CHAPTER 1
Introducing GIS

Exercise objectives

1a: Explore ArcGIS Online

- Explore a public map
- Sign in and join an organization
- Configure the map symbology
- Configure map pop-up windows
- Save a map

What is a GIS?

Probably the most commonly asked question to those working in the geographic information system (GIS) field is also one of the most difficult to answer in just a few brief paragraphs: What is a GIS? A GIS is composed of five interacting parts that include hardware, software, data, procedures, and people. You are likely already familiar with the hardware—computers, smartphones, and tablets. The software consists of applications that help make maps. The data is information in the form of points, lines, and polygons that you see on a map. People, users like you, learn how to collect data using mobile devices and then make maps using the software and data on computers. As your knowledge of GIS grows, you will learn more about procedures and workflows to make maps for yourself or your organization. Decision-makers and others in an organization rely on GIS staff to maintain data and create insightful map products.

GIS has many facets. It captures, stores, and manages data. It allows you to visualize, question, analyze, and interpret the data to understand relationships, patterns, and trends. GIS can be used simply for mapping and cartography. It can be used on the web to view maps and collections of data. It can also be used to perform spatial analysis to derive information from multiple data
sources. In any capacity, the results from a GIS can influence decisions. Organizations in almost every industry, no matter what size, benefit from GIS and realize its value.

Collecting spatial data—that is, information that represents real-world locations and the shapes of geographic features and the relationships between them—involves using coordinates and a suitable map projection to reference this data to the earth. For example, the distance that separates a conservation area and a neighborhood of a city is an example of a spatial relationship. How is wildlife in the conservation area affected by the increasing pressures of a growing urban setting? The spatial relationship between geographic features allows the comparison of different types of data.

When paired with attribute data—information about spatial data—a GIS becomes a powerful tool. For example, the location of a hospital is considered the spatial data (referenced to the earth). Information about the hospital such as its name, number of rooms available, emergency

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**GIS IN THE WORLD: Cultural heritage and GIS**

Cultural Site Research and Management and the University of Arkansas Department of Geosciences began a project more than 20 years ago to understand the accumulating effects of nature and foot traffic in the ancient city of Petra, Jordan, a stone city famously used as a backdrop in the movie *Indiana Jones*. GIS was used to create a database and model for use in archaeological research and land management and is currently used to automatically monitor and detect changes in the condition of historical sites in Petra. Read more about the project here, "Cultural Heritage Management and GIS in Petra, Jordan": [http://www.esri.com/news/arcnews/summer12articles/cultural-heritage-management-and-gis-in-petra-jordan.html](http://www.esri.com/news/arcnews/summer12articles/cultural-heritage-management-and-gis-in-petra-jordan.html).

Ad-Deir, or the Monastery, high above the valley—one of the largest of the hewn structures in Petra. Photo courtesy of Thomas Paradise.
rooms, specialization in medical procedures, patient capacity, and number of staff is all considered attribute data. This type of attribute information can be used to maintain records in a hospital network. It allows people who have that information to perform spatial analysis—a technique that reveals patterns and trends—to answer the following types of questions: What are the average travel times for emergency visits to the hospital? Is the patient capacity serving the demographics of a given city area efficiently? Do certain medical conditions happen more frequently in the area, and is the hospital equipped to handle them? To answer these questions fully, you must compare the data and attempt to explain the patterns. A children’s hospital can integrate spatial analysis with population-based resource planning to plan children’s health-care initiatives. A project like this one can greatly increase the ability of the hospital to identify and allocate resources to better meet local health-care needs, providing timely access to care for children across a city or region.


Oblique view of Petra. Blue lines represent ephemeral watercourses (wadis), and red cubes represent GPS markers at primary tomb facades. The map was created by Christopher C. Angel in ArcGIS (2012).
GIS today

GIS has been helping people better understand their world since the 1960s. It provides a framework of practical means for transforming the world with all kinds of activities, from improving emergency response to understanding bird migration patterns. People are integrating GIS into how they work with data because it is a visual, quantitative, and analytic tool. It provides people with the structures and concepts to handle data systematically.

