Introduction to Geographic Information Systems (GIS)

CHAPTER 1

LEARNING OBJECTIVES

Here is the content you will learn in this chapter:

1. The different definitions of GIS.
2. The advantages and disadvantages as well as consequences of different GIS definitions.
3. The nature of geographic questions that GIS is designed to solve.
4. The many disciplines to which GIS tools are applied every day.
5. The types of individuals, organizations, and government bodies that can benefit from GIS.
6. Examples of GIS applications for solving different types of geographic problems.
7. The way GIS knowledge and skills can empower these institutions, organizations, and government bodies.
8. The skills and knowledge needed to fulfill the needs of a geospatial workforce.
9. How geospatial knowledge and skills are incorporated into existing work environments.
10. How the incorporation of geospatial skills and understanding can transform your workplace.

BEHAVIORAL INDICATORS

When you are finished with this chapter, you will be able to:

1. Provide up to five unique definitions of GIS.
2. Explain the similarities and differences among up to five unique definitions of GIS. Define what limitations a “software only” definition places on how the discipline of GIS functions and benefits the organizations that incorporate it.
3. Provide a list of nine specific types of geographic questions GIS is designed to answer.
4. List and describe at least five different disciplinary specialties in which GIS is employed and the general tasks that GIS addresses within them.
5. Provide concrete examples of specific organizations (e.g., companies, government bodies, nonprofit organizations) that employ GIS and describe one or more applications that they perform on a regular basis.

6. Provide a list of at least five concrete examples of geographic applications for solving different types of problems.
7. Based on concrete examples of how organizations use GIS, describe how GIS empowers each organization to do what it normally does better, faster, more efficiently, or with less cost. Alternatively, describe tasks that GIS allows organizations to perform now, that they could not in the past and explain why this is so.
8. Describe the different kinds of GIS skills and knowledge that are in demand in the workplace.
9. Provide at least five concrete examples of how GIS knowledge and skills can impact your ability to obtain employment in organizations that are not normally considered "geospatial" in nature.
10. Explain how the incorporation of geospatial skills and competencies might improve the speed, quality, efficiency, or profitability of an organization that is not currently considered a "geospatial" company.

Chapter Overview

This chapter will answer the big question: Why am I learning about geographic information systems (GIS)? They have become integrated into so many facets of our lives that their influence has often been taken for granted. But like many things in our world, the commonplace tools and skills are often the most critical. This chapter provides a brief working knowledge of what GIS is, what problems it can solve, how it can empower organizations and you personally, and what skills you will need to benefit from GIS. You will examine real-world applications provided by business, industry, government, and nonprofit organizations. These examples will show you how GIS can improve the speed, efficiency, quality, and in some cases, profitability of the products and services these organizations produce. While you go through this chapter, think about the kinds of GIS-related employment you are currently involved in or wish to have. Think about how you or your organization can benefit from the use of the empowering technology, the knowledge, and ideas that drive GIS.

What Is GIS?

As a student of GIS, it might seem odd that there is a section of this chapter devoted just to defining GIS. GIS is far more complex as an idea than it is as a technology or even as a software package. The underlying disciplines related to GIS are now collectively called geographic information science and technology (GIS&T). This term implies that a major component of the definition of GIS has to do with the science that drives the GIS. The term also includes technology, and this says that there is a technological aspect to GIS. In fact, there are many different aspects and many different views of GIS depending on how the software is used; the context in which it is considered; and whether it is thought of as a tool, a conceptual framework, or an entire discipline. The following sections will examine these aspects individually.

Database Definition

GIS users who think primarily about the ability of GIS to hold lots of data for storage and eventual retrieval might be observed calling the GIS database itself the GIS. From their perspective, this definition is complete because they focus on how the database is created; how it is stored and organized; what it contains; and how it might be kept safe, remain accurate, and be timely and

useful. In many cases, these users are not really defining GIS so much as focusing on that aspect of the GIS with which they are both familiar and concerned.

Within this useful but limited definition, there are many aspects of GIS that are critical to the overall functioning of GIS. Among the most prominent of these is that the user must have the right data, they must be for the correct area, they must be safe, the user must have ready access to them and must have data descriptions that are clear to the user, and the data must be accurate. Database administrators are often the most concerned about GIS as database and therefore pay particular attention to what happens when a database is created, when and how it is accessed, and particularly when it is changed—especially when more than one person has access to the same database.

