MODULE 1

INTRODUCTION TO SPATIAL DATA AND GEOGRAPHIC INFORMATION SYSTEMS

SUMMARY:	Students will learn the fundamentals of geographic location, spatial data, and geographic information systems (GIS).
ACTIVITIES:	Learn the key elements of GIS. Interact with Google Earth. Explore an ArcGIS Online Story Map.
EDUCATION STANDARDS:	Utah Science Core 9-12 - Earth Science: Standard 5, Objectives 1c and 2d Utah Social Studies Core 9-12: Utah Studies, Strand 2, Standard 2.3 Utah Social Studies Core 9-12: World Geography, Strand 1
MODULE LINKS:	https://earth.google.com http://bit.ly/DenverHistoricMap

GLOSSARY

ArcGIS Online: An online, collaborative web-based GIS that allows individuals to use, create, and share maps and spatial data.

Attribute: Information about a geographic object that is generally stored in a table associated with a spatial data set.

Coordinates: A set of values that define the position of an object within a spatial reference.

Coordinate System: A reference framework that is used to define the position of an object in space.

Geographic Location: The location of an object on the surface of the Earth defined by two coordinates, latitude and longitude.

Geographic Information Systems (GIS): An integrated computerized framework used to manage information about geographic features, analyze spatial relationships, and model spatial processes.

Google Earth: An internet application that enables individuals to view geographic locations, maps, and spatial data.

Latitude: A measure of distance in units of degrees, minutes, and seconds north or south of the Equator to the North and South Poles.

Longitude: A measure of distance in units of degrees, minutes, and seconds east or west of the Prime Meridian.

Raster Data: A matrix of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing geospatial information.

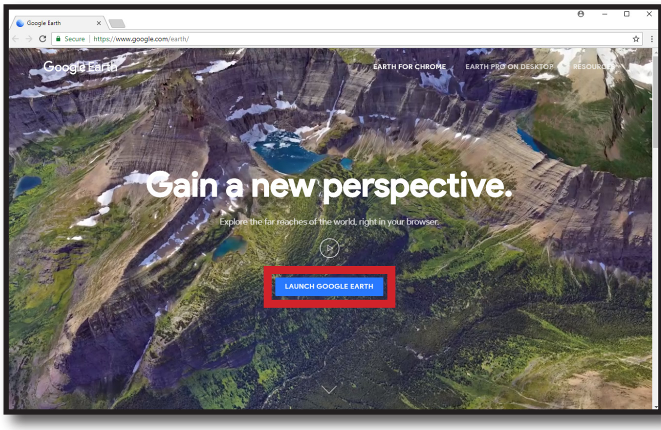
Spatial Data: Layers of information that represent objects, events, or phenonmenon that occur on or near the surface of the Earth.

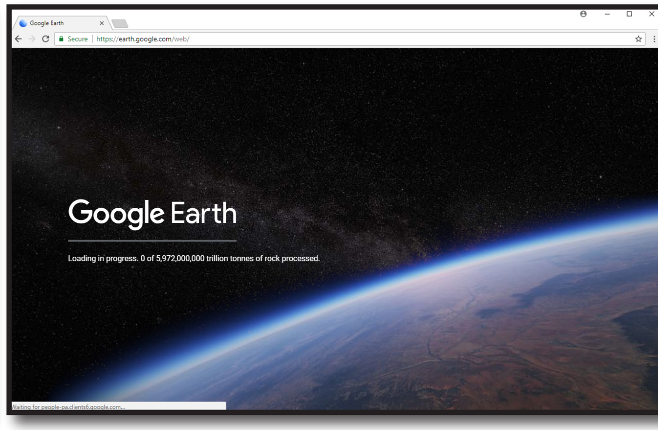
Vector Data: Spatial data that represents points, lines, and polygons.

