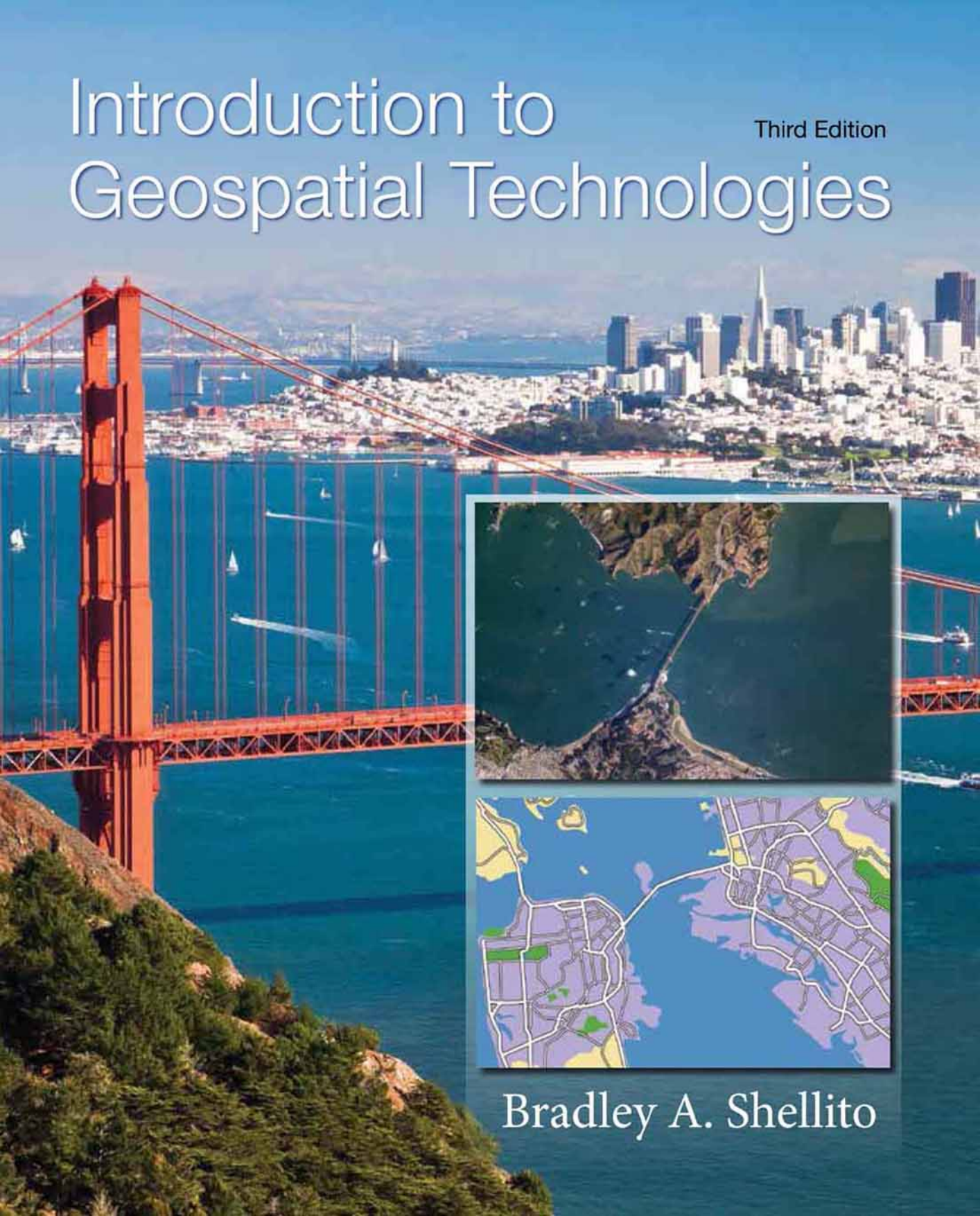
Introduction to Geospatial Technologies

Third Edition



Bradley A. Shellito

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Youngstown State University

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Dedication

This book is dedicated to my parents, David and Elizabeth, who taught me that with a lot of hard work—and a little luck—all things are possible.

About the Author

[Source: Neal P. McNally]

Bradley A. Shellito is a geographer whose work focuses on the application of geospatial technologies. Dr. Shellito has been a professor at Youngstown State University (YSU) since 2004, and was previously a faculty member at Old Dominion University. He teaches classes in GIS, remote sensing, GPS, and 3D visualization, and his research interests involve using these concepts within a variety of real-world issues. His second book, *Discovering GIS and ArcGIS*, was also published by Macmillan Education. He also serves as YSU's Principal Investigator in OhioView, a statewide geospatial consortium. A native of the Youngstown area, Dr. Shellito received his bachelor's degree from YSU, his master's degree from the Ohio State University, and his doctorate from Michigan State University.

Contents in Brief

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Preface

Why I Wrote *Introduction to Geospatial Technologies*

When people ask me what I teach, I say "geospatial technology." The usual response to this statement is a blank stare, a baffled "What?" or a variation on "I've never heard of that." However, if I say I teach "technologies like GPS, taking images from satellites, and using online tools like Google Earth or MapQuest," the response generally improves to: "GPS is great," or "Google Earth is so cool," or even "Why do I get the wrong directions from that thing in my car?" Although geospatial technologies are everywhere these days—from software to Websites to cell phones—it seems that the phrase "geospatial technology" hasn't really permeated into common parlance.

I hope that this book will help remedy this situation. As its title implies, the goal of this book is to introduce several aspects of geospatial technologies—not only what they are and how they operate, but also how they are used in hands-on applications. In other words, the book covers a little bit of everything, from theory to application.