So from the GIS database administrator perspective, this is an operational definition, but there is one major drawback to the use of this limited definition. The limitation is that many GIS practitioners do more than manage the database. As a result, when a practitioner (e.g., a GIS applications person) and a database manager are conversing about GIS, they may very well misinterpret each other's meanings. A classic example is when someone says he or she has this fabulous GIS and you respond by asking what it does. You will frequently be met by a look of consternation because the database administrator focuses on the existence and maintenance of a clean, orderly, complete database and seldom anything more. The next definition includes all of these factors and details some of the missing parts that the database definition does not include and for which software users might be most concerned.

Software Definition

Perhaps the most commonly used definition of GIS today is that it is a piece of software designed for the input, storage, editing, retrieval, manipulation, analysis, and output of geographic data (Figure 1-1). While this seems simple as a definition, it actually has several aspects that need to be examined. Look at these one at a time.

- **Input.** Much GIS data are not in a form that the computer can use. These may include analog maps (hard copy maps usually on paper or mylar), gazetteers (geographic data stored

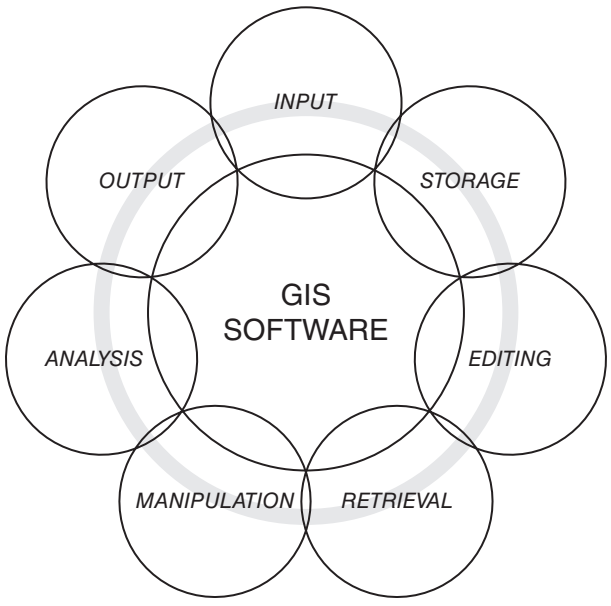

FIGURE 1-1 Components of a fully functional GIS software package.

as tables and lists), environmental field data, economic data, census data, survey measurements, and many other types of data that are not in digital (computer-compatible) form. The software has to be capable of incorporating these data not only in a form that the computer can store and manipulate but also in map-compatible form including all the appropriate locational information, projections, grid systems, and associated descriptive and symbol information. You should also note that the term *data* is purposely used here instead of information because information is most accurately defined as the outcome of some form of data manipulation. In short, information is data in the context of some question or query you pose of the software.

- **Storage.** Once the data are in the GIS, it is important that the software is able to save them so that they are there when you need them for querying or analysis. As simple as this sounds, it also means that the software has to be able to recognize available formats in which the data are stored and within which they can be edited, updated, and corrected.
- **Editing.** The ability of the software to edit data is critical. Correct data are essential to proper analysis. They must be in the correct position, have the correct categories and values, and be timely enough for a given project. GIS software contains a variety of automated and manual techniques that allow the user to ensure that the right data are in the right place.
- **Retrieval.** To perform analysis and to edit and update GIS data, the software must also be able to retrieve the portions of the database from the database that the user requires for a given task. More than just being able to load the entire database, the software must be able to target and select specific pieces of data for these operations. The software must also be able to do this efficiently and with no corruption of the database or any of its parts.
- **Manipulation.** No software definition of GIS would be complete if it did not include the ability to manipulate the data contained in the database. Manipulation has to do with grouping, sorting, geocoding (adding actual locations to the data), and adjusting to changes in map configurations (more on this in Chapter 2). Think of manipulation as preparation for more involved analysis.
- **Analysis.** The real power of the GIS is its ability to analyze spatial data. The analyses include such things as counting; measuring distance, shape, volume, and configuration; comparing individual pieces of data or whole maps; calculating missing values; performing statistical analysis; determining visibility in topographic surfaces; performing basin fill and movement of liquids; and literally thousands more individual operations and combinations of operations. The GIS is able to combine multiple analytical techniques into large, repeatable models that can answer very complex questions.
- **Output.** Without the ability to output information from the analysis of data, the GIS is of little use. I emphasize the word *information* again to remind you that the output is usually the result of answering a question and is now considered to be in the context of that question. Most GIS software is able to produce a wide variety of map types, each with a different purpose in mind. Modern GIS also produces 3-D images, animations, fly-throughs, road logs, and charts, and a host of electronic output including, believe it or not, automated phone calls.