GEOGRAPHIC LOCATION

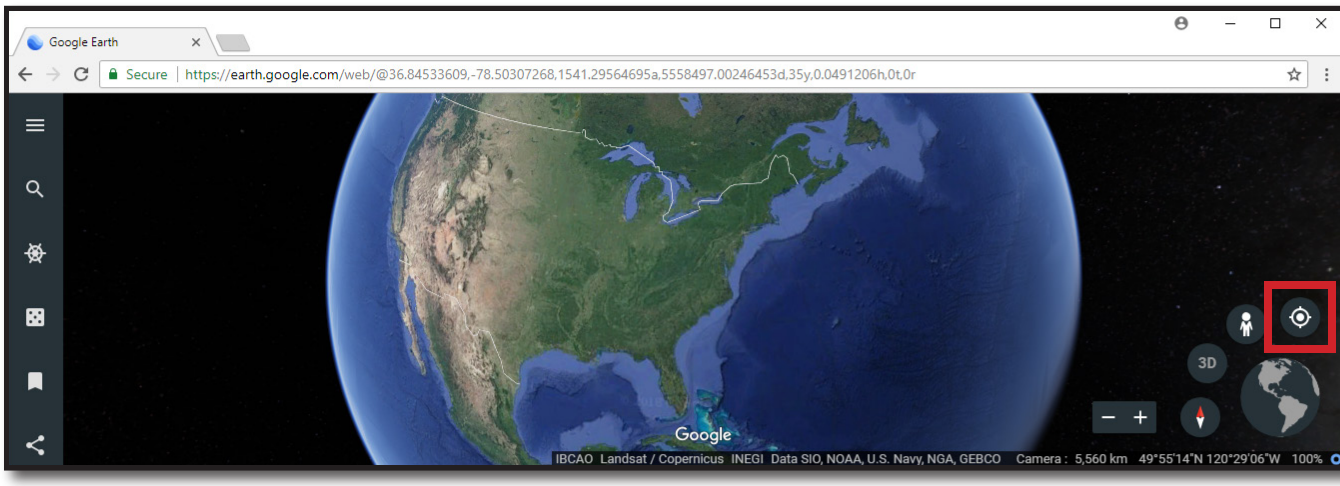
Geographic location refers to the location of an object on the surface of the Earth. Geographic locations are defined by two **coordinates**, called **latitude** and **longitude**. Coordinates of latitude and longitude identify the spatial location of a person, place, feature, or object on the surface of the Earth. For example, the house you live in or the school you attend has a set of geographic coordinates. By knowing these geographic coordinates, you can tell another person, or even an application, where you or these buildings are located.

Google Earth is a popular internet application in which users can view geographic locations, maps, and spatial data. To access Google Earth, open your internet browser, go to https://earth.google.com, and click *Launch Google Earth*.



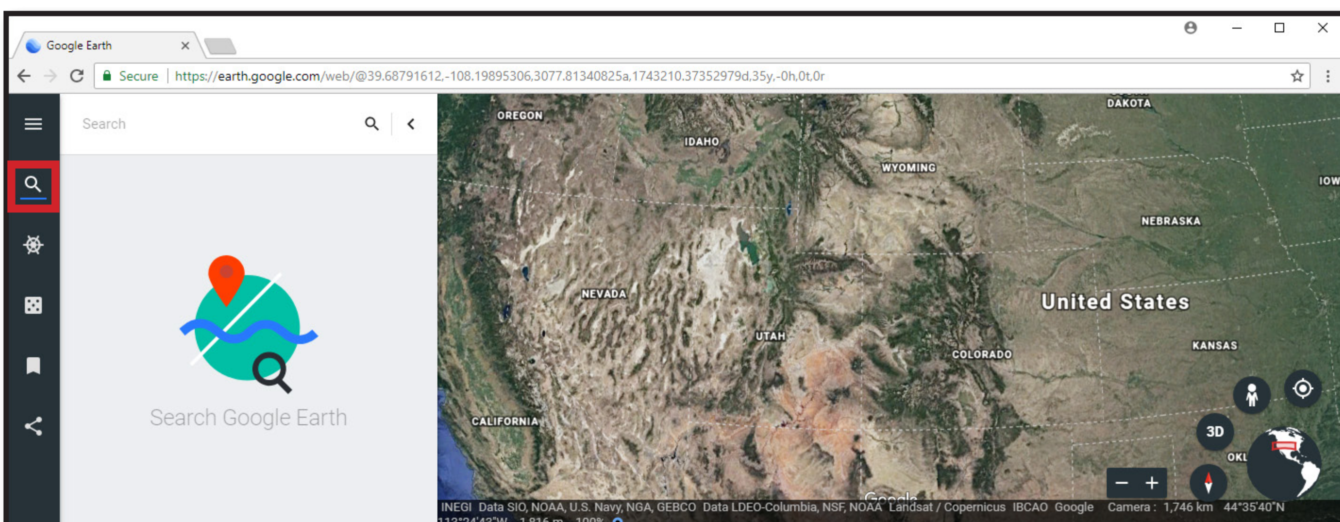


In Google Earth, you can find your geographic location using two different methods. First, at the bottom right of the computer screen, you will see a small compass button.



