause harm, are labeled “invasive.” Florida has identified a large number of invasive insects, plants, and animals (see Figure 21).

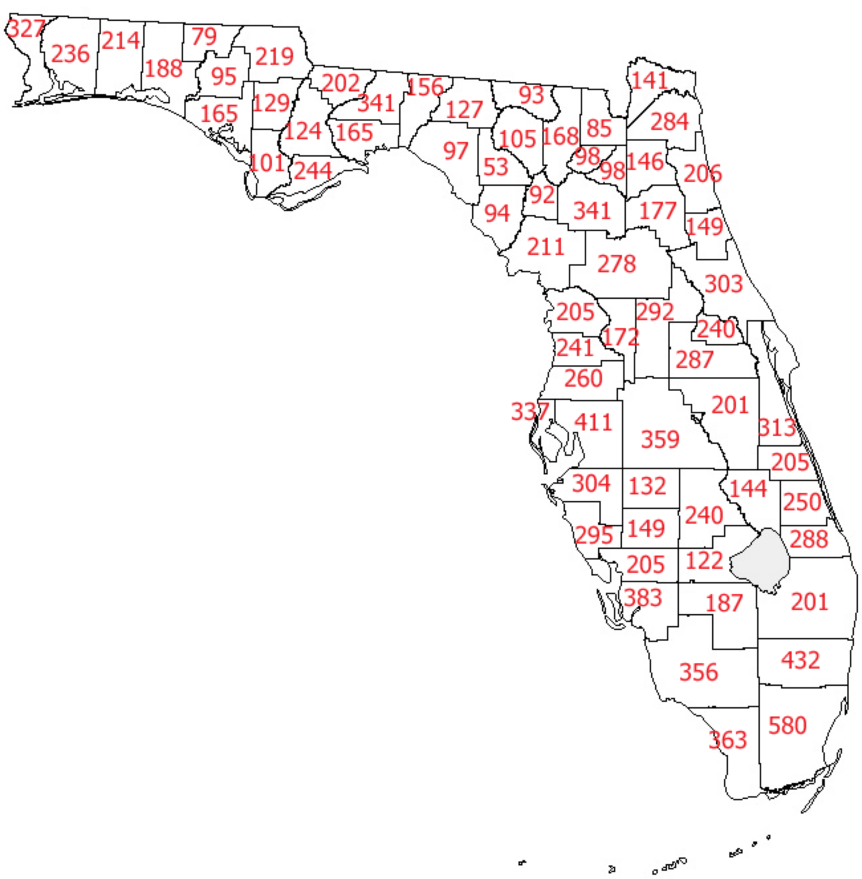


Figure 21: Number of invasive species identified by county, based on UG Center for Invasive Species and Ecosystem Health based on 2019 data.

A **nonnative** species could become invasive soon after becoming established, like the Cuban tree frog. It was introduced in 1931 unintentionally through packing materials and has invaded Florida's natural areas, **preying** on our native tree frogs. Cuban tree frogs rapidly spread in south Florida and were common throughout most of the state by the 1970s. It might take years for the right factors to fall into place to allow a species to expand its range and cause ecological problems. For example, green iguanas (see Figure 22) have resided in Florida since the 1960s, but their population has only increased greatly since Hurricane Andrew. Although green iguanas have not had large ecological impacts, this Central and South American lizard causes significant economic damage to landscape plants, primarily in Miami-Dade and Broward Counties. On Florida's west coast, black spinytail iguanas have reached such abundance that many residents view them as a nuisance.

Figure 22: Green iguana now found throughout South Florida and the Keys. Photograph courtesy of T. Cavanaugh.

How did these invasive species get to Florida? One answer to that question is that invasive species are spread by human activities, although often unintentionally. Any way that people travel (plane, boat, car, walking), that way can also carry uninvited species with them (think about how sandburs get attached to your clothes after walking across a field - now you are an unintentional plant species transporter). Ships can carry aquatic organisms in ballast water, boats on their hulls and propellers. Insects can get into shipping crates, and others can just be bought for one purpose and then escape into the wild when they can. Escaping is how Armadillos, which were first brought to Florida back in the 1920s for private zoos but then dug their way out at night and how Rhesus Macaques were brought to Florida in 1938 for a Jungle Boat Tour, where the six rhesus macaques swam off the island they were put on, and both of these species since expanded across the state. The boa constrictors and pythons now in the Everglades escaped when facilities of reptile dealers were damaged by hurricanes, such as Hurricane Andrew in 1990. The Giant African Land Snails (*Lissachatina fulica*), which can grow to almost eight inches long, were first imported to as pets and educational animals in 1966 but are now wild in south Florida. Some species move to Florida on their own, such as how Lovebugs migrated here from Mexico along the Gulf Coast and were first seen in Florida in 1947. Of course, some invasive species intentionally brought and released, such as the hogs now known as wild boar that were brought by the first Spanish back in the 1500s to be a food stock but are today causing extensive damage to the environment (see Figure 23).

Figure 23: Result of Hog/Feral pig rooting, causing damage to native wildlife and the environment in Flagler County. Photograph courtesy of T. Cavanaugh.

Timeline of Animal Introduction (some of the animals)

Animal (*Year introduced*) Method of introduction

Hogs (*1500s*) Hogs were released to become a food/hunting resource
Black Rat (*late 1700s*) Believed to have been unintentionally transported with cargo/ships
Norway Rat (*early 1800s*) Believed to have unintentionally transported with cargo/ships
Sambar Deer (*1908*) Purposely introduced to St. Vincent's Island
Nine-Banded Armadillo (*1924*) Escaped from roadside zoo/circuses
Palla's Mastiff Bat (*1929*) Natural range expansion
Giant Toad (*1936*) Introduced to Florida to control agricultural pests in sugarcane
Rhesus Macaque (*1938*) Escaped by swimming from tourist attraction (Silver Springs)
Lovebug (*1940s*) Natural range expansion
Vervet Monkey (*1950s*) Escaped from tourist attraction (Broward County)
Nutria (*1955*) Natural range expansion after introduction in other states
Red-eared Slider turtle (*1958*) Escaped/released pet trade
Monk Parakeet (*1960s*) Escaped/released pet trade
Squirrel monkey (*1960s*) Released by owners when small zoos tourist attraction closed (Marion & Broward County)
Spectacled Caiman crocodile (*1960*) Escaped/released pet trade (Dade & Broward)
Green Iguana (*1964*) Escaped/released pet trade (Miami-Dade)
Giant African Land Snail (1966). Escaped/released from pet trade (Miami-Dade)
Elk (*1967*) Six released on Buck Island Breeding Ranch (Highlands County)
Walking Catfish (*1967*) Release/escape from aquarium/aquaculture
Black Spinytail Iguana (*1970s*) Escaped/released pet trade
Coyote (*1970s*) Natural range expansion
Grass Carp (*1972*) Sterile fish released as aquatic plant control
Coqui frog (*1973*) Unintentionally brought in with imported ornamental plants
Prairie Dog (*1973*) Escaped from owners (Gilchrist County)
Burmese Python (*1979*) Escaped from a breeding facility that was destroyed during Hurricane Andrew