In terms of consequences, you are reasonably safe with this definition because it is a commonly accepted, although somewhat limiting definition. Most GIS practitioners are comfortable with using the term *GIS* to refer to the software but are often aware that a fully functional GIS relies on considerably more than the software. While they may not say it, practitioners often recognize that the "S" in GIS stands for system and that all systems are made of component parts (subsystems), only one of which is the software itself.

System Definition

As you can see, the often-used software-only definition has a lot in it, including all the components of the database definition. It seems to cover many aspects of the software as well. Stop and think for a moment, however, about all these aspects and how they work. If you look at the very first one, input, there are some things you must consider. The following list outlines just a few of them.

- Exactly what are you going to input?
- Who is going to perform the input functions?
- Where are you going to find the data?
- In what format do the data exist?
- Who is going to provide the data?
- What instruments do you need to input the data?
- Will you have to pay for the data?
- Do GIS personnel require training?
- Do you need to reference the data provider when you use its data?

Within that list for just that first factor (input), you start to see some of the things that a software only definition missed. There are people involved in the potential sale of the data, some involved in the data input, and still more involved in the training of the input specialist. These people rely on hardware to input the data, not to mention the storage, retrieval, manipulation, analysis of the data, and output of the results. The people who work in the GIS industry often work for organizations, and these organizations become part of the larger definition of GIS. The organizations might be where you work, or it might be your client, or even a vendor of the data, training, software and/or hardware that supports your operations (see Figure 1-2).

The system definition of geographic information systems, while more inclusive than either the database or the software definition, is less frequently used in common practice. When you are talking about the industry, your profession, or the activities in which you are engaged, you might very well be thinking about GIS from a system perspective. You may also find yourself using the software definition when you are concerned with algorithms, problem solving, and other internal

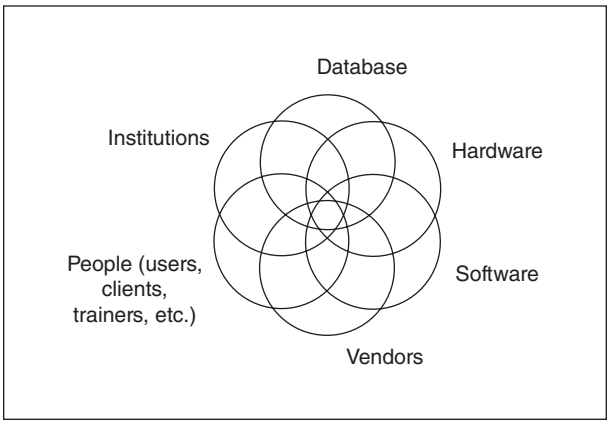

FIGURE 1-2 The system definition of GIS includes the database, hardware, software, vendors, people, and institutions.

operations. The definition you use, then, is context dependent and changes based on the nature of your work and conditions within which you are working. Academics, for example, recognize these multiple definitions and include geographic information science or geographic information science and technology (GIS&T) when including the theoretical concepts and technological advances that drive the advances in the industry.

ACTIVITY 1-1 DEFINING GIS

In this activity, you will have the opportunity to demonstrate your mastery of the basic definitions of GIS. A working knowledge of the different context-sensitive definitions of GIS will allow you to communicate effectively with other GIS professionals. The ability to understand GIS professionals that work in different parts of the industry will allow you to be understood. Of equal importance is that your colleagues will have confidence in your GIS background and training.

Scenario

You are at a GIS conference and are having a conversation with someone whom you discover was a database management person at a business and is now being asked to learn about GIS because the company plans to move toward incorporating GIS into their operations. As you converse, you discover that you seem to be talking about completely different things when you talk about GIS.

1. In the space provided, list and describe five definitions of GIS you have discovered on the Internet so you will be prepared to talk to folks at the conference intelligently.

2. Given this person's background, what do you believe will be her understanding of the definition of GIS?

3. What are the two primary missing components of that definition?

4. Describe to this person, in your own words, how the meaning of GIS is broader than the one she understands by providing examples of the importance of the database, the analysis, and the institutional components of a more complete definition of GIS.

5. You meet a software vendor who tells you that he has the best "GIS" on the market. Rather than disagreeing with him, simply understand his perspective but note below the limitation of the "software only" definition.

Further Exploration

Go onto the Internet and use your favorite browser to gather a collection of GIS definitions. Evaluate each definition for completeness and consider how each definition might relate to the author's particular bias or professional background. When you have finished, share these with your classmates. Your instructor might even assign this as a discussion activity.