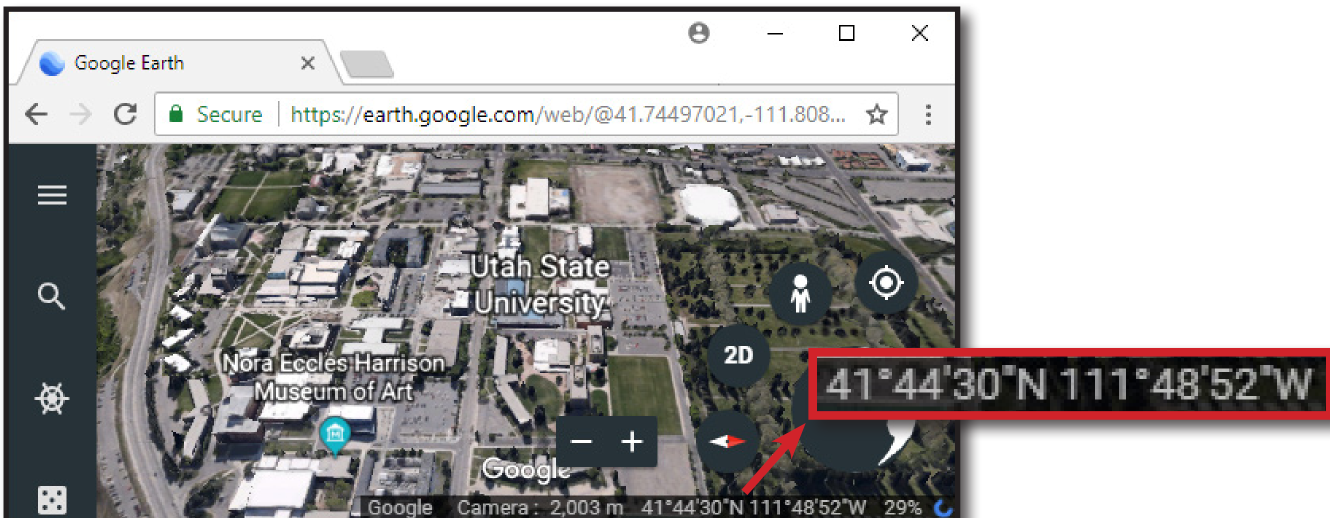
Click this button. The internet browser will ask you if it may find your location. It is okay to click *Allow*. When you allow the browser to access your location, what happens? Based on the internet address of your computer, Google Earth will attempt to find your geographic location. Did it find your location and how accurate was it?

Another way to find a geographic or spatial location in Google Earth is to click the magnifying glass on the upper left side of the computer screen. This is called the *Search* icon.



Using the *Search* feature, type in your address or approximate location and press enter. For example, if you are located near Old Main Hill at Utah State University in Logan, Utah, this is the view that will be displayed. What happens when you search for your address or location? Is this result more, less, or as equally accurate as the first method?

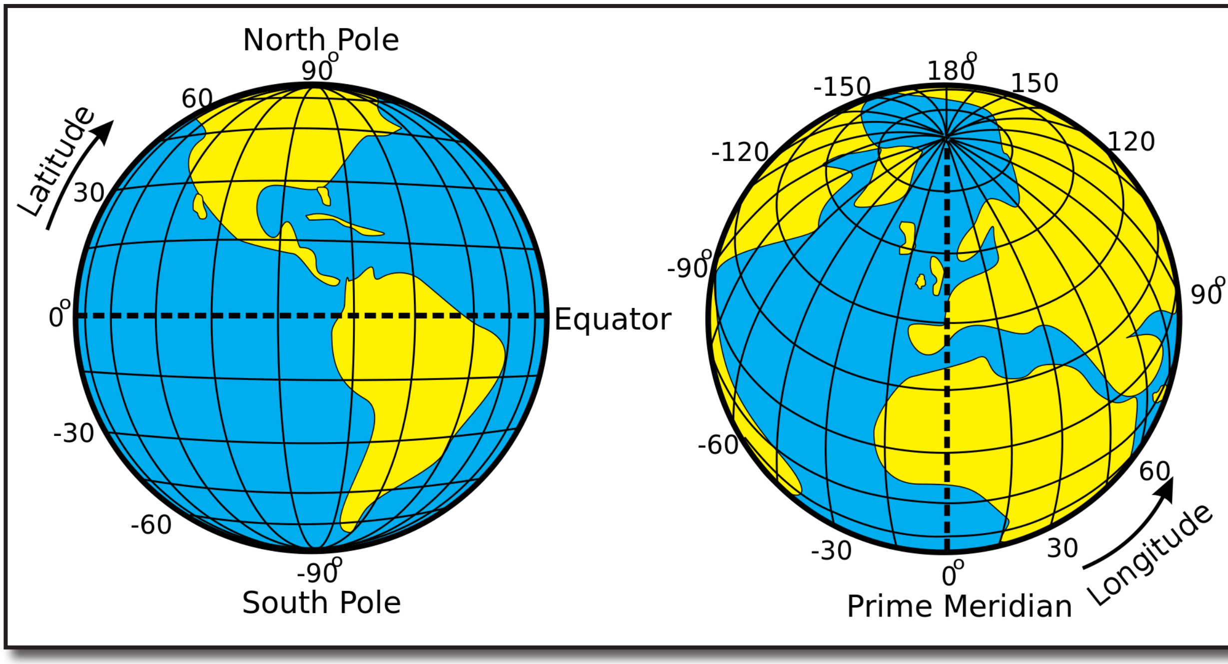
Google Earth allows you to identify a geographic or spatial location on the surface of the Earth. If you look at the bottom right corner of the browser window, you should see some numbers and symbols. Do you know what these numbers and symbols represent?