Jamaican Fruit-eating Bat (*1983*) Natural range expansion
Lionfish (*1985*) Released from aquariums
Capybara (*1990s*) Escaped from a wildlife research facility
North African Python (*2002*) Escaped/released pets trade
Clown Triggerfish (*2010*) Released from aquariums
Indian Grey Mongoose (*2016*) Unintentionally brought in with cargo

Figure 24: Invasive nine-banded armadillo, Duval County. Photograph courtesy of T. Cavanaugh.

Not all non-native animals cause problems. The nutria, a large rodent from South America, lives in warm, marshy areas. It is abundant in the lowlands of Louisiana and Mississippi, but Florida populations have not been very successful even though Florida has similar habitats to other Gulf Coast states. Some of these animals cannot be classified as intrusive, but instead just non-native. For example, during the 1970s and 1980s, there were 19 different insect species deliberately introduced as **biological control agents**, none of these insects have become pests, so they don't classify as invasive.

ONLINE EXPLORATION:

- **To learn more about Florida's nonnative fish and wildlife visit the Florida Fish and Wildlife Conservation Commission at https://myfwc.com/wildlifehabitats/nonnatives/**
- **Early Detection and Distribution Mapping System (EDDMapS), allows users to search for sightings of invasive species (plants/insects/wildlife)** [**https://goo.gl/JQAaVJ**] https://www.eddmaps.org/florida/distribution/

4.13 Natural expansion not invasive: Coyotes and Lovebugs

SC.912.L.17.17: Assess the effectiveness of innovative methods of protecting the environment.>
SC.912.L.17.8: Recognize the consequences of the losses of biodiversity due to catastrophic events, climate changes, human activity, and the introduction of invasive, non-native species.

Figure 25: Coyote (*Canis latrans*) in Jacksonville, Duval County. The coyote range expansion into Florida began in the 1970s. Photograph courtesy of Rob Bixby [https://goo.gl/1igSGC].

Coyotes are found throughout the entire state of Florida as part of **natural range** expansion from the western states. Coyotes fill an important role in the ecosystem by keeping rodent and small predator (fox, raccoon, opossum, etc.) populations under control. Coyotes are found throughout Florida and have been documented in all 67 counties. This medium-sized canid is extremely adaptable and can be found in rural, suburban and even urban landscapes. They are typically shy and elusive but encounters between people and coyotes in Florida are occurring more often. They are native to North America, have been in Florida since the 1970s, and will continue to make their homes around the state.

The "lovebug" is actually a form of March fly (also called the honeymoon fly or the double-headed bug) that got its name because of it in-flight mating and first appeared in Florida in the 1940s. The lovebug, like the coyote, came to Florida as part of its natural range expansion from Central America, and along the gulf coast. As an insect, it poses no threat to the environment. The adults do not bite or sting, instead they feed on nectar from various plants, and the larvae eat the decaying vegetation on the ground. Their biggest problem about lovebugs is that they are actually attracted to car exhaust and black road tops, so they fly to the open sunny spaces above the road and get hit by the fast moving cars, leaving their remains smeared across the car and windshield. The lovebugs actually only fly twice a year - late spring around April or May and again in the fall around August or September.

Figure 26: Lovebugs *(Plecia nearctica)* resting on a leaf. Photography courtesy of Bernard Dupont [CC-SA 2.0 https://goo.gl/aAdc8o].

ONLINE EXPLORATION:

Predator-Prey simulation of Coyotes and Rabbits allows users to run a simulation on the predator-prey relationship [https://goo.gl/tc2Jle]
http://www.netlogoweb.org/launch#http://ccl.northwestern.edu/netlogo/community/Predator,%20Prey,%20Poison.nlogo

5 Chemistry

5.1 Elements & Compounds of Florida

SC.8.P.8.6: Recognize that elements are grouped in the periodic table according to similarities of their properties.
SC.8.P.8.5: Recognize that there are a finite number of elements and that their atoms combine in a multitude of ways to produce compounds that make up all of the living and nonliving things that we encounter.
SC.8.P.8.8: Identify basic examples of and compare and classify the properties of compounds, including acids, bases, and salts.

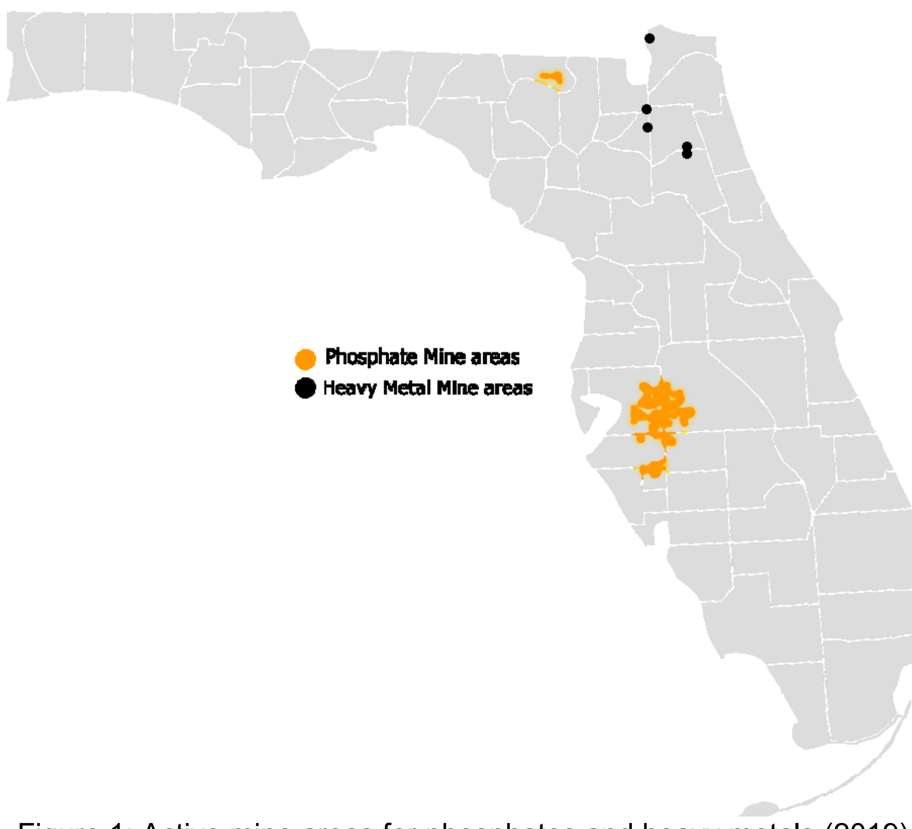


Figure 1: Active mine areas for phosphates and heavy metals (2019).