What GIS Does

In the previous section, you learned that one definition of GIS focuses on the software. You also discovered that the software definition is possibly the most prevalent. The reason for this has much to do with the focus of GIS as a tool for analysis that so many GIS practitioners perform regularly. There are many forms of analysis a GIS can accomplish from simple to complex. To understand the real power of GIS, it is best to look at what types of questions it is designed to answer rather than providing an exhaustive list of functions. The next paragraphs group these questions by type.

Questions Regarding Individual Geographic Objects

Every geographic object occurs somewhere in geographic space and its location is often important to the GIS analyst. Typical questions about individual locations of objects include:

- Where is the object located in absolute coordinates? *This piece of information allows many other questions to be asked regarding relative distance.*
- How much space does the object occupy? *Knowing how much space a geographic object occupies can be used to determine value (e.g., the size of an ore deposit) and relationships with other objects (see spatial relationships below).*
- What are the descriptions or values associated with the object? *The descriptive information of individual objects can be used to selectively search for them (e.g., to find all "urban" polygons).*
- When were the object's location, extent, or descriptive information collected (temporal information)? *These characteristics can also include things like when the object first appeared in that location. For example, if a crime occurred at a particular place, when did it occur?*
- Has the object's location, extent, or attributes changed through time? *A good example of this might be asking questions about whether a fire, disease, or insect infestation is increasing in the area or not.*

Some might recognize these as questions one might ask of a traditional map, but as the volume of data increases and as the questions become more complex, the GIS software becomes invaluable for such repetitive tasks.

Questions Concerning Multiple Geographic Entities

More difficult questions arise when we consider relationships among two or more entities. For instance, we can ask:

Questions about Spatial Relationships

- Do the entities contain one another (e.g., does a polygon representing a lake contain an island)?
- Do the entities overlap (e.g., does a study area polygon overlap a grassland polygon)?
- Are the entities connected (e.g., do two roads come together at an intersection)?
- Are the entities situated within a certain distance of one another (e.g., is a road line within 200 feet of a hospital polygon)?
- What is the best route from one entity to the other? (e.g., what is the shortest route from your home [a point entity] and a store [a point entity])?
- Where are entities with similar attributes located (e.g., where are all the urban polygons located)?

Questions about Attribute Relationships

- Do the entities share attributes that match one or more criteria (e.g., find all forest polygons that are larger than ten hectares and greater than one hundred miles from the nearest interstate highway)?
- Are the attributes of one entity influenced by changes in another entity (e.g., as the value of residential land polygons increases, does the average size of home increase)?

Questions about Temporal Relationships

- Have the entities' locations, extents, or attributes changed over time (e.g., has the extent of forest insect infestation increased from 1970 to 1980)?

Geographic data and information technologies are very well suited to answering moderately complex questions like these. GIS is most valuable to large organizations that need to answer such questions often.

ACTIVITY 1-2 WHAT GIS DOES

In the following activity, you will have the opportunity to demonstrate your mastery of the capabilities of the GIS to do analysis. Select some maps and aerial photographs you happen to like from your searches on the web and provide at least two examples of each of the following. You may have to use several maps to complete this activity. Your instructor will likely require you to attach a printout or screenshot of your map objects.

1. Absolute locations (in latitude and longitude) of two point objects (depending on scale, these could be towns, wells, mines, benchmarks, or many others).

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2. Approximate length, width, and area of an area object on a map or aerial photograph (e.g., a football field or baseball diamond, farm section).

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3. From a map of land use, such as vegetation or other categories, list some of the names you encounter for these categories.

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4. From a U.S. Geological Survey (USGS) topographic map, locate the date the map was produced and list it here.

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5. Locate maps or aerial photographs of an area from two different time periods and indicate one major change you can identify (e.g., more urban, damage from a storm or landslide).

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Thought Question: That was pretty easy, right? Now keep in mind that the computer needs to duplicate this process. That's where the power of GIS to keep track of all of this comes in handy.

6. List nine different types of questions that GIS is designed to answer rather than the five basic ones you listed previously.

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Further Exploration

Consider your answers above and see if you can come up with two or three concrete examples of each question type. This will get you started thinking like a GIS analyst.