People today have unprecedented access to data and information. A growing system of connected networks allows people to easily access data, collaborate with others, and produce and share results from desktops, laptops, and mobile devices—essentially from anywhere. The current trend of connecting people who work in the office and in the field allows for real-time analysis. Decision-makers use operations dashboards to monitor real-time data feeds and other sources of information. For example, a GIS coordinator for a local government can track real-time emergencies and respond by coordinating fire, police, and ambulance resources.

GIS is pervasive, interactive, and social. Dynamic and interactive maps on the Internet, known simply as web maps, are ideal for allowing many users to access and quickly locate features and visualize data. In the past, it took a team of GIS professionals to put together an online map. Now anyone can connect to ArcGIS Online, make a map with a few layers, and then share it with friends, co-workers, or anyone. The latest generation of web maps has simplified that process and now forms a platform that anyone can use.

Governments are opening access to data at an unprecedented rate. The open data movement is providing agencies and the public with authoritative data and enabling all levels of government to develop new tools and applications. Typically, only highly sensitive data is safeguarded or copyrighted anymore. Open data provides a way for people to extract information when they need it. It allows citizens, organizations, and governments to get right to problem solving, rather than spending a great deal of valuable time searching for and requesting data. ArcGIS Open Data, an ArcGIS Online solution, allows an organization to host the data it collects so that the public can freely view interactive maps and search for and download data.
Governments and organizations share open data through online portals.
The City of Surrey Fire Service in British Columbia, Canada, focuses on fire reduction education programs to increase prevention and awareness and create safer communities. The agency used GIS to identify areas of the city that met the requirements of being at high risk. This allowed the city to prepare a strategy of targeting education to reduce home fires. Read more about the project here, “Preventing Home Fires before They Start”: http://www.esri.com/esri-news/arcnews/winter1314articles/preventing-home-fires-before-they-start.

Residential fire incidents in the City of Surrey for a six-year period. Courtesy of the City of Surrey.
**Basic GIS principles and concepts**

Data can be visualized in a GIS as layers in a map. Geographic and man-made objects on the earth can be represented in a map by symbols: points, lines, and polygons. In the accompanying map, points represent trees and points of interest; lines represent roadways; and the polygons represent building footprints, green space, and water. Point, line, and polygon data is also called *vector* data. Features of the same type—such as trees, roadways, or buildings—are grouped together and displayed as *layers* on a map. To make a map, you add as many layers as you need to tell a story. If you are telling a story about a river that seasonally floods, you add a river layer and past flood hazard layers. You can also add a land-use layer to visualize what type of property, such as agricultural or residential, is affected by the flooded river. If you are building a city map, you start with a boundary layer, a street layer, and building footprints. By adding more layers, you can build a map that describes the city to your readers.

This map of Abu Dhabi shows building footprints, points of interest, roads, green space, and water *features*. Map courtesy of Municipality of Abu Dhabi City.
If you make a map of your house or a lake or a city park, you might draw an outline to represent the outer boundary. But what about natural phenomena—such as temperature, elevation, precipitation, ocean currents, and wind speed—that have no real boundaries? Weather maps show blue areas for cold and red areas for hot. Wind speed can be represented by a range of colors. Instead, measured values for any location on the earth’s surface can be recorded and collected to form a digital surface, also known as a raster. Captured location data is recorded in a matrix of identically sized square cells at a specific resolution—for example, 15 square meters. In the accompanying example, an analysis of an aquifer uses different rasters to calculate a result showing saturated thickness and usable lifetime.

This map of the Ogallala Aquifer shows a surface that represents the saturated thickness, water-level change, and projected usable lifetime of the aquifer. Map courtesy of Center for Geospatial Technology.
Features have locational data behind them. Features also contain attribute data, known as **attributes**. For a forestry map, point features that represent trees might include attributes such as tree species, height, bark thickness, and trunk diameter. For a utility map, lines that represent sewer pipes might include attributes such as flow rate, flow direction, pipe material, and length. Feature attribute information is stored in a table in a GIS database. Each feature occupies a row in the table, and an attribute field occupies a column. A GIS database can hold large collections of features and their corresponding attribute data, also referred to simply as “attributes.” A GIS provides many tools for you to query, manipulate, and summarize large quantities of data.