Florida is known as the sunshine state, with orange groves, beaches, hotels, and entertainment parks, and while this is all true, Florida is also a mining state (see Figure 1)

Phosphate (PO_4^{-3}): Phosphates are the naturally occurring form of the element phosphorus. In mineralogy and geology, phosphate refers to a rock or ore containing phosphate ions. Inorganic phosphates are mined to obtain phosphorus for use in agriculture and industry. Florida has the largest deposits of phosphates in a region of central Florida called the Bone Valley region (see Figure). With the large deposits, Florida is usually the United States leading phosphate rock-mining state, often producing more than six times as much as the next-highest producing state. In terms of value, phosphate rock, crushed stone, and portland cement continued to be the most important raw mineral commodities produced in Florida.

Most of the phosphoric acid produced, about 90%, is used to make agricultural products. Another 5% is used to make animal feed supplements. The remaining 5% percent is used in a wide variety of products including soap, toothpaste, and soft drinks. There is phosphate in camera film and inside light bulbs. It helps make steel harder and water softer. It plays a part in dyeing cloth and in washing clothes. Phosphate is used in the cement a dentist uses on teeth and in the fluids used to drill for oil and gas. It is part of making cloth and helps to polish aluminum. Phosphate is also used in making plastics, shaving cream, and bone china dishes.

Phosphoric acid is produced at a fertilizer manufacturing facility (sometimes called a chemical processing plant) that is not connected to the mining operations. A variety of minerals are found in Florida's heavy mineral sand deposits, including ilmenite, leucoxene, rutile (titanium minerals), and zircon. Ilmenite and rutile are primary source materials used to manufacture titanium dioxide pigments. These pigments are often used in the manufacture of paint, varnish and lacquers, plastics, and paper.

Figure 2: North Maxville Mine - Dredge mining for heavy minerals. Photograph courtesy of Florida Department of Environmental Protection.

Metals

In Florida, the phosphate rock deposits are notable for their having of significant quantities of radioactive uranium isotopes. Because of these deposits, **Uranium**($_{92}U$) has been produced as a byproduct of phosphate mining and the production of phosphoric acid fertilizer. The uranium is contained in the phosphate minerals found in sediments of the Bone Valley Formation found in central Florida. The main use of uranium is to fuel nuclear power plants.

Titanium ($_{22}Ti$) and **Zirconium** ($_{40}Zr$): Florida has been a location for heavy mineral mining since 1916 in a town that used to be known as Mineral City, but is now named Ponte Vedra Beach. At one time, there were a number of mines for heavy minerals along the east coast of Florida from Boulogne next to the Georgia border all the way to Vero Beach. There are heavy-mineral sand mines in Baker, Bradford, Clay, and Duval Counties. Ilmenite, leucoxene, rutile, and zircon are the primary minerals of interest in the heavy-mineral sand deposits of this region (see Figure 2). The minerals Ilmenite, leucoxene, and rutile are the primary sources used in the manufacture of titanium dioxide pigments, which, in turn, are used in the manufacture of lacquers, paint, paper, plastics, and varnish. The major uses of the mineral zircon are in refractories (heat resistant materials), foundry sands, and ceramic applications.

Rare Earth Elements

Rare earth elements are a set of seventeen chemical elements in the periodic table, specifically the fifteen lanthanides plus scandium and yttrium. Along the west side of the St. Johns River from between Palatka and Jacksonville, you can find active mining for monazite which can contain rare earth elements. The generic chemical formula for monazite, $(Ce,La,Nd,Th)(PO_4,SiO_4)$, reveals that the rare earth elements cerium (Ce), lanthanum (La), and neodymium (Nd).

- $_{57}La$ **Lanthanum** is used in creating high refractive index and alkali-resistant glass, flint, hydrogen storage, battery-electrodes, camera lenses, and as a fluid catalytic cracking catalyst for oil refineries.
- $_{58}Ce$ **Cerium** is used as a chemical oxidizing agent, polishing powder, yellow colors in glass and ceramics, catalyst for self-cleaning ovens, fluid catalytic cracking catalyst for oil refineries, and in ferrocerium flints for lighters.
- $_{60}Nd$ **Neodymium** is used in rare-earth magnets, lasers, violet colors in glass and ceramics, didymium glass, ceramic capacitors, and electric motors of electric automobiles.

ONLINE EXPLORATION:

TEDed Periodic Videos [**https://goo.gl/WmtyXT**] (http://ed.ted.com/periodic-videos) or **pTable** (https://www.ptable.com/) **are both interactive periodic tables that allow users to explore more about the elements.**

5.2 Chemical Process: Limestone erosion

SC.912.E.7.8: Explain how various atmospheric, oceanic, and hydrologic conditions in Florida have influenced and can influence human behavior, both individually and collectively.
SC.8.P.9.2: Differentiate between physical changes and chemical changes.
SC.8.P.8.8: Identify basic examples of and compare and classify the properties of compounds, including acids, bases, and salts.

The Florida peninsula is a porous **limestone** sitting atop bedrock known as the Florida Platform. This limestone is a karst formation formed by chemical weathering as the limestone rock under the ground can react chemically and dissolve away. **Chemical weathering** involves the decomposition of rocks due to chemical reactions between minerals such as calcite with water and gases in the atmosphere, such as carbon dioxide (CO_2) and sulfur dioxide (SO_2). The process of solution of soluble minerals is important in limestone landscapes like Florida. As water falls as rain, the water can form a weak acid because it reacts chemically with carbon dioxide that occurs naturally in the atmosphere and the soil. This acid is named **carbonic acid** (H_2CO_3) and is the same compound that makes carbonated beverages taste tangy.

$$H_2O(l) + CO_2(g) \rightarrow H_2CO_3(aq)$$

Rainwater seeps downward through the soil and through fractures in the rock due to the force of gravity. The carbonic acid in the moving groundwater reacts with the bedrock along the surfaces of joints, fractures and bedding planes, eventually forming cave passages and caverns. Limestone is a sedimentary rock consisting primarily of **calcium carbonate** ($CaCO_3$) in the form of the mineral known as calcite. You don't just encounter calcium carbonate in the rocks beneath you, you also use it in medicine, specifically in a number of antacids that containing small amounts of calcium carbonate, a base, which are used in the treatment of 'acid stomach'. The chemical reaction is one of the neutralization of excess acid with calcium carbonate, for example, TUMS has calcium carbonate as the "active" ingredient. You will also find calcium carbonate as a key ingredient in many household cleaning powders, for example, Comet (cleanser) uses it as a scrubbing agent.