These numbers and symbols represent **coordinates** of **latitude** and **longitude**. As previously noted, these coordinates define the geographic location of an object on the surface of Earth within a specified reference framework (called a **coordinate system**). The **°** symbol is referred to as degrees, the **'** symbol (which looks like a single quotation mark) is referred to as minutes, and the **"** symbol (which looks like a double quotation mark) is referred to as seconds. If you were to read the above numbers, you would say "41 degrees, 44 minutes, and 30 seconds North Latitude and 111 degrees, 48 minutes, and 52 seconds West Longitude."

Latitude is a measure of distance in units of degrees, minutes, and seconds north or south of the Equator to the North and South Poles. Lines of latitude are parallel to each other and are often referred to as parallels. The Equator is 0°, the North Pole is 90° North Latitude, and the South Pole is 90° South Latitude. A measure of latitude can be used to determine how far north or south an object is located from the Equator.

Longitude is a measure of distance in units of degrees, minutes, and seconds east or west of the Prime Meridian, which runs through Greenwich, England. The Prime Meridian is considered 0°, or the origin point, of longitude measurements and it separates the Western and Eastern Hemispheres of the Earth. Lines of longitude, or meridians, run around the Earth vertically and meet at the North and South Poles.



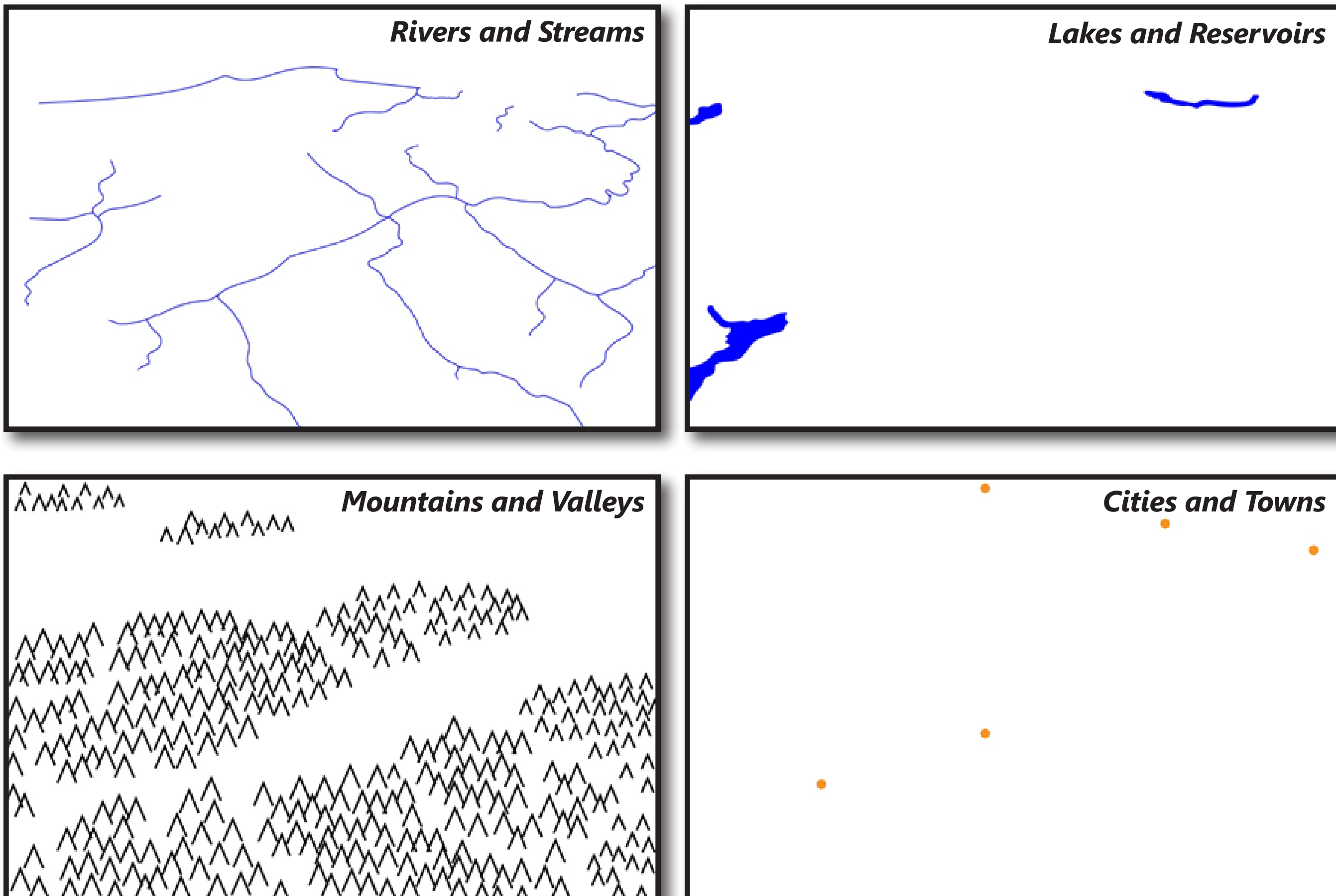
So, why are coordinates of latitude and longitude used to identify geographic locations? The answer is fairly simple. The Earth is not flat. The Earth is a sphere, much like a giant beach ball. Although, to be more accurate, the Earth is shaped more like an ellipse and it is called an ellipsoid. An ellipsoid is similar to a slightly squished ball and it is more representative of the shape of the Earth since the Earth is wider at the Equator and flattened at the North and South Poles. The Earth is roughly 7,926 miles (12,756 kilometers) in diameter (wide) and 7,900 miles (12,714 kilometers) from the North Pole directly through the center of the Earth to the South Pole. Coordinates of latitude and longitude are used to identify geographic, or spatial, locations on the surface of the ellipsoid-shaped Earth.