A map with parcels, water lines, and valves. Attributes of the valve features include maintenance dates and information about valve type, size, usage, cover, lid type, and condition.
Data can be queried and analyzed. In a GIS, you can perform a query on all the data that relates to phrases, terms, or features that you choose. For example, you might be looking for clusters of low-income neighborhoods to analyze poverty levels per square mile. Querying data from a database allows you to display only the data that relates to a certain theme. Additionally, a GIS enables you to identify spatial patterns in the data through the use of geospatial processing tools.

What is the problem you are trying to solve, and where is it located? The accompanying map shows analysis and a complex pattern of senior citizen out-migration. Depending on your project, there are hundreds of analysis tools to choose from.

This map of Portland, Oregon, shows net migration or deaths per acre because of “senior shedding” or out-migration. The red isolines identify concentrated areas in which mothers age 30 and over gave birth. Map courtesy of Portland State University.
The ArcGIS platform

ArcGIS Pro is designed for GIS professionals to analyze, visualize, edit, and share maps—in both 2D and 3D. ArcGIS Pro is the latest app in the ArcGIS for Desktop suite, which also includes ArcMap, ArcCatalog, ArcScene, and ArcGlobe. ArcGIS for Desktop is organized in a three-level subscription-based licensing model that includes Basic, Standard, and Advanced. Each level offers increased tools and functionality.

ArcGIS for Desktop is part of the much larger ArcGIS platform, which also includes ArcGIS Online, ArcGIS for Server, and Portal for ArcGIS. Organizations can leverage the entire platform to share maps and apps with their end users.

ArcGIS includes ready-to-use spatial data and related GIS services, such as global basemaps, high-resolution imagery, demographic reports, lifestyle data, geocoding and routing, hosting, and much more.

Finally, the ArcGIS platform includes essential tools for developers to build web, mobile, and desktop apps.
ArcGIS Pro

In this book you will learn how to use ArcGIS Pro and ArcGIS Online. Your work in ArcGIS Pro is organized into projects. These projects contain maps, layouts, layers, tables, tasks, tools, and connections to servers, databases, folders, and styles. Essentially all the resources needed for a project are in one place. ArcGIS Pro can also connect to ArcGIS Online public content and to your organization’s content. Projects are designed to be collaborative so that they can be shared and opened by others.

Maps and layouts display a project’s spatial data in either 2D maps or 3D scenes, or both simultaneously. You can create, view, and edit multiple maps, layouts, and scenes side by side, and even link them so that they can be panned and zoomed together. ArcGIS Pro uses ArcGIS Online basemaps, which provide a backdrop or frame of reference as you add your own layers.

A collection of geoprocessing tools allows you to perform spatial analysis and manage GIS data. Geoprocessing involves an operation that manipulates spatial data such as in creating a new dataset or adding a field to a table. Tools can be combined in ModelBuilder to create a diagram or model of your spatial analysis or data management process. For advanced users, Python, the scripting language of ArcGIS, provides a way to write custom scripting functions to help automate ArcGIS workflows. And tasks can be created and defined for people of an organization who are required to follow specific workflow steps.

Being able to share your work is a central part of the ArcGIS platform. In ArcGIS Pro, you can share components of your work, including maps, layers, or entire projects. Sharing involves packaging components into a compressed file, which can be distributed to others within your organization or externally. You can store your package on a shared network drive, or serve it across a website or mobile device.

To work through the exercises in this book requires that you have ArcGIS Pro loaded on a desktop or laptop computer that is running the Windows operating system, an Internet connection, and an up-to-date web browser to access ArcGIS Online. Optionally, you might use a smartphone or tablet to access some of the ArcGIS apps that run on smartphones and tablets.
EXERCISE 1A

Explore ArcGIS Online

Estimated time to complete: 45 minutes

You will begin your ArcGIS journey by exploring an ArcGIS Online map of earthquake locations, and then configure a new map of bicycle accident data.

Exercise workflow

- Explore ArcGIS Online to find a public map that shows real-time earthquake data.
- Open a map that shows pedestrian and bicycle accidents.
- Configure symbology for accidents and municipal boundaries.
- Configure map pop-up windows to make them easier to read.
- Save the map to your My Content page.