The GIS User Community

As a GIS practitioner, you will soon discover that you are part of a large and growing user community composed of everything from suppliers and programmers to vendors and users. The focus of this chapter is primarily on the largest of these groups—the GIS user community. An awareness of the many aspects and communities of GIS will allow you to know whom to turn to when you need an applications programmer or when you need to design a **geodatabase** (a proprietary database type used by Esri in its ArcGIS software) for a new type of application or when you wish to share data from one application to another. Knowledge of the uses for each discipline and the many different models they employ may also suggest unique and often innovative uses of the many algorithms included in your GIS software. One of the really nice things about the diversity of the user community is that each presents a unique set of challenges and subsequent solutions to often difficult problems. The cross-pollination of ideas from discipline to discipline is one reason that large international user group meetings attract many thousands of users as they share their ideas.

Disciplines Employing GIS

As you can see from Figure 1-3, there are many basic categories of GIS communities and disciplines. The organization into the ten categories in the figure is by no means exhaustive, nor is it the only one that you could find in the literature. Still, it's a reasonable and relatively short list and is easily accessible via the Esri website.

A quick dissection of the groupings is a useful exercise if for no other reason than it allows you to determine into which general category your own applications might fall. The dissemination of GIS is becoming invasive—so invasive that by the time you read Figure 1-3, it is entirely

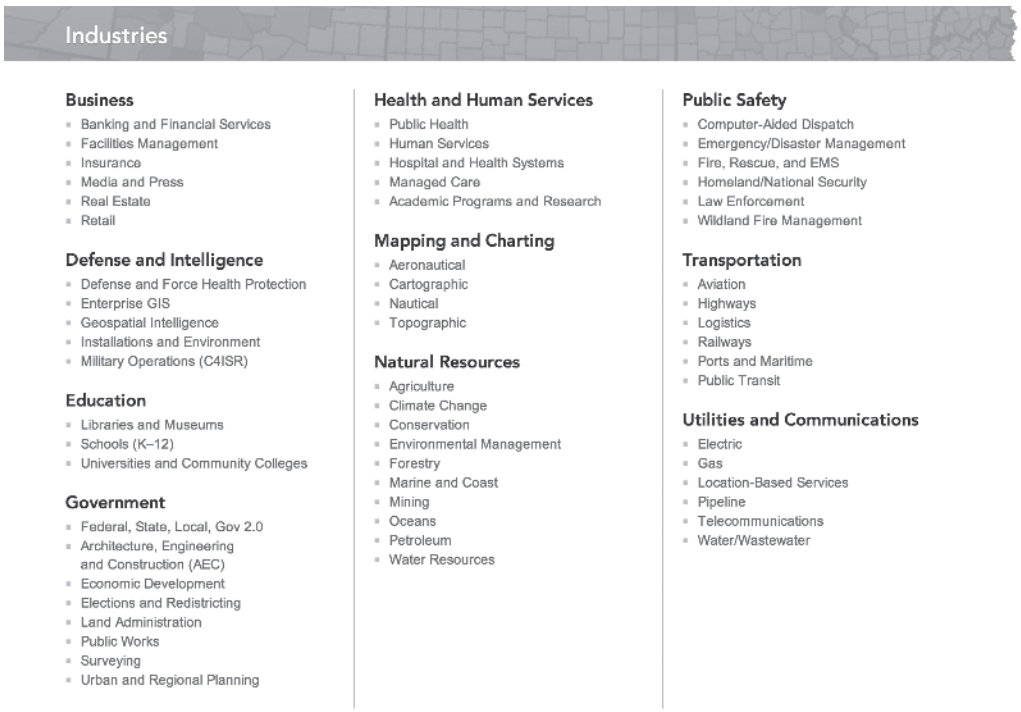

FIGURE 1-3 A list of GIS community types supplied by Esri on its website.

likely that many additional applications will be added to the list. In some cases, there may even be whole new communities of users. Many—perhaps most—of you are studying GIS because you intend to be part of one of the current or future communities of GIS users. It is impossible to detail for each of your individual uses how GIS will affect what you do currently. As technology, data availability, and different circumstances drive GIS in your own industry, take the time to keep abreast of how these changes might impact your career. Just as a practical matter, I will now provide a few examples of users and their evolution.

Examples of Users

As you just read, there are many communities and far more individual users of GIS. Each of you is likely to be working with some subset of the industries in Figure 1-3 and you will discover that each industry has multiple communities (subsets) of users who may specialize in one field or another. One quick example would be the water resources industry. Within that group are many different focus groups, and each has its own issues and community (Figure 1-4).

What Questions Users Ask of GIS

Earlier in the chapter, you examined different types of basic questions as well as more complex questions a GIS can answer. Searching the Internet will allow you to find an enormous amount of specific information about how both simple and complex questions are applied by different industries. Let me provide you with a quick example to get you started.