In a sense, the book's goal is to offer students an overview of several different fields and techniques and to provide a solid foundation on which further knowledge in more specialized classes can be built, such as those delving further into geographic information systems (GIS) or remote sensing. Whether the book is used for a basic introductory course, a class for non-majors, or as an introduction to widely used geospatial software packages, this book is aimed at beginners who are just starting out. At Youngstown State University (YSU), I teach an introductory class titled "Geospatial Foundations," but similar classes at other universities may have names like "The Digital Earth," "Introduction to Geospatial Analysis," "Survey of Geospatial Technologies," "Introduction to GIS," or "Computer Applications in Geography." All of these courses seem aimed at the audience for which *Introduction to Geospatial Technologies* was written.

Organization of the Book

This book is divided into four main parts.

Part 1: Geospatial Data and GPS focuses on geospatial technology as it relates to spatial measurements and data.

- Chapter 1, "It's a Geospatial World Out There," introduces some basic concepts and provides an overview of jobs, careers, and some key technologies and applications (such as Google Earth).
- Chapter 2, "Where in the Geospatial World Are You?," explains how coordinates for location-based data and measurements from a three-dimensional (3D) world are translated into a two-dimensional (2D) map on a computer screen.
- Chapter 3, "Getting Your Data to Match the Map," discusses reprojection and georeferencing, important information when you're using any sort of geospatial data.
- Chapter 4, "Finding Your Location with the Global Positioning System," introduces GPS concepts. Taking a hand-held receiver outside, pressing a button, and then having the device specify your precise location and plot it on a map sounds almost like magic. This chapter demystifies GPS by explaining how the system works, why it's not always perfectly accurate, and how to get better location accuracy.

Part 2: Geographic Information Systems focuses on geographic information systems (GIS).

- Chapter 5, "Working with Digital Geospatial Data and GIS," serves as an introduction to GIS, examining how real-world data can be modeled and how GIS data can be created and used.
- Chapter 6, "Using GIS for Spatial Analysis," covers additional uses of GIS, including querying a database, creating buffers, and geoprocessing.
- Chapter 7, "Using GIS to Make a Map," offers instruction on how to classify your data and how to transform GIS data into a professional-looking map.
- Chapter 8, "Getting There Quicker with Geospatial Technology," discusses concepts related to road networks, such as: How are streets, highways, and interstates set up and used in geospatial technology? How does the computer translate a set of letters and numbers into a map of an actual street address? How do programs determine the shortest route from point *a* to point *b*?

Part 3: Remote Sensing examines issues related to remote sensing.

- Chapter 9, "Remotely Sensed Images from Above," focuses on aerial photography. It explains how the field started over 150 years ago with a man, a balloon, and a camera, and how it continues today with unmanned aircraft systems flying over Iraq and Afghanistan. This chapter also describes how to visually interpret features in aerial imagery and how to make accurate measurements from items present in an image.
- Chapter 10, "How Remote Sensing Works," delves into just what remote sensing is and how it works, and how exactly that image of a house is acquired

by a sensor 500 miles away. This chapter also discusses all of the things that a remote sensing device can see that are invisible to the human eye.

- Chapter 11, "Images from Space," focuses on the field of satellite remote sensing and how satellites in orbit around Earth acquire images of the ground below.
- Chapter 12, "Studying Earth's Climate and Environment from Space," discusses the Earth Observing System, a series of environmental observatories that orbit the planet and continuously transmit data back to Earth about the land, seas, and atmosphere.

Part 4: Geospatial Applications focuses on individual topics in geospatial technology that combine GIS and remote sensing themes and applications.

- Chapter 13, "Digital Landscaping," describes how geospatial technologies model and handle terrain and topographic features. Being able to set up realistic terrain, landscape features, and surfaces is essential in mapping and planning.
- Chapter 14, "See the World in 3D," delves into the realm of 3D modeling, shows how geospatial technologies create 3D structures and objects, and then explains how to view or interact with them in programs like Google Earth.
- Chapter 15, "Life in the Geospatial Cloud and Other Current Developments," wraps things up with a look at the influence and advantages of the cloud, information regarding organizations and educational opportunities within geospatial technologies, and a look ahead to the future of the field.

Geospatial Lab Applications

Each chapter of *Introduction to Geospatial Technologies* covers one aspect of geospatial technology with an accompanying Geospatial Lab Application. The goal of these lab applications is not to teach software, but to help students work directly with the chapter's concepts. Each lab application uses freely available software that can be downloaded from the Internet or accessed through a Web browser. These software packages include:

- ArcGIS Online
- Google Earth Pro
- MapCruncher
- MultiSpec
- QGIS
- SketchUp
- Trimble GNSS Planning Online

Three of the chapters in Part 2 (Geographic Information Systems) offer two versions of the lab application. Instructors can choose to use either the free QGIS or ArcGIS for Desktop. The labs provide hands-on application of the concepts and theories covered in each chapter—it's one thing to read about how 3D structures can be created and placed into Google Earth, but it's another thing entirely to use SketchUp and Google Earth to do exactly that. Each lab application has integrated questions that students must answer while working through the lab. These questions are designed both to explore the various topics presented in the lab and also to keep students moving through the lab application. Note that words or phrases highlighted in purple text in the labs indicate menu items or icons that are clicked on or specific items that are typed in during the lab.

Some labs use sample data that comes with the software when it's installed; others require students to download sample data for use in the lab. Each lab provides links to a Website from which you can download the software. (The Website will also provide information regarding the necessary hardware or system requirements. Not all computers or lab facilities work the same, so be sure to check the software's Internet resources for help on installing the software.) The Instructors' section of this book's catalog page also offers a "tech tips" section with some additional information related to installing or utilizing some of the software.