SPATIAL DATA

Spatial data, or geospatial data, represent the geographic locations, or coordinates, of objects, events, or phenomenon that occur on or near the surface of the Earth. Spatial data, which often contain information about the geographic objects and the relationships between objects, can be generated by evaluating images of the Earth. Images of the Earth, taken from an airplane or satellite, allow geographers to create spatial data through digital mapping. For example, if you examine an image from Google Earth, you can begin to map major geographic features. In the following Google Earth image of Idaho, what geographic features or objects can you identify? Are there some events or phenomenon that may be occurring in the image that we can not see in the image?

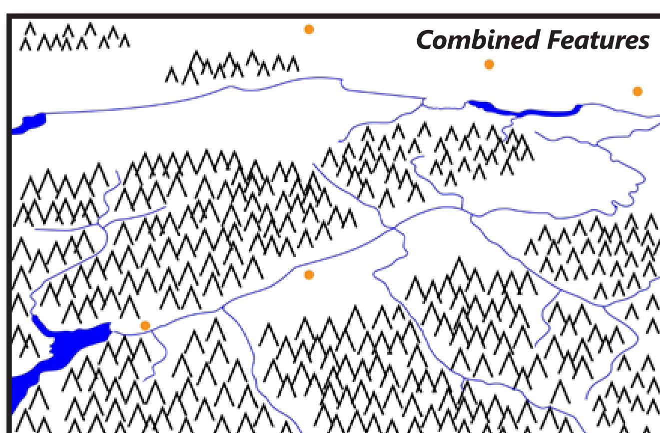
Some of the most basic geographic features that can be recognized from the image are mountains, lakes, rivers, and towns. However, there are other objects (such as roads and agricultural fields), events (such as fire or flooding), or phenomena (such as erosion or sedimentation) that may be identified. Some of these objects can not be seen due to the scale of the image and some of the events and phenomena can not be seen because they may occur at different times or over longer periods of time.

Collectively, these geographic objects, events, and phenomena make the Earth an infinitely complex system. To simplify how the Earth is observed and evaluated, spatial data can be developed to allow geographers and scientists to study one layer of information at a time. For example, if a hydrologist wanted to study rivers, streams, lakes, and reservoirs, spatial data representing water features may be informative. If a geologist was interested in studying mountains and geological processes, spatial data representing topographical features may be useful, or if an urban planner or sociologist was interested in studying settlement patterns, spatial data representing cities, towns, and demographics may be valuable.

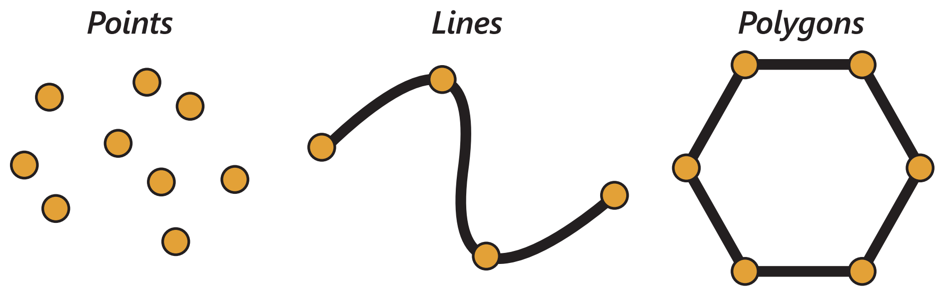


Spatial data allow scientists, geographers, and students to study complex systems and enivronments by assessing one geographic feature or process at a time. These spatial data layers can then be combined to provide greater understanding of the Earth and to support informed decision-making about the environment.