The very first GIS question listed in this chapter was about locating objects. This means the GIS software needs to help you identify where things are on the map. Zoom in to this example from the Internet that illustrates how police know the exact location of crimes because the data

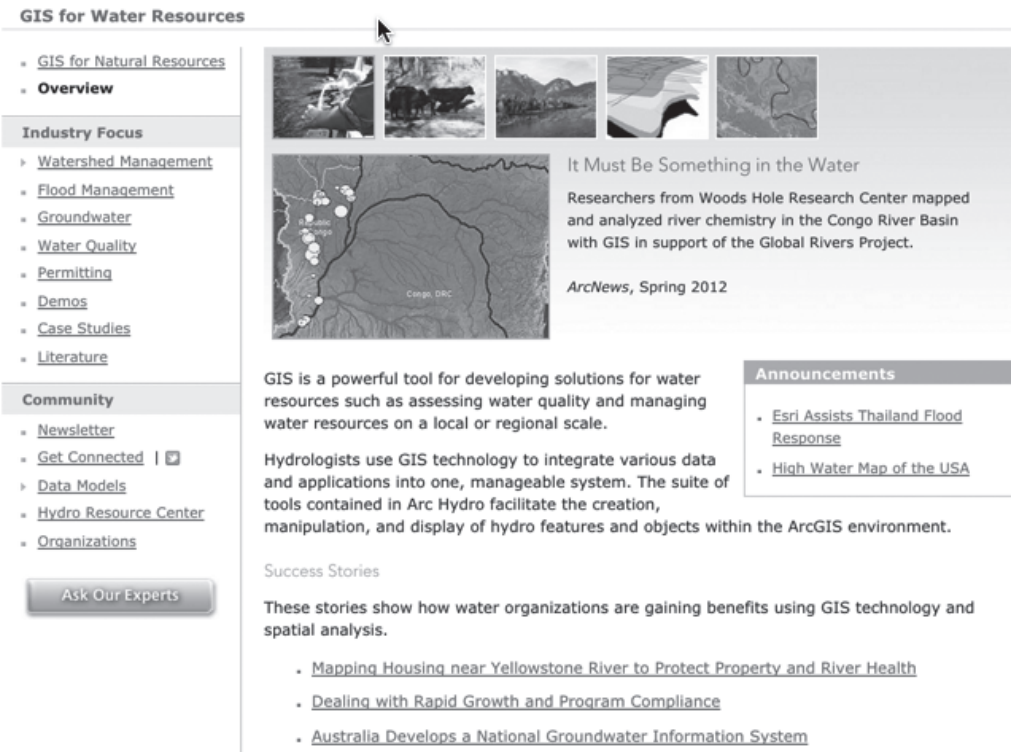

FIGURE 1-4 Screenshot of the Esri website looking at the GIS for the water resources industry.

are clearly indicated both graphically and in specific location data in the GIS data tables. Notice the descriptions of the crimes—the crime types—are also indicated by different symbols. A more sophisticated analysis you will learn about later created those patches of color indicating **hot spots** or **clusters** of crime. Another question this clearly demonstrates is how change has taken place in crime based on the housing foreclosure crisis in Oakland, California. This is a classic example of how the GIS can assist with analysis of temporal change.

How GIS Empowers These Industries

No matter what the industry, there are major general types of advantages to the use of GIS as long as spatial data are used in everyday operations. The shear number of operations (e.g., map analyses) that are capable with a computer and the massive savings in time often translate directly into savings in costs, increased profits, and greater efficiencies in the workplace. In some cases, even entirely new business ventures and new products develop where operations allow analysis of volumes of data previously beyond manual approaches. Businesses also benefit from the perception by their clients of being advanced and familiar with modern technology. That perception alone can increase the client base, increase visibility and use of industry services, and often increase profits. Digital data archiving alone allows access to data that may have been long ignored. The improved quality and increased quantity and variety of digital products developed through GIS is another way GIS empowers organizations.

The addition of GIS as a technology often forces organizations to reconsider inefficient workflows and improve the overall organizational efficiency. While the introduction of GIS can cause some conflicts in organizations, especially among nontechnical personnel, wise GIS implementations through effective design strategies can actually improve morale and promote a sense of belonging and esprit de corps.

ACTIVITY 1-3 THE GIS USER COMMUNITY

In the following activity, you will have the opportunity to demonstrate your mastery of the industries and communities that use GIS. You will also be given an opportunity to relate the types of work these groups do to the kinds of analysis of which GIS is capable and how these techniques can benefit and empower the industries that employ GIS.