The lab applications for each chapter are set up as follows:

- Chapter 1: This lab introduces the free Google Earth Pro as a tool for examining many facets of geospatial technology.
- Chapter 2: Students continue using Google Earth Pro, investigating some other functions of the software as they relate to coordinates and measurements.
- Chapter 3: Students use Microsoft's MapCruncher program to match a graphic of a campus map with remotely sensed imagery and real-world coordinates.
- Chapter 4: This lab uses Trimble GNSS Planning Online and some other Web resources to examine GPS planning and locations. It also provides suggestions for expanding the lab activities if you have access to a GPS receiver and want to get outside with it.
- Chapter 5: This lab introduces basic GIS concepts using QGIS. An alternate version of the lab uses ArcGIS for Desktop.
- Chapter 6: This lab continues investigating the functions of QGIS (or ArcGIS for Desktop) by using GIS to answer some spatial analysis questions.
- Chapter 7: This lab uses QGIS (or ArcGIS for Desktop) to design and print a map.
- Chapter 8: This lab uses Google Maps and Google Earth Pro to match a set of addresses and investigate shortest paths between stops on a network.

- Chapter 9: This lab tests students' visual image interpretation skills by putting them in the role of high-tech detectives who are trying to figure out just what a set of aerial images are actually showing.
- Chapter 10: This lab is an introduction to MultiSpec, which allows users to examine various aspects of remotely sensed imagery obtained by a satellite.
- Chapter 11: This lab continues using MultiSpec by asking students to work with imagery from the Landsat 8 satellite and investigate its sensors' capabilities.
- Chapter 12: This lab uses NASA data and Google Earth Pro to examine phenomena such as hurricanes, fires, and pollution on a global scale.
- Chapter 13: This lab uses Google Earth Pro to examine how terrain is used in geospatial technology (and film a video of flying over 3D-style terrain). It also uses the various terrain functions of Google Earth Pro for work with several digital terrain modeling features.
- Chapter 14: This lab introduces 3D modeling. Starting from an aerial image of a building, students design a 3D version of it using SketchUp, and then look at it in Google Earth.
- Chapter 15: This lab utilizes Esri's free ArcGIS Online to stream data from the cloud, create Web maps, wrap things up, and look at many of the book's concepts combined in a single package.

Additional Features

In addition to the lab applications, each chapter contains several **Hands-On Applications,** which utilize free Internet resources to help students further explore the world of geospatial technologies and get directly involved with some of the chapter concepts. There's a lot of material out there on the Internet, ranging from interactive mapmaking to real-time satellite tracking, and these Hands-On Applications introduce students to it. In the third edition, each Hands-On Application has a set of Expansion Questions for students to answer while working with that Application's Web resources.

Each chapter also has one or more boxes titled **Thinking Critically with Geospatial Technology.** These boxes present questions to consider regarding potential societal, privacy, design, or ethical issues posed by geospatial technologies and their applications. The questions presented in these boxes are open-ended and are intended to stimulate discussion about geospatial technologies and how they affect (or could affect) human beings. For instance, how much privacy do you really have if anyone, anywhere, can obtain a clear image of your house or neighborhood and directions to drive there with just a few clicks of a mouse?

Lastly, each chapter ends with two boxes. The first of these, chapter **Apps,** presents some representative apps for a mobile device related to the chapter's content that you may wish to investigate further. For instance, Chapter 8's *Geocoding and Shortest Paths Apps* box showcases apps for your

phone or your tablet. Note that at the time of writing, all of these apps were free to obtain and install.

The second section, **Social Media,** highlights some representative Facebook, Twitter, and Instagram accounts, as well as YouTube videos and blogs, that are relevant to the chapter's topics. For instance, Chapter 11's *Satellite Imagery in Social Media* box features Facebook and Twitter accounts from satellite imagery sources such as DigitalGlobe or the USGS updates on Landsat, as well as videos of satellite imagery applications. (Note that all of these apps and social media accounts are examples, not recommended products.)

New to This Edition

The third edition contains multiple key updates. Each chapter has something new within it, whether it's a newly added or revised text section, Hands-On Application, or Lab Application. At the end of each chapter, there is an updated section on available smartphone and tablet apps as well as resources for using geospatial technologies in social media. The Lab Applications have been updated to use current software and techniques, including all new Lab Applications that utilize ArcGIS Online (Chapter 15), Trimble GNSS Planning Online (Chapter 4), and the now-free Google Earth Pro (Chapters 1, 2, 8, 12, and 13). In addition, Landsat 8 imagery is now used with Multispec (Chapters 10 and 11), and the most recently available version of QGIS is used for the GIS Lab sections (Chapters 5, 6, and 7).

There are many other updates and revisions throughout each chapter. For instance, Chapter 1 showcases using geospatial technologies on mobile devices and how geolocation works. The remote sensing focused chapters (9, 10, 11, and 12) have been expanded to include many topics about the state of remote sensing today, including UAS, Landsat 8, Sentinel-2, Skysat, Suomi-NPP, small satellites, cubesats, and using remote sensing for disaster monitoring. Chapter 13 includes more information about US Topos as well as the change from the National Elevation Dataset to the new 3DEP elevation data used by the USGS. Chapter 15 has been expanded and revised for a focus on the use of the cloud with geospatial technologies, including new Hands-On Applications that utilize Esri Story Maps. Also, throughout the book there are new Hands-On Applications that use new Web resources, including Tomnod, Landsat Live, Indiemapper, Census Mapping tools, and CityEngine Web Scenes.

Ancillary Materials and Student and Instructor Resources

The catalog page **macmillanhighered.com/shellito/catalog** offers a set of valuable resources for both students and instructors.

For **students,** the catalog page offers a multiple-choice self-test for each chapter, as well as an extensive set of references, categorized by topic, to

provide further information on a particular topic. There are also a set of links to the free software packages needed to complete the lab activities, as well as the datasets required for specific lab applications. A set of world links is also provided.