TIP Because of the dynamic nature of websites, you should be aware that the appearance or options of ArcGIS Online may change at any time.
Explore a public map

1. In a web browser, go to arcgis.com.

The ArcGIS Online home page is your starting point for learning more about the ArcGIS platform. It has access to information about how ArcGIS Online is used, resources, and help documentation. Even without signing in, you can view and interact with a plethora of community-created public maps and shared data.

ON YOUR OWN

Click the Features tab to learn more about how developers and professionals use ArcGIS Online as well as how you can get maps, apps, and other services.
2. **On the main navigation bar, click the Gallery tab.**

The gallery displays Esri featured content with maps and apps from all over the world. Map categories include imagery, basemaps, and maps about people, the earth, and lifestyles. Gallery content is constantly evolving.

3. **In the Search box, type recent earthquakes and press Enter or click Search All Content.**
To be more specific in your search, you can also add the owner as a search parameter. Try adding “owner:esri_atlas” after your search term. It will only return maps owned by esri_atlas.

4. **Click the title of the search result named Recent Earthquakes (a web map by esri_atlas).** (Clicking the thumbnail opens it in the map viewer.) The web page provides additional details about the map, including a description, map contents, and other properties.

5. **Click Open and then Open in map viewer from the drop-down menu.**

The map shows earthquakes from the last 90 days. Your map will look different from the one shown here because the map shows earthquake data dynamically in real time. Earthquakes in California are broadcast every few minutes, and about every 30 minutes for worldwide events. The legend shows three circles that increase in size: the larger the magnitude, the larger the circle.
6. **Click an earthquake point on the map.**

7. **View the pop-up information.**

You can see the earthquake’s magnitude, depth, location, date, and time—all of which are considered attribute data. You can click a web link for even more information.
8. Close the pop-up window. Zoom out (with the scroll wheel of your mouse or with the navigation control in the upper-left corner of the map) to see other areas of the world that have a lot of earthquake activity (namely around the Pacific Ocean).

9. Click Basemap to see available basemaps and then click Oceans.
Basemaps provide a backdrop and frame of reference for operational layers such as earthquakes. Now you can see the earthquakes in relation to the ocean floor. As you zoom in, with each zoom level the basemap provides more detail. In this case, you see more details about the ocean floor. In other basemaps, you might see city streets and eventually building outlines. In the satellite basemap, you can see your house, school, work, park, lake, and more.

The side pane to the left of the map contains three tabs: About, Content, and Legend. The side pane can be hidden, or you can adjust its width.

10. **Click the Content tab.**

![Content tab](image)

The contents include the Recent Earthquakes layer and the Oceans basemap. Layers have a check box so you can turn them on and off. The basemap is always on and has no check box. You can expand the Recent Earthquakes layer to see the symbology and other options to show a table, change style, and filter data.

11. **Click Modify Map in the upper-right corner of the page.**
Public maps, such as this one, can be modified without affecting the author’s original map. You can add more layers from ArcGIS Online, the web, or from your own computer.

12. **Click Add and select Search for Layers.**

![Search for Layers](image)

13. **In the Find box, type Earth’s tectonic plates and click Go. In the search results list, locate Earth’s Tectonic Plates and click Add. Click Done Adding Layers below the results box.**

![Search Results](image)

A layer that shows tectonic plates is added to the map. You will zoom in to a part of the world that has many fault lines and tectonic plates.
14. **Zoom in to the country of Japan or type Japan in the Search box.** Notice how the fault lines are drawn right across some of the earthquake points. The Japan Median Tectonic Line is Japan’s longest fault system. Many earthquakes have occurred along these fault lines and are bound to continue.

15. **Click Details. Then if necessary, activate the Content pane. In the Content pane, expand the drop-down menu next to the Earth’s Tectonic Plates layer. Click Move Down.**
The Tectonic Plates layer is moved below the Recent Earthquakes layer. Generally, points are placed above lines and lines above areas to create a visual hierarchy.