Rainwater reacts with the limestone by the following reaction:
Limestone (Calcium Carbonate) reacts with acidic rainwater (Carbonic acid, H_2CO_3), to form calcium bicarbonate [$Ca(HCO_3)_2$], an ionic compound.

$$H_2O(l)+CO_2(g) \rightarrow H_2CO_3(aq)$$

$$H_2CO_3(aq)+ CaCO_3(s) \rightarrow Ca(HCO_3)_2(aq)$$

The compound calcium hydrogen carbonate [$Ca(HCO_3)_2$], is composed of component ions of calcium (Ca^{++}) and Bicarbonate (HCO_3^-) which are soluble in water and is removed in solution.

If the rock is dolomite [$CaMg(CO_3)_3$], then it contains both magnesium and calcium. Then it will form ions of calcium (Ca^{++}), magnesium (Mg^{++}) and Bicarbonate (HCO_3^-), which will dissolve into the water.

You can test for yourself how limestone reacts to acid. While the water formed from carbon dioxide and water is only slightly acidic, you can see it happen quickly if you use an acid like vinegar (acetic acid - CH_3COOH) which is much stronger by comparison. Find a piece of limestone (in Florida usually you can find them alongside roads as they are often used for the roadbed), which is made of calcium carbonate ($CaCO_3$). Put the limestone in a bowl, pour some vinegar on top of it and watch what happens (see Figure 3). It will fizz or form bubbles, as the vinegar reacts with the carbonate ions (acid + base → salt + water). As it reacts with the limestone a new compound is formed which is transported away.

Figure 3: Close up of vinegar (acetic acid) reacting with limestone, producing carbon dioxide, water, and calcium acetate ($Ca(CH_3COO)_2$). Photography courtesy of T. Cavanaugh.

5.3 Hard Water

SC.912.E.7.8: Explain how various atmospheric, oceanic, and hydrologic conditions in Florida have influenced and can influence human behavior, both individually and collectively.
SC.912.E.6.4: Analyze how specific geologic processes and features are expressed in Florida and elsewhere.
SC.8.P.8.5: Recognize that there are a finite number of elements and that their atoms combine in a multitude of ways to produce compounds that make up all of the living and nonliving things that we encounter.

According to the U.S. Geological Survey (USGS), most of the **groundwater**, from which we get our drinking water, found in Florida contains between 121 and 180 milligrams per liter of hard **minerals**, although in some parts of the state it is even higher while others are much lower (see Figure 4). These minerals, include calcium, iron, and magnesium, that are **dissolved** in the water. Hard water requires more soap and synthetic detergents for home laundry and washing, and contributes to scaling in boilers and industrial equipment. Drinking hard water may actually be beneficial for your health. The benefits of hard water include fulfilling your dietary needs of essential minerals, such as calcium, iron, and magnesium.

General guidelines for classification of waters are 0 to 60 mg/L (milligrams per liter) as calcium carbonate is classified as *soft*; 61 to 120 mg/L as moderately hard; 121 to 180 mg/L as *hard*; and more than 180 mg/L as *very hard*.

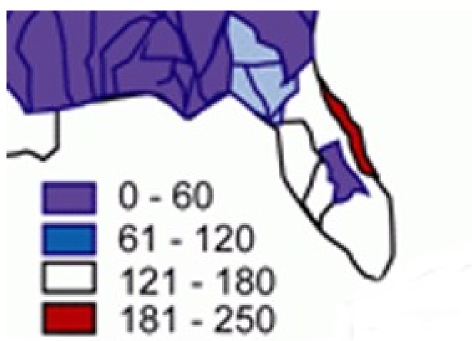


Figure 4: Concentration of hardness as Calcium Carbonate, in milligrams per liter.
Image courtesy of USGS.

A typical city water-softening system will remove calcium and magnesium ions from hard water using lime [calcium hydroxide $Ca(OH)_2$]. When the lime is added in the water processing facility, the hardness-causing minerals [$Ca(HCO_3)_2$] form a nearly insoluble precipitate of calcium carbonate ($CaCO_3$).

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 + 2H_2O$$

Excess amounts of calcium and magnesium are not the only things found in Florida water, you can also find high concentrations of other materials such as sulfur and iron (see Figure 5). Detrimental effects of these kinds of hardness include the formation of scums (like soap scum or tub rings) and the yellowing of fabrics.

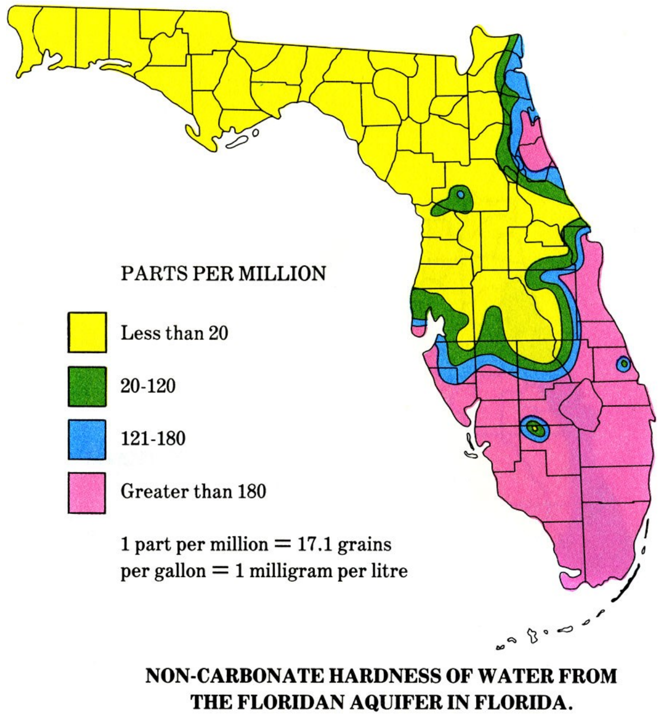


Figure 5: Non-carbonate hardness of aquifer water.
Image courtesy of Florida Bureau of Geology.