For **instructors,** the catalog page offers an instructor's manual, which provides teaching tips for each chapter on presenting the book's material, a set of "tech tips" related to software installation and usage, a set of key references for the chapter materials, and an answer key for all the lab activities. A test bank of questions is also provided.

Acknowledgments and Thanks

Books like this don't just spring out of thin air—I owe a great deal to the many people who have provided inspiration, help, and support for what would eventually become this book.

Bill Minick, my editor, has offered invaluable help, advice, patience, and guidance throughout this entire project. I would also very much like to thank Abigail Fagan, Sheena Goldstein, Paul Rohloff, and Christine Buese at Macmillan Education for their extensive "behind the curtain" work that shaped this book into a finished product.

I want to thank Sean Young for his very helpful comments and feedback on the previous editions and for his close reading and review of the labs in this third edition. Neil Salkind and Stacey Czarnowski gave great representation and advice. The students who contributed to the development of the YSU 3D Campus Model (Rob Carter, Ginger Cartright, Paul Crabtree, Jason Delisio, Sherif El Seuofi, Nicole Eve, Paul Gromen, Wook Rak Jung, Colin LaForme, Sam Mancino, Jeremy Mickler, Eric Ondrasik, Craig Strahler, Jaime Webber, Sean Welton, and Nate Wood) deserve my sincere thanks. Many of the 3D examples presented in Chapter 14 wouldn't have existed without them. Others who supported this book in various ways include: Jack Daugherty, for tech support, assistance with the labs, and help with the GeoWall applications; Lisa Curll, for assistance with the design and formatting of the lab applications; Grant Wilson, for his insightful technical reviews of the ArcGIS lab applications; Margaret Pearce, for using an earlier draft of the manuscript with her students at the University of Kansas and for her extremely useful comments and feedback; Hal Withrow, for invaluable computer tech assistance; and Mark Guizlo for assistance with data sources.

I offer very special thanks to all of my professors, instructors, colleagues, and mentors, past and present (who are too numerous to list), from Youngstown State University, the Ohio State University, Michigan State University, Old Dominion University, OhioView, and everywhere else, for the help, knowledge, notes, information, skills, and tools they've given me over the years. I am also deeply indebted to the work of Tom Allen, John Jensen, Mandy Munro-Stasiuk, and the members of SATELLITES for some methods used in some of the chapters and labs.

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A Rapidly Changing Field

As Chapter 15 points out, geospatial technology has become so widespread and prevalent that no book can cover every concept, program, or online mapping or visualization tool (as much as I'd like this one to). I hope that the students who use this book will view the concepts and applications presented herein as an introduction to the subject—and that this will motivate them to take more advanced courses on the various aspects of geospatial technology.

One thing to keep in mind: In such a rapidly advancing field as geospatial technology, things can change pretty quickly. New satellites are being launched and old ones are ending their mission lives. Websites get updated and new updates for software and tools are released on a regular basis. As of the writing of this book, all of the Web data, software, and satellites were current, but if something's name has changed, a Website works differently, or if a satellite isn't producing any more data, there's probably something newer and shinier to take its place.

I'd very much like to hear from you regarding any thoughts or suggestions you might have for the book. You can reach me via email at **bashellito@ysu.edu** or follow me on Twitter **@GeoBradShellito**.

Bradley Shellito
Youngstown State University

Accessing Data Sets for Geospatial Lab Applications

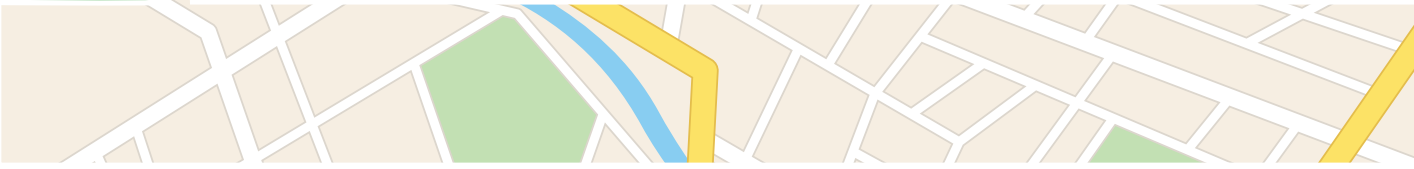
Some of the Geospatial Lab Applications in this book use data that comes with the software, sample data that gets installed on your computer when you install the software itself, or data that you'll create during the course of the lab. However, the lab applications for Chapters 3, 5, 6, 7, 9, 10, 11, and 12 require you to download a set of data that you'll use with those labs.

The lab applications will direct you to copy the dataset before beginning the lab. Each dataset is stored in its own folder online. To download these folders, please visit **macmillanhighered.com/shellito/catalog.** Under "Student Options," you'll find access to student resources, including "Lab Data Sets."

ArcGIS 10.3 (Esri), ArcGIS Online (Esri), Google Earth Pro 7.1 (Google), SketchUp Make (Trimble), MapCruncher 3.2 (Microsoft), MultiSpec 3.4, QGIS 2.8.1, Trimble GNSS Planning Online.

PART 1 GEOSPATIAL DATA AND GPS

1 It's a Geospatial World Out There



An Introduction to Geospatial Technologies, Geospatial Jobs, Geospatial Data, Volunteered Geographic Information, Geolocation, and Google Earth

Have you ever done any of the following?

- Used a smartphone, tablet, or other mobile device to find your location, coordinates, or directions, or to look for the nearest restaurant or gas station?
- Used an online mapping service like MapQuest, Google Maps, or Bing Maps to find directions (and the best route) to a destination or to print a map of an area?
- Used an in-car navigation system (say, one from Garmin, Magellan, or TomTom) to navigate to or from a destination?
- Used social media (such as Facebook or Twitter) to add your location information to a post or tweet?
- Used a Global Positioning System (GPS) receiver while hiking, jogging, hunting, fishing, golfing, or geocaching?
- Used a Web resource to find a map of your neighborhood so that you can compare nearby housing values or see exactly where your property ends and your neighbor's begins?
- Used a virtual globe program (like Google Earth) or an online map to look at photos or images of your home, street, school, or workplace?