**TIP**

When you open someone else’s map, you cannot save it. You can only share the original owner’s map. You can share and copy a shortened link so that you can send the link to colleagues or use the social media links to share on Facebook and Twitter. In later exercises, you will learn how to share your own maps.
A web map can also be embedded on a website. You can customize its size as well as map options and custom location or marker symbol.

In the next section, you will join an ArcGIS Online organization and work with a map as a member, allowing you to save the map as your own.

**ON YOUR OWN**

*Return to the Gallery and explore other Esri featured content.*
Sign in and join an organization

Some exercises in this book require you to sign in to your ArcGIS organizational account. To do so, you must first have an ArcGIS Online Public Account. In a web browser, go to arcgis.com and click Sign In. If you already have an Esri account, you can just sign in. If you do not have one, click Create a Public Account and follow the instructions provided. Record your account user name and password somewhere safe because you will use them to sign in again throughout this book. To get an organizational account, go to the sign in page and click Try ArcGIS. An organizational account provides you a suite of ready-to-use apps that run on browsers, desktops, and mobile devices; access to maps and data; 200 ArcGIS Online service credits; and more.

You will visit ArcGIS Online using an organizational account to explore accident data in the City of Wilmington, Delaware.
1. **Go to arcgis.com and click Sign In in the upper-right corner. Enter the organizational account user name and password and click the Sign In button. (Also click OK to agree to the conditions to join an organization.)** Notice that you were redirected to a different URL that represents an organization named http://<yourusername>.maps.arcgis.com/home/organization.html. This is your organization’s main page, in which you edit settings (such as changing your organization’s name), invite other people to join, and see administrative information such as your license and subscription status.

Your trial account automatically makes you the administrator of your organization. As administrator, you have access to everything in your organization, including maps, data, and other resources, and see a customized view of the site. Organizations have private content, which is available only to their members, or public content, which is available to the entire ArcGIS Online community.

**TIP**

2. **In the upper-right corner, type Pedestrian and Bicycle Accidents - Wilmington, DE in the Search box and press Enter.** No results are found. This happens because the search defaults to searching only within your organization. You will disable that option to find other maps that are in ArcGIS Online and available to everyone.

3. **On the left, click the Only search in Your ArcGIS Organization check box to disable it.**
4. **One search result appears, a web map named Pedestrian and Bicycle Accidents - Wilmington, DE. Click Details below the thumbnail.**

   ![Web map thumbnail](image)

   The web page contains details about the map, including the owner, description, map layer contents, and other properties.

5. **Click Open and select Open in map viewer.** The map shows pedestrian and bicycle accidents from 2011 to 2014 in the City of Wilmington. The Contents pane contains six layers—a layer for each year, plus a municipal boundaries layer and a Streets basemap provided by ArcGIS Online. The accident data was provided by a member of the ArcGIS Online community and publicly shared. Open data is often provided by governments, agencies, or individuals for people who want to use it for collaboration, analysis, and research.

   ![Map viewer interface](image)
6. **Move the Accidents 2014 layer to the top of the contents.**

7. **Hide all layers except the Accidents 2014 layer.** The only points that remain on the map are the blue square and star symbols. Next, you will change the layer symbology to something more meaningful.

**Configure the map symbology**

1. **Click the Accidents 2014 layer name to view its current symbology.** Pedestrian accidents are represented by a blue-square symbol, and bicycle accidents are represented by a blue-star symbol.

2. **Under the Accidents 2014 layer name, click the Change Style icon.**
A check mark shows that the layer is symbolized based on Types (Unique symbols) to display the HARMFUL_EV attribute, which has only two unique values: pedestrian and bicycle. Next, you will change the symbols to something more meaningful.

3. **Under Select a drawing style, click Options in Types (Unique symbols).**

4. **Click the Pedestrian blue-square icon.**
5. Select Transportation from the drop-down list and select the red exclamation point in a triangle symbol. Adjust the symbol size to 18 and click OK.

6. Similarly, choose an appropriate symbol and size for the Bicycle icon (the yellow exclamation point in a triangle symbol is suitable) and click OK.

7. Click OK and then click Done to return to the Contents pane.
8. Expand the drop-down list next to the Municipal Boundaries layer and select Change Style.