Go to the website http://www.esri.com/ and click on the "industries" tab on the top left, right next to the Esri logo. Select two industries, at least one of which is of interest to you, from among the many.

1. Name the two industries you have selected and next to each list the different industry focus groups.

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2. Select at least one of the industries you identified in the first activity, in particular one that you are interested in. On the website for that industry, go to community and click on the Get Connected button. Describe the types of information you find there.

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3. List and describe at least five of the disciplinary specialties from within the two industries you selected. Next to each industry, indicate the general tasks that GIS addresses for it.

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ACTIVITY 1-3 (CONTINUED)

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4. Select from your two industries the names of organizations that belong to the user community (e.g., company names, nonprofits, government agencies).*

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5. Go back to the list of questions GIS is capable of answering. Keep them handy. Now do a WebQuest (search the Internet) by picking keywords related to two or more industries and examine examples of GIS work. The keywords might be selected or modified from the list of questions you have at your fingertips. As a hint, for the example from page 10, I used the following terms in a Google search ("locating crime" "GIS") and then selected images so I could visualize the output from GIS. By clicking on the image, I could also navigate to the website so I could learn about what was happening.

   Now find five examples of real GIS applications and list the URL of the image for each. Next to each of these, describe at least one question that was asked in the application (be specific; e.g., this GIS application showed the change in crime locations through time).

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These companies may very well be your future employers.

The GIS Skill Set

As a student of GIS, you might find it odd that there is a section of this chapter devoted to the skills you will learn in GIS. Unfortunately, many employers, especially those new to GIS, have little idea what specific skills they need when they advertise for open positions. You may see something as vague as, "Three years of GIS experience" to as specific as "Specializing in the development of enterprise geodatabases." Unfortunately, this doesn't give you much help in preparing for a career in GIS. It is also reasonable to assume that many of you will select different career paths in GIS from applications to modelers, to designers to programs, and many more. Fortunately, an ambitious graduate student at the University of Washington, Michalis Avraam, has created a blog with just the information you need. The URL for his blog is https://tinyurl.com/zkcteqw. Michalis divides these skills into five sets: GIS Skills (including basic spatial understanding), Programming Skills, Database Skills, Project Management and Design, and Other Skills. The relative importance of these five groups of skills varies both based on the kind of organization for which you hope to work and the ever-changing needs of the industry. Take some time to peruse Michalis' blog and read the specific examples of how the skills are exactly translated into the workplace.

Beyond these specific industry-wide and industry sector technical skills, the U.S. Department of Labor has developed a **geospatial competency model** (https://tinyurl.com/z2ly5og) that not only indicates the need for technical skills but also shows the importance of personal, academic, and workplace skills (Figure 1-5).