If so, then congratulations—you've used geospatial technologies. Anytime you're using any sort of technology-assisted information (on a computer, smartphone, or tablet) concerning maps, locations, directions, imagery, or analysis, you're putting geospatial technology applications to use.

Geospatial technology has become extremely widespread in society, with a multitude of uses in both the private and public sectors. However, more often than not, if you tell someone you're using geospatial technology, you'll be asked, "What's that?"

What Is Geospatial Technology?

Although geospatial technology is being used in numerous fields today, the term "geospatial technology" doesn't appear to have seeped into everyday usage. Words like "satellite images" and "Google Earth" and acronyms like "GIS" and "GPS" are growing increasingly commonplace, yet the phrase "geospatial technology" seems relatively unknown, though it incorporates all of these things and more. **Geospatial technology** describes the use of a number of different high-tech systems and tools that acquire, analyze, manage, store, or visualize various types of location-based data. The field of geospatial technology encompasses several fields and techniques, including:

- **Geographic information system (GIS)**: Computer-based mapping, analysis, and retrieval of location-based data
- **Remote sensing**: Acquisition of data and imagery from the use of satellites (**satellite imagery**) or aircraft (**aerial photography**)
- **Global Positioning System (GPS)**: Acquisition of real-time location information from a series of satellites in Earth's orbit

There are numerous related fields that utilize one or more of these types of technologies. For instance, an in-car navigation system already contains extensive road-network data, mapped out and ready to use, which includes information about address ranges, speed limits, road connections, and special features of roads (such as one-way streets). It also requires the mapping of points of interest (such as gas stations or restaurants), and should be capable of referencing new user-defined destinations. It also has to be able to plot the car's real-time position in relation to these maps and may even have a feature that shows a representation of the surrounding landscape as taken from an overhead viewpoint. Many of these types of systems combine different geospatial technologies to work together in one application.

geospatial technology a number of different high-tech systems that acquire, analyze, manage, store, or visualize various types of location-based data

Geographic information system (GIS) computer-based mapping, analysis, and retrieval of location-based data

remote sensing acquisition of data and imagery from the use of satellites or aircraft

satellite imagery digital images of Earth acquired by sensors onboard orbiting spaceborne platforms

aerial photography acquisition of imagery of the ground taken from an airborne platform

Global Positioning System (GPS) acquisition of real-time location information from a series of satellites in Earth's orbit

Who Uses Geospatial Technology?

Geospatial technology is used in a wide variety of fields (**Figure 1.1**), including federal, state, and local government, forestry, law enforcement, public health, biology, and environmental studies (see *Hands-On Application 1.1: Industries Using Geospatial Technology* for a look at industries employing

FIGURE 1.1 Examples of geospatial technology in action on the job.
[Source: (top left) AP Photo/ Wilfredo Lee (top right) © Ron Nickel/Design Pics/Corbis (center left) Joe Raedle/Getty Images (center right) Bob Nichols/USDA NRCS (bottom left) AP Photo/U.S. Geological Survey, Dr. Dan Dzurisin (bottom right) Justin Sullivan/Getty Images]

HANDS-ON APPLICATION 1.1

Industries Using Geospatial Technology

Geospatial technology is being used in a variety of applications in numerous different fields today. For a deeper look at some of these applications, visit **www.esri.com/industries.html**, which is run by Esri (we'll discuss more about Esri in Chapter 5, but the short version is that they're the market leader in GIS). This site lists dozens of different fields that are using geospatial technology, and describes how GIS (and other Esri products) are being utilized in them. Examine a few that are connected to your own fields of interest. For instance, if your interest is in law enforcement, examine some of the "Public Safety" applications. If you're involved in public or community health, examine some of the "Health and Human Services" applications, then describe how GIS is being utilized in some real-world, on-the-job applications.

Expansion Questions

- How is GIS being utilized in some real-world, on-the-job applications in fields of interest to you?
- Who in these fields is using GIS with what kinds of applications and why are they using GIS?

HANDS-ON APPLICATION 1.2

Jobs in the Geospatial Field

Businesses are hiring in the geospatial field. For examples of current job openings, visit some of the following Websites:

1. Geography Jobs: **www.geographyjobs.com**
2. Geosearch: **http://jobs.geosearch.com /JobSeeker/Jobs.aspx**
3. GIS Careers: **http://giscareers.com**
4. GIS Jobs.com: **www.gisjobs.com**
5. The GIS Jobs Clearinghouse: **www.gjc.org**
6. GIS Lounge: **http://jobs.gislounge.com**

These are just a sampling of Websites where employers post job openings worldwide. Examine several jobs from areas near where you are (or where you'd like to go to).

Expansion Questions

- What kinds of jobs are being advertised?
- What kinds of job qualifications, training, and skill sets are employers looking for?
- What kinds of starting salary ranges are employers offering?

people in these fields). As long as the job field involves the utilization of some sort of information or data that has a location associated with it, chances are that some sort of geospatial technology is being used. Geospatial technology has been heralded by the U.S. Department of Labor as one of the main emerging and evolving job fields in the United States, with enormous growth potential. For instance, the Department of Labor's O*NET (Occupational Information Network) OnLine utility contains job descriptions in fields such as "Geospatial Information Scientists and Technologists," "Remote Sensing Scientists and Technologists," and "Geographic Information Systems Technicians" (see *Hands-On Application 1.2: Jobs in the Geospatial Field* for more information about types of jobs).

The following are just a handful of examples of fields that utilize geospatial technology.