9. Click Options.

10. Click the area symbol.

11. Click Fill and select a light-purple color. Adjust the Transparency slider to about 50%.
12. Click Outline and select a purple color. Adjust the Transparency slider to about 75% and outline width to 3 px, and then click OK.

13. Change the Overall transparency to about 50%.
14. Click OK and then click Done to return to the Contents pane.

The municipal boundary can now be more clearly seen with detail from the basemap still visible.

**ON YOUR OWN**

*Experiment with symbolizing the other layers. Pay attention to how symbol size and map scale relate to each other and how they appear on the map.*

You will customize this map further by configuring descriptive information about features in map pop-up windows.
Configure map pop-up windows

1. Make sure all layers are hidden except Accidents 2014.

2. Click an accident location on the map to open its pop-up window.

The default pop-up configuration shows an unformatted list of fields and values sourced from the layer’s attributes. Although it is useful to know all this information, for display purposes it is unnecessary to show all of it. You will adjust what attribute fields are displayed so that it is clearer as to what type of accident occurred.
3. **Close the pop-up window. Under the Accidents 2014 layer, click the More Options icon and select Configure Pop-up.** The pop-up title is Year 2014: {ROAD_NAME_}. Not a particularly useful name. The curly brackets indicate that it is a variable. You will use a more suitable name for the title instead.

4. **In the Pop-up Title box, type Accident Details.** In the Pop-up Contents section, a list box contains all the field attributes that are displayed in the pop-up window. It is not necessary to display all of them, and you will configure the pop-up window to display only the information that is relevant.

5. **Under the list box of attributes, click Configure Attributes.** The Configure Attributes window allows you to adjust field visibility and field alias as well as provide a way to move the order of fields.
6. In the Display column, clear all the check boxes (click the top display check box twice—to select all and then clear all).

7. Scroll down the list and select the Display check box for {LOCATION_4}. Rename the field alias to LOCATION.

8. Similarly, select the Display check box for {HARMFUL_EV} and rename its field alias to INVOLVES. Do the same for {DATE_OF_CR} and rename it to DATE.

9. Click OK in the Configure Attributes window and then click Save Pop-up.
10. Click an accident point on the map to see its new pop-up window.

The pop-up window is much more reader-friendly. Pop-up windows can also contain images and charts.

11. Close the pop-up window.

Save a map

As an organizational account user, you have the ability to save the map to your own workspace. By default, any maps that you make in the map viewer are private (only you can see them). You will save your map and add it to your own content.

**Tip** You are allowed to save a copy of any map that you work on unless the original map author has enabled Save As protection. You cannot update any existing layers that belong to the original map author. However, you can save any changes you make to the map, which then only you can see.
1. **Click the Save icon and then Save As.**

![Save icon and Save As](image)

2. **In the Save Map dialog box, change the title to** City of Wilmington Pedestrian and Bicycle Accidents 2011 to 2014.

3. **Add several tags:** pedestrian, accidents, City of Wilmington.

![Save Map dialog box](image)

4. **Click Save Map.** You have saved your first ArcGIS Online map. All saved maps appear in My Content and are accessible at any time. Even though the original map was shared with everyone, the map you worked on is considered private and is not shared with anyone in the organization, a group, or the public. You do not need to share this map right now. However, you will learn how to share maps and other content throughout this book as it is an essential part of the ArcGIS platform.

**ON YOUR OWN**

Go to My Content and find your own map.
Summary

This chapter introduced you to some background information about what GIS is and how the ArcGIS platform is structured. You started with opening a public map, one that everyone has access to, to see how easy it is to view data and basemaps. You learned how to sign into your organizational account and opened a map that was saved to your account. You learned how to configure symbology and pop-up windows to make the data layers and their attributes more usable. You then learned how to save the map to your own organizational account space.

You should be getting comfortable using ArcGIS Online. It will be used throughout the book, in which you will learn how to share layers, export content to your organizational account, and open maps in ArcGIS Pro. In chapter 2, you will take a first look at ArcGIS Pro.

Glossary terms

GIS
map
vector
layer
raster
attribute
ArcGIS Pro
ArcMap
ArcCatalog
project
geoprocessing