Now that you know that spatial data represent objects, events, or phenomenon that occur on, or near, the surface of the Earth, it is important to understand that there are two general types, or models, of spatial data. The first type is **vector data** and the second type is **raster data**.

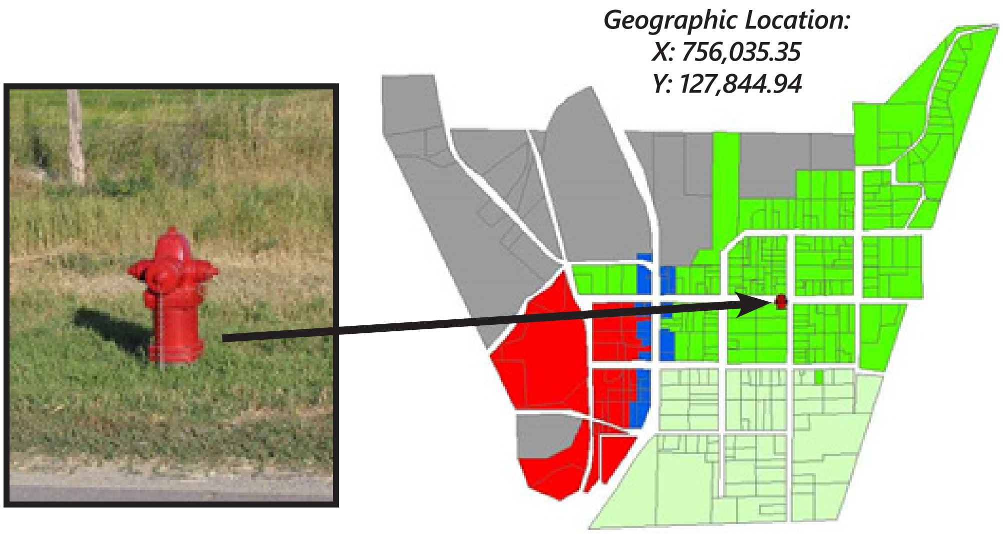


Vector data represent geographic objects using points, lines, and polygons. Point features are represented as a single coordinate pair, while line and polygon features are represented as a series of coordinate pairs, or vertices. In the previous Google Earth exercise, the cities and towns are represented by points. The rivers and streams are represented by lines, and the lakes and reservoirs are represented by polygons.



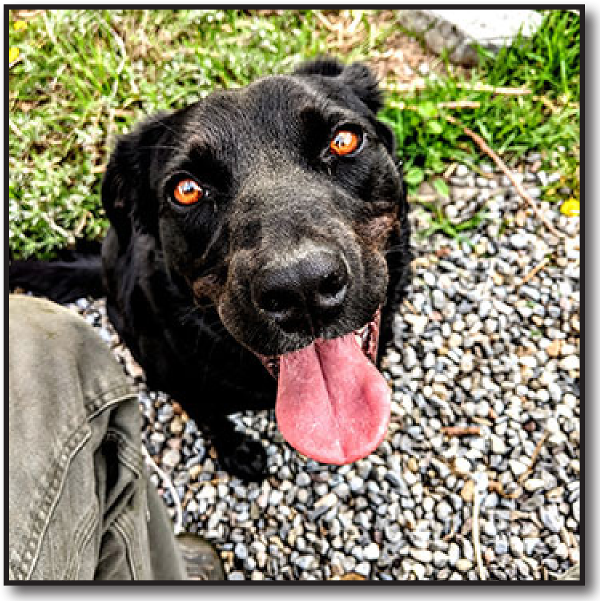
Vector data, whether points, lines, or polygons, commonly contain **attributes**, or non-spatial information about geographic objects. For instance, while you have a specific geographic location, you also have several attributes or features that make you a unique and special person. Your hair and eye color, the activities or sports you enjoy, and your favorite foods are a few of the attributes that describe you. With respect to spatial data, an attribute provides some detailed information, most often in a table or database, about a geographic feature.