If the sprinkler systems spray water on a house and a brown stain forms, then there is a large amount of iron (Fe) in your water. The groundwater where the water came from has filtered through rocks containing iron-rich minerals before being pumped to the surface using a well. In Florida, the standard for iron content in the drinking water has a maximum of 300 micrograms per liter (300 ug/l), although private wells can be higher. While the high iron content in your water might be staining your home or clothes, and it might also be helping you. Iron is essential for your good health, as helps transport oxygen in the blood. Most tap water in the United States supplies approximately 5 percent of the daily dietary requirement for iron.

In some parts of Florida, drinking or well water can contain the chemical hydrogen sulfide (H_2S) gas, which smells like rotten eggs or burnt matches. The sulfur (S) smell can be objectionable, but it is generally not harmful to health. This sulfur concentration can occur when groundwater filters through organic material or rocks that contain sulfur or sulfate (SO_4^{--}) compounds.

ONLINE EXPLORATION:

Virtual chemistry experiment of Cleaning Capacity of Soap with Hard and Soft Water: [https://goo.gl/fu7nm4]
http://amrita.olabs.edu.in/?sub=73&brch=3&sim=120&cnt=4

6 Physics

6.1 Early Crumple Zones: From 300-year-old stone forts to the today's cars

SC.912.E.6.4: Analyze how specific geologic processes and features are expressed in Florida and elsewhere.
SC.912.P.12.3: Interpret and apply Newton's three laws of motion.
SC.6.P.13.1: Investigate and describe types of forces including contact forces and forces acting at a distance, such as electrical, magnetic, and gravitational.
SC.6.P.13.3: Investigate and describe that an unbalanced force acting on an object changes its speed, or direction of motion, or both.

Figure 1: Crumple zone damaged in a car collision.
Photography courtesy of Julo [CC-SA 3.0 https://goo.gl/jsL8Ax].

The **crumple zone** technology of today is the use of a structural safety feature designed into today's automobiles that absorbs the energy that results from a collision by controlled deformation. Crumple zones work to manage crash energy, absorbing it through **deformation** with the outer parts of the vehicle, preventing it from being directly transferred through the car to the occupants, protecting them against injury (see Figure 1). This crumple zone form of technology was invented for cars back in 1952 by a Mercedes-Benz engineer Bela Barenyi, but the technology has actually been applied in Florida as far back as 1672 with the building of Castillo de San Marcos in St. Augustine.

Crumple zones save lives by changing how the **force** is applied in a crash by expanding the time of the collision, and redistributing the force before it reaches the vehicle's occupants. Consider the math for the situation. A car (or cannonball) is a mass traveling at some speed or velocity which results in an amount of **kinetic energy** ($KE = {}^{1}/_{2}m * v^2$), and all that energy has to go someplace during a collision. In a car, that energy absorption during the collision occurs when the outer edges of the car body fold up and the next inner structure. This folding takes energy to change the shape and expands the amount of time it takes for the energy to be transferred. The transference of that energy will be some amount of **Work**, and for that Work to happen there must be Forces. In a collision, slowing down the deceleration by even a few tenths of a second can create a drastic reduction in the force involved. The equation for Force is:

Force = mass * acceleration ($F=ma$),

And as acceleration is the change in velocity over time, the formula can be re-written as:

Force = mass * velocity/time ($F = mv/a$).

So the car or the cannonball traveling at some speed must come to a stop, which is an acceleration a change in speed over time. In an accident or any collision, slowing down the deceleration by even by a small amount can drastically reduce in the force. For example, changing the time to accelerate from .2 seconds to .8 seconds will result in a 75% reduction in total force. Think about this, you have probably experienced a car slowing down over a good amount of time versus when the driver makes a sudden stop, the less time to change the velocity the greater the forces.

Figure 2: Natural outcropping of coquina, a sedimentary rock south of St. Augustine in Flagler County. Photography courtesy of T. Cavanaugh.

So what does this have to do with a 300-year-old fort? The simple answer is coquina (see Figure). Thousands of years ago, the tiny coquina clam donax varibilis lived in the shallow waters of coastal Florida (they still do). These are the small pink, lavender, yellow, or while shells you can see where the beach meets the water as they dig down after the wave recedes. As the clams died, the shells accumulated in deposits several feet thick. Coquina is a loosely packed sedimentary rock found on the east coast of Florida (see Figure 2), and it contains many pores and is relatively soft when quarried, but will harden when exposed to air (see Figure 3).

Figure 3: Magnification of coquina from Florida. The scale is 1 cm (0.39 in). Photograph courtesy of T. Cavanaugh.

In 1702, English forces captured the town of St. Augustine and set up their cannon next to the houses to shoot at the Spanish fort. When fired upon a strange thing happened, instead of shattering, the coquina stone merely compressed and absorbed the shock of the hit. The coquina crush zones caused the cannon balls to bounce off or sink a few inches into the rock. What happened was that the energy of the impact was absorbed into the wall due to the progressive crushing of the coquina. The microstructure of coquina rock doesn't just break or fracture like granite would, instead it absorbs impact energy by progressive crushing layer after layer of shell, taking some of the energy by breaking the shells and spreading the force over more time as this occurs (see Figure 4).

As for the future, well it is widely believed that sooner or later the exploration of Mars will collect Mars samples that will be sent to Earth. When these samples are collected from the surface of Mars and shipped back to Earth, there exist several options for the final leg through the Earth's atmosphere and final impact with the Earth's surface. To ensure sample safety there will be multiple systems used, such as parachute, airbag, or other deployable systems, but also some form of a crushable energy absorber to cushion the payload during a hard surface landing. For relatively fragile articles or for low-speed impacts where all of the energy is to be dissipated by the energy absorber, it is expected that the package will use a hard-shell filled with crushable material surrounding the payload. You have probably already received such a payload design container, as this is the typical approach used with shipping packages for home electronics. A relatively stiff box acts as a protective shell for the electronics and using some form of energy absorbers, such as styrofoam or air pillows, against crushing inside.

Figure 4: Crumple zones in the coquina walls of the fort Castillo de San Marcos in St. Augustine. Photograph by T. Cavanaugh

ONLINE EXPLORATION:

CK12 Simulation of Automobile crash testing: [https://goo.gl/46eDnG]
https://interactives.ck12.org/simulations/physics/crash-test-dummy/app/index.html?referrer=ck12Launcher&backUrl=https://interactives.ck12.org/simulations/physics.html&_ga=2.235744897.1422048966.1509465714-880448487.1509465714

6.2 Lighting Strikes (Electrical Potential - Voltage)

SC.912.E.7.8: Explain how various atmospheric, oceanic, and hydrologic conditions in Florida have influenced and can influence human behavior, both individually and collectively.
SC.6.E.7.7: Investigate how natural disasters have affected human life in Florida.
SC.912.P.10.15: Investigate and explain the relationships among current, voltage, resistance, and power.