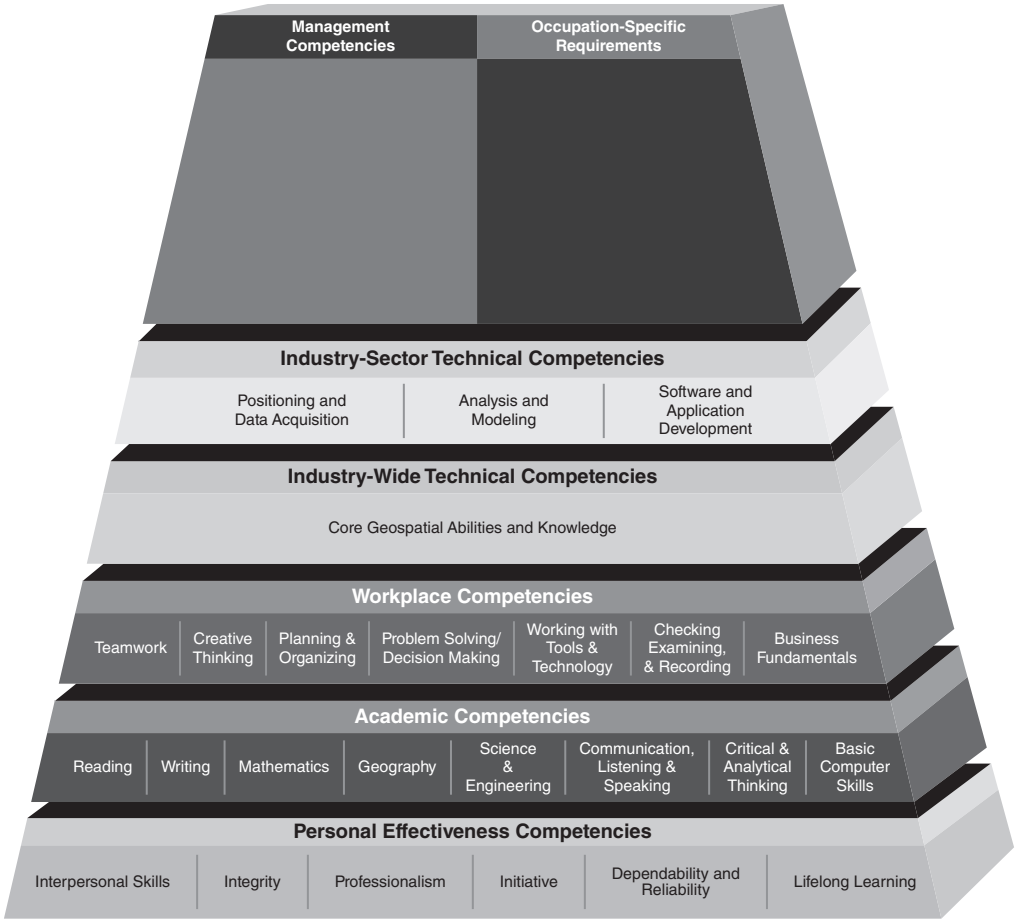

FIGURE 1-5 U.S. Department of Labor Geospatial Competency Model. https://tinyurl.com/z2ly5og

ACTIVITY 1-4 THE GIS SKILL SET

In the following activity, you will have the opportunity to demonstrate your mastery of the GIS skill sets that will assist you in employment.

1. What are the five categories of skill sets listed in Michalis' blog?

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2. From that blog, your text, and any outside reading, list five concrete examples of how specific GIS knowledge and skills can help you in obtaining employment in non-GIS organizations.

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Incorporating GIS Knowledge and Skills into Your Work and the Workplace

Depending on what career path you choose within or outside the GIS industry, your technical GIS skills will no doubt improve your chances of employment and also improve, if not transform, the workplace. Your spatial understanding, ability to work with different data models and data structures, knowledge of computer science and programming, modeling and data management skills, ability to move between computer platforms, and project management skills are all transferable to nearly all GIS-related industries and a great many non-GIS industries. As you move up in the industry, it is often likely that you will move into the institutional design and strategic planning aspects of the industry. There are instances when companies do not currently use GIS but whose businesses constantly rely on spatial information. Some examples are grocery stores that need to understand their nearby customer needs, hospitals that need to route ambulances and have enough beds for patients in their area, and drug stores that are attempting to make sure they have the kinds of pharmaceuticals for a neighborhood that has a large concentration of elderly. Places that deliver pizza that want to improve delivery times for their pizza will benefit from the routing capabilities of GIS. Colleges and universities can use GIS to recruit the best students. Mapping companies can produce considerably more maps and map updates digitally than they can manually. These are just a few examples. Perhaps you can think of many more.

ACTIVITY 1-5 THE GIS SKILLS AND KNOWLEDGE AT WORK

In the following activity, you will have the opportunity to demonstrate your mastery of the GIS skill sets as they apply to improving the workplace.

1. Select some form of business and describe how GIS tools might be applied to improving profitability. The business type must be real (e.g., liquor store, grocery), but the specific store name is not necessary.

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2. Select some form of nonprofit organization and describe how GIS tools might improve its ability to perform its mission.

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3. Explain to your friend how GIS might make government (local, regional, county, federal, etc.) more efficient and more responsive.

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ADDITIONAL READING AND RESOURCES

Mitchell, Andy. *The Esri Guide to GIS Analysis*. Vol. 1, *Geographic Patterns and Relationships*. Redlands, CA: Esri Press, 2001.

INDUSTRY PROFILE

United States Department of Labor, Employment and Training Administration. http://www.doleta.gov/brg/indprof/geospatial_profile.cfm

KEY TERMS

cluster: An agglomeration of geographic objects so that they occur in close proximity to one another leaving empty space surrounding them.

geodatabase: A proprietary database model that stores, queries, and manipulates spatial data. Beyond a mere geographic database it stores geometry, spatial reference, attributes, and behavioral rules for the data.

geospatial competency model: A collaborative effort of the Employment and Training Administration (ETA), the GeoTech Center, and industry standards that provides guidance for the skills and knowledge needed by today's geospatial technology professionals.

hot spot: An area on a map that displays concentrations, or relatively high densities, of events or geographic features.