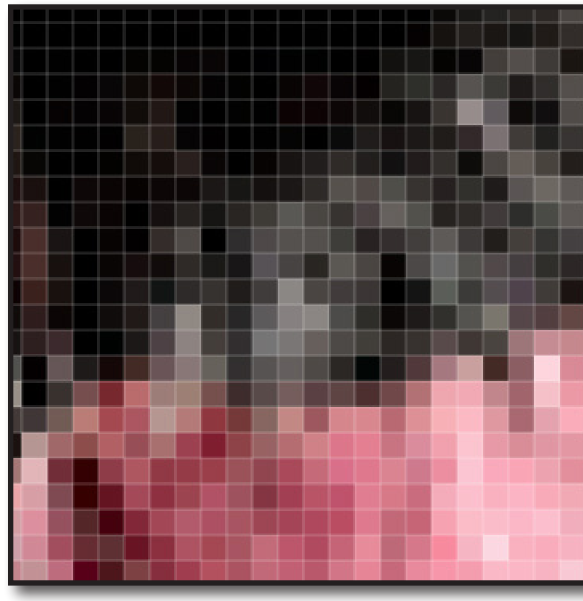
A geographic feature in your neighborhood, such as a fire hydrant, may have several spatial and nonspatial attributes associated with it. First and foremost, it has a geographic location. If you were to take a global positioning system (GPS) outside and record its latitude and longitude, you would identify its geographic location. While the spatial location provides you with meaningful information, you may not know anything else about it. If you were an emergency responder, you would likely need to know more details, or attributes, about this specific fire hydrant. You might want to know what color it is, when it was last maintained, how much water flows from it, and if it needs to be repaired. These attributes, which are stored in an attribute table, provide more information about the fire hydrant.



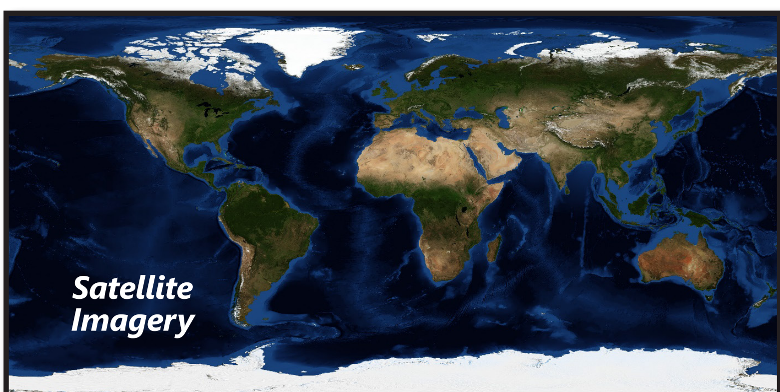
TYPE	COLOR	MAINTENANCE	FLOW RATE (GPM)	REPAIR
Fire Hydrant	Red	6/23/2017	200	No

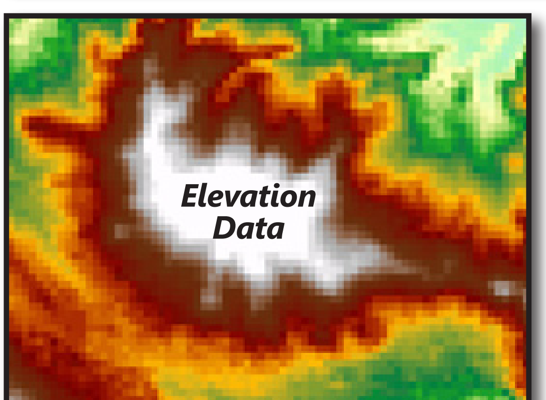
Raster data, the second type of spatial data, are grids of cells, called pixels, organized into rows and columns, much like a sheet of graph paper. Each cell or pixel contains a value or series of values that describe geospatial information. You may not be aware of it, but you likely use or create raster data every day. Every time you take a photograph with a digital camera or a phone, you are creating raster data. In the case of a digital photograph, what happens when you zoom into the picture? What do you see? The photograph becomes blurry and you can no longer see the crisp detail. But, what you can see is a series of pixels. Each of those pixels has a value, or several values. These values tell the computer or device how to display the raster data or image. Take a look at the images below. If you take the photograph of the dog on the left and zoom in, you will eventually see a grid of cells or pixels.





In geographic sciences, satellite images, aerial photographs and imagery, elevation data, and land cover data are examples of raster data. These raster data sets are representations of the surface of the Earth that are frequently used to provide greater understanding and management of environmental and natural resources.