Figure 5: Spider lightning and a cloud-to-ground strike. Photograph courtesy of NOAA.

Florida has a lot of lightning strikes, averaging about 1.2 million cloud-to-ground strikes a year, or around 3,500 a day (see Figure 5). With that many strikes, some will hit people, and on average, about five people a year in Florida are killed by the electricity in lightning.

It is relatively simple to calculate the voltage needed for electricity to jump across a spark gap or the **voltage potential** for air with a simple formula:

$$\mathbf{V = d_{ag} \cdot 30000\ V/cm}$$

where
V is voltage (volts)
d_{ag} is the air gap length in centimeters
30000 is the ionization requirement for air in volts/cm

Air is normally an **electrical insulator**; electricity can't jump out of a wall socket and shock you because the surrounding air does not conduct it, but with the electric fields of a charged thunder cloud and impurities in the air, **ionization** can occur at much lower voltages during a storm. But usually, it requires very high voltages to have enough energy to turn air into a conductor, allowing electricity to jump across the gap. To calculate a spark gap voltage, first, measure the gap with a ruler, then use the formula mentioned above to find the voltage needed to arc across. The less the distance between an object and the cloud the lower the voltage necessary to create the spark. This is why you don't want to the tallest object or near a tall object during a thunderstorm.

A car uses the spark gap of the spark plugs in the car and the voltage generated by the coils in the car. For example, a Transit Connect spark plug has a recommended gap of 0.054 inches (or 0.137 cm). So the minimum voltage necessary for the car to spark in the air would have to at least be:

$$\mathbf{V = d_{ag} \bullet 30000\ V/cm}$$
$$\mathbf{V = 0.137\ cm \bullet 30000\ Volts/cm = 4110\ volts}$$

Lightning is the electrical discharge that results from crossing between two points of different electrical potential. The lightning strike pulls its electrons from the cloud, (the cathode), and transmits them to the earth (the anode) with the lightning strike. It is estimated that an anvil-shaped thunderstorm might hold over 100 million volts of potential and that a lightning strike from such a storm may have may have 1,000 Gigawatts of power. Lightning doesn't last long though, so while there is lots of voltage potential and power, the currents may be in thousands of amperes, but only for a few microseconds.

ONLINE EXPLORATION:

Spark Gap Simulation where you can adult the voltage to jump the electrode gap: http://vp-dei.vlabs.ac.in/Dreamweaver/sim_5/web/Exp5.html
[https://goo.gl/1hUpd7]

6.3 Making Ice and Air Conditioning

SC.6.E.7.1 Differentiate among radiation, conduction, and convection, the three mechanisms by which heat is transferred through Earth's system.
SC.7.P.11.1 Recognize that adding heat to or removing heat from a system may result in a temperature change and possibly a change of state.

Before people had refrigerators, they had something called an icebox. This icebox was an **insulated** container (usually of wood and metal) that held a large block of ice in a compartment near the top of the box. The chilled air in contact with the ice was air circulated down and around storage compartments in the lower section of the icebox. So where would Floridians get the ice? Well during winters up north it was possible to cut ice from ponds and lakes and then ship the ice to Florida where it could be held in highly insulated ice houses for later use. Then in 1840, Dr. John Gorrie thought of a better way to get ice, make it yourself. Gorrie was a doctor in Florida and that thought that many diseases, like malaria, were caused by heat and that the diseases could be avoided by staying cooler. So, instead of having the ice shipped down and stored, he designed a machine, that he patented in 1851, that created ice using a compressor (see Figure 5). The compressor he used could be powered by a variety of ways, including horse, water, wind, or steam. While he may have been wrong about preventing disease by cooling, that invention became the foundation for air conditioning and modern refrigeration.

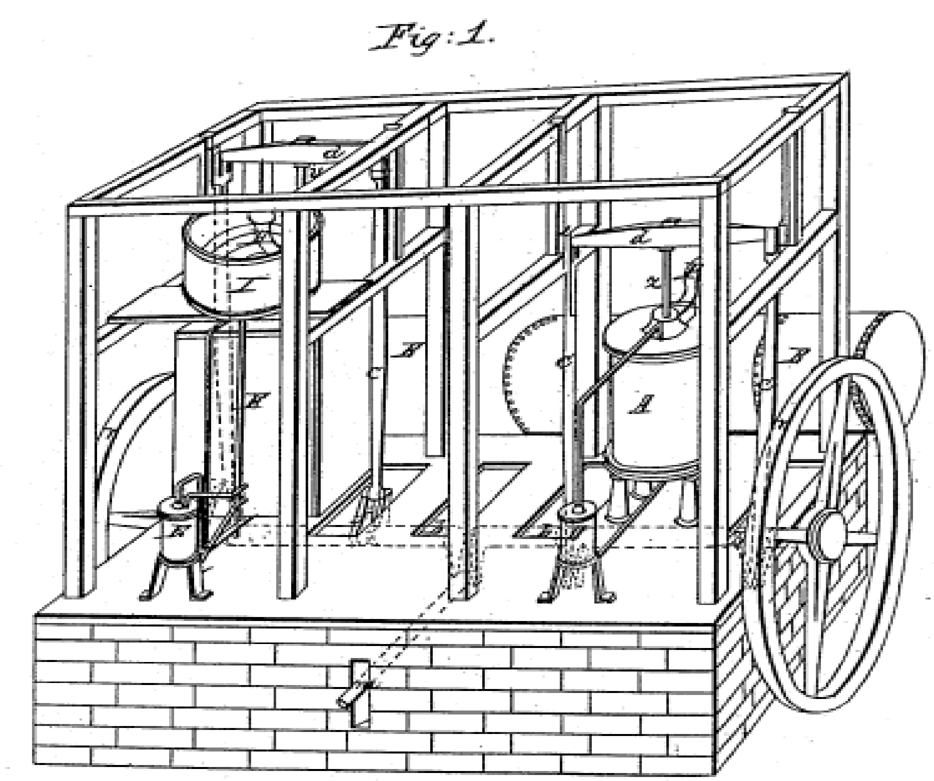


Figure 6: Patent schematic of Gorrie's ice machine.