Archeology

The ability to pinpoint the location of artifacts uncovered on a dig, construct a map of the area, and then search for patterns on the site are all archeological functions that can be rendered quickly and efficiently with geospatial technology (**Figure 1.2**). Archeologists can utilize historical maps, current aerial photography or satellite imagery, and location information obtained on the site throughout the course of their work.

City Planning

Utilities, wastewater, green space, traffic, roads, zoning, and housing are all matters of concern to urban planners. Geospatial technology provides a means of working with all of these entities together for planning purposes. Strategies for smart urban growth and the management and updating of city resources can be examined through a variety of different applications.

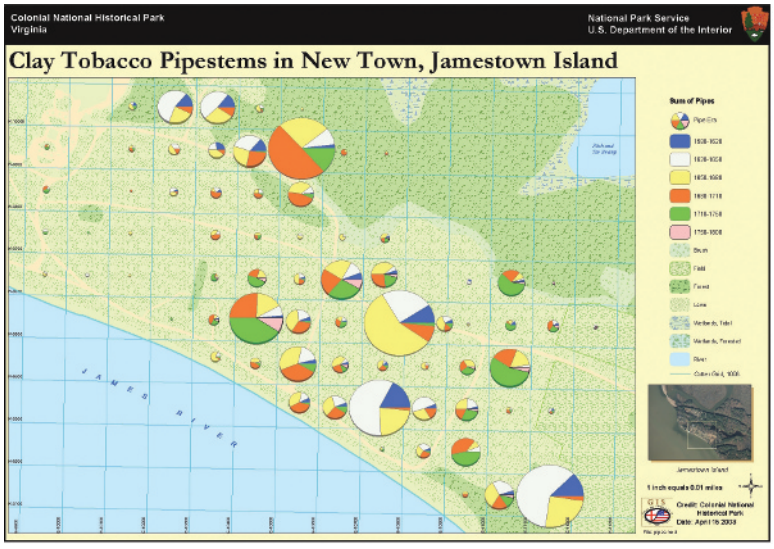


FIGURE 1.2 Using GIS for archeological mapping of Clay Tobacco Pipestems in Virginia. *[Source: Colonial National Historical Park, National Park Service]*

Environmental Monitoring

Processes that affect Earth's environment in many different ways can be tracked and assessed using geospatial technology. Information about land-use change, pollution, air quality, water quality, and global temperature levels is vital to environmental research, ranging from the monitoring of harmful algae blooms to studies in climate change (see **Figure 1.3**).

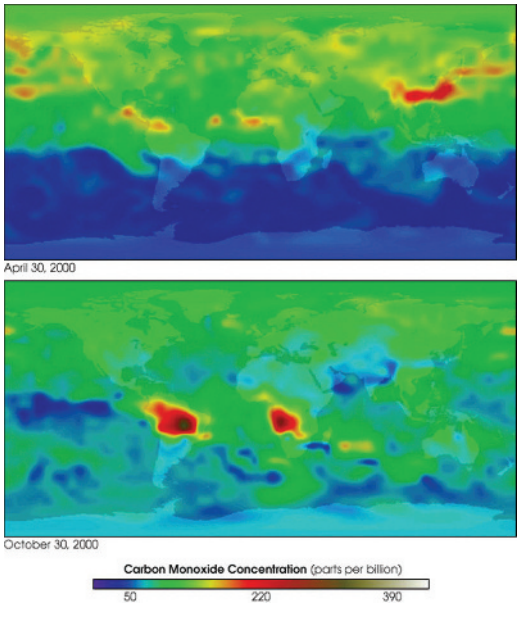


FIGURE 1.3 Global carbon monoxide concentrations as monitored by NASA remote sensing satellites. *[Source: NASA GSFC Scientific Visualization Studio, based on data from MOPITT (Canadian Space Agency and University of Toronto)]*

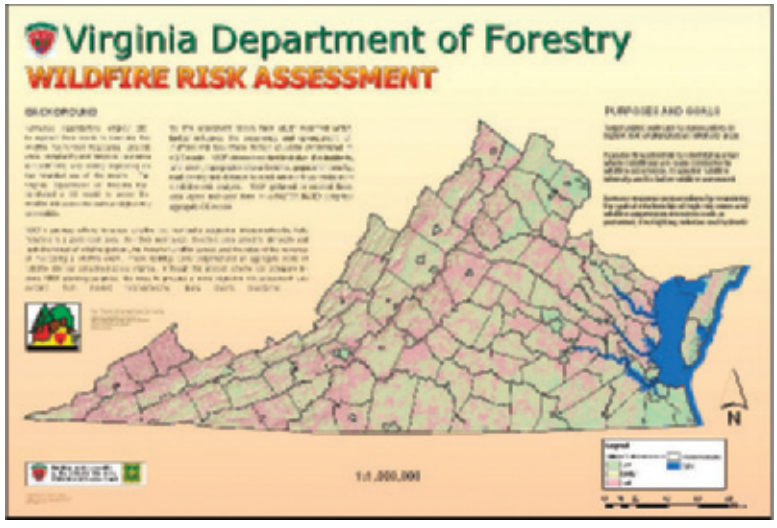


FIGURE 1.4 Geospatial technology used for assessing the risk of wildfires in Virginia. *[Source: Courtesy Virginia Department of Forestry]*

Forestry

All manner of forest monitoring, management, and protection can be aided through the use of geospatial technology. Modeling animal habitats and the pressures placed upon them, examining the spatial dimensions of forest fragmentation, and managing fires are among the many different ways that geospatial technology is utilized within the field of forestry (**Figure 1.4**).

Homeland Security

Geospatial technology is a key component in examining vulnerable areas with regard to homeland security. Risk assessment of everything from evacuation plans to smoke-plume modeling can be examined using geospatial technology. Disaster mitigation and recovery efforts can be greatly enhanced through the use of current satellite imagery and location-based capabilities.