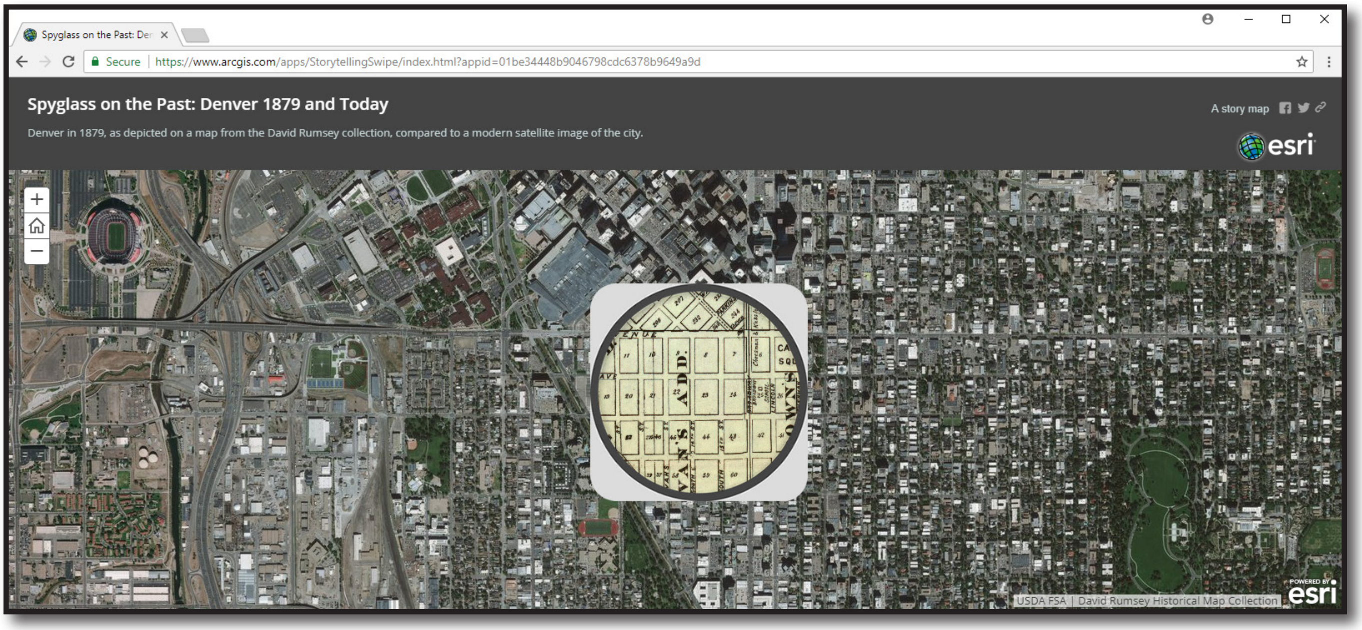




GEOGRAPHIC INFORMATION SYSTEMS (GIS)

Geographic information systems (GIS) are integrated computerized systems that are designed to manage information about geographic features, analyze spatial relationships, and model spatial processes. GIS computer programs allow geographers, scientists, and students to visualize, analyze, and share spatial data. GIS and geospatial applications are becoming widespread and there are several web- and mobile-based applications. In fact, most cell phones have basic mapping applications that can provide you with directions to specific places based on your geographic (or GPS) location. There are several desktop and online GIS software applications. Using the Google search engine, you can find applications such as Esri ArcGIS, QGIS, GRASS, and MapWindow. Some applications are free, while others are very expensive. **ArcGIS Online** is a collaborative web-based mapping application that allows individuals to visualize, develop, and share maps and spatial data.

Common ArcGIS Online applications are Story Maps. An ArcGIS Online Story Map is an interactive map that uses spatial data, multimedia images, and narrative text to tell a story. To access an ArcGIS Online Story Map, go to http://bit.ly/DenverHistoricMap. This Story Map is called *Spyglass on the Past: Denver 1879 and Today*. This Story Map compares a historic map of Denver, Colorado, from 1879 to a modern satellite image of the city.



While this map is relatively simple, it provide an incredible amount of geographic information. The image you see was acquired from a satellite and it represents present day Denver, Colorado. On the map, there is an interactive spyglass that can be moved. By moving the spyglass, a historic map representing Denver in 1879 is exposed. By examining the image, can you locate the Denver Broncos Stadium (Sports Authority Field)? Was the Stadium present in 1879? Explore the map and identify any significant changes.

This simple example of GIS demonstrates two key concepts. First, the geographic location of features on the surface of the Earth can be identified using satellite and aerial imagery. Features, such as roads, bridges, buildings, parks, and homes, can be identified in the present-day image and then compared to an image or map from a different year. Second, by having geographic coordinates of latitude and longitude, different types of data can be layered or placed on top of one another. In this example, the historic map from 1879 has been geo-located (meaning it has been assigned to a coordinate system) and layered on top of the satellite image. GIS applications, such as this Story Map about Denver, provide some remarkable information.

In the following modules, you will learn how to use ArcGIS Online and navigate through spatial data. The objectives of these modules are to promote spatial thinking and problem solving in relation to environmental planning. The central themes include planning for population growth and planning for the sustainability of environmental and natural resources.