Here is what Gorrie wrote in his patent application (No. 8,080. 4 Patented May 6, 1851):

> The nature of my invention consists in taking advantage of this law to convert water into ice artificially by absorbing its heat of liquefaction with expanding air. To obtain this effect in the most advantageous manner it is necessary to compress atmospheric air into a reservoir by means of a force-pump, to one-eighth, one-tenth, or other convenient and suitable proportion of its ordinary volume. The power thus consumed in condensing the air, to a considerable extent, recovered at the same time that the desired frigorific effect is produced by allowing the air to act with its expansive force upon the piston of an engine. which, by a connection with a beam or other contrivance common to both, helps to work the condensing-pump. This engine is constructed and arranged in the manner of a high-pressure steam-engine having out oil's and working the steam expansively. When the air, cooled by its expansion, escapes from the engine, it is made to pass round a vessel containing the water to be converted into ice, or through a pipe for effecting refrigeration otherwise, the air while expanding in the engine being supplied with an noncongealable liquid whose heat it will absorb, and which can in turn be used to absorb heat from water to be congealed. By this arrangement, I accomplish my object with the least possible expenditure of mechanical force, and produce artificial refrigeration in greater quantity from. atmospheric air than can be done by any known means.

Basically, this means the air is compressed into pipes, which causes it to heat up. Then the system allows water flows over the pipes, letting them cool to room temperature. The compressed air is let out into larger pipes where the gas expands and cools. Compression raises the temperature and expansion lowers it. The cooled air in the pipes is right next to water trays, which then freeze. If you have ever used a spray can, like compressed air to clean a keyboard, then you have felt that drop in temperature of the can as the air inside expands.

You can calculate this temperature change by using the combined gas law.

$$\mathbf{(P_1*V_1)/T_1 = (P_2*V_2)/T_2}$$

Where P is pressure in Atmospheres (atm), V is the volume in Liters (l), and T is the temperature in Kalvin (K), the subscript 1 is for the initial condition and the 2 is for the final condition.

To solve for the new temperature you get:

$$\mathbf{T_2 = (P_2*V_2*T_1)/(P_1*V_1)}$$

So if the initial temperature was around 308°K (or about 95°F or 35°C) at one atmosphere of pressure taking up one liter of space. If the air inside the container was compressed to 1.25 atmospheres, then you would get that:

$$\mathbf{T_2 = (1.25\ atm * 1\ l * 308°K)/(1\ atm * 1\ l) = 385°K\ (233°F,\ 111.6vC)}$$

Then the temperature would cool back down to the ambient temperature of 308°K, and then the pressure would drop back to 1 atm and you would get:

$$\mathbf{T_2 = (1\ atm * 1\ l * 308°K)/(1.25\ atm * 1\ l) = 246°K\ (-17°F,\ -27°C)}$$

A temperature which could then be used to freeze the water in the pans. So if you are hot in the summer and go in and get a cold drink from the refrigerator while you relax in the air conditioning, don't forget to thank John Gorrie.

ONLINE EXPLORATION:

- **Charles Law Simulation of the relation between temperature and volume:** [**https://goo.gl/RCSpDH**] https://pages.uoregon.edu/tgreenbo/charles_law.html
- **Ideal Gas Law Simulation where users can adjust the pressure, temperature, or volume of a gas:** [**https://goo.gl/kRiTHr**] http://highered.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::100%25::100%25::/sites/dl/free/0023654666/117354/Ideal_Nav.swf::Ideal%20Gas%20Law%20Simulation

6.4 Florida's Rotational Speed

SC.8.E.5.7: Compare and contrast the properties of objects in the Solar System including the Sun, planets, and moons to those of Earth, such as gravitational force, distance from the Sun, speed, movement, temperature, and atmospheric conditions.
SC.6.P.13.3: Investigate and describe that an unbalanced force acting on an object changes its speed, or direction of motion, or both.
SC.912.P.12.2: Analyze the motion of an object in terms of its position, velocity, and acceleration (with respect to a frame of reference) as functions of time.
SC.912.E.5.7: Relate the history of and explain the justification for future space exploration and continuing technology development.

Figure 7: Continental United States' southernmost point marker in Key West. Image courtesy of Radomianin [CC 4.0 International] [https://goo.gl/5VGr6b]

The Earth **revolves** around the sun (a year), but it also **rotates** on its axis (a day). As the Earth turns, and no matter where you are, it takes 24 hours to rotate around the Earth's axis one time (actually it is 23.9344699 hours, that's a sidereal day). Because of that, Florida is the fastest state in the union, and actually Key West is the fastest place in the continental United States (although Puerto Rico and the U.S. Virgin Islands are even faster) because it is the southernmost place in the continental U.S. (see Figure 7). The closer you get to the equator, the further out you are from the axis of rotation, and the further you have to travel each day, so the faster you go (see Figure 8). So Key West at latitude 24.551°N is speeding along at 946.3 miles an hour, while Seattle with a latitude of 47.6062°N, is only traveling at 701.5 mph, of course, the best speed-based location would be to launch from the equator 0°N with a speed of 1040.4 mph.

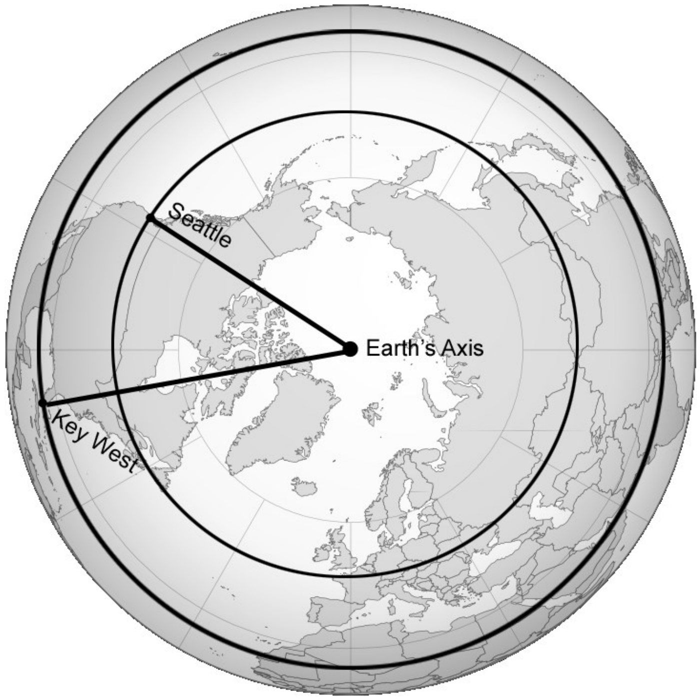


Figure 8: Earth viewed from the north pole. Key West is further from the axis and so has to go further (larger circle) a distance of 22,711 miles as compared to locations with a higher latitude (smaller circle), such as Seattle that has a rotation distance of 16,836 miles.

You can find out your speed for where you are by first finding your latitude and then calculating the speed using the Rotational Speed at Latitude formula.