Law Enforcement

The locations of various crimes can be plotted using GIS. Law enforcement officials can use this information to analyze patterns (**Figure 1.5**) and to determine potential new crime areas. Geospatial technology can be used in several other ways beyond mapping and analysis; for instance, police departments can gather high-resolution aerial photography of locations of patrols to provide further information about potentially dangerous areas.

Health and Human Services

Geospatial technology is used in a variety of health-related services. For example, monitoring of diseases, tracking sources of diseases, and mapping health-related issues (such as the spread of H1N1 or other influenza; see **Figure 1.6**) are all tasks that can be completed using geospatial technology applications.

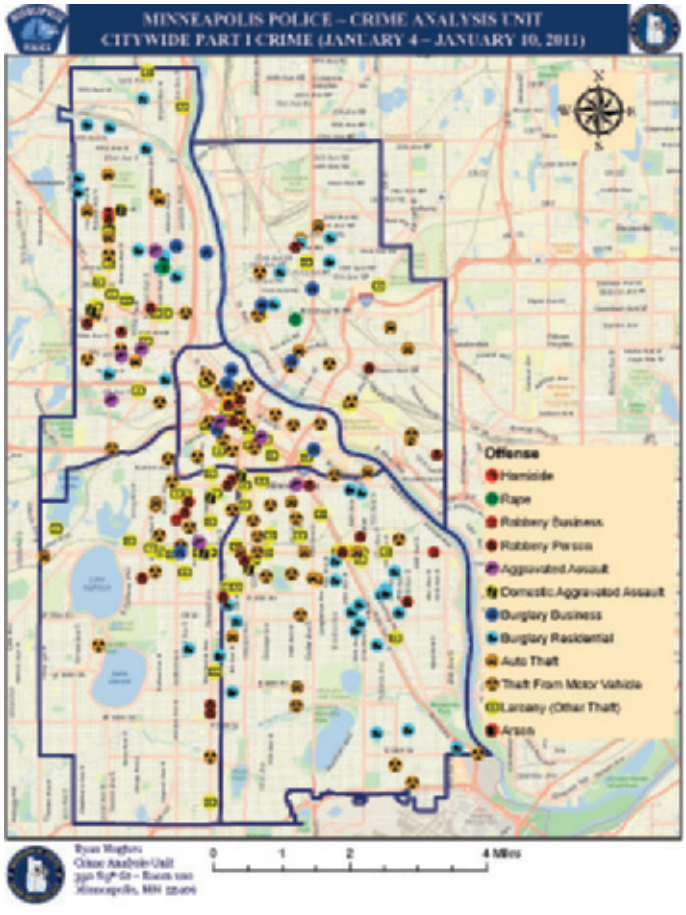


FIGURE 1.5 A GIS map showing crime locations in Minneapolis. *[Source: Minneapolis Police Crime Analysis Unit]*

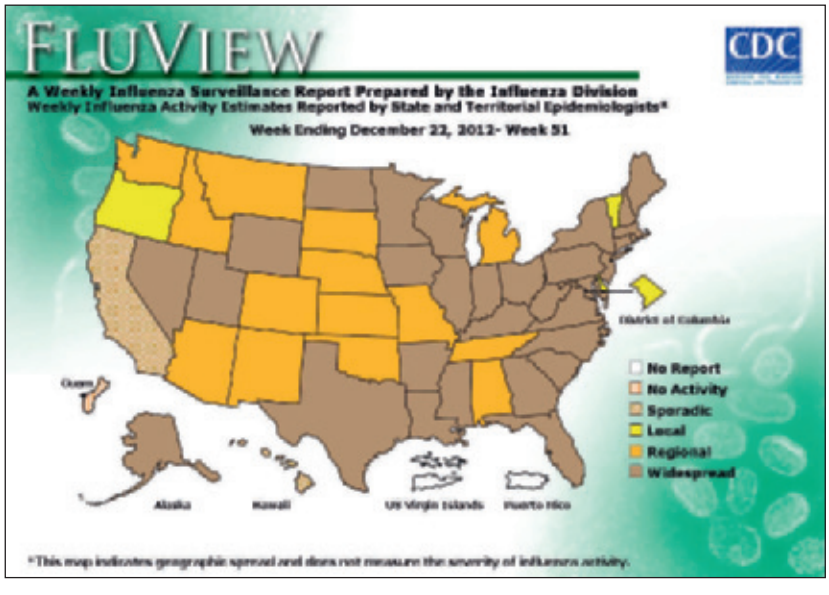


FIGURE 1.6 A CDC map examining the spatial distribution of influenza activity. *[Source: Centers for Disease Control and Prevention]*

Military and Intelligence

Geospatial technology plays a key role in today's military, defense, and intelligence worlds. Satellite imagery and aerial photography have long been used for intelligence gathering and reconnaissance, practices that continue today with an increased use of Unmanned Aerial Systems (UAS) and high-resolution satellite sensors. The field of Geospatial Intelligence (**GEOINT**) encompasses all types of remotely sensed imagery, GIS, and GPS data for information gathering and analysis related to national security and defense applications.

GEOINT Geospatial Intelligence

Real Estate

Through geospatial technology, realtors and appraisers (as well as home buyers and sellers) can create and examine maps of neighborhoods and quickly compare housing prices and values of nearby or similar properties. Other features of a property can be examined by viewing high-resolution aerial images, showing the topography, the terrain, and even if it's located on a floodplain. You can also examine where a property is located in relation to schools, highways, wastewater treatment plants, and other urban features.

All of these areas and many, many more are reliant on the capabilities of geospatial technology. No matter the field, what distinguishes geospatial technology from other types of computer systems or technologies is that it explicitly handles **geospatial data**.

geospatial data items that are tied to specific real-world locations

What Is Geospatial Data?

Geospatial data (also often referred to as "spatial data") refers to location-based data, which is at the heart of geospatial technology applications. This ability to assign a location to data is what makes geospatial technology different from other systems. You're using geospatial concepts anytime you want to know "where" something is located. For instance, emergency dispatch systems can determine the location of a 911 call. They also have access to information that tells them where the local fire stations, ambulance facilities, and hospitals are. This type of information allows the closest emergency services to be routed to its location.

When the data you're using has a location that it can be tied to, you're working with geospatial data. This isn't just limited to point locations—the length and dimensions of a hiking trail (and the locations of comfort stations along the trail) are examples of real-world data with a spatial dimension. Other kinds of data, like the boundaries of housing parcels in a subdivision or a satellite image of the extent of an area impacted by a natural disaster, would fall under this category. Geospatial technology explicitly handles these types of location-based concepts.

However, not all of the data in the world is geospatial data. For instance, data regarding the location of a residential parcel of land containing a house

and the parcel's dimensions on the ground would be geospatial information. However, other data, such as the names of the occupants, the assessed value of the house, and the value of the land is not geospatial information. A benefit of using geospatial technology is that this type of **non-spatial data** can be linked to a location. For instance, say you sell a lot of used books on eBay. You could make a map showing the locations of each of the purchasers of your online sales—this would be geospatial information. You could then link related non-spatial data (such as the name of the book that was sold or the price it was purchased for) to those locations, creating a basic database of sales.

non-spatial data data that is not directly linked to a geospatial location (such as tabular data)

Geospatial information can also be gathered about other characteristics, such as the landscape, terrain, or land use. Remote sensing provides images of the ground that serve as "snapshots" of particular locations at specific times, which can generate other forms of spatial information. For instance, a satellite image of Las Vegas, Nevada, can help ascertain the locations of new housing developments. Examining imagery from several dates can help track locations where new houses are appearing (**Figure 1.7**). Similarly,

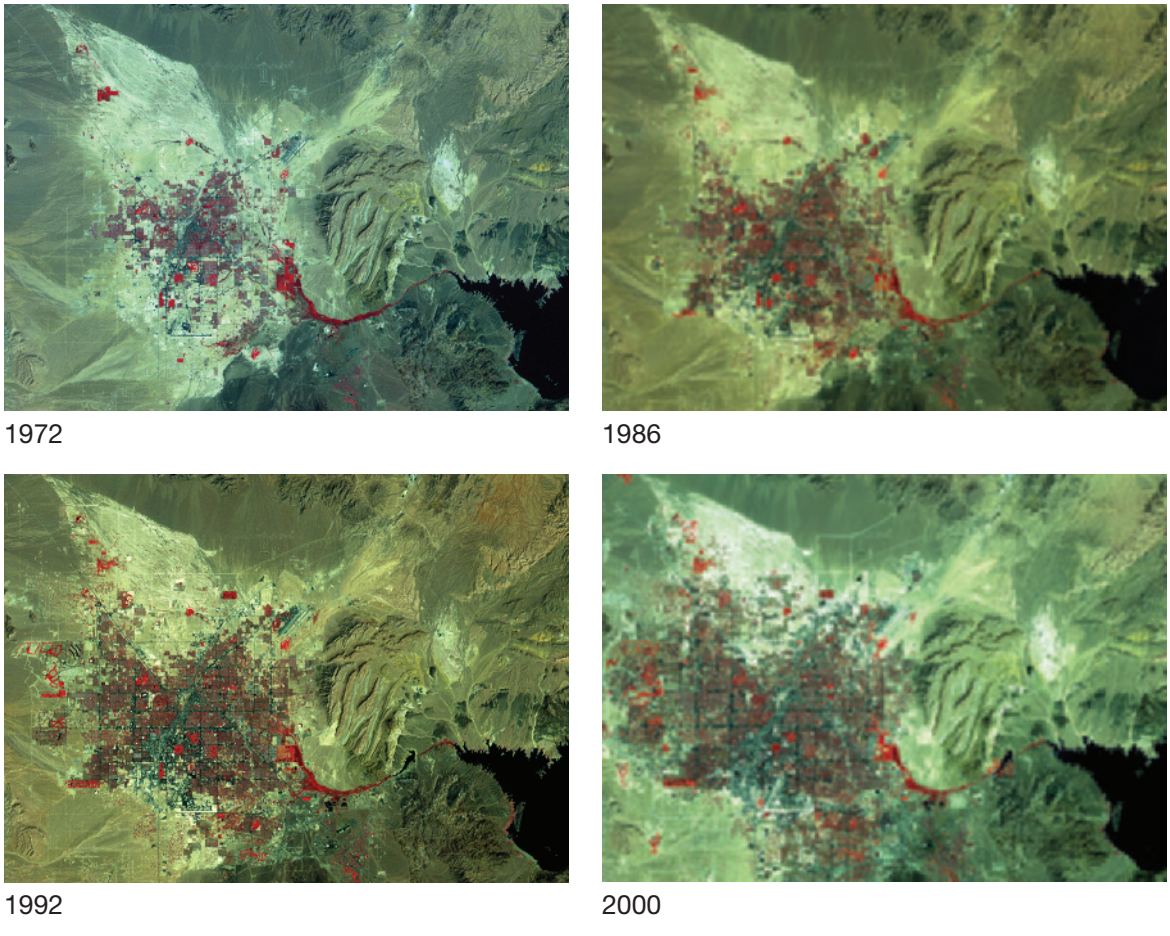


FIGURE 1.7 Satellite imagery (from 1972, 1986, 1992, and 2000) showing the growth of Las Vegas, Nevada, over time. *[Source: USGS]*