To find your latitude

1. Open the Google Maps website in a computer browser.
2. Go to a location for which you want the GPS coordinates (your location).
3. Right-click (control-click on a Mac) that location.
4. Click the "What's here?" option in the menu that pops up.
5. A small box will pop up at the bottom of the map. The numbers at the bottom of the box are the latitude and longitude of the point you selected. All you will need is the latitude number.

The Rotational Speed at Latitude formula is:

$$\mathbf{s = 2\pi \cdot R_e \cdot \cos(\alpha)/Sd}$$

where:
s is the rotational speed at a latitude on Earth
R_e is the equatorial radius of the Earth (6378137.0 m)
α is the latitude (you can look it up on Google Maps)
Sd is the duration of a sidereal day (23.9344699 hours)

Or you can just go to Kurt Heckman's Rotational Speed at Latitude page [**https://goo.gl/SwVQBC**] (https://www.vcalc.com/wiki/MichaelBartmess/Rotational+Speed+at+Latitude) and type in your latitude into the input box whereupon the site will solve the equation for you.

The fact that Florida is moving so much faster than the rest of the east coast of North America has a number of effects, although it isn't something that you usually feel when walking north or south, as each step just makes you a very little bit faster or slower going to the east, so small as to not be noticed. Things like jet airplanes are fast moving objects and when traveling north or south, have to take into account the **Coriolis Effect** caused by the spinning motion of the Earth. Think about a jet plane flying about 600 miles an hour north from Key West to Jacksonville. If you don't take into account the Coriolis effect, then in a flight of one hour, it would travel 600 miles to the north, but also would end up just over 48 miles off to the east, well out over the ocean.

Key West: 24.551°N = 946.3 mph east

⇅Speed difference between locations = 48.32 mph

Jacksonville: 30.332°N = 897.98 mph east

Figure 9: Kennedy Space Center launch facility as seen from offshore. Photograph courtesy of T. Cavanaugh.

This high-speed spin can be very useful in other situations, such as launching rockets to space (see Figure 9). When questioned about why the rocket launch facility was located in Florida, Stan Starr, then chief of the Applied Physics Branch at Kennedy Space Center said "The Cape had a big advantage over other locations. It was selected for two reasons: the fact that it is relatively near to the equator compared to other U.S. locations, and the fact that it is on the East Coast." Locating the space center on the east coast of Florida was desirable because any rockets leaving Earth's surface were already traveling at a high-speed eastward, so they would be getting a boost from the Earth's spin, and there is a big ocean to the east in case things went wrong, no towns to fall on - so speed and safety. The Kennedy Space Center is at about 28.474°N, providing the rockets is an initial speed because of the Earth of about 914 mph. The exact speed needed to orbit the earth depends on the altitude, and for a 100-mile-high orbit around the Earth, the orbital velocity is 17,478 mph, and launching to the east with over 900 mph already, will save fuel. If the launch center had been on the west coast of the USA launching against the direction of the spin (west) to avoid going over populated areas, then it would have to overcome that initial spin speed and then build up to 17,478 mph. Think about it as if you were throwing a tennis ball to a friend while you were in a moving convertible car. If your friend is in front of you when you throw the ball at 20 mph, and the car is driving at 20 mph, then your friend gets the ball at 40 mph, but if she is behind you when you throw at 20 mph out the back of the car going 20 mph, then the resulting speed is 0 mph, it just drops.

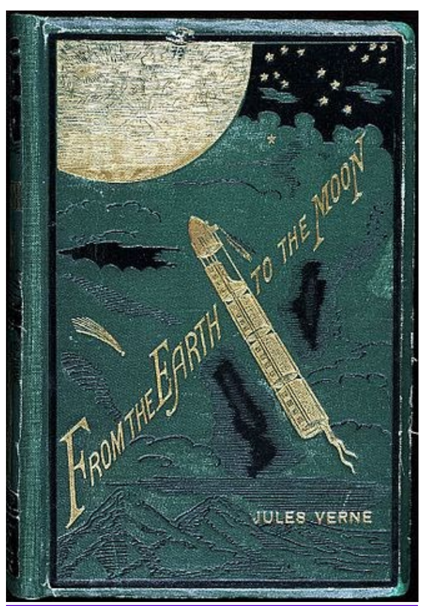
Online Exploration:

Rocket Launch Simulation shows the effect of mass (which includes fuel) on rocket launch/flight: [https://goo.gl/jq5jzT]
https://www.sciencelearn.org.nz/embeds/25-rocket-launch-simulation

Figure 10: Bumper 8 lifts off on July 24, 1950, from the Long Range Proving Grounds in Cape Canaveral, Florida. Photography courtesy of NASA.

Sidebox - reading

If you think that using Florida for the Space Center was an idea that first happened back in 1950 with the first launch from the cape when a military-civilian team launched a modified German V-2 rocket to an altitude of 10 miles (16 km) (see Figure 10), you would be wrong. Way back in 1865, Jules Verne wrote the book *From the Earth to the Moon*, and in that story, he placed his launch site in Florida for the same reasons as NASA. If you are interested in reading the book, you will find that Chapter 11 is the one where Verne wrote about Florida. The book is available for free online from Project Gutenberg: [**https://goo.gl/8BL5xc**]
https://www.gutenberg.org/files/44278/44278-0.txt



About the author/editor, Terence Cavanaugh is a native of Florida, a lover of science and Florida, and has taught science and technology across the peninsula from Jacksonville to Naples and a number of schools along the way. Currently, he is an associate professor of instructional technology at the University of North Florida. He has degrees in science education and instructional technology, and holds Florida teaching certifications for Biology, Chemistry, Earth/Space science General Science, and Physics, and is also a certified school library media specialist. His areas of research and development include digital and open source books. The educational materials he has developed include books on integrating media into science education, using electronic text in classrooms, integrating technology into the curriculum, and repurposing public domain novels by embedding reading strategies throughout. The novels with embedded reading strategies, *The Hound of the Baskervilles: Annotated with Reading Strategies* and *The Secret Garden Annotated with Reading Strategies,* are available for free from the Orange Grove: Florida's Open Education Resource Repository at https://florida.theorangegrove.org/

Florida Science:

The Science that Makes Florida Different

This book was created as a supplementary text designed to assist students with their understanding of science as it occurs in Florida. The book covers six sections of science: Earth Science, Oceanography, Weather/Climate, Biology (Biomes, Plants, and Animals), Chemistry and Physics. In total the book has 38 topic sections that are independently readable and will inform students on that aspect of science is it occurs in Florida. Also included are links to online interactive resources, simulations, and more to allow students to further their exploration, visualization, and experimentation.